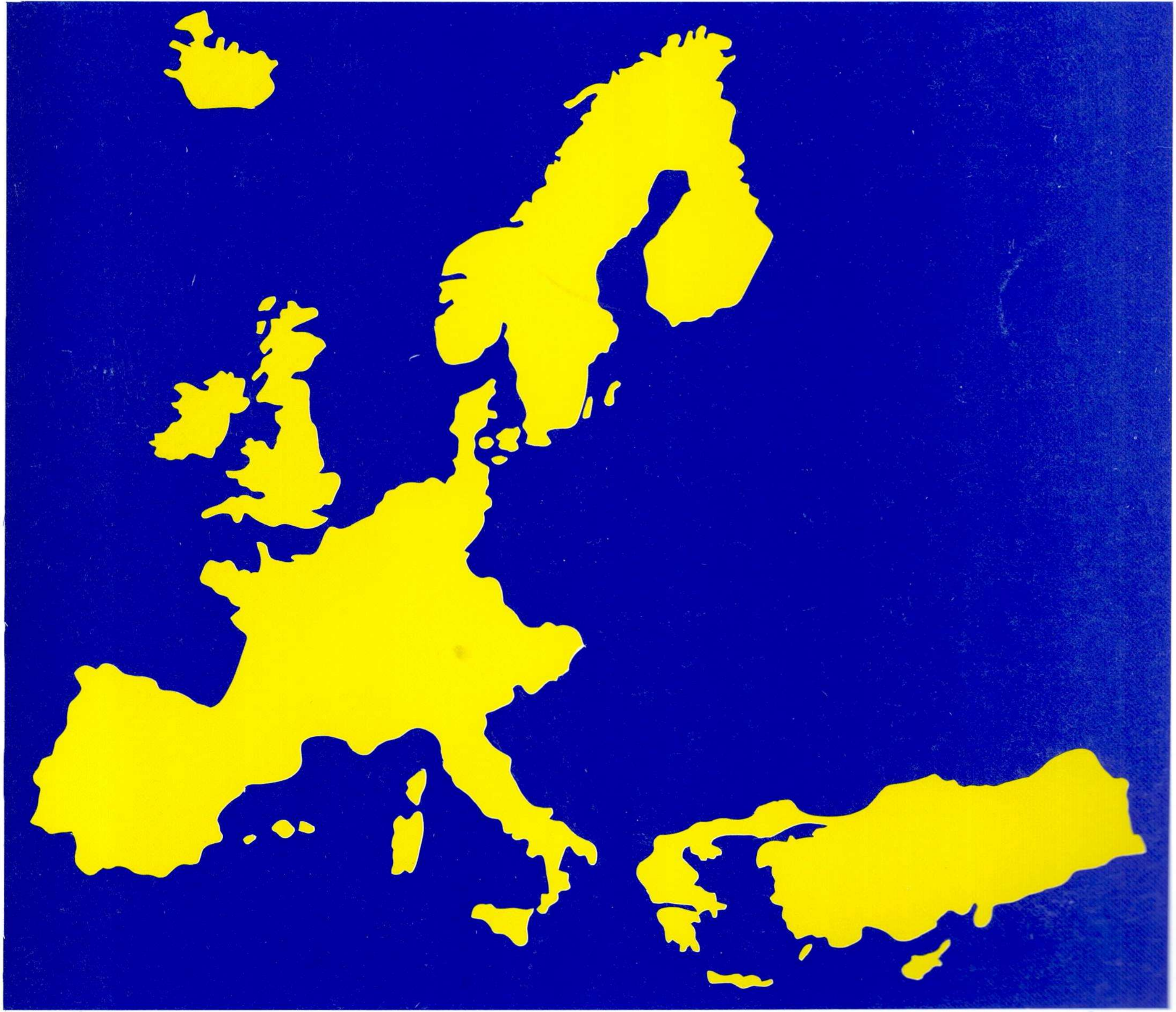
Geochemical Mapping of Western Europe
towards the Year 2000.

Pilot Project Report



Western European Geological Surveys.

Western European Geological Surveys
Working Group on Regional Geochemical Mapping

GEOCHEMICAL MAPPING OF WESTERN EUROPE TOWARDS THE YEAR 2000

PILOT PROJECT REPORT

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APPENDICES

SUMMARY

In August 1988 the Directors of the Western European Geological Surveys (WEGS) decided that the WEGS Working Group on Regional Geochemical Mapping should carry out a Pilot Project (1988 - 1990), in order to (1) prepare an inventory of regional geochemical mapping already completed in Western Europe, and (2) assess the scope and limitations of the use of overbank sediment as a sampling medium in widely spaced regional geochemical mapping. Based on the results obtained in the Pilot Project a final decision would be made by the Directors on the viability of a Main Project of geochemical mapping of Western Europe. During the last three years, the WEGS Working Group has collected and evaluated a substantial amount of information. This report highlights the main results of the work, the documentation of which is presented in 10 appendices.

The aims of the investigation were to (1) prepare an inventory of geochemical surveys of Western Europe; (2) determine the existence and extent of overbank sediment in different geological and morpho-climatic environments in Western Europe and Greenland; (3) provide data on sampling and analytical errors for overbank sediment; (4) study the vertical variations in chemical composition of overbank sediment profiles and depth of anthropogenic pollution, and confirm the existence of pristine overbank sediment at depth; (5) compare analytical results from overbank and stream sediments collected at adjacent sites, and assess the effectiveness of the two sampling media in widely spaced regional reconnaissance; (6) compare the results obtained by different analytical methods and evaluate the usefulness of the methods and (7) study the distribution of different grain size fractions in overbank sediment and determine the optimum fraction for analysis.

It is concluded that (1) although geochemical mapping is well advanced in several countries, this is mainly characterized by high sampling densities in limited areas and a variety of sampling media, analysed by different methods on different grain size fractions; (2) overbank sediment is present and can be sampled in all the WEGS countries; (3) the reproducibility of sampling and chemical analysis of overbank sediment is acceptable for regional geochemical survey purposes within the limits of analytical errors; (4) pristine samples can normally be obtained at depth even in areas polluted by mining and other human activities; (5) overbank sediment is a composite medium which is more representative of the upstream drainage area than stream sediment; (6) different chemical attacks on the samples produce complementary information; and (7) the minus 125 microns grain size fraction is considered to be the optimum after taking into account geochemical distribution patterns, as well as cost of sampling, sample preparation and chemical analysis.

The overall conclusion is that (1) overbank sediment may be used as a sampling medium for geochemical mapping at a continental scale and (2) a geochemical mapping programme of Western Europe based on the analysis of overbank sediment should be initiated. In order to provide a link to the IGCP 259 "International Geochemical Mapping" Project, and to existing regional geochemical data for Western Europe, such a programme should also include the sampling of active stream sediment.

INTRODUCTION

At the meeting of the Directors of the Western European Geological Surveys (WEGS) in Copenhagen, August 1988 (Appendix report 2), the WEGS Working Group on Regional Geochemical Mapping presented a preliminary proposal for a geochemical mapping of Western Europe, based on overbank sediment [1] (for a definition of overbank sediment, see Appendix reports 1 and 9). The WEGS Directors decided that a Pilot Project should be carried out during 1988 to 1990, in order to (1) prepare an inventory of regional geochemical mapping already completed in Western Europe, and (2) assess the scope and limitations of the use of overbank sediment as a sampling medium in widely spaced regional geochemical mapping.

Based on the results obtained in the Pilot Project a final decision would be made by the Directors on the viability of a Main Project of geochemical mapping of Western Europe. During the time of the Pilot Project (1988 - 1990) and one preceding year (Appendix report 2), the Working Group has collected and evaluated a substantial amount of information. This report highlights the main results of the work, the documentation of which is presented in the attached appendices.

The report concludes that a systematic geochemical mapping programme of Western Europe based on low density sampling of overbank sediment should be carried out. A Project Proposal for such a programme is presented in a separate volume [2].

PILOT PROJECT AIMS

The aims of the Pilot Project were to

(1) prepare an inventory of existing regional geochemical survey data for Western Europe;

(2) determine the existence and geographical extent of overbank sediment in different geological and morphoclimatic environments in Western Europe and Greenland;

(3) provide data on sampling and analytical errors for overbank sediment;

(4) study the vertical variation in chemical composition of overbank sediment profiles and depth of anthropogenic pollution, and confirm the existence of pristine overbank sediment at depth;

(5) compare analytical results from overbank and active stream sediments collected at a adjacent sites, and assess the relative effectiveness of the two sampling media in widely spaced geochemical reconnaissance;

(6) compare results obtained by different analytical methods and evaluate the usefulness of the methods;

(7) study the distribution of different grain-size fractions in overbank sediment, and determine the optimum fraction for analysis.

WORK CARRIED OUT

The following work was performed:

- A questionnaire about regional geochemical mapping in Western Europe was distributed to all WEGS Directors and the information summarized in a short report (Appendix report 10).

- Field excursions were arranged in twelve countries (Austria, F.R. Germany, Finland, France, Greece, Greenland, Iceland, Ireland, Norway, Spain, Sweden and United Kingdom) with the purpose of examining the occurrence of overbank sediment in different parts of Western Europe (Appendix reports 3.1. to 3.12).

- The reproducibility of sampling and chemical analysis of overbank sediment was tested in 19 Norwegian sites by having two independant field teams select and sample the same flood plains. The samples were analysed for their total content of 22 elements by X-ray Fluorescence Spectrometry (XRF) [3], and for their hot nitric acid soluble content of 29 elements by Inductively Coupled Argon Plasma Spectrometry (ICP) [4] (Appendix report 4.1).

- The vertical distribution of elements in overbank sediment sequences was studied in 107 profiles in different geological and morpho-climatic environments: Austria (8), F.R. Germany (50), Finland (6), Greece (20), Greenland (2), Norway (10), Spain (8) and Sweden (3). Information was also obtained from research being carried out in Ireland and the United Kingdom (Appendix reports 5.1 to 5.8).
- Comparison of the use of (1) overbank sediment and (2) stream sediment as sampling media was done in Norway, Greece and Spain by considering erosion models and comparing maps based on the two sampling media (Appendix reports 7.1 to 7.3).
- The use of different methods in the analysis of the same samples of overbank and stream sediment was studied in 5 research projects in Greece, Norway and Spain (Appendix reports 4.1, 6.2, 6.3, 7.1 and 8).
- The distribution of grain size fractions in overbank and stream sediment was studied by dry sieving of samples from Austria, Greece and Spain at a total of 58 localities. Geochemical analysis of different grain size fractions was carried out on 51 of these localities (Appendix reports 5.1 and 6.1 to 6.3).

RESULTS

INVENTORY OF GEOCHEMICAL SURVEYS OF WESTERN EUROPE

Geochemical mapping is well advanced in several countries, but is mainly characterized by high sampling densities in limited areas, and a variety of sampling media. The maximum regional geochemical coverage of Western Europe currently available (approximately 35%) is based on stream sediment samples. This compares with less than 15% for any other sample medium. The stream sediment data are, however, different suites of chemical elements as determined by different analytical methods (including 'total' and 'extractable') on different grain size fractions. It is unlikely, therefore, that a geochemical atlas of Western Europe could be compiled using available data sets. Moreover, although there are sample archives for approximately 20% of Western Europe, the size fraction stored varies.

The preparation of a regional geochemical atlas of Western Europe thus appears to require resampling and analysis based on standardized procedures (Appendix report 10).

OCCURRENCE OF OVERBANK SEDIMENT IN WESTERN EUROPE

Overbank sediment is present and can easily be sampled in most parts (>95%) of Western Europe. In southern Spain, and in parts of the French Pyrennees, Austria, the United Kingdom and Ireland, however, a more thorough knowledge of the alluvial erosion and sedimentation processes is necessary for the selection of suitable sample sites (Appendix reports 3.1 to 3.12).

SAMPLING AND ANALYTICAL REPRODUCIBILITY

For the total content of elements (XRF) the reproducibility is good for Al, Ba, Ca, Cl, Co, Fe, K, Mg, Mo, Na, P, Si, Sr, Ti, V and Zn; fairly good for Cr, Mn, Nb, Ni, Mo, Pb and Zr; and poor for As, U, W, Y and Sn.

For the hot nitric acid soluble content of the elements (ICP) the reproducibility is good for Ca, Mn, Na, Co, K, Zn, Cu, Mg, Sc and P; fairly good for Pb, Cr, Al, V, Ni, Zr, Ce, Ba, Sr and Fe; and poor for Ti, B and Mo.
It is concluded that the deviations observed in the data are mostly due to analytical limitations, because the elements with poor reproducibility are those with so low concentrations that the detection limit of the analytical method is approached (Appendix report 4.1).

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT

No serious anthropogenic pollution has been observed in the overbank sediment profiles sampled outside mining districts and major industrial sites; pristine samples can normally be obtained at depths in excess of 10 cm.

In mining districts and major industrial sites, the effects of anthropogenic pollution can be traced to greater depths (occasionally more than 1 m). Nevertheless, it is possible to obtain pristine material at depth in the overbank sediment profile even in these problem areas. However, no general rule of sampling depth can be given for such localities, and the recovery of pristine material requires an evaluation and absolute dating of profiles at each contaminated site. It should be remembered that anthropogenic influences may result in a lowering of some natural trace element levels or in enhancement, particularly in response to agricultural practices (Appendix report 5.1 to 5.8).

COMPARISON OF OVERBANK AND STREAM SEDIMENT

In most parts of Europe, except for parts of the Mediterranean countries and the Arctic, true sheet erosion can be observed only during infrequent rainstorms. Generally, active stream sediment originates in sources of limited surface extent. Active stream sediment, therefore, is not representative of whole drainage basins.

In contrast, a vertical section through overbank sediment reflects the history of sedimentation over a long period of time, and a composite sample of such a section will produce material which represents a large number of sediment sources from the drainage basin. Overbank sediment, therefore, is more representative of the whole drainage basin than stream sediment.

Active stream sediment is susceptible to contamination by mine waste or other products of human activities in the drainage basin. The lower layers of overbank sediment, however, should provide information on pre-industrial natural dispersion patterns.

It is concluded that overbank sediment is better than stream sediment as a sampling medium for low density regional and continental geochemical mapping (Appendix reports 7.1 to 7.3 and 9).

ANALYTICAL METHODS

The total content as well as the hot acid and the water extractable content of elements in overbank sediment provided complementary information.

Since the proposed geochemical map of Western Europe will be based on low density sampling it is necessary to ensure that the maximum amount of information be obtained from each sample. The Western European samples should, therefore, be analysed for the total element contents as well as for fractions extractable by hot acid or weaker extractants (Appendix reports 4.1, 6.2, 6.3, 7.1, 8 and 9).

DISTRIBUTION OF GRAIN SIZE FRACTIONS IN OVERBANK SEDIMENT

The percentage of the minus 63 microns grain size fraction in overbank and stream sediment is on average 10% of the total weight. At some sites, however, it is as low as about 1.5%, which means that a weight of about 120 to 150 kg will have to be sampled in order to obtain the required 2 kg for analysis and storage. The choice of the much larger minus 125 microns grain size fraction is proposed for the Main Project because it has been shown that the geochemical patterns in this fraction are comparable with those of the minus 63 microns fraction (Appendix report 6.1 to 6.3).

CONCLUSION

The WEGS Working Group on Regional Geochemical Mapping has carried out a Pilot Project during 1988-1990 in order to assess the viability of a Main Project to produce a geochemical atlas of Western Europe. This Pilot Project, which included preparation of an inventory of available regional geochemical data for Western Europe, field excursions, various research projects and other work, resulted in the following conclusions:

(1) Regional geochemical surveys have been carried out in most countries of Western Europe. With few exceptions, however, the coverage is partial and the surveys are not scheduled for completion until well into the next century. Moreover, sampling and analytical methods vary considerably.

(2) Overbank sediment is a suitable sampling medium for geochemical mapping in Western Europe because it is (a) representative of large drainage areas, allowing a low sampling density to be used, (b) available in all WEGS countries, (c) suitable for mapping pristine as well as polluted environments, (d) relatively easy to sample and prepare, (e) useful for linking other geochemical data sets prepared at the national level, and (f) able to provide a European input to international work such as IGCP Project 259 "International Geochemical Mapping" [4].

(3) A geochemical mapping programme of Western Europe should be established in order to prepare a systematic database and a multielement geochemical atlas based on low density sampling of overbank sediment, complemented with active stream sediment.

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WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 1

DEFINITIONS OF OVERBANK AND ACTIVE STREAM SEDIMENT

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FIGURES

1.0. INTRODUCTION

The accepted definitions of overbank and active stream sediments will be given below. The normal sampling method used in reconnaissance stream sediment geochemical surveys in two different climatic environments (temperate and semi-dry) will also be mentioned.

2.0. DEFINITION OF OVERBANK SEDIMENT

Deposits left on the flood plain by flood water outside the actual channel are described by geomorphologists as **overbank deposits** (Holmes 1966). These are generally very thin, except adjacent to the river banks, and if the flood is exceptional the alluvium swept away may exceed the amount that is afterwards left by the muddy waters as the flood subsides. Each time the river overflows its banks the current is checked at the margin of the channel, and the coarsest part of the load is dropped there. Consequently, a low embankment or levee is built up on each side. Therefore, overbank deposits are also known as **"levee sediments"**.

The A.G.I. Glossary of Geology (Gary et al. 1973, Bates and Jackson 1980), which is the most authoritative dictionary of definitions of the earth sciences defines **overbank deposit** as **"fine grained sediment (silt and clay) deposited from suspension on a flood plain by floodwaters that cannot be contained within the stream channel."** It is also considered to be synonymous to a **flood-plain deposit**, which is defined as "sandy and clayey sediment deposited by river water that was spread out over a flood-plain; a deposit beneath and forming a plain, being thickest near the river and thinning out toward the valley slopes", which is in fact the definition given by Holmes (1966). Finally, the Glossary of Geology gives the **"vertical accretion deposit"** as synonym to flood plain deposit. The vertical accretion deposit is defined as the "upward growth of a sedimentary deposit, e.g., settling of sediment from suspension in a stream subject to overflow".

The term **overbank sediment** was used for the first time in the geochemical exploration literature by Ottesen et al. (1989), who consider it to be synonymous to overbank or flood plain or levee or vertical accreted deposits (refer to Appendix 9). These authors have described in detail the deposition and features of overbank deposits. <u>The WEGS Working Group proposes, therefore, the use of their definition, which is discussed below.</u>

Overbank sediment is produced when major floods occur in a river system. During such floods the water discharge exceeds the quantity that can pass through the ordinary stream channel (bankful discharge). Even in streams of moderate size, the water level can rise a few metres above normal, thereby covering large areas. Throughout the flood, and especially during its last phases, some of the suspended load will be deposited on the flood plain at levels well above those of the ordinary stream channel (Figs. 1 and 2). Such deposits of overbank sediment may later be eroded by stream water, or overlain by more recent overbank sediments, deposited during later floods, which is most often the case. In this way nearly horizontal strata of overbank sediment are built up over long periods of time. The thickness of the layers may vary from a few millimetres to several decimetres.

A vertical section through overbank sediment reflects the history of sedimentation back through time. A composite sample of such a section will give an integrated picture of the chemical and mineralogical conditions from a large number of sediment sources opened up during many floods. As active sources eventually become palaeosources, due to exhaustion or shifts in the river channel, or other conditions affecting erosion, it is possible to characterize a large drainage area with data from just one sample.

3.0. DEFINITION OF ACTIVE STREAM SEDIMENT

Active stream sediment is carried by the river in suspension during flood, and by rolling, sliding or saltation under normal flow conditions. The term stream sediment in the geochemical prospecting usage normally means active stream sediment, collected from the stream bed in current contact with stream water. In the Mediterranean countries, however, as well as in other areas with semi-dry climate, the majority of the streams are ephemeral. Therefore, active stream sediment may mean the last sandy-silty bed load material deposited by the river.

The sample is normally collected from the moving bottom load of fine sediment at the centre of the river channel, because the velocity of the stream water is greatest at this point and, consequently its transporting capacity. In cases, where it is practically impossible to collect active stream sediment from the centre of the stream, then samples are collected as far away from the banks as possible, with special care not to sample collapsed bank material of local origin, particularly when the banks are composed of colluvium derived from the adjoining slopes. In areas with ephemeral streams, samples are collected from the centre of the channel, and in many cases by digging up the bed, removing the thin soil that may have developed, and collecting in fact the palaeo-stream sediment.

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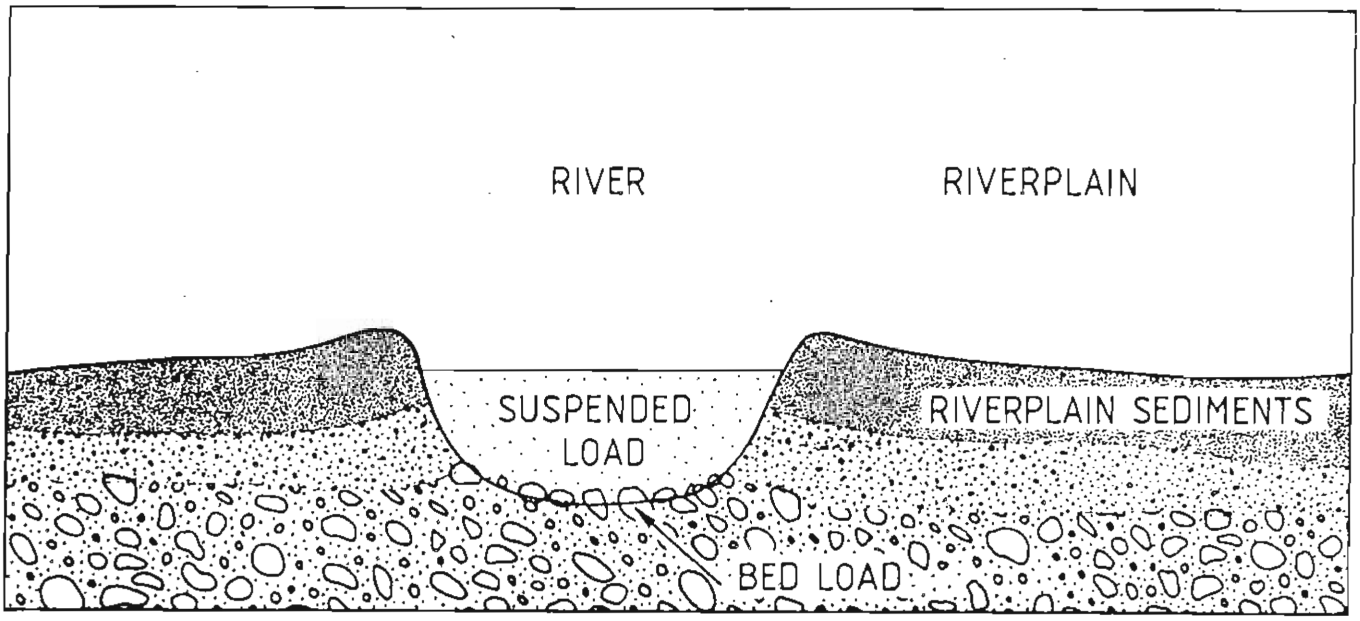

Fig. 1. Water discharge of river under ordinary conditions with normal amounts of water. (Ottesen et al. 1989, Fig. 6, p. 262)

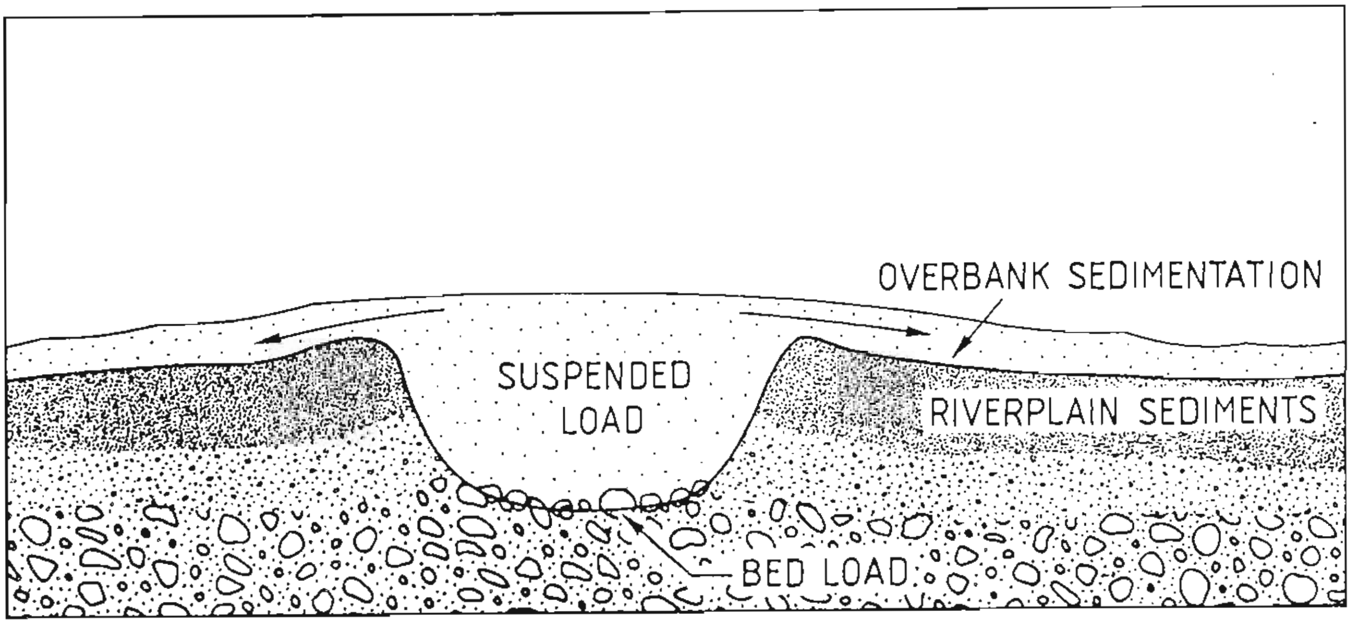

Fig. 2. Water discharge of a river during a major flood. Overbank sedimentation takes place on the river plain. (Ottesen et al. 1989, Fig. 7, p. 263)

WESTERN EUROPEAN GEOLOGICAL SURVEYS
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PILOT PROJECT

APPENDIX REPORT 2

HISTORICAL OUTLINE OF ACTIVITIES OF THE WEGS WORKING GROUP ON REGIONAL GEOCHEMICAL MAPPING

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TABLES

1.0. INTRODUCTION

Since the Pilot Project report is very important to the WEGS Working Group on "Regional Geochemical Mapping", it was considered worth while writing a concise historical outline of the Group's activities for the past four years. This is the only way that the reader will realize the great amount of work that has been carried out by the Group.

2.0. WEGS DIRECTORS' MEETING IN THESSALONIKI (1984) AND REYKJAVIC (1985)

The WEGS Working Group on "Regional Geochemical Mapping" was created after the proposal of J. Goni (BRGM) at the annual meetings of the WEGS Directors in Thessaloniki (September 1984) and Reykjavic (September 1985). J. Goni suggested the following terms of reference, that were accepted by the Directors, although the general opinion was that the group should decide its own objectives, i.e.,

(a) Main objectives:

- (i) Interpretation of geochemical anomalies (in which form the elements really are in the samples).
- (ii) The relationship between element distribution and human health.
- (iii) Establishment of geochemical and chemical standards (in water, soils, organic materials, gas, etc.).

(b) Subsidiary subjects:

- (i) The chemical mobility of elements as a function of concentration, climatic regime, topography, etc.
- (ii) Types of samples and density of sampling.
- (iii) The interpretation and selection of geochemical anomalies, particularly on a "tactical" scale.

The Directors also decided that the Group should initially include representatives from only the United Kingdom, the Federal Republic of Germany, Norway, Spain, Greece and Austria.

3.0. WORKING GROUP MEETING IN TRONDHEIM (1986)

After J. Goni's retirement from BRGM, B. Bolviken, NGU, was asked to convene a meeting of the Working Group on "Regional

Geochemical Mapping" consisting of members from Austria (O. Scherman), France (A. Bourg), F.R. Germany (R. Hindel), Greece (A. Demetriades), Norway (B. Bolviken and R.T. Ottesen), Spain (representative was unable to attend) and United Kingdom (P.J. Moore). A two day meeting was held in Trondheim during May 1986. The objectives suggested by J. Goni and the Directors were not discussed. The members of the Working Group were influenced by

(a) the widespread effects of the Chernobyl accident,

(b) the Nordkalott project report (Bolviken et al. 1986),

(c) the results of an orientation survey using overbank sediment in Norway (Ottesen et al. 1989), and

(d) A.G. Darnley's proposal (GSC) for an IGCP project on "International Geochemical Mapping".

So, the participants proposed a project for the geochemical mapping of Western Europe based upon the same type of sampling media and the same field and laboratory methods for the whole survey area. The plan specified 5 different types of samples at a sampling density of 1 sample station per 500 km^2, i.e.,

- surface water,
- ground water,
- surface soil (terrestrial organic material),
- soil c-horizon (soil parent material), and
- overbank drainage sediment.

It was known, however, that in the Mediterranean countries it would have been impossible to collect surface water samples even at the proposed density, due to the ephemeral nature of the majority of streams.

The total area of the WEGS countries is 4,727,989 km^2, and the number of sample sites at a density of 1 per 500 km^2 is 9,466. Table 1 shows the area of each country and the number of sample sites.

4.0. WEGS DIRECTORS' MEETING IN UPPSALA (1986)

The proposal was presented to the WEGS directors at their meeting in Uppsala (August 1986). Although several comments were made, especially on the 5 different sample media and sampling density, the proposal met with their general approval.

5.0. WORKING GROUP MEETING IN ORLEANS (1987)

Members of the Working Group met in Orleans during the 10th International Geochemical Symposium in April 1987. At this meeting there were participants from France (P. Lecompte and L. Laville-Timset), F.R. Germany (R. Hindel), Norway (B. Bolviken and R.T. Ottesen) and United Kingdom (J. Plant). The discussion was centred about the several types of samples collected in the Nordkalott project, and was stressed that this is difficult to manage. It was agreed, however, that the project should employ a common sample type for all Europe. B. Bolviken and R.T. Ottesen (NGU) suggested the use of overbank sediment, which is considered to be an ideal sampling medium for the proposed low sample density project. An excursion was, therefore, arranged in Norway during the autumn of 1987 in order to study Norwegian data in the use of overbank sediment as a sampling medium in regional geochemical mapping.

Table 1. The area of the individual WEGS countries and the number of sample sites at a density of 1 sample per 500 km^2.

	Area (km^2)	No. of sample sites
Austria	83,853	168
Belgium	30,513	62
Cyprus	9,251	19
Denmark	43,069	87
Finland	337,009	675
F.R. Germany	248,687	498
France	547,026	1,095
Greece	131,944	264
Greenland	341,700	684
Iceland	103,000	206
Ireland	70,283	141
Italy	301,262	603
Luxenmbourg	2,586	6
Netherlands	40,844	82
Norway	324,219	649
Portugal	92,082	185
Spain	504,782	1,010
Sweden	449,964	900
Switzerland	41,293	83
Turkey	780,576	1,561
United Kingdom	244,046	488
Total	4,727,989 km^2	9,466 sample sites

6.0. WEGS DIRECTORS' MEETING IN ANKARA (1987)

A progress report of the Working Group activities was presented to the WEGS Directors at their meeting in Ankara (August 1987). It was agreed that the Group should continue its work and report to WEGS again in 1988.

7.0. WORKING GROUP EXCURSION TO NORWAY (1987)

The Norwegian excursion was arranged in September 1987 with participants from France (I. Salpeteur), F.R. Germany (R. Hindel) and Norway (B. Bolviken, R.T. Ottesen, J. Bogen and T. Volden). The main conclusions of this excursion were:

- Overbank sediment is a composite sample that represents large drainage areas, and can, therefore, be collected at widely scattered sample sites and at low costs to each country.

- Overbank sediment is transported physically in water suspension and is less influenced by chemical processes than stream sediment, which may have coatings of secondary minerals. The interpretation of the dispersion patterns of element contents in overbank sediment may, therefore, be relatively simple.

- At a given sample site the age of overbank sediment increases with depth. By sampling at shallow depths the effects of anthropogenic pollution may be traced. Samples taken at greater depths may reflect the natural conditions that existed before the times of industrial pollution.

8.0. WORKING GROUP MEETING IN HANNOVER (1988)

The Working Group participants at the Hannover meeting in August 1988 were from Austria (O. Schermann), F.R. Germany (R. Hindel and H. Raschka), Norway (B. Bolviken, R.T. Ottesen and T. Volden) and United Kingdom (P. Simpson). During the meeting an excursion was made along the Innerste River. This river system is heavily polluted by several hundred years of mining activities in the Harz Mountains (refer to Appendix Report 3.2). It is, therefore, included in a geochemical study of pollution of soils in the F.R. Germany. The conclusions that can be drawn from the German excursion are:

- Overbank sediment is common in German river systems.

- Overbank sediment along the Innerste River is severely contaminated with heavy metals in the upper metre or so, but appears to be pristine at greater depths.

- Analysis of overbank sediment from German rivers outside mining areas, for example at Bidrgraben near Hausen, indicate that only the upper few decimetres are contaminated, while the deeper horizons are pristine.

9.0. WEGS DIRECTORS' MEETING IN COPENHAGEN (1988)

A proposal for an orientation survey was presented to the WEGS Directors at their meeting in Copenhagen in September 1988. The orientation survey consisted of the following items:

- To complete an inventory of the hitherto regional geochemical mapping in the WEGS countries.
- To collect vertical sections of overbank sediment from 10-15 localities within each country in order to investigate the depth of anthropogenic influence in the overbank sediments.
- To carry out field excursions in the Working Group countries in order to investigate the existence of overbank sediment in different geomorphological and geological provinces in Europe.

10.0. FIELD EXCURSIONS TO THE WEGS COUNTRIES

A field excursion team was put together by NGU, which consisted from two geochemists, R.T. Ottesen and T. Volden, and a geomorphologist, J. Bogen. Field excursions were organized in Austria, Finland, Greece, Greenland, Sweden, Spain, France, United Kingdom and Ireland. The excursions began in 1988 and continued throughout 1989 and 1990.

10.1. Austria

A short field excursion was arranged to Austria during October 1988. The main conclusion from this excursion is that overbank sediments are present, and may be sampled.

10.2. Finland

In June 1989 a field trip was organized to Finland. The main conclusions are that overbank sediments are present and can be sampled, although in the "lake district" small drainage basins will have to be sampled.

10.3. Greece

In the latter part of June an excursion was made to Greece. The main conclusions are:

- overbank sediment is present and constitute a significant part of the Greek riverine sedimentary environment, and
- long term evolution of a river has to be taken into account when sampling sites are selected.

10.4. Greenland

Greenland was visited in July 1989. The main conclusions are:

- the river plains and channel systems in the Arctic are characterized by abundant braiding;
- stable beds are rare, and
- true overbank sediments are uncommon.

10.5. Sweden

In September 1989 a short field excursion was arranged to Sweden. The main conclusion is that overbank sediments are present and can be sampled.

10.6. Spain and France

During the latter part of September 1989 a field trip was made to Spain and France. The main conclusion is that overbank sediment is present and can be sampled in most parts of Spain and France. It will be difficult to find, however, good sample locations representing large time spans in southern Spain and in parts of the French Pyrenees. Many localities are influenced by human activity, something which has to be taken into account when sample locations are selected.

10.7. United Kingdom

The field trip to the United Kingdom was organized in such a way as to coincide with the Working Group's meeting at B.G.S., Keyworth, during March 1990. The Working Group welcomed the participation of Dr. A.G. Darnley, project leader of IGCP 259 "International Geochemical Mapping". The main conclusion was that overbank sediment is present and can be sampled.

During the excursion it was pointed out that in areas of present and past mining activity, the overbank sediment is polluted. The sampling, however, should not present any problems provided one is aware of the mining and sedimentation history of the area. Pristine overbank sediment samples can still be found even in such heavily polluted areas.

10.8. Ireland

In April 1990 a field trip was arranged to Ireland. The main conclusion is that overbank sediment is present and can be sampled.

11.0. WEGS Directors' meeting in Rome (1989)

The Working Group reported its work with regard to the field excursions to Austria, F.R. Germany, Finland, Greece, Greenland and Norway. The main conclusion so far is that overbank sediment is present and can be sampled in the countries visited. The work on vertical sections of overbank sediment is continuing, as well as the inventory of geochemical mapping that has hitherto been carried out within the WEGS countries. The Working Group stressed the importance of continuing with the field excursions, as well as the importance of participation to a meeting in Hannover of geochemists from all WEGS countries. The Directors approved the plans of the Working Group, and commented that the pilot project report should be submitted in 1990.

12.0. WORKING GROUP MEETING IN HANNOVER (1989)

The Working Group was able to meet in Hannover between 6.-10 November 1989, and for the first time with participants from all countries, i.e., Austria (O. Scherman), F.R. Germany (R. Hindel, H. Fauth), France (I. Salpeteur), Greece (A. Demetriades and P. Stavrakis), Norway (J. Bogen, B. Bolviken, R.T. Ottesen and T. Volden), Spain (J. Locutura), and United Kingdom (J. Plant). The Working Group discussed the Pilot Project, made plans for the Main Project, and decided upon the information that should be presented to the representatives of all WEGS countries. In addition the Working Group discussed the contents that should be included in an inventory survey of regional geochemical mapping in Western European countries. Finally, the work schedule till the submission of the final report to the WEGS General Directors was discussed.

In the second part of the meeting (9.-10. November 1989) there were participants from other WEGS countries, i.e., Denmark (O. Jacobsen), Finland (R. Salminen), Greenland (A. Steenfelt), Ireland (P. O'Connor), Netherlands (J. Ebbing) and Sweden (C.A. Nilsson). The members of the Working Group presented their work, and there were discussions on the purpose of the WEGS geochemical mapping project, the use of the data, sampling scheme, randomization of sample numbers, quality control samples, sample treatment, sample containers, sample splits, sample storage, map presentation, interpretation, research projects, duration of the project, its estimated cost, and possible sources of funding outside the Geological Institutes themselves. There was also a discussion on the organization and management of the project.

An excursion was arranged for the benefit of all newcomers. During the excursion along the Innerste river a number of overbank sediment sections were shown, and there was a discussion of the advantages in the use of overbank over active stream sediment.

13.0. WORKING GROUP MEETING IN KEYWORTH (1990)

The Working Group met in Keyworth between the 19.-23. March 1990. It was a compulsory meeting for the Working Group members, because the progress of the work carried out during the last four months was reported and discussed, and a work scheduled culminating with the Orleans meeting in June was agreed upon. The participants were from Austria (O. Scherman), F.R. Germany (R. Hindel), France (I. Salpeteur), Greece (A. Demetriades), Norway (J. Bogen, B. Bolviken, R.T. Ottesen and T. Volden), and United Kingdom (J. Plant, J. Ridgway, T. Colman). The Spanish representative (J. Locutura) was not able to come due to personal problems. The Irish (P. O'Connor) and Greenland (A. Steenfelt) representatives were allowed to sit in at the meeting after their personal request. The presence at the meeting of Dr. A.G. Darnley, project leader of IGCP 259 "International Geochemical Mapping", was indeed good for he was able to see the work of the WEGS Working Group.

The contents of the Pilot and Main project reports were discussed, and some of the sub-projects were able to submit their final drafts to be included in the Main Project proposal, i.e., Field Work, Analytical Methods, Quality Control, Data Presentation and Mathematical Treatment, and Interpretation. It became apparent that there was considerable work still to be carried out in the Pilot Project.

An excursion was also organized to the Tyne river near Hexham in Northumberland, N.E. England (20.-21 March). The field trip was exceptionally interesting, because the participants of the meeting met Dr. M.G. Macklin, a geomorphologist from Newcastle University, who used overbank sediment in different aspects of his work, i.e., geomorphological evolution of the river, overbank sediment deposition, mining history of the area, pollution studies, etc. (Macklin 1985, 1986, 1988; Macklin and Dowsett 1989; Macklin and Lewin 1989; Macklin et al. 1985; Lewin and Macklin 1987; Lewin et al. 1987, 1983). Dr. Macklin strongly believes that overbank sediment is a better sampling medium than active stream sediment for almost the same reasons, which have been outlined in the main body of the Pilot Project report.

The Working Group members recognized the value of overbank sediment sampling in areas of historical mining activity for pollution control studies. It was also realized that the present day active stream sediment is polluted, and therefore ineffective in the search for new mineral deposits. Whereas pristine overbank sediment will be able to delineate both the old, and possibly other hitherto unknown mineralized targets.

Finally, the Working Group met Professor G.E. Petts from Loughborough University, who demonstrated his freeze-coring technique (Petts 1988, Petts and Thoms 1986, Petts et al. 1989, Thoms 1987). The philosophy of the method was to obtain a representative sample from the bedload of the river, at a particular site, without any loss of fines. His experimental work has shown that a composite sample of 20 kg minimum weight should be collected at each site by freeze-coring. Five sites should be combined and each must be of 2.5 kg minimum weight.

He has proven by this method that the metal content of sites sampled during the Wolfson Geochemical Atlas project (Webb 1978) was greater. This was attributed to loss of fines during the sampling of active stream sediment, and its representativity of the site. Professor G.E. Petts also considered that overbank sediment was a better sampling medium than active stream sediment for geochemical reconnaissance.

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PILOT PROJECT

APPENDIX REPORT 3.1

REPORT ON THE FIELD EXCURSION TO AUSTRIA

October 1988

O. Scherman
Austria

R.T. Ottesen
Norway

J. Bogen
Norway

1988

CONTENTS

FIGURES

1.0. INTRODUCTION

A short field excursion was arranged in Austria during October 1988, and the route followed is shown in Fig. 1. The purpose of the excursion was to investigate the existence of overbank sediment in different geomorphological and geological provinces in Austria, i.e.,

- the Bohemian Massif,
- the "Kalkalpen" (the Calcareous Alps), and
- the "Flyschalpen" (the Greywacke sequence of the Central zone of the E. Alps).

The participants of the excursion were Jim Bogen (Norway), Rolf Tore Ottesen (Norway) and Otmar Scherman (Austria).

The main conclusion is that overbank sediment is present, and may be sampled in most parts of Austria.

2.0. THE BOHEMIAN MASSIF

- The bedrock consists of crystalline rocks, such as granite, gneiss and granulite.
- The relief is low.
- The area is outside the region covered by the Pleistocene glaciations.
- The area has a dry climate and low precipitation rate (less than 350 mm per year).
- The area is characterized by extensive Tertiary weathering.
- River terraces from former climatic periods are common.
- Present rivers are small in relation to valley size.
- Present erosion rate is supposed to be moderate to low.
- Extensive flood protection works along river banks have reduced overbank flooding. Before the flood protections were made, overbank flooding was very common.
- A gravel armouring layer is present in the river beds.
- The thickness of river plain deposits above the present river banks varies from 0.5 to 2 metres.
- The river plains are often influenced by agriculture.
- Dense vegetation is common along the stream channels. Major erosion point sources are not common.
- Tertiary weathering products are the main sediment sources.

2.1. Conclusion

The investigation of river plains showed that overbank sediment is present in the Bohemian Massif, and unpolluted samples may be collected (Fig. 2).

3.0. "KALKALPEN" (CALCAREOUS ALPS)

- The bedrock consists of different series of carbonate rocks.
- The relief is high.
- The area lies within the region covered by Pleistocene glaciation.
- The major sediment cover consists of Quaternary deposits.
- Large parts of the area have no overburden cover.
- There are several levels of terraces.
- Extensive flood protection works are common.
- The river banks are often influenced by agriculture.
- The size of deltas and river plains indicate a high sediment transport rate.
- There occur gravel bed rivers with an armouring layer.
- The thickness of overbank deposits is approximately 2 metres of fine-grained material.

3.1. Conclusion

The investigation of river plains showed that overbank sediment is present, and unpolluted samples may be collected (Fig. 3).

4.0. THE CENTRAL ZONE OF THE E. ALPS

- The bedrock consists of different sequences of metamorphic rocks.
- The relief is high.
- The Central Alps are situated within the region covered by Pleistocene glaciations.
- Sediments are supplied to the rivers from the erosion of Pleistocene deposits. Erosion point sources are common (Fig. 4).
- Large amounts of sediments are supplied from the weathering of bedrock.
- The region is characterized by a high erosion rate.
- A large amount of sediment in suspension is visible in the rivers.
- Areas where the vegetation has been destroyed, are subject to intense erosion.
- The presence of river plains is limited, due to the extensive down-cutting of valley bottoms.

4.1. Conclusion

The investigation of river plains in the Central Alps showed that overbank sediments are present, and unpolluted samples may be collected. The sample sites must, however, be carefully selected. Finally, in some cases the size of drainage basins to be sampled must be reduced or largely extended.

5.0. COMMENTS

Sampling of overbank sediment sequences is not a simple matter as that of normal active stream sediment, for it is important to understand the geomorphological conditions of their formation. The sample sites should be carefully selected by the geochemist himself, after a thorough site examination.

Fig. 1. Excursion route

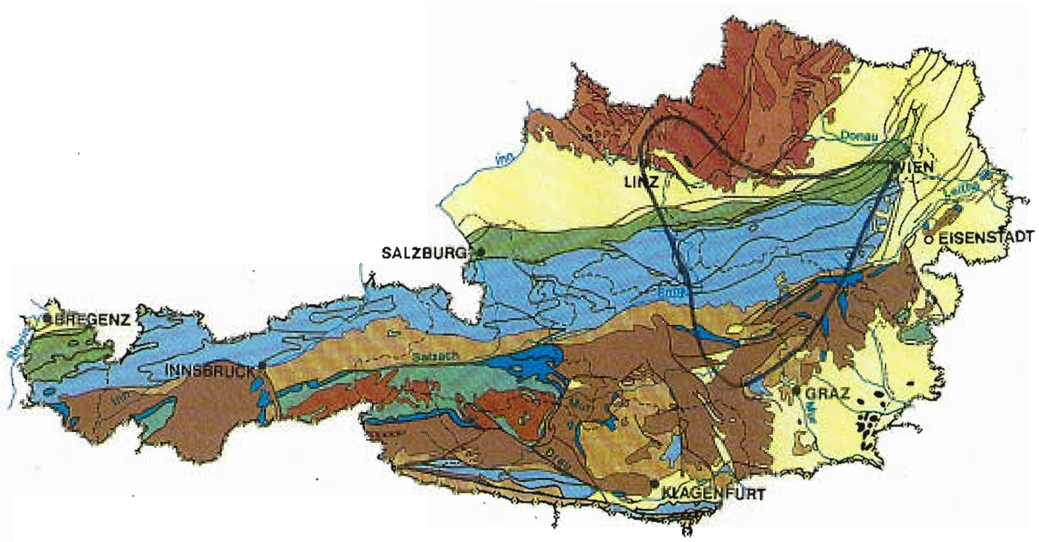

Fig. 2. River plain with overbank sediment in the Bohemean massive.

Fig. 3. River plain with overbank sediments in the "Kalkalpen"

Fig. 4. Active erosion slope.

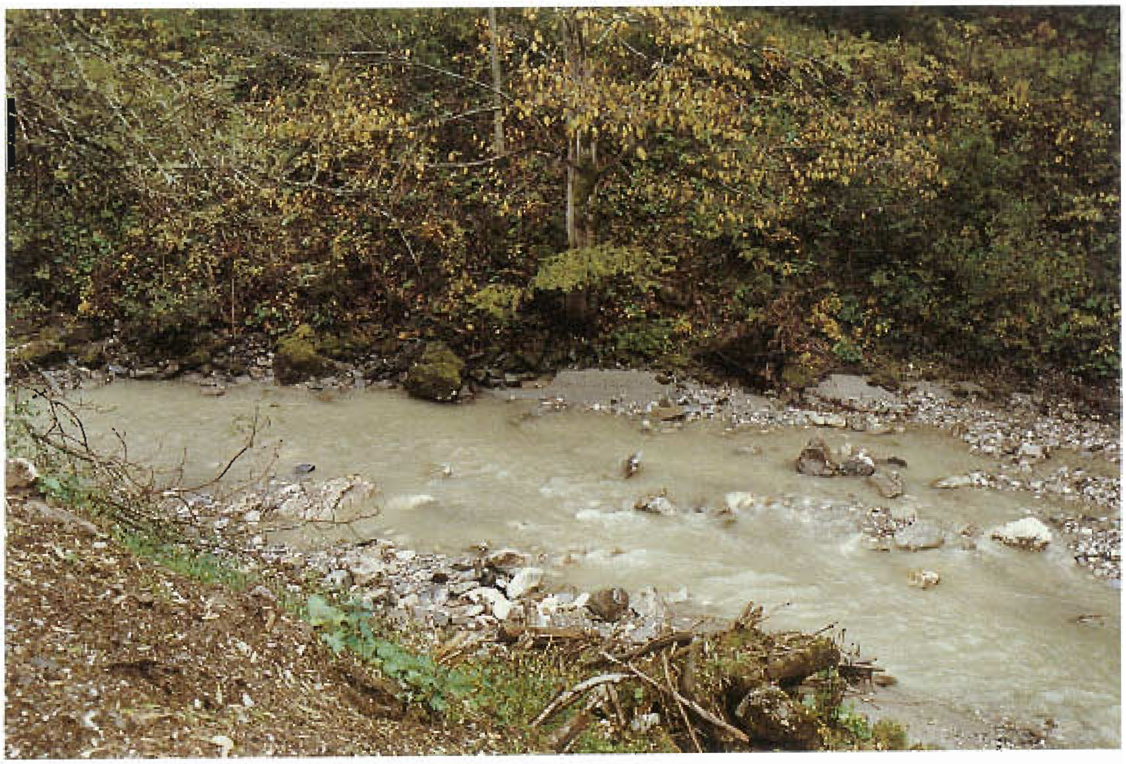

Fig. 5. Heavy sediment load in a river from the Central Alps.

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P I L O T   P R O J E C T

APPENDIX REPORT 3.2

REPORT ON THE FIELD EXCURSION TO F.R. GERMANY

6.-10. November 1989

R. Hindel F.R. Germany

J. Bogen Norway

R.T. Ottesen Norway

1989

CONTENTS

FIGURES

1.0. INTRODUCTION

Two one day field excursions were made to the F.R. Germany. The first during the Working Group meeting in August 1988 with participants from Austria (O. Schermann), F.R. Germany (R. Hindel and H. Raschka), Norway (B. Bolviken, R.T. Ottesen and T. Volden) and United Kingdom (P. Simpson). The second during the extended Working Group meeting in Hannover (9 November 1989) with participants from Austria (O. Schermann), France (I. Salpeteur), Germany (R.Hindel, H. Fauth), Greece (A. Demetriades, P. Stavrakis), Norway (J. Bogen, B. Bolviken, R.T. Ottesen, T. Volden), Spain (J.Locutura), United Kingdom (J. Plant), Denmark (O. Jacobsen), Finland (R. Salminen), Greenland (A. Steenfeldt), Ireland (P.O'Connor), The Netherlands (J. Ebbing) and Sweden (C.A. Nilsson).

The purpose of the first excursion was to demonstrate overbank sediment deposits, and their use in regional geochemical mapping, to members of the Working Group that were unable to participate in the field excursion to Norway (Appendix Report 3.7); and that of the second to participants from the WEGS countries outside the Working Group.

The conclusions from the two excursions were:

- Overbank sediment is present and can be sampled from the Innerste river;
- Even though there has been 500 years of continuous mining in the drainage basin, and the upper part of the overbank stratigraphy is strongly polluted, it is still possible to map the pristine conditions using samples from a greater depth, and
- The analysis of overbank sediment from German rivers outside mining areas, for example at Bidrgraben near Hausen, indicates that only the upper few decimetres are contaminated, while the deeper horizons are pristine.

2.0. OVERBANK SEDIMENT IN THE INNERSTE RIVER

- The Innerste river drains the Harz mountains ore field. The mineralization is mainly Pb and Zn sulphides, and several mines were in operation for at least 500 years.
- The Innerste river is heavily polluted with mine waste, which has been dispersed several tens of kilometres down stream. Active stream sediment contains considerable amounts of lead and zinc.

- Floods have occurred frequently in the during historical times, and fine-grained anthropogenic material from the mines has been deposited on the flood plains of the Innerste river during these floods.

At location 1 (Fig. 1) near Astenbeck the following themes were demonstrated:

- Overbank sediment deposited during the 1988 flood (Fig. 2);
- Overbank sediment showing clearly the individual flood layers (Fig. 3);
- Organic layers which could be used for dating, and
- Fragments of old bricks, approximately 200 years old, were pointed out at the base of the overbank sediment deposit.

At locality 2 (Fig. 4) near Hohenrode the following themes were demonstrated:

- Active erosion (sediment sources) in a highly polluted river plain (Fig. 5), and
- An overbank sediment profile with very high concentrations of lead and zinc at the top decreasing to normal unpolluted sediments at the base (Fig. 6). Refer also to Appendix Report 5.2.

2.1. Conclusion

Overbank sediment is present in the drainage basin of the Innerste river of the F.R. Germany, and can be sampled. Even in this heavily polluted stream, it is still possible to map the natural conditions prior to 500 years of mining.

Fig. 1. Shows location 1 on the Innerste river near Astenbeck, east of Heersum.

Fig. 2. Overbank sediment from the 1988 flood from the Innerste river, Germany.

Fig. 3. Overbank sediment from the river Innerste. Note the layers indicating the individual flood events.

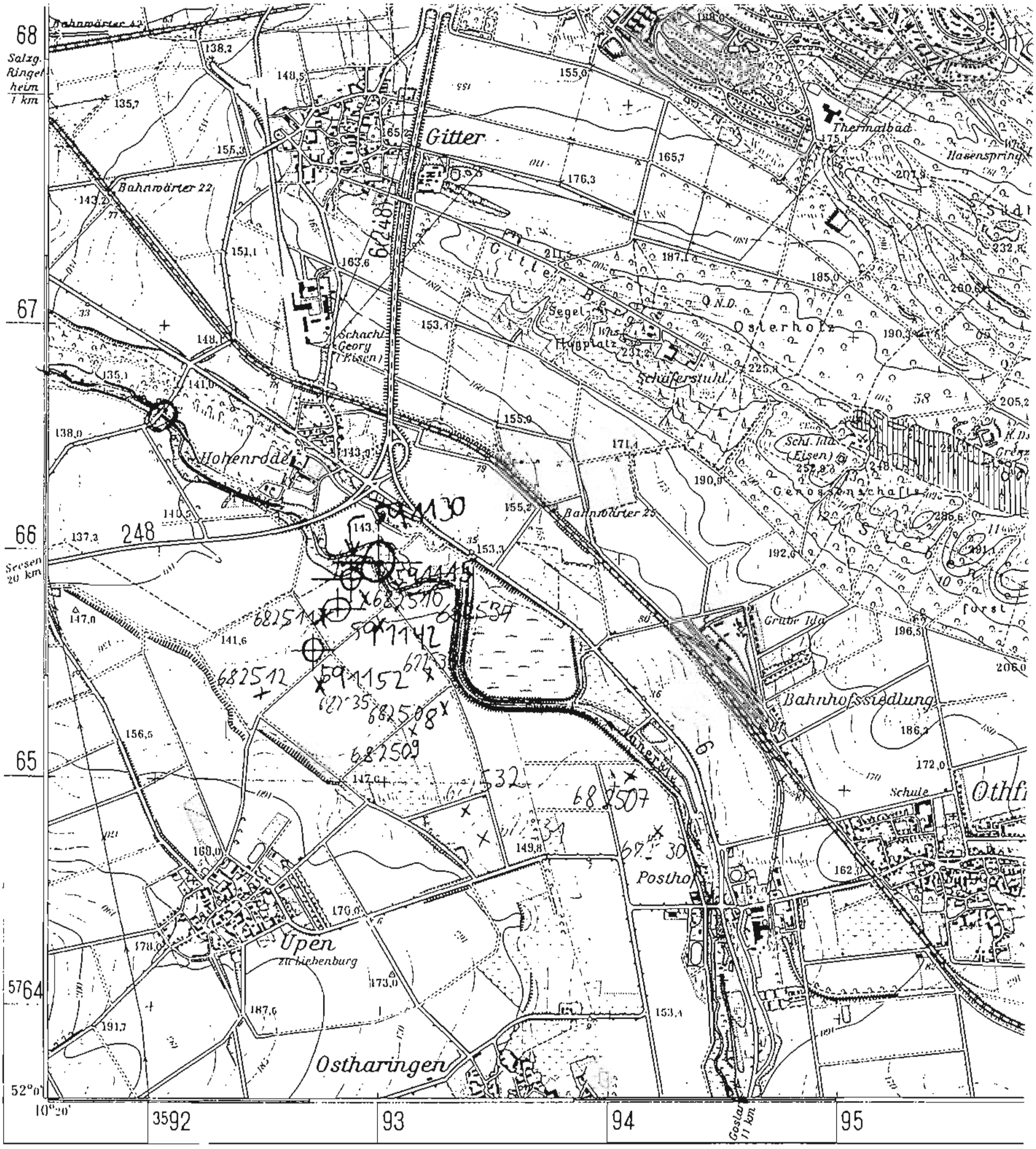

Fig. 4. Shows location 2 on the Innerste river near Astenbeck, east of Heersum.

Fig. 5. Erosion site in the river Innerste. The sediment source consists of metal-rich minewaste.

Fig. 6. Overbank sediment profile from a river plain in the Hohenrode area.

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APPENDIX REPORT 3.3

REPORT ON THE FIELD EXCURSION TO FINLAND

18.-20. June 1989

R. Salminen
Finland

M. Tehnola
Finland

R.T. Ottesen
Norway

CONTENTS

FIGURES

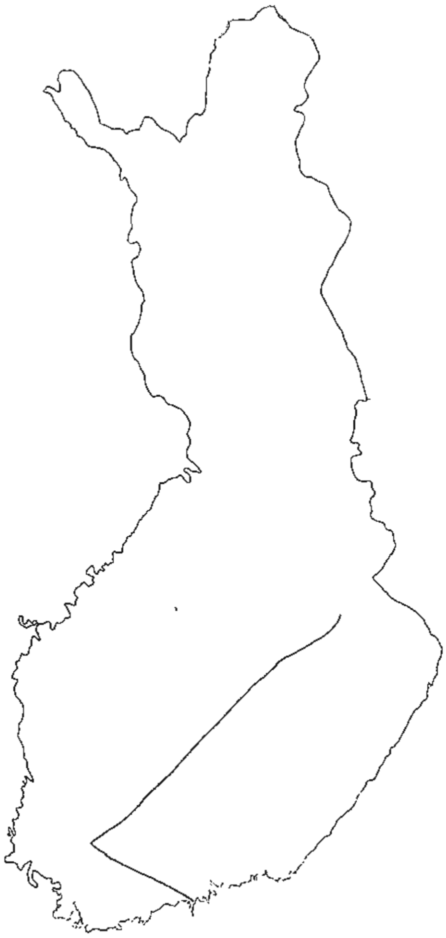

Fig. 1. Map showing the excursion route.

1.0. INTRODUCTION

A short field excursion was arranged to Finland (18.-20. June 1989) with participants from Norway (R.T. Ottesen) and Finland (R. Salminen, M. Tehnola, P. Eden).

The purpose of the excursion was to investigate the existence of overbank sediment in two different geomorphological areas of Finland, i.e.,

- areas of low relief and clay soils, and
- the lake district of central Finland.

The main conclusion is that overbank sediment exists and can be sampled in Finland.

2.0. CHARACTERISTICS OF OVERBANK SEDIMENT IN FINLAND

2.1. Areas of low relief and clay soils

- The relief is very low;
- The overburden consists of marine clay;
- Gullies are a common erosional feature in the soils;
- The sediments are introduced into the streams from gullies and farm fields;
- The sediments yield is moderate;
- Flooding is common;
- The rivers have stable channels with river plains, and
- Overbank sediment is common.

2.1.1. Conclusion

Overbank sediment is present and can be sampled in the areas of very low relief in Finland.

2.2. Lake district of central Finland

- The relief is low to moderate;
- The overburden consists of till and other glacial sediments;
- The sediment yield is low;
- Point sources in the glacial material provide the sediments to the streams;
- The drainage basin between the lakes are relatively small;
- The rivers have stable channels with river plains, and
- Overbank sediment is common.

2.2.1. Conclusion

Overbank sediment is present and can be sampled. In small drainage basins, however, it may be necessary to make composite samples.

Fig. 2. Typical overbank sediment developed in areas of low relief and clay soils in Southern Finland.

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APPENDIX REPORT 3.4

REPORT ON THE FIELD EXCURSION TO GREECE

20.-26. June 1989

A. Demetriades
Greece

R.T. Ottesen
Norway

J. Bogen
Norway

1989

CONTENTS

FIGURES

1.0. INTRODUCTION

An excursion was arranged in Greece from the 20th to the 26th June 1989 in order to study overbank sediment deposition and erosion processes in Greece. This is the third in line of the planned orientation field excursions that have been arranged in the seven WEGS countries that are participating in the first phase of this project. The first was in West Germany (22.-23. August 1988) and Austria (12.-13. October 1988).

The participants in the excursion were A. Demetriades (Greece), R. T. Ottesen (Norway), and T. Volden (Norway). Jim Bogen, hydrogeologist from the Norwegian Water Resources and Energy Administration, was invited as specialist in river erosion and sediment transport, and I. Angelikakis (Greece) represented the IGME project manager for Regional Geochemical Exploration, K. Ioannidis.

The excursion route is shown in Fig. 1.

2.0. CONCLUSION

The main conclusions from the excursion were:

- Overbank sediment is present in Greece and constitutes a significant part of the Greek riverine sedimentary environment.
- Long term evolution of a river has to be taken into account when sampling sites are selected.

3.0. CHARACTERISTICS OF OVERBANK SEDIMENTS IN GREECE

3.1. Lowland parts of streams

- A considerable amount of fine-grained sediment is available from a number of sources in the drainage basins.
- The sediment yields are high.
- The intense sediment production during flood events, supply much sediment to down-stream areas (Fig. 2).
- Thick sequences are deposited in a short time.
- Even short sections of the overbank sediment stratigraphy will be representative of the whole drainage basin.
- Large amounts of bed load in gravel and sand fractions are present.
- Human activity influences river sediment deposition. Flood protection works (Fig. 3), and other human activities have to be taken into consideration and recognized when sample locations are determined.
- Due to the large input of bed load (Fig. 4), natural activity

in the rivers has to be taken into consideration when sample sites are selected.
- A typical phenomenon in the plain and delta parts of the large (by Greek standards) rives is channel shifting with a consequent interdigitation of overbank sediment.

3.1.1. Conclusion

In the lowland streams overbank sediment is present and constitutes a significant part of the riverine sedimentary environment. It is important, however, to identify locations of overbank sediment that is representative for large areas and long time span. At locations where braiding of rivers is evident several sites in cross section should be sampled and composites made (a maximum of three sites should be carefully chosen).

3.2. Mountain part of streams

- The streams are characterized by steep slopes interchanging with channel segments of lower gradients.
- The thickness of overbank sediment layers is often moderate in these systems.
- Large amounts of bedload in very coarse-grained fractions occur (Fig. 5).
- Frequent channel shifting is also evident in this terrain.

3.2.2. Conclusion

Overbank sediment is present in mountain streams. Again, at localities where streams braid several sites in a cross section should be sampled to account for this effect (a maximum of 3 sites).

4.0. DATING

The archaeological sites in Greece offer a unique opportunity to date long sequences of overbank sediment and investigate the long term evolution of river systems (Fig. 6).

5.0. GEOMORPHOLOGICAL DATA

It will be interesting to check with hydrogeologists and geomorphologists the following items:

- flood records,

- precipitation records,
- relevant historical information with regard to riverine sedimentation,
- sea level changes, etc.

6.0. COOPERATION WITH NEIGHBOURING COUNTRIES

Greece is geographically separated from the other countries of WEGS. This problem has already been stressed by the Greek representative in written communications, and the IGME General Director, Dr. C. Papavassiliou, at the last WEGS Directors meeting, which was held in Copenhagen during September 1988. Apparently, this problem cannot be solved by WEGS themselves. There are, however, two possible solutions, i.e., firstly through international cooperation within IGCP project No. 259 "International Geochemical Mapping", and secondly by bilateral cooperation. The WEGS aim is the use of the same sampling medium for the production of the European Geochemical Atlas to begin with, and later on for the International. It is tentatively suggested, therefore, to carry out a small overbank sediment sampling survey in N.E. Greece.

7.0. COMMENTS

The sampling of overbank sediment sequences is not a simple matter, as that of normal active stream sediment, because it is important to understand the geomorphological conditions of their formation. The sample sites should be carefully selected by the geochemist himself, after a thorough site examination. Consequently, overbank sampling for this very important international project cannot be carried out by field assistants. It is becoming, in fact, very obvious after both the Austrian and Greek field excursions, that for the sake of overbank sediment sampling uniformity, the Greek member in the WEGS working group should undertake the execution of the whole survey on his own, i.e., 264 sample sites approximately for a density of 1 sample/500 square kilometres. This recommendation will also be made, and stressed, to all the WEGS countries.

ACKNOWLEDGEMENTS

The authors sincerely thank Ioannis Angelikakis for his help during the whole field excursion. Helen Karamanou (Thessaloniki branch geochemist) is thanked for the excellent social evening, which was arranged at the spur of a moment. The authors thank the IGME General Director, Dr. C. Papavassiliou, the Director of the Geochemical Exploration Division, Mr. C. Kouvelos, and the project Manager for Regional Geochemical

Exploration, Mr. K. Ioannidis, for providing the necessary funds, vehicle and driver. Finally the Norwegian quests would like to express their thanks to Alecos Demetriades for an excellent excursion.

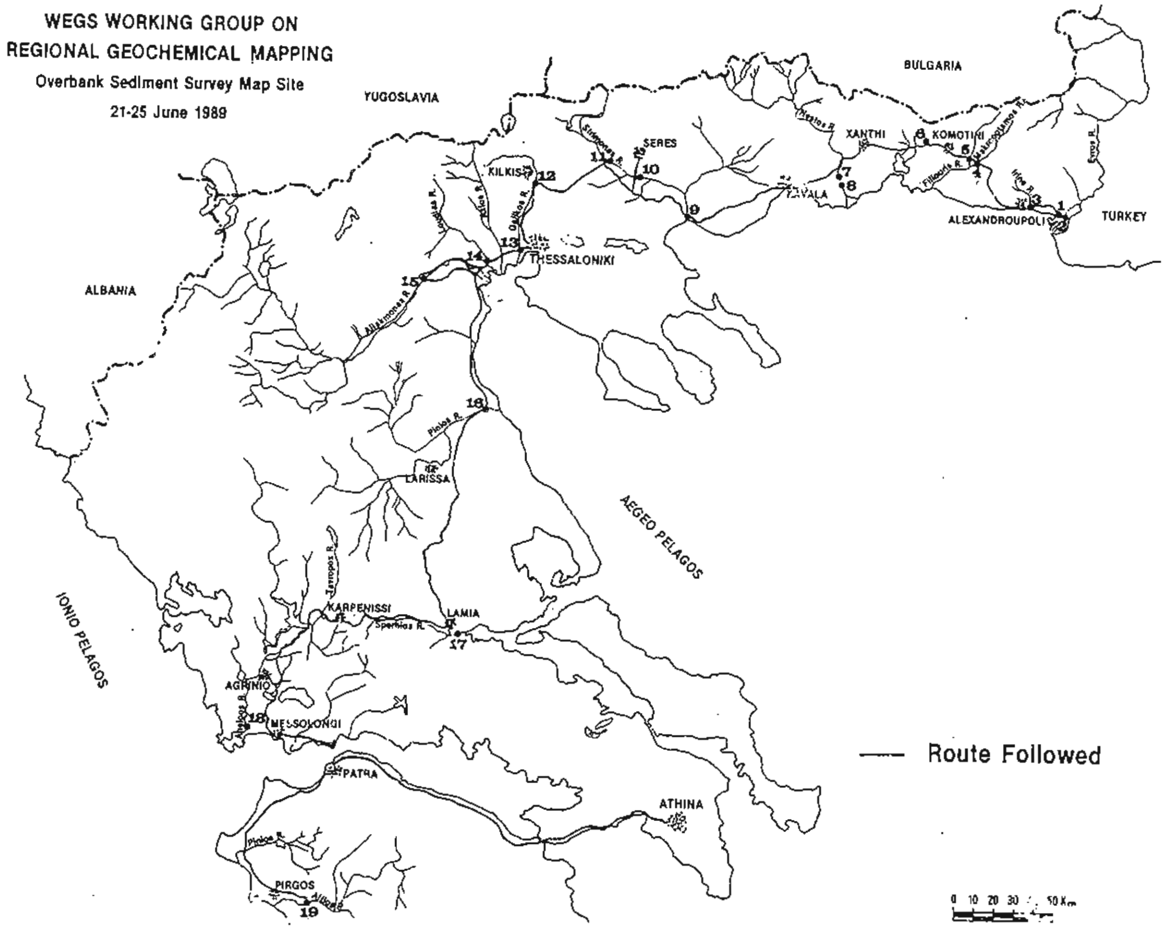

Fig. 1. Map showing the excursion route in Greece.

Sites 1 & 2: Evros R.
Site 3 : Irine R.
Site 4 : Filiouris R.
Site 5 : Makropotamos R.
Site 6 : Mountain stream
Sites 7 & 8: Nestos R.
Sites 9, 10 & 11: Strimonas R.
Sites 12 & 13: Gallikos R.
Site 14 : Loudias R.
Site 15 : Aliakmonas R.
Site 16 : Pinios R.
Site 17 : Sperhios R.
Site 18 : Aheloos R.
Site 19 : Alfios R.

Fig. 2. Overbank sediment in a lowland stream.

Fig. 3. Flood protection works.

Fig. 4. Braided river system.

Fig. 5. Mountain stream.

Fig. 6. Overbank sediment covering the archaeological site at Olympia.

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PILOT PROJECT

APPENDIX REPORT 3.5

REPORT ON THE FIELD EXCURSION TO GREENLAND

21.-28. July 1989

A. Steenfeldt
Greenland

R. T. Ottesen
Norway

1989

CONTENTS

FIGURES

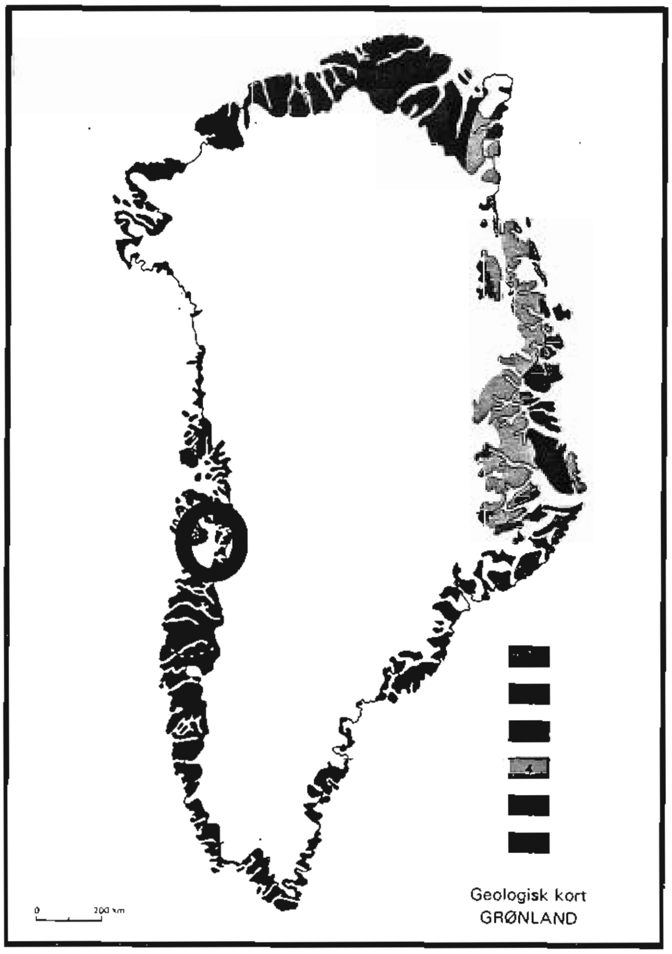

Fig. 1. Excursion area in the Disco Bay region of Western Greenland.

1.0. INTRODUCTION

A short field excursion was carried out in Greenland 21.-28. July 1989), with participants from the Geological Survey of Norway (Rolf Tore Ottesen) and Geological Survey of Greenland (Agnete Steenfeldt).

The purpose of the excursion was to investigate the existence of overbank sediment in the Disco Bay region of Western Greenland.

The main conclusion is that on Greenland the rivers are of two types, i.e.,

- stable channel rivers with overbank sediment, and
- braided river systems.

Overbank sediment may be sampled from a number of localities in glacially-fed rivers. In braided river systems and glacial outlet rivers, long term evolution of a river has to be taken into account when sampling sites are selected. In these systems several sites should be sampled in cross section and later make composites.

The small drainage basins on the islands are not suited for overbank sediment sampling.

2.0. CHARACTERISTIC OF OVERBANK SEDIMENT IN GREENLAND

2.1. Glacial outlet rivers

- The sediment yields are high.
- The intense sediment production supplies much sediment to down stream areas.
- Even short sections of the overbank sediment stratigraphy will be representative for the whole drainage basin.
- A typical phenomenon is channel shifting with consequent interdigitation of overbank sediment.
- Due to subglacial erosion sheet erosion probably exists too.

2.1.1. Conclusion

Due to the heavy sediment load of the streams traditional overbank sediment does not exist. The stream channel is very rapidly filled-up with sediments and the river very often changes its course. Samples that are representative of the drainage basin can be collected from several sites in cross-section over the valley bottom. At these locations considerable sedimentological knowledge is required for the identification of the history of the braids, so that the time dimension could be taken into consideration during sampling. Fig. 2 shows a braided river system from a glacial outlet river in the Disco Bay region.

2.2. Glacially-fed rivers

- The sediment yield is moderate to high.
- The bedload is coarse-grained.
- Sub glacial erosion and point sources along the valleys are the major suppliers of sediment. Gulleys and undercutting of adjacent slopes are the types of point sources that are developed.
- Both braided and stable channel river systems with overbank sediment occur.

2.2.1. Conclusion

Overbank sediment is present and can be sampled.

2.3. Rivers in areas with moraines and glaciofluvial deposits on the islands

- The drainage basins are small, normally less than 10 km2
- The sediment yields are low.
- The bedload is very coarse-grained, and
- Both stable channel and braided river systems exist.

2.3.1. Conclusion

Due to the low sediment yield, only very thin layers of overbank sediment are present and can be sampled. Braided river systems must be sampled in cross section and later combined into a composite.

The drainage basins are, however, too small to be included in the proposed regional geochemical mapping programme for Western Europe.

Fig 2. Braided river system in the Disco Bay area of western Greenland.

Fig 3. Overbank sediment from Nugssuq area western Greenland.

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APPENDIX REPORT 3.6

REPORT ON THE FIELD EXCURSION TO IRELAND

25.-28. April 1990

P. O'Connor Ireland
J.C. Croke Ireland
R.T. Ottesen Norway
T. Volden Norway

CONTENTS

FIGURES

1.0. INTRODUCTION

A short field excursion was arranged in Ireland (25.-28. April 1990), with participants from Norway (R.T. Ottesen and T. Volden) and Ireland (P. O'Connor and J.C. Croke). The excursion route is shown in Fig. 1.

The purpose of the excursion was:

- To investigate the existence of overbank sediment in different geomorphological and geological provinces in Ireland.
- To be informed about the work performed on overbank sediment by J.C. Croke, Department of Geography, University College Dubin, Ireland. This work is reported in Appendix 5.5.

The main conclusion is that overbank sediment is present and can be sampled in Ireland.

2.0. CHARACTERISTICS OF OVERBANK SEDIMENT IN IRELAND

2.1. The Offaly-Kilkenny area

- The bedrock consists of Carboniferous limestone.
- The overburden consists of glacial sediments from different sources.
- The relief is very low.
- The present erosion rate is believed to be low.
- Extensive flood protection works along the river banks have reduced overbank flooding. Before the building of the flood protection walls overbank flooding was very common.
- The thickness of overbank sediment sequences varies from 0.5 m or thicker.
- The river plains are often influenced by agriculture.
- Dense vegetation along the stream channel is common.
- Major point sources are not common.

2.1.1. Conclusion

Overbank sediment is present and can be sampled.

2.2. The Wicklow area

- The bedrock consists of granite, which is intruded into Palaeozoic supracrustals.
- There has been extensive Pb, Zn and Cu mining in the area.
- The overburden is dominated by till.

- The relief is moderate.
- The present erosion rate is believed to be moderate.
- Thickness of the overbank material varies from 0.2 to 4.0 m.
- Dense vegetation along the stream channel is common.
- Point sources are present in the form of gullies, bank erosion and undercutting of adjacent slopes.

2.2.1. Conclusion

Overbank sediment is present and can be sampled.

Fig. 1. Excursion route in Ireland.

Fig. 2. Overbank sediment from the river Slate, Ireland.

Fig 3. Overbank sediment from the Avoca river, Wicklow, Ireland.

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APPENDIX REPORT 3.7

REPORT ON THE FIELD EXCURSION TO NORWAY

10.-14. September 1987

R.T. Ottesen Norway
J. Bogen Norway
B. Blviken Norway
T. Volden Norway

R. Hindel Germany
I. Salpeteur France
S.A. Olhson Sweden
P. Lestinen Finland

1987

CONTENTS

FIGURES

1.0. INTRODUCTION

The WEGS Working Group on Regional Geochemical Mapping discussed in Trondheim (may 1986), and subsequently in Orleans (April 1987) a regional geochemical mapping programme for Western Europe. A low-density Norwegian mapping programme was presented to the Working Group. This programme is based upon sampling of overbank sediment. As this sampling medium has not been used before, it was decided to arrange a field excursion to Norway in order to demonstrate overbank sediment, the importance of fluvial erosion, and the need to understand the rivers as dynamic systems.

The excursion was arranged during September 10.-14. 1987, with participants from, Finland (P.Lestinen), France (I. Salpeteur), Germany (R. Hindel), Sweden (O. Olhson) and Norway (B. Blviken, J. Bogen, R.T. Ottesen and T. Volden). The excursion route is shown in Fig. 1.

The conclusion of the excursion is that overbank sediment is an interesting sampling medium for large scale geochemical and low sample density mapping owing to:

- Overbank sediment being a composite sample representing large drainage areas. Therefore, it may be collected from widely scattered sample sites, and at a low cost to each country.

- At a given sample site the age of overbank sediment increases with depth. By sampling at shallow depths the effects of anthropogenic pollution may be traced. Samples taken at greater depths, however, may reflect the natural conditions that existed before the times of industrial pollution.

2.0. SEDIMENT SOURCES AND OVERBANK SEDIMENT IN THE GAULA RIVER

The Gaula river (Locality 1, Fig. 1) was used to illustrate the difference between active stream sediment and overbank sediment, with respect to representativity of the sample types in different situations in the drainage basin.

- True sheet erosion does not often exist. From Storen to Gaulosen, a distance of 20 km, active erosion takes place only from a very limited number of point sources. Fig. 2 illustrates the main source of sediment in this part of the river. Samples of active stream sediment taken at intervals along the drainage channel are replicates of material from the same few sediment sources, producing little or no geochemical information in addition to what could be obtained from a few key samples.

- Overbank sediment is produced when major floods occur in a river system. During such floods the water discharge exceeds the quantity that can pass through the ordinary stream channel (bankful discharge). Even in streams of moderate size, the water level can reach several metres above normal, thereby covering large areas. At these times many new sediment sources open-up and the origin of the load suspended in the stream is manifold. Throughout the flood, and especially during the last phases, some of the load will be deposited on the flood plain at levels well above those of the ordinary stream channel (Figs. 3, 4 and 5). In this way, nearly horizontal beds of overbank sediment are built up over long periods of time. In Norway, the thickness of layers from individual floods may vary from a few millimetres to several decimetres, while the total thickness of overbank sediment strata could be up to a few metres (Fig. 6). A vertical section through overbank sediment reflects the history of sedimentation back through time. A composite sample of such a section will give an integrated picture of the chemical and mineralogical conditions from a large number of sediment sources opened up during many floods. As active sources eventually become palaeosources, due to exhaustion or shifts in the river channel or other conditions affecting erosion, it is possible to characterize a large drainage area with data from one sample of overbank sediment, taken as a composite through the stratigraphy.

3.0. OVERBANK SEDIMENT IN THE ROROS MINE DISTRICT

The Roros mine district was used to demonstrate how it is possible to map pollution, and natural conditions using overbank sediment. Copper mines have been in operation here for the past 300-400 years. The streams in the area are heavily polluted by mine waste, and stream sediment data are of restricted value in exploration.

- The average Cu content in active stream sediment from the Orva river is 344 ppm.

- The overbank sediment from the Orva river (Fig. 8) is heavily polluted in the upper part (3400 ppm Cu), but at a depth of 60 cm normal Cu-concentrations are found (41 ppm Cu).

4.0. SEDIMENT SOURCES, OVERBANK SEDIMENT AND SEDIMENT MONITORING IN THE ATNA RIVER SYSTEM

The Atna river was used to demonstrate sediment sources, overbank sediment, dating of strata with overbank sediment and sediment monitoring.

- The Atna river (Locality 3, Fig. 1) drains an area with glacial sediment underlain by Precambrian sandstone.

- The fluvial erosion acts at certain points which are the present sediment producers (Fig. 8).

- The river plain has thick deposits of overbank sediment (Fig. 9). The black coloured beds represent organic material and charcoal which have been dated to 1650 A.D.

- A national sediment monitoring programme has been set up by the Norwegian Water Resources and Energy Administration. One of the monitoring stations is situated in the Atna river (Fig. 10). The amount of suspended material being transported is measured together with a number of other parameters.

5.0. THE CATASTROPHIC FLOOD OF 1789 IN THE LAGEN RIVER

At his locality (No. 4, Fig. 1) overbank sediment deposits, which were deposited during the 1789 catastrophic flood were shown.

- Fig. 11 shows overbank sediment from the Lagen river at Sel. The organic rich horizon is dated to 1789 and represents the farm field at that time. On top of this layer is sediment deposited during the catastrophic flood.

6.0. THE CATASTROPHIC FLOOD OF 1987 IN THE LENA RIVER

During the spring of 1987 a local flood occurred in the Lena river (Locality 5, Fig. 1). The feature shown at this locality was the opening of a new sediment source as a result of fluvial erosion during the flood (Fig. 12), and deposition of fresh overbank sediment (Fig. 13).

7.0. MOLYBDENUM MINERALIZATION IN THE HOVERELVA RIVER

A large molybdenum deposit was discovered in the Hurdal region (Locality 6, Fig. 1). The deposit contains several tens of million tons of molybdenum at a cut-off grade of 0.05

% Mo. The river Hoverelva crosses large outcrops of the deposit, and numerous mineralized boulders are observed on the stream bed. This locality was used to demonstrate the effects of point sources to the representativity of active stream sediment in the area.

- Active stream sediment sampling failed to produce any molybdenum anomaly in the Hoverelva river. This is explained by the fact that the only sediment sources now active are located upstream of the deposit, where the overburden has a low molybdenum content.
- Several palaeo-sediment sources are visible both upstream and down stream of the deposits. The down stream sources have a high molybdenum content. Sampling of overbank sediment at a distance of 8 km down stream from the deposit, has given an average Mo-content of about 15 times higher than background.

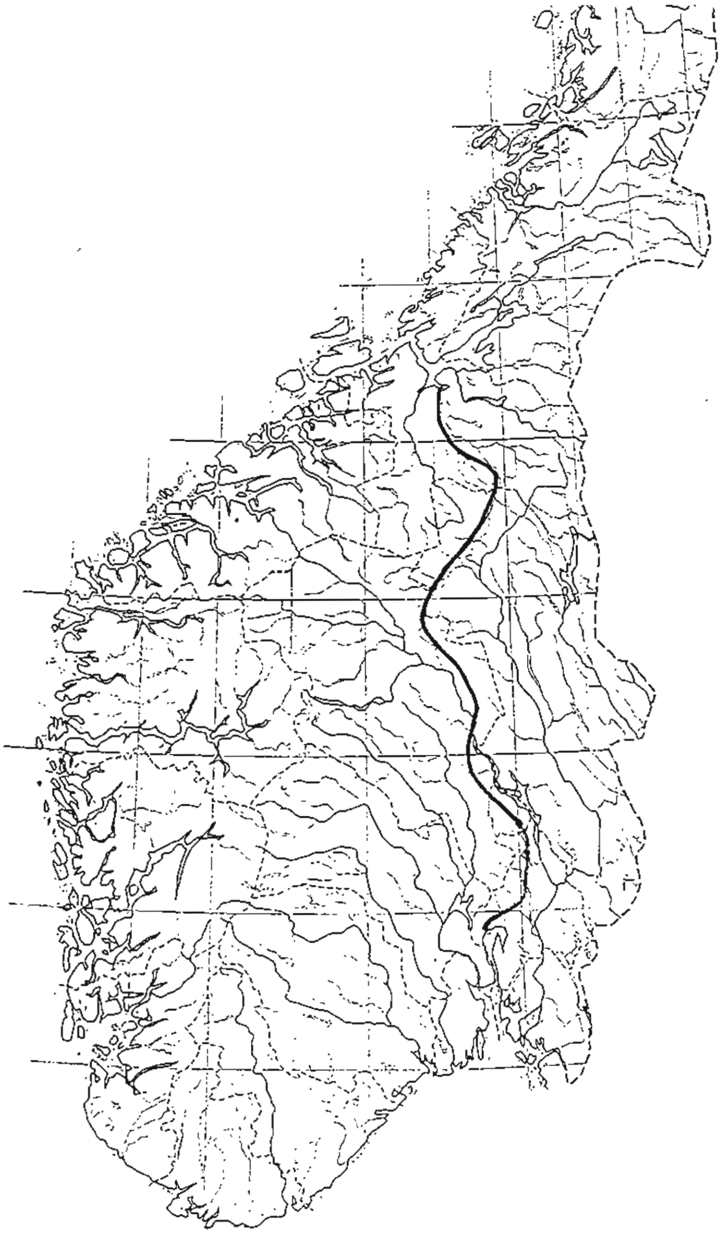

Fig. 1. Excursion route.

Fig. 2. Sediment source in the Gaula river, Trondheim area, Norway

Fig. 3. Stream at a late stage of flood. Water and sediment are flood the river plain. A layer of overbank sediment was deposited.

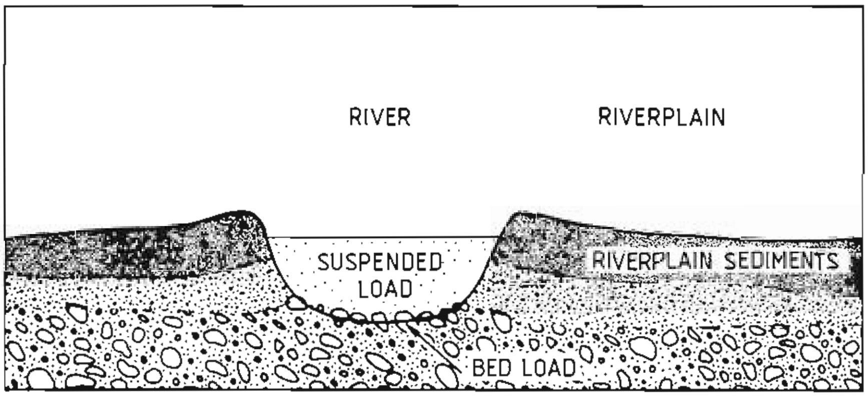

Fig. 4. Water discharge of a river under ordinary conditions with a normal amount of water.

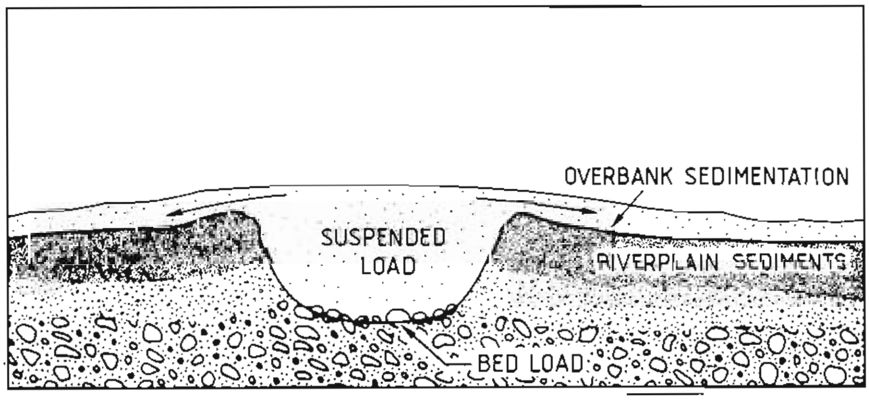

Fig. 5. Water discharge of a river during a major flood. Overbank sedimentation takes place on the river plain.

Fig. 6. Overbank sediment from the Gaula river, Trondheim area, Norway.

Fig. 7. The delta of the river Orva, Roros mining area. The youngest overbank sediment is heavily polluted by mine waste. Pristine conditions exist at depth.

Fig. 8. Sediment source of the Atna river, Norway.

Fig. 9. A section through overbank sediment at the Atna river southern Norway. Carbon-14 dating has indicated that the middle part of the section was deposited 400 years ago.

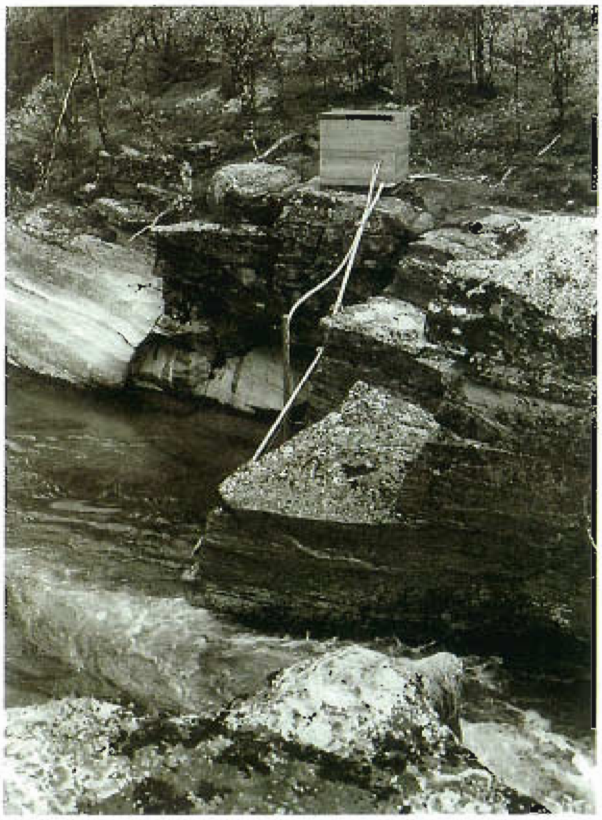

Fig. 10. The sediment monitoring station on the Atna river. The station contains an ISCO automatic sampler and a water level recorder.

Fig. 11. Sediments deposited during the catastrophic flood of 1789, in the Lagen river, Norway.

Fig. 12. Sediment source in the Lena river, which was opened up during the 1987 flood.

Fig. 13. The 1987 overbank sediment of the Lena river, Norway.

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APPENDIX REPORT 3.8

REPORT ON THE FIELD EXCURSION TO SPAIN AND FRANCE

25.-29. September 1988

J. Locutura
Spain

M. Bernabe
Spain

E.L. Pamo
Spain

R.T. Ottesen
Norway

J. Bogen
Norway

T. Volden
Norway

I. Salpeteur
France

1989

CONTENTS

1.0. INTRODUCTION

A short field excursion was arranged to Spain and France from 25 to 29 September 1989, with participants from France (Ignace Salpeteur), Norway (Jim Bogen, Rolf Tore Ottesen and Tore Volden), and Spain (Margarita Bernabe, Juan Locutura and Enrique Lopez Pamo).

The purpose of the excursion was to investigate the existence of overbank sediment in different geomorphological and geological provinces in Spain and France.

The main conclusion is that overbank sediment is present and can be sampled in the parts of Spain and France that were visited during this excursion. It might be difficult, however, in the French Pyrenees to find sample localities where sediments have been deposited over a considerable time period, and are representative of the whole catchment area.

2.0. FIELD EXCURSION TO SPAIN

2.1. Sierra de Guadarrama

- The region is characterized by moderate relief and low erosion rate.
- The rivers in this region are characterized by much transport of bed load, in the form of gravel and cobble fractions.
- The large amount of bed load gives rise to extensive braiding of river channels.
- River plains are most often composed of a gravel bed overlain by a relatively thin layer (10-20 cm) of overbank sediment.

2.1.1. Conclusion

Overbank sediment is present and can be sampled (e.g., Rio Lazoya). Composite samples from cross-sections are recommended to ensure that material from different time periods is included.

2.2. Duraton area

- The bedrock in the region consists of Tertiary and Cretaceous sedimentary rocks.
- The river valleys in the Tertiary areas are wide, compared to the gorged-like valleys in the Cretaceous areas.
- Relatively thick layers of overbank sediment are common (e.g., Rio Duraton).

2.2.1. Conclusion

Overbank sediment is present and can be sampled.

2.3. Sierra de la Demanda and Sierra de la Cebollera

- The bedrock in the areas is dominated by Palaeozoic and Cretaceous sedimentary rocks.
- The relief is moderate.
- The major rivers in the areas are characterized by much transport of bedload, in the form of gravel and cobble fractions.
- The large amount of bed load gives rise to extensive braiding of river channels (e.g., Rio Arlanzon).
- River plains are most often composed of a gravely layer overlain by a relatively thin layer (10-20 cm) of overbank sediment.
- The tributary rivers have relatively thick layers of overbank sediment (0.3 - 2.0 m).

2.3.1. Conclusion

Overbank sediment is present and can be sampled (e.g., Rio Cuevas, Rio Arlanson, Rio Najerilla), but care should be taken to avoid the influence of small tributaries.

2.4. The Zaragoza region

- The bedrock in this region consists of Tertiary sedimentary rocks.
- Transport of suspended load is large.
- Thick layers of overbank sediment are deposited (e.g., Rio Jalon, Rio Ebro).

2.4.1. Conclusion

Overbank sediment is present and can be sampled.

2.5. Pyrenees

- This region includes the N.E. part of the Spanish Pyrenees (e.g., Segre).
- The valley slopes are low when compared to the French side. The Segre river valley is composed of a number of narrow gorges interconnecting open and wide reaches.
- Sediment load of the rivers is large, and extensive sedimenta-

tion was observed in the Oleana dam.

2.5.1. <u>Conclusion</u>

Sampling locations were not investigated in detail. However, overbank sediment may be found at the open and wide reaches of the river valley.

3.0. FIELD EXCURSION TO FRANCE

3.1. Lowland areas north of the Pyrenees

- The rivers in these areas are in general characterized by a large transport of sediments both as suspensions and bed load.
- Through post-glacial time the large sediment supply has led to extensive infilling of the Tertiary valleys.
- During Holocene, terraces have been formed. On these reaches the rivers have cut through a sequence of fluvial material composed of silt, sand and gravel. The present river channel is often incised in bedrock.
- The height of the terraces above the river bottom varies from 10 to 120 metres.
- On reaches where the river has been able to degrade, narrow river channels, which are confined by high river banks, limit the deposition of recent overbank sediment (e.g., Aude at Corneilla, Ariege at Picarrou, l'Hers at Auterive).
- On reaches where the river degradation during Holocene has been limited, recent overbank sediment is present along river banks (l'Hers at l'Ambrone, La Vixiege at Tresmezess).

3.1.1. <u>Conclusion</u>

Overbank sediment is present where the river degradation during Holocene has been limited, and they can be sampled after analysis of river longitudinal profile and channel characteristics as well as sediment facies.

Further information about depositional rates and frequency of large magnitude floods should be obtained.

3.2. Pyrenees

- This region includes the N.E. part of the Pyrenees, drained by the Tech and Tet rivers.
- the upper part of the Tech valley is steep and narrow when compared with the Tet valley. There are few river plains in the upper parts. The lower part of the river valleys is

densely populated and cultivated.

- The rivers are in general characterized by large sediment transport, and the lower part of the valleys has been subject to extensive infilling during post-glacial times.
- Local rain storms influence the amount of sediment available for erosion in various parts of the drainage basin.
- The upper part of the system is often incised in bedrock. Terraces exist along the river valley, and are strongly disturbed by human activity (e.g., agriculture).

3.2.1. Conclusion

In the Tet river valley overbank sediment exists, and can be sampled (Boules river at Bouleterne, Tet at Vinca, Casteillane tributary).

In the Tech river system many locations were influenced by human activity. Convincing overbank sediment was not found. Careful investigations are, therefore, needed. Special attention should be paid to river reaches where the river valley is subject to increases in width.

4.0. CONCLUSION

- Overbank sediment is present and can be sampled in most parts of Spain and France.

- It will probably be difficult to find good sample locations, representing large time spans in southern Spain and in parts of the French Pyrenees. In mountainous (Alpine type) areas, local storms can yield a large amount of collapsed material. This local event will produce a sandy-loamy sequence downstream, which is not representative of the whole catchment area. Grain size analysis of the whole alluvial sequence must be included before placing in the same category, overbank sediments and alluvial barrier deposits of variable origin. Special sedimentological studies should be carried out here

- Many localities are influenced by human activity. This has to be taken into account when sample locations are selected.

Fig. 2 Overbank sediment in Duraton river, Spain.

Fig. 3 Terrace sediment from the french Pyrenees

Fig. 2 Overbank sediment in Duraton river, Spain.

Fig. 3 Terrace sediment from the french Pyrenees

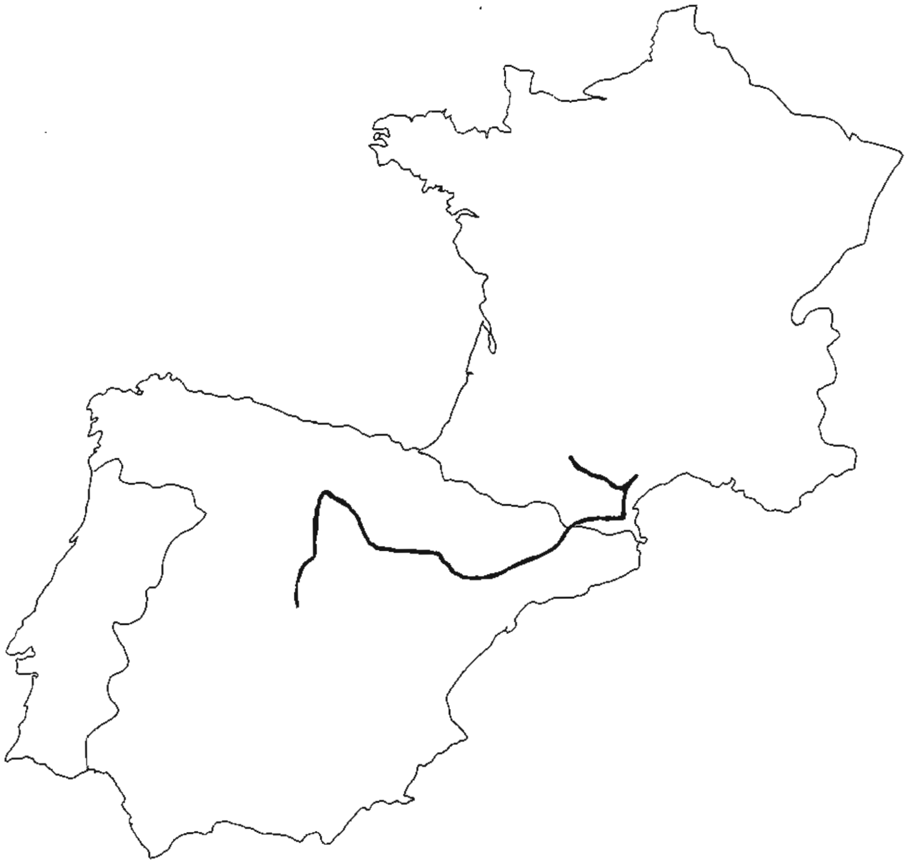

Figure 1. Map showing the excursion route.

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APPENDIX REPORT 3.9

REPORT ON THE FIELD EXCURSION TO SWEDEN

18.-20. September 1989

Olle Selinus
Sweden

Rolf Tore Ottesen
Norway

Tore Volden
Norway

1989

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FIGURES

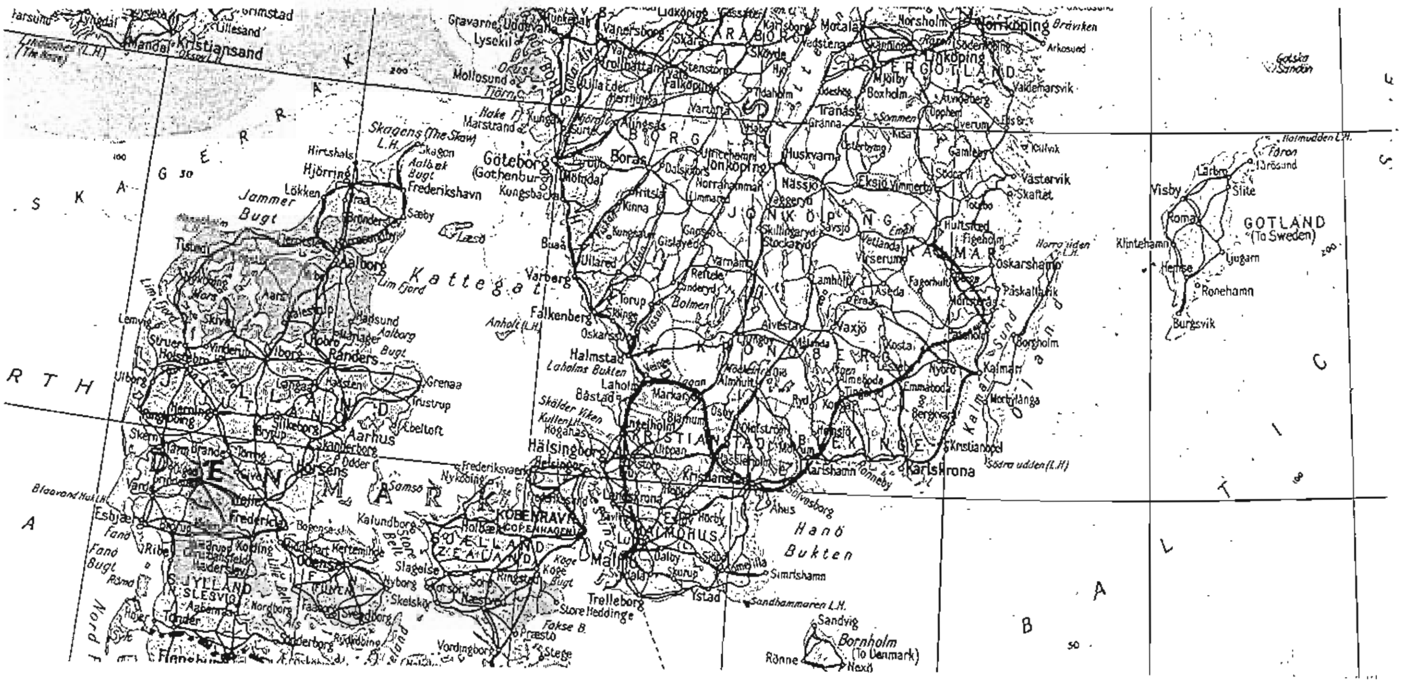

Fig. 1. Map showing the excursion route in Sweden.

1.0. INTRODUCTION

A short field excursion was arranged to Sweden from 18.-20. September 1989. The participants of the excursion were Olle Selinus (Sweden), Rolf Tore Ottesen (Norway) and Tore Volden (Norway). The excursion route is shown in Fig. 1.

The purpose of the excursion was to investigate the existence of overbank sediment in different geological and geomorphological provinces in southern Sweden, i.e.,

- the areas underlain by Mesozoic sedimentary rocks, and
- the areas underlain by Precambrian rocks.

The main conclusion from the excursion is that overbank sediment is present and can be sampled.

2.0. CHARACTERISTICS OF OVERBANK SEDIMENT IN SWEDEN

2.1. Areas underlain by Mesozoic rocks

- The sediment yield is moderate to high;
- The sediment is derived from point sources, and farm fields developed in clay-rich till;
- Channelling of streams is common, and
- Stable channel streams with overbank sediment are common.

2.1.1. Conclusion

Overbank sediment is present and can be sampled (Fig. 2). However, care must be taken during selection of sampling sites because of human influence to stream channel morphology.

2.2. Areas underlain by Precambrian rocks

- The sediment yields are low;
- Sediments are produced from point sources in till, and
- Stable channel streams with overbank sediment.

2.2.1. Conclusion

Overbank sediment is present and can be sampled.

Fig. 2. Overbank sediment developed in a stream underlain by Mesozoic sedimentary rocks, in Southern Sweden.

Fig. 3. Overbank sediment developed in a stream underlain by Precambrian rocks in southern Sweden.

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APPENDIX REPORT 3.10

REPORT ON THE FIELD EXCURSION TO ENGLAND

20.-21. March 1990

J. Ridgway
United Kingdom

T.B. Colman
United Kingdom

1990

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FIGURES

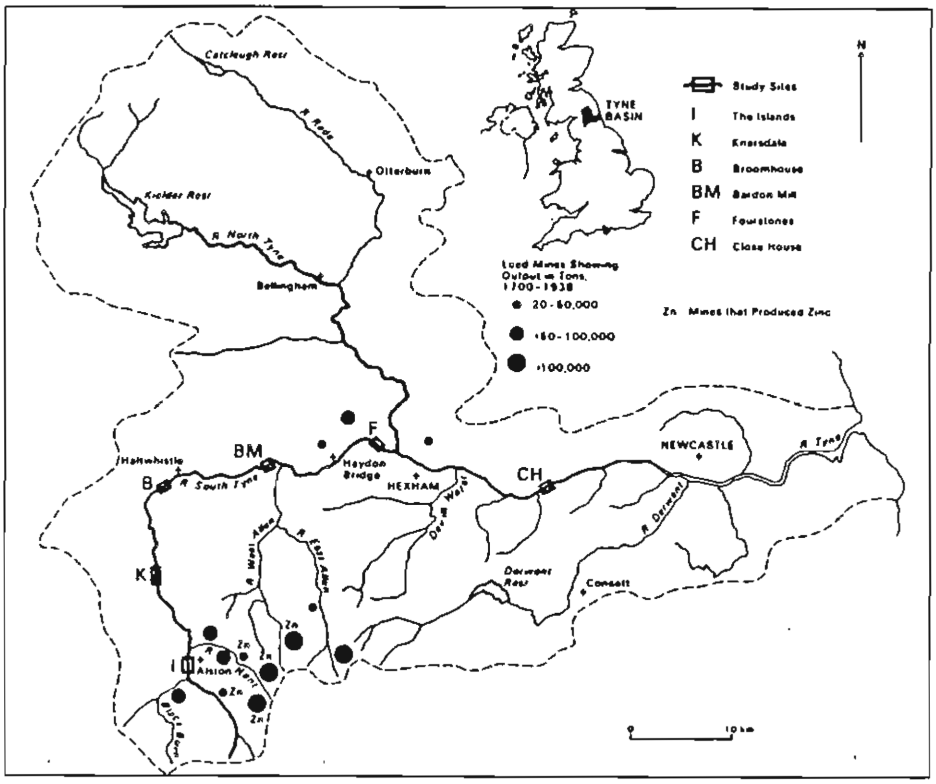

Fig. 1. Map showing the location of the Tyne valley, north eastern England.

1.0. INTRODUCTION

During a meeting of the Working Group on Regional Mapping, held at the headquaters of the BGS in Keyworth from 19 to 23 March 1990 a two-day field excursion to north eastern England was arranged with participants from Austria (O. Schermann), France (I. Salpeteur), F.R. Germany (R. Hindel), Greece (A. Demetriades), UK (J. Plant, J. Rigdeway, T. Colman), Norway (J. Bogen, B. Blviken, R.T. Ottesen, T. Volden), Ireland (P. O'Connor), Greenland (A. Steenfeldt), Sweden (O. Selinus) and Canada (A. Darnley, project leader of IGCP 259 International Geochemical Mapping). The excursion area is shown in Fig. 1.

The purpose of the excursion was to be informed about the work performed on overbank sediment deposits in the Tyne basin of north east England by Dr. M. Macklin from the Department of Geography, University of Newcastle. Dr. Macklin stressed the superiority of overbank sediment as a sampling medium, in comparison to active stream sediment.

2.0. OVERBANK SEDIMENT IN NORTH EASTERN ENGLAND

The field excursion concentrated on occurrences of overbank sediments in the South Tyne river basin (site at Warden, Broomhouse and the Nent valley) although one section of overbank material in the Lower Tyne valley was examined (Prudhoe) (Figure 1).

The River South Tyne has a total catchment area of approximately 800 km², developed on Carboniferous sandstones, limestones and shales, and in its headwaters region contains part of the Northern Pennine orefield. This orefield has been mined extensively for Pb and Zn, mainly from galena and sphalerite containing appreciable levels of Ag, Cd and Cu. Fluorite and barite occur as gangue minerals and have been extracted in the South Tyne basin, but these elements have not been considered in any of the papers mentioned below. A major witherite deposit occurs at Settling Stones in the North Tyne basin. Mining probably started in Roman times but exploitation was only on a small scale until after the introduction of new techniques of dressing and smelting in the mid-seventeenth sentury. Lead production reached a peak in the early- to mid-nineteenth sentury, while Zn output was greatest between 1880 and 1920. The last major metal mine in the region closed in the 1950's.

At <u>Prudhoe</u> the catchment area of the Lower Tyne river is 2198 km² and thus much larger than the catchment area recommended for a regional overbank sediment survey (300 km²). However, one particular feature of the section at Prudhoe may be of relevance. Floodplain sediments here were found to be composed of 2-3 m of finely laminated sands and silts overlying 2 m of sandy gravels. Using trace element analyses and the record of mining activity to date the sediments, Macklin, Rumsby and Newson (see appendix) conclude that the whole of a 2.4 m section overlying the gravels was deposited in a 60 year period between 1890 and 1950. Such rates of sedimentation are exceptionally high by British standards and even in comparison with many European and North Americal floodplains. There may thus be instances where without a means of dating the overbank material it will be difficult to ascertain whether or not a deep sample is below the level of anthropogenic influences. It should also be noted that the bank sedtion at Prudhoe was only revealed by an exceptional flood in 1986, without which the sedimentation history at the site would probably have remained unknown.

A brief stop was made at <u>Warden</u> (catchment area 800 km^2) to point out an area of Cd, Pb and Zn contamination associated with mid- and late-nineteenth century flooding. Similar contamination in two other areas, one upstream and one downstream, has been found by Macklin (1988, see appendix) to differ in detailed distribution, both horizontally and vertically.

The within-basin variation in overbank sediment profiles mentioned above is more clearly demonstrated by work in the South Tyne valley described by Macklin and Lewin (1989, see appendix). Two sections near <u>Broomhouse</u> (catchment area c. 300 km^2) were examined in the field. At the more downstream of the localities a 2 m thickness of overbank sediment contained low levels of trace metals and was thought to be composed of material liberated from the valley sides as a result of deforestation and early agriculture in Roman times. Less than 1 km upstream bank fluvial gravels and alluvial terraces are composed of mining era material, heavily contaminated with metals (c. 10000 ppm Zn and 2000 ppm Pb) and supporting metallophyte plant populations (Macklin and Smith, 1990, see appendix).

Lateral variation in chemistry across a floodplain occurs in the valley of the <u>River Nent</u> above Blagill and has been described by Macklin (1986, see appendix). Here the catchment area is 26 km^2 and the changes in composition of the floodplain sediments can be related to migration of the river channel during a period of variable mining activity. Concentrations of Pb in surface sediment less than 2 mm in diameter vary from 225 to 12700 ppm and those of Zn from 4360 to 38000 ppm according to Macklin (1986).

As a summary it might be stated that:

- Overbank sediment is ubiquitous in northern England.
- Natural overbank sediment may be overlain by polluted material from mining activities. Sampling of pristine overbank sediment in mining areas seems quite possible.
- River waters are clear.
- There must be substantial sediment transport during floods.
- There is no reason why the conditions should be entirely different in other places in Britain.

2.1. DISCUSSION

Overbank sediments are common in major river valleys in north eastern England and can be found throughout the U.K.. The field excursion demonstrated some of the problems which might be encountered in using overbank material for the preparation of regional geochemical maps, particularly where mining activity has taken place (see Lewin and Macklin, 1987 in appendix), but also in any region where human activities may have modified the natural input of sediment to river systems. Large variations in trace metal chemistry occur across floodplains and between floodplain segments separated by only short stretches of river. In addition, sedimentation rates are far from uniform, even within a single drainage basin. In these circumstances the choice of sample site is critical and a means of dating at least the base of the overbank sequence highly desirable.

The most suitable sites for regional geochemical mapping are likely to be ones where the river channel has been stable over a very long period (?100's of years) and floodplain material has accumulated chiefly through overbank sedimentation with little or no lateral accretion. Geochemists may lack the necessary expertise to select such sites and the assistance of an experienced fluvial geomorphologist may be necessary to provide detailed knowledge of the historical development of the drainage basin.

A complicating factor in the choice of sampling sites is that most of Britains rivers are now managed and have extensive flood protection works. These have altered the natural pattern of overbank sedimentation and may have released large volumes of material for sedimentation downstream. The field trip visited mainly upland streams with only limited flood protection measures. There are large areas of lowland Britain where river management has been more intensive.

2.2. Conclusion

Overbank sediment is present and can be sampled, even in areas polluted from mining activities.

3.0. ACKNOWLEDGEMENTS

The field excursion would not have been possible without the assistance of Dr. Mark Macklin and Barbara Rumsby of the Department of Geography at the University of Newcastle upon Tyne. They are thanked for the organisation of accommodation in Hexham, their expertise in the field and for giving so generously of their time.

4.0. REFERENCES

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Fig. 2. Overbank sediment in the Tyne river, north east England.

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APPENDIX REPORT 3.11

REPORT ON THE FIELD EXCURSION TO ICELAND

19. July 1990

H. Tomasson
Orkustofnun, Iceland

F. Sigurdsson
Orkustofnun, Iceland

J. Bogen
NVE, Norway

1990

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1. Key map. Triangles: Rivers referred to in this report. Circles: Rivers where the sedimentload is measured by Orkustofnun.

2. The riverplain of Reykjadalsá near Reykholt. Lok. 1 refer to location of the photographs in Figures 3 and 4. The farm of Reykholt was the home of the well known author Snorri Sturlason.

3. The Terraces of river Reykjadalsá. Lok. 1 in Fig. 2.

4. Close up of section in Lok. 1. River Reykjadalsá.

5. Overbank sediments of river Nordurá. Vulcanoe at Hredavatn in background.

6. Close up of overbank sediments of river Nordurá.

7. The Myrdalsjøkull sandur, Southern Iceland.

8. Overbank sediments of river Lonukill, Northern Iceland. Ash layer 0.5 m below the top of the deposit.

9. Loess, wind blown deposits, are often intermixed with fluvial deposits in the sedimentary sequences. In the time after the first settlers came to Iceland about 1100 BP wind erosion became more abundant. For this reason the deposits during historic time are often easily identified by its grayish colour.

1. INTRODUCTION

Overbank sediments in Iceland was discussed in meetings and an excursion arranged by the Icelandic National Energy authority, Orkustofnun, 18-19 July 1990. The participant of the excursion were:

Haukur Tomasson (Orkustofnun, Iceland), Freysteinn Sigurdsson (Orkustofnun, Iceland) and Jim Bogen (NVE, Norway).

This report summarize the discussions during the meetings and the escursion, and describe examples of overbank sediment deposits in Iceland.

2. CONCLUSION

Overbank sediments in Iceland are present and constitute a significant part of the sedimentary environment. Ash layers from known vulcanic eruptions offer excellent possibilities for dating of long sequences. Sediments representing natural conditions and the conditions after the colonisation of Iceland may be sampled for geochemical mapping.

3. CHARACTERISTICS OF OVERBANK SEDIMENTS IN ICELAND

- Sediment yields are high. Sediment supply from modern glaciers dominates the sediment load of many rivers. There is also a high sediment production outside the glacier areas. Riverplains with a top layer of fine sediments are often well developed in Northern and Western Iceland.

- Many rivers develope stable riverplains even if their channel pattern essentially is braided.

- In the sandur areas of southern Iceland, older sediments are often eroded during high floods. Long term evolution of the river system has to be taken int0o account when sampling sites are selected.

- The ash layers from vulcanic eruptions described by historical sources are visible in the overbank sequences and may be used for dating purposes.

- Wind blown material may constitute a large part of the volume of overbank sequences.

4. EXAMPLES

The observations of overbank sediemnts in some of the rivers that were examined during the excursion are reported below. The location of the rivers are shown in the key map of Fig. 1.

4.1. Reykjadalsá

Near Reykhold the rivers are meandering across a 10 km long riverplain. Fig. 2.

Several terrace levels are present along the river. The high one in Fig. 3 is about 25 m. The area is situated below the marine limit and the various levels correspond to variation in sea level. Marine clay is visible as a gray layer in the lover part of the sections.

The surface of the recent riverplain is situated about 2 m above the water level fo the river. The upper 1 m is composed of laminated overbank sediments. Fig. 4.

4.2. Laxa in Kjos

A large riverplain is formed upstream from a rock bar at Laxarnes.

Overbank sediments were investigated in a section near Laxarnes. The overbank deposit is about 1 m thick and is composed of silt and fine sand with a large content of organic material overlaying a sequence of somewhat coarsegrained material. The last spring flood nearly reached the top of the riverplain. The bed load of the river consists of gravel and sand.

4.3. Nordurá

A lavaflow from a vulcanoe at Hredavatn dammed the river and a large riverplain is formed upstream of this lavaflow. Fig. 5.

The bed load of this river consists of gravel and cobbles. Gravel bars are visible upstream from the investigated section.

The overbank sediments of the riverplain was investigated in the downstream part fo this riverplain. In this area the thickness of the sequence is about 3-4 m. Very distinct lamination with layers of 3 cm thickness are visible.

The initiation of sedimentation in this section is dated by the vulcanic eruption which took place in prehistoric time.

4.4. Jøkulsa a Bru

The sediment transport of jøkulsa a Bru is measured in a canyon shaped in bedrock at Hjardarkyn.

In this section the difference between low water level and flood water level may be as much as 10 m. Overbank deposits seem to be accumulated even above this level. Sediments are laminated and with distinct ash layer5s, gray in colour. The plain is probably receving sediment during exstreme large magnitude floods. However, normal overbank deposits exists at lower levels downstream.

4.5. Sandurs of Souther Iceland

The sandurs are characterized by extensive braiding of channels.

A stable flood plain is rarely developed. During high floods the river is subject to lateral migration and in some areas the channel system move rapidly from one end to another. Fig. 5. In this environment remnants of older sufaces have to be looked for. Composite samples in large cross sections are maybe necessary in these areas.

5. DATING

Ash layers from vulcanic eruptions in historic time offer good opportunities to date sedimentary sequences. The ash layers are often visible in the overbank sequences as distinct dark or gray layers. Fig. 8.

Loess, wind blown deposits, are often intermixed with fluvial deposits in the sedimentary sequences. In the time after the first settlers came to Iceland about 1100 BP wind erosion became more abundant. For this reason the deposits during historic time are often easily identified by its grayish colour. Fig. 9.

Thus, it seem possible to make geochemical maps to show the influence of man upon the environment.

Figure 1. Key map. Triangles: Rivers referred to in this report. Circles: Rivers where the sedimentload is measured by Orkustofnun.

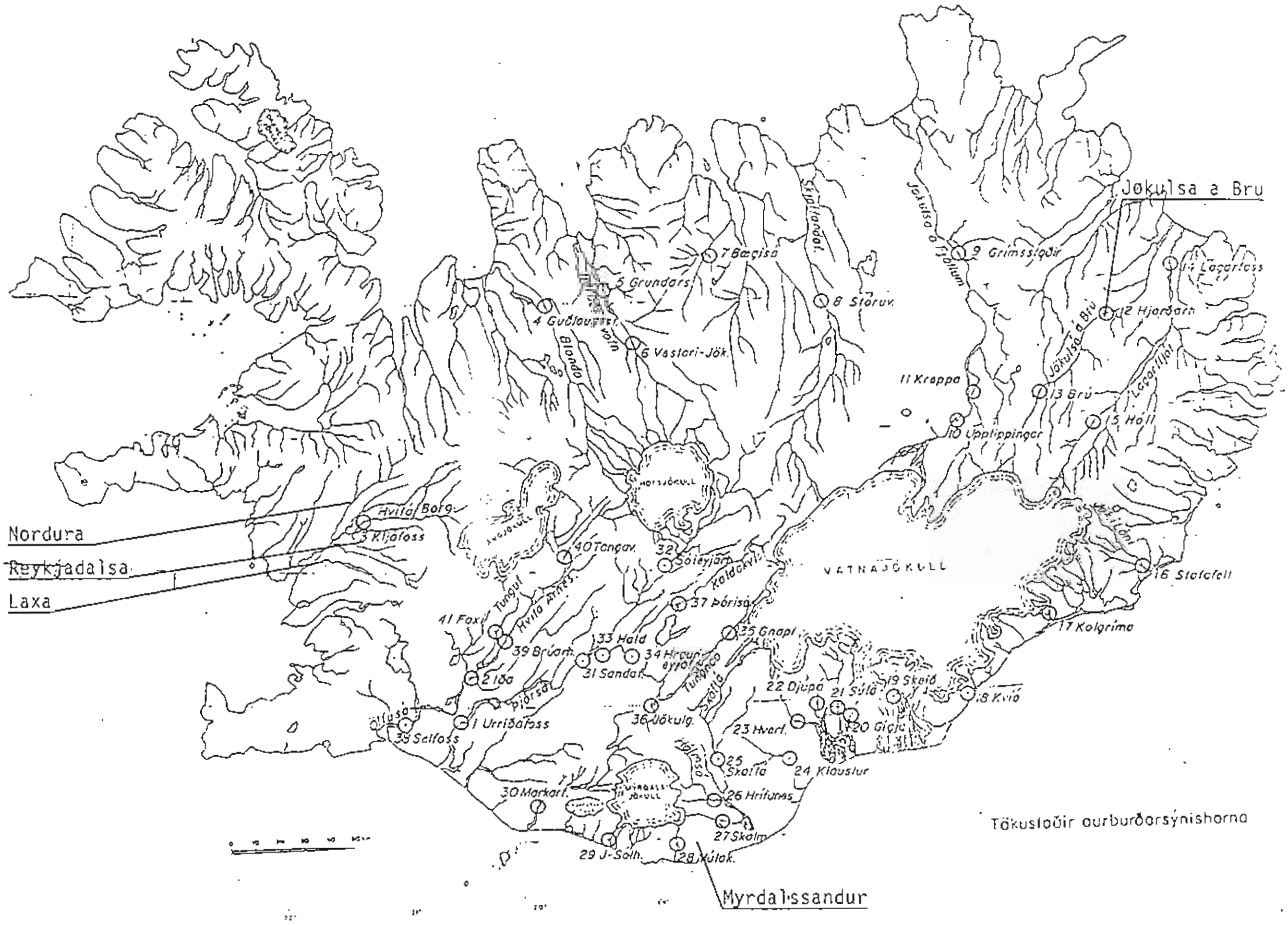

Figure 2. The riverplain of Reykjadalsa' near Reykholt. Loc. 1 refer to location of the photograpgs in figures 3 and 4. The farm of Reykholt was the home of the well known author Snorri Sturlason.

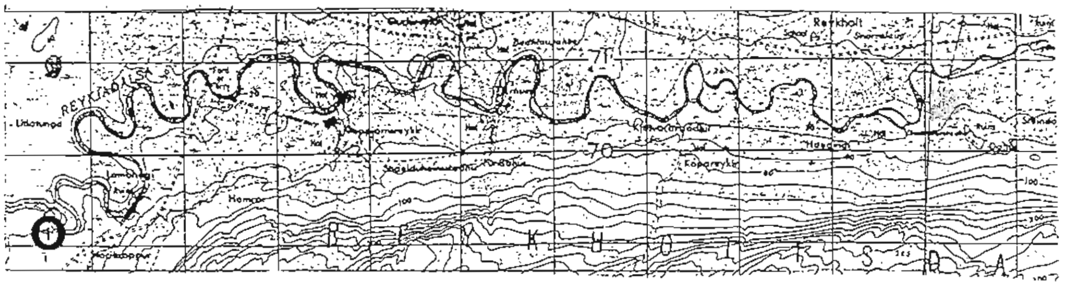

Figure 3. The terraces of river Reykjadalsa'. Loc. 1 in figure 2.

Figure 4. Close up of section in loc. 1, river Reykjadalsa'.

Figure 5. Overbank sediments of river Nordura. Vulcanoe at Hredavatn in background.

Figure 6. Close up of overbank sediments of river Nordura.

Figure 7. The Myrdalsjøkull sandur, Southern Iceland.

Figure 8. Overbank sediments of river Lonukill, Northern Iceland. Ash layer 0.5 m below the top of the deposit.

Figure 9. Loess, wind blown deposits, are often intermixed with fluvial deposits in the sedimetary sequences. In the time after the first settlers came to Iceland about 1100 BP wind erosion became more abundent. For this reason the deposits during historic time are ofteneasily identified by its grayish colour.

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APPENDIX REPORT 3.12

SUMMARY REPORT OF THE FIELD EXCURSIONS 1987-90

R.T. Ottesen
Norway

J. Bogen
Norway

T. Volden
Norway

1990

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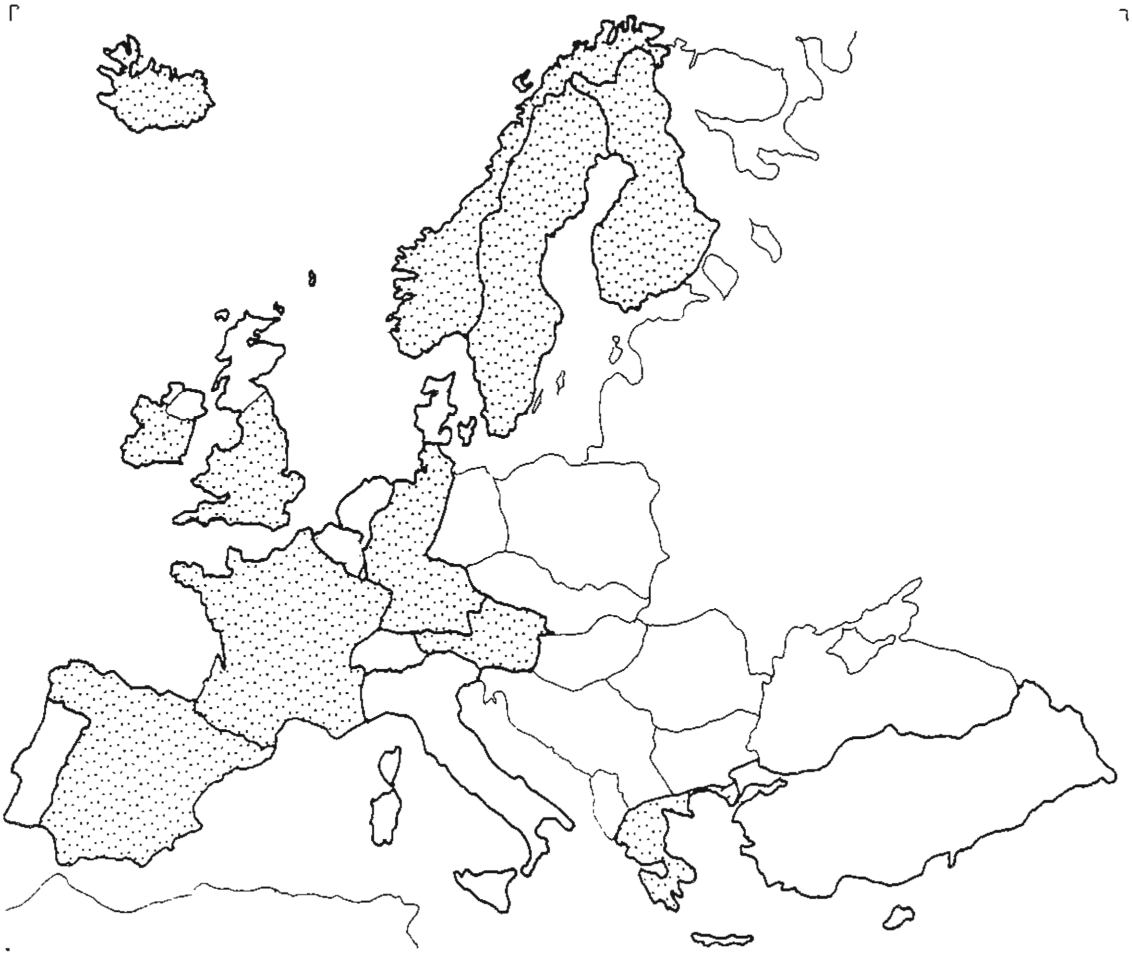

Fig. 1. Map showing the WEGS countries visited by the field excursion team.

1.0. INTRODUCTION

Field excursions have been made to Austria, England, Finland, France, Germany, Greece, Greenland, Iceland, Ireland, Norway, Spain and Sweden (Fig. 1). The main purpose of these excursions was to investigate the existence of overbank sediment in different geological and morphoclimatic conditions in Europe.

The main conclusion is that overbank sediment is present and can be sampled from most part of Europe. Some areas have been identified as "problem areas", i.e., parts of the French Pyrenees and the Austrian Alps, the semi-desert areas of southern Spain, and probably also of some parts of Turkey.

2.0. CHARACTERISTICS OF OVERBANK SEDIMENT IN THE WEGS COUNTRIES

In the WEGS countries, there are two main types of river systems: (a) braided and stable bank. Both offer the possibility of finding representative samples for the whole drainage basin.

The braided system is dominating the arctic and partly the southern European riverine environments (Fig. 2). A composite sample taken in cross section over the braided river system will be very representative of the whole drainage basin. Fluvial erosion in this environment is probably close to sheet erosion. The "time-dimension" represented by this sample may be difficult to interpret. The solution to this problem lies in the consideration of the long term evolution of the river system.

The stable bank system is most common over the whole of Europe (Fig. 3). In these rivers overbank sediment is deposited on the river flood plains. Fluvial erosion in these rivers takes place from point sources.

2.1. Arctic rivers

The rivers of the arctic are characterized by:

- continuous and large sediment yield;
- considerable run-off within short time intervals during periods of snow melting;
- much sediment transport during rare floods;
- river plain and channels with frequent braiding;
- stable river banks are uncommon;
- moderate to high erosions rate;
- the rivers are either glacier outlet rivers or glacially-fed rivers;
- sheet erosion occurs, and
- the whole drainage basin is probably represented also in active stream sediment.

2.2. Scandinavian rivers

- moderate to low sediment yields;
- transport of material is associated with a number of flood episodes;
- run-off is concentrated to snow melting and rainfall periods;
- stable river plains dominate;
- overbank sediment occurs in most river basins;
- sediment availability is limited by vegetation cover;
- sediment sources are point sources in the overburden, and
- active stream sediment is not representative of the whole drainage basin.

2.3. Central European rivers

- moderate to low sediment yields;
- transport of material is associated with a number of flood events;
- run-off is due to rainfall and snow melting in high lying areas;
- stable river plains dominate;
- overbank sediment is common in most river basins;
- sediment sources are point sources in the overburden, and
- active stream sediment is not representative of the whole drainage basin.

2.4. Southern European rivers

- much fine-grained sediment is available from a number of sources in the drainage basins;
- the sediment yields are high;
- the intense sediment transport during flood events supply much sediment to down stream areas;
- large sequences of sediment are deposited in a short period of time;
- even short sections of the sediment stratigraphy will be representative of the whole drainage basin;
- large amounts of bedload in gravel and sand fraction are present;
- human activity influences river sediment deposition, and
- a typical phenomenon in the river plain and delta parts of the large rivers is channel shifting, with consequent braiding.

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Fig. 2. Braided river system.

Fig. 3. Stable bank river system.

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APPENDIX REPORT 4.1

SAMPLING AND ANALYTICAL REPRODUCIBILITY IN OVERBANK SEDIMENT

T. Volden
Norway

1990

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1.0. INTRODUCTION

In order to estimate the total error inherent to field sampling, sample preparation and analysis, i.e., the reproducibility of results, two different samples of overbank sediment were taken from two sites at 100-200 metres apart from each of nineteen flood plains in Norway (Fig. 1). The two sets of samples were taken by different sampling teams.

2.0. SAMPLE PREPARATION AND ANALYSIS

The 38 samples collected were dried at a temperature of 60 to 80° C, and sieved through a nylon screen of 0.062 mm. Subsequently, the samples were placed in random order, and the partial and total element concentrations were determined by ICP and XRF respectively. Details of the two analytical methods are given below.

2.1. Partial analytical method

One gram of the minus 0.062 mm fraction was attacked by 5 ml of 7N HNO_3 at 110°C for three hours. After digestion the solution was diluted to 20.3 ml, centrifuged and decanted. Then, 1 ml of this solution was diluted with 4 ml of a reference element solution containing 20 ug/ml of Li and Y in deionized water as internal standards. The final solution thus contained 16 ug/ml of Li and Y. The elements Al, Ba, Ca, Ce, Co, Cr, Cu, Fe, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Sr, Ti, V, Zn and Zr were determined on the solution by ICP (Odegard 1980). The lower detection limits of the elements are shown in Table 1.

Table 1. Lower detection limits of elements determined by the partial analytical method. (Values in ppm).

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	
0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0	

2.2. XRF analytical method

Two grams of the -0.062 mm grain size fraction were added to a binder and pressed into a brickette. The samples were analyzed by XRF at the laboratories of the Swedish Geological Survey AB in Lulea. The following elements were determined: Al, Ca, Fe, K, Mg, Mn, Na, P, Si, Ti, As, Ba, Cl, Co, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Sn, Sr, Th, U, V, W, Y, Zn and Zr. Their lower detection limits are given in Table 2.

Table 2. Lower detection of elements determined by XRF. (Values in ppm)

Al	Ca	Fe	K	Mg	Mn	Na	P	Si	Ti	Pb
500	700	700	800	600	800	700	40	500	600	20
Rb	S	Sn	Sr	Th	U	V	W	Y	Zn	Zr
20	100	100	10	10	20	20	20	10	10	20

3.0. DATA TREATMENT

Scattergrams were plotted and the linear correlation coefficients between the corresponding elements of the duplicate samples were determined for both the partial (Figs. 2a, b, c; Table 3) and the total (Figs. 3a, b, c; Table 4) analytical methods. The plots and correlation coefficients were placed in order of decreasing correlation.

4.0. DISCUSSION

4.1. Hot nitric acid soluble elements

The scattergrams and correlation coefficients of hot nitric acid soluble elements, show that the series of elements under study may be subdivided into four groups according to how well they are correlated, i.e.,

(a) Ca, Mn, Na, Co, K, Zn, Cu, Mg, Sc and P have a fairly good correlation;

(b) Cr, Pb, Al, V, Ni, Zr, La, Ce, Ba, Sr and F show a moderately good correlation;

(c) Ti, B and Mo have a poor correlation, and

(d) Be, Li and Bi a very poor correlation.

It is quite apparent, from the above grouping of the elements determined, that the poor correlation of the last two groups (c) and (d) is due to the analytical method. This inference is based on the fact that it is an acid attack, and the elements are close to their detection limits.

4.2. Total element concentrations determined by XRF

The study of the scattergrams and linear correlation coefficients, analyzed by XRF, can be subdivided into three groups, i.e.,

(a) Al, Ba, Ca, Cl, Co, Fe, K, Mg, Mo, Na, P, Si, Sr, Ti, V, and Zn, which have a fairly good correlation;

(b) Co, Mn, Nb, Ni, Mo, Pb and Zr, which show a moderately good correlation, and

(c) As, U, W, Y and Sn with a poor correlation.

5.0. CONCLUSION

The conclusion of this study is that the reproducibility for the acid soluble and total contents of elements is good, when overbank sediment is sampled 100-200 metres apart on the same alluvial deposit. It appears, therefore, that over short distances the fine-grained fraction (-0.062 mm) of overbank sediment under Norwegian fluvial conditions is fairly homogeneous.

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Fig. 1. Map showing the 19 flood plains of duplicate overbank sediment sample sites in Norway.

Fig. 2a. Scattergrams of Ca, Mn, Na, Co, K, Pb, Zn, Cu, Mg, Sc, P and Cr between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.

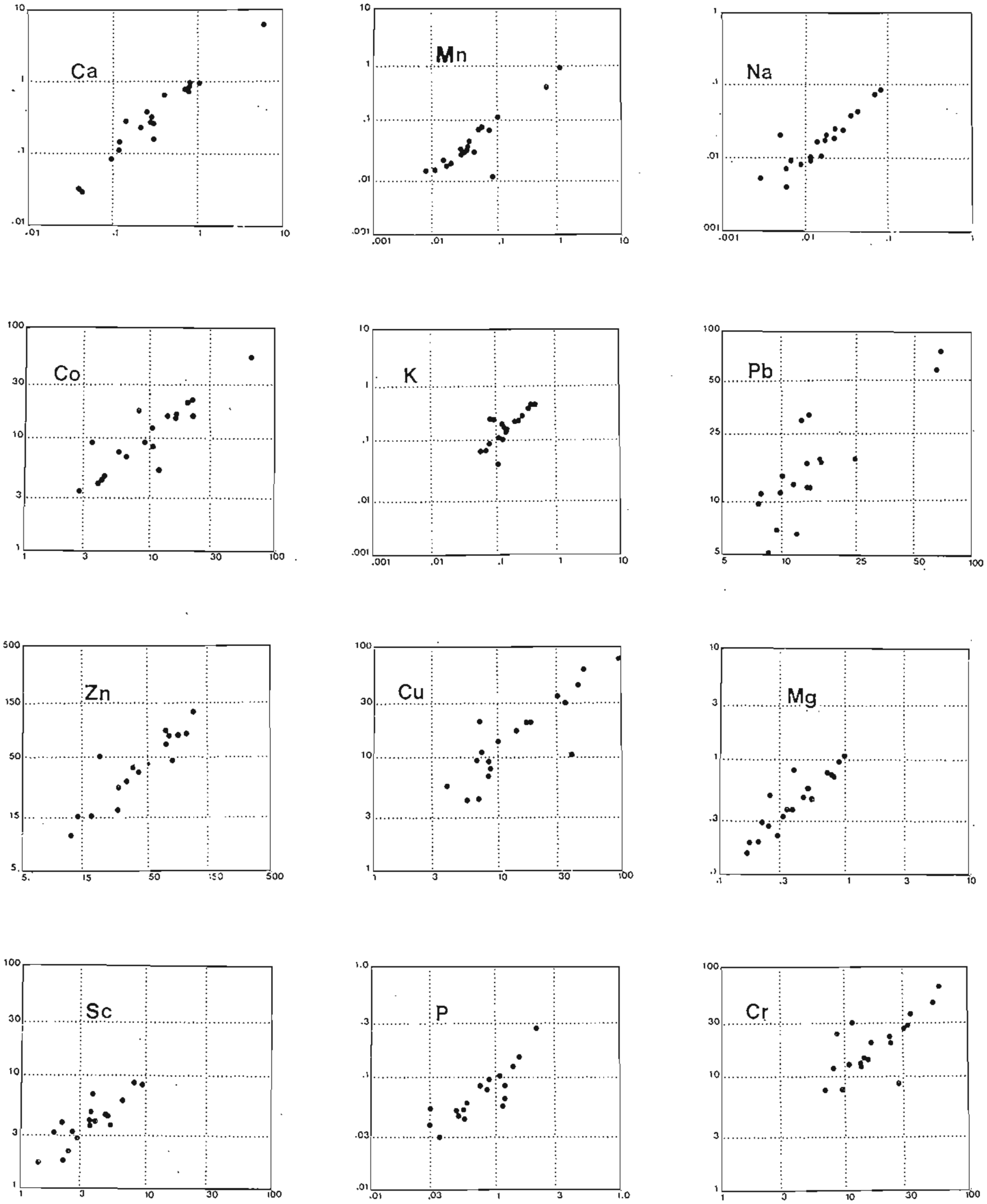


Fig. 2b. Scattergrams of Al, V, Ni, Zr, La, Ce, Ba, Sr, Fe, Ti, B and Mo between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.

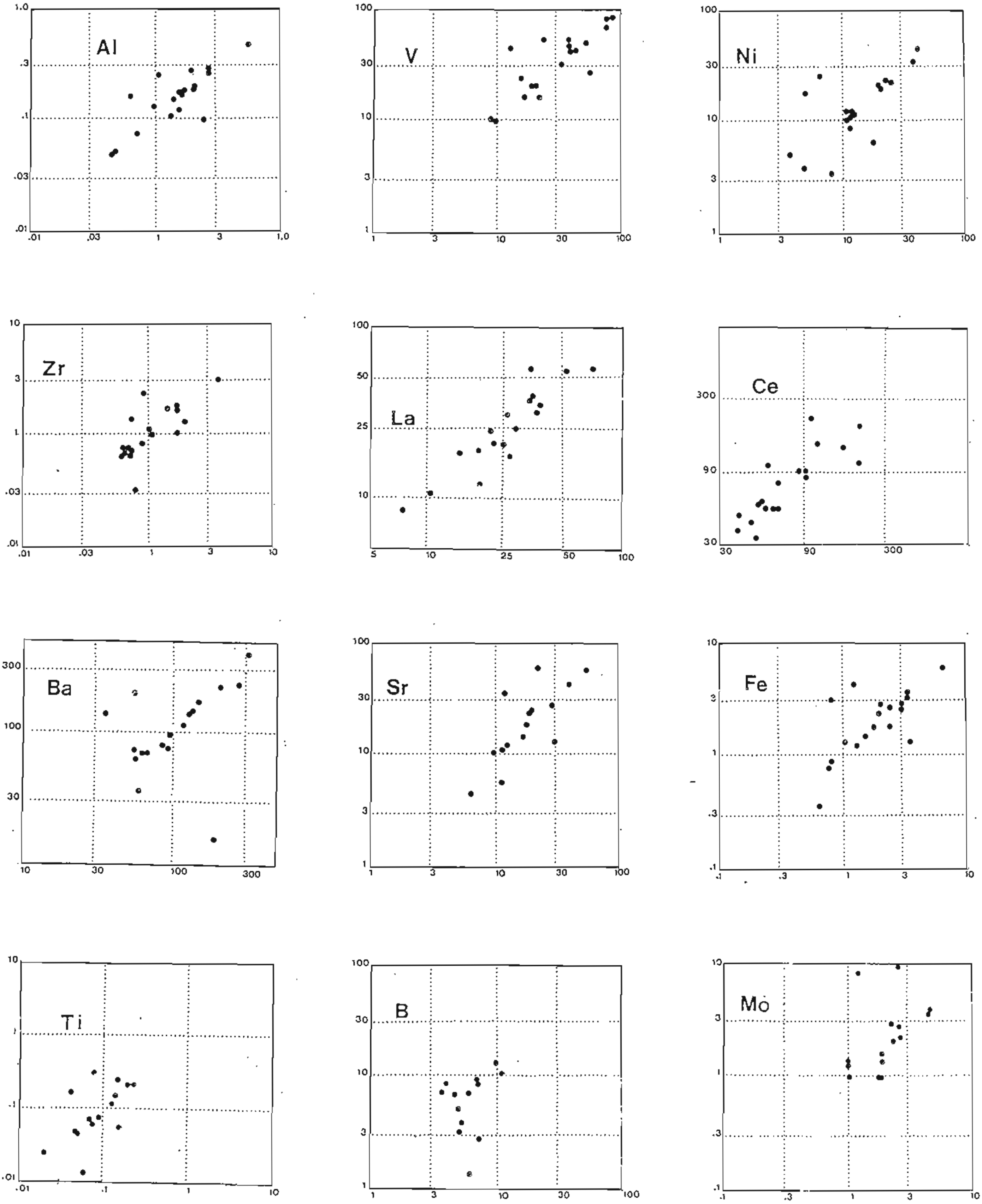


Fig. 2c. Scattergrams of Be, Li and Si between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.

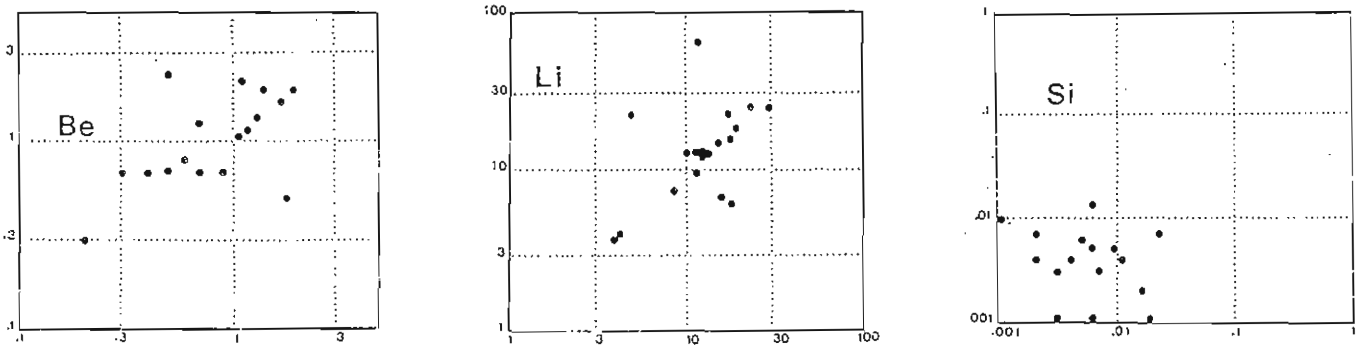
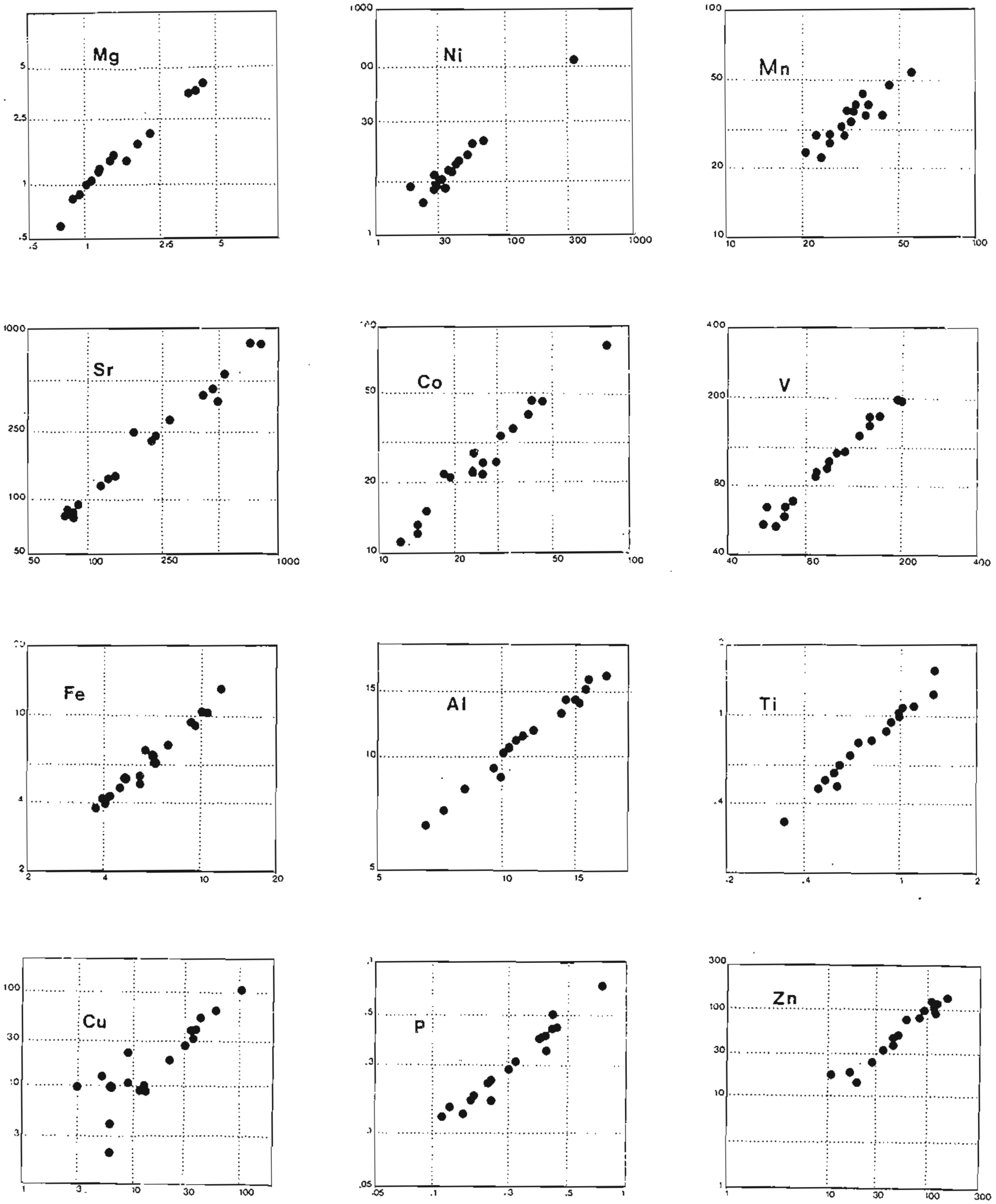


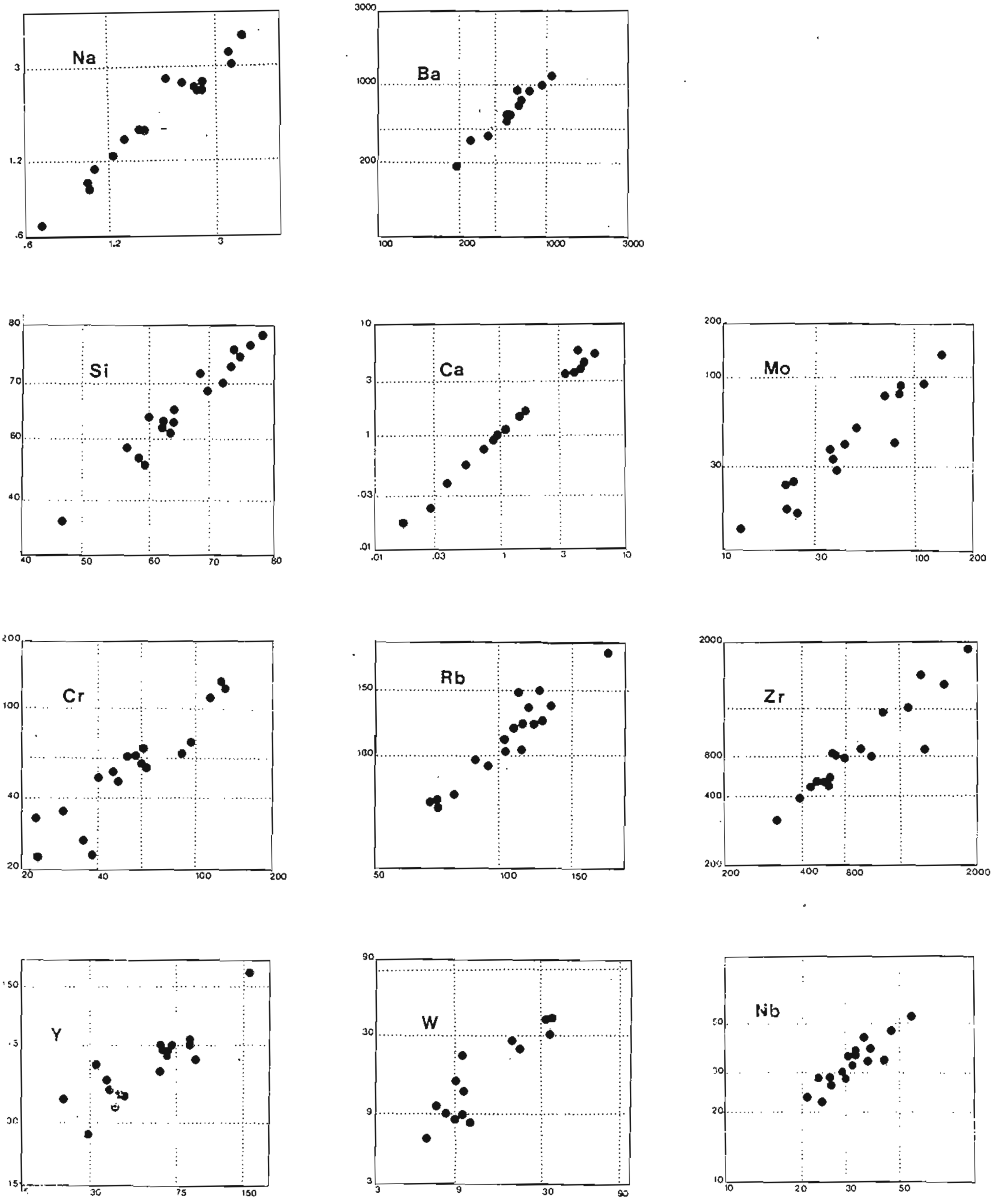
Table 3. Element correlation coefficients of the duplicate overbank sediment samples taken from 19 different flood plains in Norway.

Element	Correlation coefficient (r)	Element	Correlation coefficient (r)
Ca	1.0	V	.84
Mn	.99	Ni	.82
Na	.98	Zr	.78
Co	.96	La	.74
K	.94	Ce	.72
Pb	.93	Ba	.71
Zn	.91	Sr	.70
Cu	.91	Fe	.69
Mg	.91	Ti	.52
Sc	.89	B	.50
P	.89	Mo	.49
Cr	.86	Be	.32
Al	.85	Li	.22
		Si	-.22

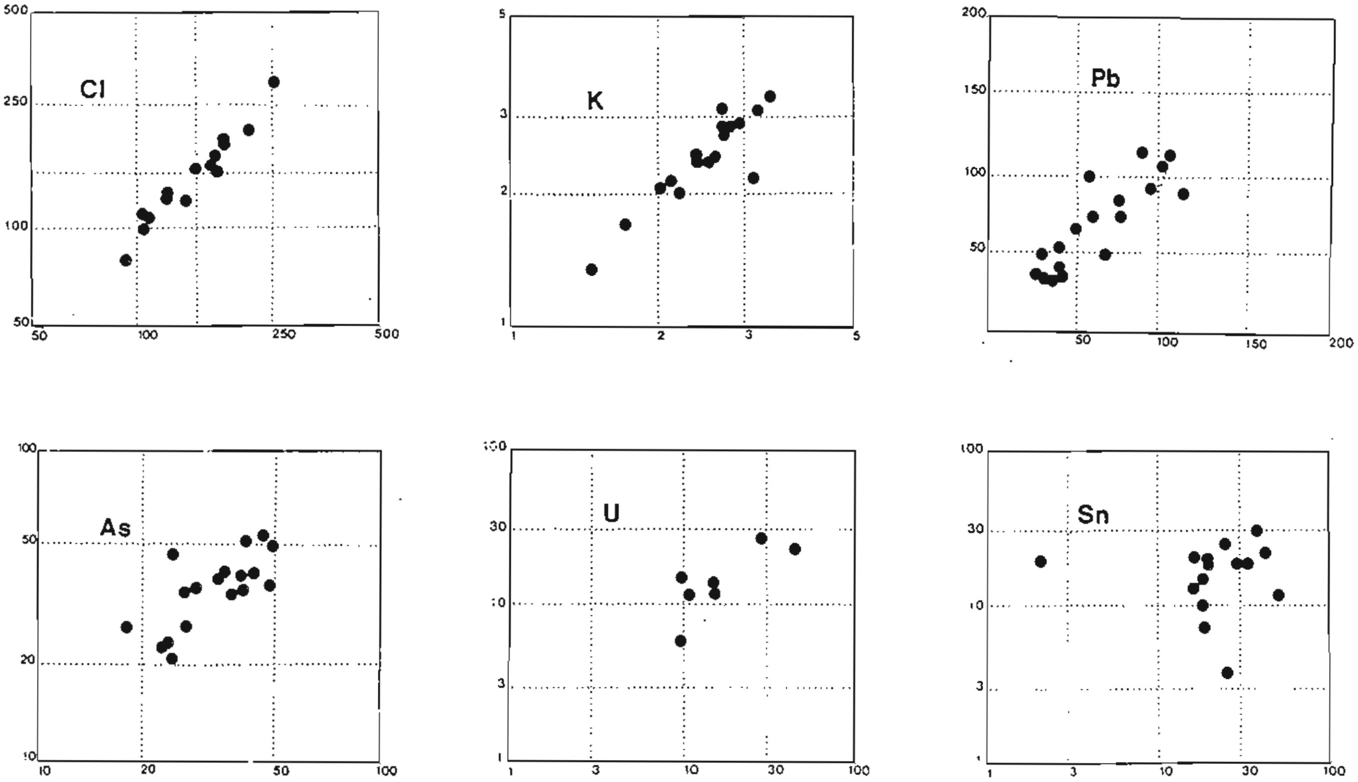
3a. Scattergrams of total element contents of Mg, Ni, Mn, Sr, Co, V, Fe, Al, Ti, Cu, P and Zn between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.



3b. Scattergrams of total element contents of Na, Ba, Si, Ca, Mo, Cr, Rb, Zr, Y, W and Nb between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.



3c. Scattergrams of total element contents of Cl, K, Pb, As, U and Sn between the duplicate overbank sediment samples taken from 19 different flood plains in Norway.



Element	Correlation coefficient (r)	Element	Correlation coefficient (r)
Mg	1.0	Ca	.97
Ni	1.0	Mo	.95
Mn	.99	Cr	.95
Sr	.99	Rb	.94
Co	.99	Y	.93
V	.99	W	.93
Fe	.99	Nb	.91
Al	.99	Mo	.91
Ti	.98	Cl	.90
Cu	.98	K	.87
P	.98	Pb	.86
Zn	.97	U	.80
Na	.97	As	.70
Ba	.97	Sn	.19
Si	.97		

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APPENDIX REPORT 5.1

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT PROFILES, AUSTRIA

O. Scherman
Austria

1990

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1.0. INTRODUCTION

The main objectives of the pilot study on overbank sediments were to obtain: (a) information on the percentage proportion of the -0.063 mm (240 mesh) grain size fraction in this sampling medium, and (b) significant field data upon which the sampling was going to be planned according to Austrian legal and infrastructure aspects.

2.0. SAMPLE SITE SELECTION

The eight overbank sediment sample sites were randomly selected about Vienna, and cover a variety of morphological and geological units (Fig. 1). They are referred to by the code names ERL, HOF, HI, NMURZ, NMZII, SPITZ, WEIT and ABSD.

ERL and HOF lie in the Quaternary of the Viennese Basin, and are not too far away from their source in the midlands. HI is situated in the same unit, but further away from its source region; anthropogenic influence is probable for the upper 1-1.5 m. NMURZ is located in the Alps, downstream of an area with abandoned mines of Cu, Ag, (with associated Pb) and iron carbonate veins. The source area is of moderate altitude. According to local information, the sample location was in a back-filled gravel and sand pit. So, an alternative sample site, NMZII, was chosen a few hundred metres upstream.

The sites SPITZ and WEIT are situated in the Bohemian Massif, a peneplain of Tertiary or greater age, close to its margin. ABSD represents a site which is entirely in a slightly graded lowland of younger Tertiary age.

3.0. SAMPLING

The sample material was obtained by a drill with a 1 m spiral rod (plus extension rods) to depths varying from 1.5 to 5.0 m. The individual sample sections were of 0.5 m length. Thus, contamination of the respective lower sections cannot be excluded, although efforts were made to keep this as low as possible. The surface area at each sample site was covered with a plastic sheet, which was thoroughly cleaned before drilling the next section. This procedure and the attempt to prevent contamination of succeeding samples, are the reasons for the variation in the total weights of the overbank sediment samples.

The top soil, down to the bottom of the grass roots, which in general does not exceed 10 cm in thickness, has been excluded in all cases from the surface sample section (0 - 0.5 m).

4.0. SAMPLE PREPARATION

A few days after completion of the sampling, the overbank sediment was removed from the plastic bags and dried in a thermostatically controlled oven at a temperature below 80°C. The whole sample, after drying, was weighed, disaggregated and sieved to different grain size fractions (i.e., -2 to 0.5 mm, -0.5 to +0.25 mm, -0.25 to +0.063 mm and -0.063 mm). It was found, that after weighing the individual fractions, there was on average a loss of 0.3% out of the original total weight (Table 1).

One grain size fraction of sample NMZII was discarded by mistake prior to weighing; so the weight of fraction -0.25 to +0.063 mm was calculated by subtracting the sum of the weights of the other fractions from the original total weight.

A sub-sample of the -0.063 mm fraction was ground to -300 mesh (0.053 mm), and about 2.5 g of the ground material was pressed with borate into 6 cm diameter pellets.

5.0. ANALYSIS

The overbank sediment samples were analyzed by a Philips OW 1404 XRF instrument with a 100 kV excitation, and the results obtained on a direct print-out, after automatic correction for the chemical matrix.

The reproducibility of the XRF determinations is better than +/- 10%, unless the values are close to the lower detection limit from where on the reproducibility is better than +/- 100%.

The lower detection limit for each element is given in Table 1. The asterisks denote the existence of values below the stipulated lower detection limit, thus implying a worse reproducibility.

6.0. DATA PRESENTATION

The grain-size distribution weights and all the analytical data tabulated in Table 1 are presented in graphical form (Figs. 2 to 9).

The data points on the plotted graphs are the mid-points for each section, i.e., a point at 0.25 m depth represents the section 0 - 0.5 m, and a depth of 0.75 m the section 0.5 - 1.0 m, etc.

Diagrams of the cumulative grain size are not included due to lack of sufficient data, especially on the lower end. It may be stated, however, that the sediments, in the majority of cases, fall into the "well-sorted" group, and any deviation possibly implies an artificial back-fill, which cannot easily be detected in the case of drilling.

7.0. DISCUSSION

The most important points of the results presented in Table 1 and Figs. 2 - 9 will be discussed. It is noted at the outset, that in all cases pristine samples are found at depth.

7.1. Sample site Erl (Fig. 2)

There is a marked upward increase in the Cu, Pb and U contents, and a slight but gradual increase in the Zn, Zr, P and Ti concentrations. On the other hand there is a striking upward depletion in W, and a gradual decrease in the Mo and Y contents.

The enrichment in Cu, Pb and Zn in the upper layers is possibly due to industrial pollution, and P to fertilizers. The reasons for the increase in U, Ti and Zr should be investigated.

7.2. Sample site Hof (Fig. 3)

There is a slight but gradual upward increase in the Cu, Pb, Zn, P and Th contents, and a striking increase in W.
Whereas, there is a marked upward depletion in U, and a less pronounced in Cr, Y and Sr.

The enrichment in Cu, Pb and Zn is possibly due to industrial pollution, and that in P to fertilizers. The reasons for the increase in Th should be investigated.

7.3. Sample site Hi (Fig. 4)

There is an upward increase in the Cu, Pb, Zn, P and Zr concentrations.

The enrichment in Cu, Pb and Zn is possibly due to industrial pollution, and that in P fertilizers. The reasons for the increase in Zr should be investigated.

7.4. Sample site NMurz (Fig. 5)

There is a marked upward increase in the Cu content, and a gradual upward enrichment in the Pb, Mn, Ni, P, Sr and Y concentrations.

There is a marked decrease in the Ga content of the surface layer.

The enrichment in Cu, Pb and Mn is possibly due to artificial backfill. In this particular catchment area there is no agriculture, only forests and pastures for grazing cows. Hence, the reasons for the increase in P, Ni, Sr and Y should be investigated.

7.5. Sample site NMzII (Fig. 6)

There is a marked upward increase in the P, Sr, Cu, Pb, Zn, Co, Ni, Ba, Mn, Mo, W, U and Nb. This increase is more pronounced in the surface layer. The elements Cr, Co, V, Fe show an enrichment, whereas Na, K and Mg a depletion in the top layer.

The increase in the base metal concentrations could easily be interpreted as due to the nearby mining activity.

7.6. Sample site Spitz (Fig. 7)

The geochemical changes in this overbank sediment profile are imperceptible, so it is assumed that this sample is not polluted, and is wholly pristine. It, therefore, represents a profile, which is typical of unpolluted areas.

7.7. Sample site WEIT (Fig. 8)

The only striking feature of this sample site is the increase in Cu in the top layer.

7.8. Sample site Absd (Fig. 9)

At this sample site the driller penetrated accidentally the young sediments underlying the overbank sediment, due to the fact that the two units were macroscopically similar in appearance. The boundary between the two is, however, marked by a decrease in the Al, Si, K and Ti contents from a depth of 3.25 m upwards. The interpretation given for this feature is that the overbank sediment is depleted in clay minerals.

The catchment area is almost entirely agricultural, thus the enrichment in the P content in the upper two samples. The increase in the concentration of Cu in the top layer may be associated with its use as a pesticide in vineyards.

8.0. CONSEQUENCES OF LOW DENSITY SAMPLING

A minimum weight of 2 kg of the -0.063 mm grain size fraction is proposed for the WEGS project. According to data fro the Austrian pilot study, a weight of at least 100 kg per section must be sampled, or 200 kg per sample site, as a safety precaution for obtaining the agreed amount of the -0.063 mm grain size fraction for analysis and storage. Under the Austrian conditions, the digging of shafts for sampling overbank sediments, will cause severe conflicts with (a) labour safety, (b) some local authorities, and (c) small-scale land owners.

The following problems, with regard to the large sample weight required, are not only valid for Austria, but for other countries as well, i.e., transportation cost, drying and sieving in an almost contamination-free environment.

The objections raised during the meetings of the Working Group can only be repeated here. The only possibility to avoid some of the problems that have been mentioned above is to reduce the required amount of the -0.063 mm sample material. This would only mean a reduction in the analytical material for the noble metals, thus accepting a greater splitting error.

9.0. CONCLUSIONS

The study of grain size distribution in the overbank sediment samples has pointed to a very important problem, with regard to the proposed 2 kg weight of the -0.063 mm fraction for analysis and storage for future use. The enormous weight of sample required, i.e., 200 kg per sample site, will create severe problems under Austrian field sampling conditions. It is, therefore, proposed that a coarser grain size fraction should be agreed upon or the required amount of 2 kg to be reduced.

The geochemistry of the overbank sediment profiles has shown that anthropogenic pollution has affected the top layers of most profiles, and in all cases pristine samples can be obtained at depth. It is, therefore, concluded that overbank sediments are generally a good sampling medium for environmental pollution studies.

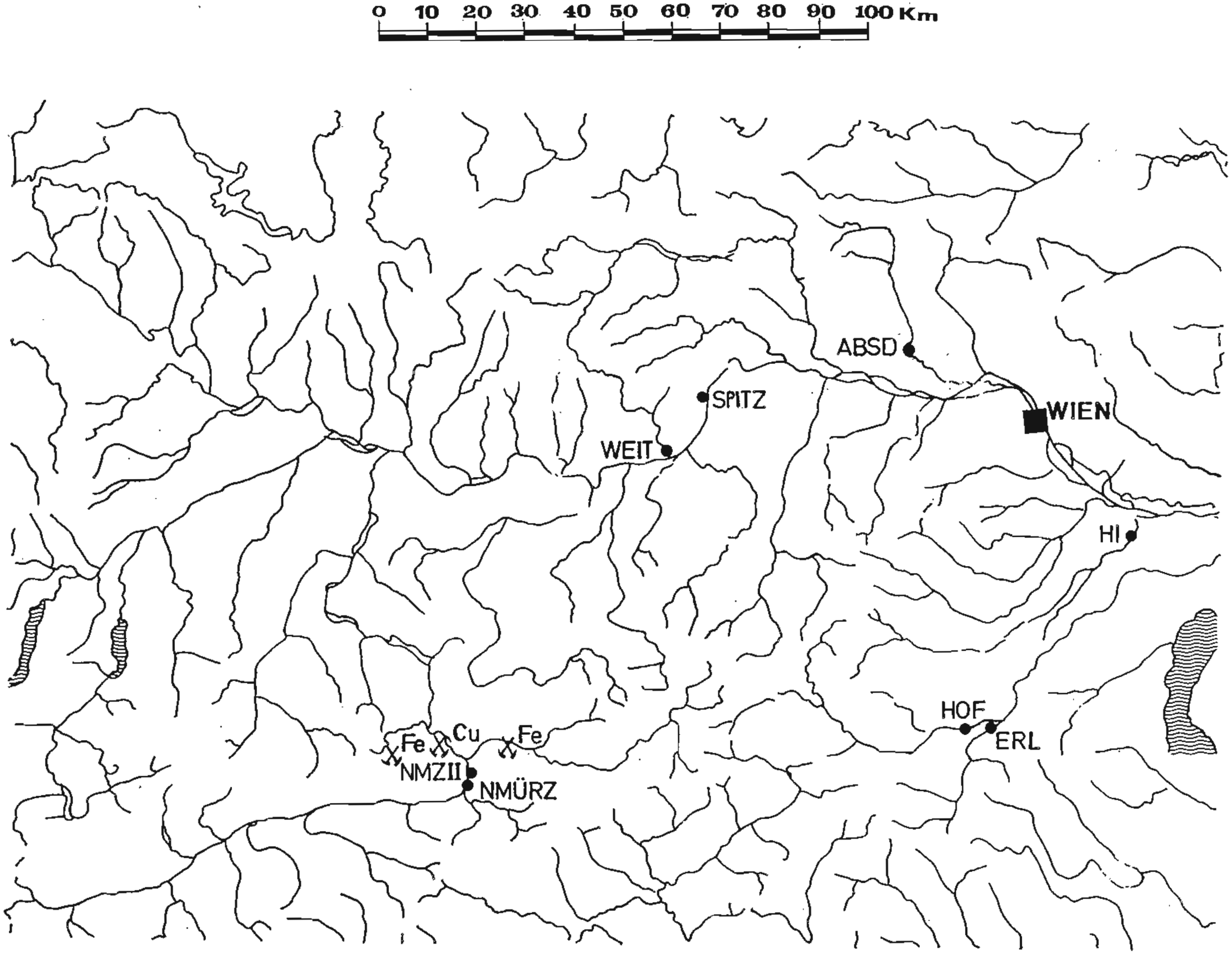
ACKNOWLEDGEMENTS

The sample preparation and analysis were made by the Geo-Technical Institute of the BVFA Arsenal free of charge, so the author expresses his gratitude.

TABLE 1. Data on sample sites Weit, Erl, Hof, Spitz, NWzll, NWurz, NI and Abad: sample depth, total weight, weight of individual grain-size fractions and analyses on the -0.063 mm fraction.

SAMPLE		DEPTH (m)	TOTAL WEIGHT (grams)	WEIGHT (gms) IN DIFFERENT GRAIN-SIZE FRACTIONS >2 mm	>0.5 mm	>0.25 mm	>0.063 mm	<0.063 mm	Nb (ppm)	Mo (ppm)	Ba (ppm)	W (ppm)	Pb (ppm)	Th (ppm)	U (ppm)	V (ppm)	Cr (ppm)	Ni (ppm)	Co (ppm)	Cu (ppm)	Zn (ppm)	Ba (ppm)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Na (%)	Mg (%)	Al (%)	Si (%)	P (%)	K (%)	Ca (%)	Ti (%)	Mn (%)	Fe (%)
		Lower detection limit:							5	5*	50	5*	5	5	1	5	5	5	1	5	5	1	5	10	5	10	0.05	0.01	0.1	0.5	0.005	0.05	0.05	0.005	0.001	0.05
Weit	A	0.0-0.5	151.2	17.5	45.4	25.6	45.8	13.2	16	7	477	-1	32	22	5	152	108	47	22	81	88	16	107	133	42	422	0.94	1.84	7.20	26.6	0.087	2.05	1.74	0.835	0.113	5.32
	B	0.5-1.0	172	18.5	52.8	33.7	64.2	20.1	19	7	453	5	31	22	3	146	102	51	20	39	91	18	111	139	45	444	0.92	1.76	7.42	27.0	0.086	2.04	1.67	0.836	0.118	5.43
	C	1.0-1.5	228.3	39.1	99.7	29.5	44.7	19	16	7	468	1	27	22	1	138	109	51	20	40	91	19	105	143	43	397	1.07	1.80	8.70	29.1	0.078	2.04	1.77	0.800	0.106	4.99
	D	1.5-2.0	355	10.8	80.9	113.4	128.7	18.4	16	7	468	-1	22	27	3	158	103	52	23	47	98	20	108	178	50	476	1.19	2.05	7.64	26.0	0.074	2.22	2.05	0.890	0.121	5.80
	E	2.0-2.5	954.9	125.7	271.8	229	292.6	32	15	8	486	6	28	30	5	154	101	54	24	51	97	18	105	185	55	532	1.23	[illegible]	7.37	26.3	0.083	2.13	2.04	0.869	0.155	6.02
	F	2.5-3.0	799.6	118.2	293.9	148	206.3	29.2	18	8	456	4	22	25	2	152	100	49	24	49	90	20	107	166	47	451	1.14	1.90	7.33	26.3	0.077	2.14	1.94	0.868	0.140	5.97
Erl	A	0.0-0.5	515.6	164.7	78.1	82.4	135.8	52.4	18	4	545	-1	152	15	3	111	76	39	16	66	128	24	154	104	22	312	0.95	1.53	10.52	24.6	0.107	3.24	1.83	0.575	0.115	4.45
	B	0.5-1.0	1194.7	641.9	184.3	113	176.4	56	18	5	570	8	66	16	2	104	78	44	19	37	103	23	151	103	25	271	1.05	1.54	10.35	25.5	0.091	3.17	1.66	0.501	0.127	4.26
Hof	A	0.0-0.5	349.7	6	76.6	141.5	110.6	12.9	10	7	477	2	44	21	1	152	100	52	21	77	113	18	102	160	53	493	1.16	2.02	6.18	26.2	0.123	2.01	2.75	0.723	0.115	5.23
	B	0.5-1.0	416.5	5.1	103.8	164.6	119.8	21.2	13	7	469	3	38	20	2	153	107	54	22	65	106	19	103	171	54	539	1.10	2.03	5.42	26.5	0 08	1.90	2.57	0.742	0.118	5.49
	C	1.0-1.5	1300.9	390.4	411.6	303	169.3	23.6	11	7	445	-1	35	18	3	150	99	53	23	66	97	18	104	184	60	485	1.29	2.07	6.25	26.9	0.106	1.99	3.00	0.683	0.109	5.18
Spitz	A	0.0-0.5	993.4	465.1	294.2	116.3	89.9	24.1	14	7	450	1	30	22	3	137	107	59	[illegible]	54	89	18	105	180	47	412	1.10	1.99	6.85	26.6	0.102	2.09	2.68	0.703	0.120	5.25
	B	0.5-1.0	370.7	87.5	154.9	57.2	55.7	13.8	14	7	456	1	35	24	3	144	116	56	22	57	88	18	113	153	45	445	0.88	2.04	6.82	26.3	0.107	2.15	2.46	0.739	0.126	5.35
	C	1.0-1.5	687.6	349.8	164.6	91.2	64.7	15.2	11	8	462	2	24	18	3	129	122	71	24	56	84	20	96	200	47	402	1.26	2.00	6.87	26.8	0.101	2.04	2.72	0.662	0.128	5.11
NWzll	A	0.0-0.5	245.3	58	89.8	27.6	47.2	21	14	13	1483	13	180	18	6	296	169	104	48	150	339	20	75	489	21	113	0.29	2.40	10.83	19.2	0.367	1.24	9.93	0.615	0.188	8.45
	B	0.5-1.0	736.8	140.9	220.7	119.8	190.4	62.2	10	8	619	7	85	10	2	114	71	50	[illegible]	65	151	14	93	223	32	205	0.42	3.82	8.42	24.0	0.155	2.18	9.54	0.452	0.119	3.88
	C	1.0-1.5	830.4	139.7	257.7	173.9	200.4	61.1	7	6	453	3	64	9	-1	100	69	40	15	76	99	12	82	143	23	148	0.50	5.27	7.67	20.7	0.100	2.05	11.34	0.365	0.104	3.38
	D	1.5-2.0	1080.6	155	396.2	232.3	231.1	62.4	7	6	370	4	51	10	1	93	63	37	18	28	83	12	80	135	25	153	0.55	5.51	7.44	21.1	0.086	2.02	11.35	0.349	0.088	3.22
	E	2.0-2.5	535	125.6	119	109.6	143.7	35.7	6	5	354	-1	38	10	1	95	61	34	[illegible]	18	63	11	73	118	26	151	0.57	6.12	7.34	20.6	0.074	1.93	12.07	0.332	0.078	3.01
	F	2.5-3.0	1231.6	387.1	325.3	226.1	246.4	46.7	4	5	330	-1	33	11	2	92	57	31	[illegible]	14	59	12	73	112	25	150	0.58	6.01	7.08	21.1	0.067	1.91	11.68	0.319	0.074	2.95
NWurz	A	0.0-0.5	514.4	69.3	136	126.8	121.4	34.1	5	6	[illegible]	-1	54	10	1	88	64	38	16	27	78	11	72	119	27	147	0.47	5.91	6.78	18.5	0.098	1.76	12.41	0.325	0.115	3.07
	B	0.5-1.0	1079.8	132.2	356.1	231.1	298.2	67	5	6	373	[illegible]	39	8	1	94	65	35	20	21	73	16	86	113	25	152	0.59	5.73	7.93	22.1	0.078	2.18	10.33	0.369	0.097	3.34
	C	1.0-1.5	1153.4	227.9	406.5	232.9	217	63.4	7	4	357	6	41	12	-1	96	67	33	18	13	77	14	88	107	24	136	0.59	5.75	8.00	23.0	0.078	2.28	9.88	0.366	0.090	3.42
	D	1.5-2.0	1359.3	368.1	702.9	123.6	118.1	42.8	5	5	366	-1	34	9	1	89	56	28	12	9	58	13	75	104	23	128	0.59	6.23	7.26	20.7	0.061	1.99	11.83	0.306	0.070	2.84
NI	A	0.0-0.5	701	437	175.9	38.5	31.5	16.5	9	6	375	-1	74	12	1	85	79	43	13	54	92	13	75	192	33	240	0.50	3.47	6.40	25.4	0.111	1.61	9.65	0.408	0.070	2.88
	B	0.5-1.0	906.4	578.1	208.5	37.8	57.6	20.2	9	6	385	1	48	12	-1	92	81	49	15	70	90	12	80	189	29	202	0.43	3.18	7.16	25.8	[illegible]	1.51	9.83	0.400	0.073	3.18
	C	1.0-1.5	792.2	610.1	130.3	19.3	20.9	9.9	8	6	380	1	56	11	-1	112	94	50	19	55	88	14	95	176	26	169	0.41	3.19	7.71	26.8	0.102	1.75	6.64	0.427	0.076	3.61
	D	1.5-2.0	854.3	581.2	249.1	25.1	18.8	8.5	5	6	356	-1	39	11	-1	97	82	49	16	48	71	12	83	176	27	172	0.39	3.99	7.20	24.4	0.085	1.52	10.35	0.366	0.076	3.35
	E	2.0-2.5	604.5	148.6	155.2	179.8	106.5	11.8	6	6	318	-1	26	9	1	82	66	38	16	28	40	9	62	182	28	191	0.46	4.11	6.19	22.6	0.059	1.20	12.09	0.326	0.044	2.68
	F	2.5-3.0	1847.6	710.2	562.8	361.2	185.7	21.8	6	6	297	1	23	9	1	79	64	45	15	40	44	12	62	183	30	192	0.43	4.59	6.01	21.6	0.060	1.17	12.54	0.307	0.049	2.76
Abad	A	0.0-0.5	414.8	154.7	137.8	[illegible]	49.8	25	9	4	445	3	23	12	-1	85	71	34	13	29	51	10	79	136	34	258	0.79	2.38	5.41	26.3	0.136	1.62	7.65	0.424	0.074	2.63
	B	0.5-1.0	[illegible]	384.8	165	[illegible]	48	44.6	10	3	410	2	24	14	0	96	79	35	17	20	49	14	85	129	30	221	0.66	2.42	6.11	25.8	0.092	1.66	7.50	0.446	0.080	3.03
	C	1.0-1.5	751.6	484.3	137.5	29	39.8	58.5	10	3	457	3	22	10	1	94	78	37	15	9	47	14	90	124	26	188	0.60	2.41	6.50	25.7	0.074	1.77	7.43	0.432	0.078	3.24
	D	1.5-2.0	1151.3	842.9	161	33	43.3	66	9	2	434	-1	23	11	1	100	82	36	17	9	46	14	93	116	24	174	0.56	2.37	6.64	25.4	0.079	1.81	7.32	0.436	0.085	3.50
	E	2.0-2.5	945.5	698.2	114.6	24.7	52.4	51.9	13	4	421	1	23	11	1	100	80	37	16	12	48	15	91	125	28	234	0.58	2.23	6.46	25.9	0.088	1.73	6.96	0.485	0.089	3.31
	F	2.5-3.0	388.3	290.3	45.6	10.2	21.4	17.2	12	4	418	6	27	13	1	100	85	45	19	22	56	14	95	138	32	230	0.56	2.29	6.55	25.6	0.090	1.76	7.21	0.479	0.086	3.46
	G	3.0-3.5	947.2	732.1	109.2	22.6	44.1	36.4	13	2	396	-1	22	15	1	100	82	38	17	16	36	14	97	131	28	191	0.59	2.05	8.43	29.5	0.073	2.11	6.85	0.553	0.088	3.90
	H	3.5-4.0	1007.5	643.4	183.5	39.6	62.6	74.1	11	3	381	-1	20	13	2	97	94	56	18	14	51	12	90	128	28	191	0.63	2.40	8.17	29.4	0.076	2.09	7.22	0.557	0.093	3.91
	I	4.0-4.5	1027.2	704.5	177.9	36.7	51.5	53.2	10	2	446	-1	22	11	1	104	81	35	18	6	49	12	96	116	22	150	0.63	2.10	8.35	29.4	0.082	2.18	6.84	0.539	0.093	3.96
	J	4.5-5.0	871	628.4	142.9	31.1	44.7	21.3	10	3	423	-1	22	12	1	114	94	49	20	14	58	15	109	115	23	176	0.54	2.19	7.22	25.9	0.111	2.07	5.62	0.468	0.089	3.89

Fig.1. **Wegs Overbank sediment profile location map, Austria**



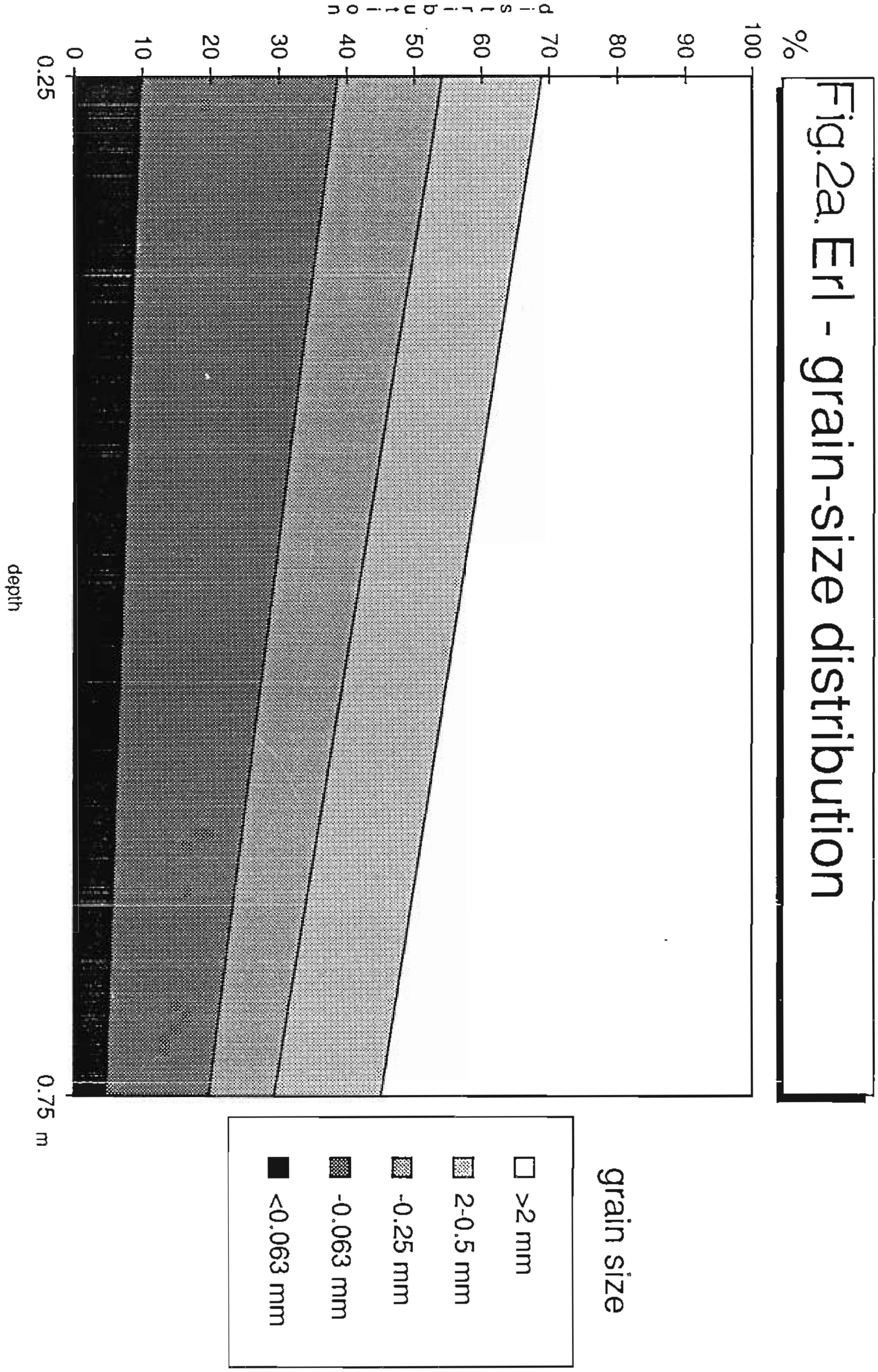


Fig.2a. Erl - grain-size distribution

Fig.2b. Erl - chemical data - XRF analysis

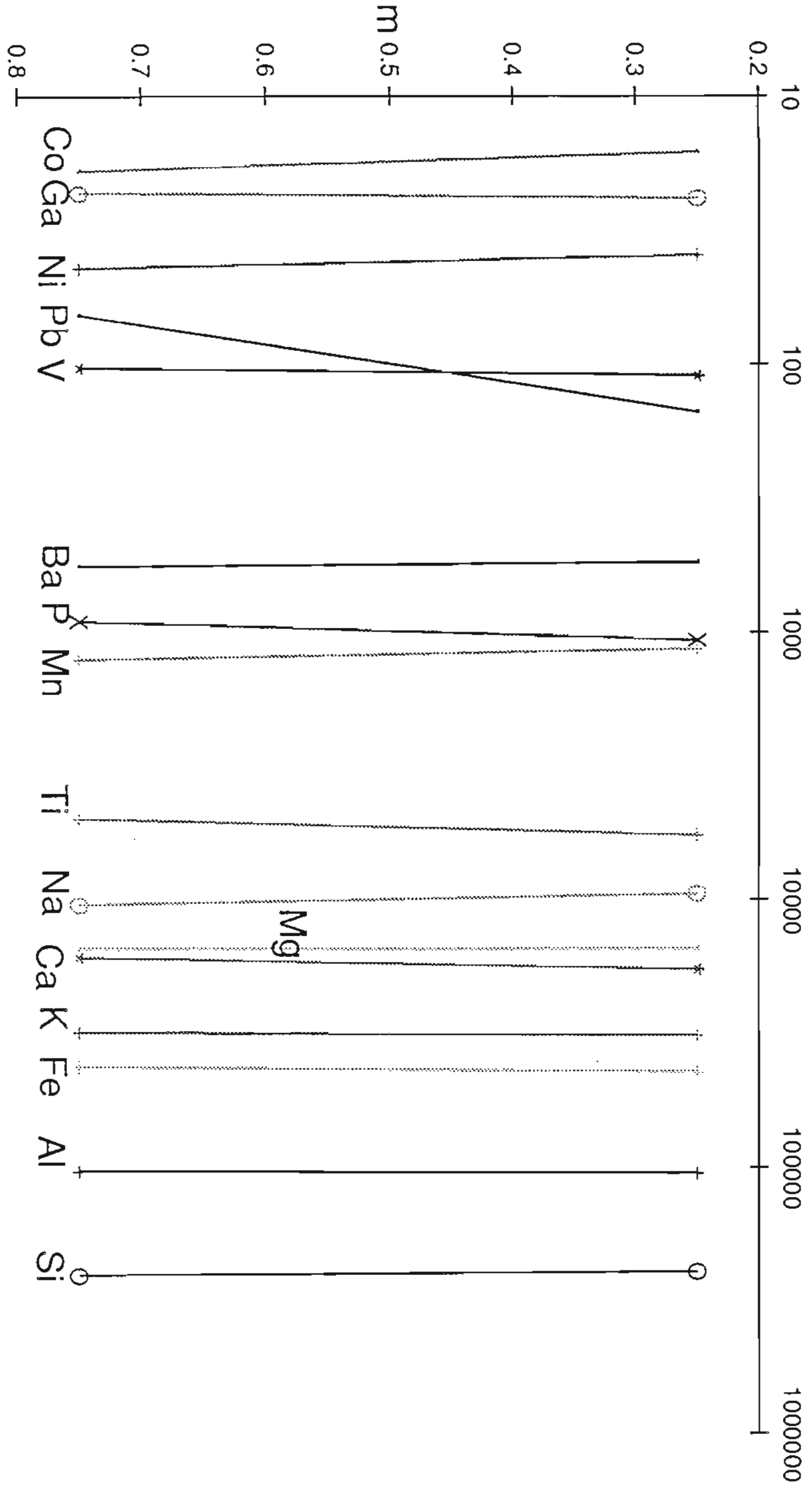


Fig.2c. Erl - chemical data - XRF analysis

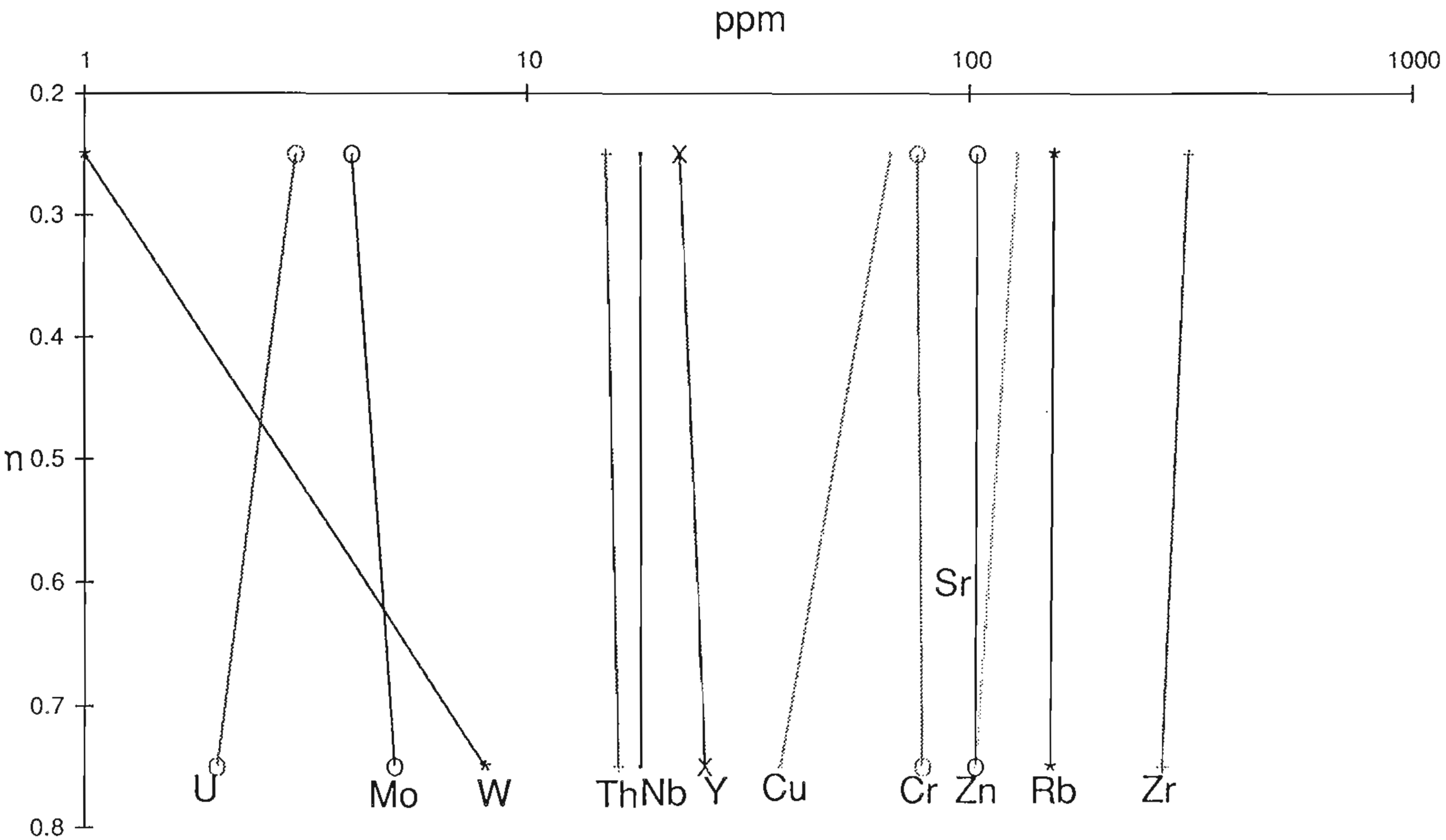


Fig.3a. Hof - grain-size distribution

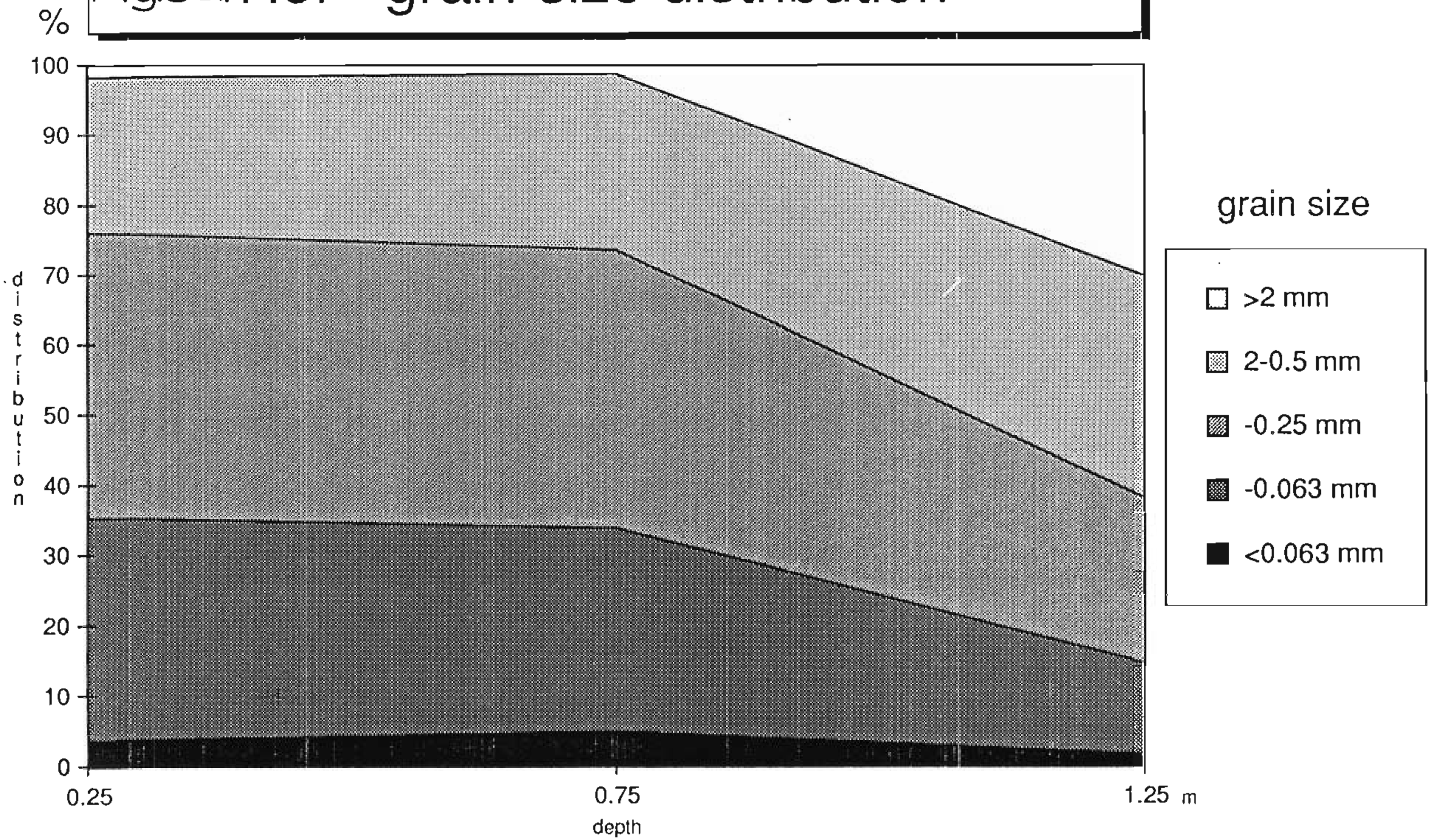


Fig.3b. Hof - chemical data - XRF analysis

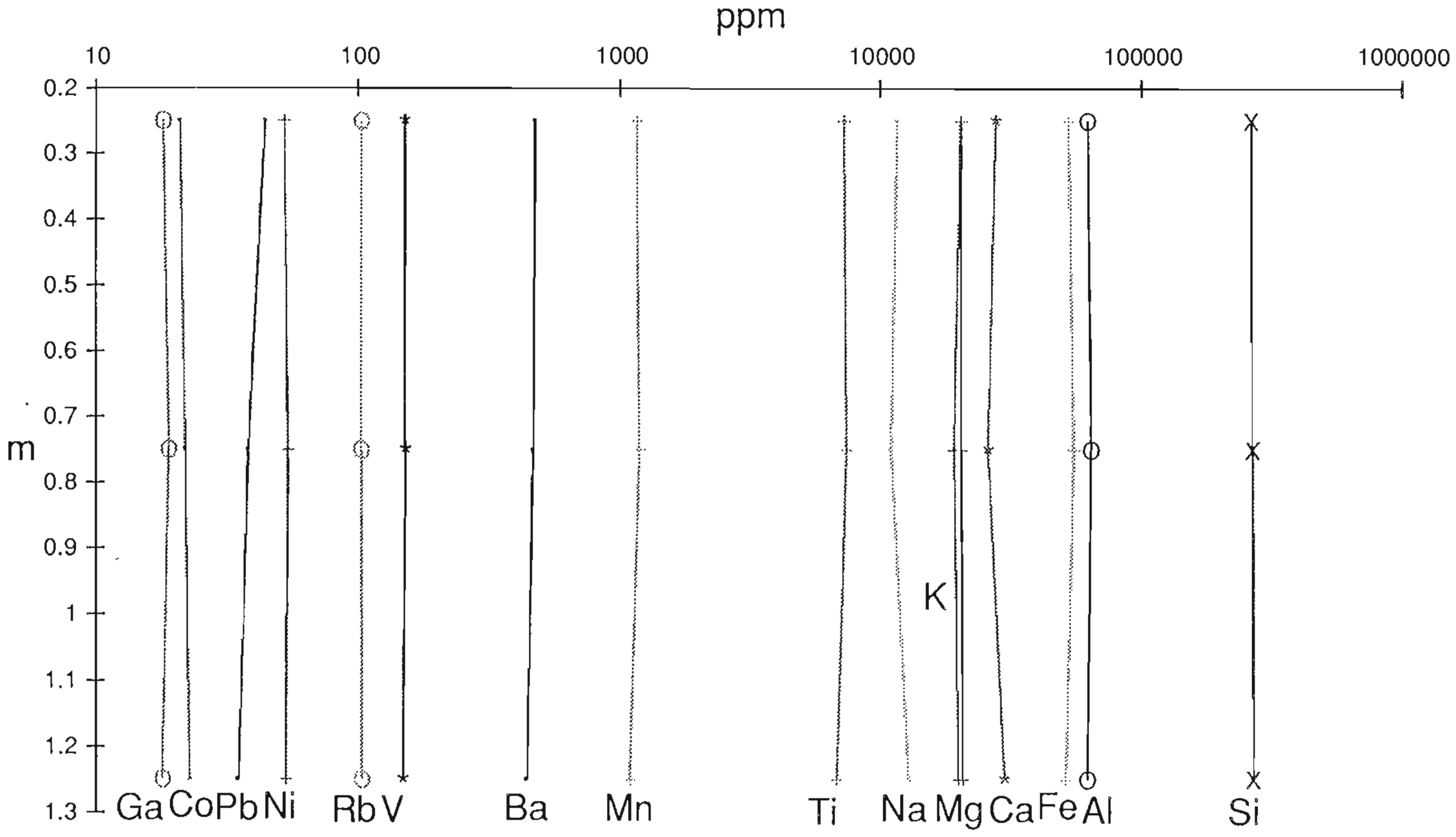
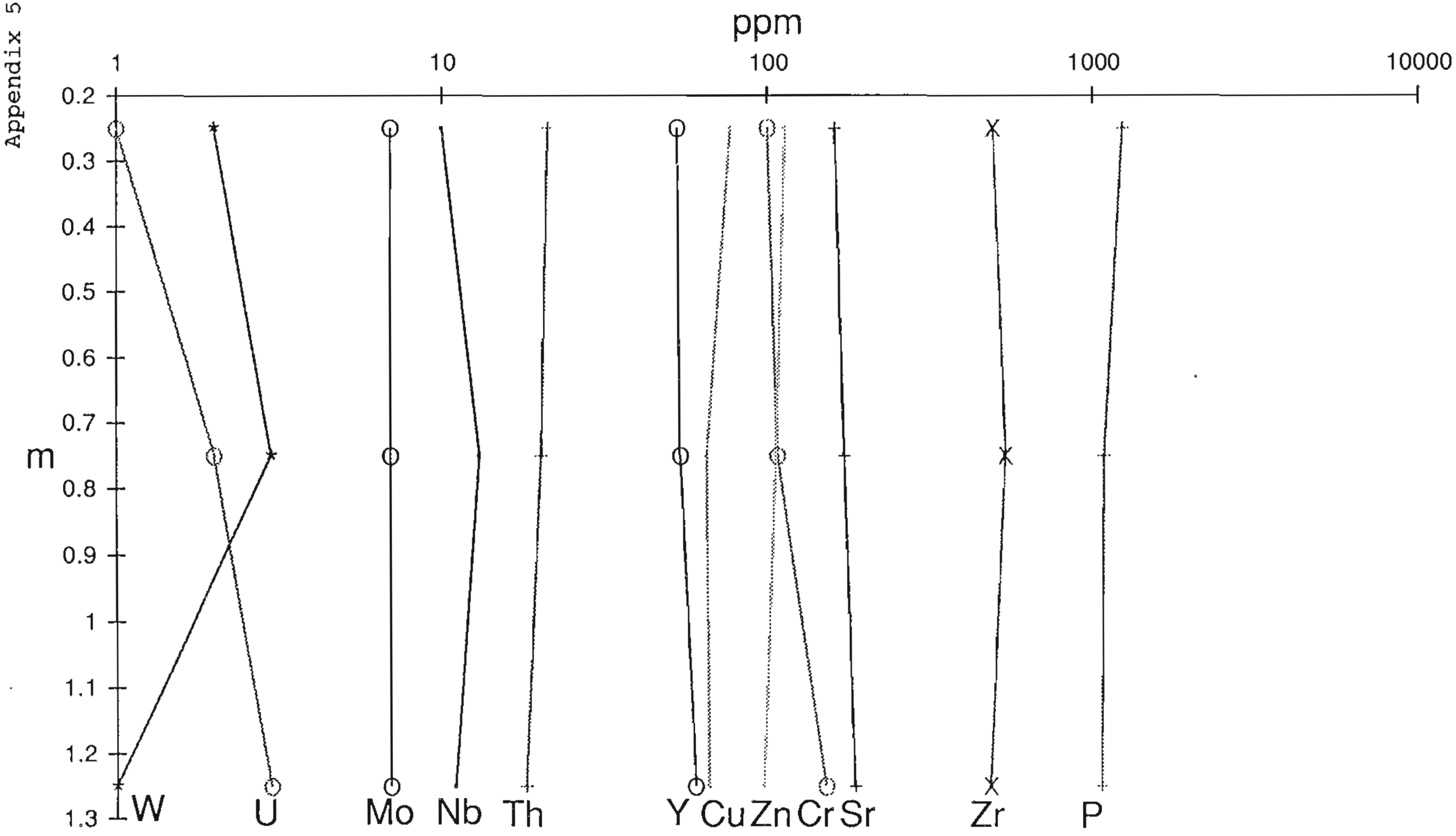


Fig.3c. Hof - chemical data - XRF analysis



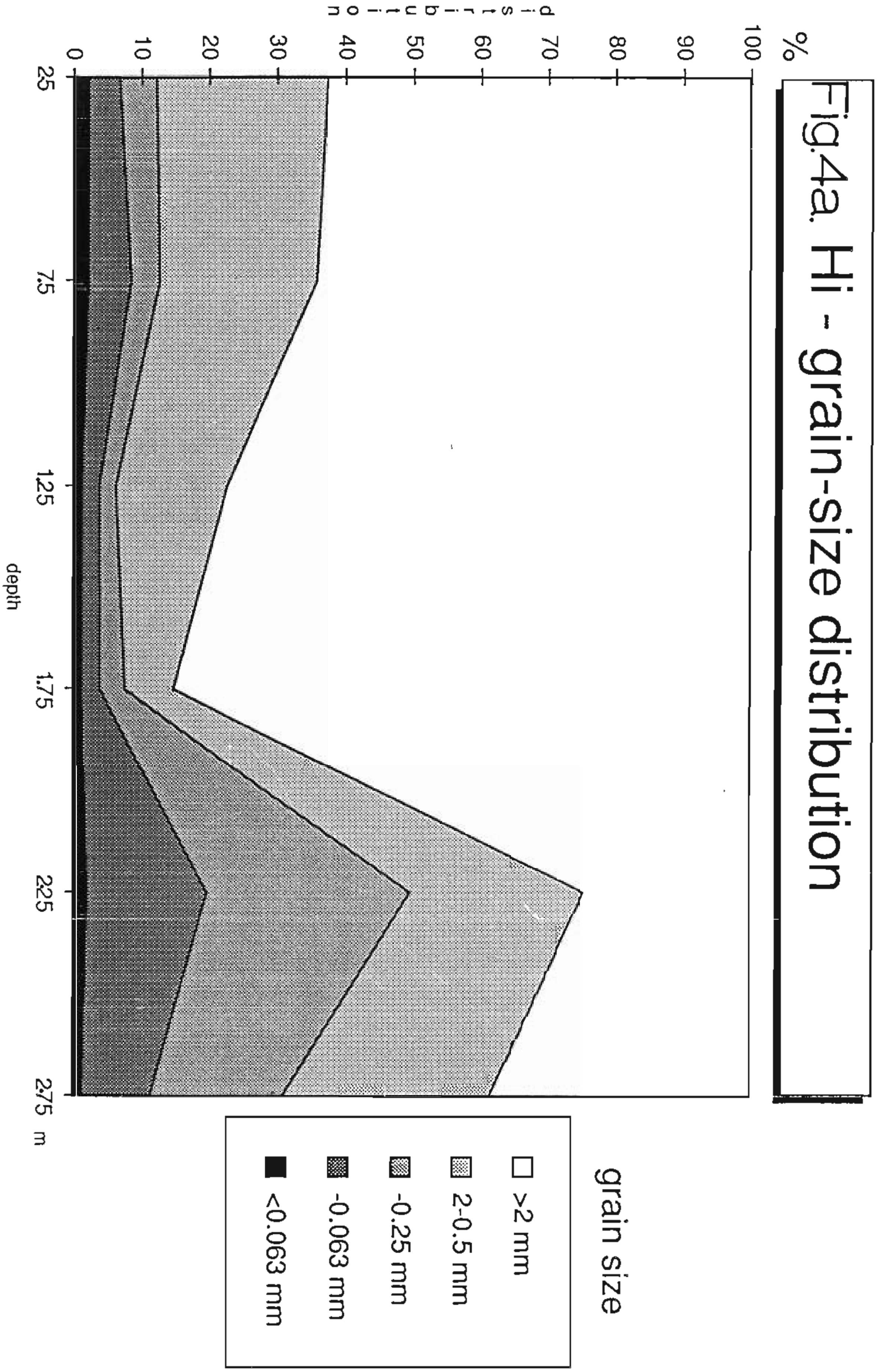


Fig.4a. Hi - grain-size distribution

Fig.4b. Hi - chemical data - XRF analysis

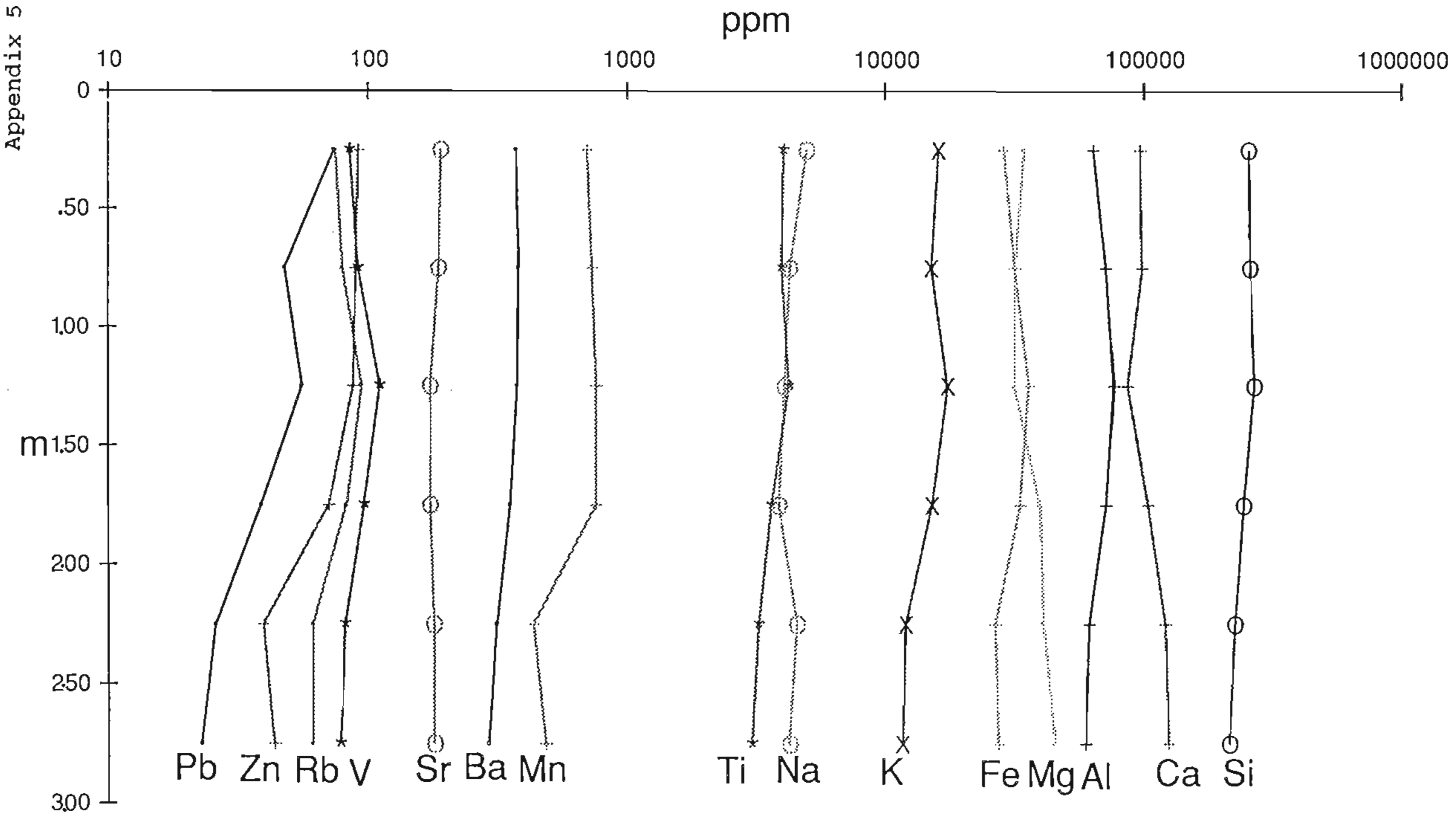
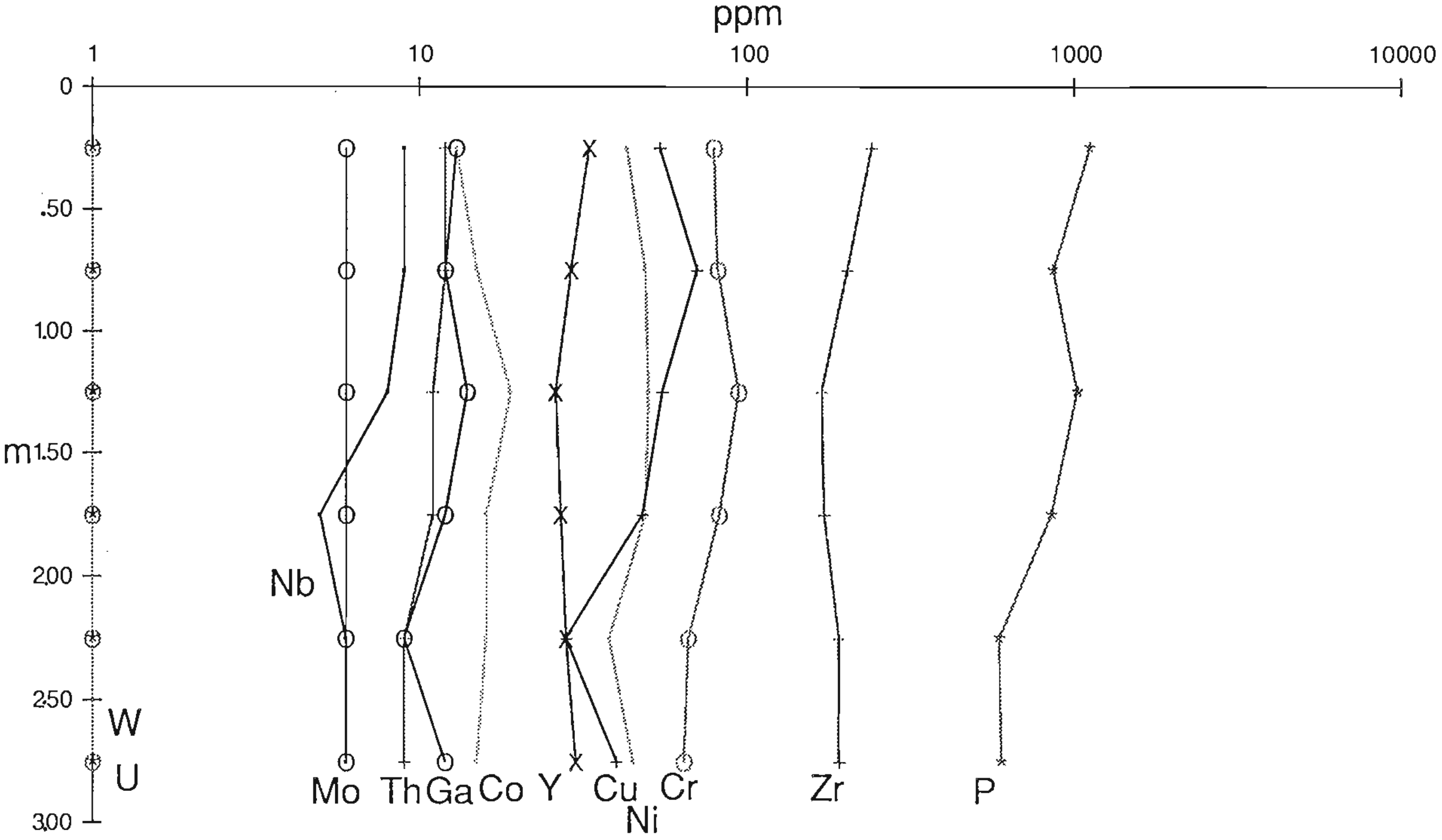


Fig.4c. Hi - chemical data - XRF analysis



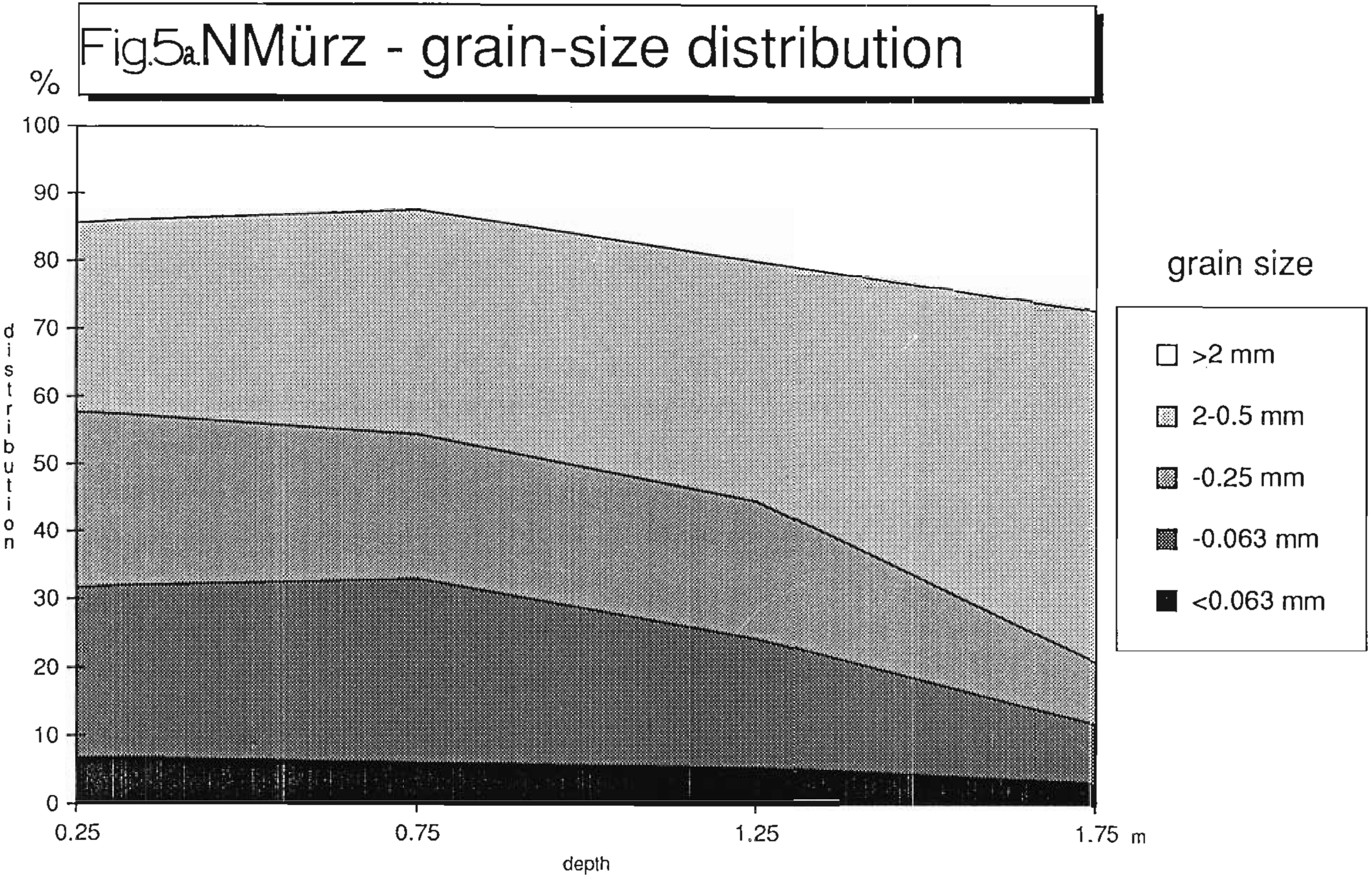


Fig.5a NMürz - grain-size distribution

Fig.5b.NMürz - chemical data - XRF analysis

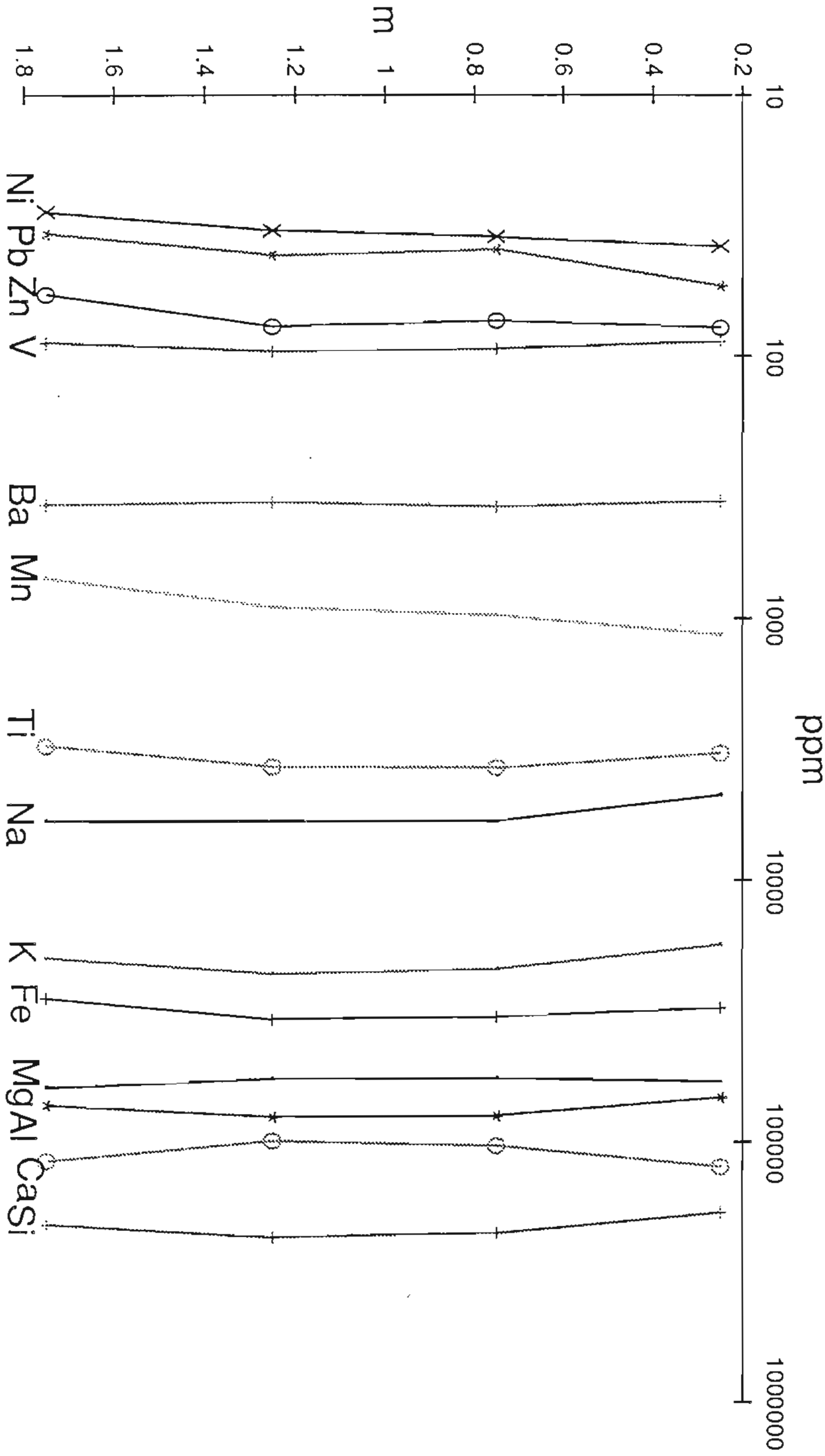


Fig.5c.NMürz - chemical data - XRF analysis

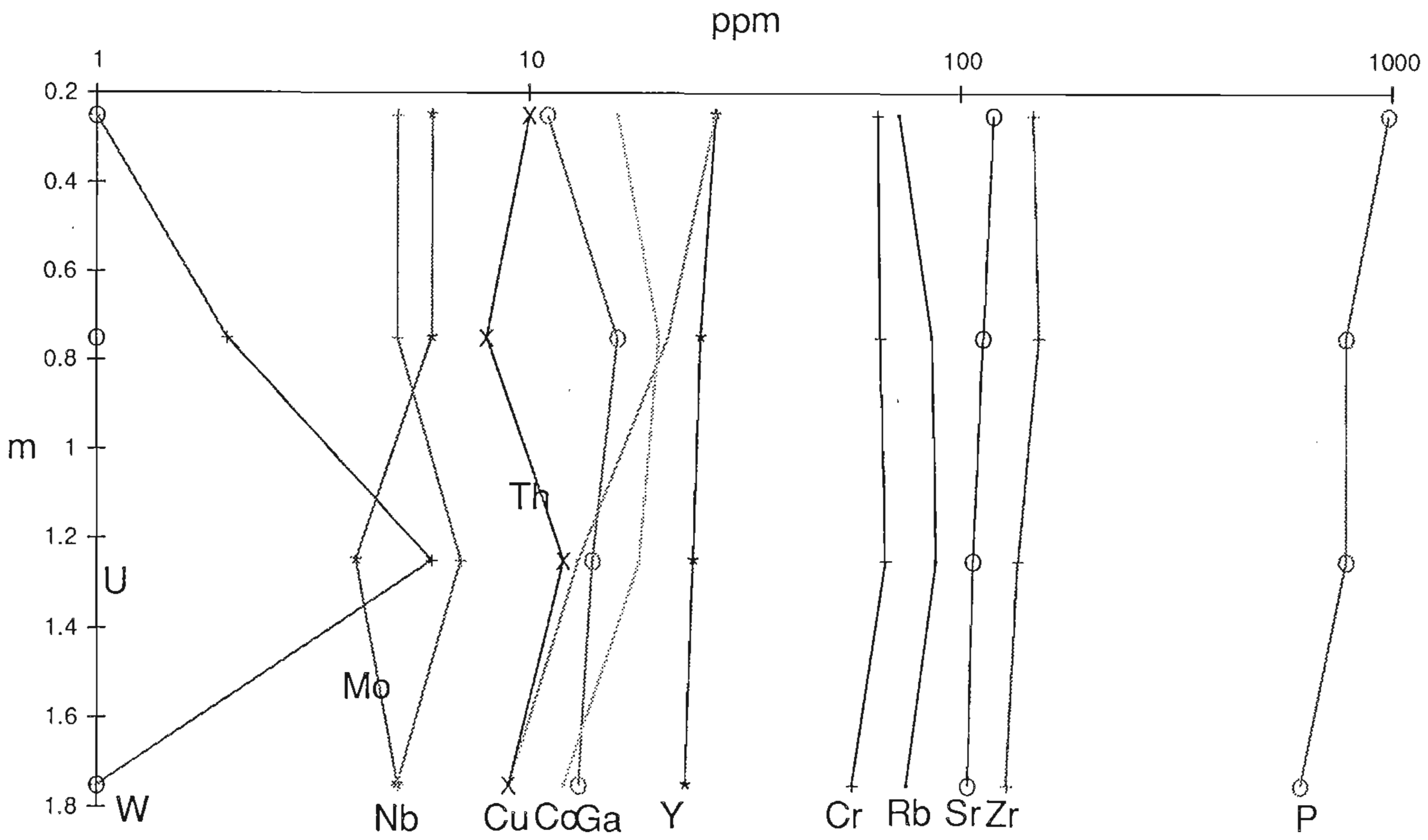


Fig6a.NMzII - grain-size distribution

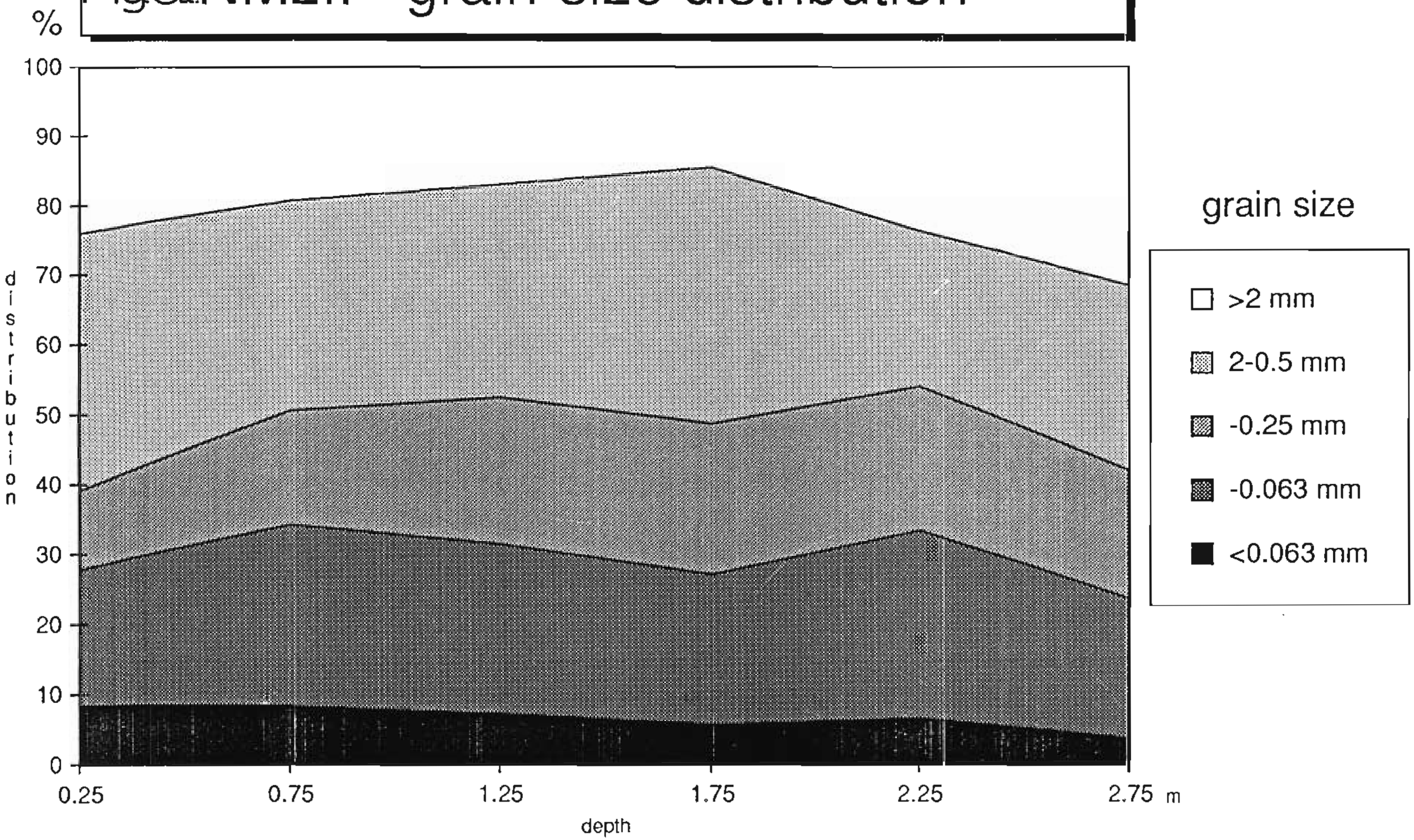


Fig.6b. NMzII - chemical data - XRF analysis

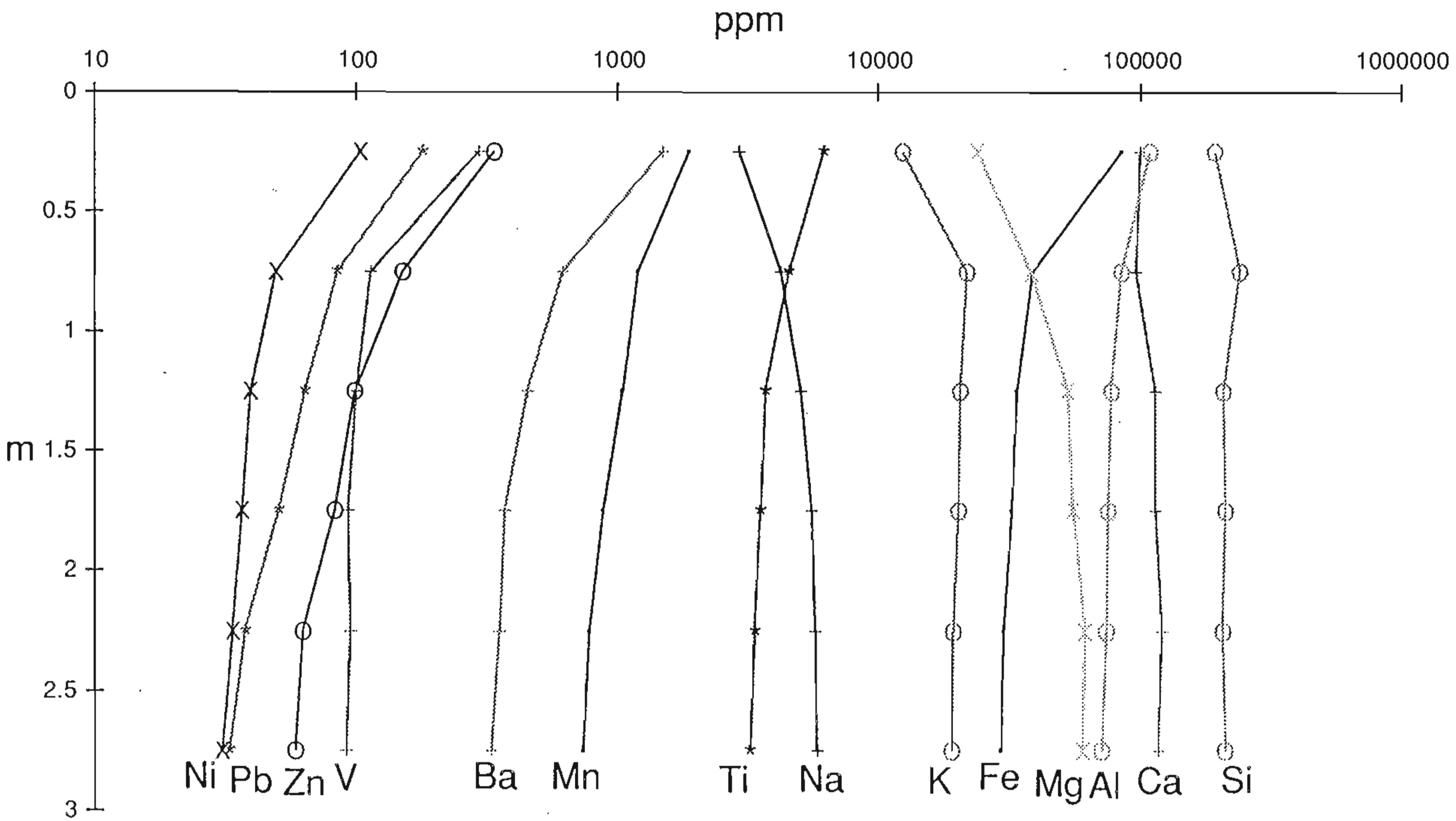


Fig.6c. NMzII - chemical data - XRF analysis

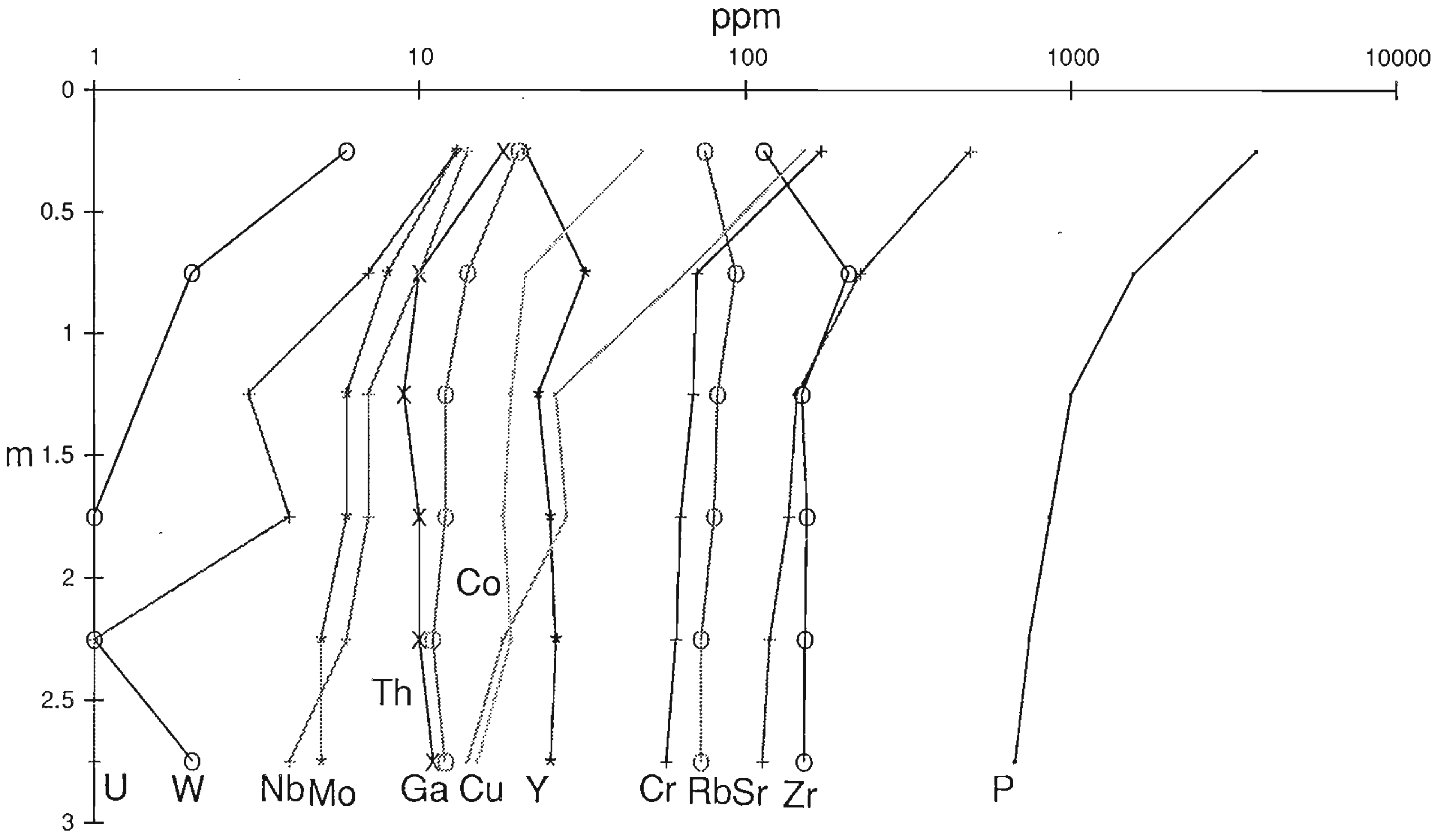


Fig.7a.Spitz - grain-size distribution

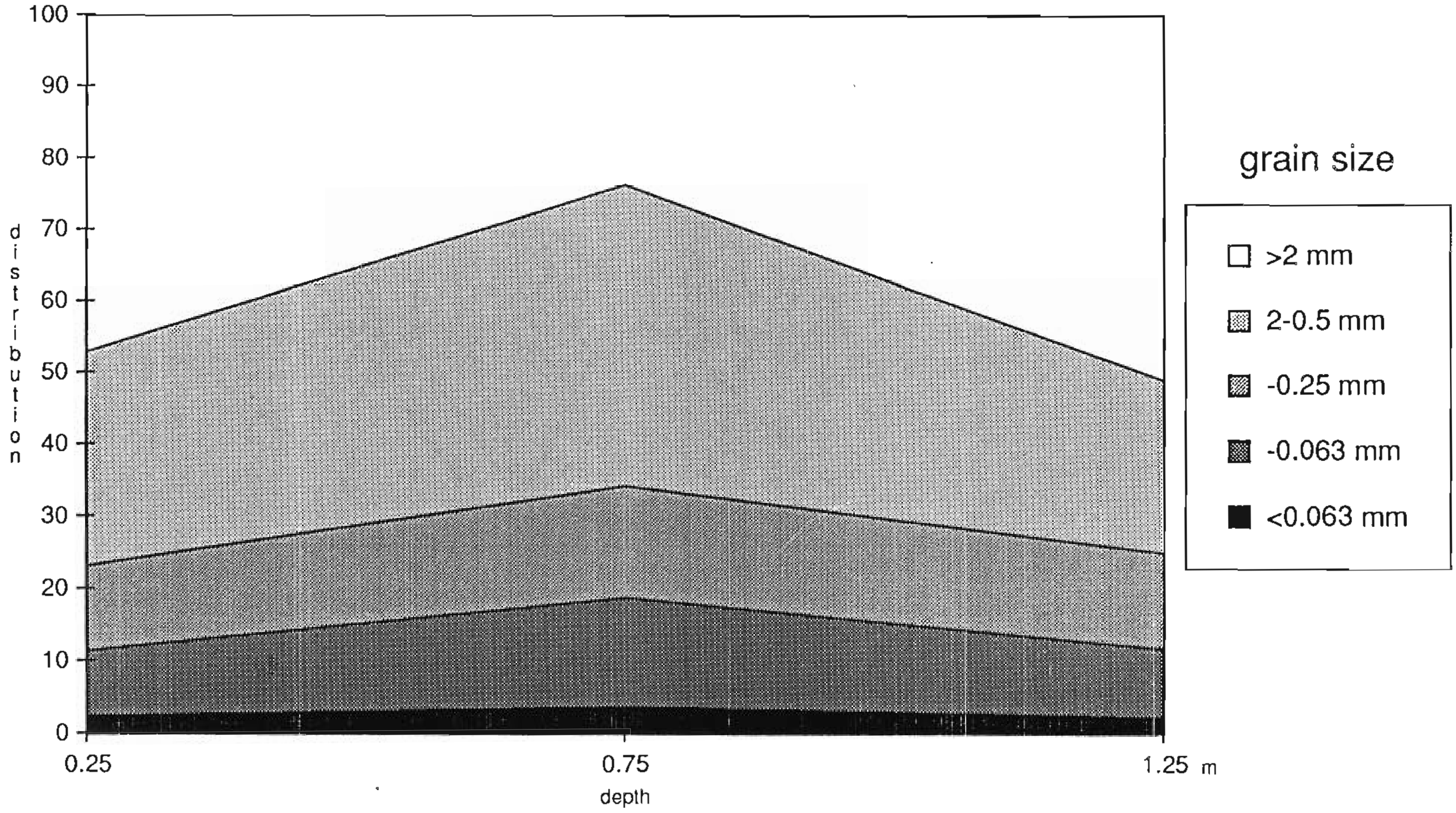


Fig.7b. Spitz - chemical data - XRF analysis

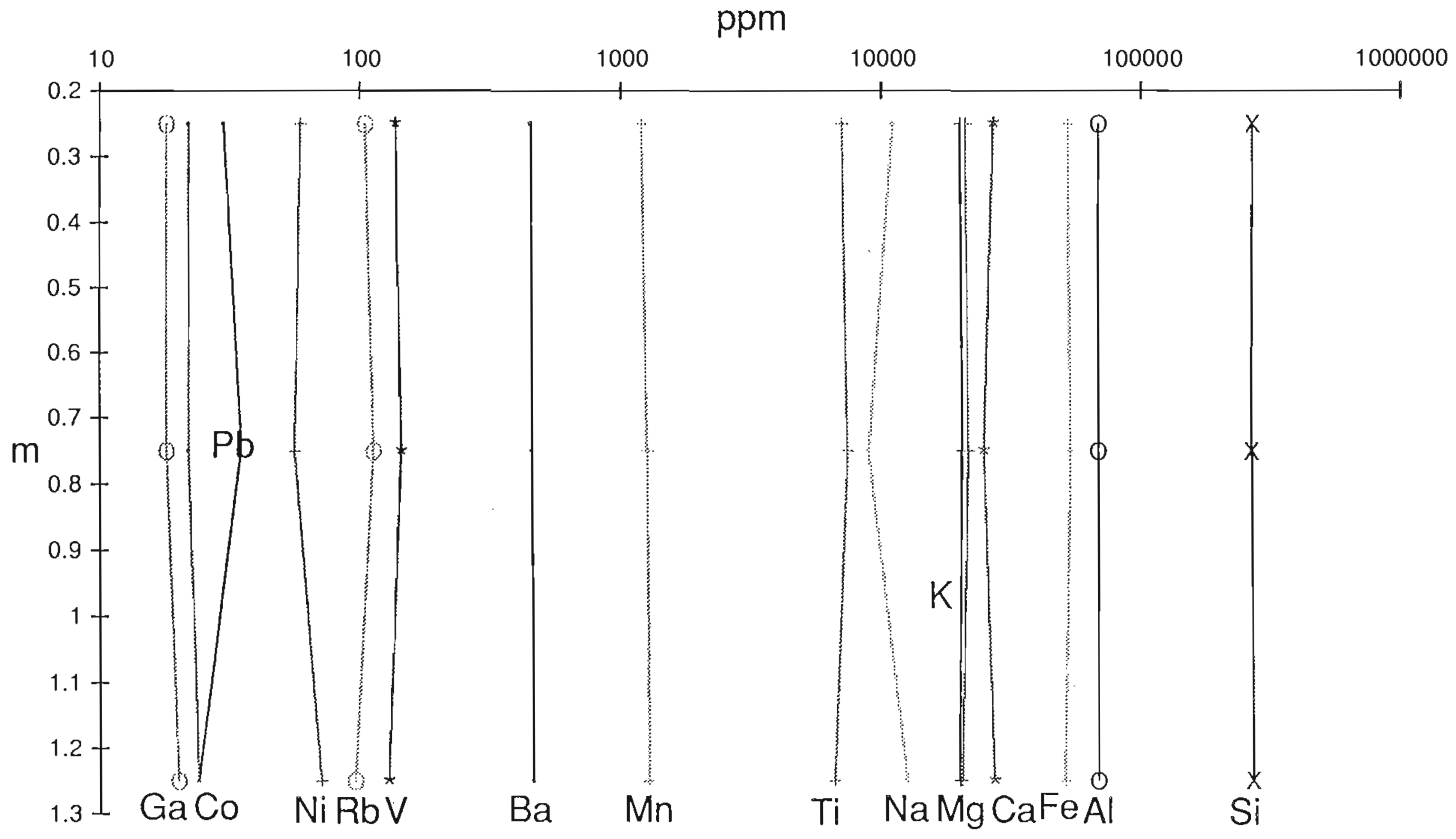


Fig. 7c. Spitz - chemical data - XRF analysis

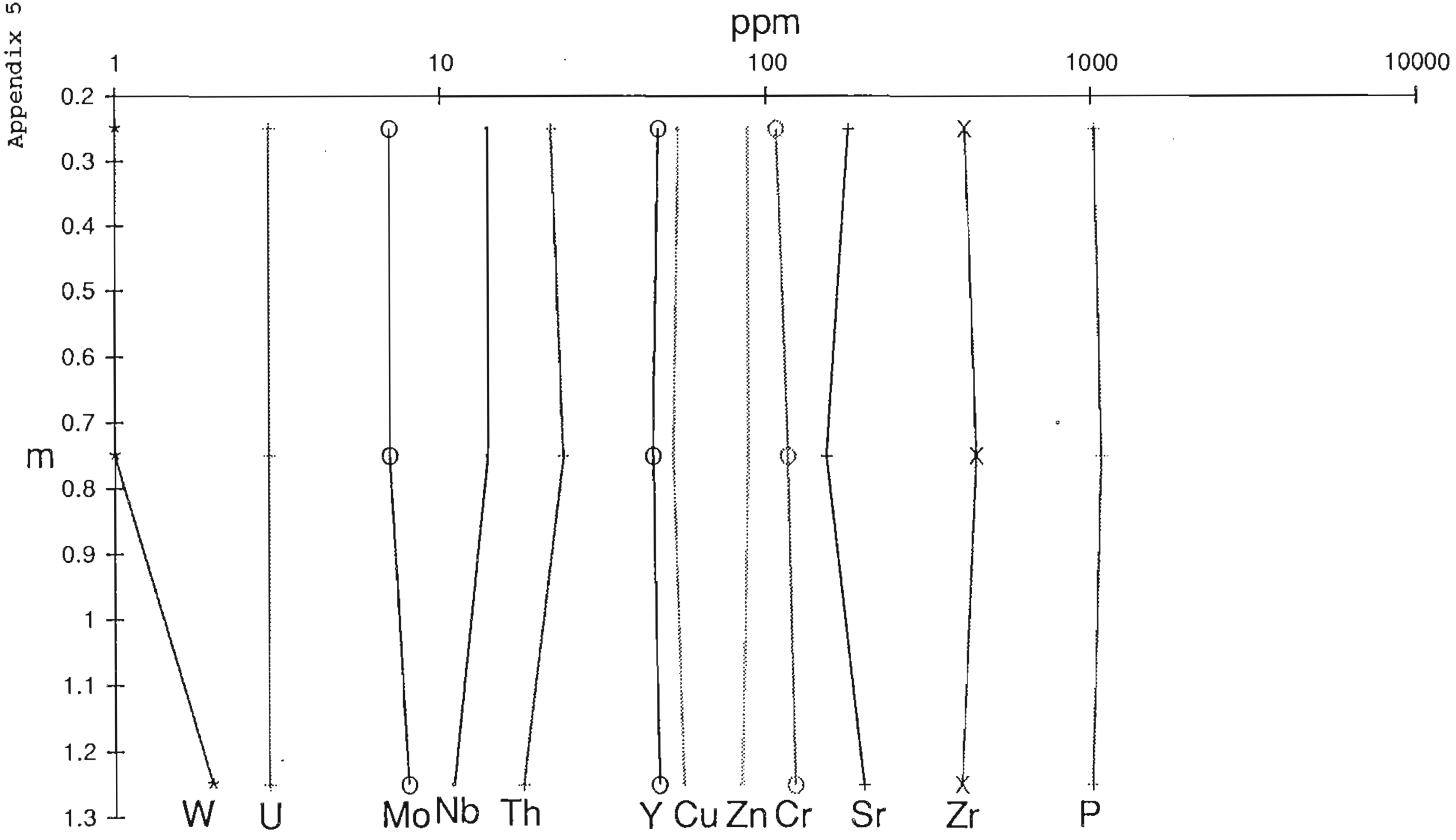
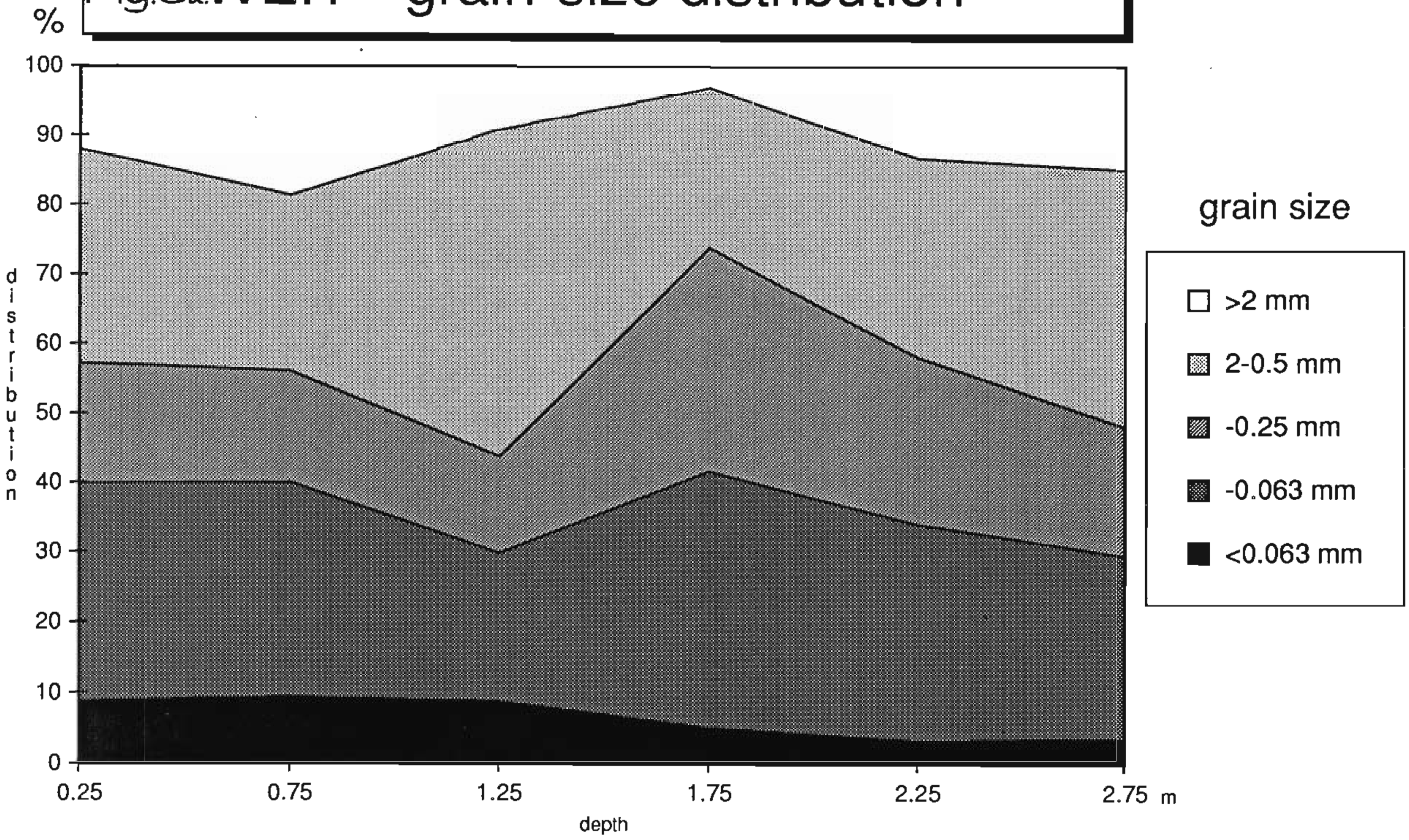


Fig.8a.WEIT - grain-size distribution



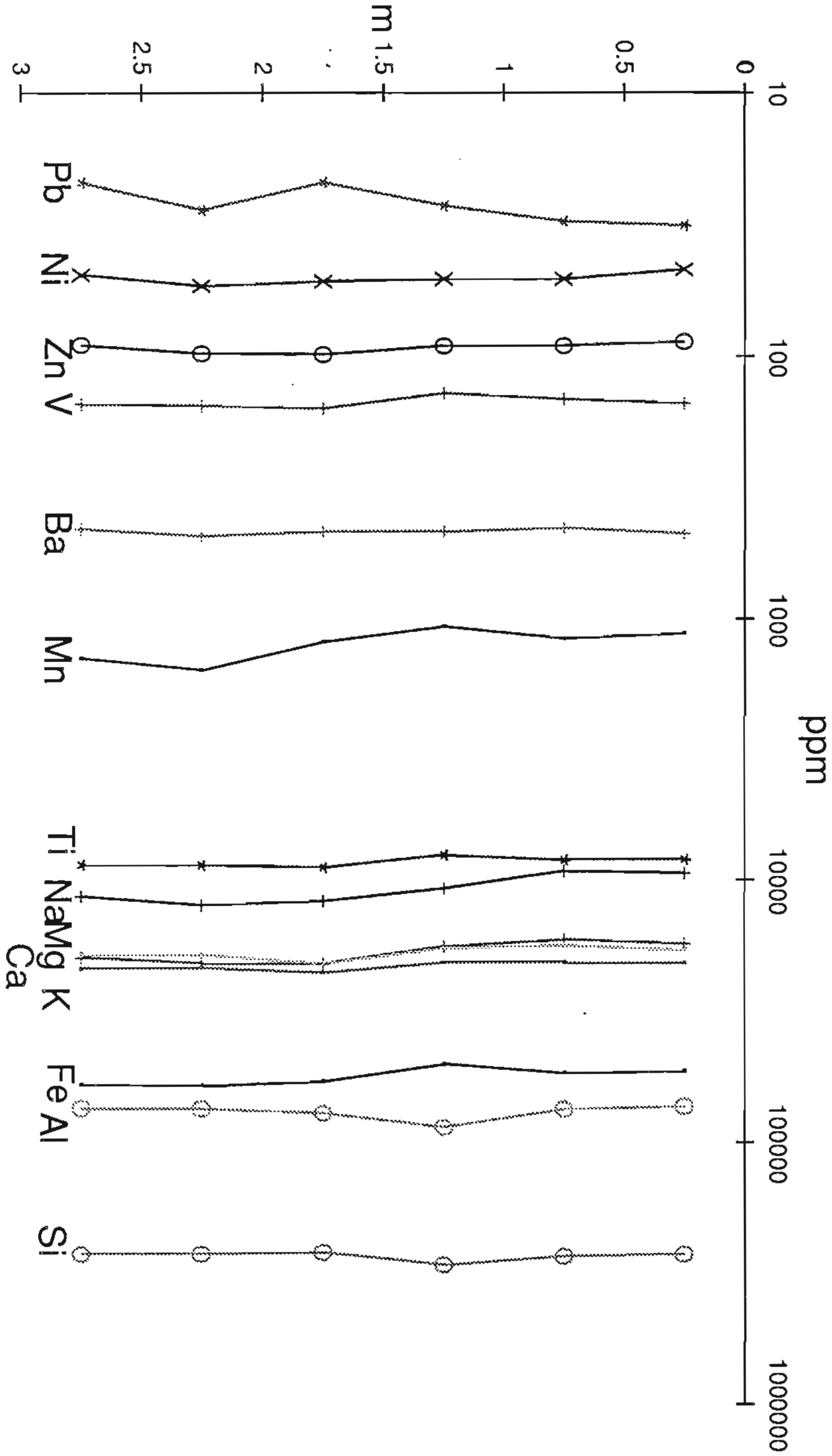
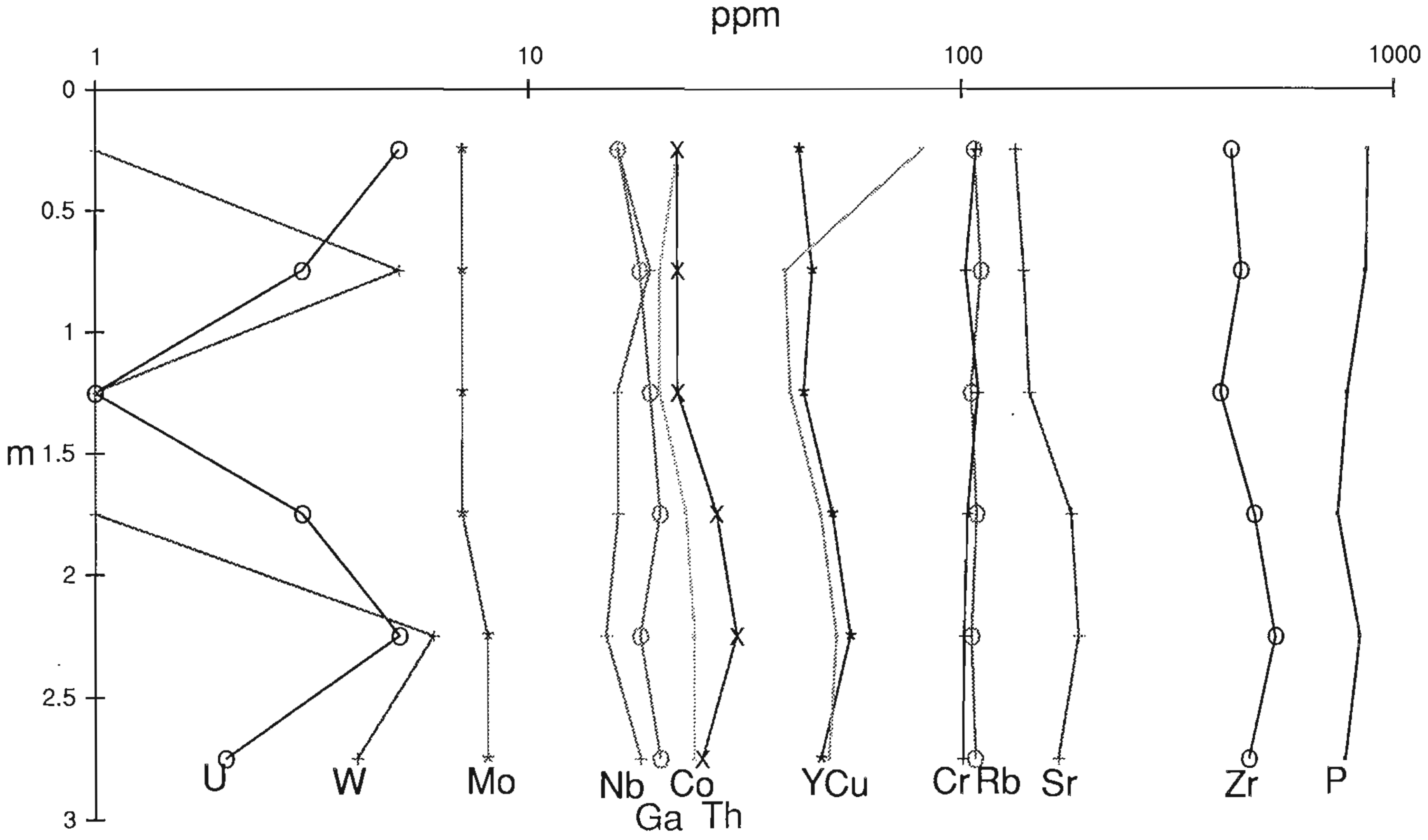


Fig.8b. WEIT - chemical data - XRF analysis

Fig.8c. WEIT - chemical data - XRF analysis



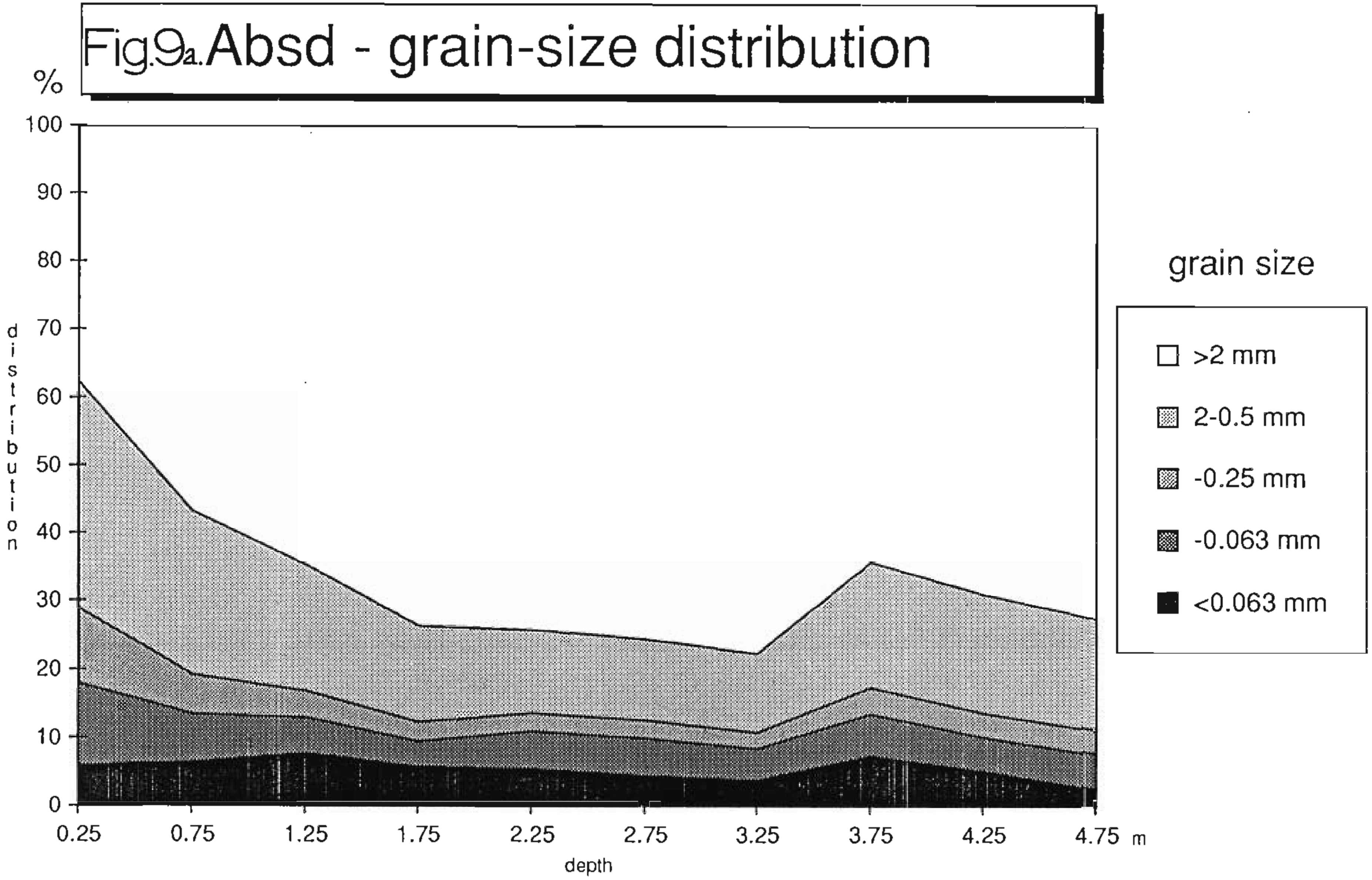


Fig.9a. Absd - grain-size distribution

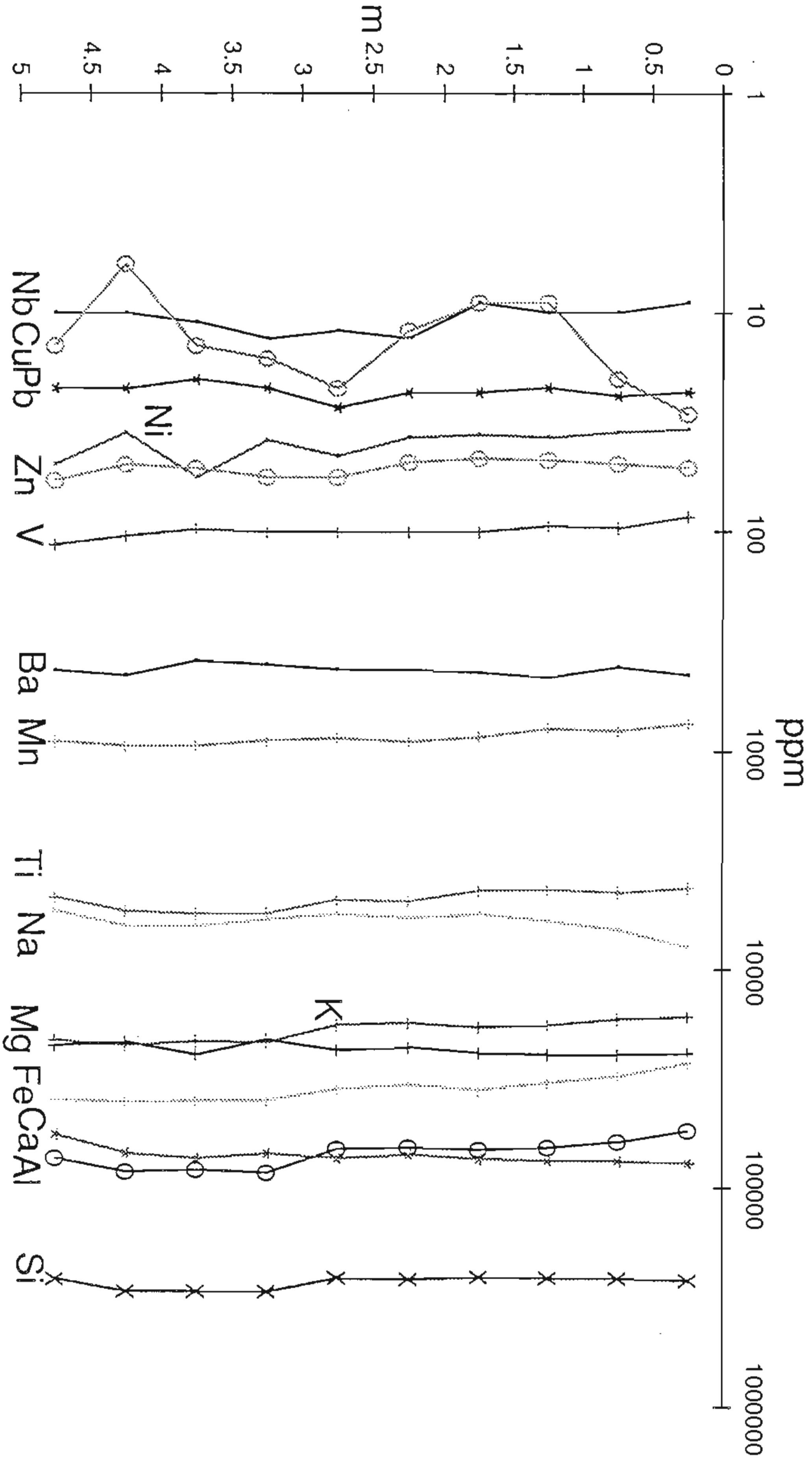
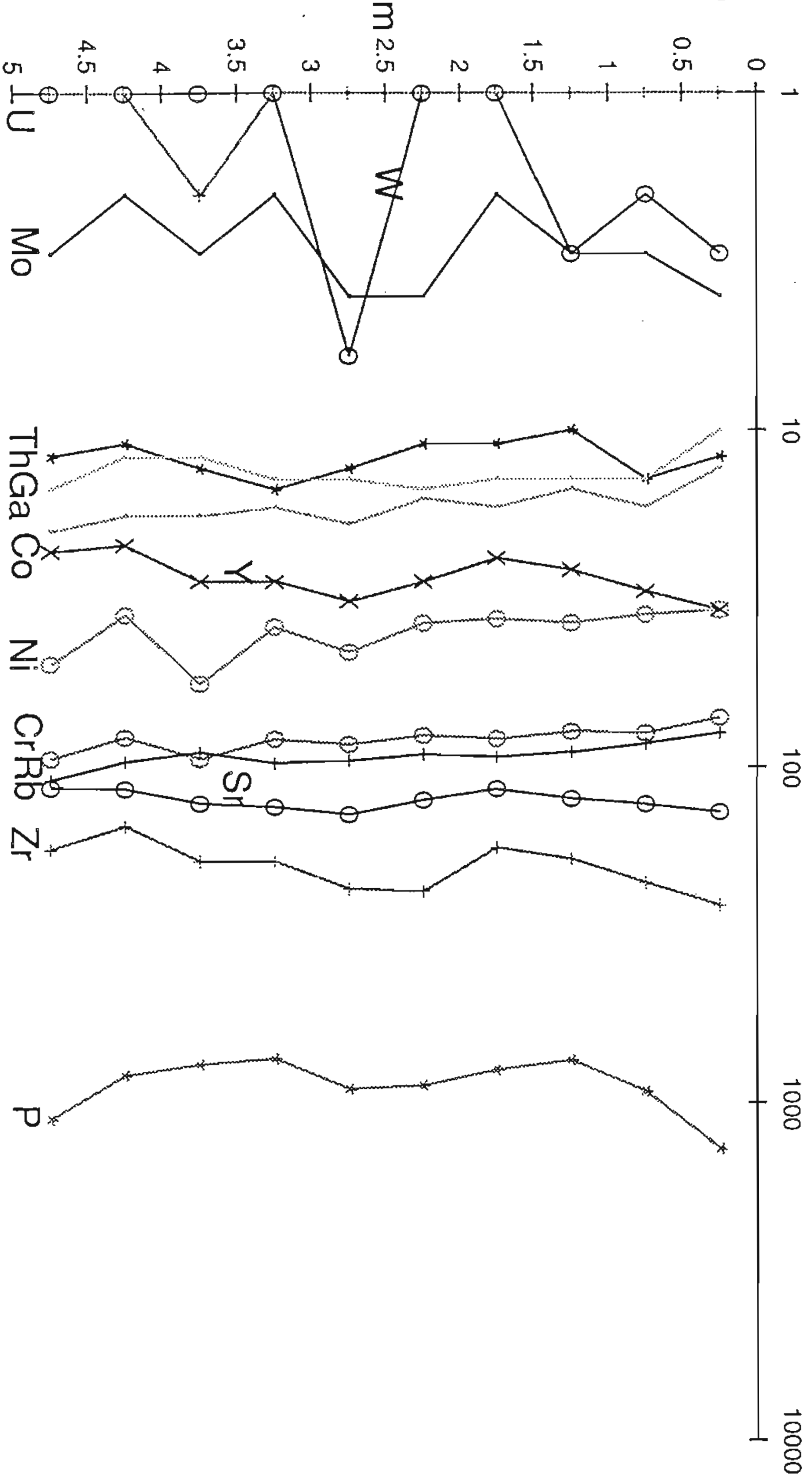


Fig. 9b. Absd - chemical data - XRF analysis

Fig. 9c. Absd - chemical data - XRF analysis



WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 5.2

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT PROFILES, F.R. GERMANY

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F.R. Germany

1990

CONTENTS

FIGURES

TABLES

1.0. INTRODUCTION

In the course of a soil research project about fifty overbank sediment profiles were investigated in various parts of the Federal Republic of Germany. The objectives of the project were to study (a) the vertical variation of a number of elements in the overbank sediments, (b) the depth of anthropogenic pollution, and (c) the effectiveness of overbank sediments in low density sampling surveys. The sample sites are shown in Fig. 1.

2.0. SAMPLING

At each location a pit (80 - 200 cm deep) was dug. The description of the overbank sediment profile was done according to the guidelines given for pedological mapping (Bodenkundliche Kartieranleitung, published in 1982 by the Federal Institute of Geosciences and Natural Resources in cooperation with the Geological Surveys of the Federal German States). Special emphasis was placed on the soil horizon classification as well as the organic matter status and particle-size class.

In each pit all the horizons described were sampled individually. When an apparently homogeneous soil horizon was more than thirty centimetres thick, then it was divided equally, and samples were taken from each sub-horizon (thickness 10 - 20 cm).

In forest areas samples were also taken from the litter layers (L) and the organic horizons (e.g., Of, Oh).

3.0. SAMPLE PREPARATION

The samples were dried at 40°C in a drying cabinet for nearly one week. Then the samples were disaggregated in a jaw-crusher and sieved to a <2 mm fraction (fine earth) and >2 mm fraction (gravel and stones) with a 2 mm nylon sieve.

4.0. ANALYSIS

The fine-earth fraction (<2 mm) was dissolved in a mixture of HF (38 -40%) and $HClO_4$ (70%) acid, and analyzed by an atomic absorption spectrophotometer (Instrumentation Laboratory - IL 951 and VIDEO 22) for the following elements: Pb, Cu, Zn, Cd, Ni, Co, Li, Fe and Mn. Mercury was determined by pyrolysis, and As and Sb by determination of their gaseous hydrides by atomic absorption spectrophotometry.

The lower detection limits of the elements determined by atomic absorption spectrophotometry are based on 500 mg sample weight and 25 ml sample solution, and are Pb = 5 ppm, Cu = 3 ppm, Zn = 3 ppm, Cd = 0.3 ppm, Ni = 3 ppm, Co = 3 ppm, Li = 1 ppm, Fe = 1 ppm, Mn = 1 ppm, As = 1 ppm and Sb = 0.3 ppm. The lower detection limit of Hg is 0.01 ppm, and is based on a 200 mg sample weight.

5.0. INTERPRETATION

Table 1 shows the vertical distribution of the elements Pb, Cu, Zn, Cd, Ni, Co, Li, Fe, Mn, Hg, As and Sb in an overbank sediment profile from an oxbow of the River Saar near Dillingen. In this profile there are only minor variations in the element concentrations from layer to layer. There is no recognizable pronounced enrichment of elements in the upper layers. This profile can, therefore, be considered to be typical of uncontaminated areas.

Table 2 shows the vertical distribution of some elements in an overbank sediment profile from the River Weser near Höxter. In this profile a slight increase of Mn and Hg can be recognized in the cultivated A-horizon (Ap). This may be due to minor anthropogenic contamination caused by farming. Apart from this the profile can be considered to be typical of more or less uncontaminated areas.

Table 3 shows an overbank sediment profile from the River Lippe near Dorsten. In this profile a sharp increase in the concentrations of Pb, Cu, Zn, Cd, Ni, Hg and Sb can be recognized in the litter layer (L), the organic horizon (Of), and the uppermost part of the Ah mineral horizon. These high element concentrations are probably caused by emission of heavy metals by industrial plants in the Ruhr District. A sharp increase of Pb, Zn and Hg can also be recognized in the upper 40 cm of the profile (Ap and M horizons) in an overbank sediment profile from the River Rhein near Leverkusen (Table 4). These high element concentrations are probably caused by emissions from the industrial plants of this area. In contrast to the profile shown in Table 3, where the high element concentrations are restricted to the upper 4 cm of the mineral horizon, the profile in Table 4 displays high element concentrations down to a depth of 40 cm. This results from intensive intermixing due to ploughing.

Table 5 shows the element distribution in an overbank sediment profile which is strongly influenced by former mining activity. This profile was taken from the bank of the River Innerste, which rises near Clausthal-Zellerfeld in the Harz Mountains. In the upper course of this river, between Clausthal-Zellerfeld and Lautenthal, there are several lead-zinc deposits which have been mined from the 15th up to the 20th century. In

Table 5 one can recognize a stepwise increase in the concentrations of the elements Pb, Cu, Zn, Cd, Hg, As and Sb from the lowest layer (IIGo) up to the top layer of the mineral horizons (Ah). There are some sharp rises (e.g., between samples 591126 and 591127 as well as between 591122 and 591123), which can be interpreted as the start of intensified mining activity. The relatively low element concentrations in layer IIGo (100-120 cm) of this profile are probably representative of the pristine (pre-mining) status of the overbank sediment in this area. The present day stream sediment of the River Innerste is strongly contaminated due to mining in the Harz Mountains. A stream sediment sample taken in the vicinity of the overbank sediment profile, showed lead values up to 8000 ppm.

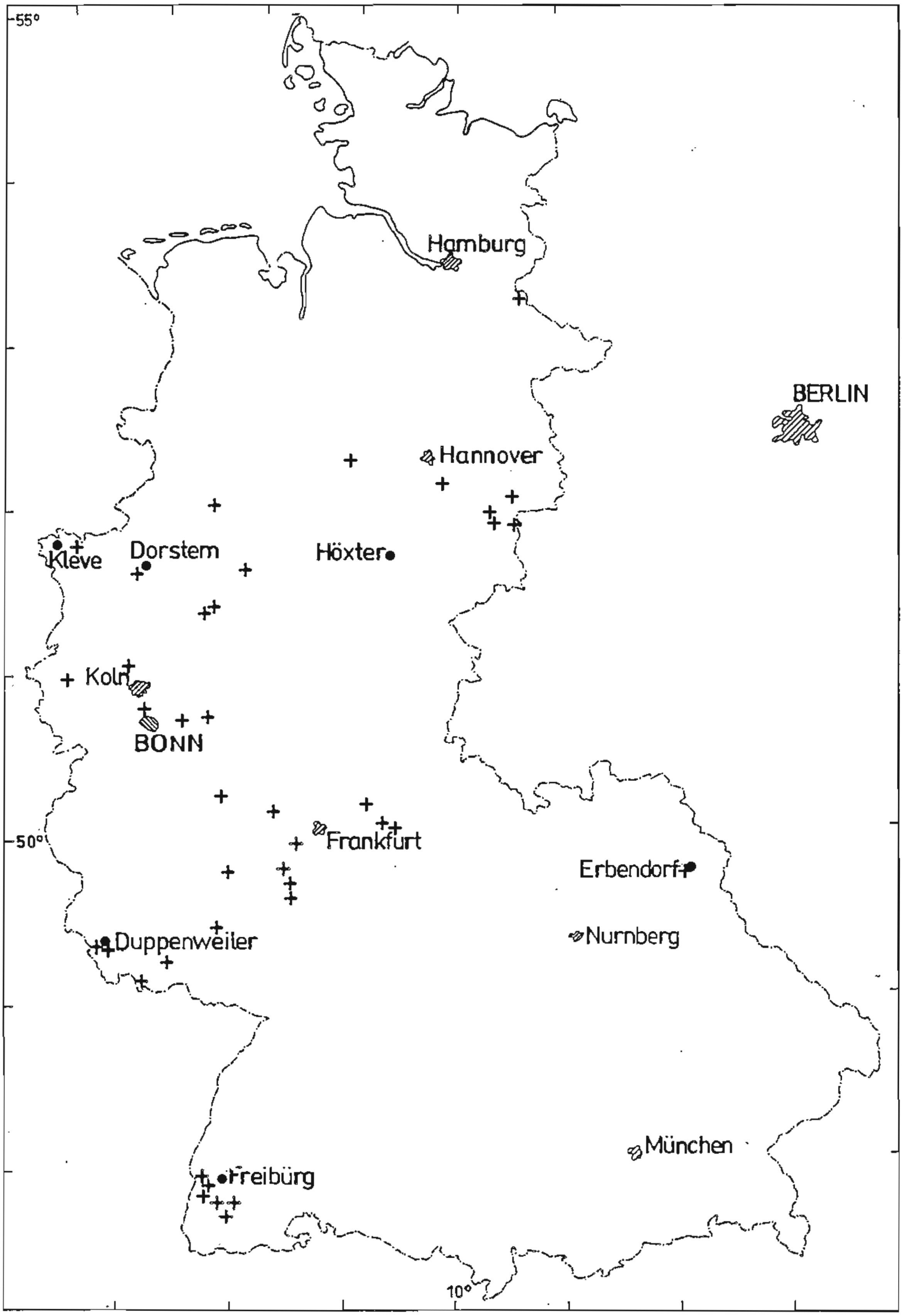
In Table 6 the element distribution is shown in an overbank sediment profile taken near Bieber (Spessart). In this area the Kupferschiefer (copper shale) of the Zechstein Formation crops out and vein-type cobalt mineralization (kobaltrucken) occurs. The Kupferschiefer was mined first. In addition to copper the Kupferschiefer also has high concentrations of lead and zinc. In the 19th century mining of the Kupferschiefer was no longer economic; however, there was much for cobalt. Therefore, mining of the vein-type cobalt mineralization (Kobaltrucken) started up. In Table 6 it can be seen that in the lower layers (55 - 125 cm) of the overbank sediment profile there are high concentrations of Pb, Cu, Zn, Cd, Hg, As and Sb. These high element concentrations are caused by former Kupferschifer mining. At 55 cm in the profile there is a sharp break. Above this the concentrations of Pb, Cu, Zn, Cd, Hg, As and Sb are lower than in the layers below. In contrast, we recognize an increase of the cobalt concentrations in the upper layers of the profile, which is due to the starting of cobalt mining in the 19th century. This demonstrates that the mining history of the Bieber area can be clearly reconstructed with the help of the investigation of overbank sediments. By taking overbank sediment samples from a greater depth (deeper that 125 cm) it might be possible to determine the pristine (pre-mining) element concentrations.

Tables 7, 8 and 9 show additional overbank sediment profiles from the river Innerste. The contamination is recognizable in the profiles.

6.0. CONCLUSION

In conclusion it may be said that, even in heavily contaminated areas, in most cases overbank sediment samples taken at a certain depth in a profile, will reflect the pristine (pre-mining or pre-industrial) status of the area.

Fig. 1: Location of overbank sediment profiles W. Germany



Tab.1: Element distribution in an overbank sediment profile (concentration in ppm, Hg in ppb)

	TK	oT	uT	Hori	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
593875	6606	0	-3	Ah1	g2Su3	36	11	65	.4	11	-3	19	8000	347	50	6	0.3
593876	6606	-3	-10	Ah2	g2Su3	35	11	78	.5	10	4	18	10000	393	60	6	0.5
593877	6606	-10	-20	Ah3	g2Su3	39	13	71	.5	11	-3	20	10000	410	60	6	0.5
593878	6606	-20	-24	Ah4	g2Su3	32	13	57	.6	11	5	20	9000	370	50	6	0.5
593879	6606	-24	-30	Ah-Bv11	g2Su3	50	13	55	.5	9	4	19	8000	340	50	6	0.5
593880	6606	-30	-40	Ah-Bv12	g2Su3	37	12	45	.6	8	4	18	8000	330	20	5	0.5
593881	6606	-40	-58	Ah-Bv13	g2Su3	19	11	42	.6	10	-3	19	8000	363	30	4	0.4
593882	6606	-58	-68	Ah-Bv21	g2Su3	15	10	38	.4	10	-3	20	9000	340	20	4	0.5
593883	6606	-68	-77	Ah-Bv22	g2Su3	17	8	38	.6	10	6	19	9667	397	20	5	0.6
593884	6606	-77	-85	Bv1	g2Su2	26	8	33	.4	8	5	20	9000	380	20	5	-0.3
593885	6606	-85	-93	Bv2	g2Su2	13	6	25	-0.3	7	5	19	9000	320	20	4	1.0
593886	6606	-93	-100	Go-Cv1	g2Su2	11	4	19	.3	8	3	17	7667	167	20	3	1.0
593887	6606	-100	-110	Go-Cv2	g2Su2	29	12	67	.6	10	4	20	8000	277	50	3	-0.3
593888	6606	-110	-118	Go-Cv3	g2Su2	18	8	29	.6	8	4	18	9000	253	30	4	-0.3
593889	6606	-118	-130	IIGo-Cv	g4Sl2	10	6	34	.6	15	5	19	13000	210	10	4	-0.3

Tab.2: Element distribution in an overbank sediment profile (concentration in ppm, Hg in ppb)

	TK	oT	uT	Hori	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
588736	4222	0	-20	Ap	Sl3-Sl3,u3	39	17	51	-0.3	18	6	22	13260	510	215	5	-0.3
588737	4222	-20	-35	Ap	Sl3-Sl3,u3	40	17	51	-0.3	20	6	24	13540	530	250	5	-0.3
588738	4222	-35	-45	M	Sl3-Sl3,u3	30	11	31	-0.3	20	7	24	12700	370	55	4	-0.3
588739	4222	-45	-60	M	Sl3-Sl3,u3	28	11	31	-0.3	20	8	24	13420	370	70	4	-0.3
588740	4222	-60	-75	M	Sl3-Sl3,u3	28	11	31	-0.3	18	7	24	13680	340	45	4	-0.3
588741	4222	-75	-85	M	Sl3-Sl3,u3	28	10	33	-0.3	20	8	25	13600	360	90	3	0.3
588742	4222	-85	-100	M	Sl3-Sl3,u3	27	12	44	-0.3	25	8	28	14040	260	105	3	0.3
588743	4222	-100	-115	M	Sl3-Sl3,u3	29	14	59	-0.3	27	7	27	16810	190	90	3	0.3
588744	4222	-115	-130	Go-Sg	Ul2,s3	33	15	80	-0.3	37	13	31	23880	220	80	4	0.3
588745	4222	-130	-145	Sg-Go	Lu3,s3	32	19	93	-0.3	43	17	31	31000	290	80	4	0.3

Abbreviations in Tables 1 - 10:
TK = No. of 1:25 000 topographical map sheet
oT = upper depth of each soil horizon (cm)
uT = lower depth of each soil horizon (cm)
Hori = soil horizon notation
Bod.Art = paricle size class

Tab.3: Element distribution in an overbank sediment profile (concentration in ppm, Hg in ppb)

	TK	oT	uT	Hori	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
588789	4307	+2	+1	L		62	16	136	0.9	8	-3	2	-100	1550	300	2	1.0
588790	4307	+1	0	Of		258	47	215	1.3	27	5	7	13130	920	950	6	4.0
588791	4307	0	-4	Ah	U12,s2	275	39	147	.6	23	8	15	22670	270	700	20	4.0
588792	4307	-4	-15	Ah	U12,s2	45	6	47	-0.3	8	4	13	18050	250	95	9	0.5
588793	4307	-15	-27	Ah	U12,s2	29	5	53	-0.3	8	6	15	21240	330	90	8	0.3
588794	4307	-27	-40	M-Bvh	U12,s2	22	5	61	-0.3	10	7	17	21840	430	60	9	0.3
588795	4307	-40	-53	M-Bvh	U12,s2	24	5	87	-0.3	12	9	21	31000	480	70	12	-0.3
588796	4307	-53	-66	M-Bv	S13-S12	21	5	99	-0.3	11	7	20	33000	250	60	12	0.3
588797	4307	-66	-78	Go-Bv	S-S12	14	4	57	-0.3	10	7	13	18960	220	30	9	-0.3
588798	4307	-78	-90	Go-Bv	S-S12	12	4	39	-0.3	6	3	10	13180	110	15	7	-0.3
588799	4307	-90	-105	Go-Bv	S-S12	13	4	46	-0.3	7	5	11	19780	360	25	14	0.3
588800	4307	-105	-120	Go-Bv	S-S12	13	4	36	-0.3	8	7	9	24830	320	20	13	-0.3
588801	4307	-120	-135	Go-Bv	S-S12	12	4	37	-0.3	7	-3	9	21070	90	35	8	-0.3
588802	4307	-135	-150	Go	S	9	3	21	-0.3	8	-3	8	6360	50	15	2	0.8

TAB. 4. Element distribution in an overbank sediment profile from the river Rhein near Leverkusen (concentration in ppm, Hg in ppb).

	TK	OT	UT	Hori.	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
588832	4907	0	-10	Ap	U12, fs3	192	87	466	2.4	49	16	34	26810	900	2500	18	1.5
588833	4907	-10	-25	Ap	U12, fs3	194	89	442	2.1	40	14	32	24890	940	2300	21	1.8
588834	4907	-25	-35	Ap	U12, fs3	178	63	361	1.5	36	12	30	22120	840	1300	17	1.5
588835	4907	-35	-45	M1	U12, fs3	140	39	269	1.1	32	12	26	18770	750	900	13	1.3
588836	4907	-45	-60	M1	U12, fs3	81	22	153	0.3	28	10	25	18390	720	300	7	0.5
588837	4907	-60	-70	M1	U12, fs3	72	21	135	0.4	29	11	25	18320	680	205	6	0.5
588838	4907	-70	-85	M1	Ufs3	61	18	124	-0.3	27	10	24	16860	610	165	5	0.3
588839	4907	-85	-100	M2	Ufs-fSu3	54	15	102	-0.3	22	8	21	15290	540	115	4	0.3
588840	4907	-100	-115	M2	Ufs3-fSu3	56	17	100	-0.3	28	10	24	16650	580	115	4	0.5
588841	4907	-115	-130	M2	Ufs3-fSu3	55	19	88	-0.3	30	11	27	19580	700	160	5	0.5
588842	4907	-130	-145	M2	Ufs3-fSu3	56	20	88	-0.3	32	11	28	20640	760	105	5	0.3
588843	4907	-145	-155	M3	Ufs3, 12	55	20	87	-0.3	34	13	28	20760	770	100	6	0.3

Tab. 5: Element distribution in an overbank sediment profile (concentration in ppm, Hg in ppb)

	TK	oT	uT	Hori	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
591115	3928	+6	+5	L-Of		6050	162	1395	7.8	23	11	42	22770	2090	2350	15	24.0
591116	3928	+5	0	Oh		13800	340	4190	20.5	28	15	82	43000	5600	7800	22	44.0
591117	3928	0	-8	Ah	S12	19000	349	4620	21.0	28	15	89	48000	7000	8700	24	63.0
591118	3928	-8	-15	M	fSu3	17300	262	3956	19.5	28	14	91	43000	5950	4600	22	60.0
591119	3928	-15	-24	M	S12,lag(fSms)	15600	211	3582	14.6	27	13	96	41000	5200	4100	20	55.0
591120	3928	-24	-33	M	S12,lag(fSms)	16500	219	3370	14.7	28	15	99	40000	5000	4700	20	57.0
591121	3928	-33	-40	M	S12,lag(fSms)	14000	181	3283	10.6	28	16	99	34000	3700	3900	20	53.0
591122	3928	-40	-48	M	S12,lag(fSms)	11800	229	3960	11.4	35	18	78	37000	3350	2150	16	41.0
591123	3928	-48	-53	Go-M	Slu,lag(fSms)	3733	173	3739	11.4	38	20	54	32000	1600	700	12	19.0
591124	3928	-53	-75	Go-M	Slu,lag(fSms)	3323	174	3112	8.6	38	22	49	32000	1510	670	11	15.0
591125	3928	-75	-80	fGo-M	Slu,lag(fSms)	3718	150	2559	5.5	39	22	56	35000	1850	940	12	16.0
591126	3928	-80	-85	fGo-M	Lsu	1696	116	2123	6.0	48	20	54	39000	1620	550	10	8.0
591127	3928	-85	-95	fGo-M	Lsu	617	57	1222	4.0	47	20	55	36000	1740	270	8	5.0
591128	3928	-95	-100	fGo-M	Lsu	314	42	810	2.5	41	19	49	33000	1430	210	7	3.5
591129	3928	-100	-120	IIGo	G,13,x3	142	40	309	.7	51	17	43	37000	1230	145	7	2.3

TAB. 6. Element distribution in an overbank sediment profile from the river Bieber near Bieber (concentration in ppm, Hg in ppb).

	TK	OT	UT	Hori.	Bod.Art	Pb	Cu	Zn	Cd	Ni	Co	Li	Fe	Mn	Hg	As	Sb
578730	5821	+6	+5	L		37	26	119	-0.3	10	7	6	1537	264	100	22	3.5
578731	5821	+5	0	Of		246	173	447	1.5	87	194	21	25140	5677	400	440	45.0
578732	5821	0	-15	Ah, (Ap)	U13, s3	285	211	488	1.4	103	226	25	28117	6867	870	450	46.7
578733	5821	-15	-30	Go	Ls2, wl (S)	228	174	336	0.9	82	162	25	27887	2111	630	510	48.3
578734	5821	-30	-45	Go	Lu3, wl (S)	209	142	361	0.8	77	148	27	19457	2052	470	220	43.3
578735	5821	-45	-55	Go	Lt3, s3	331	293	967	2.4	85	150	34	27553	1820	450	300	43.3
578736	5821	-55	-65	IIfAh-Gor	Ut3	1853	1390	1780	9.5	83	157	31	22813	3577	950	350	63.3
578737	5821	-65	-80	IIIGor	Su3	2777	1570	1620	11.0	41	81	23	19587	4520	1900	470	70.0
578738	5821	-80	-95	IIIGr	Su3	3710	2007	4213	30.8	49	61	24	19840	4533	2300	980	110.0
578739	5821	-95	-110	IIIGr	Su2	2980	1743	5640	36.6	67	78	22	11163	2233	1600	1100	116.7
578740	5821	-110	-125	IIIGr	S	1980	1313	4400	16.1	77	130	25	11297	1362	1450	840	100.0

TAB.7 . Element distribution in an overbank sediment profile from the river Innerste, north of Upen (TK 25) near Salzgitter Bad (3928). (Concentration in ppm, Hg in ppb).

	TK	OT	UT	Hori.	Bod.Art	Genese	pH	Pb	Cu	Zn	Cd	Ni	Co	Hg	As	Sb
591130	3928	0	-28	Ap	U13	Lf	7.5	11000	270	4620	18.6	31	16	8000	19	35.0
591131	3928	-28	-33	fGo-M	Slu, lag (fSms)	Lf	7.6	16200	231	3652	17.0	30	15	5800	17	44.0
591132	3928	-33	-37	fGo-M	Slu, lag (fSms)	Lf	7.6	15000	187	2993	13.7	30	14	4200	18	52.0
591133	3928	-37	-42	fGo-M	Slu, wl (fSms)	Lf	7.6	14600	177	3209	14.0	32	14	2000	21	55.0
593411	3928	-42	-47	fGo-M	Slu, wl (fSms)	Lf	7.6	19900	244	3039	9.7	33	15	3700	18	54.0
591135	3928	-47	-52	fGo-M	Ut2	Lf	7.6	19900	233	2613	8.7	33	14	3300	16	57.0
591136	3928	-52	-58	fGo-M	Ut2	Lf	7.6	21300	278	2639	7.3	37	15	5600	20	63.0
591137	3928	-58	-63	fGo-M	U14, g2	Lf	7.4	8400	219	2953	8.2	44	28	1500	20	36.0
591138	3928	-63	-75	fGo-M	U14, g2	Lf	7.4	3134	148	1709	5.1	41	23	450	14	14.0
591139	3928	-75	-80	fGo-M	U14, g2	Lf	7.2	863	60	627	1.8	43	20	390	14	6.0
591140	3928	-80	-85	fGo-M	Lts, g3	Lf	7.3	563	47	663	2.7	45	22	300	10	5.0
591141	3928	-85	-100	fGo-M	Lts, g3	Lf	7.3	329	38	417	2.0	48	21	230	12	3.0

TAB. 8. Element distribution in an overbank sediment profile from the river Innerste, north of Upen (TK 25) near Salzgitter Bad (3928). (Concentration in ppm, Hg in ppb).

	TK	OT	UT	Hori.	Bod.Art	Genese	pH	Pb	Cu	Zn	Cd	Ni	Co	Hg	As	Sb
591142	3928	0	-30	Ap	U13, g1	Lf	6.9	2163	68	889	3.5	36	17	950	12	9.0
591143	3928	-30	-35	fGo-M	U14, g2	1f	6.9	744	37	361	1.2	28	15	420	8	4.0
591144	3928	-35	-50	fGo-M	U14, g2	Lf	7.0	326	27	259	1.0	31	16	165	8	2.0
591145	3928	-50	-55	fGo-M	U14, g2	Lf	7.0	220	22	212	0.7	28	15	146	7	1.0
591146	3928	-55	-60	fGo-M	Lt2, g2	Lf	7.0	161	19	157	0.4	27	15	105	6	1.0
591147	3928	-60	-72	fGo-M	Lt2, g2	Lf	7.0	147	20	141	-0.3	29	15	120	6	1.0
591148	3928	-72	-78	fGo-M	Lt2, g2	Lf	7.1	101	17	105	0.6	28	9	90	6	2.0
591149	3928	-78	-85	fGo-M	Ls3, g3	Lf	7.1	84	15	105	-0.3	27	8	40	6	1.6
591150	3928	-85	-95	fGo-M	Ls3, g3	Lf	7.2	88	18	92	0.3	29	13	40	5	1.1
591151	3928	-95	-110	fGo-M	Slu, g4	Lf	7.1	91	29	114	-0.3	48	14	80	-1	-0.3

TAB. 9. Element distribution in an overbank sediment profile from the river Innerste, north of Upen (TK 25) near Salzgitter Bad (3928) (concentration in ppm, Hg in ppb).

	TK	OT	UT	Hori.	Bod.Art	Genese	pH	Pb	Cu	Zn	Cd	Ni	Co	Hg	As	Sb
591152	3928	0	-28	Ap	U14, g2	Lf	7.1	353	37	303	1.2	33	16	370	11	1.8
591153	3928	-28	-35	M	Lsu, g2	Lf	7.1	316	36	288	1.0	34	16	330	9	1.8
591154	3928	-35	-53	M	Lsu, g2	Lf	7.3	746	35	392	0.5	39	17	145	9	4.3
591155	3928	-53	-58	M	Lsu, g2	Lf	7.1	185	33	213	0.4	44	18	180	10	1.3
591156	3928	-58	-65	M	Lsu, g4	Lf	7.3	94	33	156	-0.3	49	18	155	10	1.3

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 5.3

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT PROFILES OF MORE THAN SIXTY CENTIMETRES IN THICKNESS, FINLAND, GREENLAND, NORWAY, SPAIN AND SWEDEN

T. Volden
Norway

1990

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1.0. INTRODUCTION

The vertical distribution of elements in overbank sediment profiles was studied in altogether twenty-one profiles (Norway 10, Finland 6, Greenland 2, Sweden 2 and Spain 1). This is a summary report of overbank sediment profiles thicker than 60 cm.

2.0. OBJECTIVE

The aim of this survey was to study the depth to which the effects of possible anthropogenic pollution can be traced in overbank sediment.

3.0. SAMPLING

The overbank sediment profile samples were taken from exposed river bank sections after cleaning, and digging to as deep as possible. The individual samples were taken according to the following scheme, i.e., 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, etc.

4.0. SAMPLE PREPARATION AND ANALYSIS

The samples were dried at a temperature of 60 - 80 oC, and after disaggregation by porcelain pestle and mortar were sieved to the -0.063 mm fraction with a nylon screen. The +0.063 mm was discarded.

The samples were analyzed for hot nitric acid soluble and water soluble elements by ICP. The analytical methods used are described in Appendix 8.

The loss on ignition was determined in samples from profiles deeper than 80 cm (10 profiles) 5 gm sub-sample was heated to a temperature of 430°C (Table 1-10). At this temperature the LOI determines essentially the part which is related to the constituent organic matter.

5.0. DATA PRESENTATION

All the data are shown in Table 1-30. The profiles with minimum 60 cm depth were selected for a more detailled presentation of the distribution of acid soluble Cu, Zn, Pb, Ni and Co and water soluble Al, Fe, Mg, Ca, Na, K, Mn and Cu.

The contents were normalized against the concentration in the upper sample, which have therefore the value of 1.0.

6.0. DISCUSSION

All the overbank sediment profile samples apparently reflect natural conditions. There seems to be, however, some minor variation in the vertical distribution of the elements. This may be due to (a) temporal changes in the sediment source, and (b) variable contents in organic matter.

The linear correlation coefficients between L.O.I. and elements Cu, Zn, Pb, Ni and Co.

The observed element variation appears to have, in most cases, some relationship to organic matter, but the results are not absolutely conclusive. Therefore, other reasons should be sought for this minor element variation, such as the prevailing physico-chemical conditions or the percentage of the clay fraction at each depth and its adsorption capacity or the occurrence of minerals that are slightly enriched in these elements, etc. The use of, however, composite samples from a range of depths will reduce considerably the error caused by variation in composition with depth.

Table 29 listing the geometric mean values of the 21 overbank sediment profiles at each depth with respect to the acid soluble Cu, Zn, Pb, Ni and Co, shows that the deeper samples have overall lower values than the surface sample. It is, therefore, concluded that at a depth below 10 cm pristine overbank sediment samples are found.

Table 30 tabulating the geometric mean values of water soluble Al, Fe, Mg, Ca, Na, K, Mn and Cu, shows a more complex situation. Only K and Cu have the same pattern as their acid soluble part, i.e., lowering of the normalized geometric mean values with depth. Fe and Ca values increase with depth, probably suggesting the downward movement and precipitation of these elements by soil water under different physico-chemical conditions. Mn shows a relative enrichment at 10-40 cm, and then a depletion (compare to the surface sample), ad depth below 40 cm. Al shows an erratic behaviour.

It appears that overbank sediment samples, unaffected by anthropogenic pollution, are found in Norway, Finland, Greenland and Spain below a depth of 10 cm.

7.0. CONCLUSION

The final conclusion is that no serious anthropogenic pollution has been observed in the overbank sediment profiles that have been sampled outside mining districts, and major industrial sites. In this type of area pristine samples can certainly be obtained at depths of even 10 cm.

In mining districts and major industrial sites, the effects of anthropogenic pollution can be traced to considerable depths.

Nevertheless, it is possible to sample pristine material at depth even in these problem areas. However, no general rule of sampling depth can be given for such localities.

Table 1. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	4.62	1035	7.	22.	9.	7.	8.
10 - 20	1.61	1036	5.	14.	10.	6.	7.
20 - 40	2.92	1037	6.	16.	5.	7.	7.
40 - 60	2.31	1038	5.	16.	6.	6.	7.
60 - 80	2.30	1039	7.	18.	11.	8.	6.
80 - 100	1.90	1040	9.	17.	11.	6.	6.

Table 1b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Finland.

VAR	1	2	3	4	5	6
1	1.00000	.10629	.86898	-.24254	.38576	.74575
2	.10629	1.00000	.46159	.56183	.16151	-.43797
3	.86898	.46159	1.00000	.18075	.48132	.40787
4	-.24254	.56183	.18075	1.00000	.12649	-.44589
5	.38576	.16151	.48132	.12649	1.00000	-.10847
6	.74575	-.43797	.40787	-.44589	-.10847	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 2. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	2.17	1016	11.	23.	8.	11.	9.
10 - 20	2.69	1017	13.	27.	9.	14.	10.
20 - 40	3.69	1018	22.	43.	14.	22.	15.
40 - 60	15.26	1019	18.	29.	9.	12.	7.
60 - 80	8.39	1020	10.	29.	6.	14.	8.

Table 2b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Finland.

VAR	1	2	3	4	5	6
1	1.00000	.19725	-.03227	-.23580	-.28074	-.58036
2	.19725	1.00000	.82940	.90618	.71198	.63019
3	-.03227	.82940	1.00000	.83827	.96363	.81936
4	-.23580	.90618	.83827	1.00000	.82883	.87629
5	-.28074	.71198	.96363	.82883	1.00000	.91824
6	-.58036	.63019	.81936	.87629	.91824	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 3. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	5.56	1029	7.	19.	12.	8.	6.
10 - 20	4.75	1030	10.	22.	10.	10.	6.
20 - 40	3.38	1031	7.	18.	8.	9.	7.
40 - 60	3.66	1032	9.	21.	8.	12.	10.
60 - 80	3.39	1033	8.	23.	9.	13.	10.
80 - 100	4.59	1034	9.	20.	7.	11.	6.

Table 3b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Finland.

VAR	1	2	3	4	5	6
1	1.00000	.06837	-.19977	.65774	-.61383	-.73359
2	.06837	1.00000	.61791	-.27696	.44137	-.00000
3	-.19977	.61791	1.00000	.00000	.77143	.51427
4	.65774	-.27696	.00000	1.00000	-.53785	-.28307
5	-.61383	.44137	.77143	-.53785	1.00000	.78493
6	-.73359	-.00000	.51427	-.28307	.78493	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 4. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Greenland.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	1.09	308A	20.	16.	5.	22.	7.
10 - 20	3.52	309A	36.	50.	10.	27.	12.
20 - 40	1.82	310A	12.	22.	6.	22.	6.
40 - 60	0.55	311A	26.	29.	6.	19.	8.
60 - 80	0.35	312A	7.	7.	5.	11.	4.
80 - 100	0.44	313A	11.	6.	5.	9.	4.
100 - 120	2.37	314A	16.	11.	5.	8.	5.
120 - 140	2.12	315A	19.	25.	5.	14.	8.
140 - 160	3.59	316A	57.	93.	8.	42.	27.

Table 4b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Greenland.

VAR	1	2	3	4	5	6
1	1.00000	.74127	.76195	.74152	.65313	.71236
2	.74127	1.00000	.97168	.74105	.89351	.96148
3	.76195	.97168	1.00000	.74951	.93007	.98294
4	.74152	.74105	.74951	1.00000	.71812	.64034
5	.65313	.89351	.93007	.71812	1.00000	.91063
6	.71236	.96148	.98294	.64034	.91063	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 5. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Greenland.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	1.25	308B	15.	16.	5.	24.	7.
10 - 20	4.57	309B	40.	56.	13.	30.	12.
20 - 40	2.70	310B	18.	33.	5.	29.	8.
40 - 60	0.50	311B	26.	25.	5.	19.	8.
60 - 80	0.30	312B	6.	8.	5.	11.	4.
80 - 100	0.45	313B	13.	8.	6.	10.	4.
100 - 120	0.40	314B	5.	12.	5.	10.	2.
120 - 140	2.67	315B	38.	36.	5.	20.	12.
140 - 160	3.59	316B	51.	97.	5.	46.	27.

Table 5b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Greenland.

VAR	1	2	3	4	5	6
1	1.00000	.82046	.81567	.60795	.80742	.71822
2	.82046	1.00000	.90587	.35232	.80949	.90520
3	.81567	.90587	1.00000	.26990	.92811	.96854
4	.60795	.35232	.26990	1.00000	.20411	.10124
5	.80742	.80949	.92811	.20411	1.00000	.90855
6	.71822	.90520	.96854	.10124	.90855	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 6. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Spain.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 20	3.31	901	12.	24.	13.	10.	6.
20 - 40	2.66	902	13.	22.	12.	12.	5.
40 - 60	2.18	903	19.	31.	14.	12.	7.
60 - 80	1.43	904	16.	36.	16.	14.	8.
80 - 100	1.58	905	14.	25.	15.	12.	6.
100 - 120	1.02	906	14.	23.	16.	11.	6.
120 - 140	3.32	907	15.	25.	21.	13.	6.
140 - 160	2.08	908	17.	29.	15.	13.	7.
160 - 180	1.16	909	18.	35.	20.	14.	8.

Table 6b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Spain.

VAR	1	2	3	4	5	6
1	1.00000	-.38689	-.45949	-.15324	-.35961	-.51529
2	-.38689	1.00000	.77338	.36832	.64466	.75358
3	-.45949	.77338	1.00000	.35710	.75499	.97203
4	-.15324	.36832	.35710	1.00000	.58976	.41685
5	-.35961	.64466	.75499	.58976	1.00000	.68351
6	-.51529	.75358	.97203	.41685	.68351	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 7. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	12.98	201A	22.	62.	7.	19.	10.
10 - 20	10.19	202A	16.	72.	9.	18.	10.
20 - 40	7.26	203A	11.	39.	10.	10.	6.
40 - 60	9.77	204A	14.	45.	10.	14.	5.
60 - 80	18.63	205A	14.	53.	11.	16.	7.
80 - 100	20.02	206A	14.	67.	5.	15.	7.
100 - 120	13.21	207A	10.	59.	6.	13.	7.

Table 7b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6
1	1.00000	.09216	.44561	-.39761	.33282	.06078
2	.09216	1.00000	.42166	-.09047	.85117	.71066
3	.44561	.42166	1.00000	-.58823	.73422	.76276
4	-.39761	-.09047	-.58823	1.00000	-.14302	-.26249
5	.33282	.85117	.73422	-.14302	1.00000	.80296
6	.06078	.71066	.76276	-.26249	.80296	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 8. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	8.3	201B	20.	48.	9.	20.	8.
10 - 20	9.99	202B	14.	60.	12.	20.	8.
20 - 40	7.26	203B	13.	60.	8.	14.	7.
40 - 60	9.45	204B	14.	47.	14.	15.	6.
60 - 80	22.26	205B	16.	56.	5.	20.	8.
80 - 100	19.76	206B	12.	53.	5.	16.	7.
100 - 120	17.99	207B	12.	61.	6.	14.	7.

Table 8b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6
1	1.00000	-.27789	.19925	-.74987	.06740	.14059
2	-.27789	1.00000	-.53720	.14694	.71657	.55845
3	.19925	-.53720	1.00000	-.35881	-.17822	.26468
4	-.74987	.14694	-.35881	1.00000	.04942	-.30553
5	.06740	.71657	-.17822	.04942	1.00000	.84013
6	.14059	.55845	.26468	-.30553	.84013	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 9. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 10	2.66	601A	25.	39.	10.	23.	11.
10 - 20	2.51	602A	21.	38.	12.	24.	11.
20 - 40	2.39	603A	25.	34.	10.	26.	12.
40 - 60	1.11	604A	24.	22.	15.	38.	12.
60 - 80	2.30	605A	18.	26.	9.	22.	10.
80 - 100	1.42	606A	30.	22.	19.	41.	13.
100 - 120	1.75	607A	13.	24.	11.	17.	8.
120 - 140	1.88	608A	21.	27.	14.	27.	11.
140 - 160	1.62	609A	13.	20.	6.	14.	8.

Table 9b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6
1	1.00000	.02020	.88273	-.46399	-.45074	-.02572
2	.02020	1.00000	.29934	.70086	.84429	.96839
3	.88273	.29934	1.00000	-.17374	-.14958	.26084
4	-.46399	.70086	-.17374	1.00000	.89988	.72790
5	-.45074	.84429	-.14958	.89988	1.00000	.88556
6	-.02572	.96839	.26084	.72790	.88556	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 10. Hot nitric acid soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LOI %	Samples no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0 - 20	2.54	613B	25.	44.	13.	27.	12.
20 - 40	1.75	614B	20.	28.	9.	24.	11.
40 - 60	2.05	615B	19.	26.	9.	21.	10.
60 - 80	1.45	616B	36.	24.	22.	49.	14.
80 - 100	1.85	617B	15.	26.	8.	18.	8.
100 - 120	1.09	618B	12.	20.	8.	13.	7.
120 - 140	0.85	619B	14.	21.	5.	13.	7.
140 - 160	1.68	620B	18.	28.	5.	20.	10.
160 - 180	0.98	621B	14.	21.	8.	17.	8.

Table 10b. Linear correlation coefficient matrix of hot nitric acid soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6
1	1.00000	.38720	.87026	.24033	.28768	.56072
2	.38720	1.00000	.38330	.91852	.98254	.95192
3	.87026	.38330	1.00000	.22017	.24857	.53465
4	.24033	.91852	.22017	1.00000	.94295	.81260
5	.28768	.98254	.24857	.94295	1.00000	.91799
6	.56072	.95192	.53465	.81260	.91799	1.00000

Var	
1	LOI
2	Cu
3	Zn
4	Pb
5	Ni
6	Co

Table 11. Water acid soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	4.62	1035	7.109	8.967	18.910	51.410	8.900	20.900	21.500	.092
10 - 20	1.61	1036	5.692	8.000	7.408	22.120	5.400<	5.000	11.600	.073
20 - 40	2.92	1037	5.692	8.967	6.431	27.280	5.500<	5.000	3.800	.079
40 - 60	2.31	1038	5.716	8.797	7.326	35.580	6.100<	5.000	1.700	.038
60 - 80	2.30	1039	6.376	10.220	10.340	40.180	6.400<	5.000	.757	.092
80 - 100	1.90	1040	11.740	18.300	13.930	38.240	9.400	8.191<	.500	.154

Table 11b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Finland.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	-.12955	-.28674	.66068	.71171	.39381	.86638	.70263	-.06236
2	-.12955	1.00000	.97242	.53294	.32805	.83045	.21058	-.20472	.90671
3	-.28674	.97242	1.00000	.35312	.20882	.70351	-.00231	-.42434	.87815
4	.66068	.53294	.35312	1.00000	.86582	.89837	.90716	.57333	.54291
5	.71171	.32805	.20882	.86582	1.00000	.75254	.78281	.34549	.27378
6	.39381	.83045	.70351	.89837	.75254	1.00000	.69712	.24288	.74094
7	.86638	.21058	-.00231	.90716	.78281	.69712	1.00000	.81398	.22733
8	.70263	-.20472	-.42434	.57333	.34549	.24288	.81398	1.00000	-.10784
9	-.06236	.90671	.87815	.54291	.27378	.74094	.22733	-.10784	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 12. Water soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	2.17	1016	3.062	21.600	9.077	31.870	9.000	11.610	4.100	.037
10 - 20	2.69	1017	1.589	6.007	17.950	64.580	15.000	12.580	10.500	.045
20 - 40	3.69	1018	1.077	12.150	35.930	125.000	24.200	18.780	43.000	.046
40 - 60	15.26	1019	2.800	2.847	36.330	91.880	49.300<	5.000	10.400	.060
60 - 80	8.39	1020	2.360	3.302	20.860	48.880	65.600<	5.000	2.400	.016

Table 12b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Finland

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	.43215	-.64583	.57720	.20385	.74855	-.74869	-.23417	.30083
2	.43215	1.00000	.17470	-.39719	-.66567	.18986	-.71504	-.78020	-.07696
3	-.64583	.17470	1.00000	-.50937	-.26571	-.74352	.54179	.12507	-.04111
4	.57720	-.39719	-.50937	1.00000	.91333	.40425	.06926	.64421	.53217
5	.20385	-.66567	-.26571	.91333	1.00000	.05708	.46495	.88514	.56957
6	.74855	.18986	-.74352	.40425	.05708	1.00000	-.72844	-.24587	-.33906
7	-.74869	-.71504	.54179	.06926	.46495	-.72844	1.00000	.79426	.20922
8	-.23417	-.78020	.12507	.64421	.88514	-.24587	.79426	1.00000	.36648
9	.30083	-.07696	-.04111	.53217	.56957	-.33906	.20922	.36648	1.00000

Var

1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 13. Water soluble elements and LOI in an overbank sediment profile, Finland.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	5.56	1029	3.914	2.506	9.240	27.760	5.000<	5.000	3.100	.068
10 - 20	4.75	1030	4.282	9.084	5.659	22.460	4.500<	5.000	2.400	.062
20 - 40	3.38	1031	1.783	7.857	4.152	20.560	4.300<	5.000	8.400	.031
40 - 60	3.66	1032	3.371	17.280	6.431	44.440	4.800<	5.000	8.400	.031
60 - 80	3.39	1033	2.276	9.995	6.537	45.360	4.800<	5.000	3.100	.031
80 - 100	4.59	1034	2.003	1.594	9.362	50.890	5.200<	5.000	1.700	.033

Table 13b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Finland

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	.63021	-.62950	.69027	-.20972	.46836	.00000	-.61578	.86383
2	.63021	1.00000	.16410	.14079	-.35720	-.00260	.00000	-.21434	.82386
3	-.62950	.16410	1.00000	-.59353	.09233	-.41942	.00000	.64577	-.37493
4	.69027	.14079	-.59353	1.00000	.51345	.95619	.00000	-.62696	.29848
5	-.20972	-.35720	.09233	.51345	1.00000	.74136	.00000	-.20926	-.55981
6	.46836	-.00260	-.41942	.95619	.74136	1.00000	.00000	-.54502	.04336
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
8	-.61578	-.21434	.64577	-.62696	-.20926	-.54502	.00000	1.00000	-.46513
9	.86383	.82386	-.37493	.29848	-.55981	.04336	.00000	-.46513	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 14. Water soluble elements and LOI in an overbank sediment profile, Greenland.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	1.25	308B	7.504	5.941	2.761	6.477	5.000	8.142<	.500	.054
10 - 20	4.57	309B	1.999	1.253	2.589	6.470	11.100<	5.000<	.500<	.010
20 - 40	2.70	310B	9.963	5.906	6.181	21.870	9.200	7.397<	.500	.023
40 - 60	0.50	311B	20.620	20.090	11.820	166.700	5.800	15.940<	.500	.025
60 - 80	0.30	312B	10.680	4.888	3.993	54.980	4.900	10.780<	.500<	.010
80 - 100	0.45	313B	9.666	4.437	3.107	28.660	6.500	10.000<	.500	.041
100 - 120	0.40	314B	8.682	3.414	3.849	50.570	5.000	9.542<	.500<	.010
120 - 140	2.67	315B	34.290	20.800	10.380	20.810	20.600	30.630<	.500	.176
140 - 160	3.59	316B	14.430	7.047	10.740	51.410	15.200	25.670<	.500	.038

Table 14b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Greenland.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	-.04153	-.10806	.14703	-.43705	.69058	.19281	.00000	.16922
2	-.04153	1.00000	.91826	.78142	.30638	.63869	.86999	.00000	.83285
3	-.10806	.91826	1.00000	.82048	.54974	.43607	.70948	.00000	.66757
4	.14703	.78142	.82048	1.00000	.60457	.54715	.81029	.00000	.42406
5	-.43705	.30638	.54974	.60457	1.00000	-.27027	.18563	.00000	-.22438
6	.69058	.63869	.43607	.54715	-.27027	1.00000	.78420	.00000	.74999
7	.19281	.86999	.70948	.81029	.18563	.78420	1.00000	.00000	.74557
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
9	.16922	.83285	.66757	.42406	-.22438	.74999	.74557	.00000	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 15. Water soluble elements and LOI in an overbank sediment profile, Greenland.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	1.09	308A	6.669	5.115	2.554	5.974	4.700	8.861<	.500	.054
10 - 20	3.52	309A	4.469	3.098	2.375	4.913	8.900<	5.000<	.500	.031
20 - 40	1.82	310A	15.650	9.320	6.691	14.700	9.300	8.468<	.500	.023
40 - 60	0.55	311A	19.120	17.320	12.040	202.700	7.400	14.890<	.500	.054
60 - 80	0.35	312A	9.038	3.441	3.507	64.750	5.300	10.330<	.500<	.010
80 - 100	0.44	313A	5.919	3.070	2.127	16.610	5.400	9.472<	.500<	.010
100 - 120	2.37	314A	2.394	2.358	1.494	11.550	4.000	5.891<	.500	.069
120 - 140	2.12	315A	30.150	17.960	9.411	19.170	16.200	25.740<	.500	.145
140 - 160	3.59	316A	18.890	10.240	21.580	100.900	18.400	28.970<	.500	.035

Table 15b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Greenland.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	.08107	-.01157	.36496	-.23365	.60603	.27813	.00000	.20315
2	.08107	1.00000	.93334	.68643	.38638	.77367	.82673	.00000	.61360
3	-.01157	.93334	1.00000	.64397	.56863	.60726	.69749	.00000	.61896
4	.36496	.68643	.64397	1.00000	.62129	.81817	.86725	.00000	.15230
5	-.23365	.38638	.56863	.62129	1.00000	.16589	.38798	.00000	-.06593
6	.60603	.77367	.60726	.81817	.16589	1.00000	.88501	.00000	.41134
7	.27813	.82673	.69749	.86725	.38798	.88501	1.00000	.00000	.47057
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
9	.20315	.61360	.61896	.15230	-.06593	.41134	.47057	.00000	1.00000

Var

1 LoI
2 Al
3 Fe
4 Mg
5 Ca
6 Na
7 K
8 Mn
9 Cu

Table 16. Water soluble elements and LOI in an overbank sediment profile, Spain.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 20	3.31	901	8.265	5.223	29.230	470.200	14.000	173.500<	.500	.060
20 - 40	2.66	902	1.255<	.100	149.200	1500.000	26.200	40.460<	.500	.032
40 - 60	2.18	903	2.210	.937	102.800	618.500	76.500	17.670<	.500	.022
60 - 80	1.43	904	4.342	2.299	68.220	575.200	45.300	37.420<	.500	.022
80 - 100	1.58	905	21.780	16.040	29.190	302.200	13.100	37.530<	.500	.039
100 - 120	1.02	906	17.570	13.520	23.150	239.200	8.000	27.030<	.500	.022
120 - 140	3.32	907	12.370	9.000	48.170	514.900	18.400	68.410<	.500	.098
140 - 160	2.08	908	16.080	11.500	35.120	393.100	16.400	42.020<	.500	.039
160 - 180	1.16	909	21.690	15.500	33.880	323.000	22.200	28.690<	.500	.030

Table 16b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Spain.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	-.90576	-.92501	.72677	.96019	-.37352	.81432	-.63992	.59035
2	-.90576	1.00000	.95844	-.59428	-.95617	.41028	-.72097	.79182	-.45074
3	-.92501	.95844	1.00000	-.50039	-.94815	.37138	-.78762	.69907	-.42025
4	.72677	-.59428	-.50039	1.00000	.73834	-.61046	.73710	-.33578	.73826
5	.96019	-.95617	-.94815	.73834	1.00000	-.48292	.87613	-.85267	.55248
6	-.37352	.41028	.37138	-.61046	-.48292	1.00000	-.62978	.13268	-.54359
7	.81432	-.72097	-.78762	.73710	.87613	-.62978	1.00000	-.32951	.60787
8	-.63992	.79182	.69907	-.33578	-.65267	.13268	-.32951	1.00000	-.53515
9	.59035	-.45074	-.42025	.73826	.55248	-.54359	.60787	-.53515	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 17. Water soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LoI. %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	12.98	201A	5.662	3.860	6.098	49.700	3.800	42.340	6.000	.099
10 - 20	10.19	202A	3.525	.367	3.251	67.150	2.900	6.605	8.400	.068
20 - 40	7.26	203A	4.107	.794	3.463	62.130	3.000<	5.000	7.200	.062
40 - 60	9.77	204A	3.815	1.249	4.951	78.210	3.300<	5.000	4.800	.068
60 - 80	18.63	205A	9.026	.906	17.480	172.800	5.300	7.680	13.300	.075
80 - 100	20.02	206A	9.470	1.362	31.970	274.700	6.100	14.010	11.900	.078
100 - 120	13.21	207A	5.514	.368	26.290	232.000	5.200	15.390	2.200	.032

Table 17b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	.96250	.10957	.80076	.77304	.91624	.17708	.63880	.23837
2	.96250	1.00000	.11110	.77270	.74562	.90357	.13016	.70385	.25354
3	.10957	.11110	1.00000	-.18838	-.32587	-.04306	.89067	-.05062	.78255
4	.80076	.77270	-.18838	1.00000	.98821	.95971	.02712	.23179	-.28854
5	.77304	.74562	-.32587	.98821	1.00000	.93568	-.12371	.26244	-.36658
6	.91624	.90357	-.04306	.95971	.93568	1.00000	.11398	.38634	-.09439
7	.17708	.13016	.89067	.02712	-.12371	.11398	1.00000	-.21134	.52240
8	.63880	.70385	-.05062	.23179	.26244	.38634	-.21134	1.00000	.48677
9	.23837	.25354	.78255	-.28854	-.36658	-.09439	.52240	.48677	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 18. Water soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	2.66	601A	2.475	1.249	9.219	67.660	2.900	27.800<	.500	.192
10 - 20	2.51	602A	4.359	1.704	6.090	69.000	3.000	18.520	.999	.226
20 - 40	2.39	603A	3.961	2.727	4.780	60.810	2.800	14.700	1.300	.213
40 - 60	1.11	604A	4.316	3.662	3.192	30.910	1.900<	5.000	.762	.161
60 - 80	2.30	605A	3.908	1.733	4.603	58.770	2.900	8.333	.752	.213
80 - 100	1.42	606A	3.802	3.438	3.560	38.280	2.200<	5.000	.510	.215
100 - 120	1.75	607A	4.232	2.728	2.032	50.260	2.600<	5.000<	.500	.122
120 - 140	1.88	608A	3.600	2.047	2.924	52.610	2.800	5.060	.957	.154
140 - 160	1.62	609A	4.773	3.185	1.263	37.640	2.500<	5.000	.720	.109

Table 18b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	-.49052	-.88593	.75573	.97510	.92542	.82166	.31648	.51181
2	-.49052	1.00000	.59375	-.76497	-.48569	-.33357	-.64531	.25079	-.34530
3	-.88593	.59375	1.00000	-.71703	-.90324	-.89143	-.70872	-.07821	-.36812
4	.75573	-.76497	-.71703	1.00000	.74051	.49980	.94342	.00909	.65522
5	.97510	-.48569	-.90324	.74051	1.00000	.92484	.78730	.31307	.52688
6	.92542	-.33357	-.89143	.49980	.92484	1.00000	.58702	.33011	.31434
7	.82166	-.64531	-.70872	.94342	.78730	.58702	1.00000	.09310	.49443
8	.31648	.25079	-.07821	.00909	.31307	.33011	.09310	1.00000	.31654
9	.51181	-.34530	-.36812	.65522	.52688	.31434	.49443	.31654	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 19. Water soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 10	8.3	201B	4.502	1.702	9.110	62.860	3.000	27.380	31.600	.078
10 - 20	9.99	202B	2.947	.340	7.869	83.120	3.600	23.470	15.400	.045
20 - 40	7.26	203B	3.539	.340	9.641	121.600	6.300	20.090	13.200	.091
40 - 60	9.45	204B	3.737<	.100	14.290	170.900	3.500	8.627	14.500	.045
60 - 80	22.26	205B	11.410	1.475	53.400	468.200	7.600	24.660	33.100	.062
80 - 100	19.76	206B	8.052	1.132	52.250	470.000	8.400	19.090	15.300	.052
100 - 120	17.99	207B	5.638	.993	49.680	495.000	9.000	19.430	11.800	.060

Table 19b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	.89812	.49748	.97585	.94966	.79529	.12186	.20657	-.32332
2	.89812	1.00000	.63514	.84641	.78475	.62850	.25681	.53587	-.07967
3	.49748	.63514	1.00000	.47817	.37970	.26708	.69436	.76379	.26870
4	.97585	.84641	.47817	1.00000	.99093	.87874	.03577	.09497	-.23638
5	.94966	.78475	.37970	.99093	1.00000	.90504	-.06134	-.01763	-.25234
6	.79529	.62850	.26708	.87874	.90504	1.00000	.01958	-.20000	.05326
7	.12186	.25681	.69436	.03577	-.06134	.01958	1.00000	.62376	.42697
8	.20657	.53587	.76379	.09497	-.01763	-.20000	.62376	1.00000	.23875
9	-.32332	-.07967	.26870	-.23638	-.25234	.05326	.42697	.23875	1.00000

Var	
1	LoI
2	Al
3	Fe
4	Mg
5	Ca
6	Na
7	K
8	Mn
9	Cu

Table 20. Water soluble elements and LOI in an overbank sediment profile, Norway.

Depth cm	LoI %	Samples No	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppm
0 - 20	2.54	613B	2.529	1.392	7.222	60.690	2.400	8.966	.634	.182
20 - 40	1.75	614B	3.255	2.644	4.390	51.610	2.400	7.230<	.500	.160
40 - 60	2.05	615B	2.210	.908	4.337	56.880	2.200	8.560<	.500	.165
60 - 80	1.45	616B	4.889	5.342	4.891	41.720	2.400<	5.000<	.500	.190
80 - 100	1.85	617B	3.377	2.301	1.962	46.880	2.600<	5.000<	.500	.093
100 - 120	1.09	618B	5.950	5.370	1.496	37.450	2.700<	5.000	.730	.083
120 - 140	0.85	619B	7.428	6.939	2.484	32.080	2.400<	5.000	1.100	.080
140 - 160	1.68	620B	2.809	3.100	4.705	51.420	2.400	6.079	.605	.080

Table 20b. Linear correlation coefficient matrix of water soluble elements and LOI in an overbank sediment profile profile, Norway.

VAR	1	2	3	4	5	6	7	8	9
1	1.00000	-.46498	-.46958	.25917	.40306	-.01702	.67969	.00000	.75889
2	-.46498	1.00000	.99839	-.79950	-.72699	-.64918	-.13771	.00000	.08568
3	-.46958	.99839	1.00000	-.79772	-.72871	-.65368	-.15456	.00000	.08716
4	.25917	-.79950	-.79772	1.00000	.92660	.57341	-.26698	.00000	-.23060
5	.40306	-.72699	-.72871	.92660	1.00000	.25285	-.03989	.00000	-.06187
6	-.01702	-.64918	-.65368	.57341	.25285	1.00000	-.33992	.00000	-.36481
7	.67969	-.13771	-.15456	-.26698	-.03989	-.33992	1.00000	.00000	.53827
8	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
9	.75889	.08568	.08716	-.23060	-.06187	-.36481	.53827	.00000	1.00000

Var

1 LoI
2 Al
3 Fe
4 Mg
5 Ca
6 Na
7 K
8 Mn
9 Cu

Table 21. Acid soluble elements in profiles from Finland.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	1001	23.	37.	11.	28.	10.
10- 20	1002	24.	37.	10.	28.	11.
20- 40	1003	29.	42.	8.	32.	13.
40- 60	1004	26.	38.	7.	28.	11.
0- 10	1005	24.	37.	5.	30.	14.
10- 20	1006	26.	39.	8.	31.	11.
20- 40	1007	30.	39.	8.	30.	11.
0- 10	1008	8.	11.	5.	13.	6.
10- 20	1009	8.	11.	8.	15.	6.
20- 40	1010	9.	14.	6.	13.	6.
40- 60	1011	15.	14.	5.	14.	6.
0- 10	1012	9.	14.	5.	14.	6.
10- 20	1013	9.	15.	5.	21.	7.
20- 40	1014	9.	16.	7.	16.	7.
40- 60	1015	12.	21.	7.	20.	9.
0- 10	1021	13.	31.	8.	11.	10.
10- 20	1022	11.	27.	8.	10.	8.
20- 40	1023	11.	26.	8.	10.	7.
0- 10	1024	6.	13.	11.	8.	6.
10- 20	1025	6.	14.	6.	9.	6.
20- 40	1026	5.	15.	7.	9.	6.
40- 60	1027	4.	12.	7.	6.	5.
60- 80	1028	6.	16.	9.	13.	6.
0- 10	1041	5.	13.	7.	6.	5.
10- 20	1042	5.	16.	10.	7.	5.
20- 40	1043	5.	16.	9.	5.	6.
40- 60	1044	4.	16.	9.	5.	6.
60- 80	1045	8.	20.	9.	7.	7.
80-100	1046	7.	19.	9.	10.	6.
0- 10	1047	10.	33.	15.	15.	10.
10- 20	1048	10.	26.	8.	14.	10.
20- 40	1049	12.	23.	9.	15.	11.
40- 60	1050	17.	27.	5.	21.	13.
0- 10	1051	16.	34.	14.	15.	8.
10- 20	1052	10.	28.	11.	14.	10.
20- 40	1053	8.	18.	5.	11.	10.
40- 60	1054	10.	23.	5.	14.	12.
0- 10	1055	7.	11.	11.	7.	5.
10- 20	1056	7.	10.	10.	6.	5.
20- 40	1057	7.	12.	9.	9.	5.

Table 21. Acid soluble elements in profiles from Finland.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	1058	8.	32.	8.	9.	4.
10- 20	1059	15.	27.	12.	8.	5.
20- 40	1060	8.	23.	10.	8.	5.
0- 10	1061	17.	43.	14.	18.	12.
10- 20	1062	17.	45.	13.	16.	12.
20- 40	1063	19.	44.	11.	18.	12.
40- 60	1064	17.	39.	5.	17.	10.
0- 10	1065	33.	201.	55.	24.	14.
10- 20	1066	30.	76.	17.	29.	17.
20- 40	1067	30.	52.	7.	30.	17.
0- 10	1068	4.	15.	15.	8.	4.
10- 20	1069	4.	18.	10.	8.	5.
20- 40	1070	3.	11.	13.	7.	5.
0- 10	1071	4.	9.	10.	5.	4.
10- 20	1072	2.	7.	10.	4.	3.
0- 10	1073	8.	22.	14.	10.	7.
10- 20	1074	11.	24.	16.	10.	9.
20- 40	1075	12.	26.	9.	11.	9.
0- 10	1076	10.	20.	11.	8.	7.
10- 20	1077	8.	26.	86.	10.	8.
20- 40	1078	10.	19.	10.	8.	7.
0- 10	1079	9.	27.	11.	7.	8.
10- 20	1080	4.	15.	5.	4.	5.
20- 40	1081	5.	19.	9.	4.	5.
0- 10	1082	11.	37.	12.	10.	10.
10- 20	1083	17.	50.	14.	17.	14.
20- 40	1084	16.	46.	8.	15.	14.
0- 10	1085	10.	62.	7.	8.	8.
10- 20	1086	11.	64.	8.	9.	9.
20- 40	1087	11.	64.	11.	9.	8.
0- 10	1088	11.	65.	11.	9.	8.
10- 20	1089	10.	65.	16.	9.	8.
20- 40	1090	11.	63.	12.	8.	7.
0- 10	1091	21.	51.	12.	17.	10.
10- 20	1092	25.	52.	16.	18.	9.
20- 40	1093	20.	44.	11.	18.	10.
40- 60	1094	14.	41.	10.	16.	10.
0- 10	1095	20.	41.	13.	15.	7.
10- 20	1096	10.	26.	9.	14.	7.
20- 40	1097	9.	25.	6.	13.	8.

Table 21. Acid soluble elements in profiles from Finland.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	1098	13.	50.	11.	14.	14.
10- 20	1099	12.	50.	10.	16.	15.
20- 40	1100	13.	54.	13.	15.	18.
40- 60	1101	14.	44.	11.	14.	14.
60- 80	1102	11.	39.	8.	12.	9.
80-100	1103	12.	43.	10.	14.	12.
0- 10	1104	20.	71.	11.	29.	13.
10- 20	1105	16.	60.	12.	23.	12.
20- 40	1106	12.	51.	11.	17.	10.
0- 10	1107	11.	24.	6.	9.	8.
10- 20	1108	12.	24.	10.	11.	7.
20- 40	1109	20.	61.	15.	18.	14.
0- 10	1110	20.	76.	17.	21.	16.
10- 20	1111	20.	80.	13.	20.	16.

Table 22. Acid soluble elements in profiles from Norway.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	209A	26.	178.	21.	47.	15.
10- 20	210A	20.	112.	17.	28.	9.
20- 40	211A	22.	143.	15.	34.	9.
40- 60	212A	22.	145.	13.	38.	14.
0- 10	214A	11.	63.	14.	21.	7.
10- 20	215A	10.	59.	16.	17.	8.
20- 40	215A	15.	89.	19.	27.	12.
40- 60	216A	11.	58.	13.	24.	7.
60- 80	217A	12.	66.	11.	23.	7.
0- 10	219A	8.	64.	13.	10.	4.
10- 20	220A	6.	33.	10.	8.	8.
20- 40	221A	6.	25.	9.	11.	6.
40- 60	222A	8.	36.	9.	13.	9.
0- 10	224A	17.	50.	13.	20.	12.
10- 20	225A	21.	51.	13.	23.	13.
20- 40	226A	15.	36.	7.	18.	10.
40- 60	227A	17.	48.	10.	21.	11.
60- 80	228A	22.	56.	15.	26.	13.
0- 10	236A	5.	41.	15.	7.	5.
10- 20	237A	6.	52.	16.	8.	9.
20- 40	238A	8.	56.	9.	11.	9.
40- 60	239A	9.	44.	5.	16.	11.
0- 10	241A	10.	27.	9.	16.	8.
10- 20	242A	18.	39.	15.	21.	11.
20- 40	243A	10.	30.	12.	15.	8.
40- 60	244A	11.	38.	9.	14.	7.
0- 10	248A	32.	103.	17.	62.	16.
10- 20	249A	30.	83.	9.	59.	16.
20- 40	250A	31.	79.	9.	61.	14.
40- 60	251A	32.	80.	15.	61.	18.
60- 80	252A	32.	89.	15.	64.	24.
80-100	253A	36.	95.	14.	65.	24.
0- 10	626A	18.	26.	10.	12.	14.
10- 20	627A	23.	29.	14.	15.	20.
20- 40	628A	25.	30.	11.	15.	16.
40- 60	629A	24.	29.	9.	15.	13.
0- 10	634A	10.	20.	6.	13.	6.
10- 20	635A	9.	19.	5.	13.	6.
20- 40	636A	11.	21.	5.	12.	7.
40- 60	637A	15.	28.	8.	16.	8.
0- 10	641A	80.	48.	10.	39.	16.
10- 20	642A	58.	47.	11.	35.	15.
20- 40	643A	93.	43.	8.	38.	19.

NORWAY

Table 22. Acid soluble elements in profiles from Norway.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	647A	14.	38.	5.	27.	11.
10- 20	648A	14.	33.	10.	27.	10.
20- 40	649A	17.	40.	7.	31.	13.
40- 60	650A	16.	38.	5.	26.	12.
60- 80	651A	16.	46.	8.	28.	13.
80-100	652A	16.	43.	5.	31.	11.
0- 10	659A	29.	36.	5.	27.	13.
10- 20	660A	22.	35.	8.	30.	14.
20- 40	661A	18.	28.	7.	26.	12.
40- 60	662A	27.	38.	5.	32.	16.
0- 10	667A	69.	24.	5.	15.	12.
10- 20	668A	55.	18.	6.	12.	9.
20- 40	669A	53.	17.	8.	14.	9.
40- 60	670A	50.	16.	5.	13.	9.
0- 10	676A	20.	19.	5.	8.	7.
10- 20	677A	17.	20.	7.	8.	7.
20- 40	678A	15.	17.	7.	6.	6.
40- 60	679A	15.	17.	7.	8.	6.
60- 80	680A	18.	18.	8.	8.	7.
80-100	681A	18.	20.	5.	9.	9.
100-120	682A	17.	19.	5.	7.	8.
120-140	683A	15.	19.	5.	8.	8.
140-160	684A	17.	17.	8.	10.	8.
160-180	685A	17.	22.	5.	8.	7.
180-200	686A	20.	20.	6.	9.	8.
200-220	687A	23.	23.	7.	10.	10.
0- 10	694A	24.	49.	12.	27.	18.
10- 20	695A	29.	48.	9.	29.	20.
20- 40	696A	29.	50.	9.	28.	20.
0- 10	697A	18.	37.	103.	12.	6.
10- 20	698A	15.	29.	89.	7.	6.
20- 40	699A	10.	24.	46.	6.	5.
40- 60	700A	15.	30.	59.	6.	7.
60- 80	703A	7.	27.	80.	2.	5.
0- 10	704A	9.	28.	61.	2.	6.
10- 20	705A	7.	29.	63.	4.	6.
20- 40	706A	8.	27.	44.	2.	6.
40- 60	707A	7.	28.	43.	3.	5.
0- 10	708A	10.	20.	30.	3.	4.
10- 20	709A	15.	30.	53.	2.	4.
20- 40	710A	14.	22.	58.	3.	4.
40- 60	711A	11.	27.	62.	4.	4.
60- 80	712A	9.	20.	44.	3.	3.
80-100	713A	3.	35.	13.	5.	6.
100-120	714A	14.	45.	41.	8.	7.
120-140	715A	15.	49.	49.	8.	6.

Table 23. Acid soluble elements in profiles from Greenland.

Depth cm	Samples No.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	319A	10.	15.	5.	18.	6.
10- 20	320A	10.	13.	5.	16.	6.
20- 40	321A	12.	13.	5.	17.	6.
40- 60	322A	16.	16.	5.	26.	8.
60- 80	323A	16.	18.	9.	33.	8.

Table 24. Acid soluble elements in profiles from Sweden.

Depth cm	Samples No.	Co ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	601	11.	59.	21.	10.	6.
10- 20	602	8.	40.	20.	9.	5.
20- 40	603	9.	39.	21.	11.	7.
40- 60	604	8.	29.	15.	10.	8.
0- 10	607	9.	83.	13.	6.	8.
10- 20	608	17.	174.	25.	13.	14.
20- 40	609	15.	111.	22.	10.	9.
40- 60	610	11.	120.	16.	10.	10.
60- 80	611	21.	187.	25.	13.	14.
80-100	612	17.	67.	17.	6.	5.
100-120	613	17.	100.	21.	8.	7.
120-140	614	18.	92.	26.	8.	7.
140-160	615	16.	95.	23.	8.	7.
0- 10	624	9.	33.	25.	4.	5.
10- 20	625	6.	26.	22.	2.	4.
20- 40	626	4.	19.	23.	3.	4.
40- 60	627	4.	18.	12.	2.	5.

Table 25. Water soluble elements in profiles from Finland.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	1001	8.709	15.830	2.472	9.256	4.900	14.060	.787	.047
10-20	1002	4.969	12.190	2.028	9.021	5.300	5.643<	.500	.038
20-40	1003	4.359	24.640	2.583	9.480	6.200<	5.000	.894	.047
40-60	1004	5.588	30.360	1.551	6.325	6.900<	5.000	.582	.037
0-10	1005	5.164	9.483	6.009	11.830	11.400<	5.000	.636	.062
10-20	1006	4.571	9.661	5.313	10.890	9.600<	5.000<	.500	.061
20-40	1007	5.509	22.400	6.718	15.200	11.400<	5.000<	.500	.047
0-10	1008	4.438	1.619	2.228	11.090	5.400<	5.000<	.500<	.010
10-20	1009	4.041	2.955	1.052	7.050	3.600<	5.000<	.500<	.010
20-40	1010	4.995	2.727	1.429	7.699	4.000<	5.000<	.500<	.010
40-60	1011	7.570	4.982	1.773	5.578	3.700<	5.000<	.500	.029
0-10	1012	4.471	3.730	4.487	7.686	3.000	9.585<	.500	.029
10-20	1013	4.175	2.932	4.958	8.338	3.000	10.110<	.500	.016
20-40	1014	5.440	3.388	4.962	5.773	2.600	12.650<	.500	.029
40-60	1015	9.598	4.184	3.909	4.901	2.400	8.989<	.500	.029
0-10	1021	5.173	12.380	10.670	37.480	41.200	5.880	2.800	.073
10-20	1022	1.686	2.847	9.795	34.570	35.300<	5.000	3.600	.060
20-40	1023	3.309	4.641	21.260	60.870	50.600<	5.000	6.300	.075
0-10	1024	14.080	20.670	7.636	41.040	6.700<	5.000	17.600	.068
10-20	1025	11.640	24.370	8.131	46.760	6.500<	5.000	15.100	.052
20-40	1026	15.980	24.740	17.620	82.230	7.800<	5.000	4.500	.068
40-60	1027	3.696	.769	18.090	59.690	7.800<	5.000<	.500	.029
60-80	1028	3.018	.456	29.110	63.600	8.600<	5.000	.742	.016
0- 10	1041	12.630	17.620	20.760	51.520	7.900	13.720	2.300	.071
10- 20	1042	10.860	15.710	20.770	56.570	6.900	9.004	1.300	.077
20- 40	1043	5.545	10.790	8.710	22.830	7.200<	5.000<	.500	.044
40- 60	1044	7.738	7.030	8.848	21.130	10.100<	5.000<	.500	.031
60- 80	1045	8.037	5.437	8.466	19.580	10.700	5.777<	.500	.033
80-100	1046	10.360	6.000	8.040	18.110	10.500	9.543<	.500	.032
0-10	1047	2.449	8.503	2.835	7.601	6.500<	5.000	2.900<	.010
10-20	1048	3.084	12.400	3.099	7.244	5.200<	5.000	2.900<	.010
20-40	1049	4.617	16.370	3.663	6.832	5.800<	5.000	3.000<	.010
40-60	1050	9.625	20.350	4.579	5.383	7.800<	5.000	2.600	.010
0-10	1051	3.054	12.410	3.256	7.222	8.100<	5.000	3.500<	.010
10-20	1052	2.345	8.626	2.870	6.052	9.000<	5.000	1.900<	.010
20-40	1053	8.159	32.880	2.605	3.555	7.000<	5.000	2.200<	.010
40-60	1054	2.687	10.930	3.663	6.185	6.200<	5.000	2.700<	.010
0-10	1055	19.180	8.626	4.233	55.980	21.700	8.598	3.300	.056
10-20	1056	16.860	7.145	2.707	41.820	34.800<	5.000	1.200	.046
20-40	1057	12.120	5.694	1.547	26.690	35.400<	5.000	.534	.046
0-10	1058	6.083	.911	13.290	55.650	2.900	8.801<	.500	.033
10-20	1059	5.203	.996	12.620	54.540	3.200<	5.000<	.500	.031
20-40	1060	6.083	.683	13.760	58.940	3.300<	5.000<	.500	.069

Table 25. Water soluble elements in profiles from Finland.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	1061	12.320	13.370	28.650	76.980	24.800	10.280	4.700	.273
10-20	1062	9.966	10.440	24.490	69.080	16.400<	5.000	2.900	.211
20-40	1063	15.920	13.630	21.100	32.100	13.100	8.137	.618	.129
40-60	1064	14.460	11.380	10.350	13.610	10.400	8.358<	.500	.119
0-10	1065	7.360	13.370	35.220	83.850	12.000	14.710<	.500	.219
10-20	1066	25.190	34.070	29.060	41.540	16.600	16.030	1.900	.166
20-40	1067	28.870	46.880	26.310	35.810	18.000	16.710	3.100	.127
0-10	1068	6.880	5.337	3.846	6.251	2.800	6.792	1.300	.027
10-20	1069	5.494	3.548	2.768	3.063	2.700	5.072	.651	.027
20-40	1070	3.573	2.271	1.221	4.145	2.800<	5.000	.621	.013
0-10	1071	9.213	4.201	2.340	13.080	4.200<	5.000<	.500	.013
10-20	1072	7.001	2.839	2.279	15.210	4.200<	5.000<	.500	.037
0-10	1073	7.439	14.220	8.059	21.200	7.100<	5.000	1.900	.050
10-20	1074	3.379	13.630	7.408	17.220	10.000<	5.000	.852	.029
20-40	1075	6.588	12.290	8.629	20.810	9.900<	5.000	1.800	.050
0-10	1076	9.602	18.510	12.210	32.950	6.300	8.027	3.300	.104
10-20	1077	4.667	4.542	5.800	12.120	7.400	10.010<	.500	.027
20-40	1078	3.962	2.328	11.320	31.290	12.500	5.270	2.100	.019
0-10	1079	5.372	7.154	5.474	8.836	7.100<	5.000	.728	.042
10-20	1080	3.209	6.359	8.059	15.670	6.100<	5.000	1.300	.027
20-40	1081	2.596	5.903	6.876	14.260	6.200	5.861	1.400	.031
0-10	1082	3.789	2.266	8.539	24.540	14.700	10.730<	.500	.061
10-20	1083	4.677	4.537	5.693	13.400	14.600<	5.000	.984	.054
20-40	1084	9.167	13.750	5.079	8.723	8.400	7.690	.937	.044
0-10	1085	4.777	2.041	10.780	47.380	6.300	21.380<	.500	.069
10-20	1086	4.693	1.845	11.240	50.290	7.800	16.560<	.500	.079
20-40	1087	6.598	2.920	11.090	49.070	7.700	16.470<	.500	.092
0-10	1088	5.600	2.296	10.610	61.030	4.400	53.950<	.500	.102
10-20	1089	4.918	2.270	9.546	54.040	4.100	37.350<	.500	.092
20-40	1090	5.997	2.867	9.494	53.850	5.300	23.130<	.500	.092
0-10	1091	7.189	7.521	24.320	57.470	18.200	15.710<	.500	.140
10-20	1092	6.473	5.898	24.830	56.580	15.700	17.580<	.500	.154
20-40	1093	13.490	12.400	17.080	33.200	13.100	10.130<	.500	.106
40-60	1094	8.070	8.621	18.360	32.630	15.500	7.669<	.500	.075
0-10	1095	5.675	5.785	14.290	45.350	12.900	12.230<	.500	.184
10-20	1096	5.800	4.111	8.553	28.590	13.200<	5.000<	.500	.092
20-40	1097	8.369	6.834	7.171	20.840	12.100<	5.000<	.500	.030

Table 25. Water soluble elements in profiles from Finland.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0- 10	1098	9.173	9.871	8.865	27.750	5.700	21.170<	.500	.131
10- 20	1099	8.787	7.067	8.951	29.320	6.400	20.470	4.200	.133
20- 40	1100	11.210	10.560	9.474	26.120	9.300	15.420	5.700	.127
40- 60	1101	7.794	7.267	10.180	26.370	13.700	8.684	2.800	.092
60- 80	1102	8.793	8.743	10.180	23.600	12.500	11.130	.852	.079
80-100	1103	19.540	24.250	11.840	21.800	15.900	12.460	.984	.054
0-10	1104	11.960	6.862	35.940	54.760	65.600	13.500<	.500	.092
10-20	1105	10.360	6.012	28.210	43.630	53.800	8.539<	.500	.100
20-40	1106	12.160	12.720	18.420	27.560	43.900	6.930<	.500	.084
0-10	1107	12.160	2.268	27.020	74.150	19.700	30.460	3.800	.075
10-20	1108	15.730	6.692	26.710	80.660	19.400	21.740	4.800	.073
20-40	1109	13.650	6.350	29.410	72.840	37.900	13.630	3.100	.100
0-10	1110	4.952	12.870	22.600	77.550	25.800	15.630	2.000	.123
10-20	1111	31.320	41.120	21.570	31.950	29.000	14.810	3.300	.123

Table 26. Water soluble elements in profiles from Norway.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	209A<	1.000	.341	98.450	1100.000	19.800	110.400	13.200	.025
10-20	210A<	1.000	.909	48.870	422.000	11.700	32.230<	.500	.023
20-40	211A<	1.000	.795	61.690	485.800	18.800	57.750<	.500	.036
40-60	212A	1.533	.339	90.550	688.100	21.700	58.500	1.100	.030
0-10	214A<	1.000	.484	13.280	215.800	9.400<	5.000	1.700<	.010
10-20	215A<	1.000	.228	7.135	148.100	13.600<	5.000<	.500<	.010
20-40	216A	1.285	2.160	3.926	86.460	20.700<	5.000<	.500	.031
40-60	217A	1.142	1.391	9.956	162.800	11.100	6.896	8.400<	.010
0-10	219A	2.424	1.052	4.285	63.210	2.400<	5.000<	.500	.016
10-20	220A	7.473	5.450	2.156	59.330	1.900<	5.000<	.500	.025
20-40	221A	9.006	5.366<	.700	65.600	2.700<	5.000	.625	.053
40-60	222A	7.480	5.508<	.700	68.980	4.900<	5.000	1.000	.023
0-10	224A	1.142	.540	17.460	87.010	5.100<	5.000<	.500	.025
10-20	225A<	1.000	.342	40.510	149.400	3.300<	5.000<	.500	.027
20-40	226A	1.151	.682	21.630	153.000	2.400<	5.000<	.500<	.010
40-60	227A	1.246	.568	28.440	142.000	3.600<	5.000<	.500	.025
60-80	228A<	1.000	.341	18.340	105.100	4.600<	5.000<	.500	.036
0-10	231A	1.060	1.050	4.717	50.380	2.500	9.099<	.500	.010
10-20	232A<	1.000	.823	4.267	63.920	3.100	7.762<	.500<	.010
20-40	233A<	1.000	1.250	5.373	75.940	4.200	8.843<	.500	.010
40-60	234A	2.010	4.320	3.566	55.550	3.200<	5.000<	.500<	.010
0-10	236A	6.523	2.158	6.316	65.810	3.300<	5.000<	.500<	.010
10-20	237A	9.006	1.250	5.597	65.970	3.400<	5.000	1.700<	.010
20-40	238A	8.721	1.363	3.800	54.520	3.400<	5.000<	.500<	.010
40-60	239A	4.215	2.782	2.358	27.400	3.100<	5.000	3.500<	.010
0-10	241A	25.872	27.423	7.245	78.408	2.200	5.781<	.550	.034
10-20	243A	21.320	23.620	8.833	123.700	2.200<	5.000	.617	.010
20-40	244A	17.080	17.620	7.590	91.670	2.800<	5.000<	.500	.016
0- 10	248A	3.026	1.362	16.260	149.700	6.900	7.599	1.100	.095
10- 20	249A	4.164	2.157	14.730	111.400	6.500<	5.000<	.500	.091
20- 40	250A	4.867	3.407	16.020	105.100	7.100<	5.000<	.500	.071
40- 60	251A	6.011	4.885	16.750	99.300	8.000<	5.000<	.500	.054
60- 80	252A	8.604	11.530	18.310	101.200	8.700	6.678	2.800	.063
80-100	253A	21.110	29.870	19.710	87.050	8.400	12.070	.576	.055
0-10	626A	1.467	1.022	7.111	27.910	13.200<	5.000	7.100	.042
10-20	627A	1.202	1.619	5.668	23.260	11.000<	5.000	8.000	.022
20-40	628A	1.137	1.507	6.038	24.460	9.200<	5.000	8.600	.017
40-60	629A	2.635	3.637	4.447	18.610	9.300<	5.000	5.700	.022
0-10	634A	4.264	2.388	7.099	11.580	9.900	7.545	2.400	.042
10-20	635A	5.605	4.887	6.201	8.226	8.600<	5.000	1.100	.061
20-40	636A	4.938	5.006	6.398	11.010	10.800<	5.000	1.100	.040
40-60	637A	4.243	4.010	8.903	23.680	14.700<	5.000	1.500	.040

Table 26. Water soluble elements in profiles from Norway.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	641A	2.278	3.981	7.481	45.810	3.200	20.070	3.000	.537
10-20	642A	6.472	5.119	5.682	71.440	4.400	12.740	3.000	.465
20-40	643A	4.481	6.825	5.527	45.170	3.100	11.710	2.600	.427
0- 10	647A	2.438	1.706	2.840	32.570	4.300<	5.000	1.900	.093
10- 20	648A	3.080	4.438	1.688	39.660	6.500<	5.000	2.800	.131
20- 40	649A	2.230	5.575	1.866	31.700	3.700<	5.000	2.800	.063
40- 60	650A	1.872	5.222	1.769	28.650	4.300<	5.000	3.000	.037
60- 80	651A	1.241	9.199	3.081	30.690	5.500<	5.000	2.600	.018
80-100	652A	1.559	11.530	3.791	37.180	4.900<	5.000	5.400	.011
0-10	659A	7.621	1.818	10.640	71.670	6.300	17.760	5.300	.091
10-20	660A	9.876	2.500	10.910	77.690	7.800	20.350	1.400	.133
20-40	661A	5.198	2.303	4.727	23.280	4.700<	5.000	4.100	.101
40-60	662A	3.823	4.210	3.643	17.280	4.800<	5.000	3.800	.078
0-10	667A	2.025	.994	4.714	24.330	4.900	23.450	.776	.365
10-20	668A	10.190	7.963	6.038	17.640	4.200	7.677<	.500	.183
20-40	669A	12.310	10.150	6.460	16.200	4.100	6.896<	.500	.154
40-60	670A	10.730	9.273	5.709	17.330	3.500<	5.000<	.500	.147
0- 10	676A	4.885	.455	3.643	21.770	10.000	8.483<	.500	.152
10- 20	677A	8.470	1.136	5.113	30.080	12.200	7.853	1.000	.139
20- 40	678A	5.729	2.161	3.728	27.550	5.700<	5.000	.712	.091
40- 60	679A	5.287	2.273	3.205	23.850	3.400<	5.000<	.500	.070
60- 80	680A	3.536	1.278	3.293	22.000	4.000<	5.000	1.300	.093
80-100	681A	3.802	2.415	1.873	11.140	3.900<	5.000	1.300	.068
100-120	682A	2.953	1.875	1.873	17.400	3.800<	5.000	1.800	.062
120-140	683A	3.483	2.159	2.028	16.770	3.600<	5.000	1.500	.070
140-160	684A	3.064	2.046	2.121	17.190	4.000<	5.000	.970	.038
160-180	685A	3.536	1.988	2.672	17.320	4.900<	5.000	.926	.047
180-200	686A	3.483	1.931	2.295	13.860	5.400<	5.000	1.300	.083
200-220	687A	2.756	2.389	3.306	18.620	8.300<	5.000	1.800	.078
0-10	694A	2.777	.824	22.180	52.390	2.400	9.396	.814	.122
10-20	695A	1.347	1.816	15.350	42.970	3.100<	5.000<	.500	.152
20-40	696A	3.420	5.233	14.390	39.380	3.100<	5.000	1.400	.166
0-10	697A	27.810	30.010	9.241	15.290	20.100	22.850	.580	.061
10-20	698A	17.060	22.360	10.460	15.110	20.300	29.720	.604	.062
20-40	699A	12.000	10.490	7.089	12.070	11.800	17.110<	.500	.038
40-60	700A	8.895	5.029	10.730	38.190	14.000	15.190	1.300	.043
60-80	703A	5.835	4.607	16.080	18.760	17.500	35.730	.624<	.010
0-10	704A	2.555	1.590	12.330	21.570	10.800	13.480	.712<	.010
10-20	705A	1.029	.793	12.480	24.450	11.300	12.840	.708<	.010
20-40	706A<	1.000<	.100	9.557	24.680	8.900<	5.000	.708<	.010
40-60	707A	1.070	.454	10.130	20.800	9.000	8.678	.634<	.010

Table 26. Water soluble elements in profiles from Norway.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0- 10	708A	7.815	3.718	6.009	11.390	10.300	15.830<	.500	.015
10- 20	709A	21.520	15.480	12.240	18.720	21.400	46.920<	.500	.060
20- 40	710A	24.860	15.460	13.260	16.990	20.400	48.040<	.500	.032
40- 60	711A	1.600	.539	14.990	33.350	23.600	34.410<	.500	.022
60- 80	712A	3.044	1.248	10.530	96.670	12.200<	5.000<	.500<	.010
80-100	713A	6.569	3.065	11.330	25.930	11.100	6.242<	.500<	.010
100-120	715A	2.248	.680	9.202	77.730	15.800<	5.000<	.500<	.010

Table 27. Water soluble elements in profiles from Greenland.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	319A	5.007	3.523	2.460	8.105	4.600	6.875<	.500	.031
10-20	320A	5.438	4.209	2.405	6.992	3.900	6.220<	.500	.035
20-40	321A	6.126	4.888	2.172	5.163	4.500	5.762<	.500	.054
40-60	322A	7.058	5.797	2.824	6.661	5.000	8.294<	.500	.054
60-80	323A	6.569	4.769	2.372	7.455	6.100<	5.000<	.500	.053

Table 28. Water soluble elements in profiles from Sweden.

Depth cm	Samples No.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu
0-10	601	1.096	.882	15.930	503.800	16.900<	5.000<	.500	.062<
10-20	602<	1.000	.654	16.180	434.900	12.200<	5.000<	.500	.025<
20-40	603<	1.000	.683	18.950	459.400	21.800<	5.000<	.500	.023<
40-60	604	19.030	30.000	13.630	235.300	30.300<	5.000	.509	.013<
0- 10	607	10.780	10.590	7.048	75.270	11.300	64.850<	.500	.083
10- 20	608	1.508	1.224	13.050	121.500	14.600	70.990<	.500	.100
20- 40	609	3.488	3.612	15.420	125.400	16.100	33.580<	.500	.052
40- 60	610	7.169	7.278	10.660	91.420	10.400	46.870<	.500	.083
60- 80	611	2.552	1.591	13.710	125.200	15.200	27.660<	.500	.090
80-100	612	4.784	3.953	7.879	73.390	16.600	38.830<	.500	.206
100-120	613	2.790	1.820	9.992	87.990	20.200	56.920<	.500	.121
120-140	614	2.691	.995	11.790	101.800	26.700	93.080<	.500	.090
140-160	615	2.77	1.704	13.020	120.100	24.900	112.800<	.500	.090
0-10	624	6.771	1.023	8.635	39.360	44.300	12.230	3.900	.054
10-20	625	4.485	.882	11.530	52.990	46.000	8.187	6.100	.021
20-40	626	3.423	1.960	7.358	33.340	23.900<	5.000	2.600<	.010<
40-60	627	3.388	1.593	8.048	31.250	20.000<	5.000<	.500<	.010<

Table 29. Geometric mean of nitric soluble elements in 21 overbank profiles from nroway (10), Finland (6), Greenland (2), Sweden (2) and Spain (1). The data are normalized against the most shallow sample.

Average of normalized values

Depth (cm)	Cu	Zn	Pb	Ni	Co
0-10	1.0	1.0	1.0	1.0	1.0
10-20	0.97	0.97	0.95	0.99	0.99
20-40	0.97	0.97	0.95	0.99	1.02
40-60	0.96	0.97	0.99	1.05	0.99
60-80	0.78	0.80	0.96	0.93	0.82

Table 30. Geometric mean of water soluble elements in 21 overbank profiles from Norway (10), Finland (6), Greenland (2), Sweden (2) and Spain (1). The data are normalized against the most shallow sample.

Averages of normalized values

Depth (cm)	Al	Fe	Mg	Ca	Na	K	Mn	Cu
0-10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10-20	1.01	1.28	0.83	0.90	0.96	0.78	1.08	0.90
20-40	0.98	1.25	0.90	.106	1.03	0.75	1.04	0.90
40-60	1.04	1.34	0.93	1.13	0.97	0.66	0.87	0.69
60-80	1.11	1.45	0.96	1.25	1.11	0.73	0.79	0.60

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 5.4

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT, GREECE

Alecos DEMETRIADES

I.G.M.E., Greece

1990

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FIGURES

TABLES

1.0. INTRODUCTION

During the WEGS overbank and stream sediment survey of the Rhodope region, N.E. Greece, twenty overbank sediment profiles were sampled from ten river basins of variable size (Fig. 1). Their catchment area, however, was generally in excess of 60 km2. In each drainage basin two sample sites were selected at a distance of 60 to 100 metres apart. In addition at each sample site an active stream sediment sample was collected.

2.0. OBJECTIVES

The major objectives of the overbank sediment profile sampling were:

1. To ascertain the existence of pristine overbank sediment samples at depth.
2. To study the vertical element variation, and to determine the depth of anthropogenic pollution.
3. To study the horizontal element variation in the same drainage basin at distances up to 100 metres apart.
4. To study the element variation in different grain size fractions, and
5. To compare the results of three analytical methods, i.e., total element contents, hot nitric acid and water soluble element concentrations.

3.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

3.1. Sampling

The drainage basins for the overbank sediment profile sampling were chosen very carefully, since it was required to collect samples from two different sites 60 to 100 metres apart. At each site the overbank sediment section was cleaned, and the samples collected from the whole profile according to the following scheme: 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm, etc. till the base of the exposed section. Each sample weighed approximately 5 kg. In addition at each site a stream sediment sample was collected.

A total of hundred-and-one overbank sediment and twenty stream sediment samples were collected.

3.2. Sample preparation

All the samples were dried in two stages, i.e., initially in a heated room at a temperature of about 35°C, and then in a thermostatically controlled oven at a temperature of 80°C. The samples were afterwards disaggregated by a porcelain pestle and mortar, and sieved to the -240 mesh (-0,063 mm) fraction with a nylon screen. The whole fraction was homogenized and subsamples were placed in 125 cm^3 plastic vials.

At the Hannover meeting (6.-10.11.1989) of the Working Group, it was decided to study the element variation in different grain size fractions. So, the +0,063 mm fraction was sieved to the agreed grain-size fractions, i.e.,

-2.00 +1.00 mm
-1.00 +0.5 mm
-0.5 +0.25 mm
-0.25 +0.125 mm
-0.125 +0.063 mm.

These fractions were sent to BGR and NGU for analysis. There was a considerable delay in the preparation of these samples due to the non-availability of all the screen sizes in Greece, and the construction of a suitable sieving scheme. The results were not available during the writing of the present report. It is hoped, however, that they will be presented in the Orleans meeting in June 1990.

3.3. Analytical methods

The analysis of the Greek pilot project samples, as agreed at the Hannover meeting in November 1989, was undertaken by (a) the B.G.R. (R. Hindel) for total contents of elements, and (b) the N.G.U. (R.T. Ottesen) for acid and water soluble element concentrations.

3.3.1. Analysis of total element contents

At B.G.R. major and trace elements were determined on a 500 mg aliquot after hot digestion by a mixture of HF (38-40%) and $HClO_4$ (70%) acid, and analyzed by an atomic absorption spectrophotometer (Instrumentation Laboratory - IL 951 and VIDEO 22) for the following elements: Fe (1 ppm), Al, Ti, Ca, Pb (5 ppm), Cu (3 ppm), Zn (3 ppm), Cd (0.3 ppm), Ni (3 ppm), Co (3 ppm), Li (1 ppm), Cr, V, Mo, Be, Sr, Ba, Mn (1 ppm), Sc and Y. The values in bracket are the lower detection limits for each element, which was determined on a 500 mg sample weight and a 25 ml sample solution.

3.3.2. Analysis of hot nitric soluble elements

One gram of the minus 0.063 mm fraction was attacked by 5 ml of 7N HNO_3 at 110°C for three hours. After digestion the solution was diluted to 20.3 ml, centrifuged and decanted. Then, 1 ml of this solution was diluted with 4 ml of a reference element solution containing 20 ug/ml of Li and Y in deionized water as internal standards. The final solution thus contained 16 ug/ml of Li and Y. The elements Al, Ag, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Si, Sr, Ti, V, Zn and Zr were determined on the solution by ICP (Odegard 1980). The lower detection limits of the elements were obtained by measuring the background signal of the element line on blank samples, and then multiplying the value by 100, which is the dilution factor of the solutions. The lower detection limits of the elements in ppm are tabulated below, i.e.,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	
0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0	

3.3.3. Analysis of water soluble elements

Two grams of fine grained material (-0.062 mm) was weighed into a screw-capped plastic bottle. Afterwards 20 ml of pure water were added, the bottle was capped and shaken up and down by slow motion for two hours at a temperature of 20°C in a specially designed apparatus. The suspension was left to stand for 20 hours, and then centrifuged and decanted through a nylon filter (20 u). The solution was acidified with one drop of ultra-pure HNO3. The elements Al, Ba, Be, Ca, Cd, Co, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Si, Sr, Ti, V and Zn were finally determined on the weakly acidified solution by ICP (Odegard and Andreassen 1986). The lower detection limits of the elements in ppb are tabulated below, i.e.,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn
300	100	10	4	70	20	30	500	50
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Ba
1	6	90	40	20	4	10	6	25
Be	Sr	Li						
1	1	5						

4.0. DATA TREATMENT

The results were received just before the Orleans meeting, so it was impossible to carry out any sophisticated statistical treatment. In this report the results of only the hot nitric acid soluble elements are presented (Tables 1 to 10). Reference is made, however, to the total element concentrations.

The results of the routine overbank and active stream sediments, and those of the stream sediment sample collected near the site of the profile are tabulated for comparison purposes. The lower detection limits of the elements are also given in each table for easy reference.

5.0. DISCUSSION

Essentially, the majority of the overbank sediment profiles show pristine conditions either over their whole section or at depth. The only two profiles that are really worth discussing with respect to anthropogenic pollution are PR1 and PR2, which are sited in the Irine river to the east of Alexandroupolis (Fig. 1 and Tables 1a & 1b).

The Irine river drains an area with many mixed sulphide prospects, and particularly the St. Philip mine and its ore dressing plant. Both operations were throwing their wastes in the river for the past fifty years. The pollution of the overbank sediment is quite evident from the high values of Zn, Pb and Cu in the top 40 cm of sample site PR1 (Table 1a). Other elements, such as P, Ba, Sr and B show also anomalous values. Pristine conditions appear to exist, nevertheless, below 40 cm depth, as is indicated by the hot nitric acid soluble element contents. The total element contents, however, show a different picture with respect to Pb, which has high values over the whole section.

Site PR2 (Table 1b) has anomalous concentrations over the whole profile.

It is interesting to compare the values of Zn, Pb and Cu of the routine overbank sediment sample with especially those of profile PR1 (Table 1a), because the two sites were very close. The values of the routine overbank sediment sample (OB1) do not show the anthropogenic pollution, and are, in fact within the normal background range of the area. The reason for this abnormality lies in the way the overbank sediment sample was taken, i.e., it was collected over the whole section, but a considerably more material was taken from the lower part of the profile. So, the corollary is that in the proposed WEGS Regional Geochemical Mapping programme, although it is recommended to take the sample over the whole profile below the top first ten centimetres, in areas where there is known mining activity the sample should be collected from as low as is practically possible. This apparently is the case in other WEGS countries, where mines were in operation, i.e., Austria (Appendix 5.1), F.R. Germany (Appendix 5.2), and United Kingdom (Appendix 5.6).

The Ardas River overbank sediment profiles, PR3 and PR4 (Tables 2a & 2b) as well as the routine sample (OB1), show relatively increased levels in Pb. The routine sample has also high values in Zn. The active stream sediment sample, in this case, has values within the normal background range. The high values in Pb and Zn are from the mining activities in the Bulgarian part of Rhodope.

Other interesting geochemical features shown by the overbank sediment data are due to changes in the source material. The overbank sediment profiles from the Xanthi River, PR9 and to a lesser extent PR10 (Tables 5a & 5b) show an increase in Fe, Mg, Ni and Cr and a decrease in Ti below a depth of 40 cm, indicating that more basic material was being eroded during this period. The Filiouris River profile PR11 (Table 6a) shows a similar geochemical signature, but in this case increased values with respect to Ca and Na below 20 cm. Whereas, profile PR12 (Table 6b) has relatively high values in Si, Mg, Ca, P, Ni and Ba below a depth of 40 cm.

Overbank sediment profiles showing completely pristine conditions are PR5 (Table 3a), PR7 & PR8 (Tables 4a & b), PR9 & PR10 (Tables 5a & b), PR11 & 12 (Tables 11a & b), PR13 & PR14 (Tables 7a & b), PR17 & PR18 (Tables 9a & b) and PR19 & PR20 (Tables 10a & 10b).

6.0. CONCLUSION

The conclusions of this study are:

(i) pristine overbank sediment is common in the Rhodope region of N.E. Greece, even in areas where there is anthropogenic pollution. In such cases, where there is a known history of mining activity in the catchment area, the overbank sediment samples should be collected as low as is practically possible. It is also recommended two collect an additional sample in these areas, i.e., the first to be a composite of the whole section and should be sampled uniformly, thus recording the pollution, and a second from the lower parts of the profile, aiming for the pristine overbank sediment.

(ii) the superiority of overbank sediment sampling for low density geochemical reconnaissance has been shown in the sections where there is a definite change in the transported material as a function of point source erosion. Overbank sediment, compared to active stream sediment, is definitely a composite and reflects better the erosional history of the whole drainage basin. It is, therefore, undoubtedly is more representative than stream sediment.

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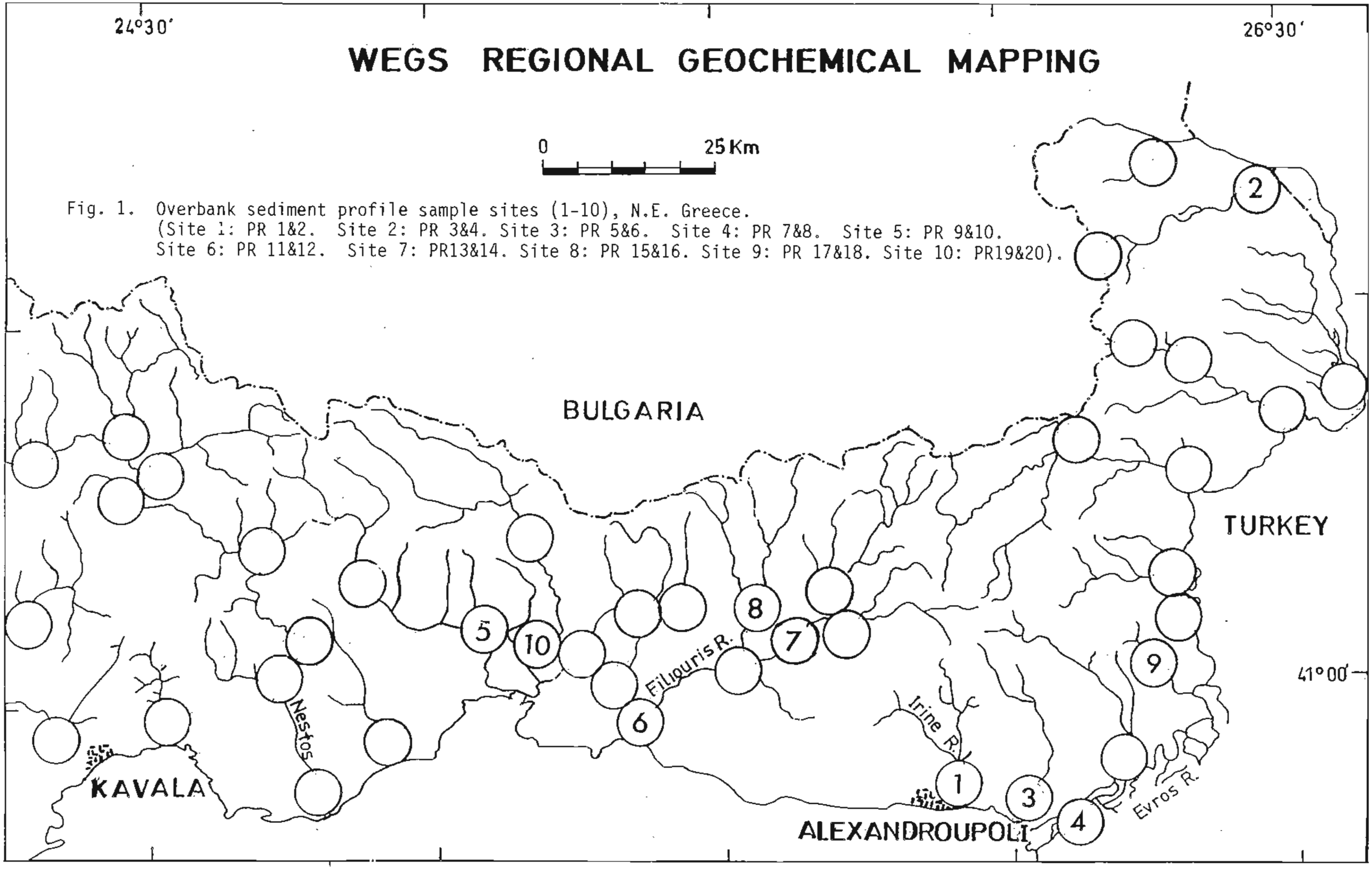

Fig. 1. Overbank sediment profile sample sites (1-10), N.E. Greece. (Site 1: PR 1&2. Site 2: PR 3&4. Site 3: PR 5&6. Site 4: PR 7&8. Site 5: PR 9&10. Site 6: PR 11&12. Site 7: PR13&14. Site 8: PR 15&16. Site 9: PR 17&18. Site 10: PR19&20).

Table 1a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Irine River, east of Alexandroupolis. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L.		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR1-1	0 - 10	165.6	19800.0	26500.0	480.5	7200.0	40400.0	312.3	3300.0	712.7	1500.0	60.3	202.1	79.7	38.3	15.0	52.5	4.0	1.0	44.6	343.4	128.5	10.2	0.9	14.9	1.3	13.5	6.5	15.8	26.7
PR1-2	10 - 20	162.7	20600.0	27100.0	474.2	7400.0	43000.0	301.6	3200.0	736.2	1500.0	64.4	214.6	97.9	38.9	15.0	52.8	4.0	1.0	45.4	370.2	136.6	8.1	1.0	15.8	1.5	13.9	6.8	15.0	27.7
PR1-3	20 - 40	148.9	21500.0	28000.0	494.8	7600.0	39800.0	315.9	3100.0	705.7	1300.0	56.0	182.9	73.6	41.9	14.0	55.7	4.2	1.0	45.8	311.7	123.8	8.1	1.1	11.4	1.4	14.7	7.0	19.0	28.0
PR1-4	40 - 60	125.6	25000.0	32800.0	630.8	8300.0	27400.0	497.0	2700.0	650.6	597.4	29.2	62.7	21.1	44.8	16.2	73.2	4.3	1.0	46.0	124.7	77.9	10.2	1.1	5.0	1.5	15.9	8.4	31.0	32.7
PR1-5	60 - 80	149.0	24300.0	30600.0	828.5	8400.0	25700.0	1100.0	2400.0	604.3	603.6	24.5	52.7	20.3	40.2	15.7	75.9	4.2	1.0	38.0	113.3	77.2	8.6	0.8	3.9	1.6	14.5	7.6	27.6	30.5
OB1		90.9	23000.0	29200.0	554.5	8100.0	24900.0	1400.0	2200.0	590.3	545.8	25.4	56.7	13.7	38.2	15.8	66.1	5.5	1.0	37.8	118.9	74.7	9.8	1.2	5.8	0.9	14.0	7.5	38.6	21.8
SS1		108.8	24700.0	27600.0	304.9	7600.0	42300.0	312.1	2200.0	916.5	627.2	71.6	787.3	311.6	44.8	13.8	50.7	4.4	8.3	37.7	219.8	91.0	9.3	1.1	8.0	0.8	14.8	6.7	25.4	20.6
PRS-1		79.7	19200.0	28900.0	815.6	7600.0	24800.0	4100.0	2700.0	670.7	850.3	37.3	157.9	72.0	33.3	14.8	79.1	5.3	1.0	38.4	143.3	79.4	8.5	1.1	12.8	2.3	14.7	6.7	22.4	27.5

Table 1b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Irine River, east of Alexandroupolis. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L.		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR2-1	0 - 10	147.0	20200.0	32500.0	378.5	6700.0	66100.0	335.9	3400.0	936.5	2000.0	111.5	568.0	236.8	42.7	15.8	48.2	5.4	1.9	58.5	959.4	206.3	8.8	4.0	20.1	1.7	12.9	6.1	8.5	28.3
PR2-2	10 - 20	133.9	19700.0	32500.0	369.0	6400.0	53300.0	253.4	3000.0	826.4	1700.0	90.5	529.0	201.3	42.5	14.6	50.3	4.9	1.5	57.4	912.5	167.8	9.3	3.4	13.1	1.5	12.7	6.2	11.0	26.7
PR2-3	20 - 40	157.2	19600.0	31600.0	355.2	6400.0	82100.0	370.3	3000.0	1000.0	2400.0	90.5	620.9	258.0	42.5	14.1	43.7	5.1	1.3	65.8	1700.0	299.1	8.2	1.6	27.9	1.7	12.1	5.5	3.0	28.0
PR2-4	40 - 60	108.5	22300.0	29000.0	340.5	7300.0	52600.0	334.9	2200.0	663.2	1000.0	56.4	317.9	147.2	42.5	13.8	53.4	3.4	1.1	47.4	392.5	239.4	9.1	1.1	8.5	1.5	13.9	6.8	13.0	26.7
OB1		90.9	23000.0	29200.0	554.5	8100.0	24900.0	1400.0	2200.0	590.3	545.8	25.4	56.7	13.7	38.2	15.8	66.1	5.5	1.0	37.8	118.9	74.7	9.8	1.2	5.8	0.9	14.0	7.5	38.6	21.8
SS1		108.8	24700.0	27600.0	304.9	7600.0	42300.0	312.1	2200.0	916.5	627.2	71.6	787.3	311.6	44.8	13.8	50.7	4.4	8.3	37.7	219.8	91.0	9.3	1.1	8.0	0.8	14.8	6.7	25.4	20.6
PRS-2		104.6	15300.0	17500.0	427.6	4900.0	20200.0	2800.0	2200.0	325.3	378.7	24.5	272.0	141.6	19.4	56.4	44.6	3.7	1.7	21.0	101.6	67.1	6.5	0.8	5.6	1.5	8.9	4.0	11.7	17.5

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 2a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Ardas River, north-east of Kastanies. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR3-1	0 - 10	69.4	11900.0	13000.0	739.4	4300.0	5700.0	512.9	1800.0	401.5	474.2	20.1	81.7	76.3	16.0	59.3	32.0	1.9	1.0	24.4	91.3	37.6	5.8	0.6	0.3	0.7	6.1	3.5	22.4	19.7
PR3-2	10 - 20	81.8	15000.0	14600.0	996.0	5200.0	7200.0	1200.0	2600.0	427.3	426.2	23.3	87.4	94.4	18.8	50.8	39.2	2.0	1.0	29.7	109.0	48.3	6.4	0.8	0.5	0.9	6.2	4.1	34.4	26.6
PR3-3	20 - 40	73.6	14600.0	15100.0	1000.0	5200.0	7600.0	1100.0	2400.0	426.5	446.1	27.9	90.5	96.4	15.3	47.6	38.8	1.7	1.0	29.2	106.7	48.7	6.4	0.8	1.6	0.9	6.1	4.2	34.7	26.2
PR3-4	40 - 60	74.8	12200.0	11400.0	750.6	4100.0	5000.0	1000.0	2200.0	351.2	330.3	15.4	69.0	64.0	12.3	57.2	29.0	2.1	1.0	22.7	98.7	42.8	5.7	0.7	0.6	0.7	5.2	3.4	21.2	18.3
OB7		58.8	18100.0	24900.0	1000.0	6800.0	9500.0	461.1	2300.0	681.1	765.0	66.9	159.6	200.5	30.6	14.3	53.2	3.6	1.9	41.6	164.4	59.1	10.9	1.4	5.1	0.8	9.9	4.9	50.5	23.6
SS																														
PRS-3		54.8	7700.0	6800.0	398.1	2500.0	4800.0	1000.0	1800.0	275.1	229.5	9.4	61.8	53.4	9.2	89.0	17.4	2.2	1.0	14.4	89.1	40.4	4.6	0.5	0.3	0.9	3.7	2.3	14.8	14.1

Table 2b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Ardas River, north-east of Kastanies. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L.		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR4-1	0 - 10	78.3	13600.0	13400.0	885.0	4500.0	6000.0	992.9	2300.0	402.7	422.2	17.9	85.4	77.0	15.4	54.0	35.9	2.5	1.0	26.3	106.5	45.9	6.6	0.7	0.3	0.7	5.7	3.8	31.0	24.8
PR4-2	10 - 20	62.7	10400.0	12100.0	718.9	4000.0	4900.0	544.3	1600.0	360.6	402.9	19.8	79.8	87.8	13.5	45.6	30.5	1.9	1.0	21.5	89.5	37.2	5.5	0.6	0.3	0.7	5.2	3.1	23.4	19.6
PR4-3	20 - 40	75.6	13500.0	13100.0	878.2	4700.0	6000.0	1100.0	2300.0	386.7	406.1	16.9	81.8	75.0	15.8	53.3	34.2	1.8	1.0	26.6	103.0	46.2	5.8	0.6	0.6	0.7	5.7	3.7	26.0	22.0
PR4-4	40 - 60	70.4	12100.0	11900.0	770.1	4100.0	5600.0	1100.0	2100.0	350.4	361.5	15.9	65.6	67.4	14.0	58.7	30.8	1.8	1.0	23.7	91.7	42.7	5.6	0.5	0.3	0.8	4.9	3.6	26.5	22.4
OB7		58.8	18100.0	24900.0	1000.0	6800.0	9500.0	461.1	2300.0	681.1	765.0	66.9	159.6	200.5	30.6	14.3	53.2	3.6	1.9	41.6	164.4	59.1	10.9	1.4	5.1	0.8	9.9	4.9	50.5	23.6
SS																														
PRS-4		64.8	8600.0	7400.0	461.8	2800.0	3700.0	897.1	1900.0	365.2	259.3	10.6	57.3	41.6	10.0	73.9	19.6	1.8	1.0	16.8	83.3	37.3	5.1	0.7	0.3	0.7	4.0	2.5	18.0	14.9

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 3a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Tsai River, south of Loutros. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L.		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR5-1	0 - 10	70.5	20200.0	28700.0	178.6	7000.0	18000.0	262.9	2200.0	644.6	655.9	28.7	66.3	18.1	35.3	12.8	52.2	4.7	1.0	38.6	121.3	70.2	7.7	0.5	1.8	1.7	17.1	7.0	31.0	31.0
PR5-2	10 - 20	68.3	21700.0	29800.0	197.8	7200.0	18000.0	259.2	2400.0	689.3	671.0	29.3	71.0	23.8	37.3	14.2	54.9	4.5	1.0	40.6	125.1	70.5	8.0	0.5	2.6	1.8	17.8	7.6	32.0	32.3
PR5-3	20 - 40	71.6	21800.0	30800.0	214.3	7500.0	19800.0	257.4	2500.0	698.5	693.9	29.6	73.0	25.9	38.8	15.6	57.1	4.7	1.0	42.1	126.9	72.5	7.9	0.8	3.6	2.0	17.5	7.5	36.4	33.3
PR5-4	40 - 60	78.1	20800.0	29900.0	182.2	7300.0	19000.0	267.7	2400.0	653.5	692.1	28.6	69.7	16.1	36.7	14.0	54.4	3.9	1.0	40.2	122.8	70.1	8.0	0.8	5.0	2.0	17.1	7.2	34.2	32.4
PR5-5	60 - 80	69.0	20300.0	29500.0	191.7	7100.0	19600.0	269.1	2300.0	629.2	730.5	27.6	66.0	17.5	36.8	14.0	54.2	4.4	1.0	38.1	118.3	72.0	7.8	0.8	5.6	1.8	16.8	7.1	35.1	32.4
PR5-6	80 - 100	73.5	19900.0	29000.0	163.4	7000.0	19000.0	268.6	2400.0	638.0	696.1	27.1	66.4	13.4	34.9	14.0	51.5	4.4	1.0	37.9	117.1	70.3	7.7	0.8	3.1	2.0	16.8	6.9	33.9	31.9
PR5-7	100 - 120	77.1	21900.0	30600.0	235.2	7400.0	19800.0	299.7	2500.0	725.5	754.6	29.0	69.7	17.8	38.4	14.9	57.7	4.5	1.0	39.7	135.2	74.7	8.2	0.8	4.2	1.9	17.1	7.5	37.7	34.3
PR5-8	120 - 140	81.5	22400.0	31000.0	235.5	7500.0	18900.0	289.0	2600.0	834.9	714.4	29.3	70.7	21.1	40.4	17.2	58.6	4.6	1.0	41.4	158.5	73.1	8.4	0.8	4.4	1.9	17.6	7.5	37.6	33.3
OB10		66.2	19400.0	29200.0	124.1	7000.0	18300.0	234.4	2100.0	654.8	687.6	27.8	66.5	18.2	37.3	14.6	48.8	4.6	1.0	37.3	121.2	68.8	8.2	0.9	4.9	0.8	15.7	6.9	44.2	23.0
SS10		113.2	20100.0	26800.0	168.1	6800.0	47900.0	316.5	2000.0	628.2	677.0	28.0	62.3	12.5	32.1	14.0	48.3	4.5	1.0	31.9	181.9	150.5	7.2	0.8	8.5	0.8	15.0	6.3	33.3	22.1
PRS-5		163.9	25500.0	26900.0	144.2	8100.0	89900.0	955.2	3200.0	677.4	566.9	28.8	66.9	21.0	39.0	13.3	52.2	5.3	1.0	42.7	160.8	285.5	6.5	1.3	11.7	3.2	20.0	7.8	7.7	30.9

Table 3b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Tsai River, south of Loutros. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR6-1	0 - 10	124.9	26500.0	31800.0	327.1	8800.0	26100.0	233.6	1900.0	887.3	560.8	34.9	97.1	33.9	45.0	16.2	62.9	4.6	1.0	52.0	137.2	70.2	7.6	0.8	3.0	1.9	16.6	8.1	30.9	33.5
PR6-2	10 - 20	93.4	27800.0	32200.0	282.9	8900.0	26100.0	219.0	1900.0	956.3	524.8	37.0	106.4	40.1	46.8	16.8	63.6	4.8	1.0	55.8	134.7	71.8	7.5	0.8	2.1	1.9	17.2	8.5	31.1	35.4
PR6-3	20 - 40	84.2	24900.0	30800.0	243.4	7600.0	23100.0	255.3	1700.0	782.2	546.6	31.0	81.7	26.9	39.7	15.6	60.7	4.0	1.0	46.4	113.8	73.9	8.2	0.8	2.1	1.8	16.3	7.8	32.3	32.1
PR6-4	40 - 60	82.6	25700.0	31500.0	242.4	8300.0	18800.0	218.1	1700.0	910.8	540.3	35.0	112.1	45.5	42.4	16.3	60.2	3.8	1.0	53.9	115.7	69.2	7.3	0.8	1.5	2.0	17.3	7.8	31.0	32.5
PR6-5	60 - 80	68.7	25000.0	30600.0	288.9	7800.0	16500.0	244.0	1700.0	850.4	573.1	32.0	88.4	27.3	38.2	15.7	61.8	3.8	1.0	48.4	106.6	66.3	7.6	0.9	2.7	2.0	17.5	7.6	33.0	31.1
PR6-6	80 - 100	102.7	26500.0	32000.0	278.8	7800.0	14800.0	266.3	1900.0	946.8	548.6	33.5	88.9	34.7	43.7	16.5	62.8	4.5	1.0	51.6	120.2	64.4	8.1	0.6	2.4	2.0	19.1	8.2	34.9	34.9
PR6-7	100 - 120	87.4	23500.0	31400.0	352.8	7600.0	13100.0	275.9	1700.0	860.0	620.3	32.6	86.5	28.3	42.1	14.8	63.5	4.0	1.0	54.1	115.5	59.7	6.9	0.7	2.2	1.8	19.4	7.4	29.3	31.7
OB10		66.2	19400.0	29200.0	124.1	7000.0	18300.0	234.4	2100.0	654.8	687.6	27.8	66.5	18.2	37.3	14.6	48.8	4.6	1.0	37.3	121.2	68.8	8.2	0.9	4.9	0.8	15.7	6.9	44.2	23.0
SS10		113.2	20100.0	26800.0	168.1	6800.0	47900.0	316.5	2000.0	628.2	677.0	28.0	62.3	12.5	32.1	14.0	48.3	4.5	1.0	31.9	181.9	150.5	7.2	0.8	8.5	0.8	15.0	6.3	33.3	22.1
PRS-6		119.0	23400.0	29500.0	285.7	7700.0	23000.0	388.8	2800.0	495.9	697.9	29.4	78.6	22.7	39.4	15.6	58.3	5.1	1.0	43.2	122.2	90.5	7.1	1.1	5.8	2.7	19.0	8.0	34.5	31.8

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS'its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 4a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Evros River, south of Ferae. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR7-1	0 - 10	125.5	35600.0	28600.0	976.5	9300.0	11600.0	1000.0	4400.0	752.1	618.1	28.8	75.7	37.7	47.0	15.2	62.0	2.6	1.0	54.5	159.7	64.9	15.1	0.7	6.6	2.3	22.0	8.4	42.7	40.4
PR7-2	10 - 20	119.9	37100.0	29300.0	1100.0	9600.0	9600.0	983.0	4400.0	657.2	642.5	31.2	88.4	40.7	44.2	15.2	63.0	2.7	1.0	56.5	169.0	62.2	14.9	0.7	4.8	2.4	22.5	8.6	44.4	41.6
PR7-3	20 - 40	122.5	37200.0	29800.0	1100.0	9400.0	6800.0	1300.0	5300.0	646.5	553.0	26.6	65.8	13.4	45.5	15.6	59.8	1.9	1.0	57.8	177.2	55.1	16.2	0.7	10.5	2.7	24.5	8.5	43.0	41.5
PR7-4	40 - 60	93.6	30400.0	26000.0	1100.0	8500.0	5600.0	1700.0	4300.0	617.1	647.9	21.9	56.1	20.1	38.2	15.2	52.7	2.9	1.0	49.2	153.1	50.7	13.2	0.6	7.7	2.2	21.7	7.2	41.5	38.4
OB22		94.4	29400.0	25500.0	782.9	8500.0	8000.0	1400.0	4200.0	542.6	575.8	26.6	67.8	28.4	37.0	13.4	50.0	4.4	1.0	49.5	165.0	53.4	14.1	1.2	9.3	1.4	19.3	6.9	49.5	26.2
SS22		91.8	33100.0	31700.0	971.8	9400.0	10600.0	382.4	3600.0	833.1	704.7	31.0	69.9	30.5	43.3	17.1	59.1	3.4	1.0	50.7	168.6	54.9	9.4	1.2	4.4	0.9	18.4	7.5	56.7	30.3
PRS-7		80.4	24300.0	21600.0	1100.0	7100.0	11200.0	504.0	3500.0	716.7	834.1	18.7	52.4	18.0	35.1	12.5	53.0	3.5	1.0	40.9	135.6	60.4	11.4	1.1	5.8	2.5	16.2	6.1	44.9	36.1

Table 4b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Evros River, south of Ferae. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR8-1	0 - 10	79.3	30900.0	26000.0	1100.0	8100.0	10400.0	551.4	4100.0	599.9	919.2	26.9	81.0	55.9	36.3	14.5	58.9	2.0	1.0	45.7	151.4	58.8	13.8	0.7	3.0	2.2	18.6	7.4	46.3	41.0
PR8-2	10 - 20	167.4	47200.0	35000.0	1000.0	11400.0	10900.0	818.7	5300.0	897.9	738.4	35.9	84.7	35.2	53.3	10.8	72.0	2.7	1.0	64.5	210.3	69.6	18.6	0.7	5.1	3.1	27.3	10.5	51.4	48.1
PR8-3	20 - 40	169.6	46400.0	34900.0	944.0	11700.0	11600.0	926.5	5000.0	928.9	731.0	34.8	76.2	26.3	53.1	19.6	70.0	2.8	1.0	65.9	209.6	70.5	18.3	0.7	5.1	3.1	27.3	10.4	52.3	49.4
PR8-4	40 - 60	118.1	39400.0	30800.0	925.1	10200.0	10600.0	819.1	4300.0	750.1	685.9	29.9	65.6	25.3	47.8	14.6	63.5	2.3	1.0	58.9	185.5	69.1	15.9	0.7	4.9	2.7	23.3	8.9	44.7	42.1
PR8-5	60 - 80	131.1	39300.0	30600.0	964.7	10700.0	9600.0	1000.0	4600.0	747.9	639.5	30.4	65.6	18.4	48.1	15.6	62.2	2.5	1.0	57.3	183.7	66.1	15.7	0.6	4.6	2.7	25.0	8.9	45.6	42.7
OB22		94.4	29400.0	25500.0	782.9	8500.0	8000.0	1400.0	4200.0	542.6	575.8	26.6	67.8	28.4	37.0	13.4	50.0	4.4	1.0	49.5	165.0	53.4	14.1	1.2	9.3	1.4	19.3	6.9	49.5	26.2
SS22		91.8	33100.0	31700.0	971.8	9400.0	10600.0	382.4	3600.0	833.1	704.7	31.0	69.9	30.5	43.3	17.1	59.1	3.4	1.0	50.7	168.6	54.9	9.4	1.2	4.4	0.9	18.4	7.5	56.7	30.3
PRS-8		95.0	33500.0	29800.0	1100.0	9600.0	13100.0	502.3	4300.0	1100.0	858.4	27.4	57.3	37.3	45.4	19.3	66.9	6.1	1.0	54.8	226.2	76.8	15.0	1.5	6.1	3.5	21.3	8.3	55.1	42.8

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS'its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 5a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Xanthi River, south of Iasmos. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR9-1	0 - 10	74.5	25400.0	23500.0	1400.0	7700.0	9100.0	377.2	3500.0	442.5	916.3	26.2	55.6	19.1	47.5	13.5	49.4	3.6	1.0	59.9	107.2	47.7	5.6	0.9	0.6	1.9	14.7	6.3	42.5	37.8
PR9-2	10 - 20	66.4	25600.0	24800.0	1300.0	8000.0	8500.0	365.9	3100.0	499.7	906.8	26.9	54.9	14.1	50.4	14.8	52.8	3.5	1.0	60.3	103.1	41.6	6.1	1.1	0.3	1.9	15.4	6.6	45.5	38.3
PR9-3	20 - 40	72.1	26600.0	25300.0	1300.0	8500.0	8500.0	362.6	3100.0	498.0	794.6	23.8	52.0	13.2	59.7	15.7	52.8	3.5	1.0	65.8	114.1	42.3	5.5	0.9	0.7	1.9	16.3	6.8	43.2	39.2
PR9-4	40 - 60	82.9	26200.0	29100.0	842.8	12100.0	6800.0	266.5	2900.0	617.3	715.4	23.6	53.8	15.3	104.4	19.4	53.7	4.0	1.0	95.0	113.5	38.5	6.2	1.0	0.9	2.2	19.3	6.9	47.8	40.9
PR9-5	60 - 80	73.8	29100.0	30600.0	917.6	11000.0	6800.0	315.0	3200.0	654.1	629.0	28.2	59.4	18.4	101.8	20.1	57.1	4.6	1.0	91.8	120.7	42.5	6.2	0.8	0.9	2.4	20.3	7.4	45.2	41.7
OB35		73.9	26800.0	24200.0	1100.0	8000.0	10100.0	327.0	2600.0	488.3	553.5	23.4	53.7	14.9	55.9	14.7	49.1	4.8	1.0	60.5	93.3	40.9	7.4	1.1	6.0	1.1	20.4	6.3	51.8	27.6
SS35		135.1	49100.0	37800.0	1100.0	11300.0	18600.0	392.5	4200.0	1100.0	740.2	43.9	85.5	24.4	82.0	20.1	70.7	7.3	1.0	87.9	198.1	87.7	9.8	1.7	5.0	1.7	22.4	11.1	71.3	38.3
PRS-9		60.0	9800.0	8100.0	481.7	2800.0	3800.0	736.6	2100.0	201.3	203.6	10.5	16.3	11.4	14.4	82.2	19.0	2.6	1.0	19.6	54.5	26.5	3.2	0.6	11.6	0.9	5.4	2.4	16.8	16.0

Table 5b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Xanthi River, south of Iasmos. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR10-1	0 - 10	69.6	26200.0	23000.0	1300.0	7700.0	8100.0	353.0	3500.0	419.6	809.4	26.2	53.7	15.0	49.0	13.0	47.7	2.6	1.0	60.8	103.0	46.5	5.1	0.8	0.3	1.9	14.7	6.2	34.9	33.5
PR10-2	10 - 20	56.5	23400.0	22900.0	1200.0	7300.0	6900.0	350.2	3200.0	448.8	859.5	22.5	48.5	14.1	46.5	13.3	48.8	2.5	1.0	56.1	100.1	35.2	5.9	0.7	[illegible]	1.9	14.7	6.0	44.5	38.6
PR10-3	20 - 40	64.8	26600.0	26900.0	1100.0	9800.0	7700.0	327.6	3200.0	580.6	743.3	25.1	54.3	13.9	78.6	17.4	52.5	3.4	1.0	78.4	113.5	41.5	5.9	0.9	2.4	2.2	17.4	6.7	45.5	39.2
PR10-4	40 - 60	68.4	26100.0	28300.0	863.6	10500.0	6900.0	298.2	2700.0	685.1	636.8	25.0	53.5	18.9	97.8	19.5	52.2	2.2	1.0	88.9	102.7	40.6	6.0	0.8	0.9	2.2	18.1	6.6	45.9	40.4
PR10-5	60 - 80	79.5	24900.0	28800.0	1300.0	8500.0	7400.0	364.6	3000.0	567.0	976.0	27.1	50.5	21.2	64.6	18.6	57.9	2.6	1.0	69.9	104.9	39.0	5.9	0.9	0.7	2.0	15.9	6.7	53.0	44.7
OB35		73.9	26800.0	24200.0	1100.0	8000.0	10100.0	327.0	2600.0	488.3	553.5	23.4	53.7	14.9	55.9	14.7	49.1	4.8	1.0	60.5	93.3	40.9	7.4	1.1	6.0	1.1	20.4	6.3	51.8	27.6
SS35		135.1	49100.0	37800.0	1100.0	11300.0	18600.0	392.5	4200.0	1100.0	740.2	43.9	85.5	24.4	82.0	20.1	70.7	7.3	1.0	87.9	198.1	87.7	9.8	1.7	5.0	1.7	22.4	11.1	71.3	38.3
PRS-10		84.1	20400.0	14900.0	677.7	4900.0	5600.0	494.6	3000.0	317.2	342.7	15.0	32.5	10.0	30.4	57.5	34.7	2.8	1.0	37.0	80.7	33.2	4.6	1.0	2.0	1.8	10.2	4.4	27.2	22.6

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS'its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 6a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Filiouris River, west of Xilagani. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR11-1	0 - 10	89.0	34700.0	35000.0	860.1	15300.0	5800.0	812.8	2800.0	732.1	495.1	38.1	66.3	17.4	102.0	20.1	71.6	3.5	1.0	124.0	188.0	35.6	9.4	0.8	4.2	2.6	18.7	10.5	26.7	34.0
PR11-2	10 - 20	106.0	39200.0	37900.0	1000.0	18000.0	7100.0	996.3	3300.0	794.8	519.6	41.4	71.8	21.2	118.2	22.9	80.6	4.7	1.0	140.5	221.2	42.5	10.1	1.0	6.7	2.6	20.4	11.7	30.0	37.4
PR11-3	20 - 40	128.9	42100.0	40200.0	989.4	20300.0	14800.0	1400.0	3400.0	808.3	528.4	45.1	77.6	13.4	125.5	23.2	84.4	4.1	1.0	151.7	239.0	57.5	11.0	1.5	8.3	3.1	21.4	12.4	33.9	39.9
PR11-4	40 - 60	137.1	38600.0	37300.0	889.5	18700.0	16700.0	2200.0	3600.0	841.8	542.0	40.5	72.8	17.8	113.2	20.8	76.1	4.2	1.0	133.8	196.8	66.9	10.5	1.3	5.5	2.7	19.9	11.4	32.7	36.2
PR11-5	60 - 80	116.5	33500.0	32800.0	783.8	15400.0	11500.0	3300.0	3600.0	709.6	516.7	34.0	66.5	12.8	89.9	18.0	66.8	3.6	1.0	112.7	141.0	54.4	9.3	1.1	4.4	2.5	17.4	9.5	30.6	33.9
OB36		77.7	29000.0	31400.0	759.5	14400.0	9200.0	1400.0	2800.0	624.1	529.7	32.7	64.3	16.9	104.1	18.3	64.1	7.0	1.0	119.4	155.9	41.7	9.9	1.5	7.2	1.4	14.5	8.9	42.5	23.0
SS36		120.3	34400.0	35700.0	463.2	16800.0	17800.0	8700.0	4900.0	1300.0	575.2	33.2	80.0	16.6	108.7	20.7	64.4	7.4	1.0	106.3	190.4	72.5	11.1	1.3	17.0	1.6	23.5	9.5	49.1	28.5
PRS-11		137.2	37500.0	37200.0	707.9	16500.0	9700.0	9000.0	5600.0	892.2	588.4	36.1	79.5	27.2	98.1	20.9	76.0	6.7	1.0	108.0	147.8	54.1	11.3	1.5	18.9	4.0	25.7	11.0	40.7	38.3

Table 6b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Filiouris River, west of Xilagani. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR12-1	0 - 10	77.2	34700.0	33400.0	761.3	13600.0	5600.0	640.6	3200.0	492.0	405.0	34.9	64.1	8.8	90.2	15.4	68.3	3.2	1.0	117.6	110.1	31.3	10.1	0.7	2.5	2.4	17.6	10.3	20.4	31.4
PR12-2	10 - 20	80.4	35800.0	35000.0	829.5	14000.0	5900.0	643.0	3000.0	649.7	420.4	36.4	64.7	15.2	91.9	17.7	71.9	2.3	1.0	117.5	121.6	32.9	10.4	1.0	2.1	2.4	18.1	10.5	24.9	32.4
PR12-3	20 - 40	89.9	36000.0	35700.0	874.0	15200.0	6200.0	652.9	2800.0	758.5	441.9	37.4	67.0	17.2	103.1	20.2	73.1	3.2	1.0	124.2	138.1	34.1	9.9	1.1	2.6	2.6	18.4	10.6	29.4	34.4
PR12-4	40 - 60	114.9	38000.0	36500.0	919.0	17300.0	12500.0	752.8	3000.0	768.4	484.0	39.7	68.8	16.6	110.0	21.2	75.5	4.2	1.0	134.2	177.5	45.4	9.9	1.2	3.7	2.9	19.3	11.2	31.4	35.9
PR12-5	60 - 80	126.7	37300.0	35900.0	962.6	17800.0	15700.0	1200.0	3100.0	807.0	474.1	39.8	66.1	16.3	112.9	20.6	75.0	3.7	1.0	132.2	192.3	61.0	9.3	1.1	5.	2.6	19.4	11.[illegible]	29.3	36.3
OB36		77.7	29000.0	31400.0	759.5	14400.0	9200.0	1400.0	2800.0	624.1	529.7	32.7	64.3	16.9	104.1	18.3	64.1	7.0	1.0	119.4	155.9	41.7	9.9	1.5	7.2	1.4	14.5	8.9	42.5	23.0
SS36		120.3	34400.0	35700.0	463.2	16800.0	17800.0	8700.0	4900.0	1300.0	575.2	33.2	80.0	16.6	108.7	20.7	64.4	7.4	1.0	106.3	190.4	72.5	11.1	1.3	17.0	1.6	23.5	9.5	49.1	28.5
PRS-12		70.8	15900.0	9100.0	418.2	3400.0	7300.0	1300.0	2800.0	419.6	152.8	6.0	25.6	10.5	24.0	30.2	24.2	1.7	1.0	18.5	130.5	61.3	8.8	0.5	1.3	1.1	6.1	2.6	16.5	16.1

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 7a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Xiroremma River, east of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR13-1	0 - 10	92.2	26400.0	34000.0	1500.0	12100.0	13400.0	600.9	3300.0	705.7	884.6	36.8	53.1	15.6	63.4	21.3	78.3	5.0	1.0	92.1	88.6	35.4	6.2	1.2	3.1	2.1	12.6	10.8	21.4	27.8
PR13-2	10 - 20	90.5	29000.0	35800.0	1600.0	13100.0	15800.0	682.5	3100.0	772.5	812.2	41.0	56.4	11.6	63.7	22.1	85.5	5.5	1.0	93.5	94.4	42.2	6.3	1.3	4.5	2.3	13.9	11.8	22.8	29.7
PR13-3	20 - 40	93.5	30000.0	37300.0	1600.0	13900.0	16600.0	728.3	2900.0	812.9	791.5	43.5	58.6	11.3	69.4	23.0	89.0	6.0	1.0	100.5	96.0	44.3	6.1	1.4	3.2	2.3	13.8	12.4	23.6	30.6
PR13-4	40 - 60	85.2	27600.0	35900 0	1500.0	13300.0	18500.0	691.5	2900.0	757.9	776.0	38.4	53.7	13.7	66.9	21.7	83.8	4.7	1.0	95.8	94.4	49.4	5.9	1.2	1.7	2.1	13.0	11.9	24.4	30.7
PR13-5	60 - 80	103.0	31000.0	39500.0	1400.0	15900.0	20100.0	1500.0	2900.0	811.6	736.7	44.4	59.8	14.4	78.9	24.1	89.9	6.1	1.0	105.4	125.6	59.8	6.1	1.3	2.5	2.4	14.1	12.9	26.9	33.5
PRS-13		144.3	36000.0	36000.0	636.3	17700.0	15200.0	12400.0	5600.0	1400.0	616.0	34.2	79.6	26.3	112.1	20.1	72.6	6.8	1.0	116.2	165.4	77.7	10.3	1.4	23.5	3.8	26.0	10.4	40.8	39.2

Table 7b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Xiroremma River, east of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR14-1	0 - 10	81.0	28800.0	33400.0	1400.0	11500.0	13500.0	602.4	4000.0	726.3	856.2	36.3	58.3	12.3	59.5	19.9	76.6	4.3	1.0	85.8	101.6	40.5	7.6	1.3	3.2	2.1	15.0	10.6	22.1	27.4
PR14-2	10 - 20	86.5	30000.0	35100.0	1500.0	12300.0	15300.0	669.5	3300.0	777.2	779.5	39.0	58.0	11.3	63.0	22.5	81.0	5.6	1.0	91.6	102.9	42.5	7.6	1.4	3.6	2.3	15.6	11.3	24.2	29.4
PR14-3	20 - 40	75.9	28000.0	33200.0	1400.0	11000.0	14200.0	638.9	3000.0	731.9	731.2	36.2	54.2	13.3	61.2	20.5	75.8	4.5	1.0	85.8	99.7	39.9	7.1	1.1	1.7	2.0	14.7	10.6	21.1	27.9
PR14-4	40 - 60	76.1	27900.0	32100.0	1300.0	9900.0	13300.0	537.7	3100.0	703.8	738.5	34.4	52.2	14.0	57.5	20.0	73.1	4.3	1.0	83.0	104.8	39.6	7.9	1.3	1.7	2.3	14.1	10.3	22.4	26.1
PR14-5	60 - 80	98.9	27500.0	32200.0	1300.0	10200.0	14200.0	605.7	3000.0	704.3	759.3	34.2	51.8	14.2	61.6	20.6	75.3	4.3	1.0	84.3	115.1	41.6	7.4	1.3	4.9	2.2	13.8	10.4	22.3	25.9
PRS-14		81.6	19900.0	23400.0	1400.0	9700.0	13000.0	997.0	3000.0	464.3	480.2	20.5	35.0	9.1	45.4	40.0	63.3	3.7	1.0	77.0	65.2	32.2	4.5	1.0	1.7	2.0	8.8	8.5	13.9	19.8

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample.

Table 8a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Makropotamos River, east of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR15-1	0 - 10	76.8	21000.0	32000.0	647.3	18200.0	7200.0	275.5	2300.0	875.3	626.8	23.9	50.6	22.1	190.1	24.6	63.2	6.1	1.0	195.0	110.1	33.7	6.6	1.2	3.0	2.5	10.2	6.6	35.8	33.1
PR15-2	10 - 20	85.0	21200.0	30400.0	192.2	8500.0	26500.0	203.1	2100.0	980.4	575.0	27.6	55.4	25.3	58.9	18.5	58.1	5.0	1.0	59.8	146.4	78.9	7.3	1.0	2.7	2.2	11.2	6.7	32.3	30.7
PR15-3	20 - 40	74.5	22800.0	36000.0	339.9	9500.0	11700.0	270.4	2100.0	597.5	527.7	34.0	68.6	43.1	87.9	23.7	64.8	5.9	1.0	99.1	148.5	48.5	9.2	1.4	[illegible]	2.7	10.6	6.3	35.9	33.3
PR15-4	40 - 60	98.0	32900.0	47900.0	92.7	7100.0	6200.0	259.0	2400.0	593.2	554.8	62.4	116.8	62.4	26.0	19.6	80.6	8.6	2.5	33.8	169.8	41.4	10.7	1.5	0.5	3.4	12.2	6.8	31.5	34.3
PRS-15		74.0	16000.0	20400.0	1200.0	8500.0	9800.0	779.4	2100.0	407.9	416.4	18.8	29.7	9.6	41.8	[illegible]	53.9	4.0	1.0	67.5	51.8	27.1	3.6	1.0	0.6	1.8	7.2	7.4	11.3	16.8

Table 8b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Makropotamos River, east of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR16-1	0 - 10	72.0	20600.0	28300.0	610.7	16800.0	6500.0	331.1	2400.0	636.3	594.4	22.4	54.0	21.7	174.8	22.0	59.5	5.4	1.0	171.6	97.1	31.8	6.9	1.3	3.1	2.1	10.1	6.4	31.4	28.9
PR16-2	10 - 20	73.5	21600.0	30800.0	549.6	14900.0	6000.0	342.6	2300.0	625.1	569.2	24.8	51.0	20.1	149.3	23.2	58.4	5.3	1.0	155.4	113.2	31.8	7.0	1.0	1.6	2.3	10.9	6.7	32.3	30.6
PR16-3	20 - 40	74.7	22000.0	35500.0	419.6	10400.0	5200.0	307.7	2000.0	520.5	559.0	31.4	61.8	39.1	94.4	23.7	69.0	5.8	1.0	122.1	148.9	36.1	8.5	1.3	0.4	2.6	11.0	6.5	38.9	34.1
PR16-4	40 - 60	126.6	38000.0	34200.0	91.0	7300.0	5400.0	312.0	2800.0	1200.0	216.4	58.3	121.8	57.9	24.9	16.7	70.6	5.3	1.0	35.8	203.2	46.1	13.1	1.1	0.3	2.8	14.1	8.1	38.8	34.1
PRS-16		84.3	27500.0	31200.0	637.0	16000.0	9100.0	251.4	3100.0	763.3	579.3	31.1	65.4	32.0	138.4	22.6	64.6	5.7	1.0	137.8	125.5	40.2	8.8	1.0	2.7	3.0	15.9	8.3	37.2	36.2

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample.

Table 9a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Kara River, south of Provatonas. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.l		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR17-1	0 - 10	142.4	22800.0	12800.0	548.0	5700.0	11400.0	1400.0	3500.0	300.1	231.9	8.4	27.4	12.0	39.8	34.1	31.7	1.7	1.0	32.2	174.6	92.6	12.4	0.6	2.8	1.4	9.3	3.8	20.6	19.0
PR17-2	10 - 20	115.8	20300.0	10700.0	571.3	4400.0	8300.0	1600.0	3700.0	272.8	173.4	6.5	20.4	16.1	28.4	33.2	28.6	1.8	1.0	24.7	167.1	82.0	9.9	0.5	1.1	1.1	7.3	3.3	19.4	17.8
PR17-3	20 - 40	118.4	18600.0	10600.0	568.6	4100.0	8400.0	1500.0	3300.0	279.8	178.5	5.9	19.4	11.6	27.8	32.4	29.7	1.0	1.0	23.0	147.8	78.4	9.5	0.5	2.1	1.2	6.3	3.1	20.2	18.5
PR17-4	40 - 60	81.4	16000.0	9000.0	489.7	3100.0	6900.0	1600.0	3300.0	247.9	126.7	4.9	16.0	9.5	19.6	38.4	26.1	1.6	1.0	16.2	142.0	72.3	7.6	0.5	1.2	0.8	4.9	2.4	20.1	17.4
PR17-5	60 - 80	89.0	18400.0	9100.0	453.1	3400.0	6200.0	2100.0	4200.0	270.6	101.1	4.8	16.3	6.9	19.6	35.3	24.1	1.0	1.0	15.0	192.7	87.7	8.9	0.5	0.6	1.0	5.3	2.5	17.6	15.4
OB41		65.3	23000.0	17900.0	472.4	7400.0	16300.0	474.0	2400.0	575.1	354.8	12.5	39.2	18.0	62.2	14.8	40.3	3.9	1.0	46.4	164.7	99.7	13.3	1.2	4.2	1.4	10.8	4.2	45.9	19.7
SS41		81.0	21100.0	15900.0	436.1	6400.0	25100.0	505.7	2500.0	2300.0	438.1	12.1	128.2	27.5	48.5	11.3	35.7	2.4	2.6	39.3	180.2	105.6	12.4	0.7	6.4	0.9	10.2	3.9	32.2	15.9
PRS-17		64.0	13300.0	15800.0	261.6	7200.0	4000.0	312.2	2200.0	397.9	294.5	14.9	34.0	19.8	52.5	44.3	32.3	3.1	1.0	64.2	67.8	21.2	3.9	0.5	1.3	1.6	7.5	3.5	16.3	17.4

Table 9b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Kara River, south of Provatonas. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR18-1	0 - 10	76.0	23300.0	15500.0	616.2	6800.0	17200.0	641.1	2700.0	476.5	356.2	11.5	34.7	17.4	48.4	10.6	38.4	1.9	1.0	40.1	196.1	111.2	12.4	0.9	2.6	1.8	10.4	4.0	26.9	22.9
PR18-2	10 - 20	80.4	14300.0	8900.0	450.4	2500.0	4700.0	1700.0	3200.0	289.4	111.3	4.3	14.7	5.2	14.5	31.4	26.2	1.0	1.0	12.9	138.4	64.0	7.9	0.5	1.2	0.7	4.4	2.2	17.3	16.2
PR18-3	20 - 40	116.2	19500.0	11500.0	471.3	4600.0	9600.0	1100.0	2600.0	300.2	166.1	6.6	20.8	10.7	30.3	26.1	30.8	1.3	1.0	25.3	132.4	76.6	8.5	0.9	1.9	1.1	6.9	3.0	21.7	17.9
PR18-4	40 - 60	125.9	22300.0	11700.0	525.7	5000.0	8900.0	1500.0	3600.0	317.3	156.1	6.9	21.7	8.6	33.5	27.8	29.7	1.0	1.0	25.9	190.5	97.2	10.1	0.8	1.8	1.2	7.4	3.5	21.1	17.7
PR18-5	60 - 80	87.2	24800.0	18400.0	509.1	7200.0	15900.0	445.3	2500.0	502.2	337.7	11.8	36.9	25.1	61.0	13.2	41.5	2.7	1.0	46.9	163.5	95.3	13.4	0.9	2.6	1.9	11.8	4.4	28.9	24.4
DB41		65.3	23000.0	17900.0	472.4	7400.0	16300.0	474.0	2400.0	575.1	354.8	12.5	39.2	18.0	62.2	14.8	40.3	3.9	1.0	46.4	164.7	99.7	13.3	1.2	4.2	1.4	10.8	4.2	45.9	19.7
SS41		81.0	21100.0	15900.0	436.1	6400.0	25100.0	505.7	2500.0	2300.0	438.1	12.1	128.2	27.5	48.5	11.3	35.7	2.4	2.6	39.3	180.2	105.6	12.4	0.7	6.4	0.9	10.2	3.9	32.2	15.9
PRS-18		76.9	17100.0	9900.0	424.5	4100.0	7700.0	1400.0	3200.0	219.4	174.6	6.4	19.7	8.9	24.9	32.9	25.0	1.3	1.0	20.5	152.9	72.1	10.1	0.5	0.7	1.4	6.7	2.9	18.0	17.3

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS' its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

Table 10a. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Kompsatos River, west of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR19-1	0 - 10	84.1	25300.0	27300.0	977.0	8600.0	5700.0	271.6	3700.0	577.0	904.9	23.4	61.2	30.0	51.7	15.3	55.0	4.3	1.0	55.4	115.7	34.1	8.6	1.1	2.2	2.7	15.3	6.7	52.1	41.4
PR19-2	10 - 20	90.7	25400.0	27600.0	963.2	8800.0	6000.0	276.5	3200.0	593.1	865.9	23.7	58.0	26.2	54.9	15.4	55.7	4.9	1.0	55.8	116.2	37.1	8.7	1.1	2.1	2.7	15.9	6.7	52.6	42.4
PR19-3	20 - 40	72.5	27500.0	28800.0	972.0	9200.0	6000.0	284.0	4000.0	644.8	751.7	25.7	65.8	27.4	53.3	16.3	57.3	5.1	1.0	58.8	120.9	36.6	8.9	1.0	2.3	3.0	17.9	7.2	44.2	40.0
PR19-4	40 - 60	87.4	29400.0	30900.0	1100.0	9700.0	5800.0	294.0	4600.0	723.7	844.6	26.2	69.7	34.2	54.6	17.7	61.5	5.9	1.0	59.4	126.1	36.4	9.7	1.1	3.3	3.0	18.2	7.7	50.4	41.7
PR19-5	60 - 80	99.1	27100.0	29000.0	1100.0	9600.0	5500.0	300.5	4100.0	670.9	759.0	25.3	60.6	25.8	62.8	16.4	58.8	4.6	1.0	55.9	126.3	33.2	8.6	1.2	2.9	3.1	16.7	7.3	51.8	42.8
PR19-6	80 - 100	182.2	25600.0	30300.0	1200.0	11200.0	6300.0	310.9	3400.0	716.6	948.9	24.0	58.3	26.3	78.7	18.3	62.8	5.8	1.0	64.9	127.2	34.0	8.5	1.4	3.3	3.0	15.0	7.4	60.7	47.7
OB21		90.9	26600.0	28700.0	843.9	10900.0	8700.0	1000.0	3800.0	873.9	714.2	25.5	63.3	28.2	51.3	15.4	53.0	5.7	1.0	50.2	137.5	66.8	9.1	1.2	4.8	1.5	16.0	6.9	57.5	29.6
SS21		102.9	34600.0	33300.0	1100.0	9900.0	11100.0	407.0	3800.0	875.0	765.9	33.1	73.4	30.7	46.2	18.7	62.4	2.7	1.0	52.3	178.3	58.4	9.8	1.3	4.6	1.1	19.4	7.8	59.0	32.2
PRS-19		61.0	26600.0	27200.0	987.9	10400.0	9500.0	402.9	3400.0	584.8	791.1	28.0	70.5	35.2	63.4	15.6	55.5	4.5	1.0	65.4	121.5	48.2	7.6	1.1	1.5	2.8	19.4	7.0	47.0	40.2

Table 10b. Hot HNO3 acid extractable elements in overbank sediment profile samples (-0.063 mm fraction), Kompsatos River, west of Komotini. (Values in ppm).

	Depth in cm	Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P	Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La
L.Det.L		10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0	0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3	0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0
PR20-1	0 - 10	78.6	27100.0	28600.0	999.1	8800.0	6800.0	310.0	3600.0	651.4	910.0	25.9	65.3	31.2	49.7	15.8	58.0	4.8	1.0	53.7	133.1	38.7	8.5	1.0	1.7	3.0	16.2	7.4	53.2	43.5
PR20-2	10 - 20	87.5	25000.0	27300.0	1100.0	8800.0	7200.0	325.2	3200.0	560.4	929.5	23.6	56.3	23.5	47.9	15.0	57.2	5.2	1.0	53.9	126.8	38.3	8.8	1.3	2.3	2.7	14.7	6.8	57.7	44.8
PR20-3	20 - 40	86.7	27900.0	29300.0	1100.0	9100.0	8900.0	319.5	3500.0	695.9	920.6	25.0	63.3	25.2	46.7	16.7	61.4	5.0	1.0	54.2	134.2	46.7	8.5	1.2	1.7	3.0	16.3	7.5	62.3	49.7
PR20-4	40 - 60	77.5	27400.0	29100.0	868.2	9000.0	8500.0	288.3	3000.0	711.5	803.1	23.8	58.5	20.9	49.6	16.7	56.4	5.7	1.0	54.3	132.1	46.1	8.7	1.3	1.7	3.1	15.9	7.0	58.6	44.5
PR20-5	60 - 80	78.3	33200.0	33200.0	933.3	9700.0	7200.0	286.0	3500.0	769.5	744.8	29.0	65.6	28.1	59.2	17.9	63.8	5.1	1.0	64.4	142.6	45.4	8.9	1.3	2.4	3.2	19.5	8.3	58.4	46.5
PR20-6	80 - 100	68.1	28800.0	35800.0	1300.0	11900.0	6000.0	263.9	3600.0	631.2	807.9	39.4	61.2	40.4	68.6	22.0	70.5	5.6	1.0	73.9	136.8	33.2	8.0	1.4	0.9	3.1	18.1	8.3	53.6	44.9
OB21		90.9	26600.0	28700.0	843.9	10900.0	8700.0	1000.0	3800.0	873.9	714.2	25.5	63.3	28.2	51.3	15.4	53.0	5.7	1.0	50.2	137.5	66.8	9.1	1.2	4.8	1.5	16.0	6.9	57.5	29.6
SS21		102.9	34600.0	33300.0	1100.0	9900.0	11100.0	407.0	3800.0	875.0	765.9	33.1	73.4	30.7	46.2	18.7	62.4	2.7	1.0	52.3	178.3	58.4	9.8	1.3	4.6	1.1	19.4	7.8	59.0	32.2
PRS-20		64.5	13400.0	14900.0	905.1	5500.0	4600.0	791.2	2800.0	281.0	464.0	11.3	27.1	16.0	21.0	61.4	34.8	3.0	1.0	32.6	67.9	24.7	4.4	0.6	0.7	1.5	8.4	4.4	32.9	27.7

Note: 'PR' denotes the overbank sediment samples from vertical profiles and 'PRS'its corresponding stream sediment sample. 'OB' denotes the routine overbank sediment sample and 'SS', its corresponding stream sediment.

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PILOT PROJECT

APPENDIX REPORT 5.5

AN INTRODUCTION TO FLOODPLAIN OVERBANK DEPOSITS AND HEAVY METALS IN THE WICKLOW REGION, IRELAND

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1990

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1.0. INTRODUCTION

Heavy metals have been used extensively in geomorphological studies over the past twenty years primarily as a means to elucidate the controls and processes of valley alluviation (flood-plain formation). They are used as sediment tracers, whose transport paths may be examined within the fluvial system, and as a short-term geochronological technique to provide an estimate of flood plain age (where accurate chronological records of mining activity exist).

The analysis of heavy metal concentrations, principally using the metal ores of lead, zinc and copper, has been used in the Wicklow region flood plains to help explain spatial and temporal variations in flood plain development. The relative concentrations of lead, zinc and copper within the overbank deposits provides one criterion for the identification of flood plains of differing age and construction mechanism, i.e., those dominated by fine overbank materials (vertical accretion flood plains) and those dominated by a coarser deposit of sand and gravel (lateral accretion).

2.0. STUDY AREA

Studies in this area to date have collected geochemical data from overbank facies in the Glendasan, Glengalough, and Glenmalure valleys. These three valleys from the headwater glens of the Avonmore, Avonbeg and Avoca rivers, which form the principal drainage systems within the region. The geology of this area is outlined in Figure 2.

During the eighteenth and nineteenth centuries, mining of lead and zinc ores occurred in these three glens. Rectilinear fissure veins up to two miles long typically consist of coarse grained galena and sphalerite with minor chalcopyrite and pyrite occurring in a quartz and baryte gangue. Veins were worked in shafts in the valley floor and in adits along the valley side slopes. The output from Ballinafunshogue (T055 915) in 1811 was 334 tons of lead, 270 in 1845, and 144 in 1852. Between the years 1853-1856 the mine was not in operation. The copper mine at Avoca has a more recent history. Here the ore bodies extend conformably along the strike for about 3.5 miles and dip south-easterly in direction. Between 1840 and 1918 almost 2.5 million tons of ore were mined and upon recommencing in 1958, a further 693 tons of copper concentrate were produced.

3.0. ANALYSIS

Heavy metal concentrations were analyzed using both AAS and

XRF procedures. Data is available for individual 10 cm layers within overbank facies sequences at selected sites throughout thiw region (Fig. 1). Particle size analysis allowed the relationship between metal concentration and sediment size to be examined. Additional data include carbonate and organic materials and their relationship with metal concentration.

4.0. SAMPLE SITES

Overbank materials range in thickness from 20 cm to 4 m, depending upon position within the rivers (i.e., those sites in the headwaters show a consistent tendency to have less overbank deposits - a product of energy and supply) and the nature of the depositional environment.

The concentration of lead and zinc ores varied both down valley and at-a-site. An instance of such local variability is found at site 7 along the Glenmalure River, where different levels of metals were found on the right and left bank of the contemporary channel (Fig. 3). The right bank of the river is cut into fine-grained silts and clays exposed to a depth of about 3 m. This material has been dated by radiocarbon and produced an age of about 3,900 years bp. Metal concentrations in this material are considerably lower (average 100 ppm Pb and 83 ppm Zn) than those found on the right bank immediately opposite (average 1500 ppm Pb and 500 ppm Zn). This right bank flood plain was formed as an immediate consequence of mining activity (channel shift in relation to increased sediment supply from mining activity) and is, therefore, considerably younger than the left bank flood plain. In this instance, the right flood plain was constructed contemporaneously with metal mining, and its sediments illustrate this by a much higher degree of contamination. This spatial variability exists at several other sites throughout the valley, and illustrates the caution required when sampling environments of different age and sedimentary character.

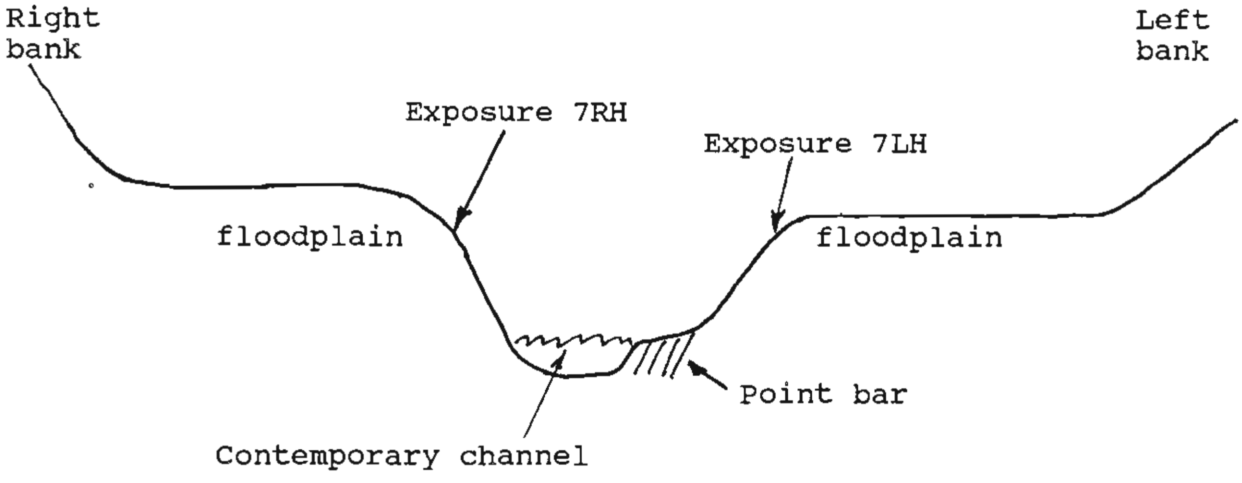
Heavy metal concentrations decline almost exponentially downstream in response to declining distance from the source of input (i.e., mining spoils and adits up-valley), but complex relationships were also found to exist between metal concentration and other variables, such as particle size, loss on ignition, and the character of the flood plain environment.

Heavy metal ores provide an excellent opportunity to examine many geomorphological processes found in flood plain formation. Overbank facies are present throughout most fluvial systems, in varying degrees of thickness, and provide the ideal sedimentary environment for assessing metal concentrations in geochemical and geomorphological investigations.

Table 1. Pb and Zn contents in overbank sediment profiles (sample sites 7RH and 7LH), Glenmalure River.

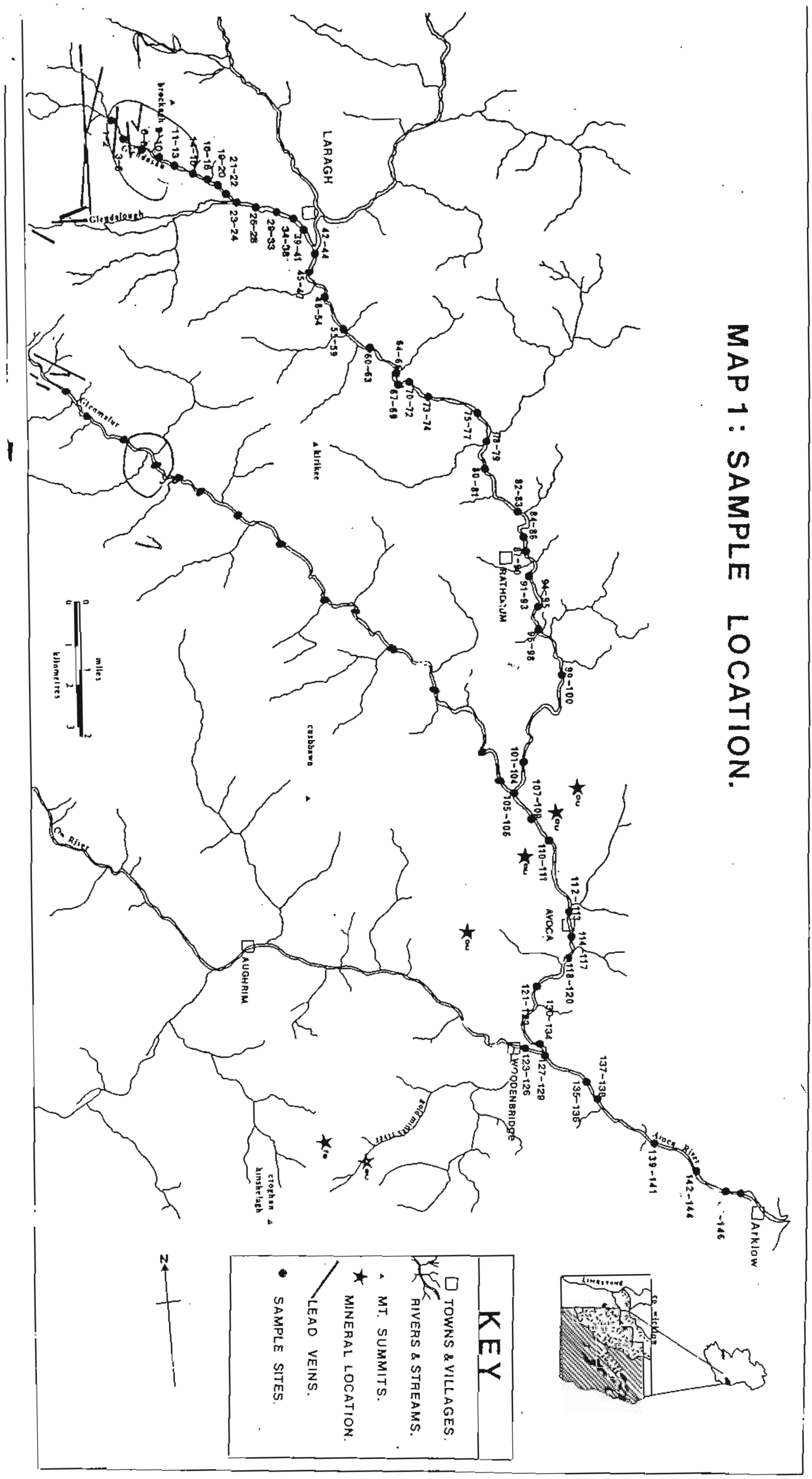
	Right bank (7RH)		Left bank (7LH)	
Depth in cm	Pb (ppm)	Zn (ppm)	Pb (ppm)	Zn (ppm)
0 - 10	218	113	2024	150
10 - 20	127	107	2986	118
20 - 30	192	121	1684	85
30 - 40	156	109	1922	98
40 - 50	83	73	1533	71
50 - 60	100	71	1352	82
60 - 70	121	100	1015	67
70 - 80	105	111	1516	84
80 - 90	132	115	1612	100
90 - 100	143	100	1718	92
100 - 110	122	101		
110 - 120	117	83		
120 - 130	121	93		
130 - 140	166	105		

Fig. 3. Schematic section showing overbank sediment sample site number seven, Glenmalure River.



Overbank sediment profile 7RH: Fine grained silty material.
Overbank sediment profile 7LH: Fine to coarse sandy material with distinct peat laminations.

MAP 1: SAMPLE LOCATION.



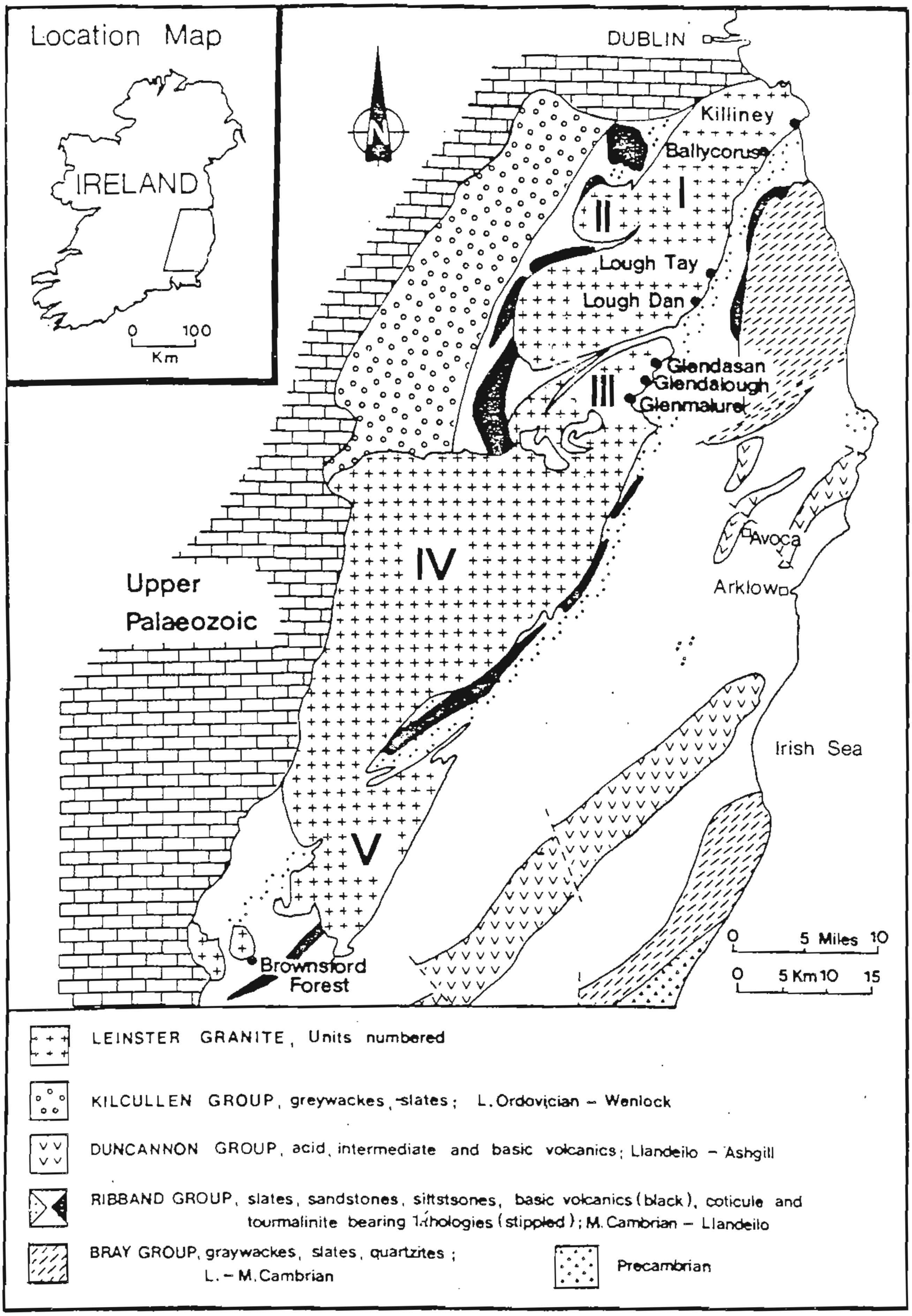


FIGURE 2. - Location and general geology (Based on Blucketal 1979).

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PILOT PROJECT

APPENDIX REPORT 5.6

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT PROFILES, SWEDEN

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1990

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FIGURES

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1.0. INTRODUCTION

During the field excursion to Sweden (18.-20. September 1989), 3 overbank sediment profiles were sampled in southern Sweden (Fig. 1). The drainage area varied between 60 and 600 km^2. In addition at each site an active stream sediment sample was collected.

2.0. OBJECTIVE

The purpose of the study was to

- determine the depth of anthropogenic pollution, and
- ascertain the existence of pristine overbank sediment samples at depth.

3.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

3.1 Sampling

At each site the overbank sediment section was cleaned, and the samples collected from the whole profile according to the following scheme: 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm etc. until the base of the exposed section. A composite sample was taken as well from 10 cm to the base of the profile. Each sample weighed approximately 2 kg. In addition, at each site, an active stream sediment sample was collected. A total of 28 samples was collected.

3.2 Sample preparation

The samples were air-dried and sieved to the -0.063 mm fraction with a nylon screen.

3.3 Analytical methods

The samples were analyzed for hot nitric acid soluble and water soluble elements by ICP. The analytical methods are described in Appendix report 8.

4.0. RESULTS

The results for a limited number of elements are shown in Tables 1 to 6. All the analytical data are given in Tables 7 and 8.

5.0. DISCUSSION

There is no systematic trend of variation in the element concentrations with depth.

6.0. CONCLUSION

There does not seem to be any serious problems with anthropogenic pollution in the three overbank sediment profiles studied in southern Sweden. It is, therefore, possible to sample pristine overbank sediment samples in this area.

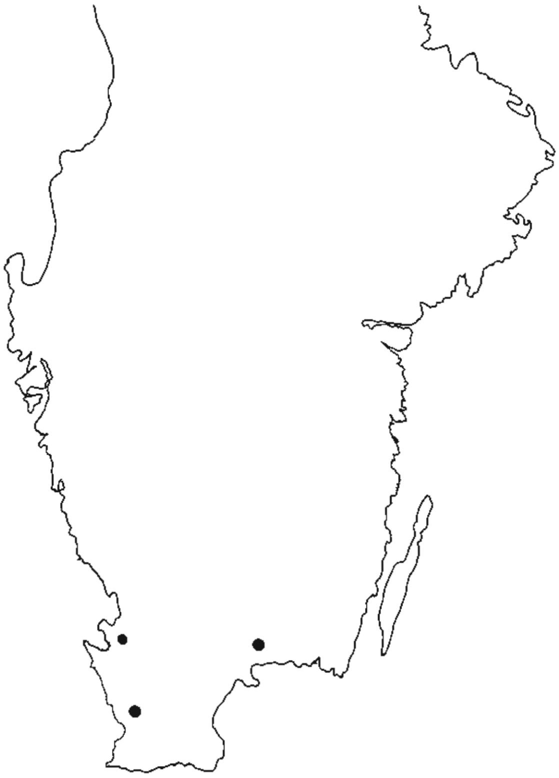

Fig. 1. Overbank sediment profile sample sites (1-3), southern Sweden.

TABLE 1. Hot nitric acid extractable elements in overbank sediment profile and active (SS) stream sediment samples (-0.063 mm fraction), Kavlingan river, southern Sweden.

Depth cm	Sample no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	601	11	59	21	10	6
10- 20	602	8	40	20	9	5
20- 40	603	9	39	21	11	7
40- 60	604	8	29	15	10	8
10- 60	605	8	35	13	10	7
Active SS	606	6	17	10	5	4

TABLE 2. Hot nitric acid extractable elements in overbank sediment profile and active (SS) stream sediment samples (-0.063 mm fraction), Ronnean river, southern Sweden.

Depth cm	Sample no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	607	9	83	13	6	8
10- 20	608	17	174	25	13	14
20- 40	609	15	111	22	10	9
40- 60	610	11	120	16	10	10
60- 80	611	21	187	25	13	14
80-100	612	17	87	17	6	5
100-120	613	17	100	21	8	7
120-140	614	18	92	26	8	7
140-160	615	16	95	23	8	7
10-160	615	16	84	17	8	7
Active SS	616	12	99	20	10	9

TABLE 3. Hot nitric acid extractable elements in overbank sediment profile and active (SS) stream sediment samples (-0.063 mm fraction), Morran river, southern Sweden.

Depth cm	Sample no.	Cu ppm	Zn ppm	Pb ppm	Ni ppm	Co ppm
0- 10	624	9	33	25	4	5
10- 20	625	6	26	22	2	4
20- 40	626	4	19	23	3	4
40- 60	627	4	18	12	2	5
10- 60	628	4	17	13	2	4
Active SS	629	4	20	12	3	3

TABLE 4. Water soluble element contents in overbank sediment profile and active (SS) stream sediment samples (- 0.063 mm fraction), Kavlingean river, southern Sweden.

Depth cm	Sample no.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppb
0- 10	601	1.1	0.88	15.9	503.8	16.9	-	-	62
10- 20	602	1.0	0.65	16.2	434.9	12.2	-	-	25
20- 40	603	1.0	0.68	19.0	459.4	21.8	-	-	23
40- 60	604	19.0	30.0	13.6	235.3	30.3	-	-	13
10- 60	605	2.7	7.7	16.1	380.2	28.1	-	-	21
Active	606	1.0	0.77	21.3	728.4	14.4	8.9	-	10

TABLE 5. Water soluble element contents in overbank sediment profile and active (SS) stream sediment samples (-0.063 mm fraction), Ronnean river, southern Sweden.

Depth cm	Sample no.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppb
0- 10	607	10.7	10.6	7.1	75.3	11.3	64.9	-	83
10- 20	608	1.5	1.2	13.1	121.5	14.6	71.0	-	100
20- 40	609	3.5	3.6	15.4	125.4	16.1	33.6	-	52
40- 60	610	7.2	7.3	10.7	91.4	10.4	46.9	-	83
60- 80	611	2.6	1.6	13.7	125.2	15.2	27.7	-	90
80-100	612	4.8	4.0	7.9	73.4	16.6	38.8	-	206
100-120	613	2.8	1.8	10.0	88.0	20.2	56.9	-	121
120-140	614	2.7	1.0	11.8	101.8	26.7	93.1	-	90
140-160	615	2.8	1.7	13.0	120.1	24.9	112.8	-	90
10-160	616	8.2	8.2	10.8	86.8	12.8	37.3	-	123
Active SS	617	1.0	2.5	18.3	138.4	36.6	24.3	-	35

TABLE 6. Water soluble element contents in overbank sediment profile and active (SS) stream sediment samples (-0.063 mm fraction) Morran river, southern Sweden.

Depth cm	Sample no.	Al ppm	Fe ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	Cu ppb
0- 10	624	6.8	1.0	8.6	39.4	44.3	12.3	3.9	54
10- 20	625	4.5	0.9	11.5	53.0	46.0	8.2	6.1	21
20- 40	626	3.4	2.0	7.4	33.3	23.9	-	2.6	10
40- 60	627	3.4	1.6	8.0	31.3	20.0	-	-	10
10- 60	628	4.8	1.8	7.6	30.3	23.3	-	1.2	10
Active SS	629	1.4	1.3	9.6	44.9	8.2	6.1	1.6	10

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PILOT PROJECT

APPENDIX REPORT 5.7

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENTS IN THE U.K.

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FIGURES

1.0 INTRODUCTION

There have been no studies of the vertical distribution of elements in overbank sediments in the U.K. which were specifically designed for the purposes of the WEGS Pilot Project. However, a number of investigations which provide information relevant to the Pilot Project have been conducted, chiefly by Macklin and his co-workers (Table 1 and Fig. 1), and some of the more important results are summarised below.

2.0 SAMPLING AND ANALYTICAL METHODS

Floodplain sediments were sampled by taking core with a percussion drill, excavating trenches with a mechanical digger, or by collecting material from exposed river bank profiles. Particle size analysis, where performed, was carried out using standard sedimentological techniques: sieving for sand grade and coarser fractions and pipette methods for silt and clays. After drying and disaggregation, the organic content of the sediment was estimated from the loss on ignition (L.O.I.) at 430 degrees C. Chemical analysis was normally by atomic absorption spectroscopy after digestion in concentrated nitric acid, a method which should extract almost all of the metals not held in silicate mineral lattices. Further details of methods are given in Macklin (1985) and Macklin et al. (1985).

3.0 RESULTS FROM INDIVIDUAL RIVER BASINS

3.1 TYNE BASIN

A 6.6 m thick overbank succession, consisting of silty clays with frequent inclusions of organic material (wood and plant remains), at Shibdon Pond (Site 1, Table 1 and Fig. 1) near Newcastle upon Tyne has been described by Macklin and Passmore (1988). The vertical distribution of Ag, Cd, Fe/Mn, Mn, Pb, Zn and L.O.I. are shown in Fig. 2. High Pb concentrations in the upper 0.5 m of silty clay indicate that this material was deposited sometime after the mid-17th century when large-scale non-ferrous industrial and mining operations were first established in the Tyne catchment (Raistrick and Jennings, 1965). Zinc levels, however, are comparatively low suggesting that active alluvial sedimentation had ceased before about 1880 when Zn mining was at its height in the North Pennine Orefield (Dunham, 1944). This was probably the result of channel incision following dredging of the river from the mid-19th century (Johnson, 1895) which reduced the frequency of overbank flooding in the lower Tyne valley significantly. The age of the lowermost sediment at Shibdon Pond is not known but is probably pre-anthropogenic influences.

The 2.4 m section of overbank sediment at Low Prudhoe in the Lower Tyne valley (Site 2, Table 1 and Fig. 1) has been described by Macklin et al. (in press) who conclude, on the basis of trace element analyses and the record of mining activity, that the major part of the sequence was deposited in the 60 years between 1890 and 1950. Variations with depth of Ag, Cd, Pb and Zn are shown in Fig. 3, from which it is clear that although no part of the section pre-dates man's influence that influence varied greatly over short time periods.

Overbank sediments of mining era age in river terraces and more recent age in floodplain deposits at Stocksfield, Warden and Hardriding (Sites 4, 6 and 7, Table 1 and Fig. 1) are described in Macklin (1988). The vertical distribution of total and available (leached by acetic acid) Cd, Pb and Zn in these sediments is illustrated in Figs. 4-6. In mining age alluvium metal concentrations generally increase up the profile and the deepest samples could represent pristine material. There is less systematic variation in the more recent floodplain deposits. Overall metal concentrations decrease downstream in the more recent overbank sediments but increase downstream in the older alluvium. Patterns of downstream metal concentration decline in the Tyne and other metal contaminated U.K. rivers have been shown (Macklin and Dowsett, 1989; Lewin and Macklin, 1987) to be controlled by a number of chemical and physical processes, including hydraulic sorting, floodplain storage, dilution by sediment from unmineralised tributaries and adsoption and complexing of metals onto particulate material. The unexpected downstream increase in metal concentrations in the mining era sediments probably reflects limited dilution by material from non-mining sources coupled with comparatively high chemical and physical mobility of the metals. After the cessation of large-scale mining activity (late 1930's) metal contaminated floodplain alluvium became the principal source of sediment-borne metals and was rapidly diluted downstream of former mining areas (Macklin, 1988). The complexities in both the vertical and horizontal patterns of metal distribution at these three locations indicate that the choice of an overbank sediment sampling site which is truly representative of the upstream drainage basin may be very difficult.

In the valley of the River Nent (Site 9, Table 1 and Fig. 1), a tributary of the River South Tyne, a 1.5 m thick overbank sediment profile (Fig. 7) shows Pb and Zn concentrations which, although they increase greatly towards the top of the sequence, are all sufficiently high to suggest that metal mining was taking place in the region during their deposition (Macklin, 1986). The whole of the overbank sequence, therefore, is composed of polluted material.

3.2 RIVER SWALE

The 1.6 m of overbank sediment exposed in the valley of the River Swale near Ivelet (Site 10, Table 1 and Fig. 1) shows unpolluted sediment at the base overlain by 1.2 m of alluvium severely contaminated by Pb from mining activity in the 18th and 19th centuries (Macklin, in press)(Fig. 8).

3.3 RIVER DERWENT

A short distance downstream of the Mill Close Mine in the Derwent Valley (Site 13, Table 1 and Fig. 1) Cd, Cu and Zn concentrations in a 2 m overbank sequence all increase near the top of the profile (Fig. 9). Lead, however, shows anomalously high values at the base of the section which indicates that the whole of the sequence may have been deposited since Roman times when mining probably in the catchment basin (Macklin and Lewin, 1987)

3.4 RIVER AXE

Figure 10 shows Cu, Pb and Zn concentrations in a 4 m core of floodplain sediment from the Axe valley (Site 19, Table 1 and Fig. 1). The low concentration of Pb in the gravels at 3.6 m suggests that this part of the core is of pre-mining age but at 1.6 m Pb levels are high and indicate deposition contemporaneously with mining activity. The upper fine-grained overbank sediment is thus all post the onset of anthropogenic influences. The rise in heavy metal concentrations immediately below the contemporary turf layer probably relects complexing by organic material as indicated by the high L.O.I. values (Macklin, 1985).

3.5 RIVER LOX YEO

The Lox Yeo (Site 20, Table 1 and Fig. 1) is a tributary of the River Axe and cores of the valley floor have yielded 10-12 m of silty clays and peats recording a long period of overbank sedimentation. Concentratons of Pb and Zn with depth are shown in Fig. 11. The highest metal values are associated with peaty horizons but by use of Pb/Zn and Pb/Cu ratios and palynological analysis Macklin et al. (1985) have been able to deduce a history for the site.

The peat layer at about 11 m is believed to have been deposited approximately 11000 years ago. Little anthropogenic interference is discernable before 5000 years bp (9-9.5 m). Above this level a rise in heavy metals concentrations is attributable to man-induced soil disturbance but the anomalous Pb values at 7.57-7.11 m and 6.45-5.61 m are believed by Macklin et al. (1985) to reflect pre-Roman and Roman mining activity. Mining related pollution is recorded at several levels in the core representing the last 1500 years.

4.0 CONCLUSIONS

The studies of the vertical distribution of chemical elements in U.K. overbank sediments have shown that the overbank medium can be used to demonstrate anthropogenic influences in drainage basins, particularly the impact of mining on the metal input to river systems. The choice of sample site, however, is critical because some locations may not be able to provide a complete succession from pristine, pre-anthropogenic influence, material through to present day sediment. A knowledge of the fluvial evolution of the drainage basin is important in sample site selection and a means of dating at least the base of an overbank sequence desirable. It may be necessary to sample very thick sequences in order to reach pristine overbank material at depth.

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TABLE 1

	RIVER	GRID REF	THICKNESS OF OVERBANK UNIT SAMPLED (METRES)	TIMEPERIOD	AUTHOR
1	TYNE	NZ195632	6.6	HOLOCENE	MACKLIN & PASSMORE,1988.
2	TYNE	NZ088636	2.4	HISTORIC	MACKLIN ET.AL., IN PRESS.
3	TYNE	NZ005633	3.8	HISTORIC & HOLOCENE	MACKLIN ET.AL.,UNPUBLISHED.
4	TYNE	NZ063624	1.3	HISTORIC	MACKLIN,1988.
5	TYNE	NZ945643	3.5	HISTORIC	MACKLIN ET.AL.,UNPUBLISHED.
6	SOUTH TYNE	NY908661	1.2	HISTORIC	MACKLIN,1988.
7	SOUTH TYNE	NY763637	1.4	HISTORIC	MACKLIN,1988.
8	WEST ALLEN	NY780538	1.1	HISTORIC	MACKLIN & ASPINALL,1986.
9	NENT	NY744467	1.5	HISTORIC	MACKLIN,1986.
10	SWALE	SD945979	1.6	HISTORIC	MACKLIN, IN PRESS.
11	SWALE	SD977975	2.0	HISTORIC	BRENNAN & MACKLIN,UNPUBLISHED
12	SWALE	SE032989	1.1	HISTORIC	BRENNAN & MACKLIN,UNPUBLISHED
13	DERWENT	SK280610	2.2	HISTORIC	LEWIN & MACKLIN,1987.
14	MANIFOLD	SK095585	1.6	HISTORIC	BRADLEY & COX,1987.
15	HAMPS	SK050552	0.8	HISTORIC	BRADLEY & COX,1987.
16	SEVERN	SO037992	0.8	HISTORIC	LEWIN & MACKLIN,UNPUBLISHED.
17	SEVERN	SJ237073	1.8	HISTORIC	LEWIN & MACKLIN,UNPUBLISHED.
18	NENE	TL227989	1.4	HOLOCENE	MACKLIN & PASSMORE,UNPUBLISHED.
19	AXE	ST531473	1.5	HISTORIC	MACKLIN,1985.
20	LOX YEO	ST384656	11.0	HISTORIC & HOLOCENE	MACKLIN ET.AL.,1985.

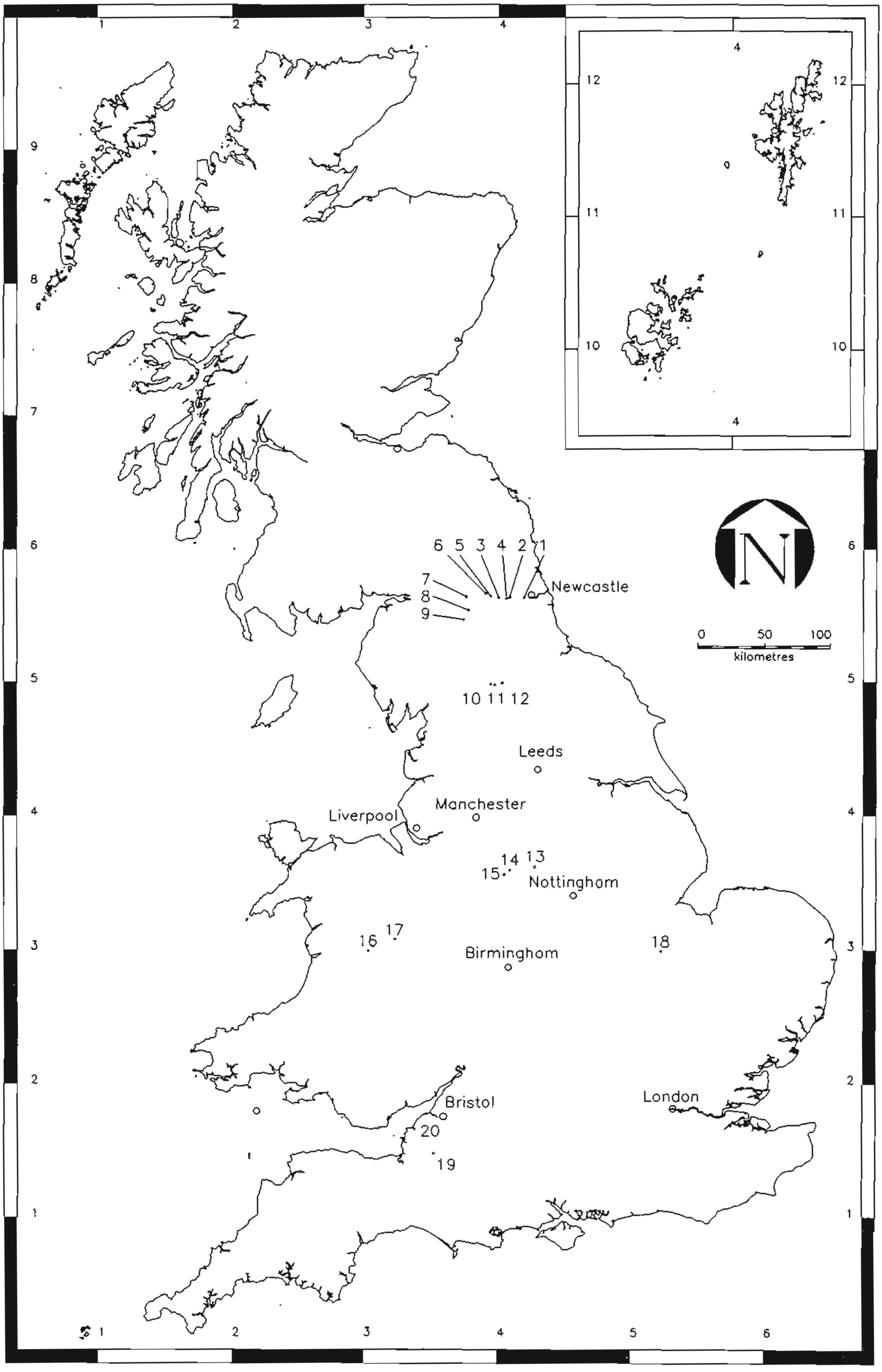


Figure 1: Location of studied overbank sediment sites in the U.K.

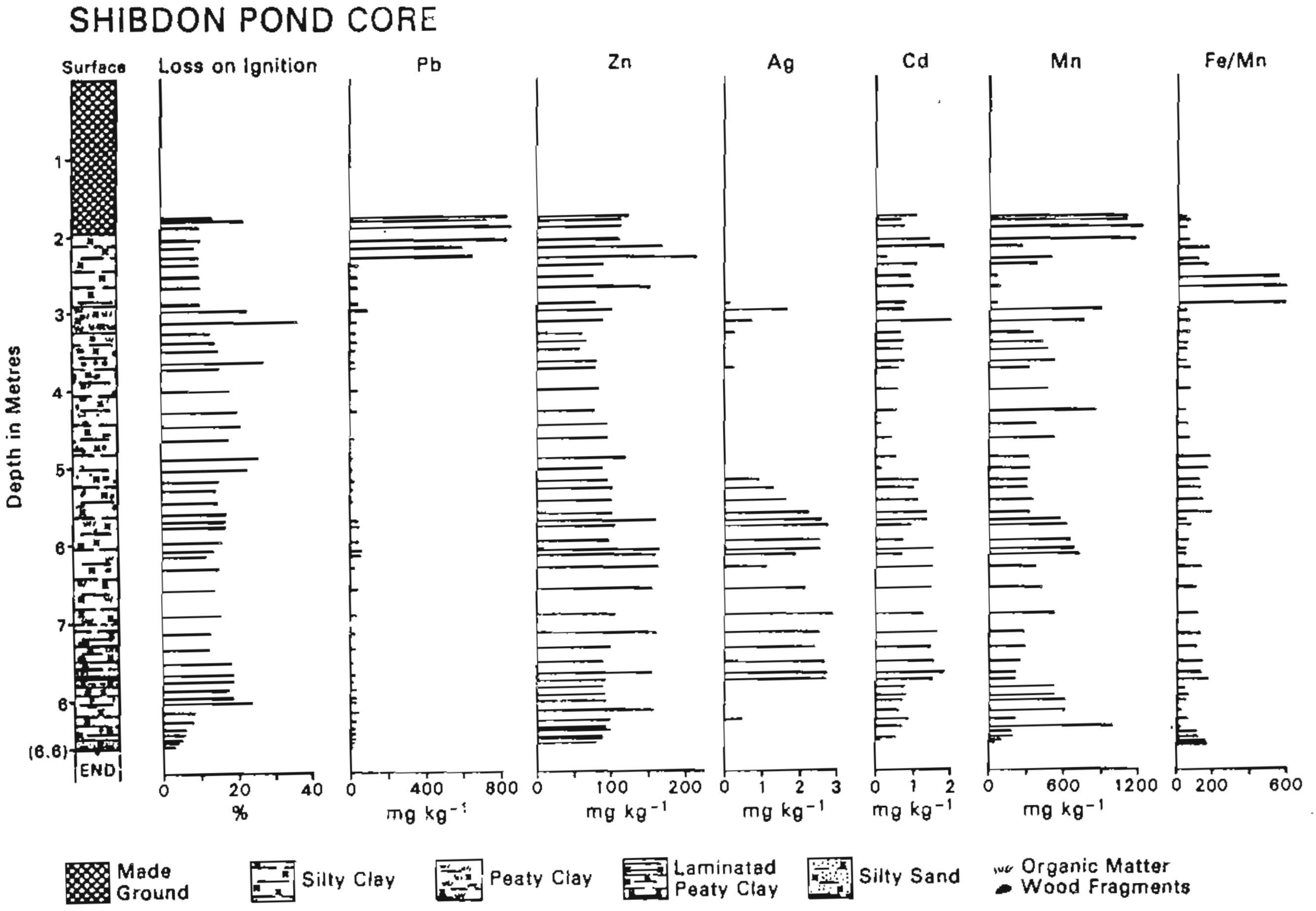


Figure 2: Sedimentary log and geochemistry of Shibdon Pond borehole (site 1, Fig. 1)

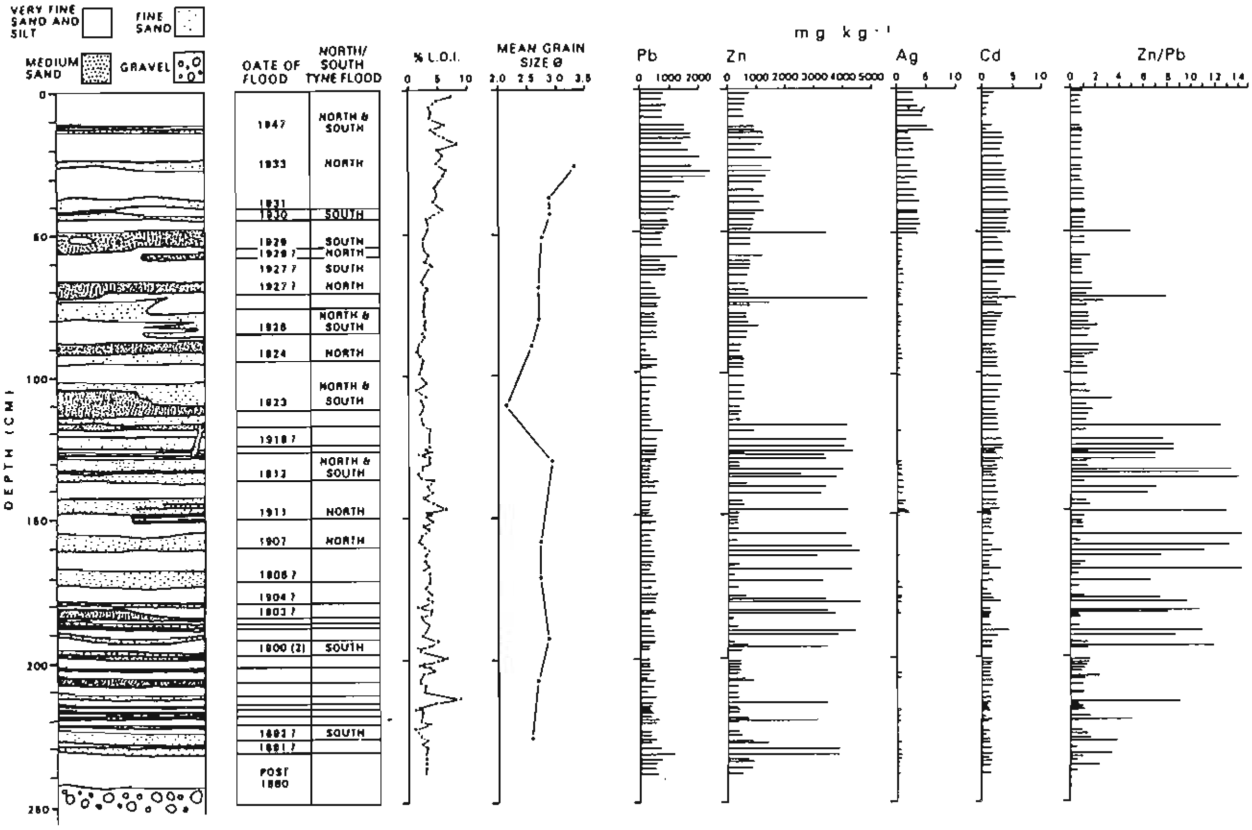


Figure 3: Sedimentary log, chemical and physical characteristics of dated overbank flood sediments at Low Prudhoe (site 2, Fig. 1).

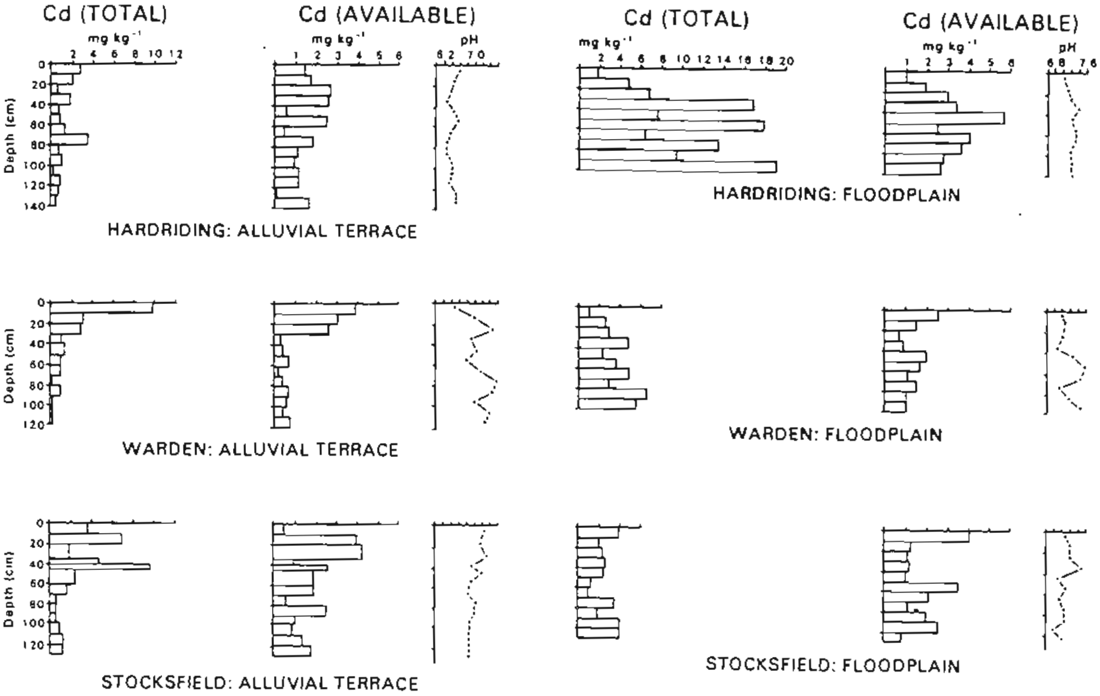


FIG. 4

Figure 4-6: Available and total Cd, Pb and Zn concentrations in sections excavated in floodplain and mining age alluvium at Hardriding, Warden and Stocksfield (sites 7, 6 and 6 respectively, Fig. 1).

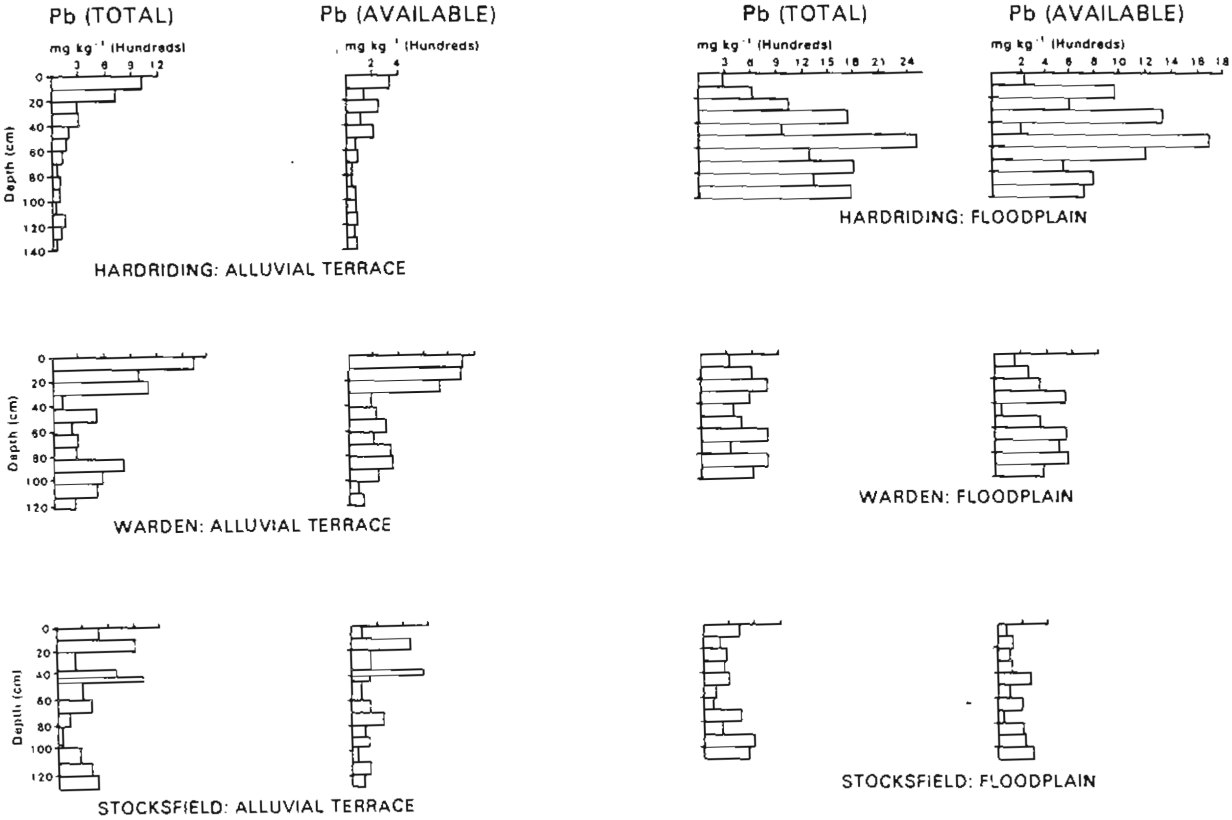

Pb (TOTAL)
Pb (AVAILABLE)
mg kg⁻¹ (Hundreds)
3 6 9 12
2 4
Depth (cm)
0
20
40
60
80
100
120
140
HARDRIDING: ALLUVIAL TERRACE
Pb (TOTAL)
Pb (AVAILABLE)
mg kg⁻¹ (Hundreds)
3 6 9 12 15 18 21 24
2 4 6 8 10 12 14 16 18
HARDRIDING: FLOODPLAIN
WARDEN: ALLUVIAL TERRACE
WARDEN: FLOODPLAIN
STOCKSFIELD: ALLUVIAL TERRACE
STOCKSFIELD: FLOODPLAIN

FIG. 5

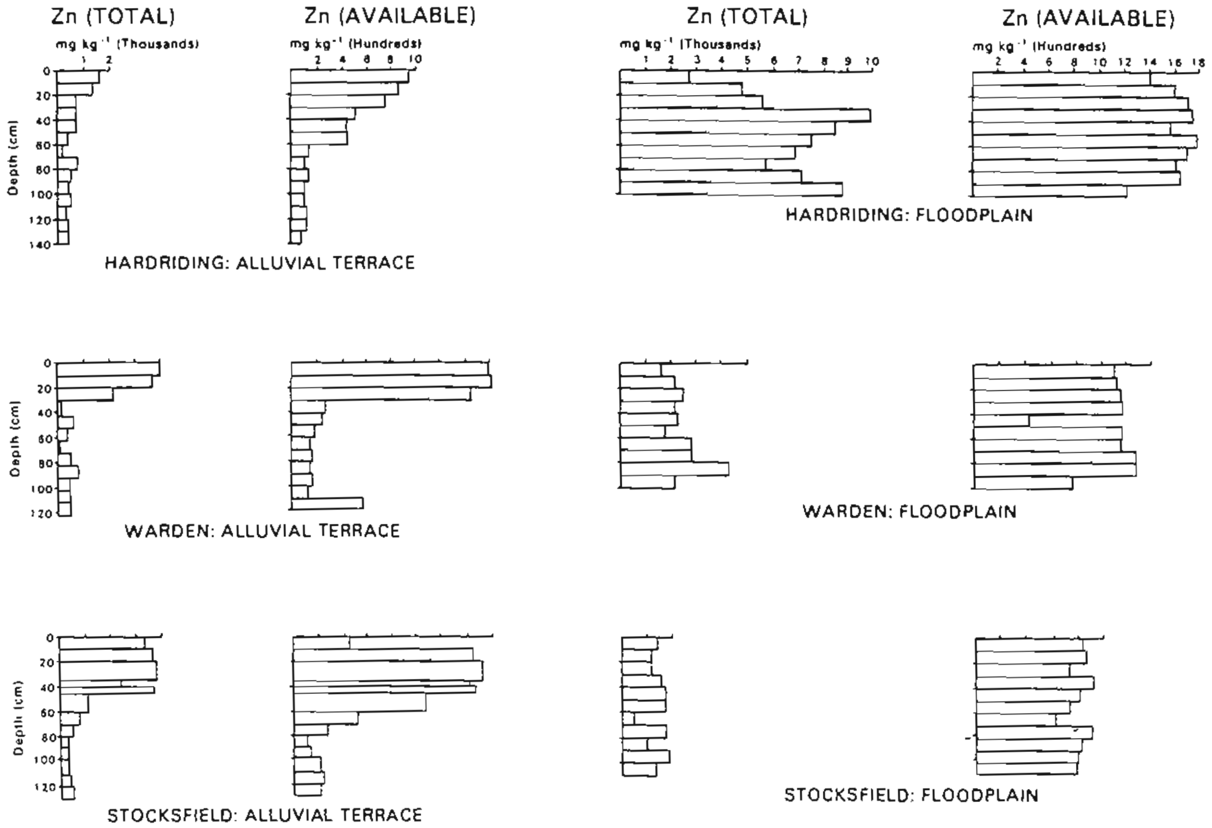

Zn (TOTAL)
mg kg⁻¹ (Thousands)
1 2
Zn (AVAILABLE)
mg kg⁻¹ (Hundreds)
2 4 6 8 10
Zn (TOTAL)
mg kg⁻¹ (Thousands)
1 2 3 4 5 6 7 8 9 10
Zn (AVAILABLE)
mg kg⁻¹ (Hundreds)
2 4 6 8 10 12 14 16 18
Depth (cm)
0 20 40 60 80 100 120 140
HARDRIDING: ALLUVIAL TERRACE
HARDRIDING: FLOODPLAIN
Depth (cm)
0 20 40 60 80 100 120
WARDEN: ALLUVIAL TERRACE
WARDEN: FLOODPLAIN
Depth (cm)
0 20 40 60 80 100 120
STOCKSFIELD: ALLUVIAL TERRACE
STOCKSFIELD: FLOODPLAIN

FIG. 6.

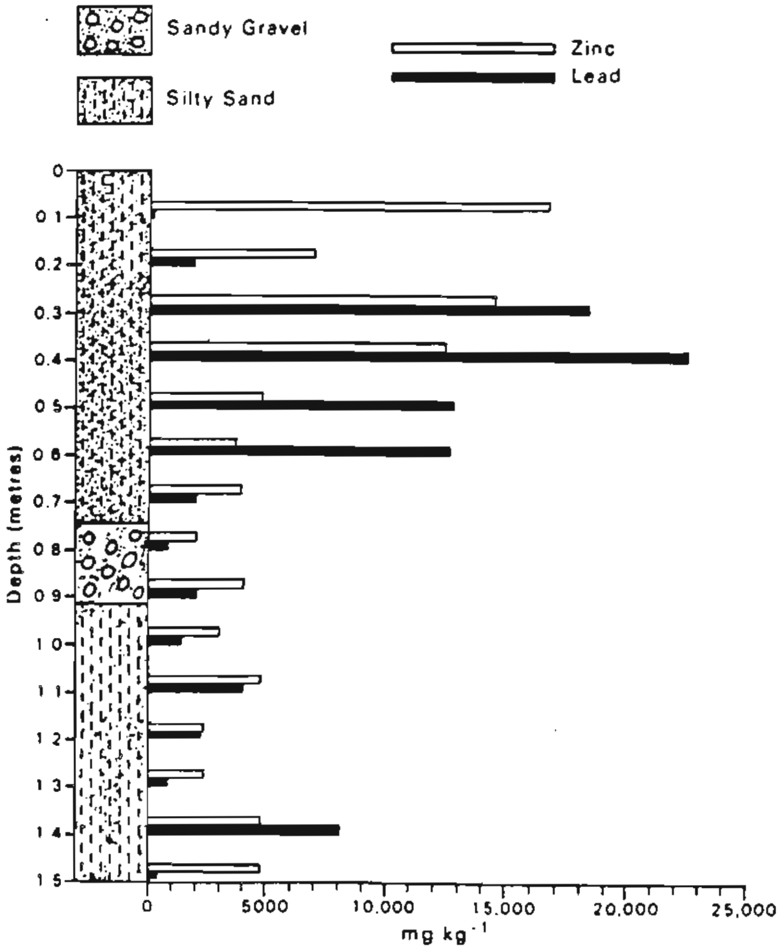


Figure 7: Sedimentary log and metal concentrations in Nent valley overbank sediment (site 9, Fig. 1).

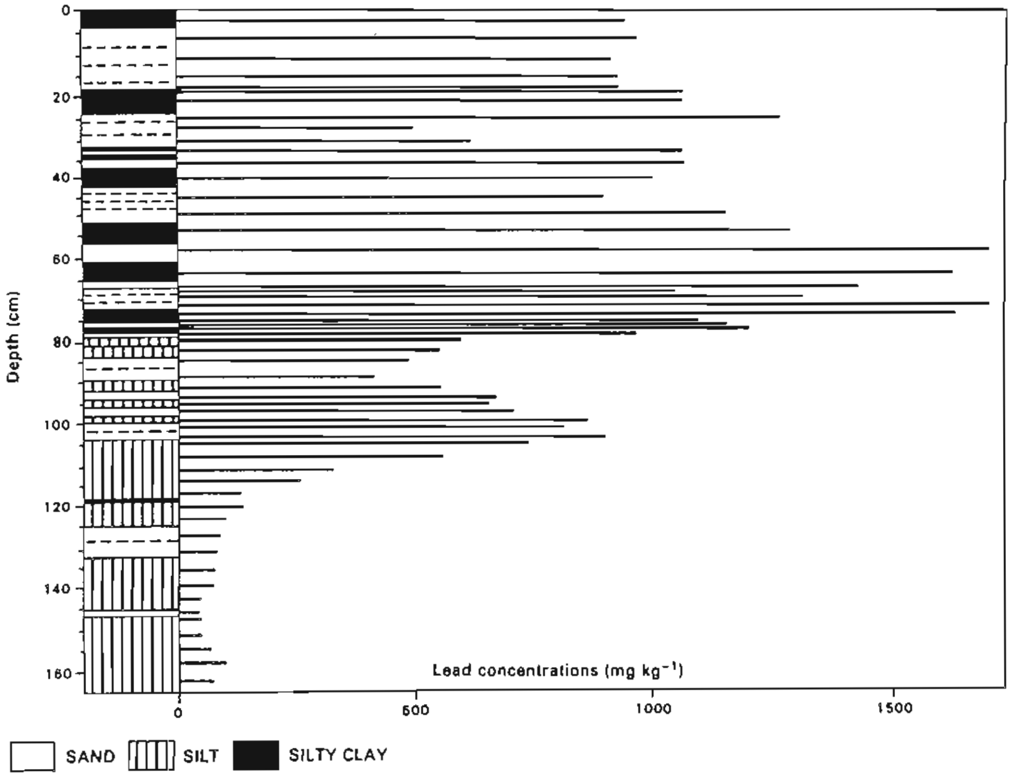


Figure 8: Sedimentary log and Pb concentrations in River Swale overbank sediment (site 10, Fig. 1).

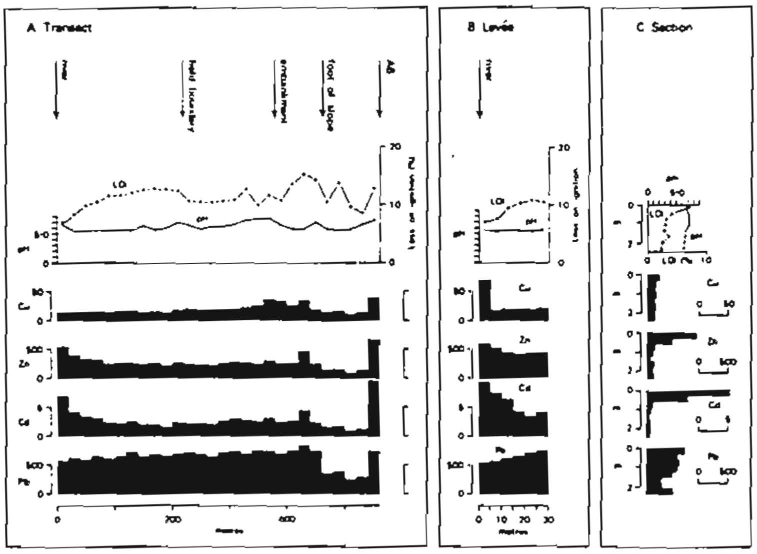


Figure 9 (C only): Metal concentrations in River Derwent overbank sediment (site 13, Fig 1)

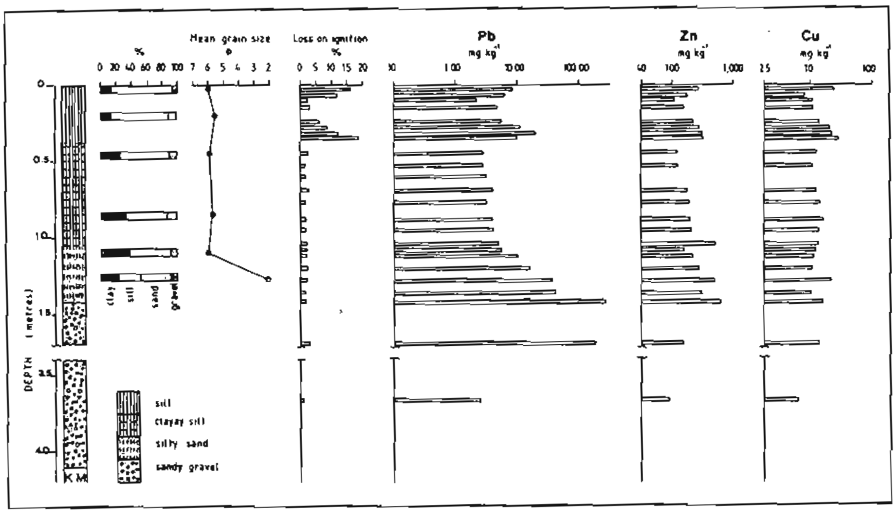


Figure 10: Sedimentary log and geochemistry of the Axe valley borehole (site 19, Fig. 1)

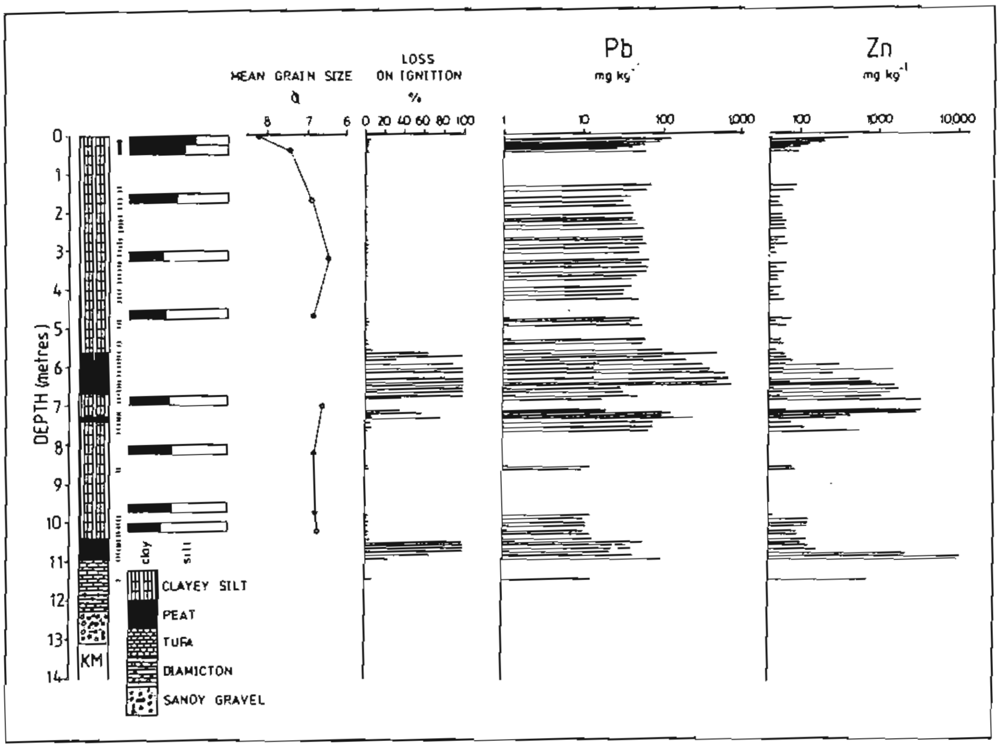


Figure 11: Sedimentary log and geochemistry of the Lox Yeo borehole (site 20, Fig. 1)

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 5.8

VERTICAL DISTRIBUTION OF ELEMENTS IN OVERBANK SEDIMENT, SPAIN

Juan LOCUTURA and Enrique LOPEZ PAMO

I.T.G.E., Spain

1990

CONTENTS

1.0. INTRODUCTION

The main objectives of this work were to assess

- the vertical variation across the river channel, and
- the longitudinal variability of overbank sediment along the river channel.

2.0. STUDY AREA

The Sierra de Guadarrama is a mountainous massif made up from granitic and medium to high grade metamorphic rocks (migmatite, gneiss) (Figs. 1 to 3). At its southern side, besides a narrow outcrop of Cretaceous age limestone, there is a wide Miocene basin, filled by clastic materials (conglomerate and sand) derived from the Palaeozoic rocks after their uplift in early Tertiary times.

Many mineralized showings, of little economic significance, occur in both the metamorphic and granitic terrains. It is worth mentioning the small quartz veins with Sn-W and W-As, which are closely related to peraluminous granite, and thin Sn-W placers.

The rivers sampled in this area are Manzanares and Jarama, both having their source over the Palaeozoic rocks, and also flowing over the Miocene sedimentary basin.

Downstream of Madrid and its industrial estate, anthropogenic and industrial pollution is very probable, especially in the Manzanares river. Upstream, only some pollution related to agricultural practice is likely.

3.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

3.1. Sampling

Overbank sediment samples, each weighing between 5 and 15 kgs, were taken over the total thickness of the profile at 20 cms intervals (except the top first 10 cms). The overbank sediment section was cleaned prior to sampling.

The rivers chosen for the overbank sediment profile sampling were the Jarama and Manzanares (Figs. 4 to 7), both draining the granitic and metamorphic terrain of Sierra de Guadarrama, and the Miocene sedimentary basin. Five sampling sites were selected in the Manzanares river, i.e., 4, 4A, 4B, 5 and 6 (Figs. 4 & 5). Sites 4, 4a and 4B lie on a line across the river channel; sample 4 being next to the channel, whereas 4a and 4B are situated at a distance of 100 m on either side of the channel. Sample 5 is about two hundred metres upstream (Fig. 4), and sample 6 is from the same river, but about forty kilometres upstream (Fig. 5).

Samples 4, 4A, 4B and 5 are located in a very polluted area downstream from the Madrid industrial estate, whereas sample 6 is sited on an unpolluted environment of granitic and metamorphic rocks.

Five sampling sites were also chosen in the Jarama river, i.e., no. 7 near the granitic rocks, and 8, 9 10 and 11 downstream (Figs. 6 & 7).

3.2. Sample preparation

All samples (overbank and stream sediment) were dried in an oven at a temperature of 40-45°C. The dried samples were disaggregated in a porcelain mortar, and afterwards sieved through a 0.063 mm nylon screen.

3.3. Analytical methods

The total element contents were determined on the -0.063 mm fraction by the Analytical Service of the I.T.G.E., whereas N.G.U. has undertaken to analyse all samples for hot nitric and water soluble elements. The latter analyses are not yet available.

The sample was homogenized prior to the taking of a 1 gm aliquot for analysis. Major and trace elements were determined by ICP after hot digestion in a mixture of HNO_3, $HClO_4$ and HF acid.

Sn was determined by D.C.P. after a two stage attack on a 1 g subsample by Na_2O_2 at 45°C, and followed by a mixture of ClO_4H, and HF.

F was determined by colorimetric methods, and Au on a 50 g subsample by A.A. graphite furnace.

The lower detection limits of the elements are tabulated below (all values in ppm except Au in ppb):

Cu	Pb	Zn	Ni	Co	Cr	Ba	V	Y
5	5	5	5	5	5	5	5	5
Mn	As	Sb	Nb	W	Ag	Cd	Be	Mo
10	10	10	10	10	1	1	1	2
Fe	Al	Ca	K	Na	K	Mg	Ti	Li
20	20	20	20	20	20	20	20	50
Sn	F	Au						
10	200	5						

The concentrations in Au, Cd, Nb, Sb, As and to a lesser extent Co were in all the samples below the lower detection limit. Therefore, these results were not considered in this study.

4.0. DISCUSSION

In the Manzanares river, the overbank sediment samples show clearly the pollution and the contrast between polluted and pristine materials (Figs. 8, 11 & 12), though the element contents are higher in the samples taken far from the river channel. It is suspected that these represent different sedimentation levels.

The most significant elements with respect to industrial contamination, as seen in the Manzanares river, are Ag, Pb, Zn, Cu, Ba, Fe and Cr (Figs. 8 to 10).

The high P contents in the near surface layers of the overbank sediment profile (Figs. 10 & 16) is related to agricultural practice, and Y (Fig. 8) shows similar but less pronounced trends.

The minor mineralization occurring in the study area is not reflected in the overbank sediment profiles. The behaviour of Sn (Fig. 15) in the Sierra de Guadarrama is somewhat erratic (i.e., questionable representativity of subsample for analysis); it can also be either related to mineralization, or lithological features.

Some elements like Ca, Mg, K, Na, Cr, V, Fe, Ni, Mn and Fe, as well as Zn, Cu and Pb are in close relationship with lithological variations.

The Jarama valley overbank sediment samples appear to show pristine conditions with respect to Cu, Pb and Zn (Figs. 13 & 14) over the total thickness of the profile.

5.0. CONCLUSION

It can be concluded that overbank sediment can map both contaminated and pristine conditions.

ACKNOWLEDGEMENTS

We thank S. del Barrio (ITGE) for the analysis of the samples, A. Olias (ITGE) for the delineation work, and M. Martinez for the preparation of the samples.

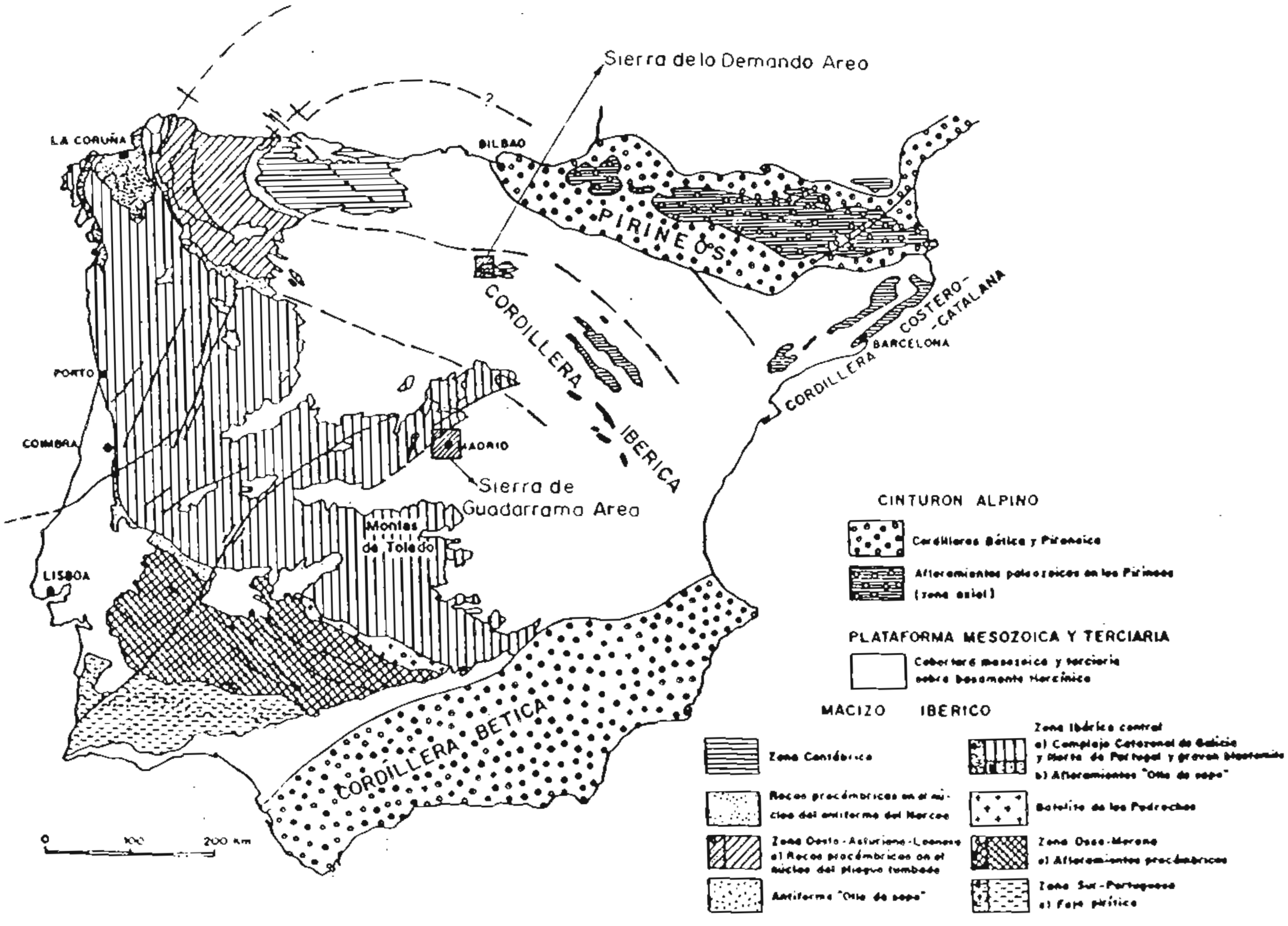
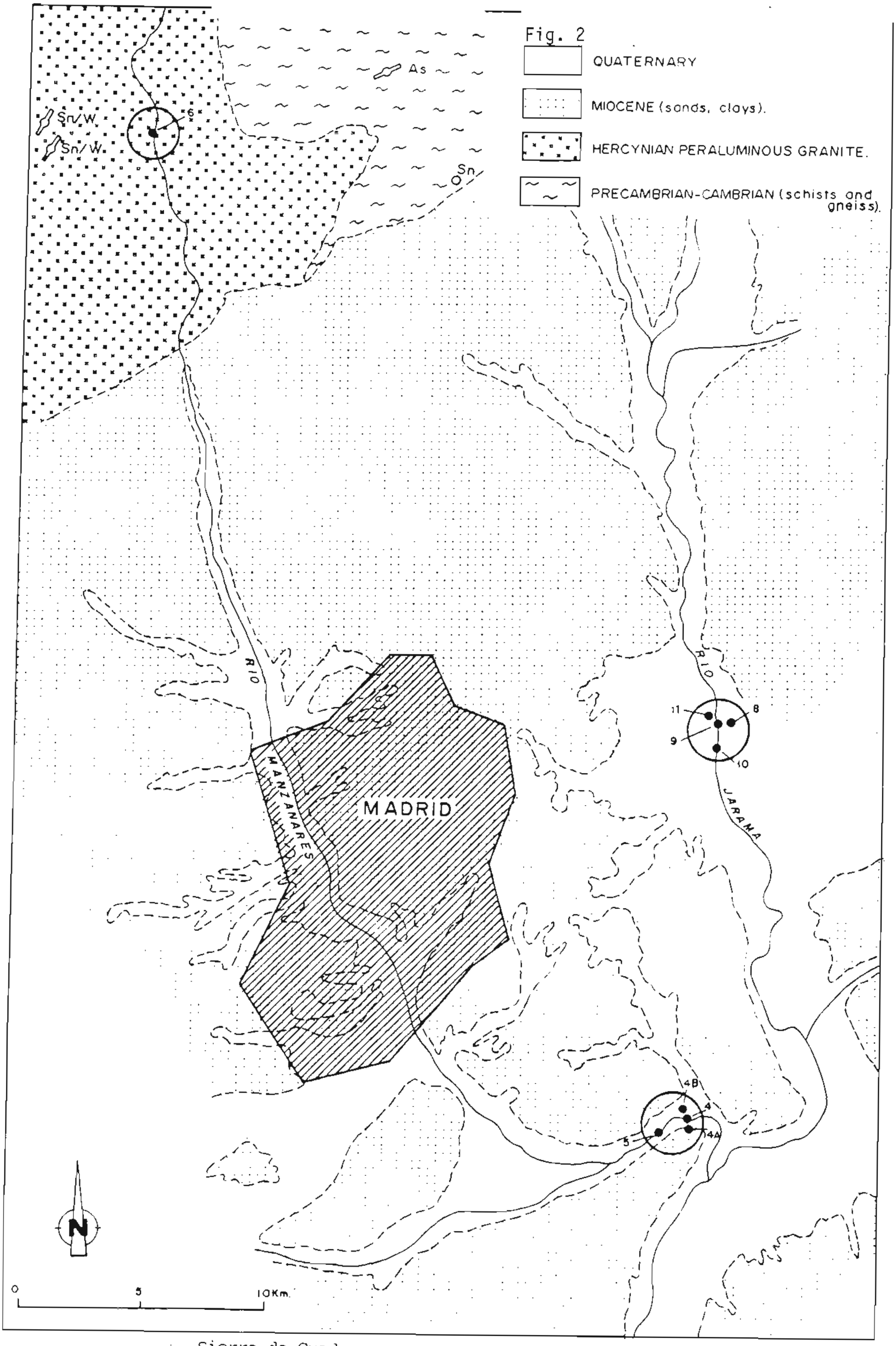


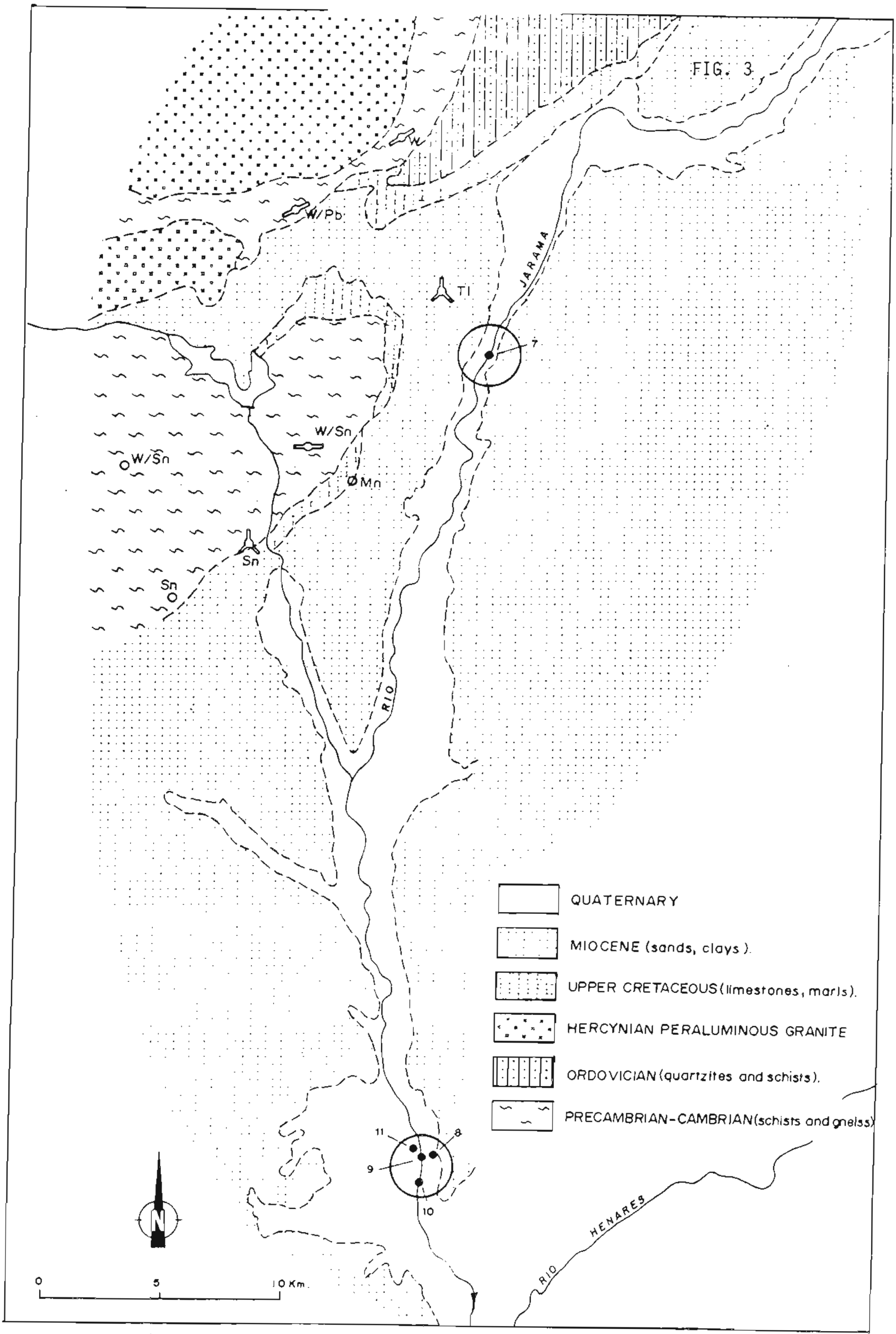
Fig nº 1.- Sampling Areas

Fig. 2



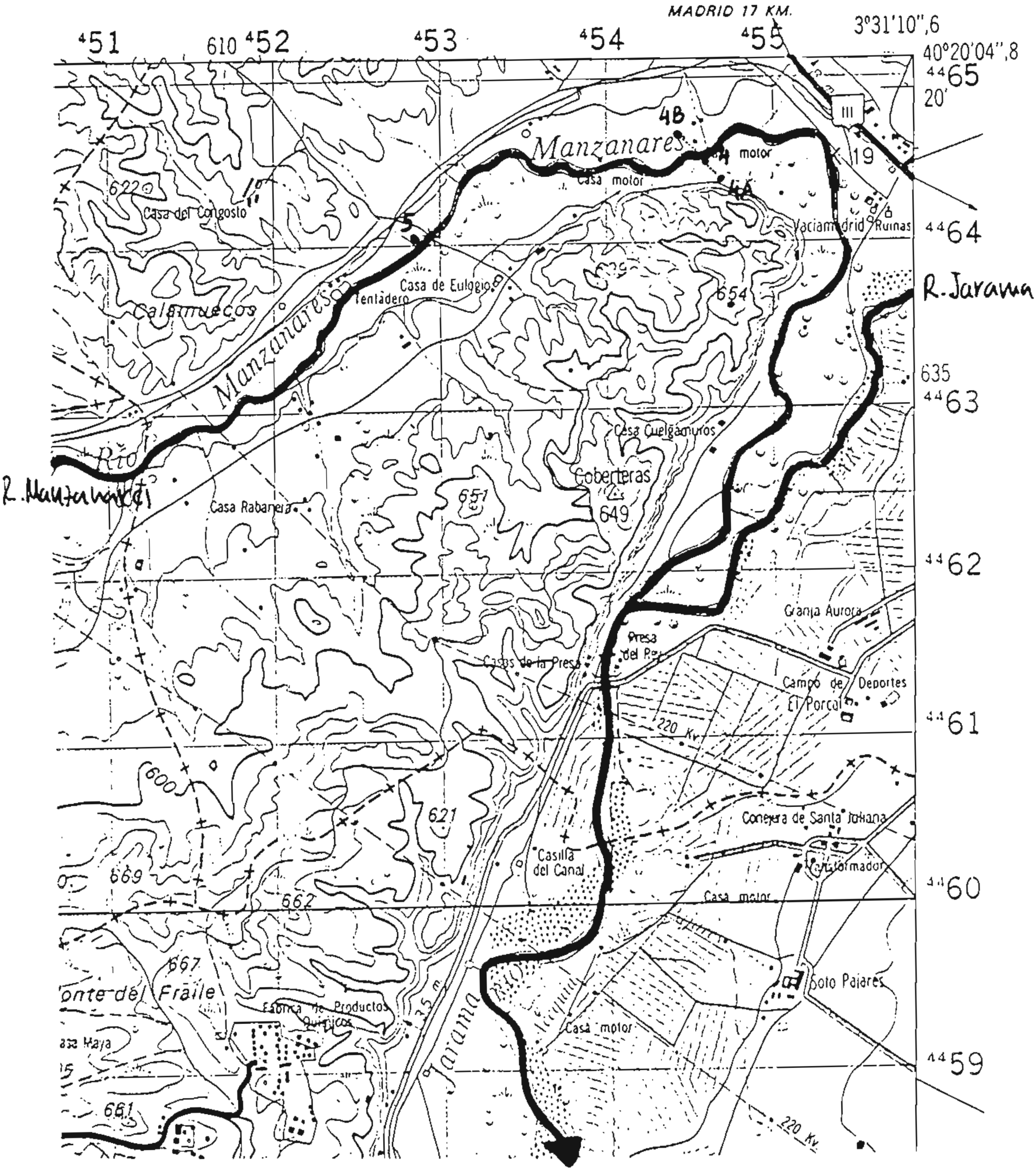
Sierra de Guadarrama Area 1/200.000

FIG. 3


W
W/Pb
Tl
JARAMA
7
W/Sn
W/Sn
ØMn
Sn
Sn
RIO
QUATERNARY
MIOCENE (sands, clays).
UPPER CRETACEOUS (limestones, marls).
HERCYNIAN PERALUMINOUS GRANITE
ORDOVICIAN (quartzites and schists).
PRECAMBRIAN-CAMBRIAN (schists and gneiss)
11
8
9
10
N
0
5
10 Km.
RIO
HENARES

[illegible]

Fig. 4.

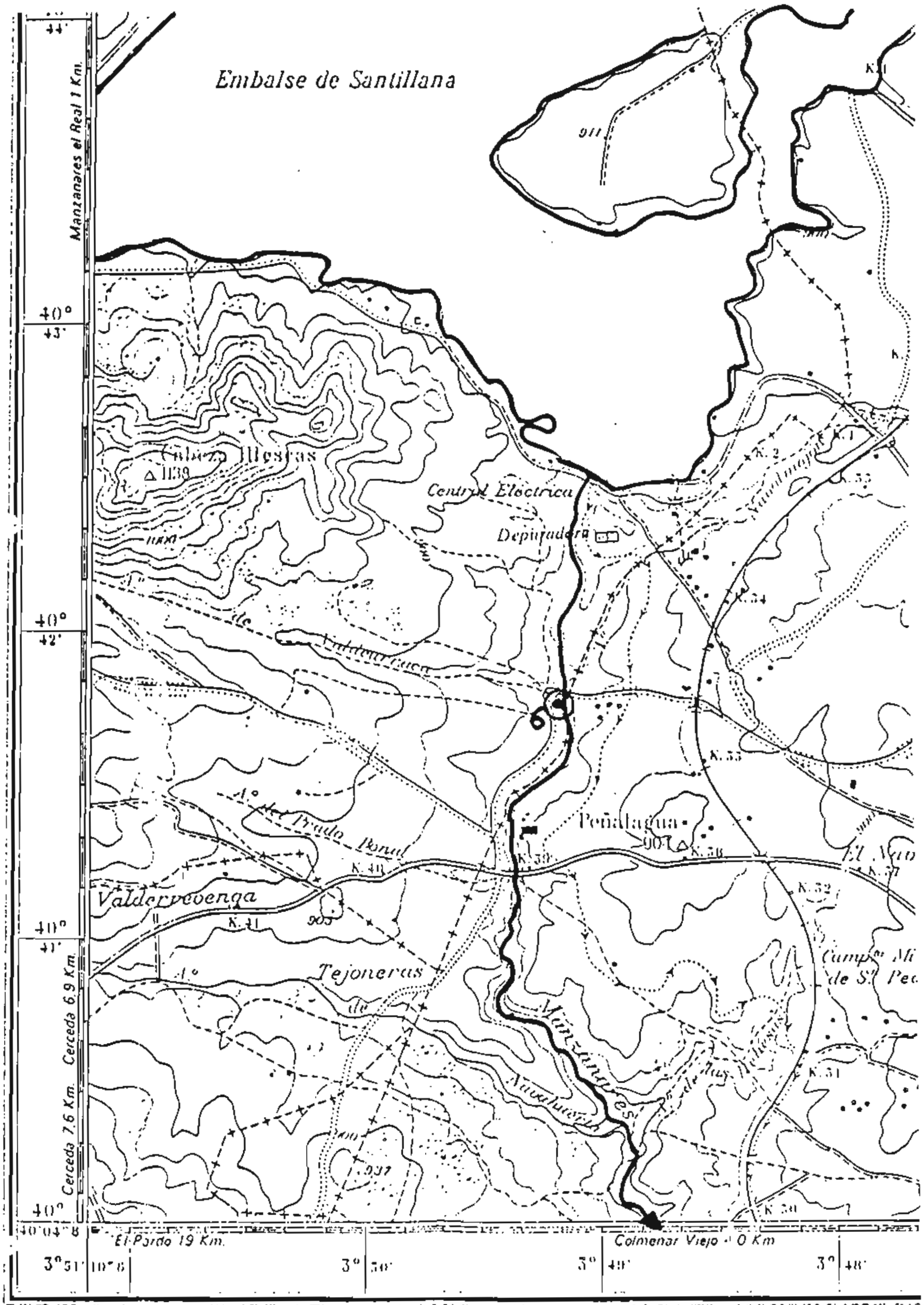


1/50.000

Sierra de Guadarrama Area. Site 4, 4A, 4B, 5

R. Manzanares

Fig. 5.

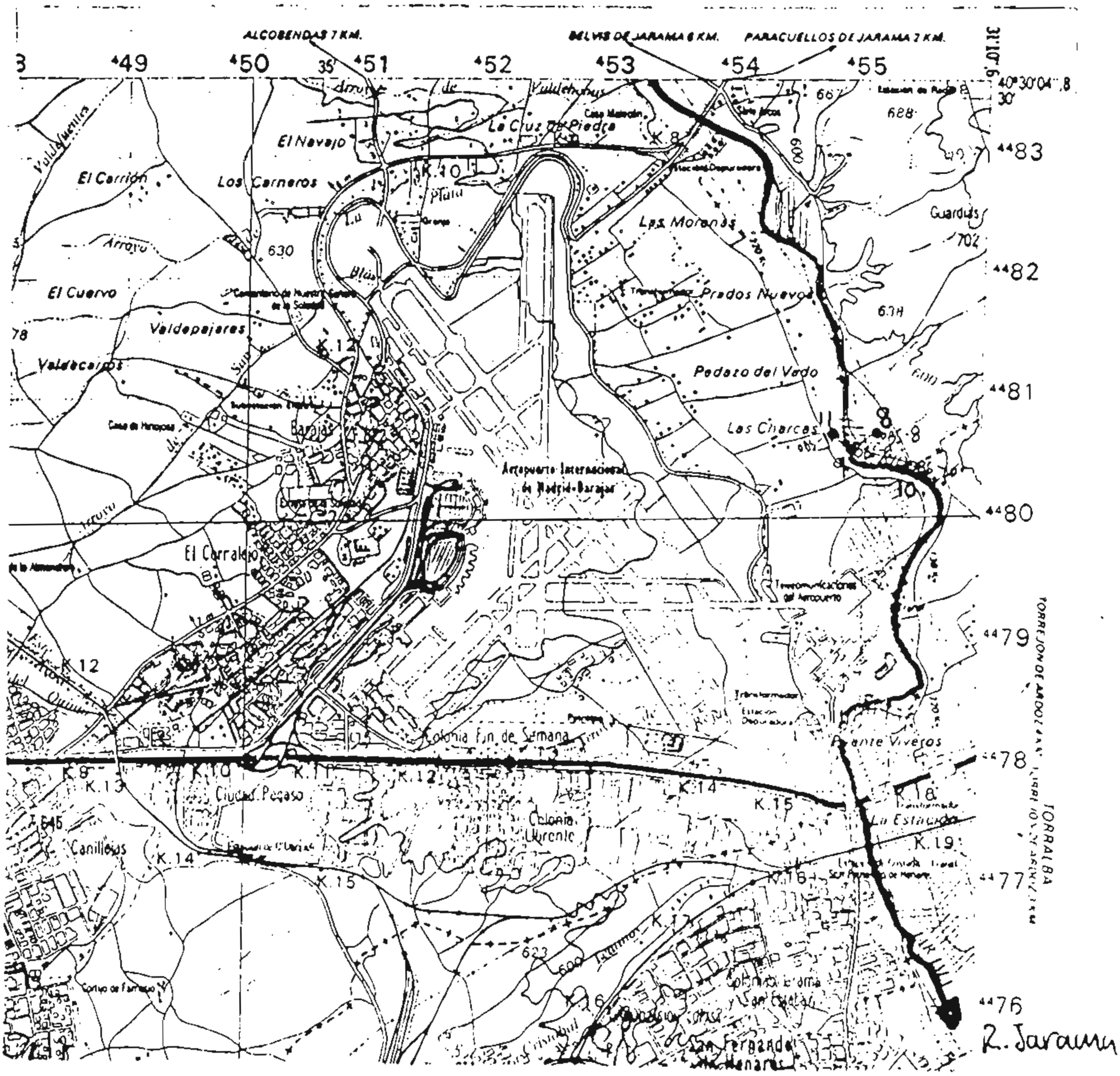


1/50.000

Sierra de Guadarrama Area. Site 6

R. Manzanares

Fig. 6.



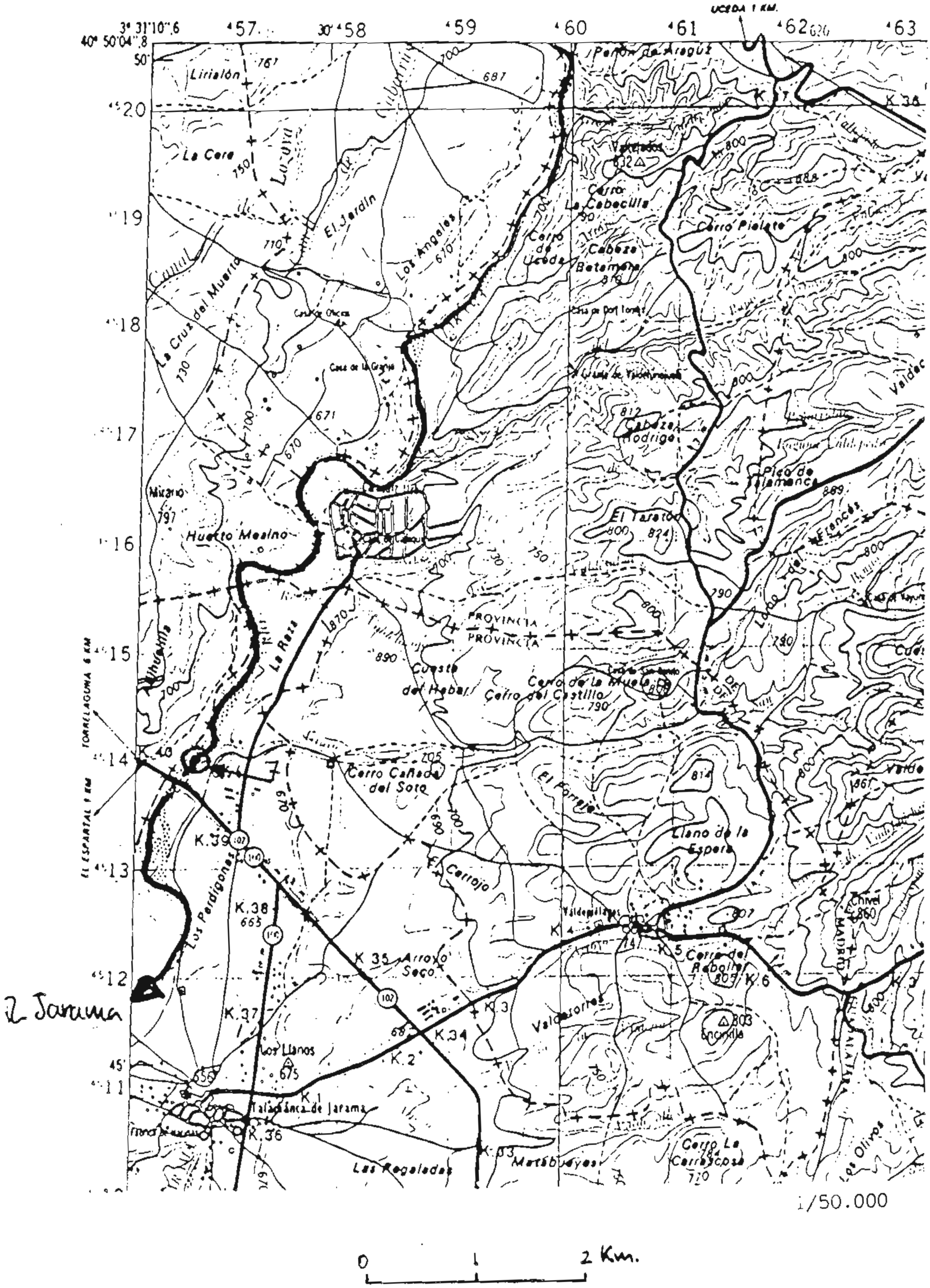
1/50.000

Fig

Sierra de Cuadarrama Area. Sites 8, 9, 10, 11

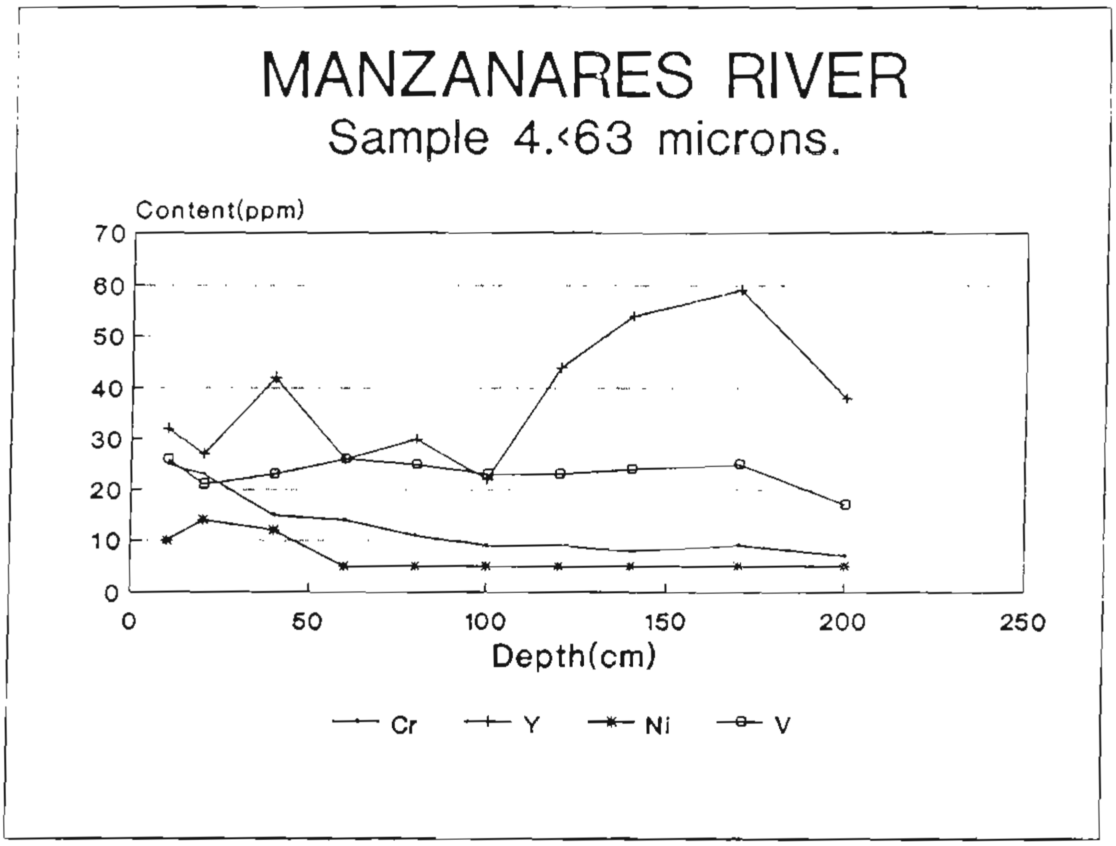
R. Jarama

Fig. 7.



. Sierra de Guadarrama Area. Site 7. R. Jarama

Fig. 8.


MANZANARES RIVER
Sample 4.<63 microns.
Content(ppm)
70
60
50
40
30
20
10
0
0
50
100
150
200
250
Depth(cm)
Cr
Y
Ni
V

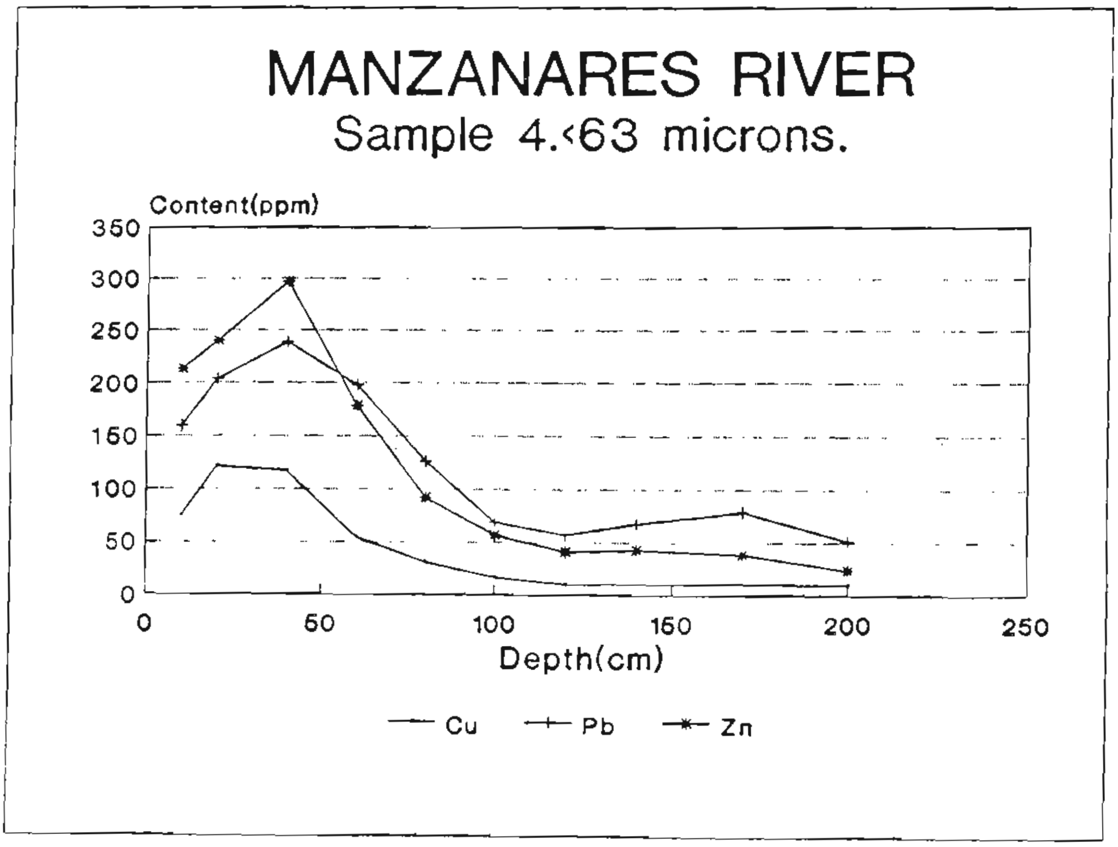
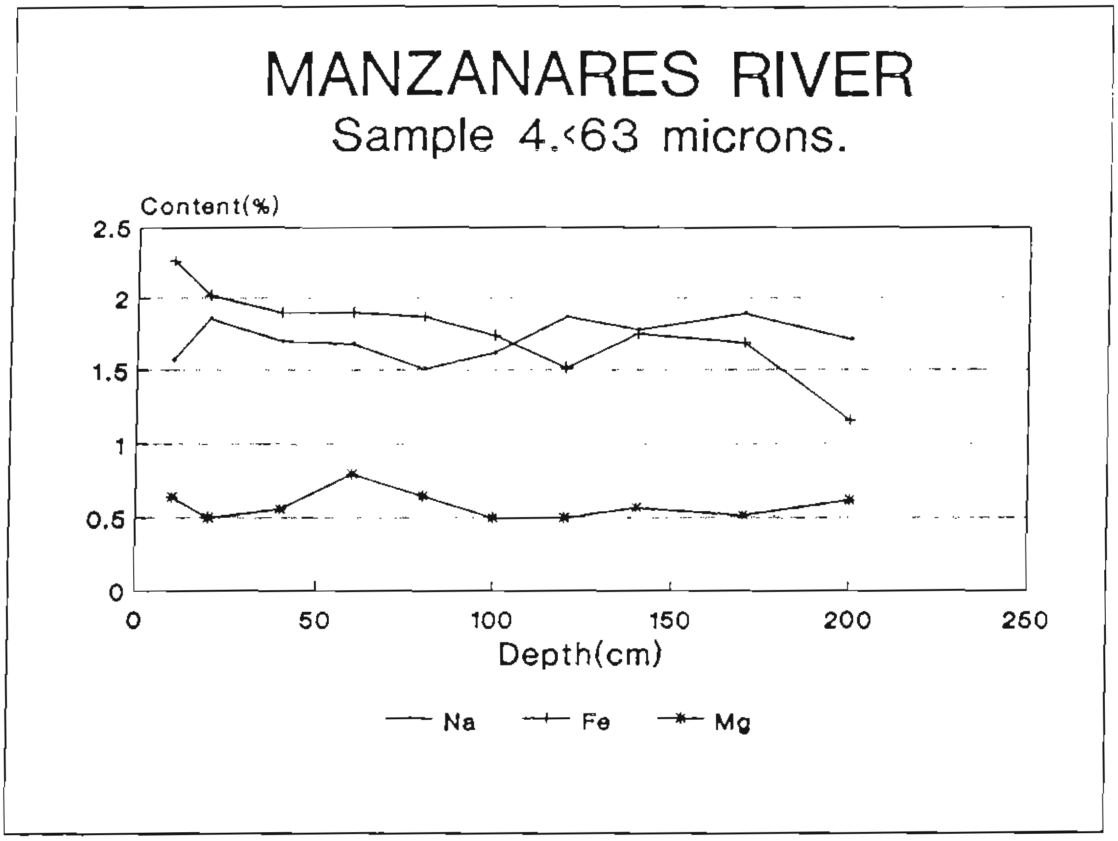

MANZANARES RIVER
Sample 4.<63 microns.
Content(ppm)
350
300
250
200
150
100
50
0
0
50
100
150
200
250
Depth(cm)
Cu
Pb
Zn

Fig. 9.


MANZANARES RIVER
Sample 4.<63 microns.
Content(%)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
Depth(cm)
Na
Fe
Mg

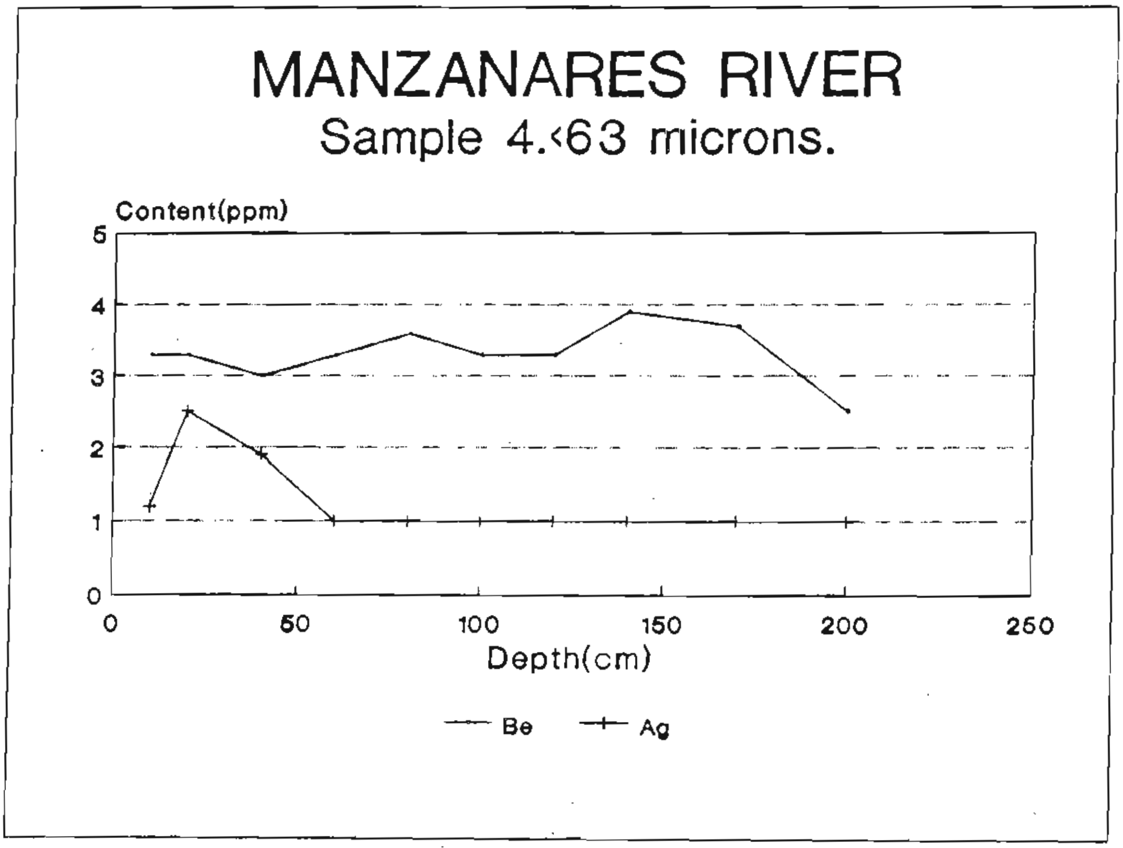

MANZANARES RIVER
Sample 4.<63 microns.
Content(ppm)
5
4
3
2
1
0
0
50
100
150
200
250
Depth(cm)
Be
Ag

Fig. 10.

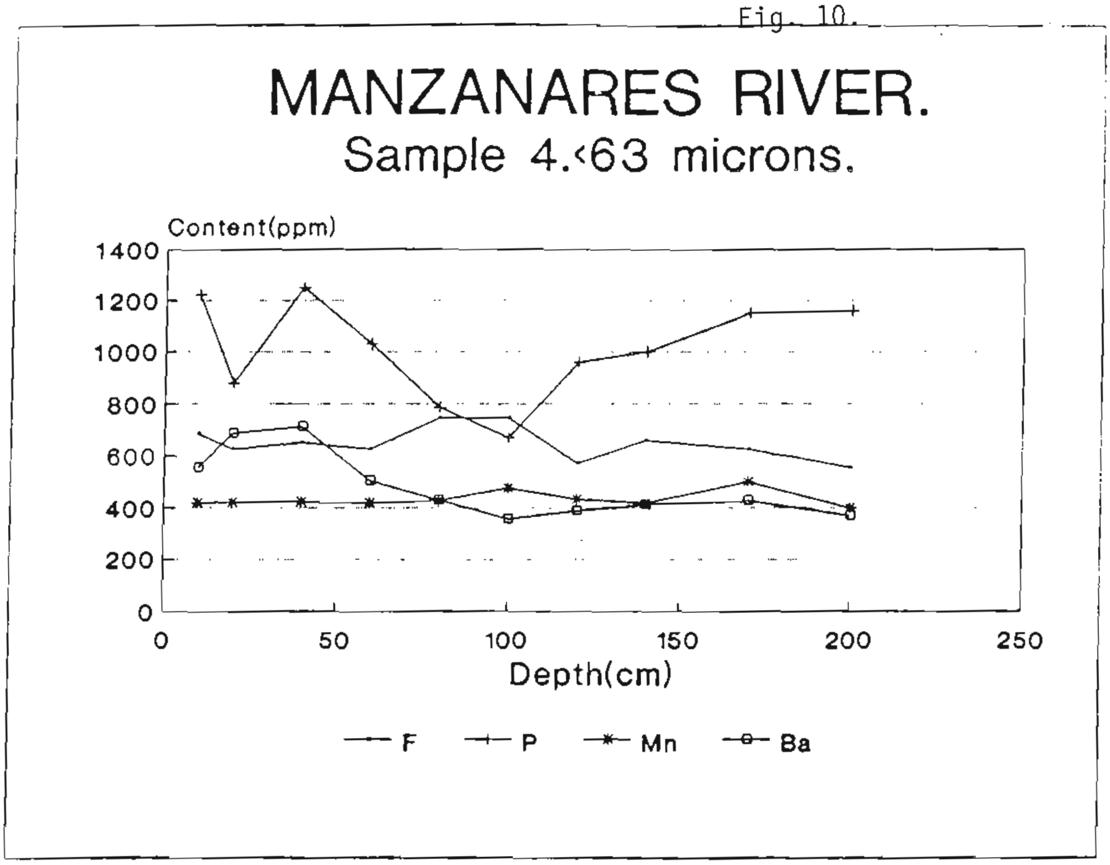
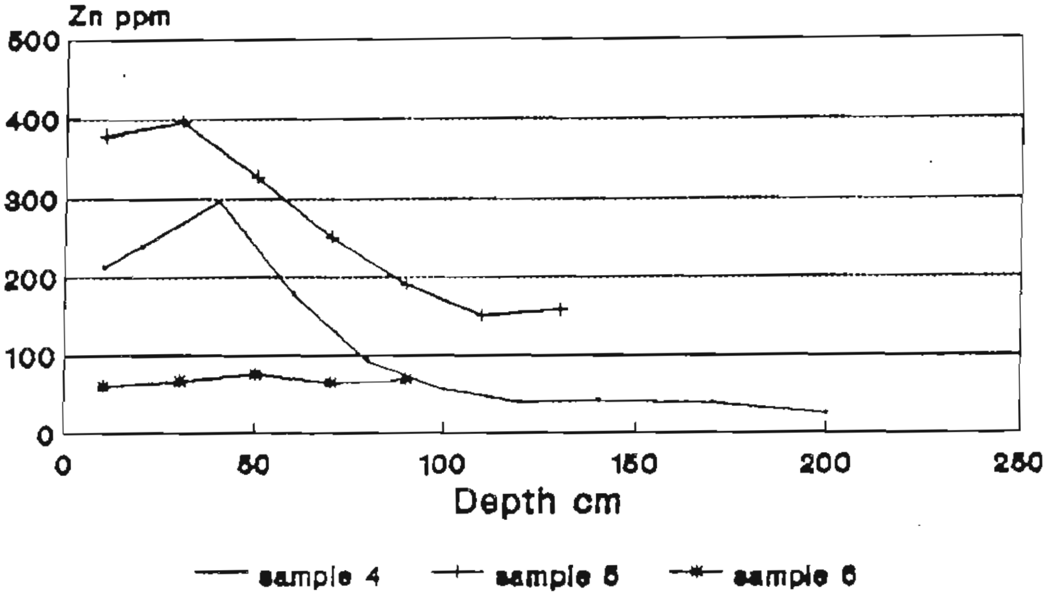

MANZANARES RIVER.
Sample 4.<63 microns.
Content(ppm)
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
Depth(cm)
F
P
Mn
Ba

Fig. 11.

Sample 4,5,6
Zn ppm <63 microns



Sample 4,5,6
Ag ppm <63 microns

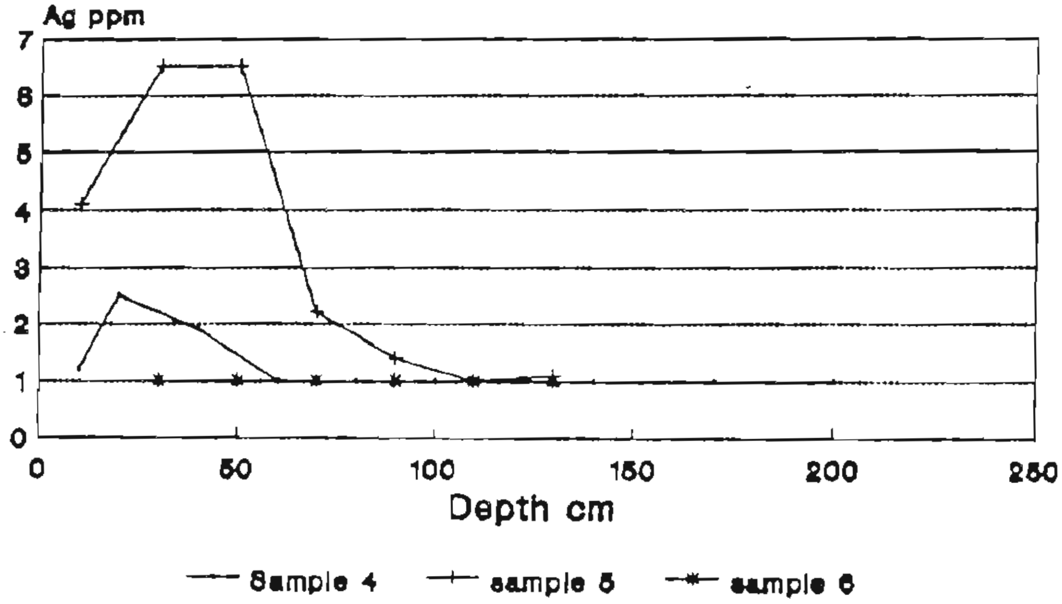
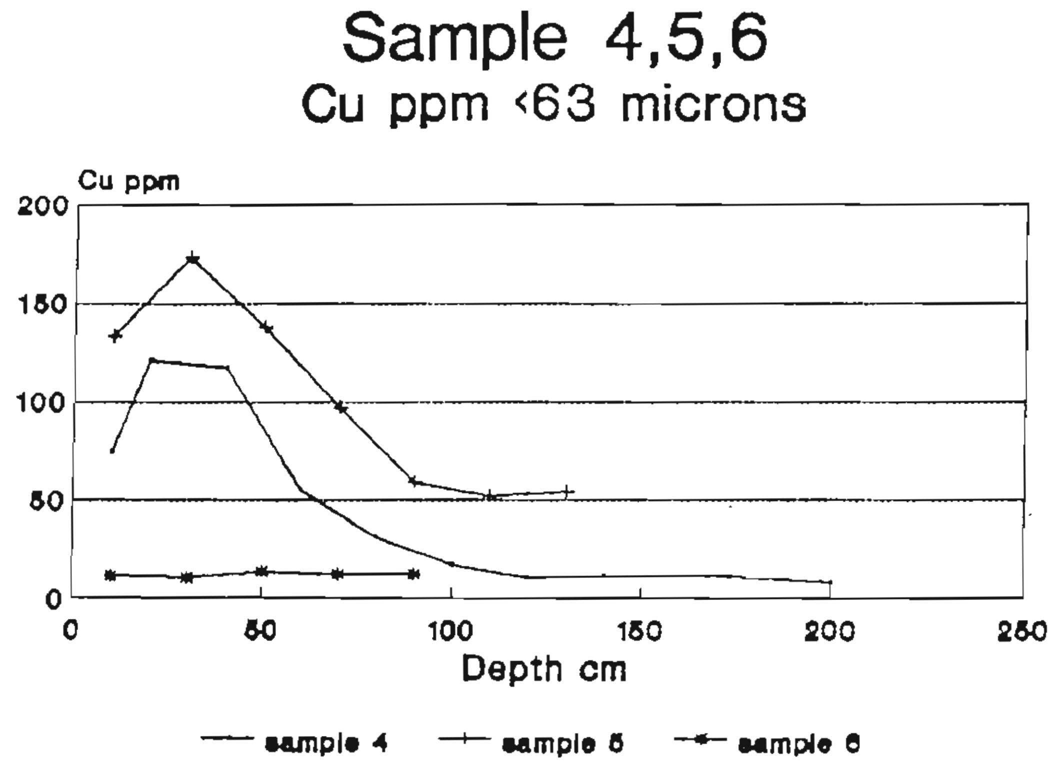


Fig. 12.


Sample 4,5,6
Cu ppm <63 microns
Cu ppm
200
150
100
50
0
0
50
100
150
200
250
Depth cm
sample 4
sample 5
sample 6

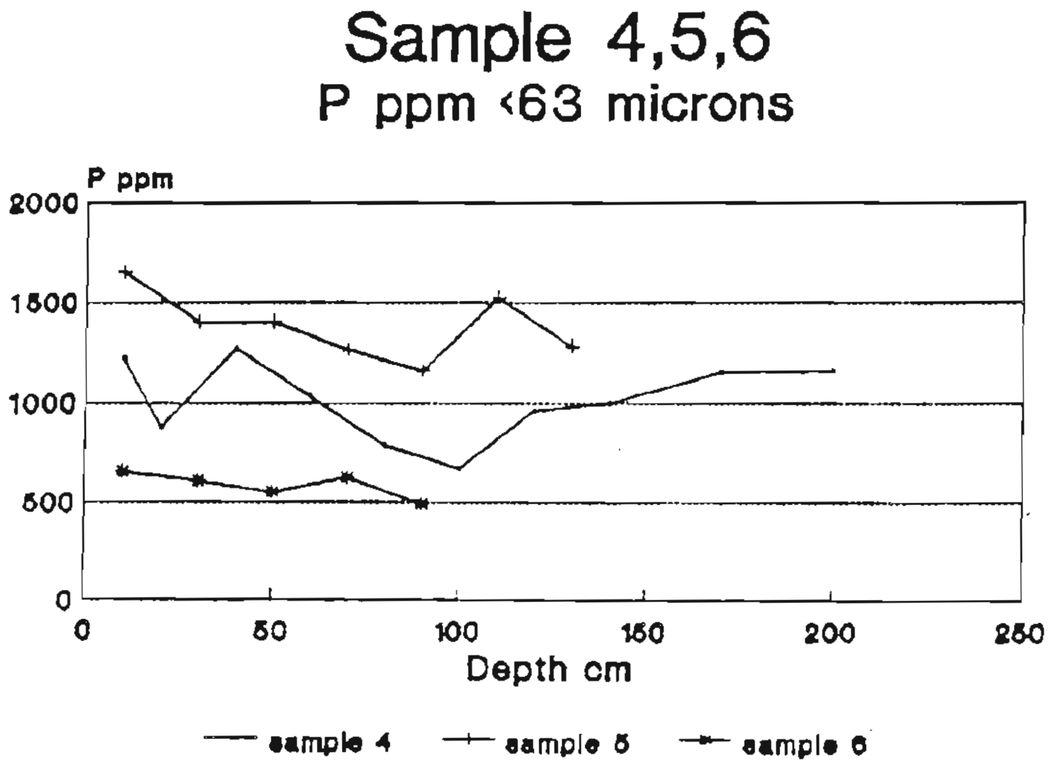
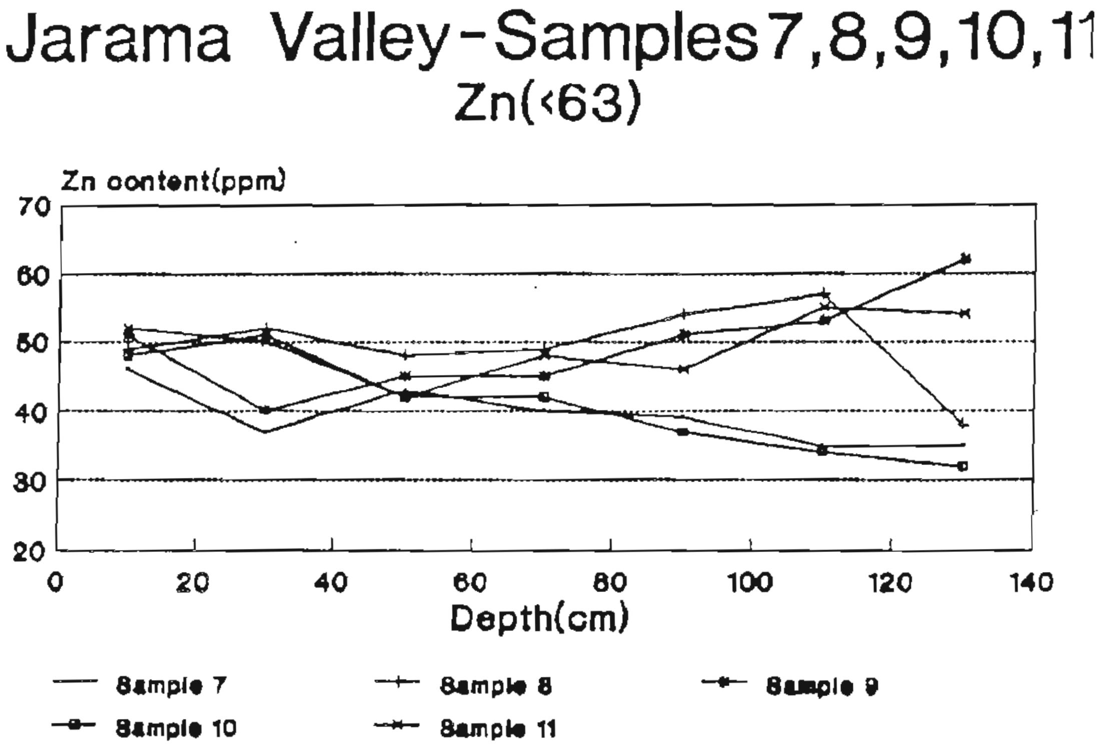
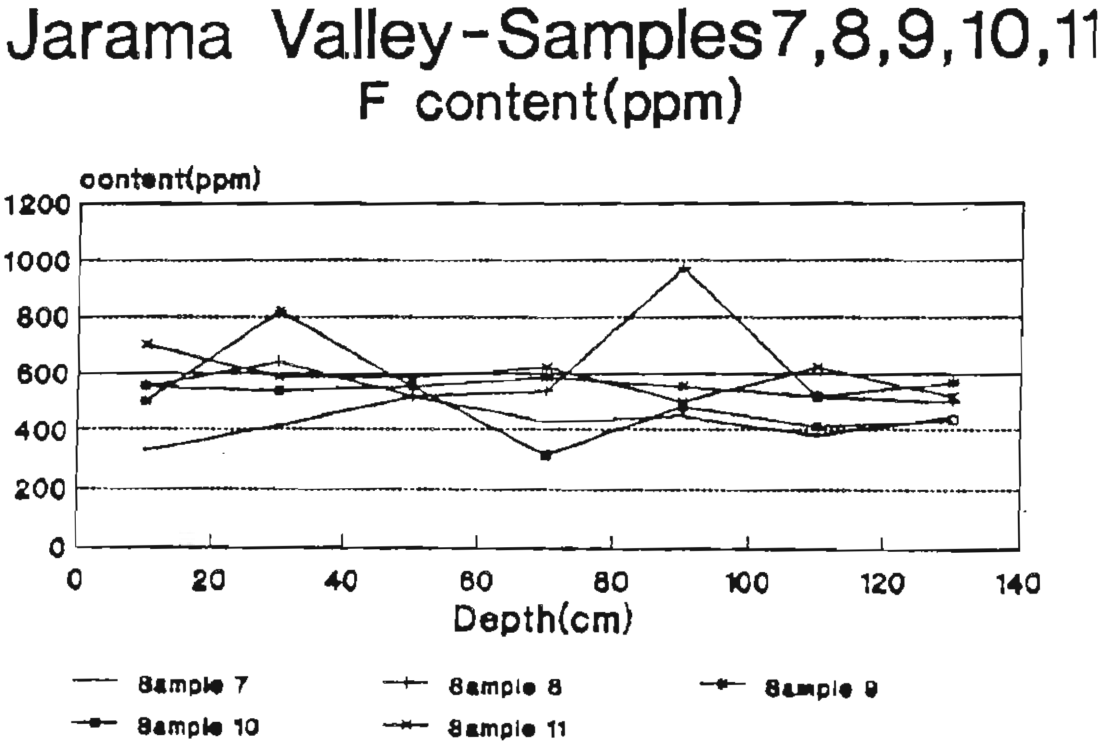

Sample 4,5,6
P ppm <63 microns
P ppm
2000
1500
1000
500
0
0
50
100
150
200
250
Depth cm
sample 4
sample 5
sample 6

Fig. 13.

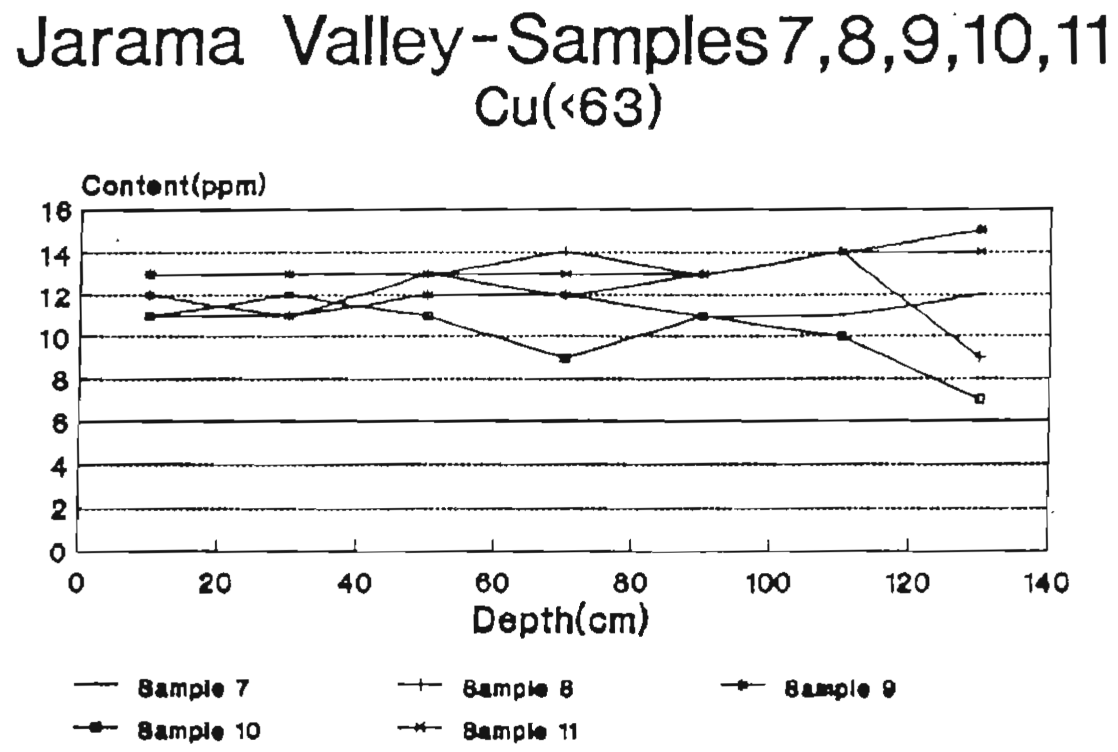


Jarama Valley-Samples7,8,9,10,11
Zn(<63)



Jarama Valley-Samples7,8,9,10,11
F content(ppm)

Fig. 14.


Jarama Valley-Samples7,8,9,10,11
Cu(<63)

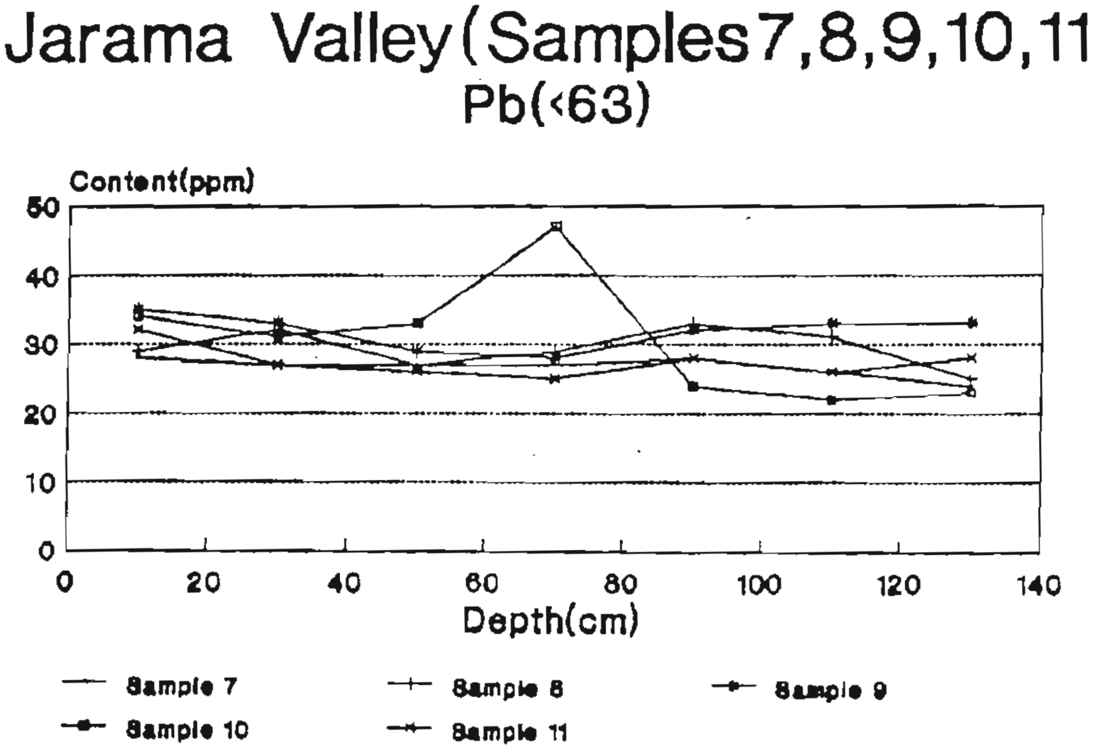
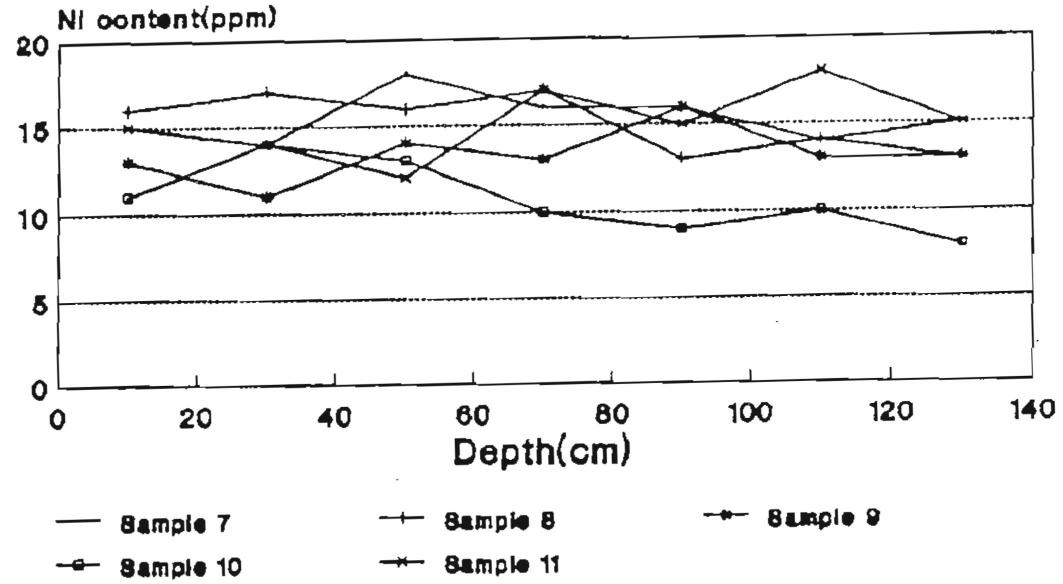

Jarama Valley(Samples7,8,9,10,11
Pb(<63)

Fig. 15.

Jarama Valley-Samples7,8,9,10,11
Ni(<63 microns)



Jarama Valley-Samples7,8,910,11
Sn(<63 microns)

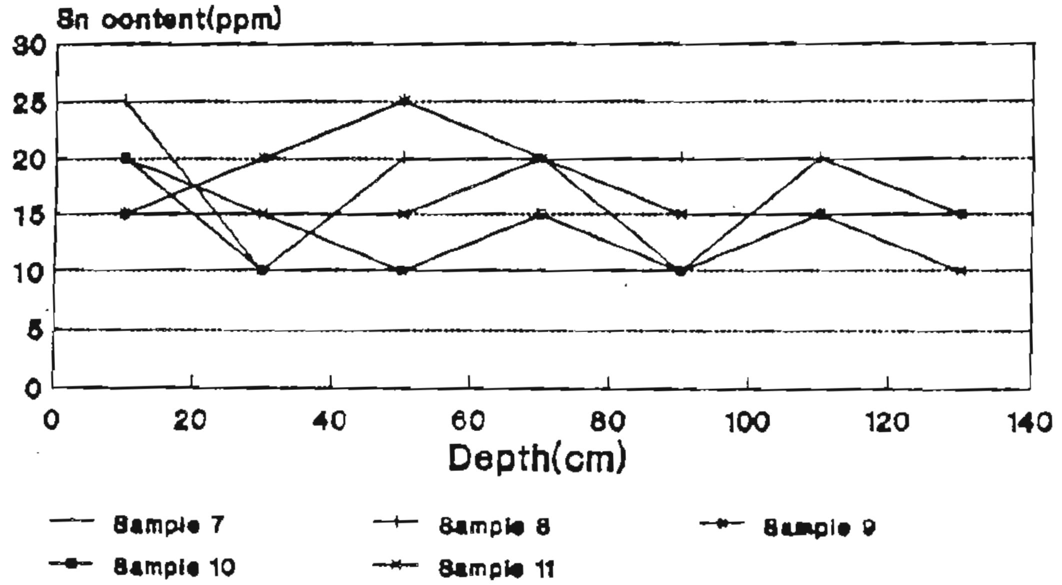
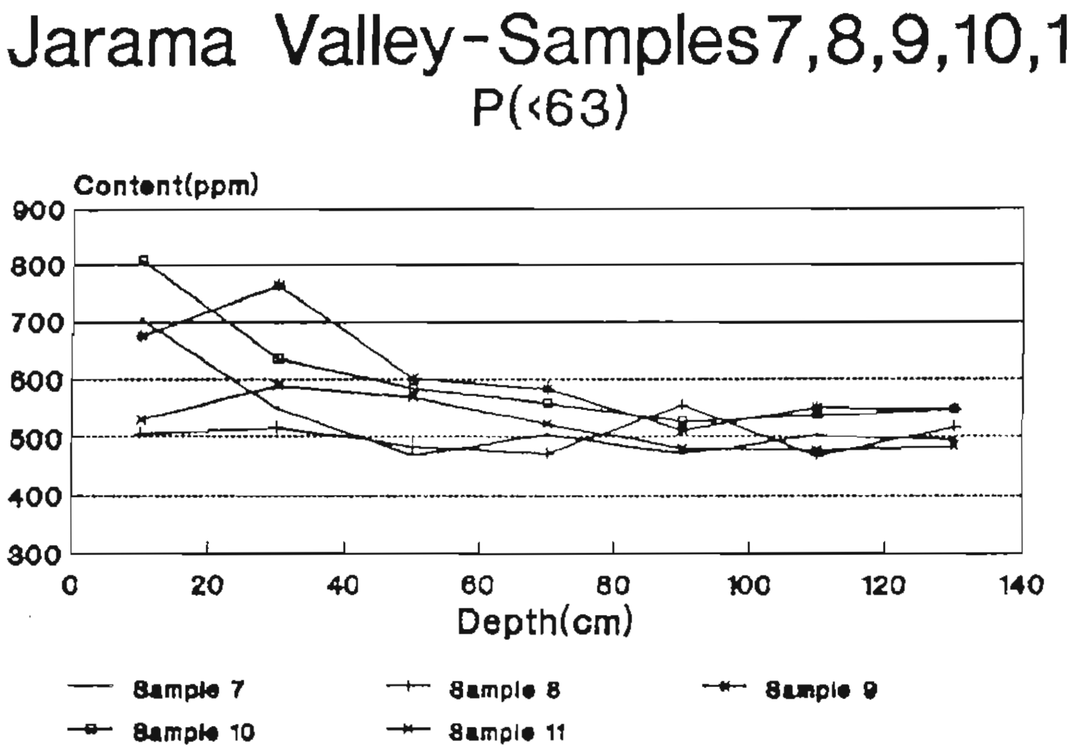


Fig. 16.


Jarama Valley-Samples7,8,9,10,11
P(<63)
Content(ppm)
900
800
700
600
500
400
300
0
20
40
60
80
100
120
140
Depth(cm)
Sample 7
Sample 8
Sample 9
Sample 10
Sample 11

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
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REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 6.1

GRAIN SIZE DISTRIBUTION IN OVERBANK SEDIMENT PROFILE SAMPLES, AUSTRIA

O. Scherman
Austria

1990

CONTENTS

1.0. INTRODUCTION

The main objective of this pilot work was the study of the grain size distribution in the collected overbank sediment profile samples, and especially the percentage proportion of the -0.063 mm (240 mesh) grain size fraction in this sampling medium. The distribution of elements in the different grain size fractions was not studied, because the samples were not stored by the laboratory.

2.0. SAMPLE SITE SELECTION

The eight overbank sediment sample sites were randomly selected about Vienna, and cover a variety of morphological and geological units (Fig. 1). They are referred to by the code names ERL, HOF, HI, NMURZ, NMZII, SPITZ, WEIT and ABSD (refer to also Appendix report 5.1).

3.0. SAMPLING

The sample material was obtained by a drill with a 1 m spiral rod (plus extension rods) to depths varying from 1.5 to 5.0 m. The individual sample sections were of 0.5 m length. Thus, contamination of the respective lower sections cannot be excluded, although efforts were made to keep this as low as possible. The surface area at each sample site was covered with a plastic sheet, which was thoroughly cleaned before drilling the next section. This procedure and the attempt to prevent contamination of succeeding samples, are the reasons for the variation in the total weights of the overbank sediment samples.

The top soil, down to the bottom of the grass roots, which in general does not exceed 10 cm in thickness, has been excluded in all cases from the surface sample section (0 - 0.5 m).

4.0. SAMPLE PREPARATION

A few days after completion of the sampling, the overbank sediment was removed from the plastic bags and dried in a thermostatically controlled oven at a temperature below 80°C. The whole sample, after drying, was weighed, disaggregated and sieved to different grain size fractions (i.e., -2 to 0.5 mm, -0.5 to +0.25 mm, -0.25 to +0.063 mm and -0.063 mm). It was found, that after weighing the individual fractions, there was on average a loss of 0.3% out of the original total weight (Table 1).

One grain size fraction of sample NMZII was discarded by mistake prior to weighing; so the weight of fraction -0.25 to +0.063 mm was calculated by subtracting the sum of the weights of the other fractions from the original total weight.

A sub-sample of the -0.063 mm fraction was ground to -300 mesh (0.053 mm), and about 2.5 g of the ground material was pressed with borate into 6 cm diameter pellets.

5.0. DATA PRESENTATION

The grain-size distribution weights are tabulated in Table 1 and are presented in graphical form (Figs. 2 to 9).

The data points on the plotted graphs are the mid-points for each section, i.e., a point at 0.25 m depth represents the section 0 - 0.5 m, and a depth of 0.75 m the section 0.5 - 1.0 m, etc.

Diagrams of the cumulative grain size are not included due to lack of sufficient data, especially on the lower end. It may be stated, however, that the sediments, in the majority of cases, fall into the "well-sorted" group, and any deviation possibly implies an artificial back-fill, which cannot easily be detected in the case of drilling.

6.0. DISCUSSION

The most important points of the results presented in Table 1 and Figs. 2 - 9 will be discussed.

A minimum weight of 2 kg of the -0.063 mm grain size fraction is proposed for the WEGS project. According to data from the Austrian pilot study, a weight of at least 100 kg per section must be sampled, or 200 kg per sample site, as a safety precaution for obtaining the agreed amount of the -0.063 mm grain size fraction for analysis and storage. Under the Austrian conditions, the digging of shafts for sampling overbank sediments, will cause severe conflicts with (a) labour safety, (b) some local authorities, and (c) small-scale land owners.

The following problems, with regard to the large sample weight required, are not only valid for Austria, but for other countries as well, i.e., transportation cost, drying and sieving in an almost contamination-free environment.

The objections raised during the meetings of the Working Group can only be repeated here. The only possibility to avoid some of the problems that have been mentioned above is to reduce the required amount of the -0.063 mm sample material. This would only mean a reduction in the analytical material for the noble metals, thus accepting a greater splitting error.

7.0. CONCLUSIONS

The study of grain size distribution in the overbank sediment samples has pointed to a very important problem, with regard to the proposed 2 kg weight of the -0.063 mm fraction for analysis and storage for future use. The enormous weight of sample required, i.e., 200 kg per sample site, will create severe problems under Austrian field sampling conditions. It is, therefore, proposed that a coarser grain size fraction should be agreed upon or the required amount of 2 kg to be reduced.

The geochemistry of the overbank sediment profiles has shown that anthropogenic pollution has affected the top layers of most profiles, and in all cases pristine samples can be obtained at depth. It is, therefore, concluded that overbank sediments are generally a good sampling medium for environmental pollution studies.

Table 1. Distribution of grain size fraction weights in overbank sediment profile samples.

SAMPLE		DEPTH	WEIGHT (gms) IN DIFFERENT GRAIN-SIZE FRACTIONS					TOTAL	W E I G H T P E R C E N T				
		(m)	>2 mm	>0.5 mm	>0.25 mm	>0.063 mm	<0.063 mm	WEIGHT	>2 mm	>0.5 mm	>0.25 mm	>0.063 mm	<0.063 mm
Weit	A	0.0-0.5	17.5	45.4	25.6	45.8	13.2	147.5	11.86	30.78	17.36	31.05	8.95
	B	0.5-1.0	18.5	52.8	33.7	64.2	20.1	189.3	9.77	27.89	17.80	33.91	10.62
	C	1.0-1.5	39.1	99.7	29.5	44.7	19	232	16.85	42.97	12.72	19.27	8.19
	D	1.5-2.0	10.8	80.9	113.4	128.7	18.4	352.2	3.07	22.97	32.20	36.54	5.22
	E	2.0-2.5	125.7	271.8	229	292.6	32	951.1	13.22	28.58	24.08	30.76	3.36
	F	2.5-3.0	118.2	293.9	148	206.3	29.2	795.6	14.86	36.94	18.60	25.93	3.67
Erl	A	0.0-0.5	164.7	78.1	82.4	135.8	52.4	513.4	32.08	15.21	16.05	26.45	10.21
	B	0.5-1.0	641.9	184.3	113	176.4	56	1171.6	54.79	15.73	9.64	15.06	4.78
Hof	A	0.0-0.5	6	76.6	141.5	110.6	12.9	347.6	1.73	22.04	40.71	31.82	3.71
	B	0.5-1.0	5.1	103.8	164.6	119.8	21.2	414.5	1.23	25.04	39.71	28.90	5.11
	C	1.0-1.5	390.4	411.6	303	169.3	23.6	1297.9	30.08	31.71	23.35	13.04	1.82
Spitz	A	0.0-0.5	465.1	294.2	116.3	89.9	24.1	989.6	47.00	29.73	11.75	9.08	2.44
	B	0.5-1.0	87.5	154.9	57.2	55.7	13.8	369.1	23.71	41.97	15.50	15.09	3.74
	C	1.0-1.5	349.8	164.6	91.2	64.7	15.2	685.5	51.03	24.01	13.30	9.44	2.22
NMzII	A	0.0-0.5	58	89.8	27.6	47.2	21	243.6	23.81	36.86	11.33	19.38	8.62
	B	0.5-1.0	140.9	220.7	119.8	190.4	62.2	734	19.20	30.07	16.32	25.94	8.47
	C	1.0-1.5	139.7	252.7	173.9	200.4	61.1	827.8	16.88	30.53	21.01	24.21	7.38
	D	1.5-2.0	155	396.2	232.3	231.1	62.4	1077	14.39	36.79	21.57	21.46	5.79
	E	2.0-2.5	125.6	119	109.6	143.7	35.7	533.6	23.54	22.30	20.54	26.93	6.69
	F	2.5-3.0	387.1	325.3	226.1	246.4	46.7	1231.6	31.43	26.41	18.36	20.01	3.79
NMurz	A	0.0-0.5	69.3	136	126.8	121.4	34.1	487.6	14.21	27.89	26.00	24.90	6.99
	B	0.5-1.0	132.2	356.1	231.1	298.2	67	1084.6	12.19	32.83	21.31	27.49	6.18
	C	1.0-1.5	227.9	406.5	232.9	217	63.4	1147.7	19.86	35.42	20.29	18.91	5.52
	D	1.5-2.0	368.1	702.9	123.6	118.1	42.8	1355.5	27.16	51.86	9.12	8.71	3.16
Hi	A	0.0-0.5	437	175.9	38.5	31.5	16.5	699.4	62.48	25.15	5.50	4.50	2.36
	B	0.5-1.0	578.1	208.5	37.8	57.6	20.2	902.2	64.08	23.11	4.19	6.38	2.24
	C	1.0-1.5	610.1	130.3	19.3	20.9	9.9	790.5	77.18	16.48	2.44	2.64	1.25
	D	1.5-2.0	581.2	249.1	25.1	18.8	8.5	882.7	65.84	28.22	2.84	2.13	0.96
	E	2.0-2.5	148.6	155.2	179.8	106.5	11.8	601.9	24.69	25.79	29.87	17.69	1.96
	F	2.5-3.0	710.2	562.8	361.2	185.7	21.8	1841.7	38.56	30.56	19.61	10.08	1.18
Absd	A	0.0-0.5	154.7	137.8	45.3	49.8	25	412.6	37.49	33.40	10.98	12.07	6.06
	B	0.5-1.0	384.8	165	39.2	48	44.6	681.6	56.46	24.21	5.75	7.04	6.54
	C	1.0-1.5	484.3	137.5	29	39.8	58.5	749.1	64.65	18.36	3.87	5.31	7.81
	D	1.5-2.0	842.9	161	33	43.3	66	1146.2	73.54	14.05	2.88	3.78	5.76
	E	2.0-2.5	698.2	114.6	24.7	52.4	51.9	941.8	74.13	12.17	2.62	5.56	5.51
	F	2.5-3.0	290.3	45.6	10.2	21.4	17.2	384.7	75.46	11.85	2.65	5.56	4.47
	G	3.0-3.5	732.1	109.2	22.6	44.1	36.4	944.4	77.52	11.56	2.39	4.67	3.85
	H	3.5-4.0	643.4	183.5	39.6	62.6	74.1	1003.2	64.13	18.29	3.95	6.24	7.39
	I	4.0-4.5	704.5	177.9	36.7	51.5	53.2	1023.8	68.81	17.38	3.58	5.03	5.20
	J	4.5-5.0	628.4	142.9	31.1	44.7	21.3	868.4	72.36	16.46	3.58	5.15	2.45
								Mean %	37.78	26.34	14.63	16.20	5.04
								Minimum %	1.23	11.56	2.39	2.13	0.96
								Maximum %	77.52	51.86	40.71	36.54	10.62

Fig.1. Wegs Overbank sediment profile location map, Austria

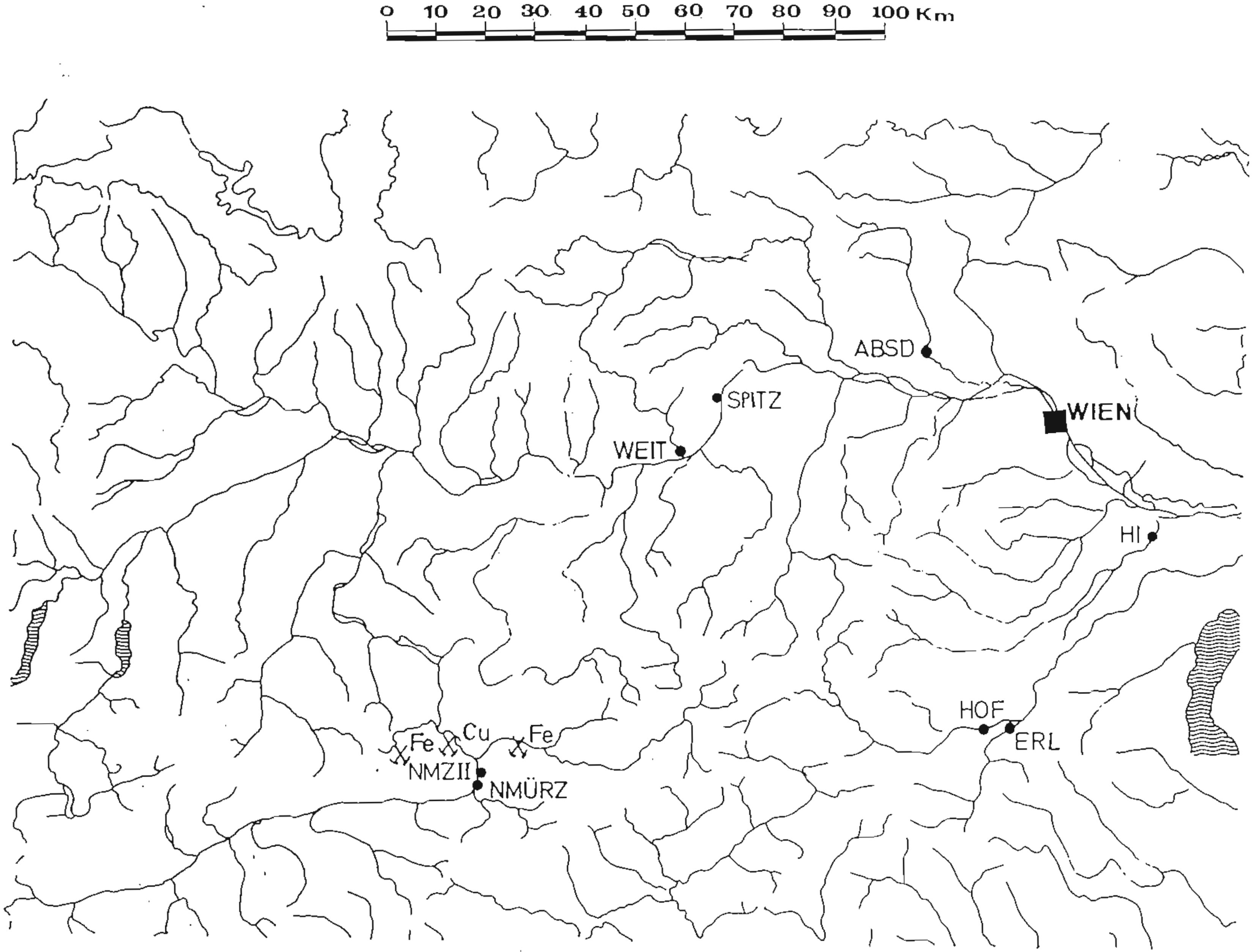


Fig.2 WEIT - grain-size distribution

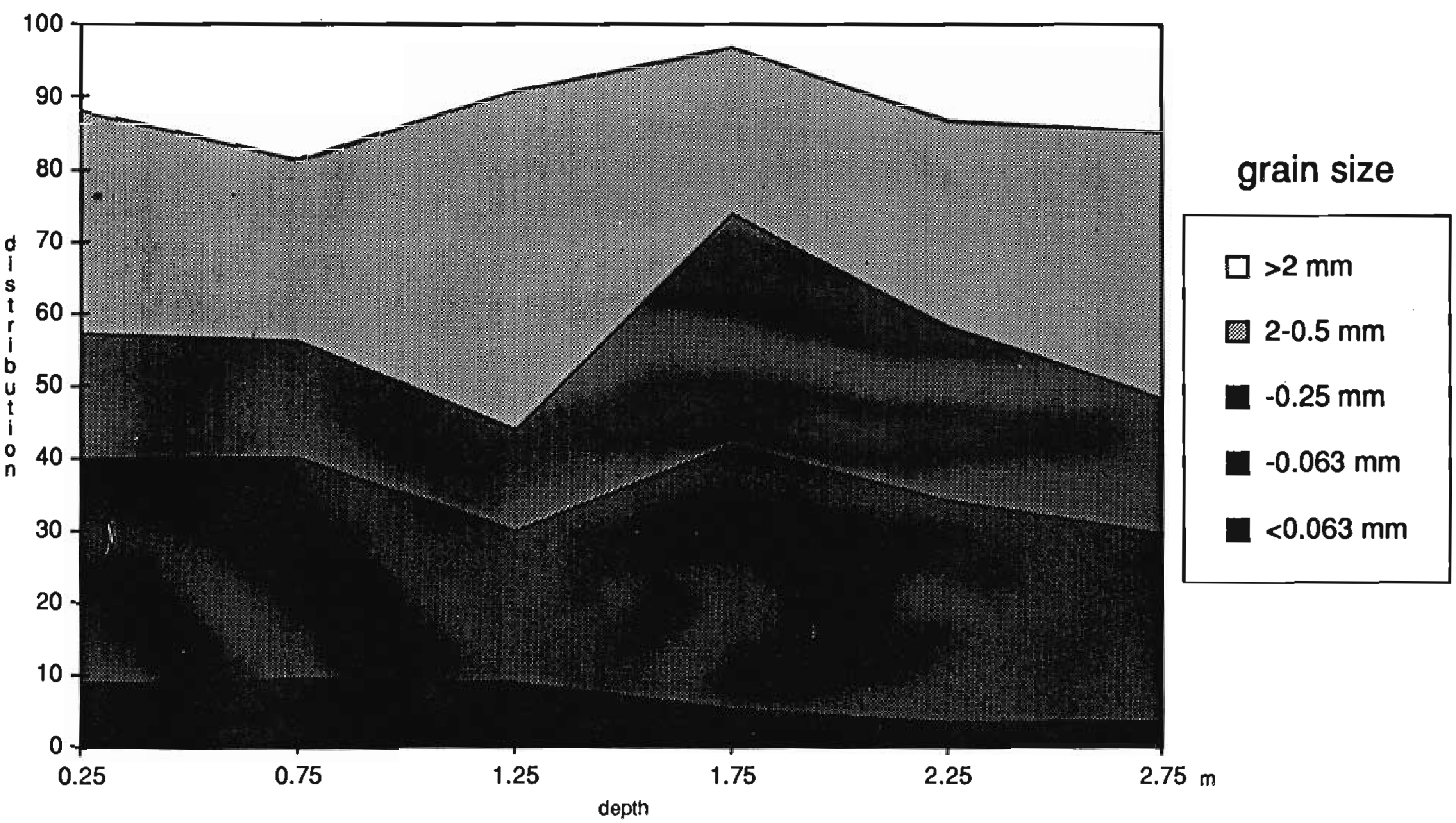


Fig. 3 Erl - grain-size distribution

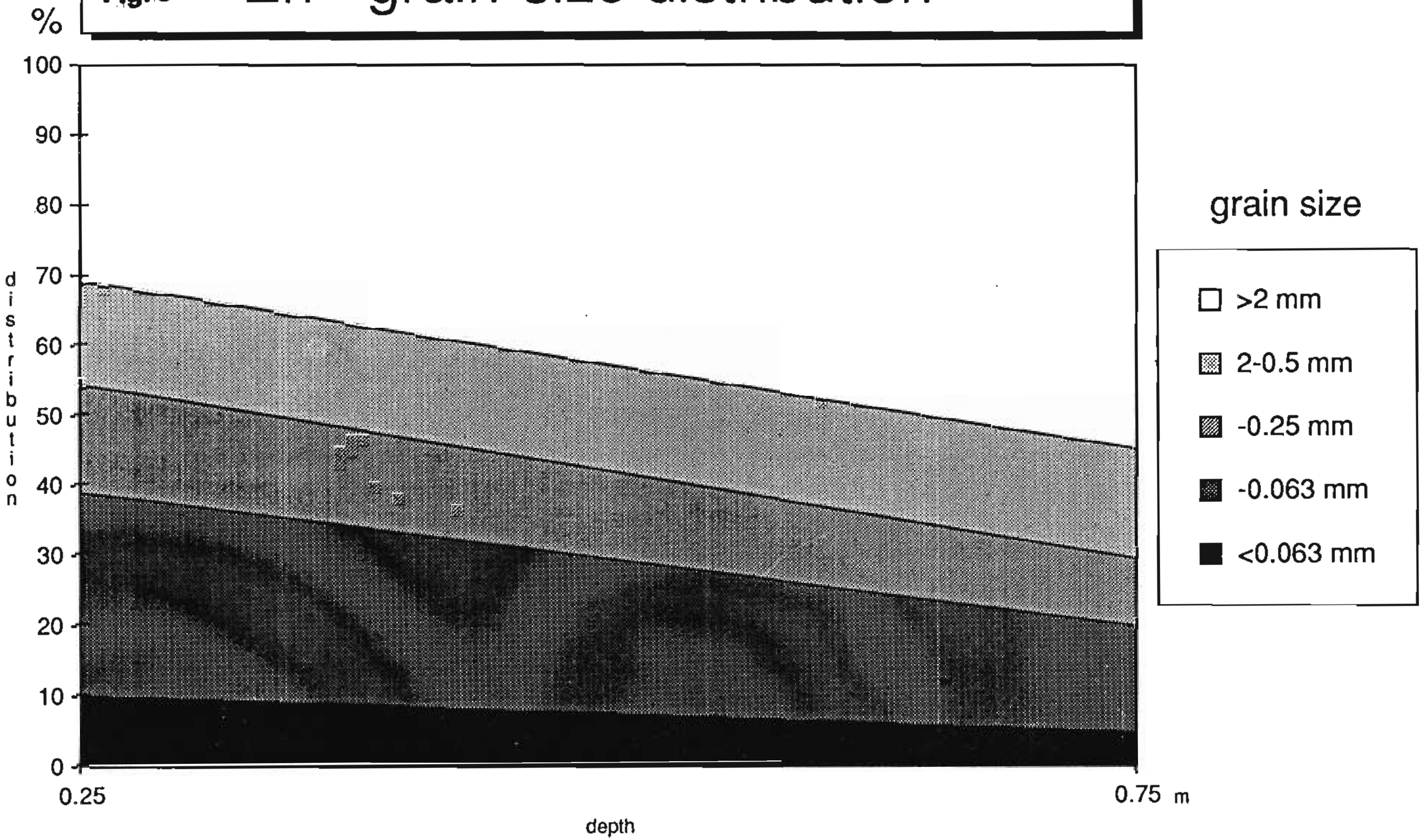


Fig. 4 Hof - grain-size distribution

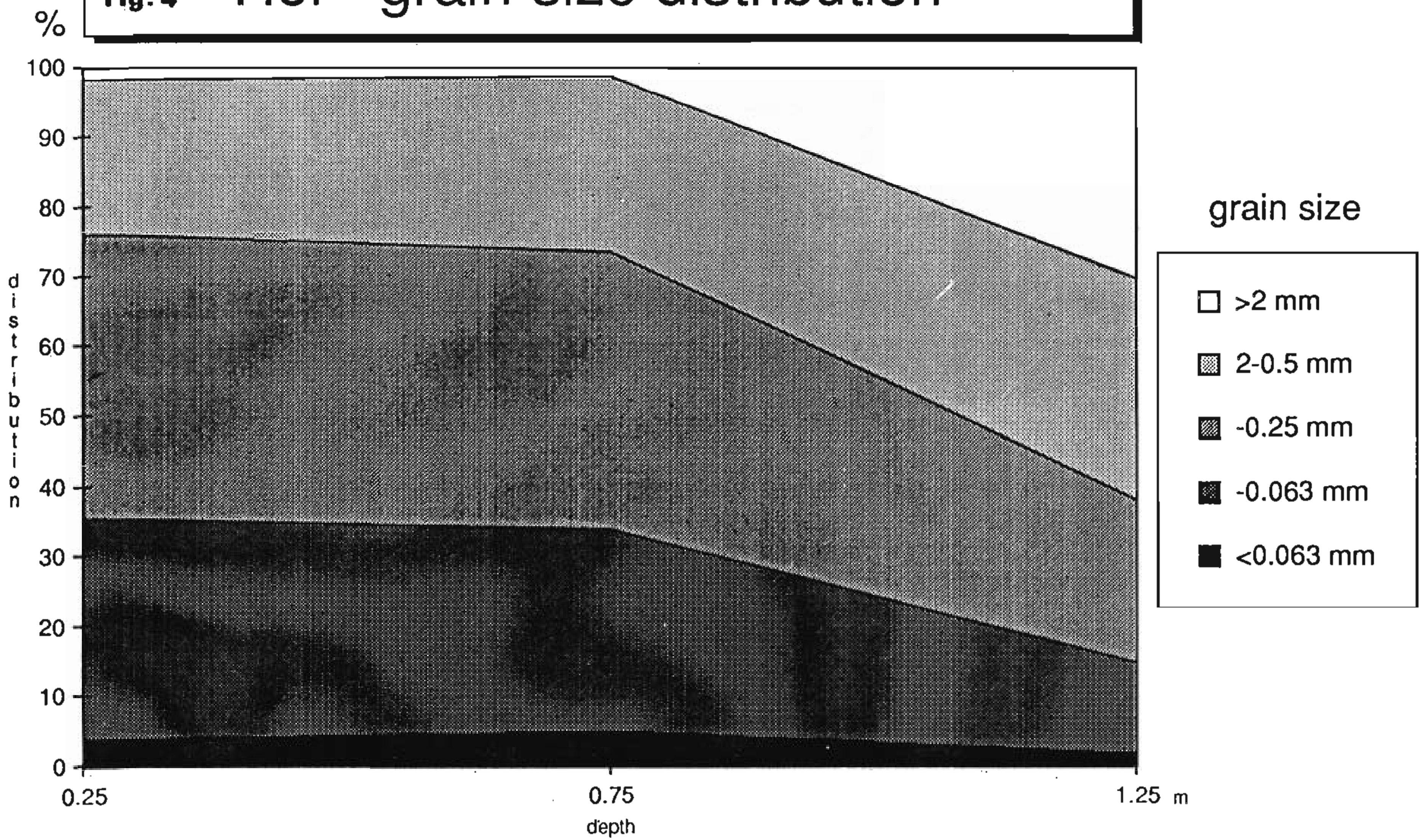


Fig.5 Spitz - grain-size distribution

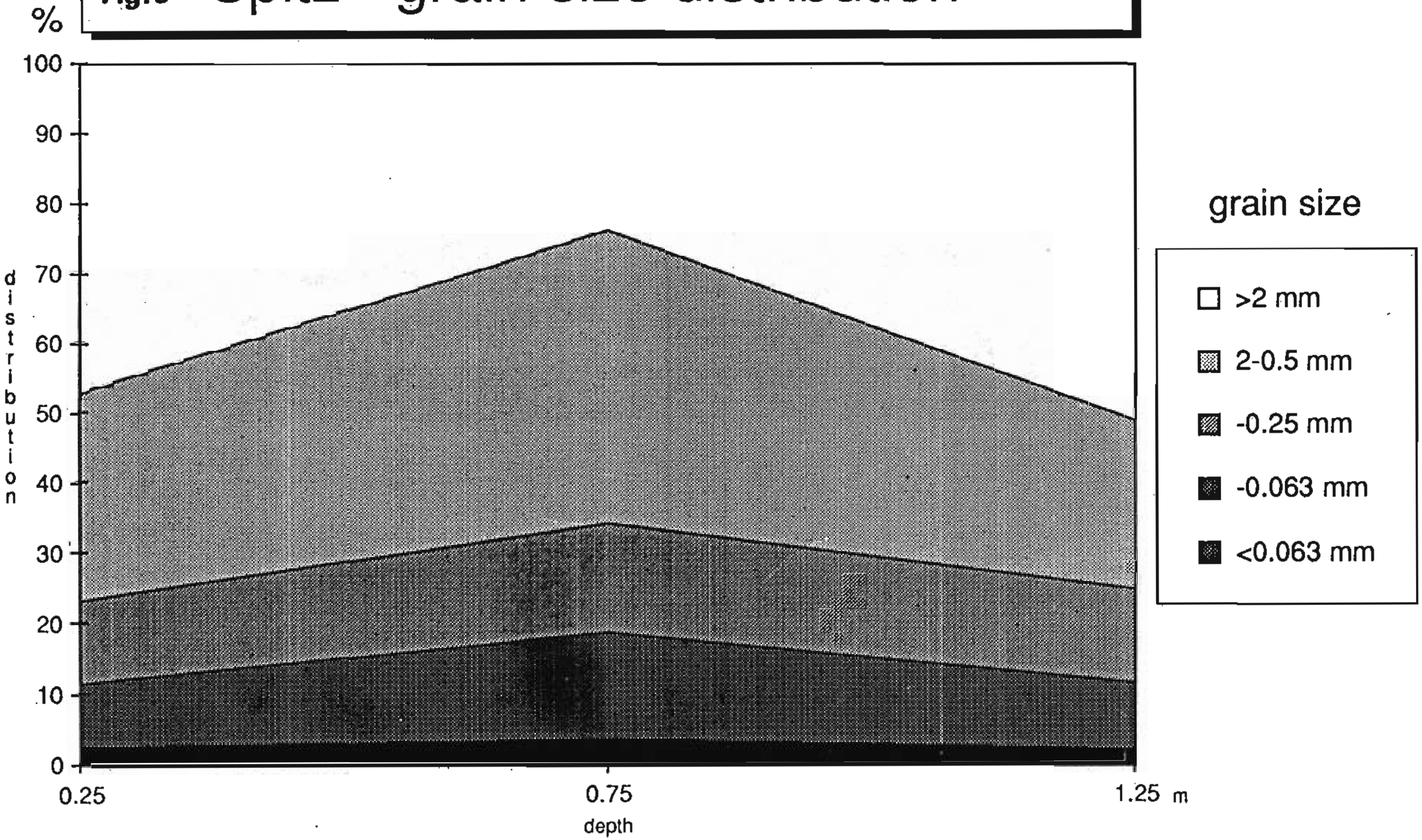


Fig.6 NMzII - grain-size distribution

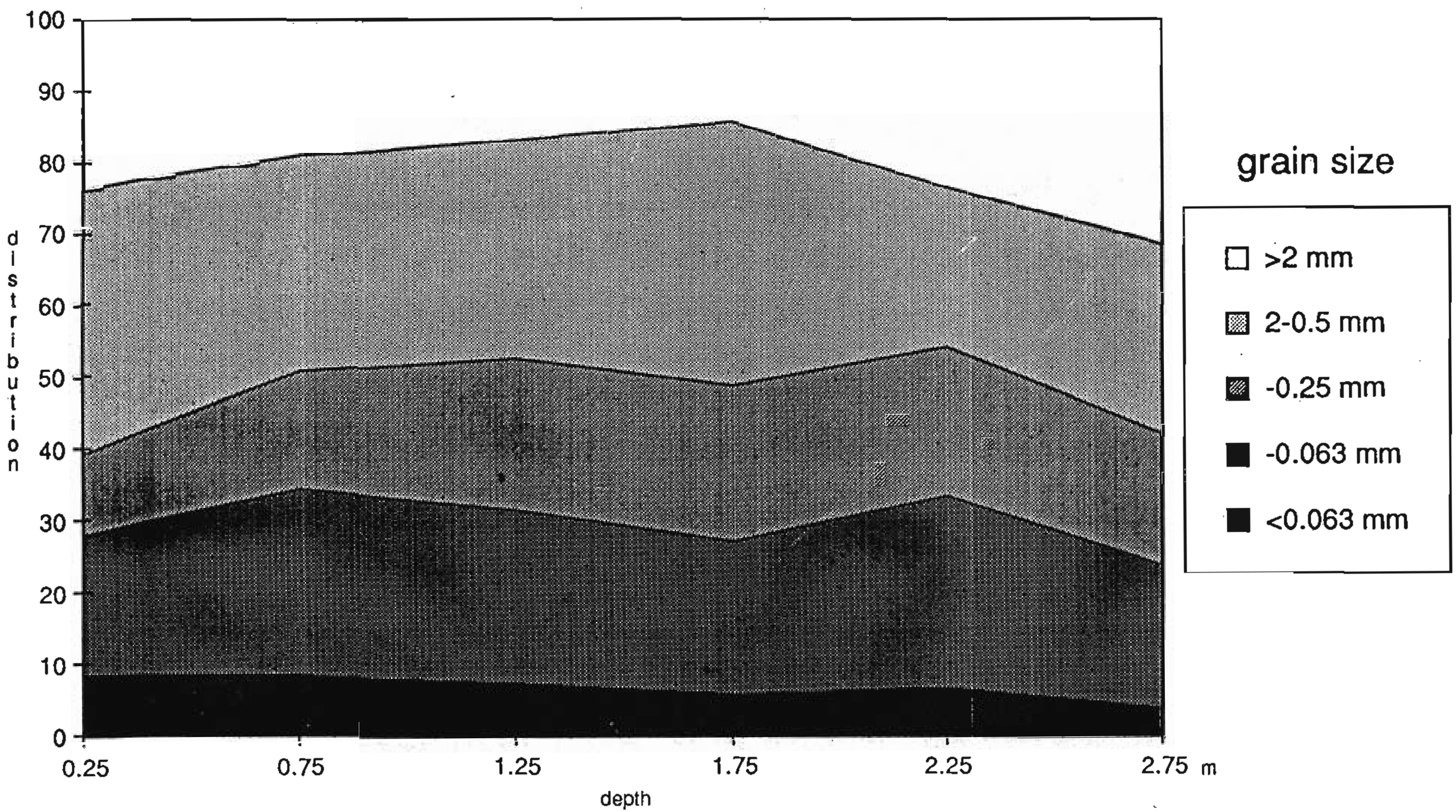
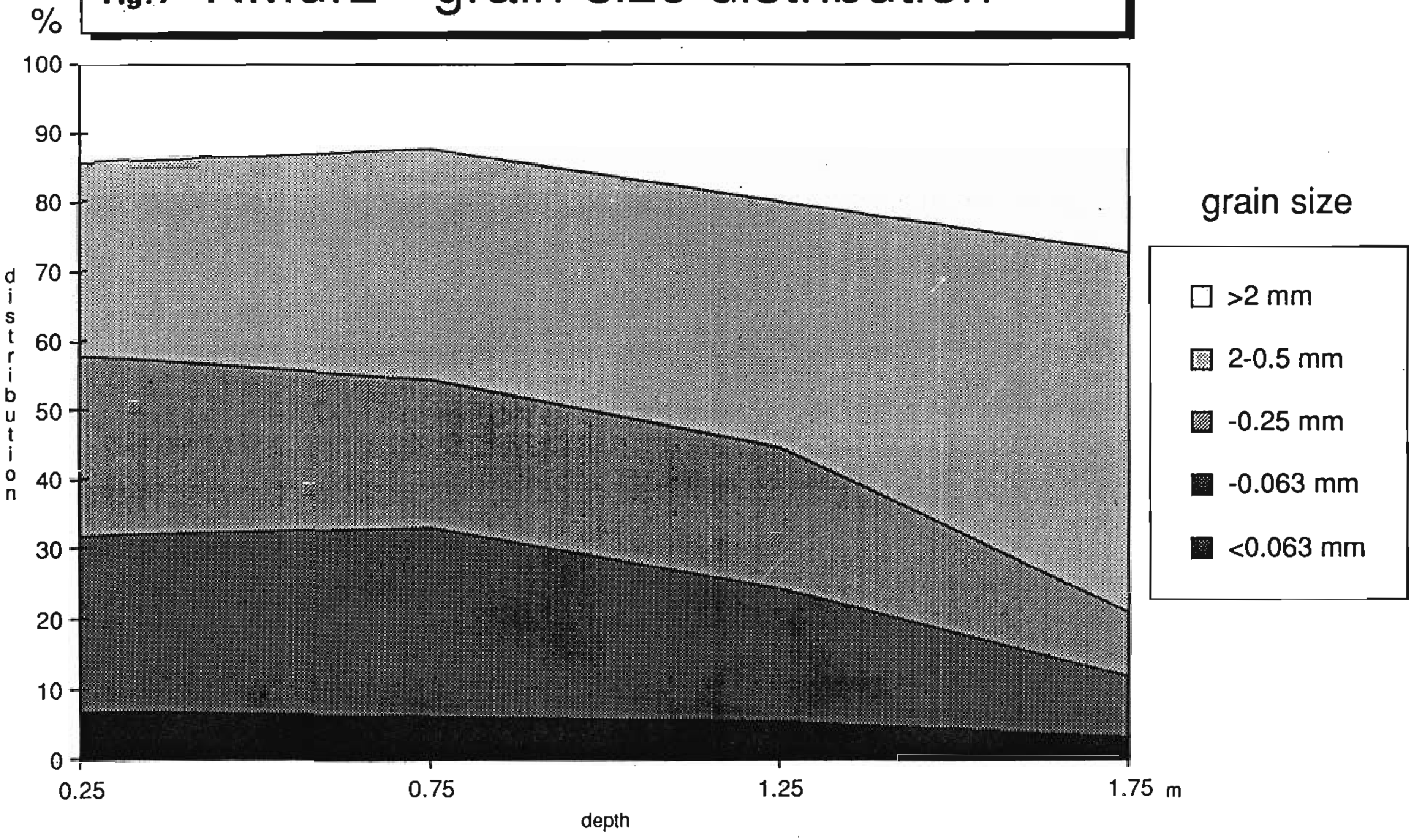


Fig.7 NMürz - grain-size distribution



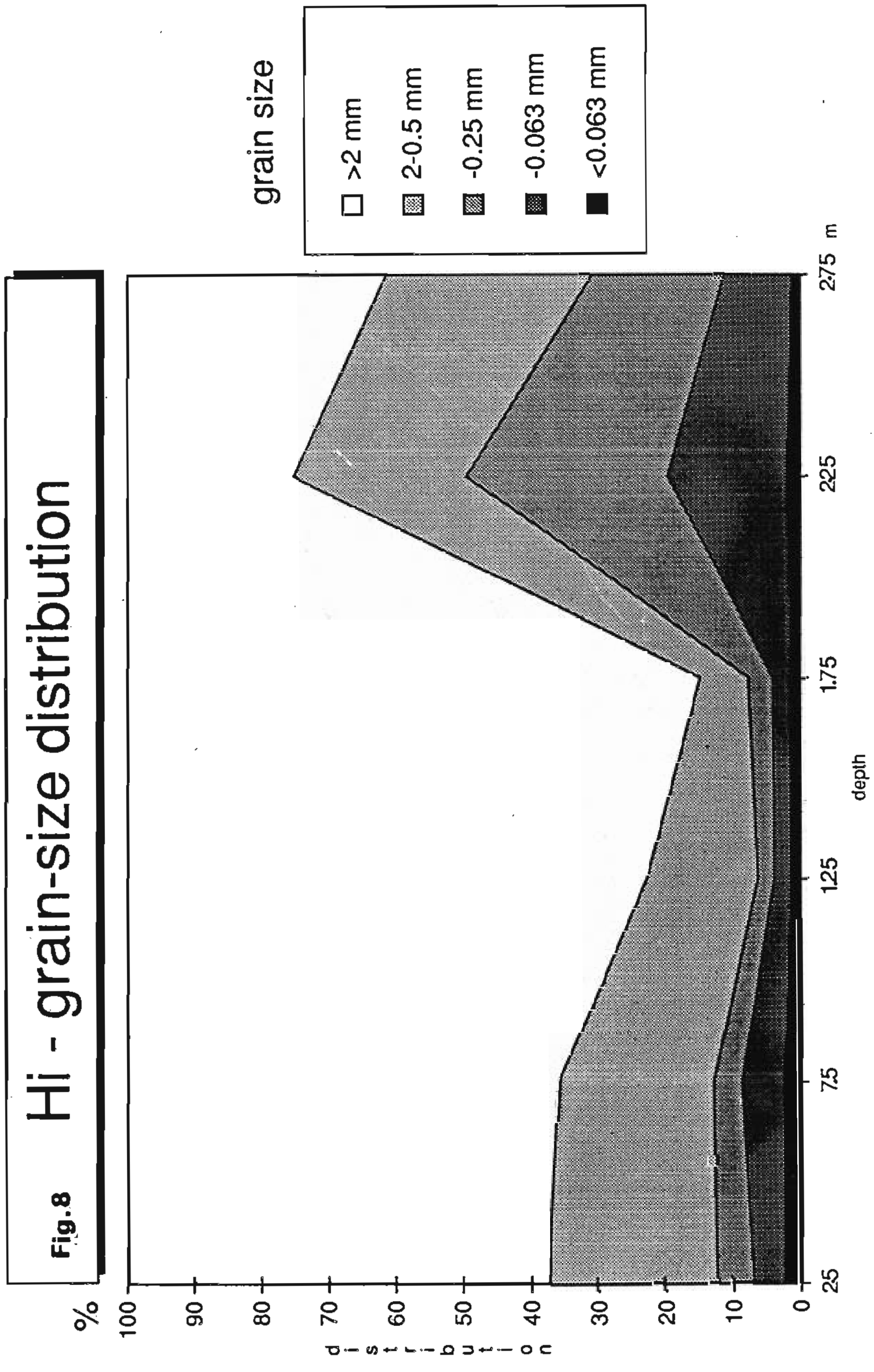
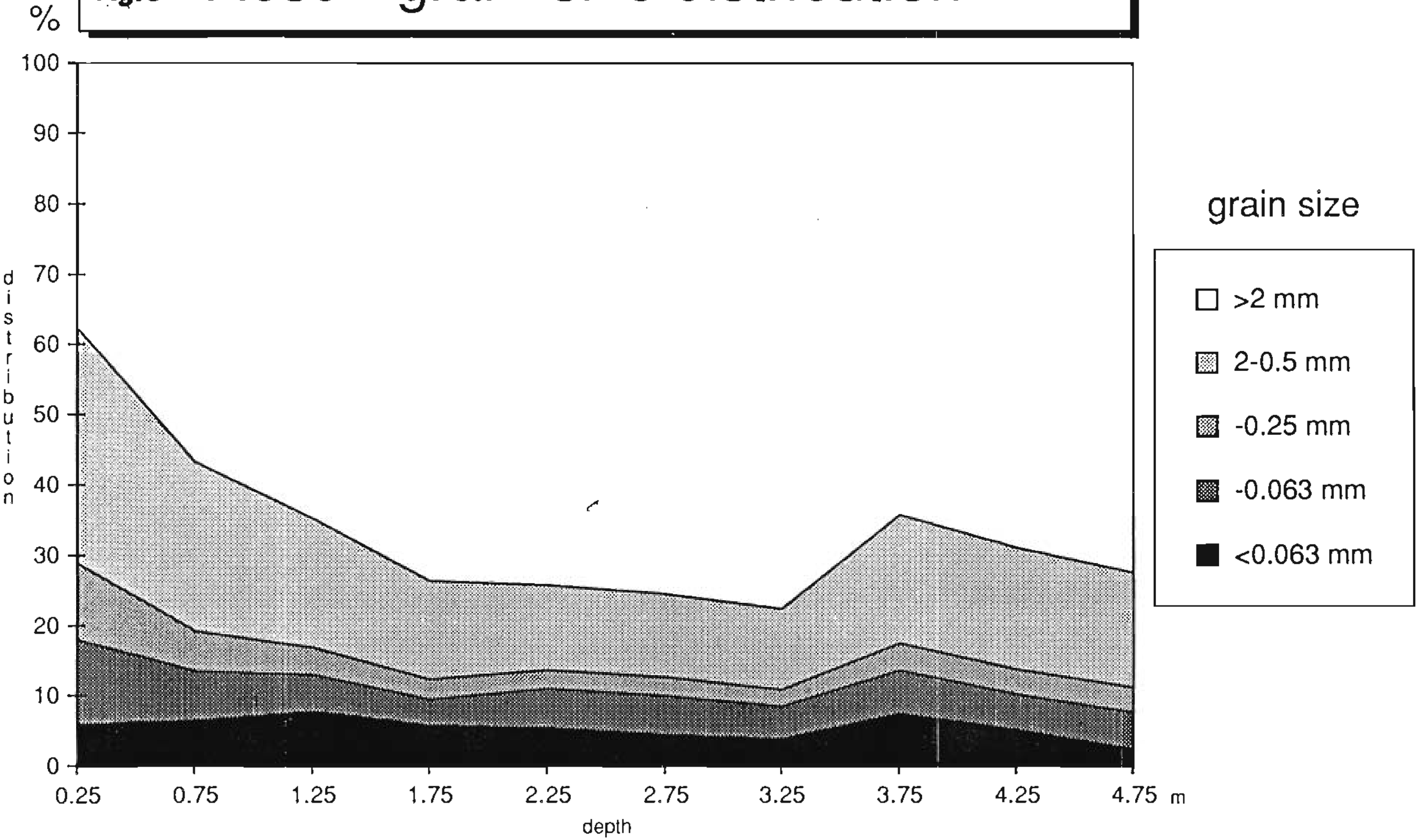


Fig.8 Hi - grain-size distribution

Fig.9 Absd - grain-size distribution



WESTERN EUROPEAN GEOLOGICAL SURVEYS
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PILOT PROJECT

APPENDIX REPORT 6.2

DISTRIBUTION OF ELEMENTS IN DIFFERENT GRAIN SIZE FRACTIONS, GREECE

Alecos DEMETRIADES

I.G.M.E., Greece

1990

CONTENTS

1.0. INTRODUCTION

The WEGS Working Group on Regional Geochemical Mapping decided at the Hannover meeting in 1989 (6.-10 Nov.) to study the distribution of elements in different grain size fractions, in relation to their weight distribution in the collected overbank and stream sediment samples of the Greek Pilot Project. Fig. 1 shows the area covered by the survey, and the sample locations.

This study was considered essential after the results of the Austrian Pilot Project (Appendix Reports 5.1 and 6.1), which indicated that there are extremely serious problems in overbank sediment sampling with the ultimate aim of obtaining a 2 kg weight of the -0.063 mm grain size fraction for analysis. It was estimated that under Austrian conditions a weight of 200 kg will be required from many sites. The Austrian reports, therefore, proposed the selection of a coarser grain size fraction.

The work was undertaken by (a) the IGME Xanthi Branch Laboratory for the preparation of the samples (C. Tsiavdaridis), (b) B.G.R. (Dr. R. Hindel) for total contents of elements, and (c) the N.G.U. (Dr. R.T. Ottesen) for acid soluble element concentrations.

2.0. OBJECTIVES

The objective of this research work was the selection of the optimum grain size fraction for analysis. This aim was accomplished by the study of

(a) the weight distribution of six grain size fractions in the samples of overbank and stream sediment, i.e., -2000 +1000, -1000 +500, -500 +250, -250 +125, -125 +63 and -63 microns (um), and

(b) the element distribution in the above six grain size fractions.

3.0. SAMPLE PREPARATION AND ANALYTICAL METHODS

3.1. Sample preparation

The overbank and stream sediment samples were dried in two stages, i.e., initially in a heated room at a temperature of about 35°C, and then in a thermostatically controlled oven at a temperature of 80°C. The samples were afterwards disaggregated by a porcelain pestle and mortar, and the whole sample was sieved through an approximately 1 cm^2 plastic sieve. The +1 cm^2 fraction was discarded. The whole -1 cm^2 fraction was sieved to the -0.063 mm (-240 mesh) fraction, for this was the fraction that was decided upon for analysis before the Hannover meeting (Nov. 1989). After the Hannover meeting the -1 cm^2 +0.063 mm component of the overbank and stream sediment samples was weighed and sieved to the decided six different grain size fractions, i.e., -2000 +1000, -1000 +500, -500 +250, -250 +125, -125 +63, and -63 microns. The +2000 microns fraction was discarded. The grain size fractions were weighed and these are tabulated in Tables 1 and 2. Each grain size fraction was homogenized and subsamples were placed in 125 cm^3 plastic vials.

3.2. Analytical methods

The analytical methods used in this study are described below.

3.2.1. Analysis of total element contents

At B.G.R. major and trace elements were determined on a 500 mg aliquot after hot digestion by a mixture of HF (38-40%) and $HClO_4$ (70%) acid, and analyzed by an atomic absorption spectrophotometer (Instrumentation Laboratory - IL 951 and VIDEO 22) for the following elements: Fe, Al, Ti, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, Cr, V, Mo, Be, Sr, Ba, Mn, Sc and Y. The lower detection limits for each element were determined on a 500 mg sample weight and a 25 ml sample solution and are tabulated below (values in ppm):

Fe	Al	Ti	Ca	Pb	Cu	Zn	Cd	Ni	Co
1	5	5	5	5	3	3	0.3	3	3
Li	Cr	V	Mo	Be	Sr	Ba	Mn	Sc	Y
1	1	1	1	1	1	1	1		

3.2.2. Analysis of hot nitric soluble elements

One gram of the minus 0.063 mm fraction was attacked by 5 ml of 7N HNO_3 at 110°C for three hours. After digestion the solution was diluted to 20.3 ml, centrifuged and decanted. Then, 1 ml of this solution was diluted with 4 ml of a reference element solution containing 20 ug/ml of Li and Y in deionized water as internal standards. The final solution thus contained 16 ug/ml of Li and Y. The elements Al, Ag, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Si, Sr, Ti, V, Zn and Zr were determined on the solution by a Jerrel-Ash 975 ICAP Atom Comp. (Odegard 1980). The lower detection limits of the elements were obtained by measuring the background signal of the element line on blank samples, and then multiplying the value by 100, which is the dilution factor of the solutions. The lower detection limits of the elements in ppm are tabulated below, i.e.,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	
0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0	

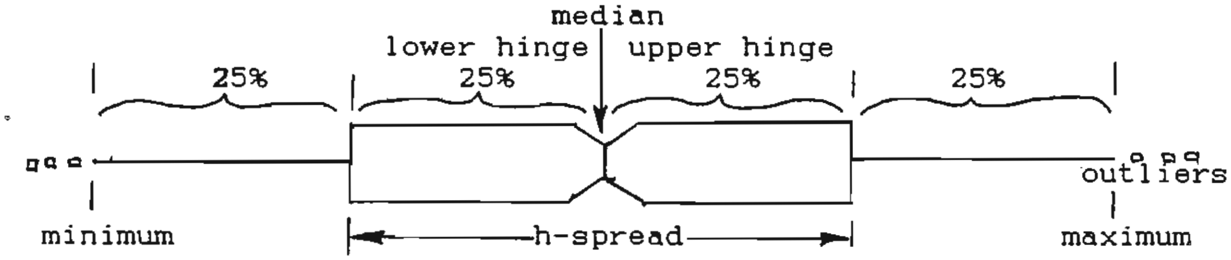
4.0. DATA TREATMENT

4.1. Grain size fraction analysis

The weight in grams of the six different grain size fractions was calculated as a percentage of the total weight. The results are given in Tables 1 and 2. Then cumulative plots were drawn of the "weight % of grain size fractions" versus the sample numbers" (Figs. 2 and 3).

4.2. Element distribution in different grain size fractions

It was decided to use the notched box-and-whisker plot of Exploratory Data Analysis (EDA), which is a very a powerful statistical tool for the direct visual comparison of different data subsets (Kurzl 1988, STSC 1986). The following diagram shows the features of the boxplot in an ideal normal distribution:



The box represents 50% of the values (h-spread or interquartile range); the cutoffs define the location of the "fences" and are established by adding and/or subtracting 1.5 times the h-spread. The whiskers extend to the two most extreme data values that are still inside the fences. All data points lying outside the fences are defined as outliers (anomalous samples), and are marked by individual open rectangles. The central line is the median; the notch corresponds to the width of the 95% confidence interval on the median, while the width of the box is proportional to the square root of the number of observations of the data set. The confidence level on the notches allows pairwise comparisons to be performed by examining whether two notches overlap. Overlapping notches indicate that there is no significant difference between the median values. Whereas, boxes with non-overlapping notches indicate significantly different median values.

One important property of the boxplot is its resistance to "wild" data, i.e., the boxplot can withstand up to 25% disturbances within the data set.

In situations where the notch extends beyond a quartile box, showing a folding-in behaviour or truncation, little confidence would be placed in such boxes. As pointed out by Kurzl (1988) this feature indicates a low variability of the respective elements, and also in the case the box is truncated to the lower values, a fault with the analytical method may be implied, i.e., detection limit too high or many values are near the detection limit.

Further, the boxplot as pointed by Kurzl (1988) and Hoaglin et al. (1983), displays the following features: (a) location, (b) spread, (c) skewness, (d) tail length, and (e) outlying data points.

The boxplots of each element (total and leachable or extractable or partial) for the two sampling media (overbank and stream sediment) were placed on a page side by side, so that the comparison can be made with ease (Figs. 4 to 33). The notation used in the figures is as follows:

(a) the total element contents of overbank sediment,
(b) the leachable (extractable or partial) element contents of overbank sediment,
(c) the total element contents of stream sediment, and
(d) the acid extractable element contents of stream sediment.

The X-axis notation of -2000, -1000, -500, -250, -125 and -63 refers to the six grain size fractions -2000 +1000, -1000 +500, -500 +250, -250 +125, -125 +63 and -63 microns respectively.

For the sake of brevity a table (Table 3) has been compiled with all the observations relating to the boxplots (Figs. 4 to 33). In this table are tabulated (a) the grain size fractions having similar medians at the 95% confidence level (the ones with significant differences are not mentioned); (b) a comparison between the -63 and -125 microns grain size fractions, i.e., whether the median value of the -63 micron fraction is similar, lower or higher; (c) a comparison of the spread or interquartile range of the two grain size fractions, and (d) the presence of outliers. Where necessary comments were made.

5.0. DISCUSSION

The weight distribution of the overbank sediment samples shows that the -63 microns grain size fraction varies from 1.76 to 23.99% of the total weight, with an average of 9.94% (Table 1, Fig. 2). Whereas, the -125 +63 microns fraction varies from 0.91 to 10.63% of the total weight, with a mean of 5.98%. The dominant grain size fractions appear to be the -500 +250 and -250 +125 microns, with a mean percentage weight of 33.68 and 23.08 respectively. If the minimum weight for analysis and storage is going to be 2 kg, then for the -63 microns fraction a sample weight of about 20 kg will be required, and in extreme cases a weight of 110 kg. Whereas, for the -125 microns grain size fraction the above weights will be reduced to 13 kg on average, and in rare cases to 75 kg.

The weight distribution of the stream sediment shows that the -63 microns fraction varies from 1.26 to 48.15% of the total weight, with a mean of 8.40% (Table 2, Fig. 3). On the other hand, the -125 +63 microns fraction varies from 0.00 to 11.81 % with a mean of 2.98%. The dominant grain size fractions are the -500 +250 and -1000 +500 microns, with an average percentage of 30.06 and 29.54 respectively. It appears that the stream sediment, as expected, is coarser that the overbank sediment. In the case, therefore, of a 2 kg weight, a sample weight of about 24 kg will be required for the -63 microns fraction, and 160 kg in rare cases. If, however, the -125 microns grain size fraction is used, then the field sample weight will be reduced to about 18 kg on average, and in extreme cases the 160 kg may still be needed.

In Table 3 are summarized the most important features of the boxplot comparison of element distribution in the different grain sizes studied. The elements having similar median values at the 95% confidence level are given below, i.e.,

(a) Overbank sediment

Total elements : Cr, Mn, Mo, Pb, Sc, Sr, Ti, V and Zn,
and Partial elements: Ca, Cd, Mn, Mo, Pb, Sr, Ti, V, Ag, (K), (La), (Mg), (Na) and (P).

(b) Stream sediment

Total elements : Ba, Ca, Cu, Fe, Mn, Mo, Pb, Sc, Sr, Ti, Zn and Y, and
Partial elements: Ca, Cd, Cr, Ni, Pb, Sr, Ti, V, (K), (La), (Na) and (P).

The elements in brackets are the ones that have been determined by the acid extractable analytical method only.

Nine out of the twenty elements determined by the total analytical method in the overbank, and twelve in the stream sediment show no significant differences of the median values at the 95% confidence level. Whereas, out of the twenty-nine elements determined by the acid extractable analytical method, fourteen elements in the overbank and twelve in the stream sediment show no significant differences of the median values at the 95% confidence level.

Median values of elements of the -63 microns grain size fraction that are higher than those of the -125 +63 microns fraction are given below:

(a) Overbank sediment

Total elements : Cd, Co, Cu, Fe, Li, Ni and (Y) [7 elements out of the 20 determined], and
Partial elements: Al, Ba, Be, Co, Cr, Cu, Fe, Li, Ni, Sc, Zn, (B), (Ce) and (Zr) [14 elements out of the 29 determined].

(b) Stream sediment

Total elements : Cd, Co, Li and Ni [4 elements out of the 20 determined],

Partial elements: Al, Ba, Be, Co, Cu, Fe, Li, Mn, Sc, (B), (Ce), (Mg) and (Zr) [13 elements out of the 29 determined].

Finally, median values of elements of the -63 microns grain size fraction that are lower than those of the -125 +63 microns fraction are given below:

(a) Overbank sediment

Total elements : Al, Ba, Be and Ca [4 elements out of the 20 determined], and

Partial elements: (Bi) [1 element out of the 29 determined].

(b) Stream sediment

Total elements : Al, Be, Cr and V [4 elements out of the 20 determined], and
Partial elements: Mo, Zn, (Ag) and (Si) [4 elements out of the 29 determined].

Outliers are exhibited for the majority of elements in both the -63 and -63 +125 grain size fractions (Figs. 4 to 33, Table 3).

The total element contents, as expected, have higher values than the acid extractable ones.

6.0. CONCLUSION

The foregoing discussion has shown that the field sample weight is reduced slightly if one considers the -125 microns grain size fraction for analysis and storage instead of the -63 microns, the fraction originally proposed. In the majority of sampling sites an overbank sediment sample of approximately 13 kg, and a stream sediment of about 18 kg, will provide the needed 2 kg weight of the -125 microns fraction, and in rare cases sample weights of 75 kg for the overbank and 160 kg for the stream sediment sample will be required.

Approximately half of the elements determined, by the two analytical methods for the two sampling media, show no significant differences of the medians in the -63 and -125 +63 microns grain size fractions, and the majority of the remaining elements have higher median values in the -63 microns fraction.

The weight distribution of the two grain size fractions (-63 and -125 +63 microns) under consideration, should be examined in conjunction with the analytical results. This study has shown that the -63 microns fraction is the major component of the -125 microns grain size fraction (Figs. 2 & 3, Tables 1 &2). It is, therefore, believed that the -125 microns fraction will give approximately the same geochemical patterns as the -63 microns component. The advantage in using the former fraction is the reduction of the field sample weight on the one hand, and the cost effective sample preparation on the other.

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Table 1. Weight distribution of grain size fractions of overbank sediment.

Code	Sample Number	W E I G H T			I N		G R A M S				R E L A T I V E			W E I G H T %		
		-2000+1000 microns	-1000+500 microns	-500+250 microns	-250+125 microns	-125+63 microns	-63 microns	Total weight	Original weight	Weight loss	-2000+1000 microns	-1000+500 microns	-500+250 microns	-250+125 microns	-125+63 microns	-63 microns
08	1	1045.60	1385.36	3497.81	4617.33	791.16	1243.23	12580.49	13334.86	754.37	8.31	11.01	27.80	36.70	6.29	9.88
08	2	2390.48	1663.31	1904.44	4443.52	1100.86	1775.18	13277.79	14480.5	1202.71	18.00	12.53	14.34	33.47	8.29	13.37
08	3	214.92	382.64	5819.43	6594.93	784.63	1205.86	15002.41	15132.73	130.32	1.43	2.55	38.79	43.96	5.23	8.04
08	4	830.52	911.16	5018.34	6619.00	1131.03	1617.61	16127.66	16469.64	341.98	5.15	5.65	31.12	41.04	7.01	10.03
08	5	690.29	755.78	2979.27	10638.98	1066.33	2020.1	18150.75	18652.04	501.29	3.80	4.16	16.41	58.61	5.87	11.13
08	6	986.86	2282.11	7567.82	2115.99	533.72	665.54	14152.03	15053.3	901.263	6.97	16.13	53.48	14.95	3.77	4.70
08	7	52.60	2741.33	14849.89	2171.00	185.98	358.47	20359.27	20819.12	459.85	0.26	13.46	72.94	10.66	0.91	1.76
08	8	2629.37	2103.18	1278.46	834.26	661.99	910.03	8417.29	8801.32	384.03	31.24	24.99	15.19	9.91	7.86	10.81
08	9	183.44	2333.87	12218.33	4434.60	1076.57	1030.31	21277.12	21860.47	583.35	0.86	10.97	57.42	20.84	5.06	4.84
08	10	2609.33	3768.05	7963.00	5472.66	1047.66	1870.36	22731.06	23880.27	1149.21	11.48	16.58	35.03	24.08	4.61	8.23
08	11	1388.52	1995.35	5057.72	5012.55	662.33	1559.37	15675.84	16642.9	967.06	8.86	12.73	32.26	31.98	4.23	9.95
08	12	1254.09	2590.32	6606.65	4653.31	1273.44	2285.26	18663.07	19459.54	796.47	6.72	13.88	35.40	24.93	6.82	12.24
08	13	1901.01	2968.63	5211.77	2944.95	1249.04	2436.23	16711.63	17471.69	760.06	11.38	17.76	31.19	17.62	7.47	14.58
08	14	2248.01	4037.38	4357.49	3157.59	573.02	1216.75	15590.24	16574.47	984.23	14.42	25.90	27.95	20.25	3.68	7.80
08	15	2199.75	1683.17	2631.73	4550.20	1743.64	3587.17	16395.66	17411.97	1016.31	13.42	10.27	16.05	27.75	10.63	21.88
08	16	712.19	3759.71	8431.06	4332.61	1120.05	1301.15	19656.77	20870.15	1213.38	3.62	19.13	42.89	22.04	5.70	6.62
08	17	643.72	8926.74	5031.24	1692.31	638.62	763.55	17696.18	18240.2	544.02	3.64	50.44	28.43	9.56	3.61	4.31
08	18	890.36	1039.94	4898.87	5899.10	1307.21	2330.56	16366.04	17085.49	719.45	5.44	6.35	29.93	36.04	7.99	14.24
08	19	1041.18	1881.91	6689.28	3683.21	975.62	1677.76	15948.96	16572.16	623.2	6.53	11.80	41.94	23.09	6.12	10.52
08	20	1724.51	3502.50	3856.21	2132.58	702.61	1239.27	13157.68	14379.6	1221.92	13.11	26.62	29.31	16.21	5.34	9.42
08	21	1747.75	1413.44	2063.11	1787.20	723.17	2441.74	10176.41	10898.77	722.36	17.17	13.89	20.27	17.56	7.11	23.99
08	22	2081.49	1314.56	1601.98	1142.61	493.16	853.89	7487.69	7875.44	387.75	27.80	17.56	21.39	15.26	6.59	11.40
08	23	2151.95	2426.45	3537.70	3677.74	1006.50	1069.42	13869.76	14953.69	1083.93	15.52	17.49	25.51	26.52	7.26	7.71
08	24	484.60	1292.54	10619.01	4485.06	972.68	1899.55	19753.44	19833.64	80.2	2.45	6.54	53.76	22.71	4.92	9.62
08	25	798.33	2068.93	3868.08	2947.28	875.77	1316	11874.39	12469.54	595.15	6.72	17.42	32.57	24.82	7.38	11.08
08	26	217.44	671.37	9222.53	2691.74	865.84	1176.72	14845.64	15319.26	473.62	1.46	4.52	62.12	18.13	5.83	7.93
08	27	1831.76	2815.17	7106.59	3586.32	1127.31	1739.14	18206.29	18832.18	625.89	10.06	15.46	39.03	19.70	6.19	9.55
08	28	860.65	3888.42	9210.72	4573.75	1059.64	1490.35	21083.53	21801.04	717.51	4.08	18.44	43.69	21.69	5.03	7.07
08	29	2733.62	1173.99	736.28	396.00	218.36	469.47	5727.72	6471.47	743.75	47.73	20.50	12.85	6.91	3.81	8.20
08	30	1537.06	2317.18	2475.11	2049.81	986.45	2271.88	11637.49	12651.54	1014.05	13.21	19.91	21.27	17.61	8.48	19.52
08	31	1183.05	1313.31	5594.67	3863.87	1064.60	2422.61	15442.11	16055.92	613.81	7.66	8.50	36.23	25.02	6.89	15.69
08	32	695.13	1750.55	6861.79	4576.54	1549.22	2866.93	18300.16	19372.91	1072.75	3.80	9.57	37.50	25.01	8.47	15.67
08	33	672.15	2190.45	6451.74	3171.42	1061.90	2070.97	15618.63	16141.07	522.44	4.30	14.02	41.31	20.31	6.80	13.26
08	34	1303.42	3291.21	4737.33	1464.09	392.53	345.1	11533.68	12304.9	771.22	11.30	28.54	41.07	12.69	3.40	2.99
08	35	2059.08	1417.80	1485.87	1820.46	593.49	645.37	8022.07	8329.93	307.86	25.67	17.67	18.52	22.69	7.40	8.04
08	36	2312.87	1625.01	1216.07	771.78	438.61	543.45	6907.79	7474.44	566.65	33.48	23.52	17.60	11.17	6.35	7.87
08	37	2031.20	2319.70	3313.39	2451.96	544.17	607.51	11267.93	12042.44	774.51	18.03	20.59	29.41	21.76	4.83	5.39
08	38	1710.16	1575.33	2313.55	4323.14	1337.03	1698.37	12957.58	14038.33	1080.75	13.20	12.16	17.85	33.36	10.32	13.11
08	39	2154.50	1944.72	2950.02	3602.37	731.39	1002.72	12385.72	13161.24	775.52	17.40	15.70	23.82	29.08	5.91	8.10
08	40	431.29	3097.48	12223.63	2603.58	639.93	907.41	19903.32	20260.12	356.8	2.17	15.56	61.42	13.08	3.22	4.56
08	41	1068.54	4546.33	8129.42	3121.02	417.25	400.72	17683.28	18334.97	651.69	6.04	25.71	45.97	17.65	2.36	2.27
										Mean %	11.31	16.00	33.68	23.08	5.98	9.94
										Minimum %	0.26	2.55	12.85	6.91	0.91	1.76
										Maximum %	47.73	50.44	72.94	58.61	10.63	23.99

Table 2. Weight distribution of grain size fractions of stream sediment.

Code	Sample Number	WEIGHT IN GRAMS									RELATIVE WEIGHT %					
		-2000+1000 microns	-1000+500 microns	-500+250 microns	-250+125 microns	-125+63 microns	-63 microns	Total weight	Original Weight	Weight loss	-2000+1000 microns	-1000+500 microns	-500+250 microns	-250+125 microns	-125+63 microns	-63 microns
SS	1	3560.58	10464.58	5261.73	661.51	151.15	418.37	20517.92	20568.37	50.45	17.35	51.00	25.64	3.22	0.74	2.04
SS	3	0.00	226.64	10798.21	5067.20	249.01	554.44	16895.5	18483.55	1588.05	0.00	1.34	63.91	29.99	1.47	3.28
SS	4	2137.80	4509.00	4054.68	1629.96	348.80	320.24	13000.48	13520.24	519.76	16.44	34.68	31.19	12.54	2.68	2.46
SS	5	0.00	2263.53	12672.53	1334.97	0.00	307.85	16578.88	17917.85	1338.97	0.00	13.65	76.44	8.05	0.00	1.86
SS	7	236.92	14491.00	9176.74	294.16	9.10	308.48	24516.4	25308.48	792.08	0.97	59.11	37.43	1.20	0.04	1.26
SS	8	4150.21	3968.93	3494.71	1305.64	387.00	497.68	13804.17	15947.68	2143.51	30.06	28.75	25.32	9.46	2.80	3.61
SS	9	8239.44	8708.41	2679.12	183.65	44.47	332.83	20187.92	20432.83	244.91	40.81	43.14	13.27	0.91	0.22	1.65
SS	10	2079.72	2886.11	4531.85	1223.41	367.74	486.6	11575.43	11638.01	62.58	17.97	24.93	39.15	10.57	3.18	4.20
SS	11	774.90	6277.95	9803.29	1673.51	353.01	535.8	19418.46	19980.44	561.98	3.99	32.33	50.48	8.62	1.82	2.76
SS	12	2409.98	2627.48	1308.61	825.82	523.14	2459.56	10154.59	12238.38	2083.79	23.73	25.87	12.89	8.13	5.15	24.22
SS	13	1237.15	1821.68	4419.91	3621.27	323.79	1779.39	13203.19	15154.64	1951.45	9.37	13.80	33.48	27.43	2.45	13.48
SS	14	1774.47	1022.01	584.10	319.68	143.79	513.53	4357.58	5207.35	849.77	40.72	23.45	13.40	7.34	3.30	11.78
SS	15	1689.44	1383.88	1069.02	765.47	412.44	1744.82	7065.07	7531.24	466.17	23.91	19.59	15.13	10.83	5.84	24.70
SS	16	5981.11	3670.17	1198.47	312.56	160.21	422.52	11745.04	12615.16	870.12	50.92	31.25	10.20	2.66	1.36	3.60
SS	17	389.08	2597.38	6298.45	4751.45	1288.60	790.04	16115	16609.3	494.3	2.41	16.12	39.08	29.48	8.00	4.90
SS	18	1663.71	2308.08	1419.96	812.14	497.42	2074.18	8775.49	8976.33	200.84	18.96	26.30	16.18	9.25	5.67	23.64
SS	19	1760.98	598.52	401.53	447.80	699.81	3630.4	7539.04	7659.91	120.87	23.36	7.94	5.33	5.94	9.28	48.15
SS	20	471.18	4449.58	11146.61	2237.19	212.13	401.8	18918.49	19848.18	929.69	2.49	23.52	58.92	11.83	1.12	2.12
SS	21	883.80	5441.68	10185.56	936.47	220.11	566.45	18234.07	18650.35	416.28	4.85	29.84	55.86	5.14	1.21	3.11
SS	22	973.80	578.02	417.80	500.99	353.47	1263.21	4087.29	4742.91	655.62	23.83	14.14	10.22	12.26	8.65	30.91
SS	23	2086.36	2536.91	3830.17	3144.60	689.83	786.63	13074.5	13877.14	802.64	15.96	19.40	29.29	24.05	5.28	6.02
SS	24	1349.66	5264.56	5386.24	3530.59	601.62	948.07	17080.74	17554.88	474.14	7.90	30.82	31.53	20.67	3.52	5.55
SS	25	205.16	4752.14	12014.35	2395.30	150.81	329.92	19847.68	20829.92	982.24	1.03	23.94	60.53	12.07	0.76	1.66
SS	26	351.65	10521.70	9106.25	793.92	0.00	313.15	21086.67	22313.15	1226.48	1.67	49.90	43.18	3.77	0.00	1.49
SS	27	3063.36	4406.72	1850.90	617.79	180.97	2088.64	12208.38	12398.82	190.44	25.09	36.10	15.16	5.06	1.48	17.11
SS	28	3636.93	3730.28	3521.32	3454.73	755.72	906.41	16005.39	16759.39	754	22.72	23.31	22.00	21.58	4.72	5.66
SS	29	2024.18	1277.15	951.79	629.33	440.48	1407.35	6730.28	7143.85	413.57	30.08	18.98	14.14	9.35	6.54	20.91
SS	30	634.82	1087.98	1403.91	2461.30	986.98	1779.43	8354.42	8543.49	189.07	7.60	13.02	16.80	29.46	11.81	21.30
SS	31	2556.49	7888.71	6478.18	1738.94	545.00	573	19780.32	20462.52	682.2	12.92	39.88	32.75	8.79	2.76	2.90
SS	32	4846.59	14782.56	3327.39	616.89	78.13	327.58	23979.14	25577.58	1598.44	20.21	61.65	13.88	2.57	0.33	1.37
SS	33	893.67	7506.63	6451.40	2609.49	735.29	1289.8	19486.28	20340.32	854.04	4.59	38.52	33.11	13.39	3.77	6.62
SS	34	3318.92	5699.16	2990.22	393.16	137.57	507.32	13046.35	14583.46	1537.11	25.44	43.68	22.92	3.01	1.05	3.89
SS	35	6609.35	5697.02	2445.21	377.29	104.61	322.84	15556.32	15622.84	66.52	42.49	36.62	15.72	2.43	0.67	2.08
SS	36	7053.31	4244.21	914.18	404.62	169.13	797.7	13583.15	14786.9	1203.75	51.93	31.25	6.73	2.98	1.25	5.87
SS	37	2470.07	12696.68	8032.90	396.74	125.05	323.61	24045.05	25073.61	1028.56	10.27	52.80	33.41	1.65	0.52	1.35
SS	38	1490.09	7029.61	8372.95	1992.68	195.69	456	19537.02	19759.24	222.22	7.63	35.98	42.86	10.20	1.00	2.33
SS	39	7420.97	3302.50	823.66	232.09	133.06	316.26	12228.54	13616.26	1387.72	60.69	27.01	6.74	1.90	1.09	2.59
SS	40	7.23	2696.65	14805.93	2324.89	324.10	415.51	20574.31	20729.88	155.57	0.04	13.11	71.96	11.30	1.58	2.02
SS	41	2331.99	3682.48	2737.74	1075.85	323.30	312.73	10464.09	10512.73	48.64	22.29	35.19	26.16	10.28	3.09	2.99
										Mean %	18.53	29.54	30.06	10.50	2.98	8.40
										Minimum %	0.00	1.34	5.33	0.91	0.00	1.26
										Maximum %	60.69	61.65	76.44	29.99	11.81	48.15

Table 3. Element distribution features in the grain size fractions of overbank and stream sediment. (Page 1 of 5)

Element	Element	Fig.	Sampling medium	Analytical method	Grain size fractions with median similarities at the 95% confidence level	-63 microns fraction compared to the -125+63						Outliers (microns)		Comments
						Medians			Spread					
						Similar	Lower	Higher	Similar	Smaller	Larger	-125	-63	
Al	Al	4a	Overbank	Total	2000. -1000. -500. -63		Yes			Yes				The total Al contents are higher than the
		4b	Overbank	Partial	(a) -2000. -125			Yes		Yes		Yes	Yes	partial ones.
					(b) -1000. -500. -125									Outliers are exhibited by partial method
		4c	St. Sed.	Total	-2000. -1000. -500. -63		Yes			Yes				only.
		4d	St. Sed.	Partial	-2000. -1000. -500			Yes			Yes	Yes		
Ba	Ba	5a	Overbank	Total	(a) -2000. -1000. -500		Yes		Yes					The total Ba contents is higher than the
					(b) -2000. -250. -125									partial ones. Outliers exhibited by
		5b	Overbank	Partial	(a) -2000. -250. -125			Yes	Yes			Yes	Yes	partial method only.
					(b) -1000. -500									St. Sed. Ba: Truncation of -2000. -1000
		5c	St. Sed.	Total	-2000. -1000. -500. -250. -63	Yes				Yes				& 500 um (total). and -2000 um fraction
		5d	St. Sed.	Partial	-2000. -1000. -500			Yes		Yes		Yes		(partial) at lower ends.
Be	Be	6a	Overbank	Total	(a) -2000. -250		Yes			Yes			Yes	The total Be contents are much higher
					(b) -1000. -500									than the partial ones.
		6b	Overbank	Partial	(a) -2000. -250. -125			Yes			Yes	Yes		Only the partial Be exhibits outliers.
					(b) -1000. -500									
		6c	St. Sed.	Total	(a) -2000. -1000		Yes			Yes			Yes	
					(b) -2000. -500. -250									
					(c) -250. -125									
			St. Sed.	Partial	-2000. -1000. -500. -250			Yes	Yes			Yes	Yes	
Ca	Ca	7a	Overbank	Total	(a) -2000. -1000. -500		Yes		Yes			Yes	Yes	The total Ca contents are higher than the
					(b) -250. -63									partial ones.
		7b	Overbank	Partial	(a) -2000. -1000. -500. -250	Yes					Yes	Yes		Overbank partial Ca: Truncation of -2000
					(b) -125. -63									um fraction at lower end.
		7c	St. Sed.	Total	(a) -2000. -1000. -500	Yes					Yes	Yes	Yes	St. Sed. total Ca: Truncation of -2000 &
					(b) -250. -125. -63									-1000 um at lower end & -250 um at upper.
		7d	St. Sed.	Partial	(a) -2000. -1000. -500	Yes					Yes	Yes	Yes	St. Sed. partial Ca: Truncation of -2000.
					(b) -125. -63									-500 & -250 um fractions at lower end.
Cd	Cd	8a	Overbank	Total	-2000. -1000. -500. -250			Yes			Yes	Yes		The total Cd contents are higher than the
		8b	Overbank	Partial	-2000. -1000. -500. -250. -125. -63	Yes			Yes			Yes	Yes	partial ones. most of which are near to
		8c	St. Sed.	Total	(a) -2000. -1000. -500			Yes			Yes	Yes	Yes	the detection limit.
					(b) -250. -125									
		8d	St. Sed.	Partial	-2000. -1000. -500. -250. -125. -63	Yes			Yes			Yes	Yes	
Co	Co	9a	Overbank	Total	(a) -2000. -1000. -500. -250			Yes			Yes	Yes	Yes	The total Co contents are higher than the
					(b) -2000. -125									partial ones.
		9b	Overbank	Partial	(a) -2000. -1000. -500. -250			Yes			Yes	Yes	Yes	St. Sed. total Co: Truncation of -1000 um
					(b) -2000. -125									fraction at lower and -125 um at upper
					(c) -2000. -63									end.
		9c	St. Sed.	Total	(a) -2000. -1000			Yes			Yes		Yes	
					(b) -2000. -500									
		9d	St. Sed.	Partial	(a) -2000. -1000. -500			Yes		Yes		Yes	Yes	
					(b) -250. -125									

Table 3. Element distribution features in the grain size fractions of overbank and stream sediment. (Page 2 of 5)

Element	Element	Fig.	Sampling medium	Analytical method	Grain size fractions with median similarities at the 95% confidence level	-63 microns fraction compared to the -125+63 Medians			Spread			Outliers (microns)		Comments
						Similar	Lower	Higher	Similar	Smaller	Larger	-125	-63	
Cr	Cr	10a	Overbank	Total	(a) -2000. -1000. -500. -250 (b) -2000. -500. -250. -125. -63 (c) -1000. -63	Yes				Yes		Yes	Yes	The total Cr contents are higher than the partial ones.
		10b	Overbank	Partial	(a) -2000. -1000. -500. -250 (b) -2000. -125			Yes			Yes	Yes	Yes	
		10c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -250. -63		Yes			Yes		Yes	Yes	
		10d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -250. -125 (c) -125. -63	Yes-just			Yes			Yes	Yes	
Cu	Cu	11a	Overbank	Total	-2000. -1000. -500. -250. -125			Yes	Yes			Yes	Yes	The total Cu contents are slightly higher than the partial ones. St. Sed. total Cu: Truncation of -1000. -250 & -125 um grain size fractions at their lower ends.
		11b	Overbank	Partial	-2000. -1000. -500. -250. -125			Yes			Yes	Yes	Yes	
		11c	St. Sed.	Total	(a) -2000. -1000. -500. -250. -125 (b) -125. -63	Yes				Yes			Yes	
		11d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -250. -125			Yes		Yes		Yes	Yes	
Fe	Fe	12a	Overbank	Total	(a) -2000. -1000. -500 (b) -2000. -250			Yes		Yes		Yes		The total Fe contents are higher than the partial ones. The partial method shows a St. Sed. partial Fe: The median values show a gradual increase in the Fe content with decreasing grain size. This feature not so evident in the total method.
		12b	Overbank	Partial	(a) -2000. -1000. -500. -250 (b) -2000. -125			Yes			Yes			
		12c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes				Yes		Yes		
		12d	St. Sed	Partial	-2000. -1000. -500			Yes	Yes					
Li	Li	13a	Overbank	Total	(a) -2000. -125 (b) -1000. -500. -250			Yes			Yes	Yes	Yes	The total Li contents are slightly higher than the partial ones. St. Sed. total Li. The -2000. -1000. -500 & -250 um fractions show truncation at lower end. St. Sed. partial Li: The median values increase with decreasing grain size.
		13b	Overbank	Partial	(a) -1000. -500. -250. -125 (b) -2000. -125			Yes			Yes	Yes	Yes	
		13c	St. Sed.	Total	(a) -2000. -1000. -500. -250 (b) -2000. -125			Yes			Yes			
		13d	St. Sed.	Partial	-2000. -1000. -500			Yes		Yes			Yes	
Mn	Mn	14a	Overbank	Total	(a) -2000. -1000. -500 (b) -2000. -250 (c) -125. -63	Yes				Yes		Yes		The total Mn contents are slightly higher than the partial ones.
		14b	Overbank	Partial	(a) -1000. -500. -250 (b) -2000. -125	Yes				Yes		Yes	Yes	
		14c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes					Yes	Yes	Yes	
		14d	St. Sed.	Partial	-2000. -1000. -500			Yes			Yes			

Table 3. Element distribution features in the grain size fractions of overbank and stream sediment. (Page 3 of 5)

Element	Element	Fig.	Sampling medium	Analytical method	Grain size fractions with median similarities at the 95% confidence level	-63 microns fraction compared to the -125+63						Outliers (microns)		Comments
						Medians			Spread			-125	-63	
						Similar	Lower	Higher	Similar	Smaller	Larger			
Mo	Mo	15a	Overbank	Total	(a) -2000. -250. -125. -63 (b) -1000. -500	Yes				Yes		Yes		The median values of extractable Mo are slightly higher than that of the total. Overbank total Mo: Folding-in behaviour is shown at the lower ends of the -1000. 500 & 125 um grain size fractions and upper end of the -250 um. Overbank partial Mo: Truncation is exhibited at lower end of -125 um fraction. St. Sed. total Mo: Truncation is shown at lower end of -2000 & -1000 um fractions. and upper end of -500 & -125 um fractions.
		15b	Overbank	Partial	-2000. -1000. -250. -125. -63	Yes				Yes			Yes	
		15c	St. Sed.	Total	(a) -2000. -1000 (b) -500. -250 (c) -125. -63	Yes					Yes		Yes	
		15d	St. Sed.	Partial	(a) -2000. -1000. -63 (b) -500. -250. -63		Yes				Yes		Yes	
Ni	Ni	16a	Overbank	Total	(a) -2000. -1000. -500. -250 (b) -2000. -1000. -250. -125			Yes		Yes		Yes	Yes	The median values of the total Ni are slightly higher than the total ones. St. Sed. total Ni: Folding-in behaviour is exhibited by the -1000. -500. -250. -125 um fractions at their lower ends.
		16b	Overbank	Partial	-2000. -1000. -500. -250. -125			Yes			Yes	Yes	Yes	
		16c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -2000. -1000. -250 (c) -250. -125			Yes		Yes		Yes	Yes	
		16d	St. Sed.	Partial	(a) -2000. -1000. -500. -250 (b) -125. -63	Yes				Yes		Yes	Yes	
Pb	Pb	17a	Overbank	Total	-2000. -1000. -500. -250. -125. -63	Yes				Yes		Yes	Yes	The median values of total Pb are higher than the partial ones. Overbank Sed. partial Pb: Truncation of -63 um fraction at lower end. St. Sed. total Pb: Truncation of -2000. -500 & -125 um fractions at lower end.
		17b	Overbank	Partial	(a) -2000. -1000. -500. -250 (b) -250. -125. -63	Yes					Yes	Yes	Yes	
		17c	St. Sed.	Total	-2000. -1000. -500. -250. -125. -63	Yes				Yes		Yes	Yes	
		17d	St. Sed.	Partial	(a) -2000. -1000. -500. -250 (b) -125. -63	Yes			Yes			Yes	Yes	
Sc	Sc	18a	Overbank	Total	(a) -2000. -1000. -250 (b) -2000. -1000. -500 (c) -125. -63	Yes				Yes		Yes		The total Sc contents are higher than the partial ones. St. Sed. total Sc: Truncation of -250 at and -125 um fraction at lower end. The similarity between -125 & 63 um fractions is disputable due to the folding-in behaviour of the -125 um fraction. St. Sed. partial Sc: The median values increase with decreasing grain size. Truncation of -125 um fraction at lower end.
		18b	Overbank	Partial	(a) -2000. -1000. -500. -250 (b) -2000. -1000. -250. -125			Yes			Yes			
		18c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes (?)				Yes		Yes	Yes	
		18d	St. Sed.	Partial	(a) -2000. -500. -250 (b) -500. -250			Yes		Yes		Yes	Yes	

Table 3. Element distribution features in the grain size fractions of overbank and stream sediment. (Page 4 of 5)

Element	Element	Fig.	Sampling medium	Analytical method	Grain size fractions with median similarities at the 95% confidence level	-63 microns fraction compared to the -125+63: Medians			Spread			Outliers (microns)		Comments
						Similar	Lower	Higher	Similar	Smaller	Larger	-125	-63	
Sr	Sr	19a	Overbank	Total	(a) -2000. -1000. -500	Yes					Yes			The total Sr contents are higher than the
					(b) -500. -250. -63									partial ones.
					(c) -250. -125. -63									St. Sed. total Sr: Truncation of -500 um
		19b	Overbank	Partial	(a) -2000. -1000. -500. -250. -125	Yes					Yes			fraction at lower end.
					(b) -125. -63									St. Sed. partial Sr: The median values
		19c	St. Sed.	Total	(a) -2000. -1000. -500. -63	Yes				Yes				increase with decreasing grain size.
					(b) -250. -125. -63									The -2000 um fraction is truncated at
		19d	St. Sed.	Partial	(a) -2000. -1000. -500. -250	Yes							Yes	lower end.
					(b) -250. -125									
					(c) -125. -63									
Ti	Ti	20a	Overbank	Total	(a) -2000. -1000. -500	Yes				Yes		Yes		The total Ti contents are higher than the
					(b) -125. -63									partial ones.
		20b	Overbank	Partial	(a) -2000. -1000. -500. -250	Yes				Yes		Yes	Yes	St. Sed. partial Ti: The median values
					(b) -250. -125									increase with decreasing grain size.
					(c) -125. -63									
		20c	St. Sed.	Total	(a) -2000. -1000. -500	Yes				Yes		Yes	Yes	
					(b) -250. -125. -63									
		20d	St. Sed.	Partial	(a) -2000. -1000. -500	Yes					Yes	Yes		
					(b) -250. -125. -63									
V	V	21a	Overbank	Total	(a) -2000. -1000. -500	Yes				Yes		Yes	Yes	The total V contents are higher than the
					(b) -125. -63									partial ones.
		21b	Overbank	Partial	(a) -2000. -1000. -500	Yes				Yes		Yes		St. Sed. total V: Truncation of -250 um
					(b) -2000. -250									fraction at upper end.
					(c) -125. -63									St. Sed. partial V: The median values of
		21c	St. Sed.	Total	(a) -2000. -1000. -500		Yes			Yes				the partial V contents increase with
					(b) -250. -125									decreasing grain size.
		21d	St. Sed.	Partial	(a) -2000. -1000. -500	Yes				Yes				
					(b) -500. -250									
					(c) -125. -63									
Zn	Zn	22a	Overbank	Total	(a) -2000. -250. -125	Yes					Yes	Yes	Yes	The total Zn contents are higher than the
					(b) -2000. -250. -63									partial ones.
					(c) -1000. -250. -125									St. Sed. total Zn: Truncation of -125 um
		22b	Overbank	Partial	-2000. -1000. -500. -250. -125			Yes	Yes			Yes	Yes	fraction at lower end.
		22c	St. Sed.	Total	(a) -2000. -1000. -500. -250	Yes				Yes		Yes	Yes	St. Sed. partial Zn: Truncation of -2000.
					(b) -2000. -500. -250. -125									-1000 & -125 um fractions at lower ends.
					(c) -250. -125. -63									
		22d	St. Sed.	Partial	(a) -2000. -1000. -500. -250		Yes			Yes		Yes	Yes	
					(b) -250. -125									
Ag	Ag	23c	Overbank	Partial	(a) -2000. -1000. -500. -250	Yes				Yes		Yes	Yes	
					(b) -250. -125									
					(c) -125. -63									
		23d	St. Sed.	Partial	(a) -2000. -1000		Yes			Yes		Yes	Yes	
					(b) -500. -250. -63									

Table 3. Element distribution features in the grain size fractions of overbank and stream sediment. (Page 5 of 5)

Element	Element	Fig.	Sampling medium	Analytical method	Grain size fractions with median similarities at the 95% confidence level	-63 microns fraction compared to the -125+63: Medians			Spread			Outliers		Comments
						Similar	Lower	Higher	Similar	Smaller	Larger	-125 (microns)	-63 (microns)	
B	B	24c	Overbank	Partial	(a) -2000. -1000. -500 (b) -2000. -1000. -250. -125			Yes		Yes		Yes	Yes	St. Sed. partial B: Truncation of -500 um fraction at lower end.
		24d	St. Sed.	Partial	-2000. -1000. -500. -250			Yes		Yes		Yes	Yes	
Ce	Ce	25c	Overbank	Partial	(a) -2000. -250. -125 (b) -1000. -500			Yes	Yes			Yes		Both sampling media show an increase in median values with decreasing grain size from -1000 to -63 um fraction. St. Sed. partial Ce: Truncation of -1000 um fraction at lower end.
		25d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -250. -125			Yes		Yes				
K	K	26c	Overbank	Partial	(a) -2000. -1000. -500. -250. -125 (b) -500. -125. -63	Yes				Yes		Yes	Yes	St. Sed. partial K: The median values increase with decreasing grain size.
		26d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -500. -250 (c) -250. -125 (d) -125. -63	Yes					Yes	Yes	Yes	
La	La	27c	Overbank	Partial	(a) -2000. -1000. -500. -250 (b) -2000. -125 (c) -125. -63	Yes				Yes		Yes	Yes	
		27d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -2000. -125. -63	Yes				Yes				
Mg	Mg	28c	Overbank	Partial	-2000. -1000. -500. -250. -125. -63	Yes					Yes	Yes	Yes	St. Sed. partial Mg: The median values increase with decreasing grain size.
		28d	St. Sed.	Partial	(a) -2000. -1000. -500. -250 (b) -250. -125			Yes			Yes	Yes	Yes	
Na	Na	29c	Overbank	Partial	(a) -2000. -1000. -500. -250. -125 (b) -125. -63	Yes			Yes			Yes	Yes	The median values for both sampling media from the -1000 to the -63 um grain size fractions increase gradually with decreasing grain size.
		29d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes			Yes			Yes	Yes	
P	P	30c	Overbank	Partial	(a) -2000. -1000. -500 (b) -125. -63	Yes			Yes			Yes		
		30d	St. Sed.	Partial	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes				Yes		Yes	Yes	
Si	Si	31c	Overbank	Partial	-2000. -1000. -500. -250. -125		Yes			Yes		Yes	Yes	
		31d	St. Sed.	Partial	-2000. -1000. -500. -250. -125		Yes			Yes		Yes		
Y	Y	32a	Overbank	Total	(a) -2000. -250 (b) -1000. -500			Yes		Yes		Yes	Yes	St. Sed. total Y: Folding-in behaviour -125 um grain size fraction at lower end.
		32c	St. Sed.	Total	(a) -2000. -1000. -500 (b) -250. -125. -63	Yes				Yes		Yes		
Zr	Zr	33c	Overbank	Partial	-2000. -1000. -500. -250. -125			Yes			Yes	Yes		St. Sed. partial Zr: Truncation of -2000 um grain size fraction at lower end. There is a gradual increase of the median values with decreasing grain size.
		33d	St. Sed.	Partial	-2000. -1000. -500. -250			Yes		Yes		Yes		

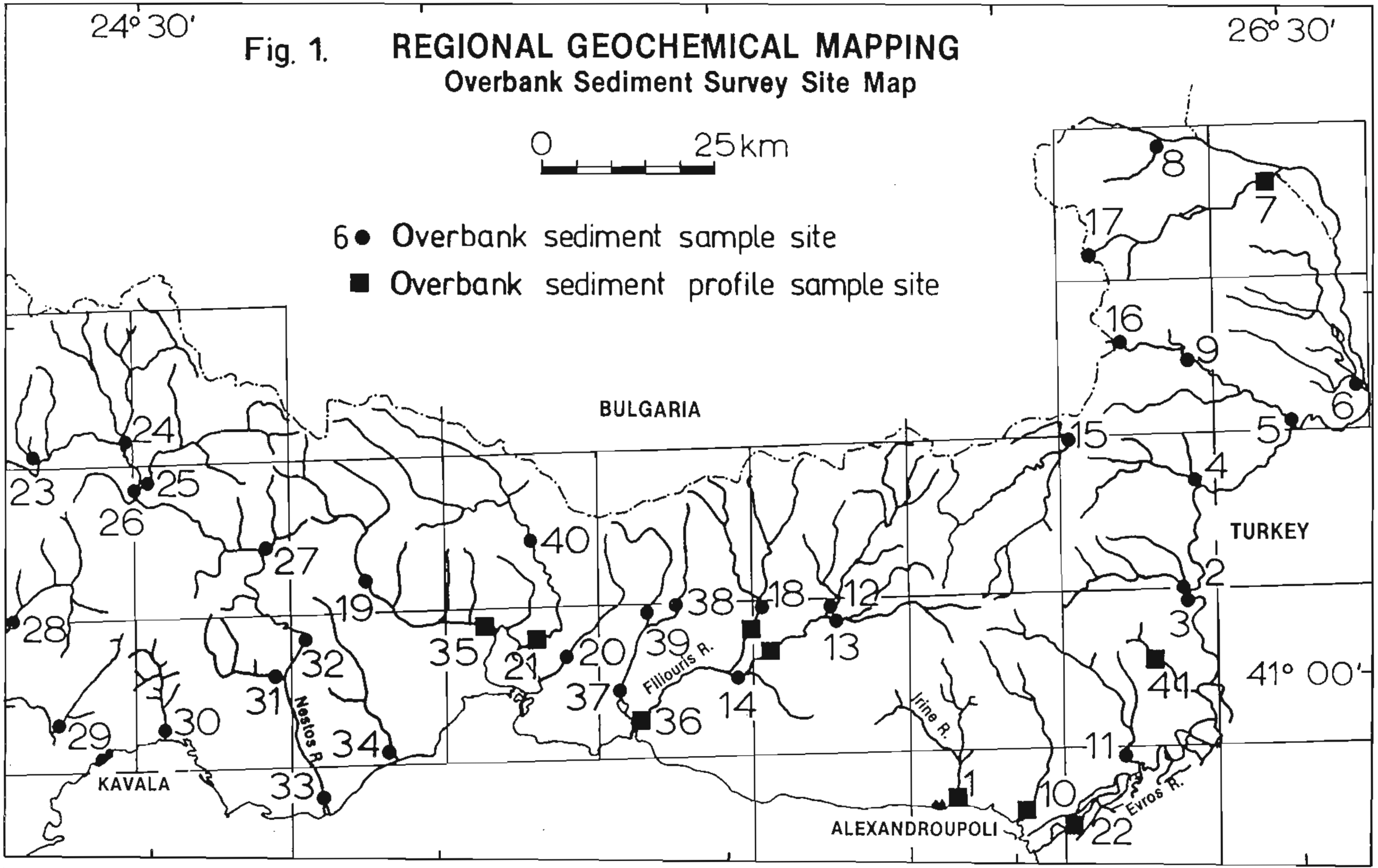


Fig. 1. REGIONAL GEOCHEMICAL MAPPING
Overbank Sediment Survey Site Map

Fig. 2a. Grain size fraction analysis of overbank sediment samples OB1 to OB10

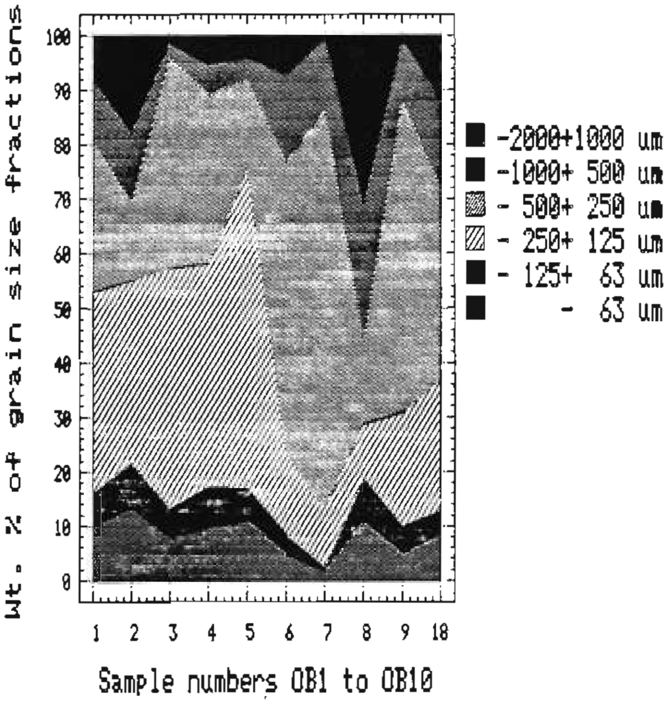


Fig. 2b. Grain size fraction analysis of overbank sediment samples OB11 to OB20

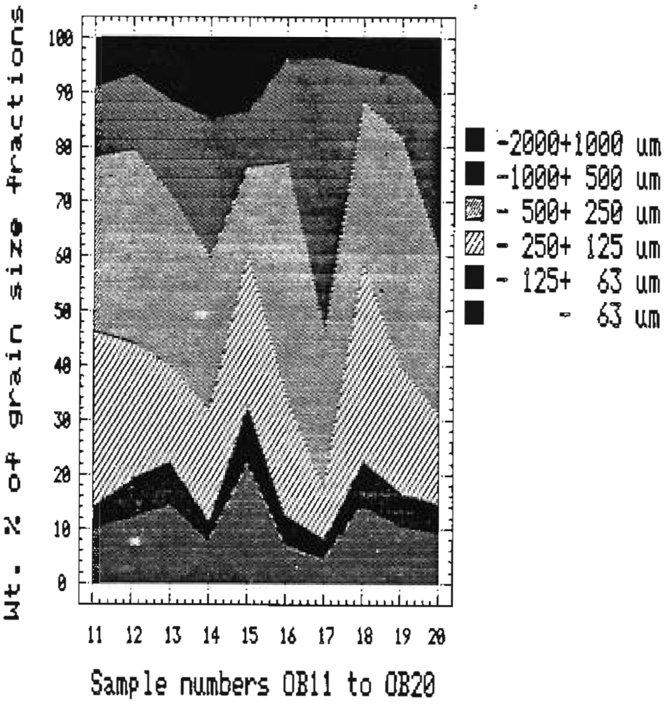


Fig. 2c. Grain size fraction analysis of overbank sediment samples OB21 to OB30

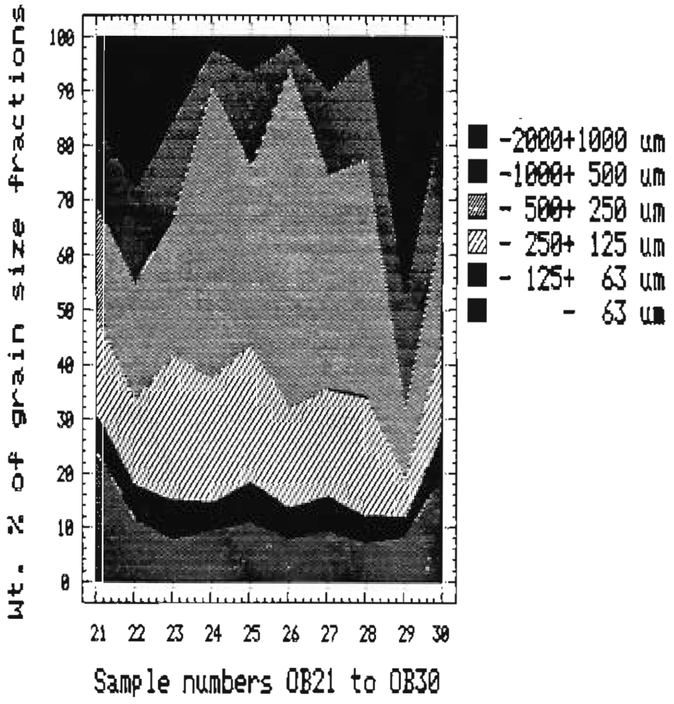


Fig. 2d. Grain size fraction analysis of overbank sediment samples OB31 to OB41

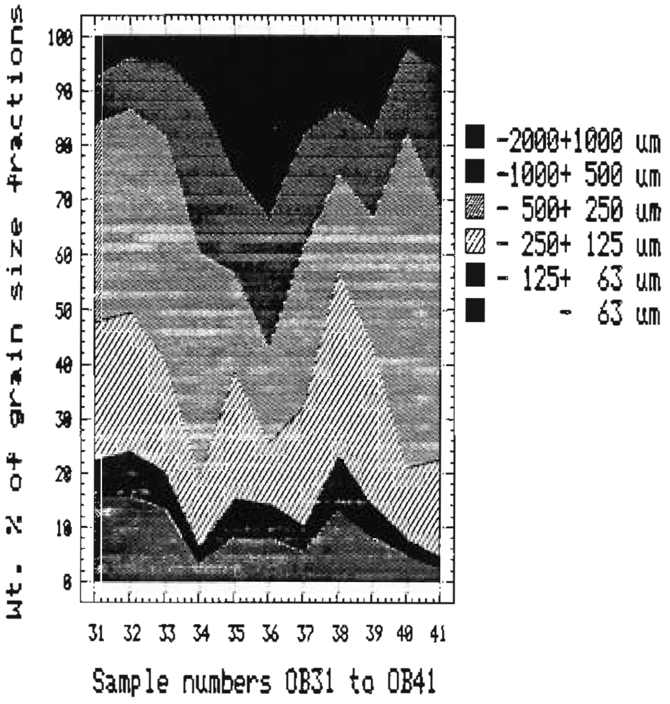


Fig. 3a. Grain size fraction analysis of stream sediment samples SS1 to SS10

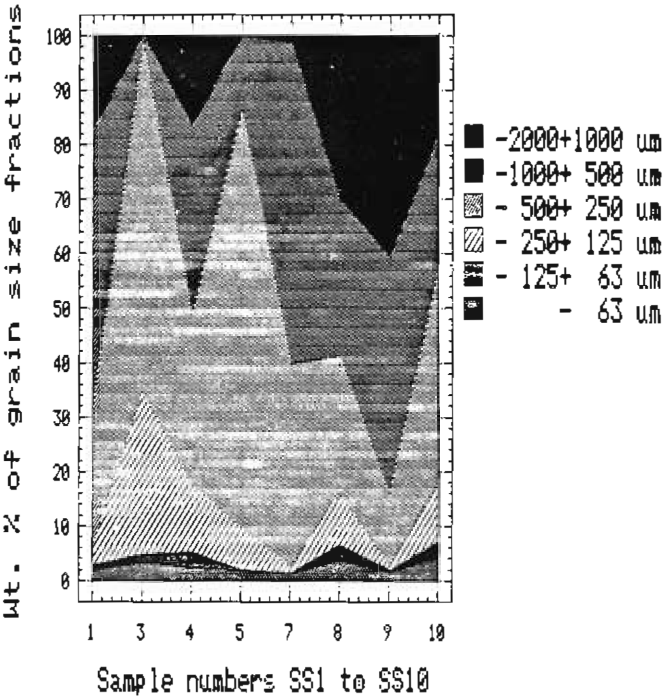


Fig. 3b. Grain size fraction analysis of stream sediment samples SS11 to SS20

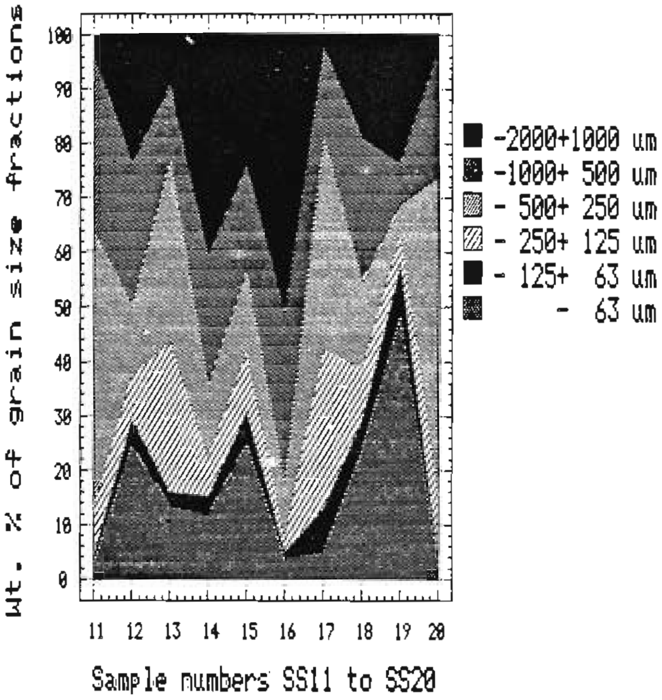


Fig. 3c. Grain size fraction analysis of stream sediment samples SS21 to SS30

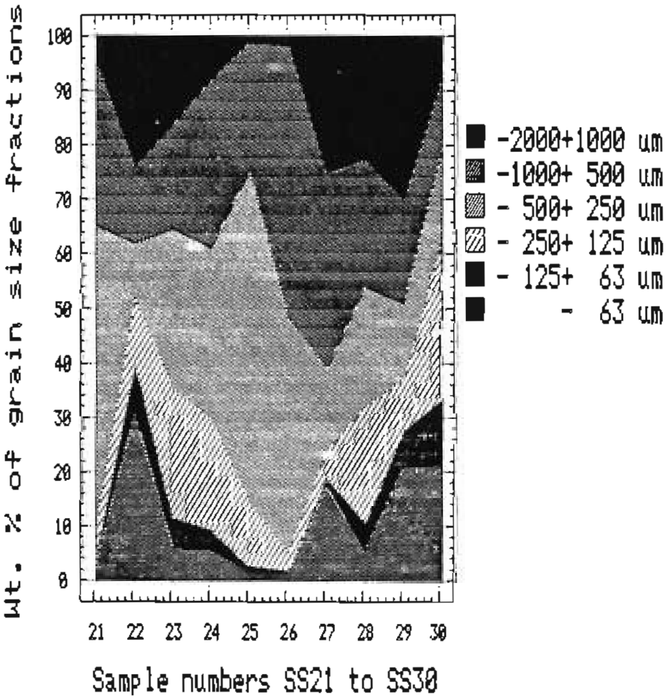


Fig. 3d. Grain size fraction analysis of stream sediment samples SS31 to SS41

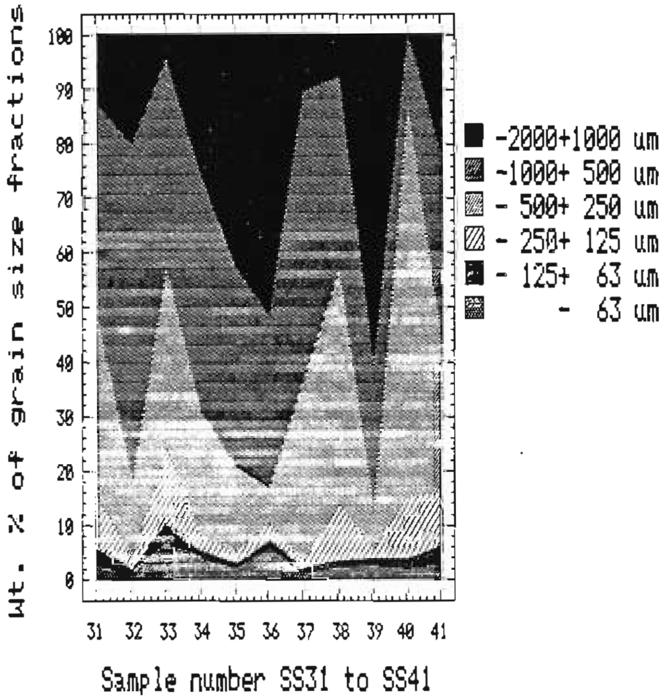


Fig. 4a. Total Al content in grain size fractions of overbank sediment

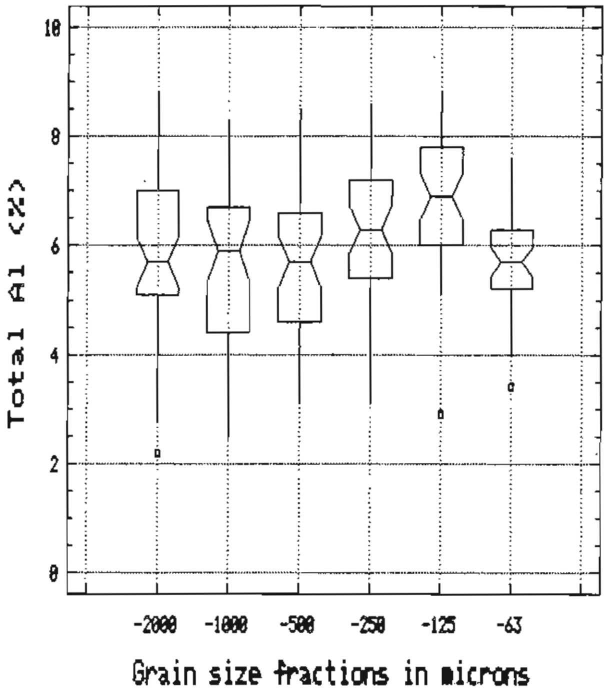


Fig. 4b. Leachable Al content in grain size fractions of overbank sediment

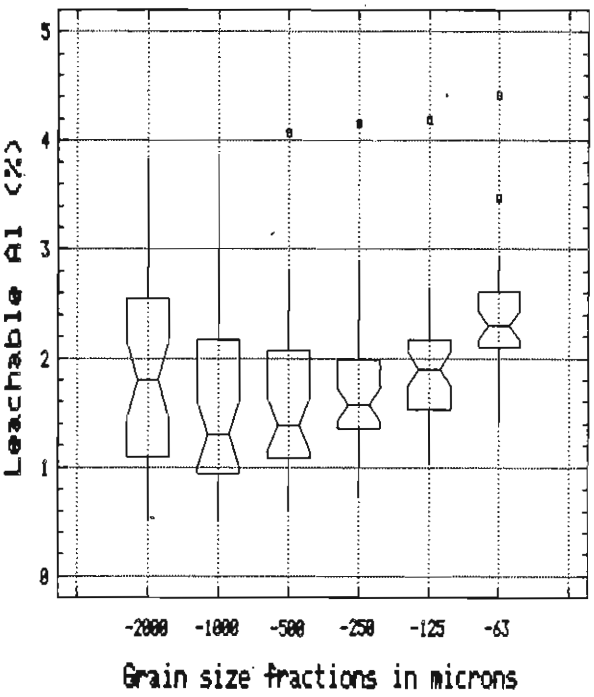


Fig. 4d. Leachable Al content in grain size fractions of stream sediment

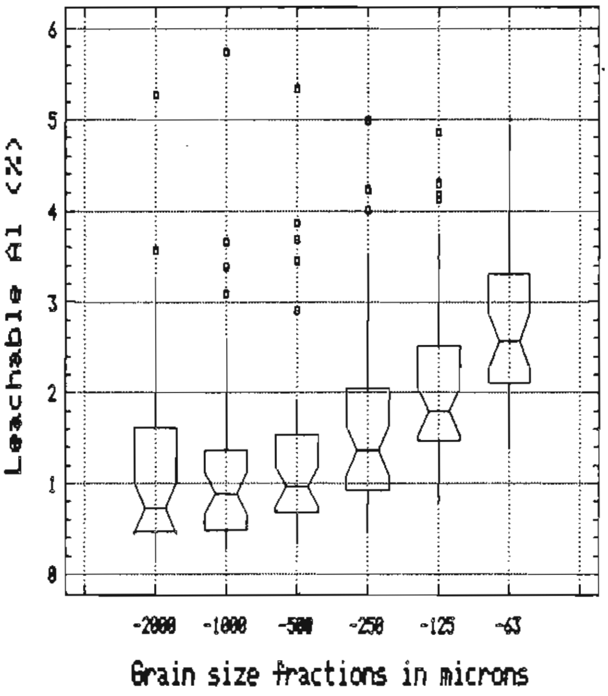


Fig. 4c. Total Al content in grain size fractions of stream sediment

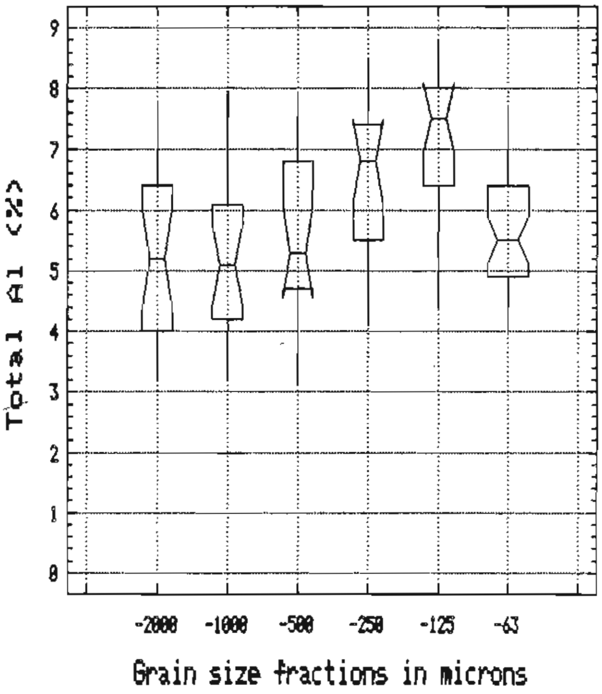


Fig. 5a. Total Ba content in grain size fractions of overbank sediment

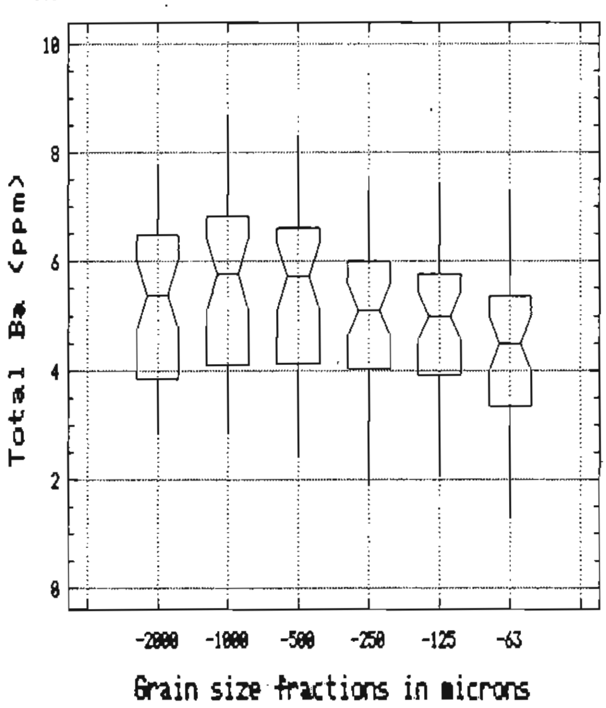


Fig. 5b. Leachable Ba content in grain size fractions of overbank sediment

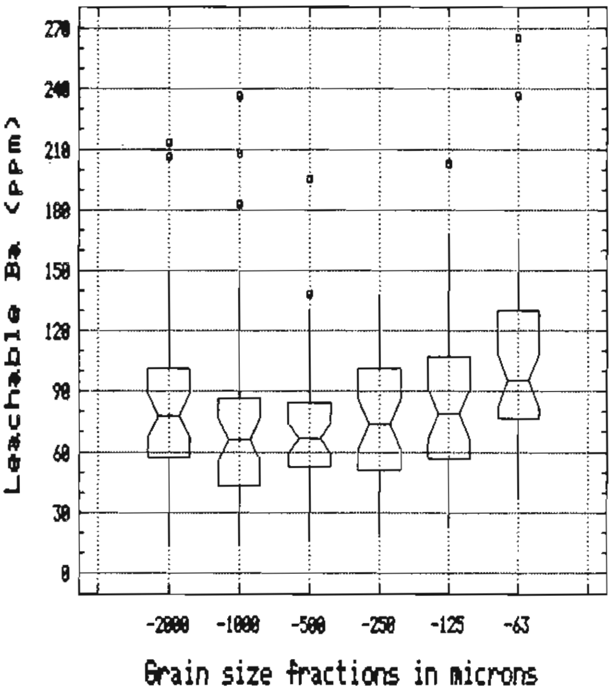


Fig. 5c. Total Ba content in grain size fractions of stream sediment

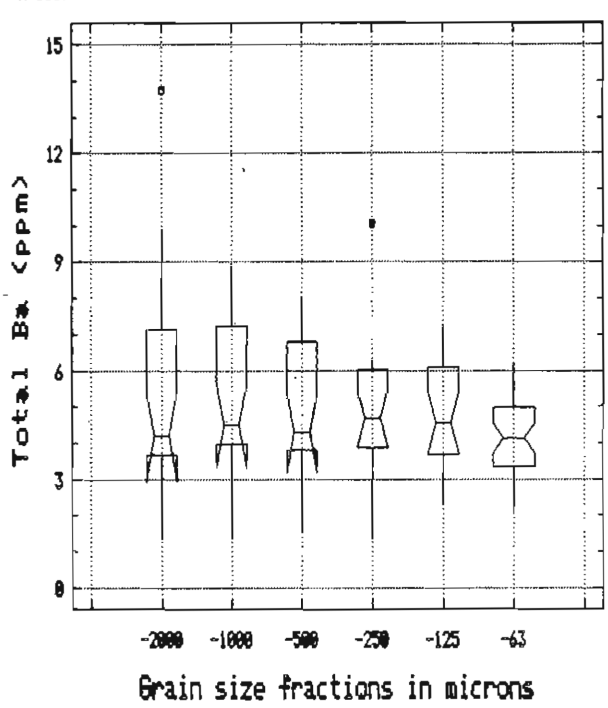


Fig. 5d. Leachable Ba content in grain size fractions of stream sediment

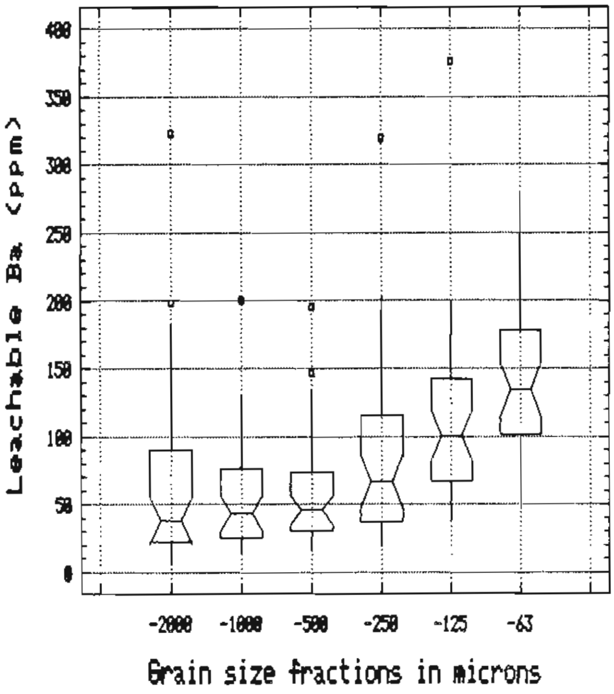


Fig. 6a. Total Be content in grain size fractions of overbank sediment

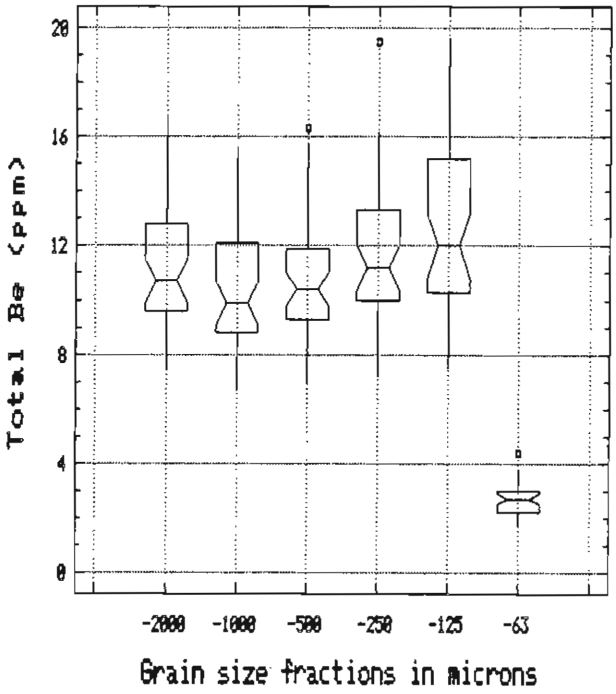


Fig. 6b. Leachable Be content in grain size fractions of overbank sediment

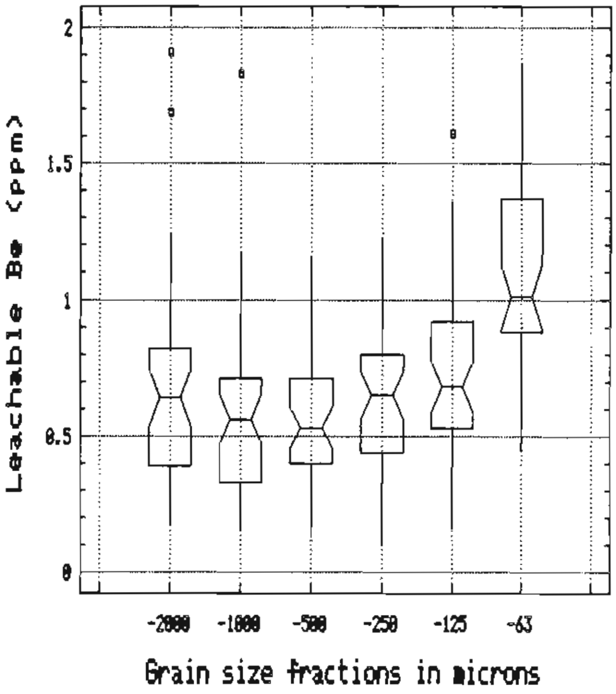


Fig. 6c. Total Be content in grain size fractions of stream sediment

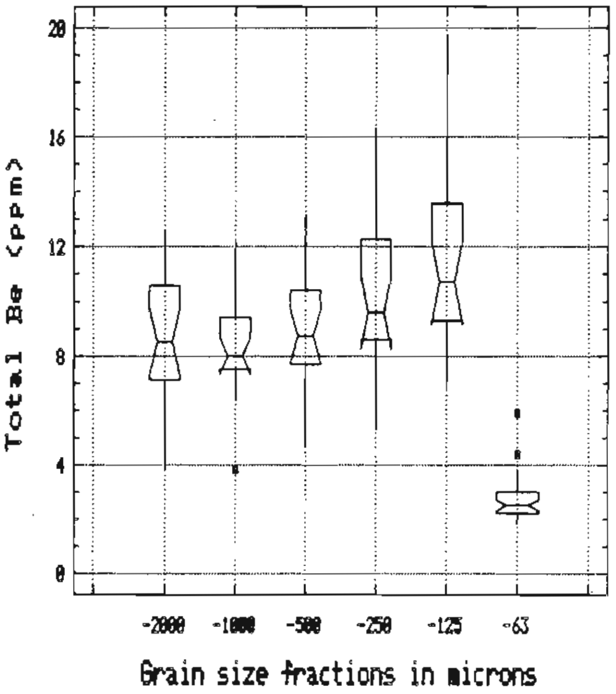


Fig. 6d. Leachable Be content in grain size fractions of stream sediment

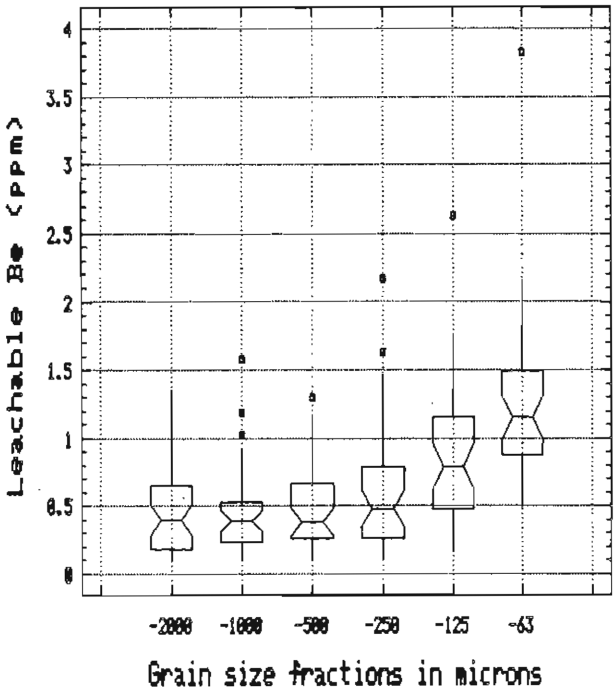


Fig. 7a. Total Ca content in grain size fractions of overbank sediment

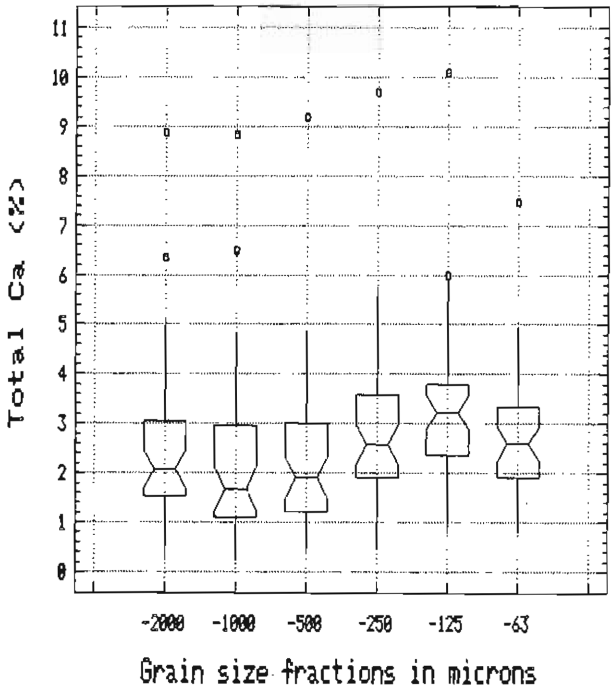


Fig. 7b. Leachable Ca content in grain size fractions of overbank sediment

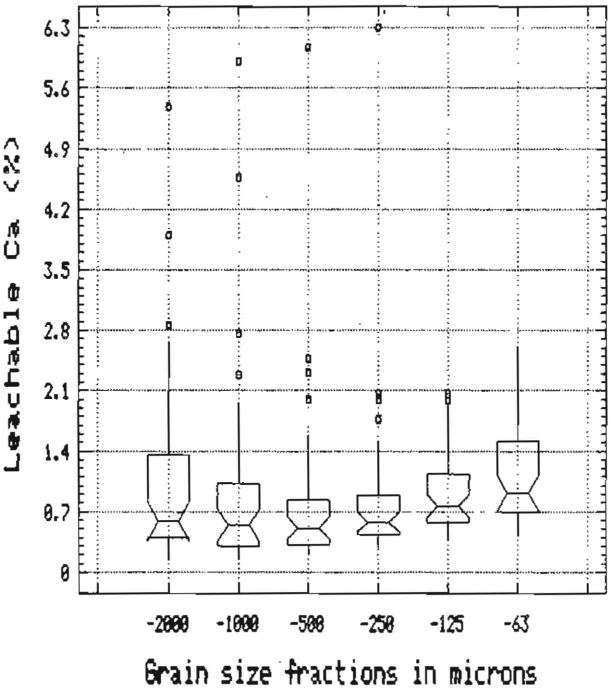


Fig. 7d. Leachable Ca content in grain size fractions of stream sediment

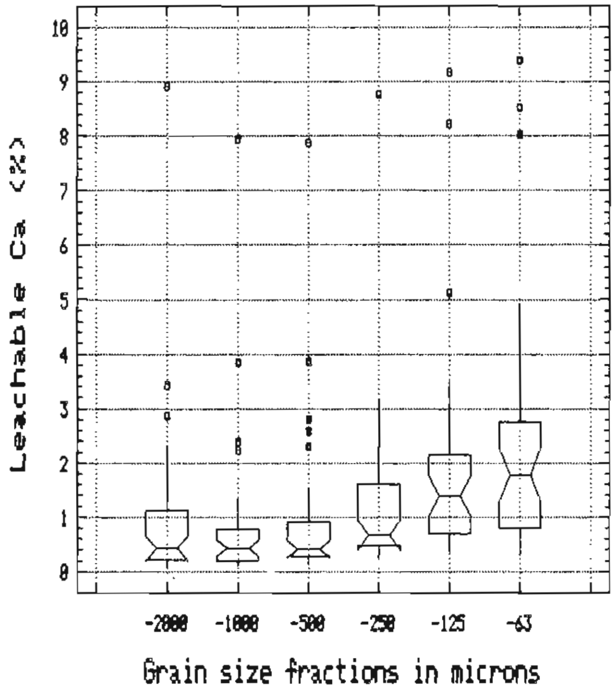


Fig. 7c. Total Ca content in grain size fractions of stream sediment

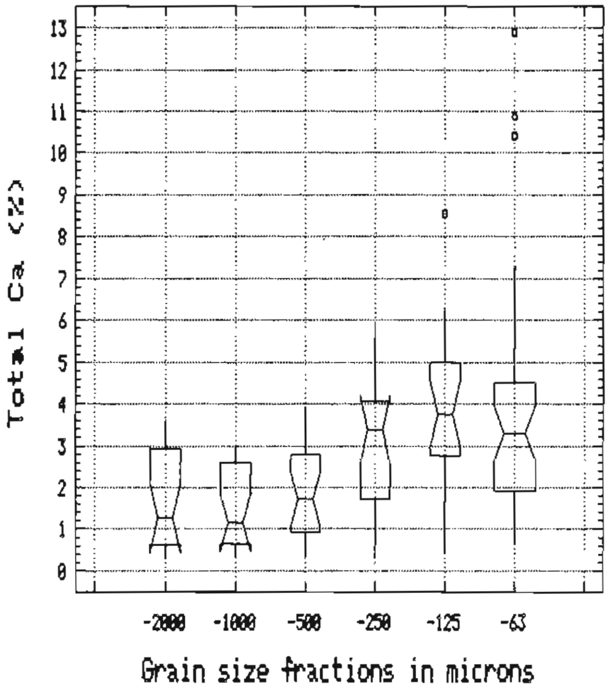


Fig. 8a. Total Cd content in grain size fractions of overbank sediment

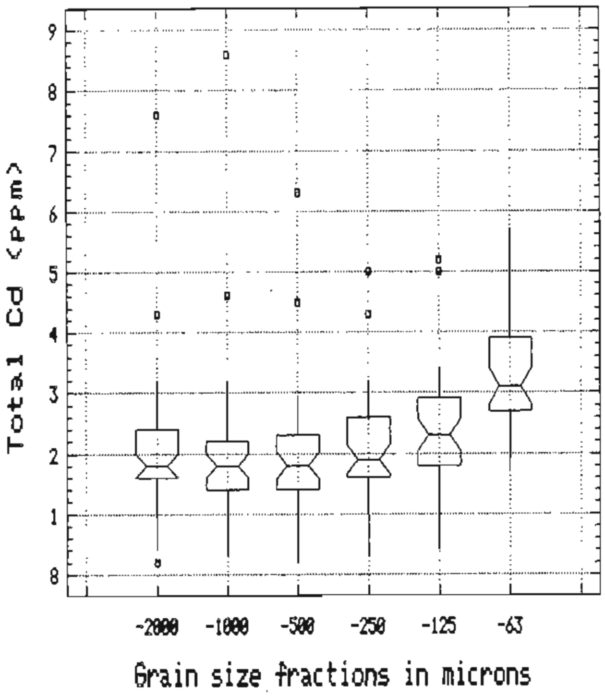


Fig. 8b. Leachable Cd content in grain size fractions of overbank sediment

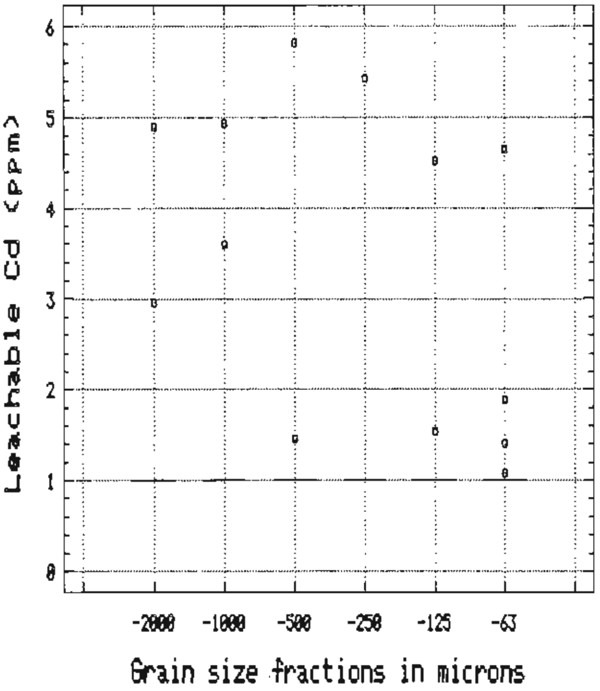


Fig. 8c. Total Cd content in grain size fractions of stream sediment

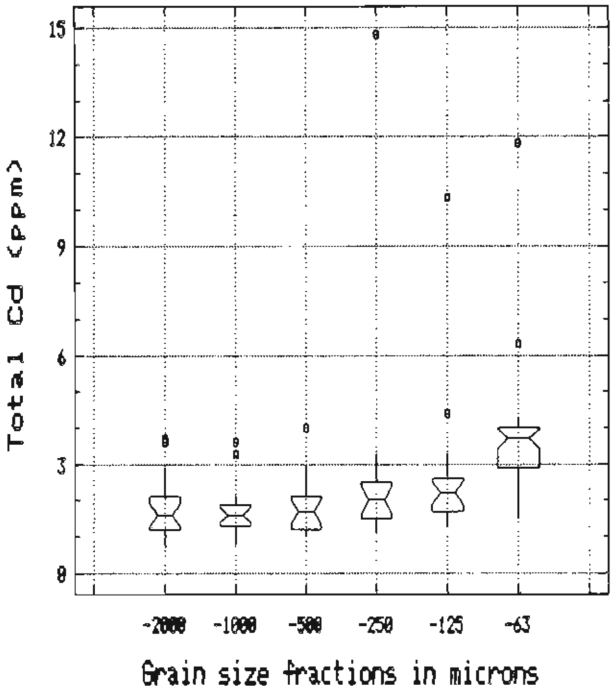


Fig. 8d. Leachable Cd content in grain size fractions of stream sediment

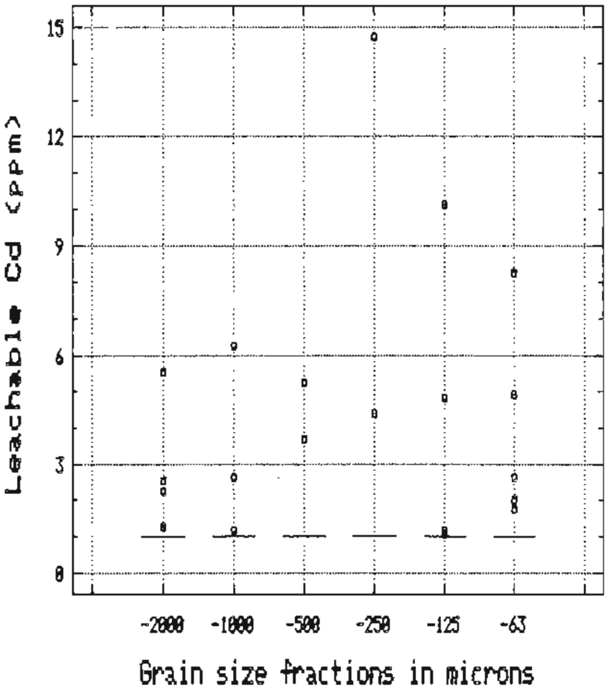


Fig. 9a. Total Co content in grain size fractions of overbank sediment

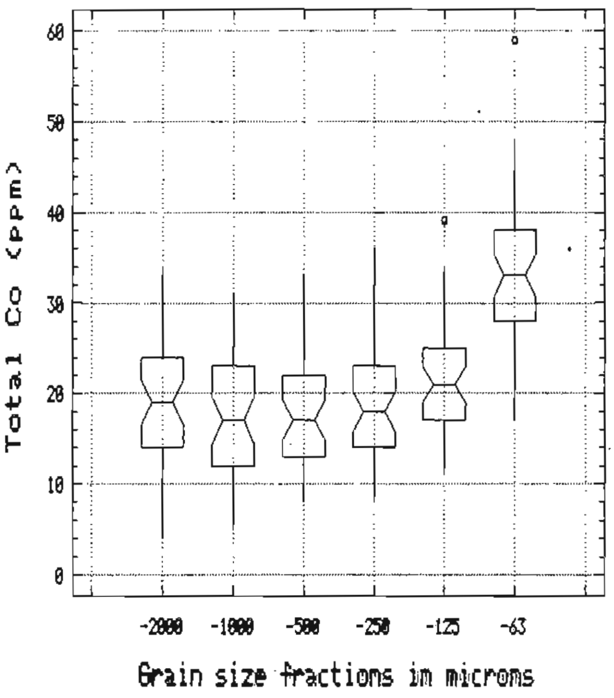


Fig. 9b. Leachable Co content in grain size fractions of overbank sediment

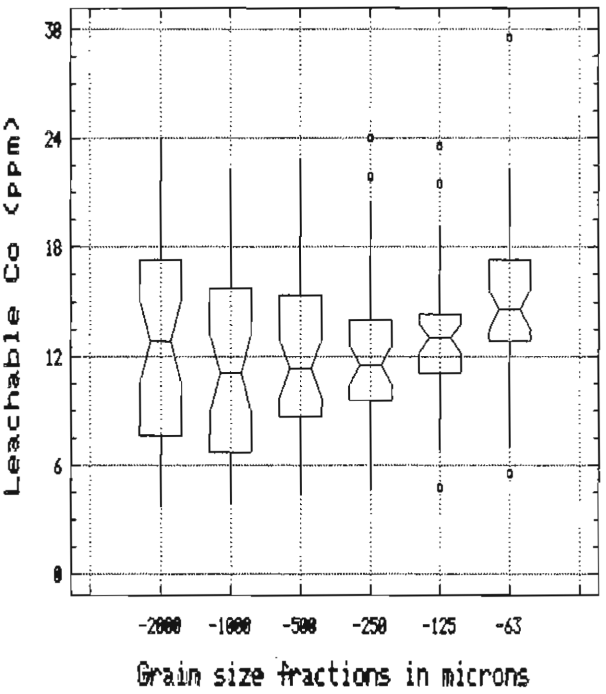


Fig. 9c. Total Co content in grain size fractions of stream sediment

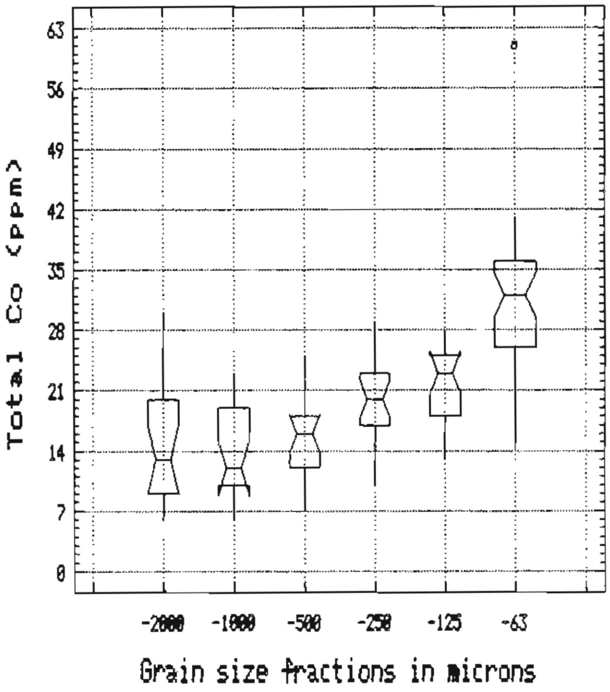
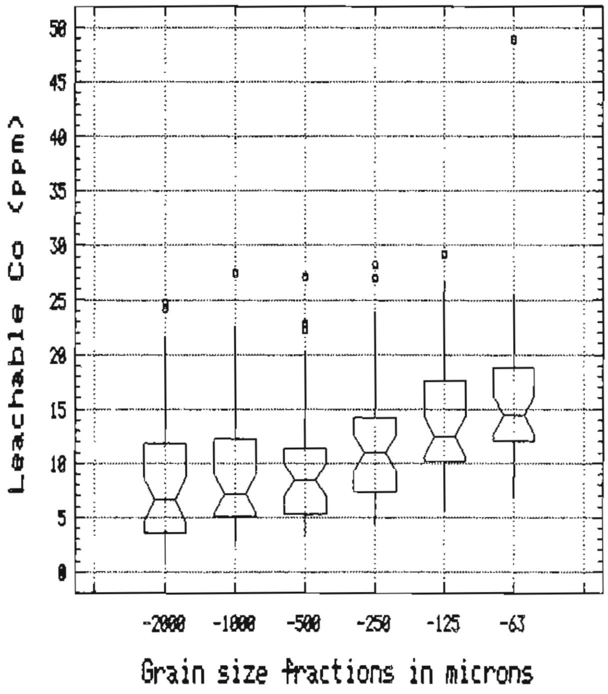


Fig. 9d. Leachable Co content in grain size fractions of stream sediment



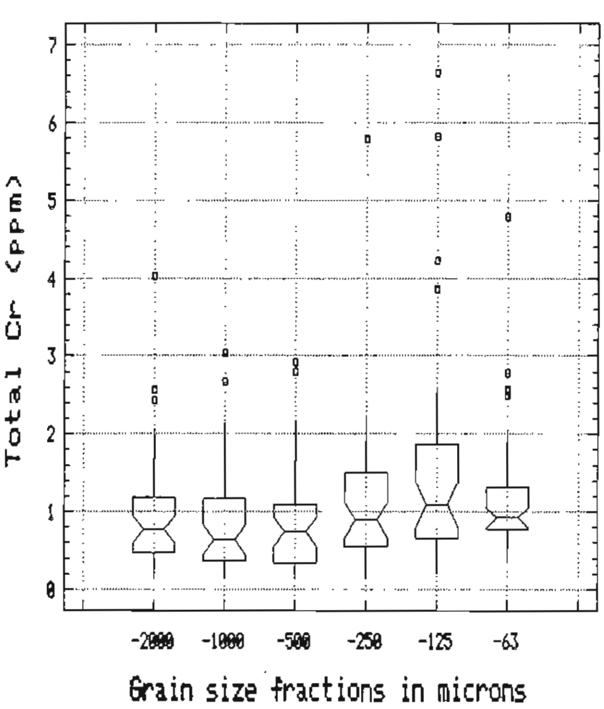


Fig. 10a. Total Cr content in grain size fractions of overbank sediment

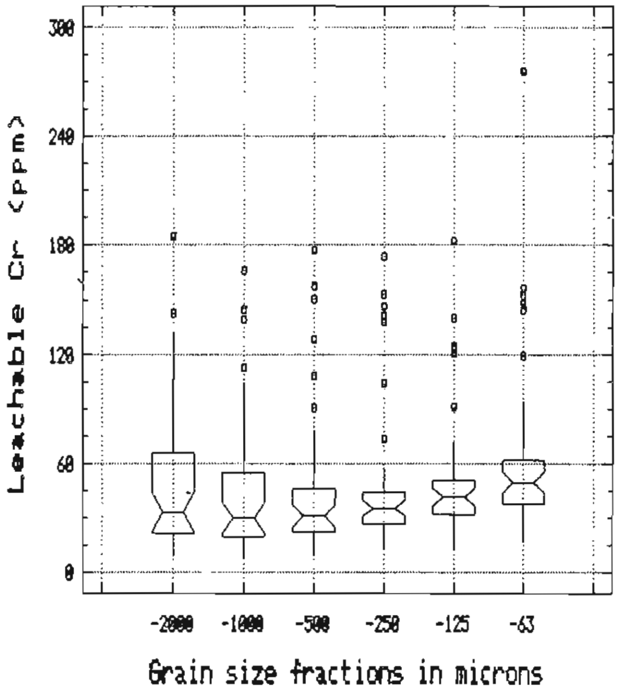


Fig. 10b. Leachable Cr content in grain size fractions of overbank sediment

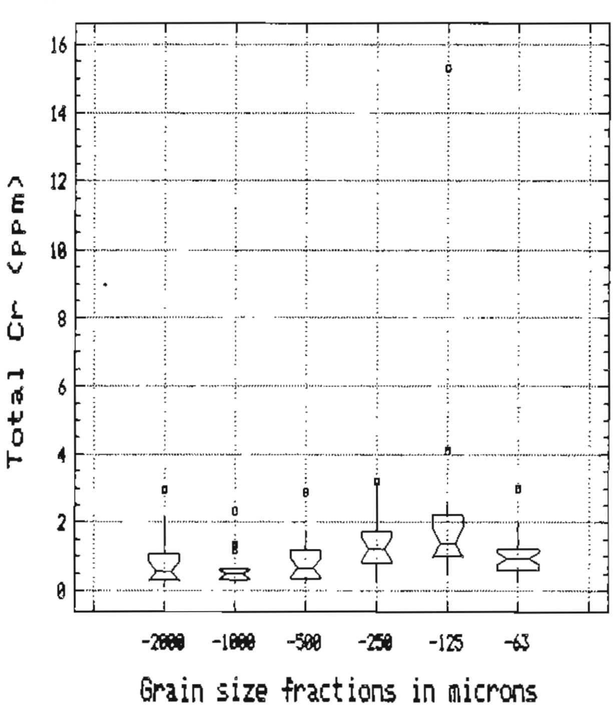


Fig. 10c. Total Cr content in grain size fractions of stream sediment

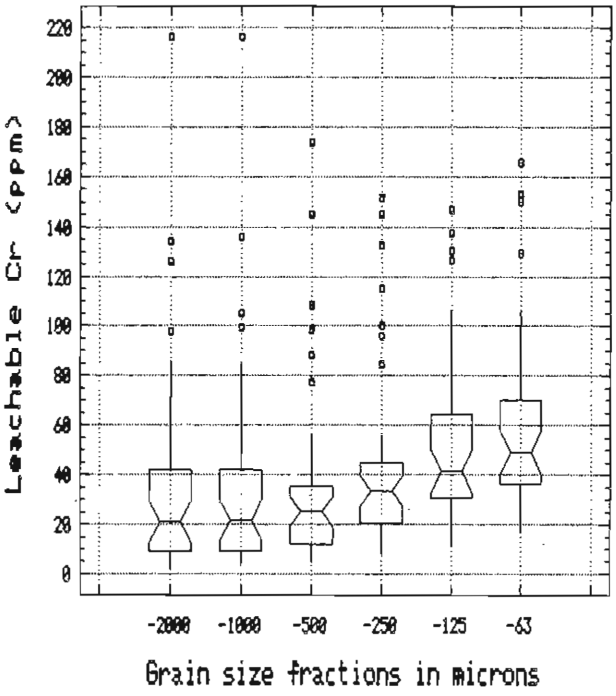


Fig. 10d. Leachable Cr content in grain size fractions of stream sediment

Fig. 11a. Total Cu content in grain size fractions of overbank sediment

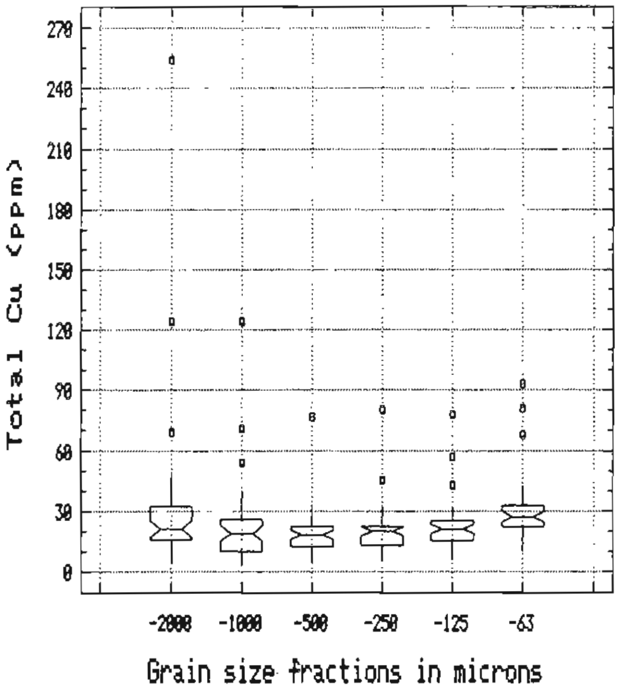


Fig. 11b. Leachable Cu content in grain size fractions of overbank sediment

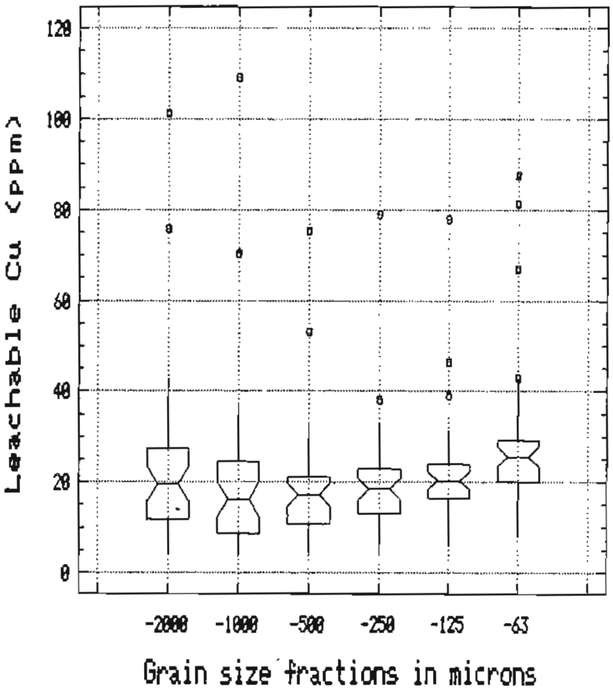


Fig. 11c. Total Cu content in grain size fractions of stream sediment

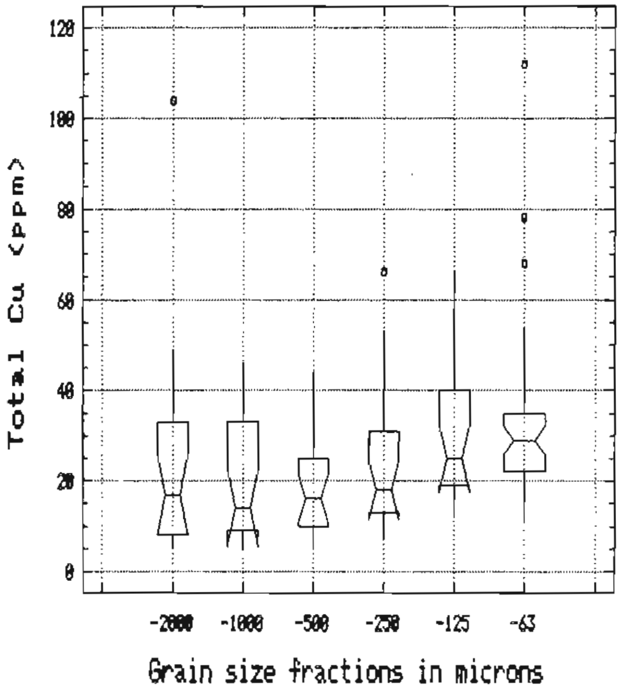


Fig. 11d. Leachable Cu content in grain size fractions of stream sediment

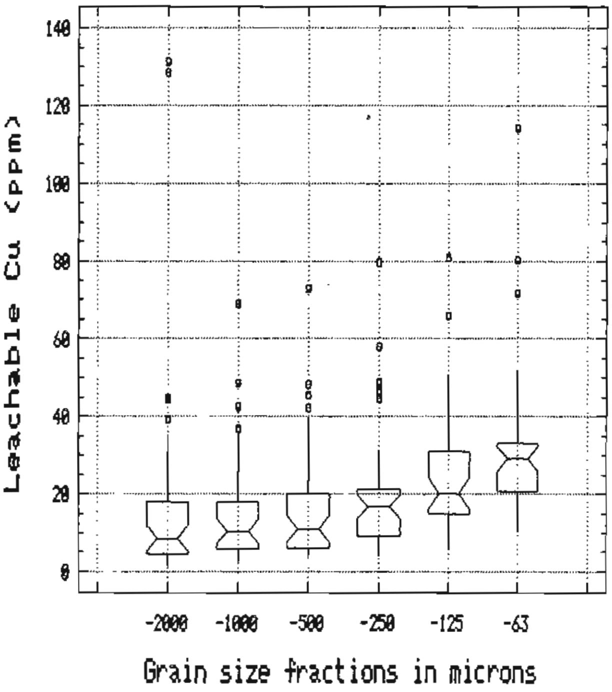


Fig. 12a. Total Fe content in grain size fractions of overbank sediment

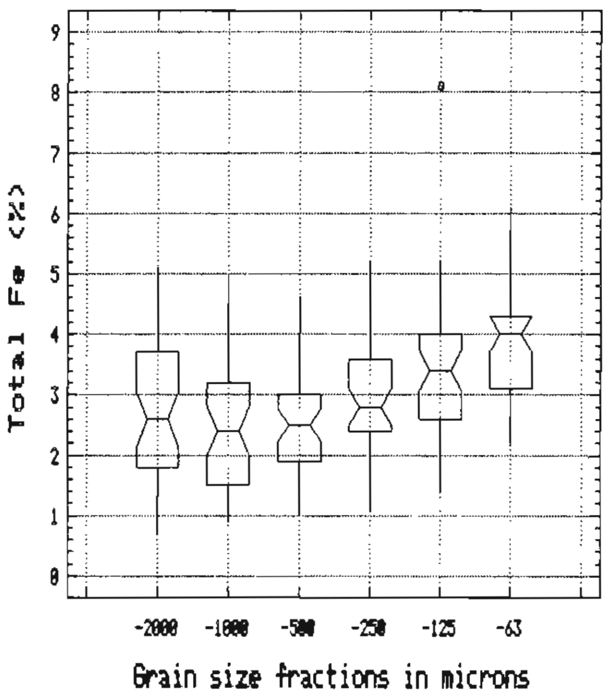


Fig. 12b. Leachable Fe content in grain size fractions of overbank sediment

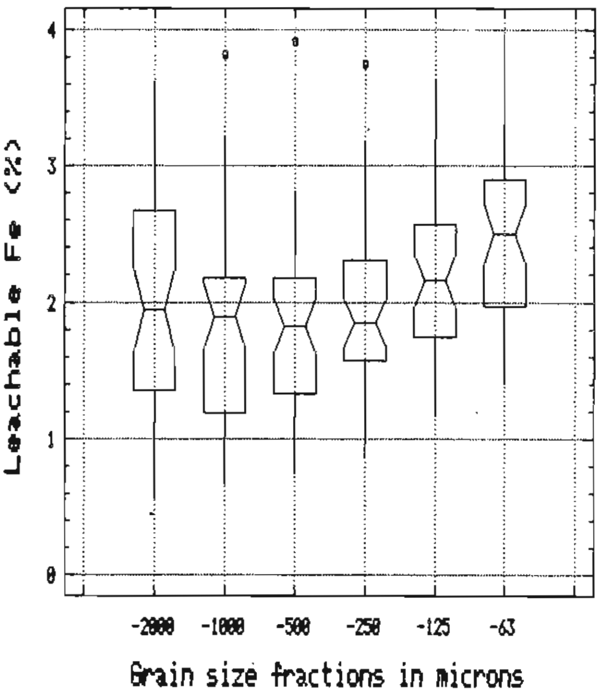


Fig. 12c. Total Fe content in grain size fractions of stream sediment

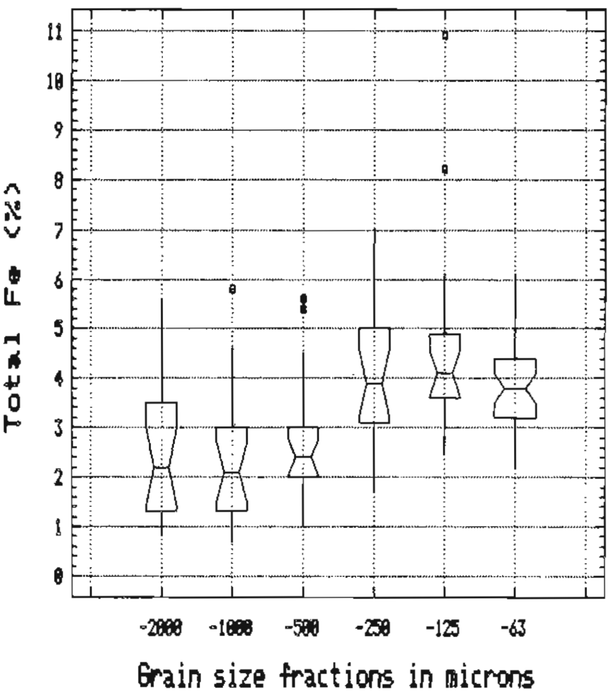


Fig. 12d. Leachable Fe content in grain size fractions of stream sediment

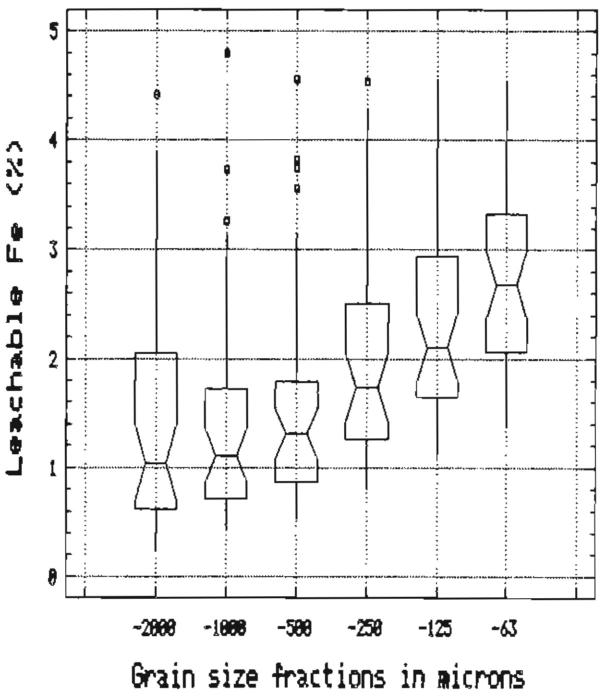


Fig. 13a. Total Li content in grain size fractions of overbank sediment

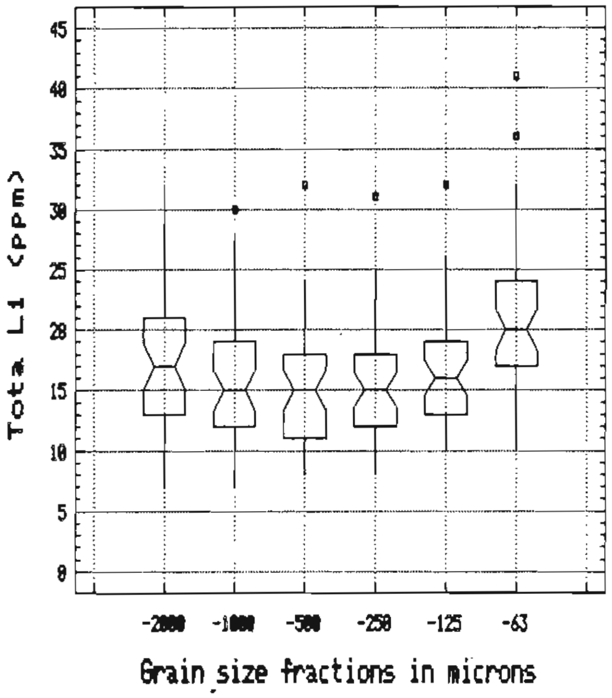


Fig. 13b. Leachable Li content in grain size fractions of overbank sediment

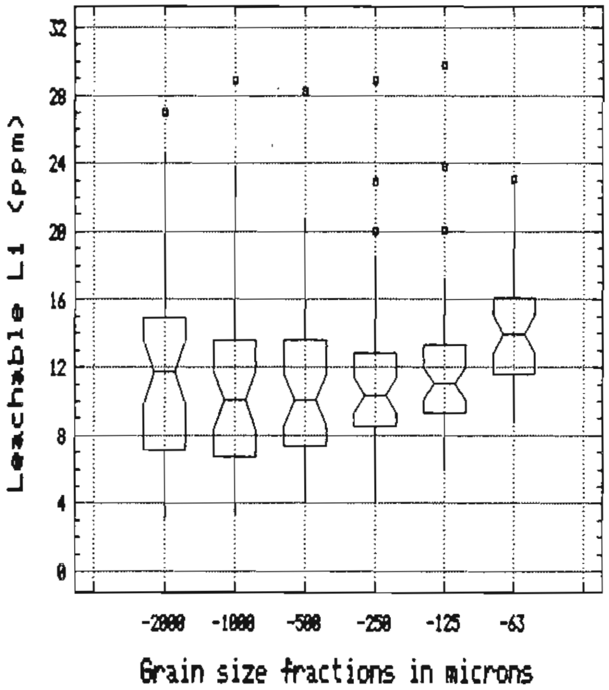


Fig. 13c. Total Li content in grain size fractions of stream sediment

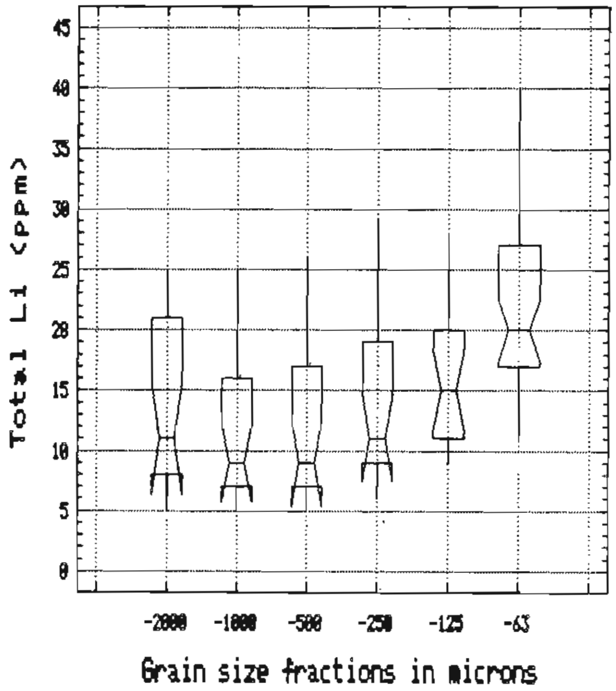
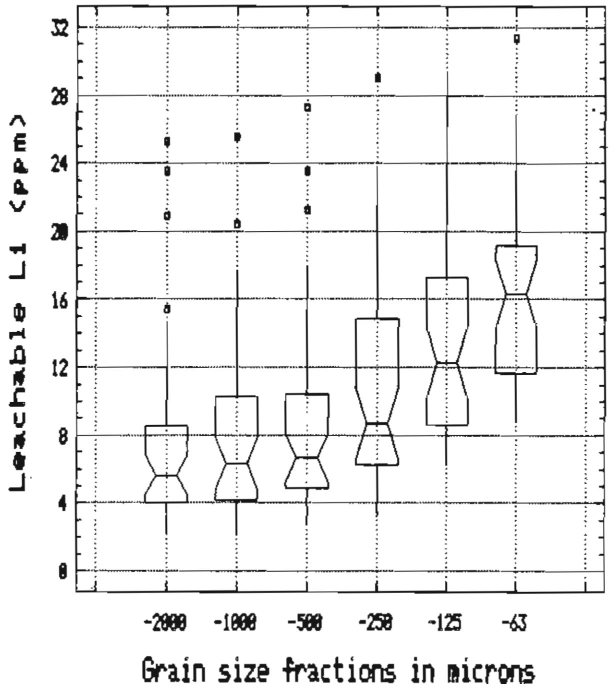


Fig. 13d. Leachable Li content in grain size fractions of stream sediment



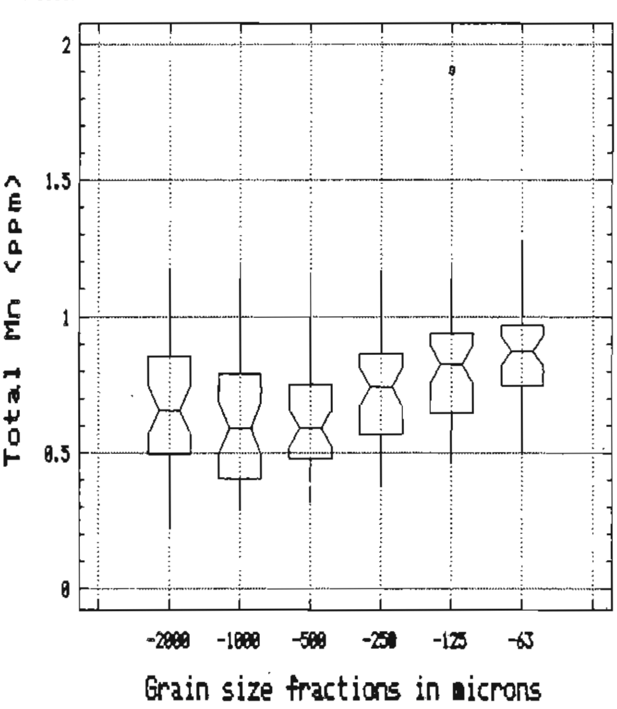


Fig. 14a. Total Mn content in grain size fractions of overbank sediment

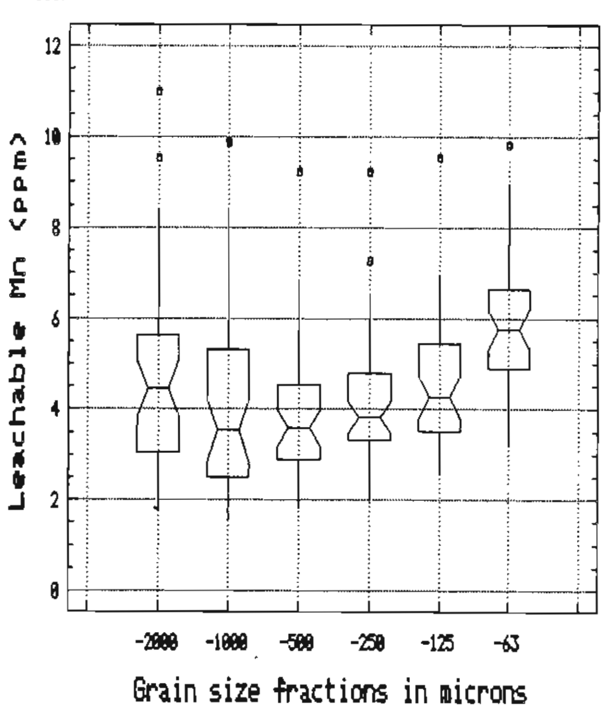


Fig. 14b. Leachable Mn content in grain size fractions of overbank sediment

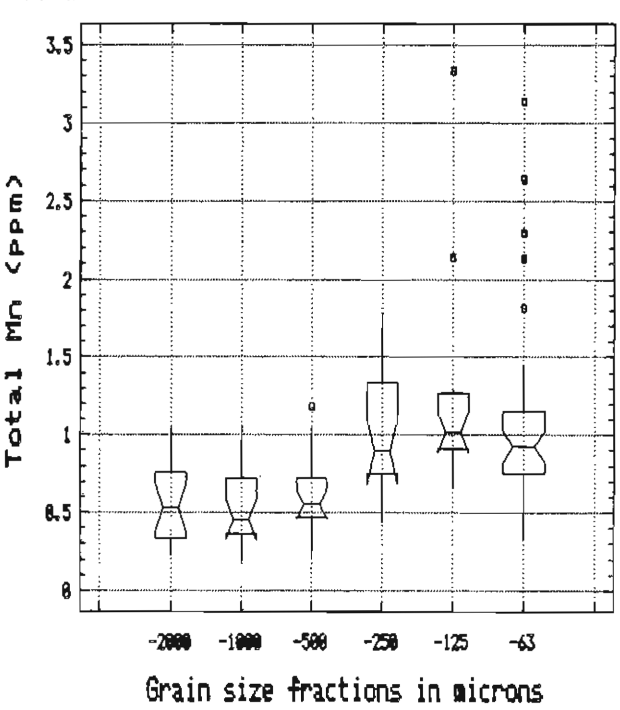


Fig. 14c. Total Mn content in grain size fractions of stream sediment

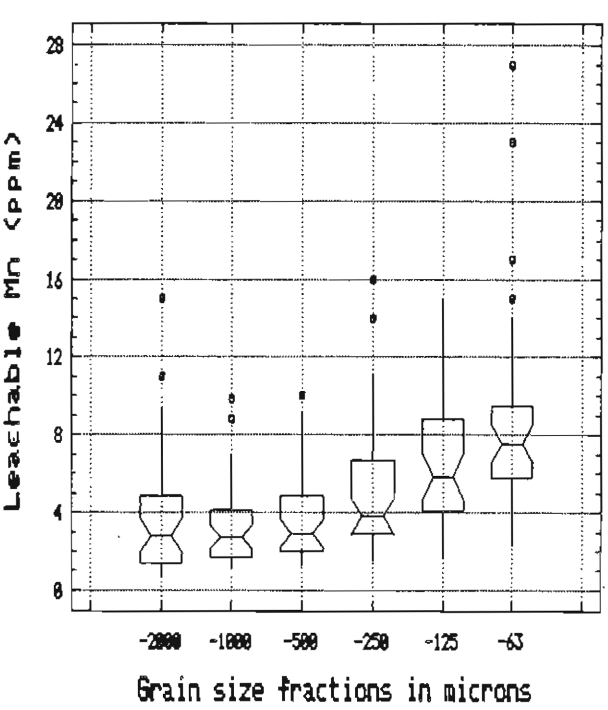


Fig. 14d. Leachable Mn content in grain size fractions of stream sediment

Fig. 15a. Total Mo content in grain size fractions of overbank sediment

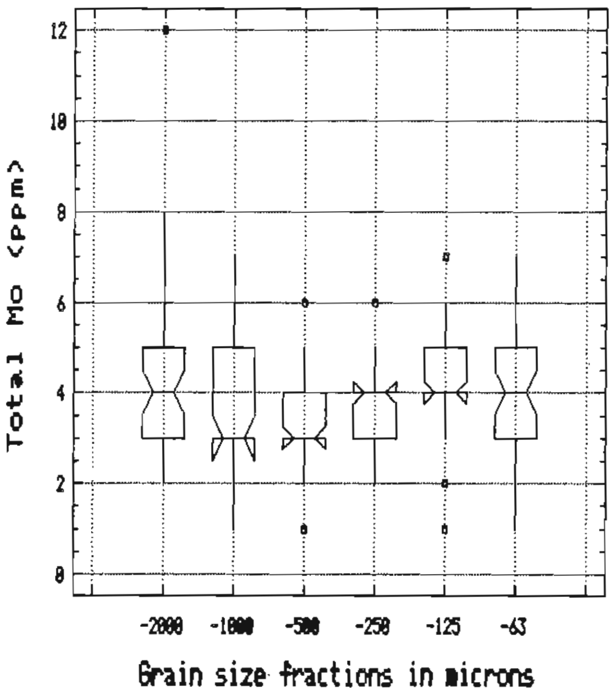


Fig. 15b. Leachable Mo content in grain size fractions of overbank sediment

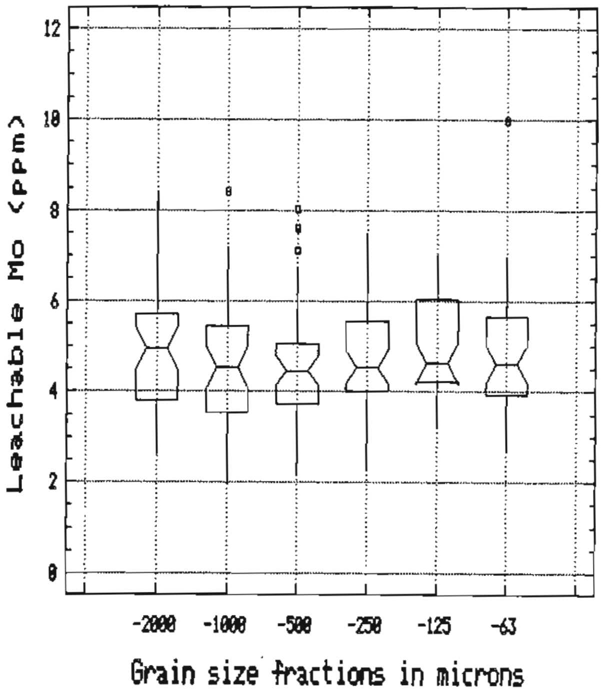


Fig. 15c. Total Mo content in grain size fractions of stream sediment

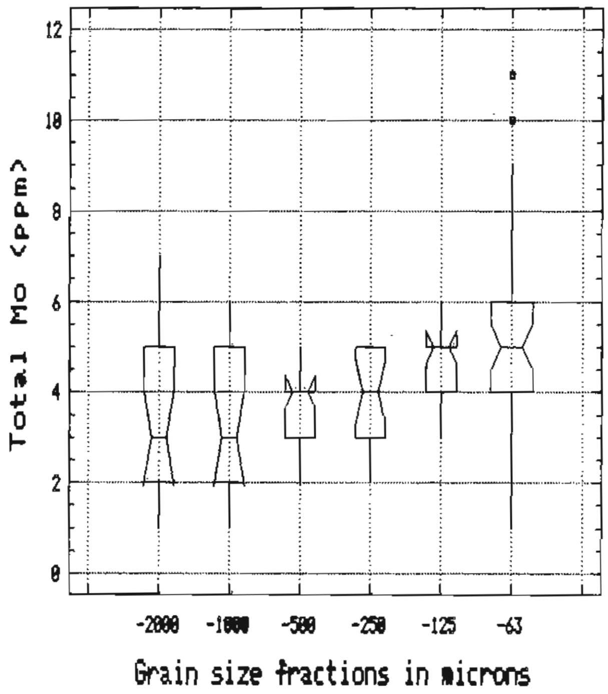


Fig. 15d. Leachable Mo content in grain size fractions of stream sediment

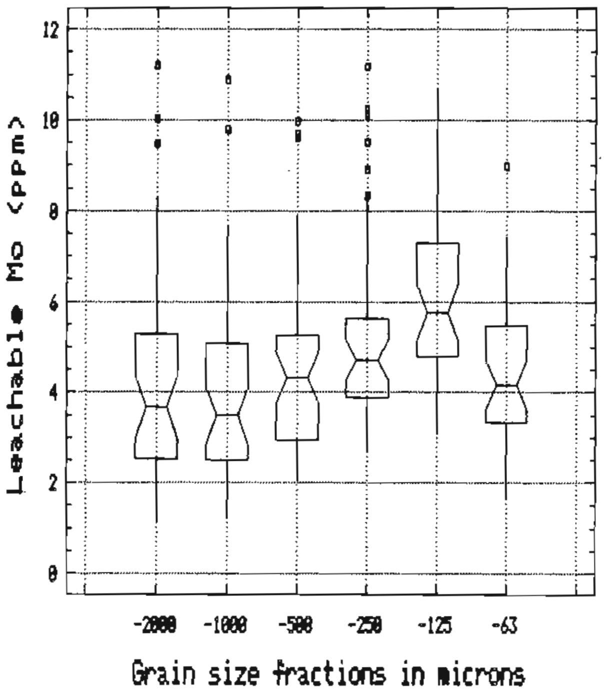


Fig. 16a. Total Ni content in grain size fractions of overbank sediment

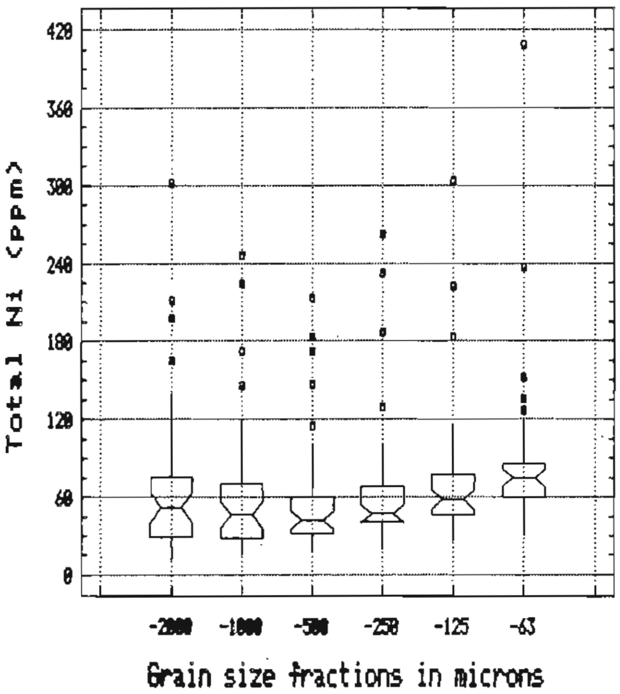


Fig. 16b. Leachable Ni content in grain size fractions of overbank sediment

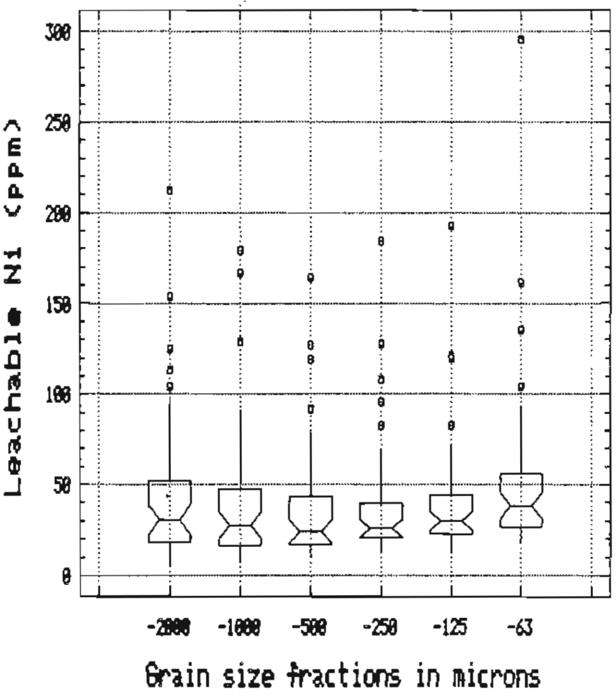


Fig. 16c. Total Ni content in grain size fractions of stream sediment

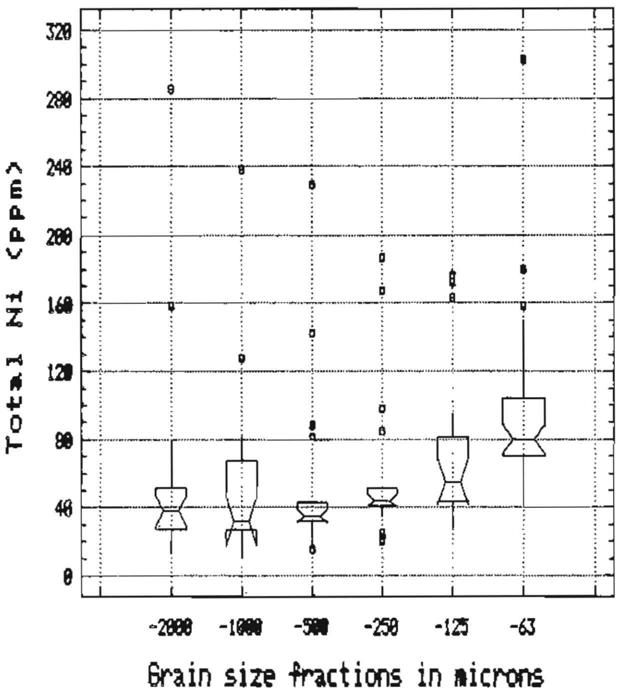


Fig. 16d. Leachable Ni content in grain size fractions of stream sediment

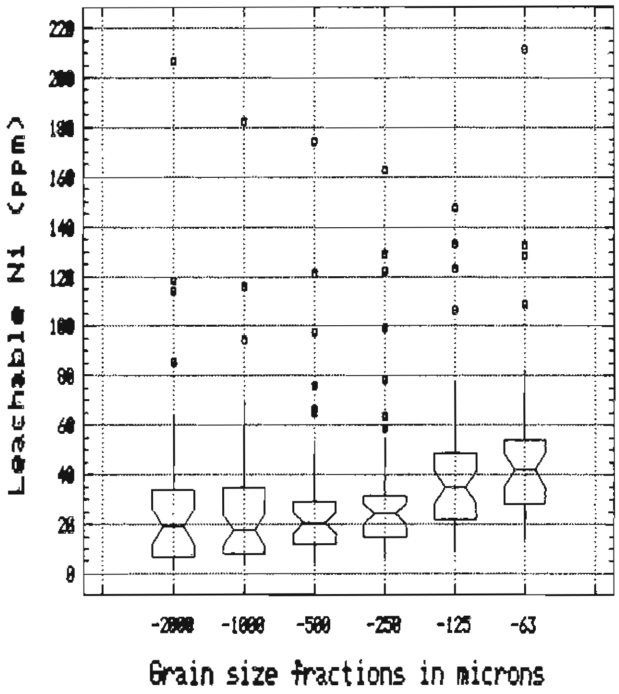


Fig. 17a. Total Pb content in grain size fractions of overbank sediment

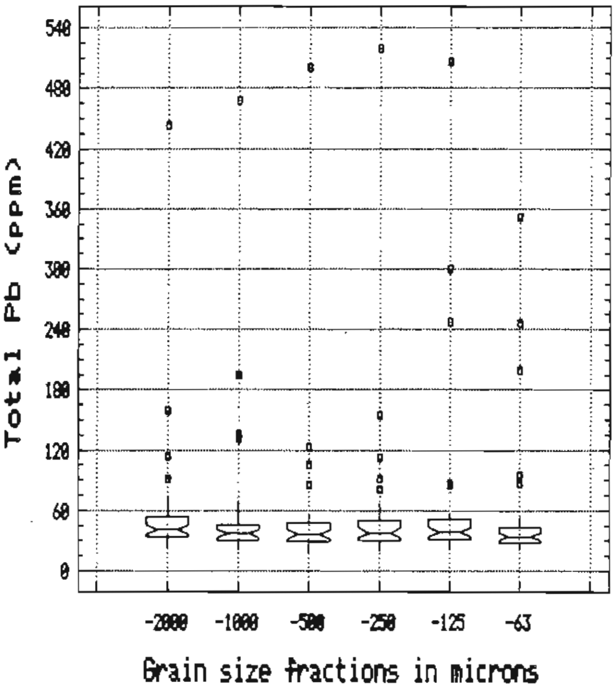


Fig. 17b. Leachable Pb content in grain size fractions of overbank sediment

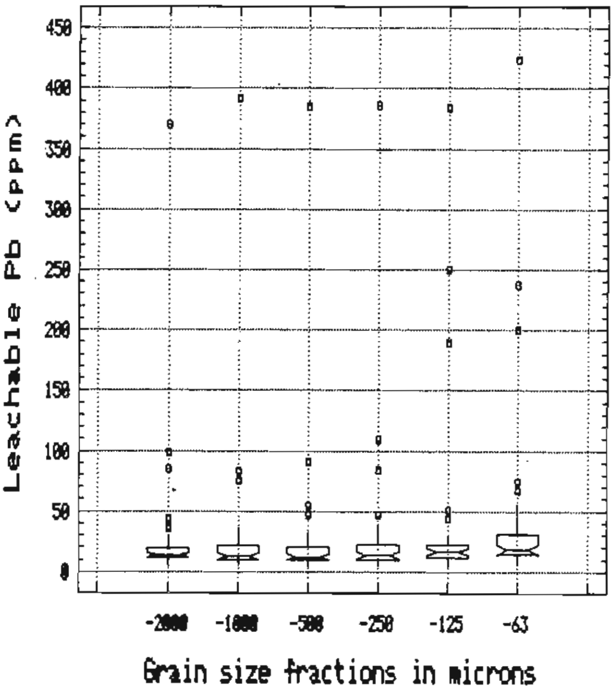


Fig. 17c. Total Pb content in grain size fractions of stream sediment

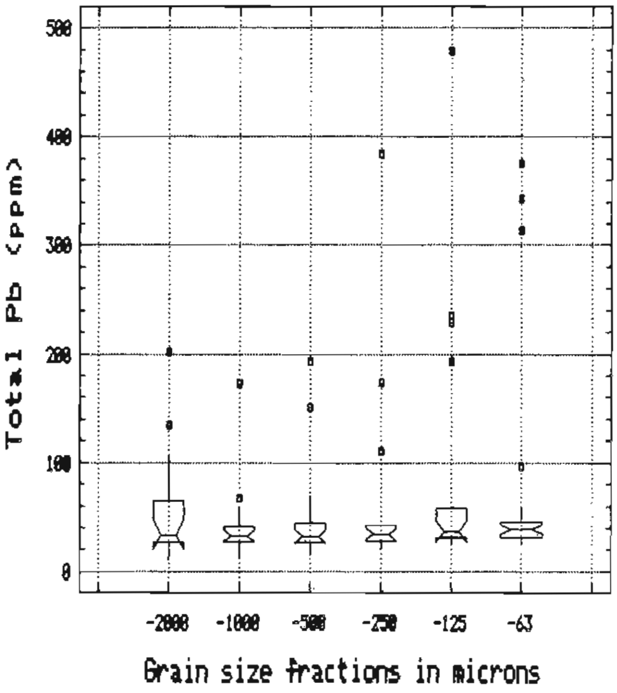


Fig. 17d. Leachable Pb content in grain size fractions of stream sediment

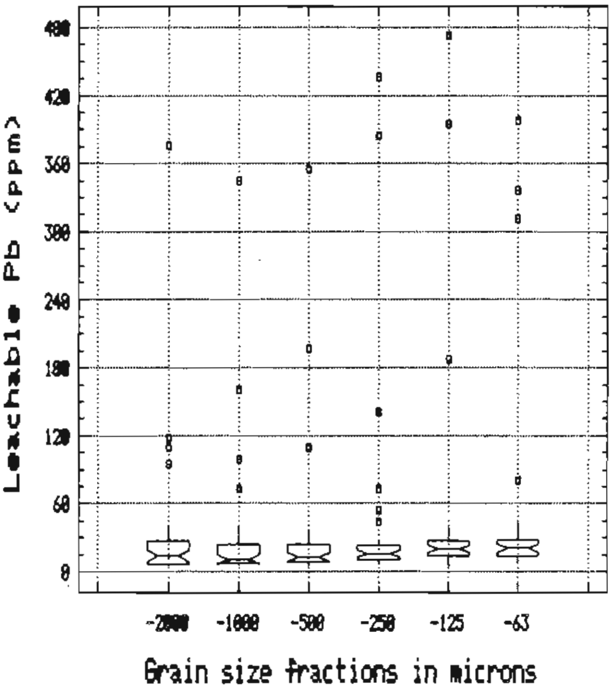


Fig. 18a. Total Sc content in grain size fractions of overbank sediment

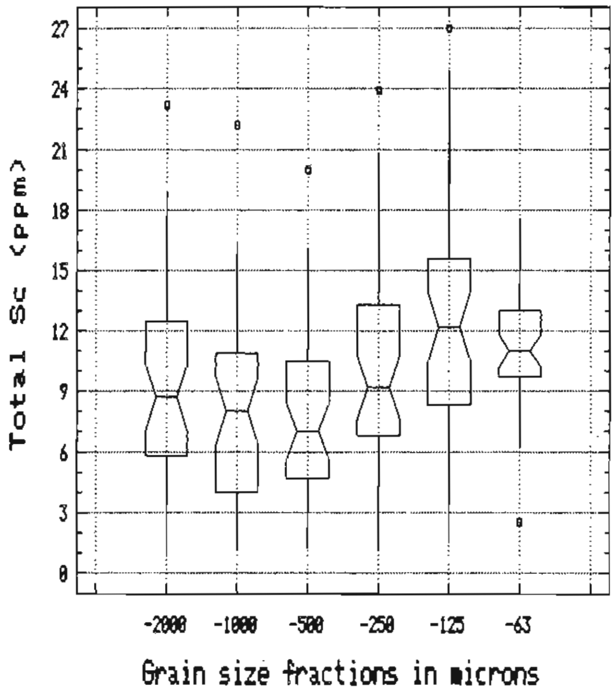


Fig. 18b. Leachable Sc content in grain size fractions of overbank sediment

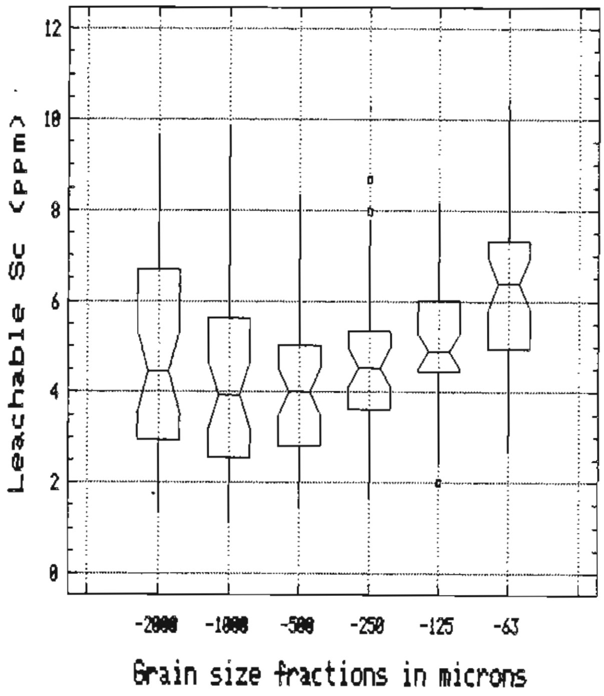


Fig. 18c. Total Sc content in grain size fractions of stream sediment

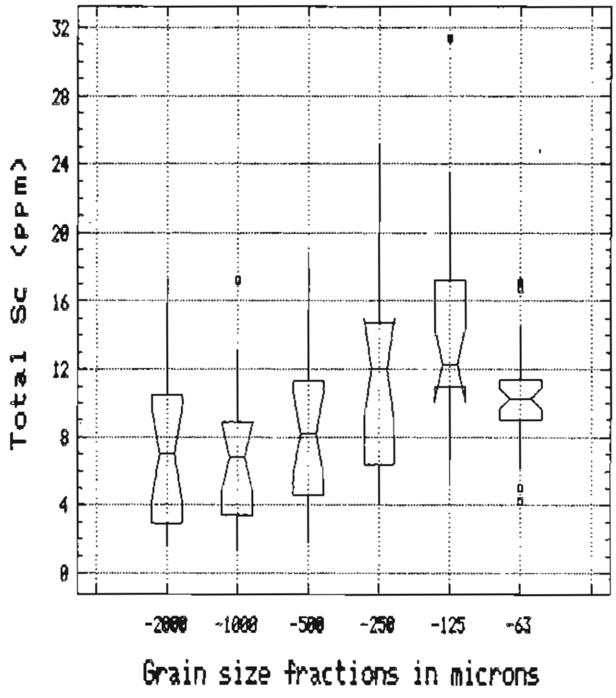


Fig. 18d. Leachable Sc content in grain size fractions of stream sediment

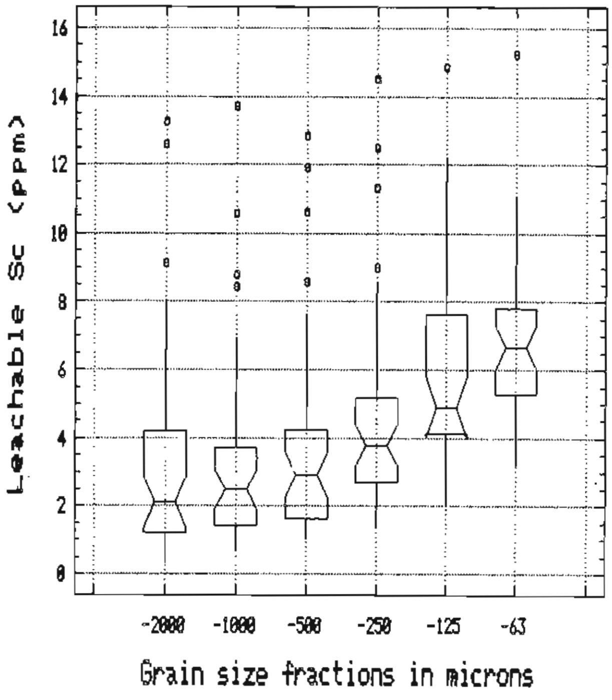


Fig. 19a. Total Sr content in grain size fractions of overbank sediment

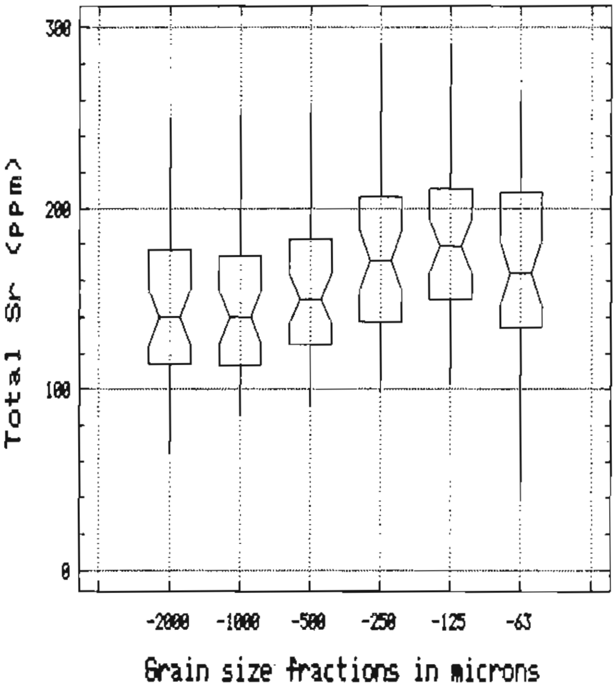


Fig. 19b. Leachable Sr content in grain size fractions of overbank sediment

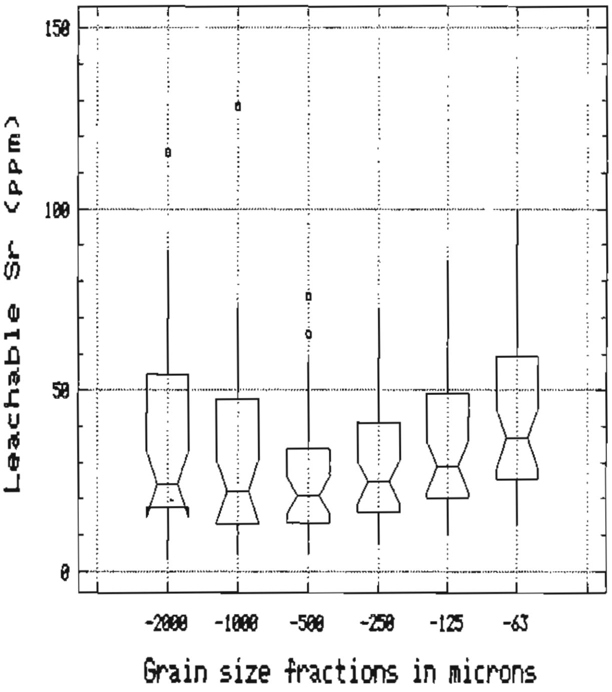


Fig. 19c. Total Sr content in grain size fractions of stream sediment

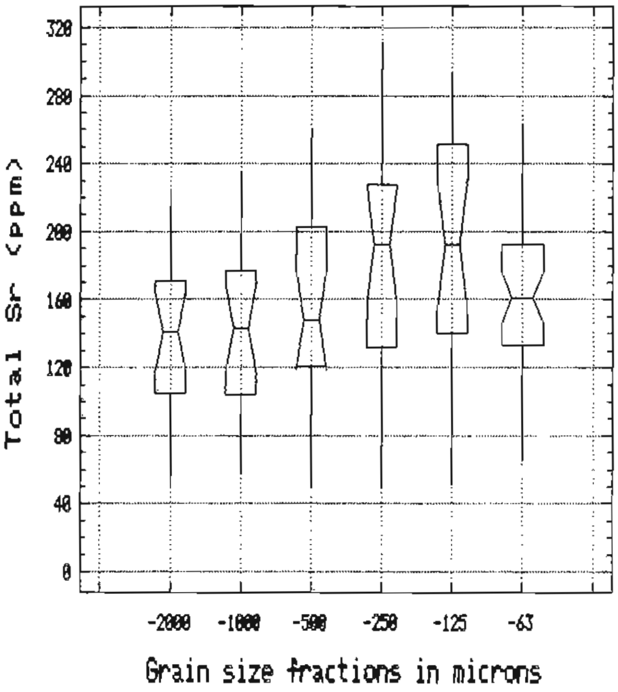


Fig. 19d. Leachable Sr content in grain size fractions of stream sediment

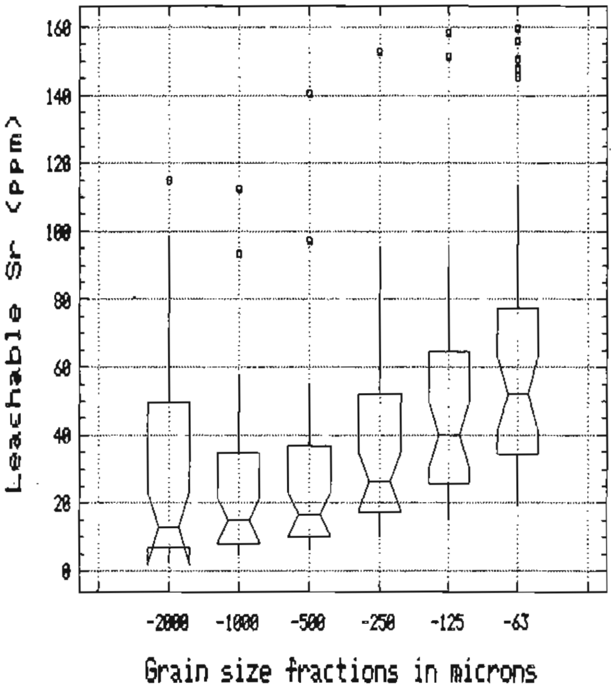


Fig. 20a. Total Ti content in grain size fractions of overbank sediment

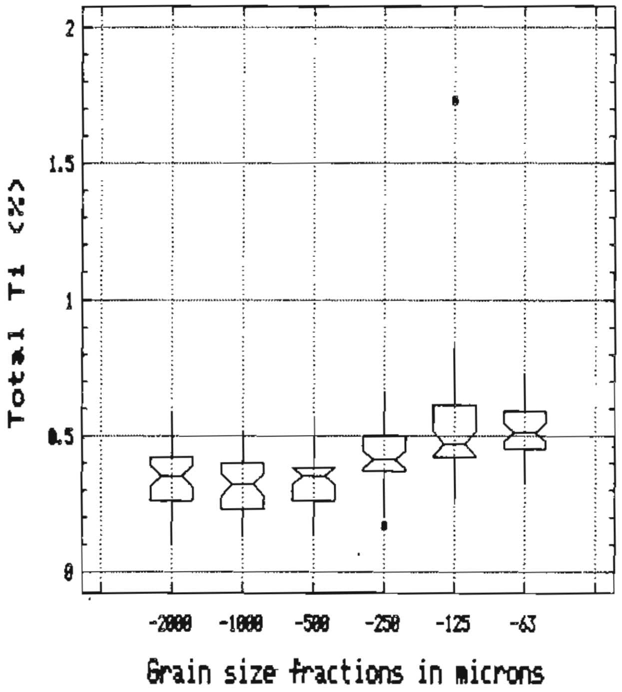


Fig. 20b. Leachable Ti content in grain size fractions of overbank sediment

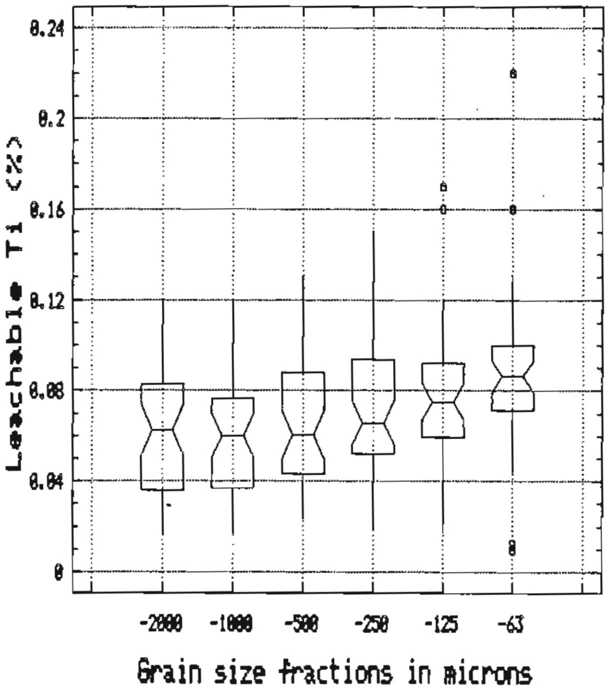


Fig. 20c. Total Ti content in grain size fractions of stream sediment

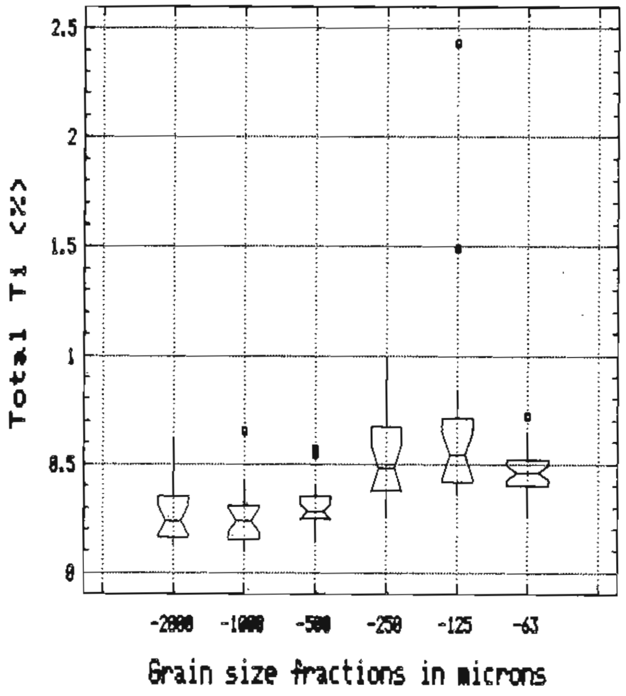


Fig. 20d. Leachable Ti content in grain size fractions of stream sediment

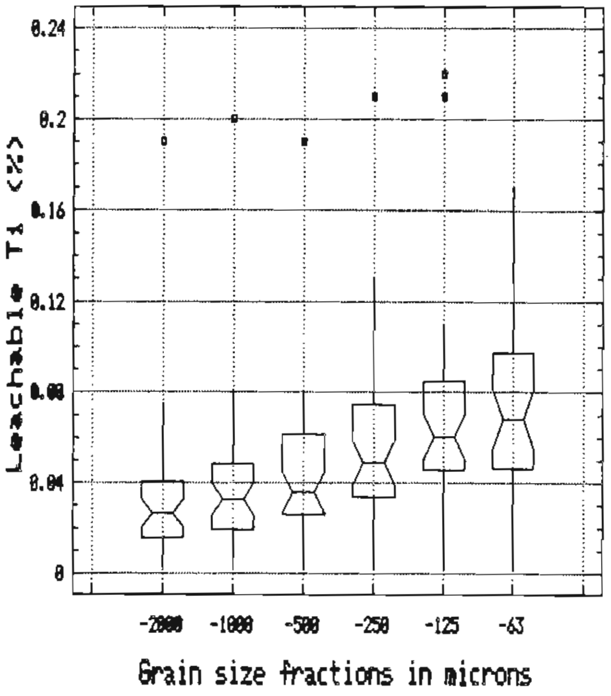


Fig. 21a. Total V content in grain size fractions of overbank sediment

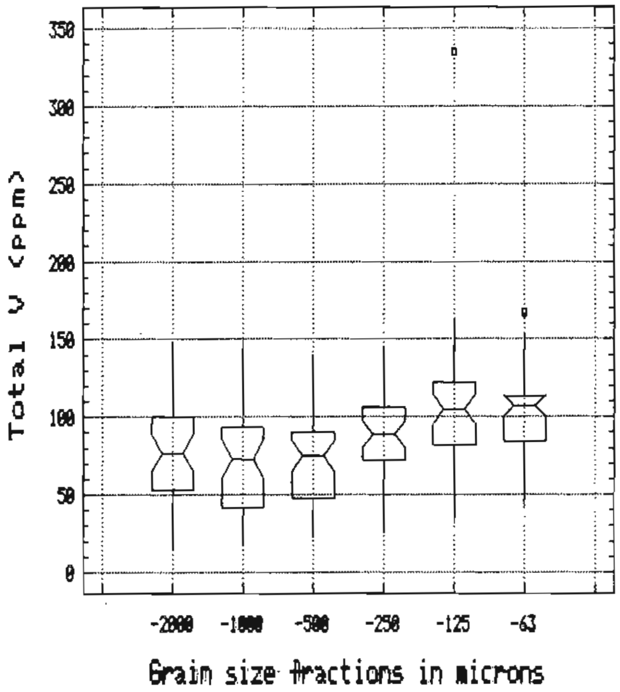


Fig. 21b. Leachable V content in grain size fractions of overbank sediment

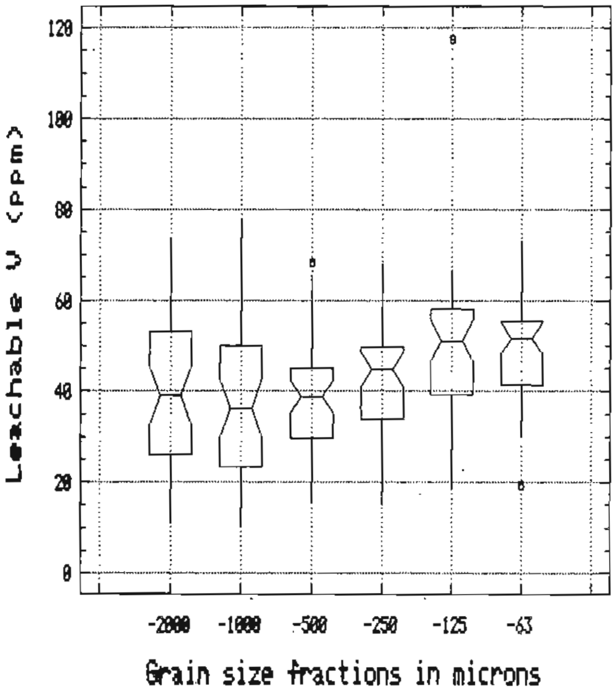


Fig. 21c. Total V content in grain size fractions of stream sediment

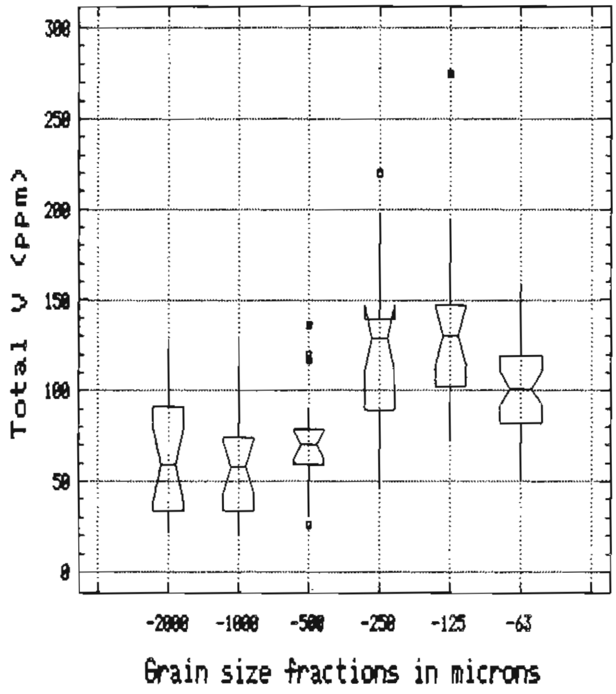


Fig. 21d. Leachable V content in grain size fractions of stream sediment

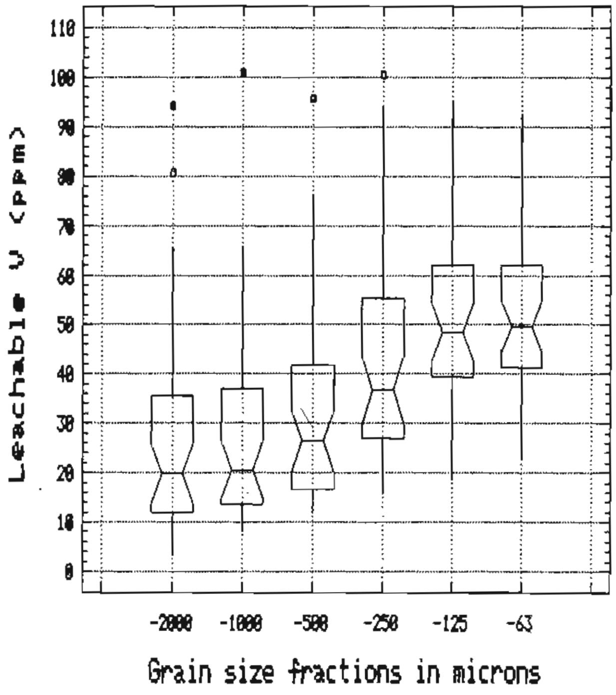


Fig. 22a. Total Zn content in grain size fractions of overbank sediment

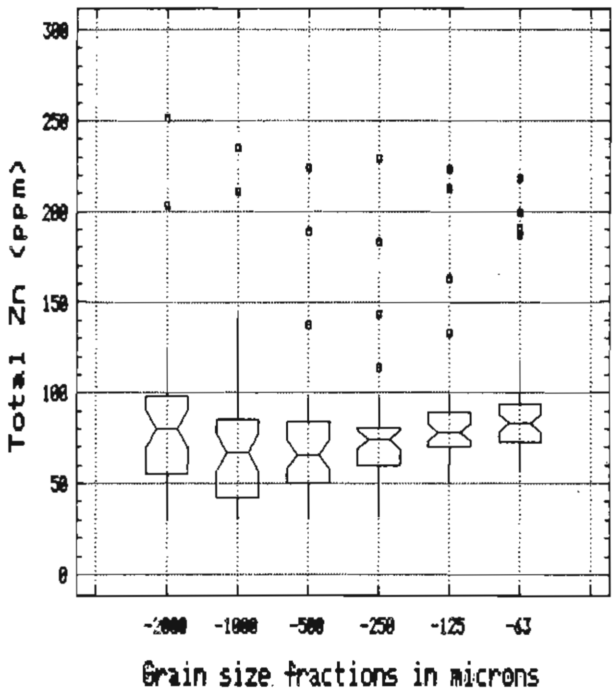


Fig. 22b. Leachable Zn content in grain size fractions of overbank sediment

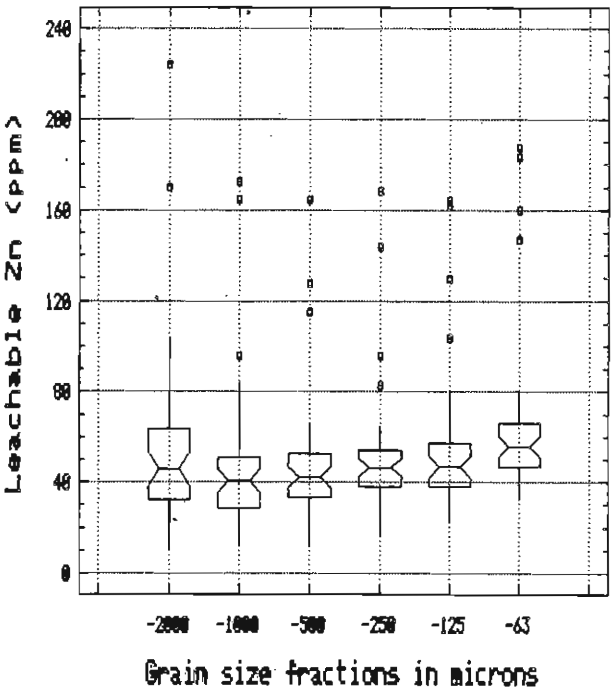


Fig. 22c. Total Zn content in grain size fractions of stream sediment

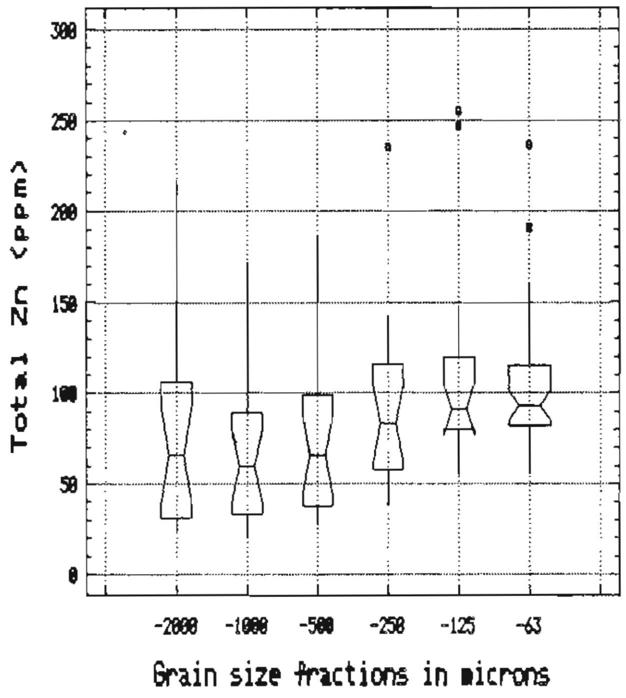


Fig. 22d. Leachable Zn content in grain size fractions of stream sediment

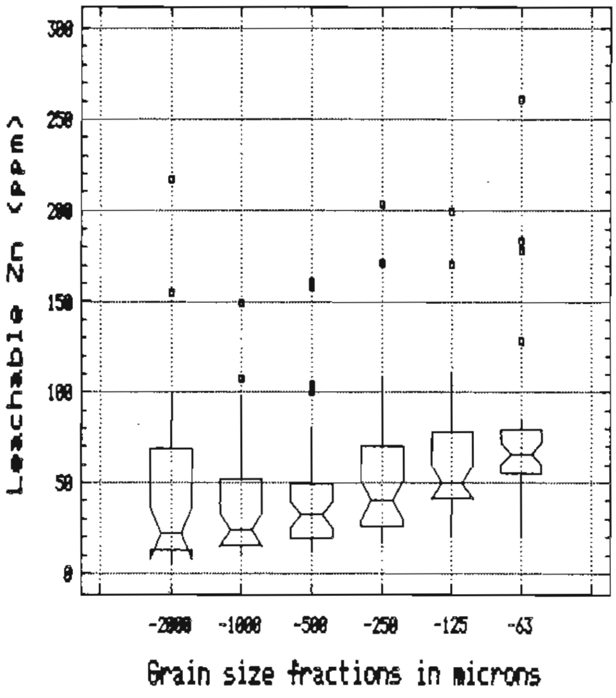


Fig. 23c. Leachable Ag content in grain size fractions of overbank sediment

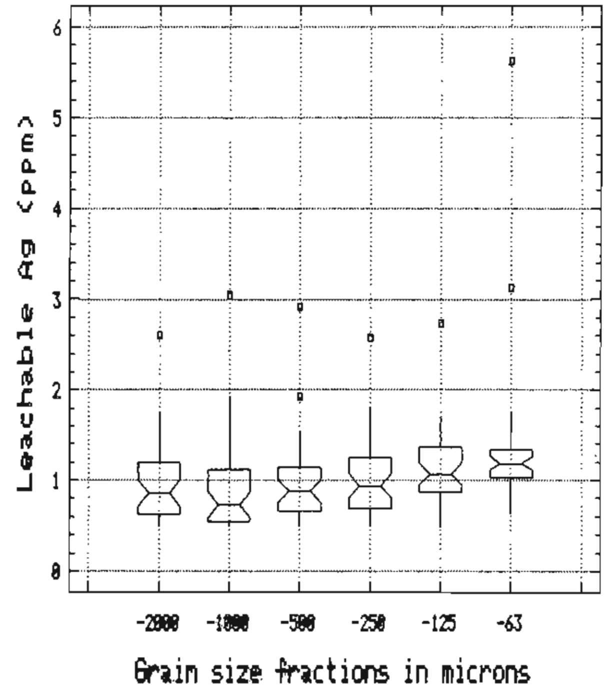


Fig. 23d. Leachable Ag content in grain size fractions of stream sediment

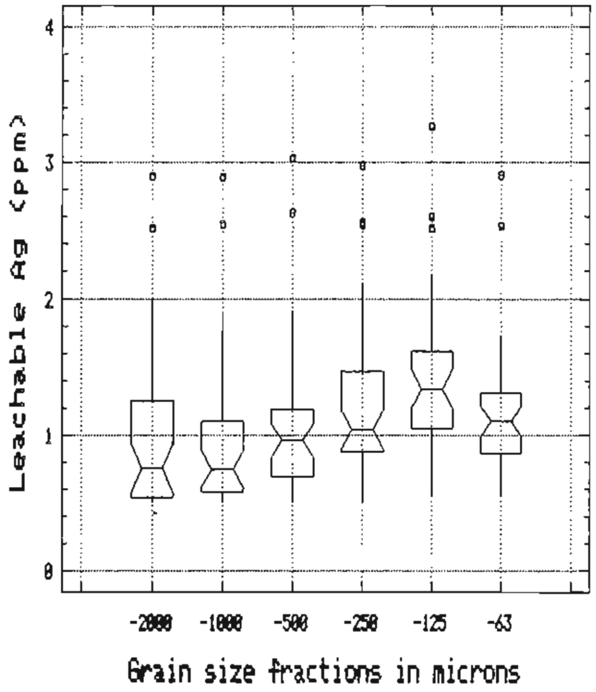


Fig. 24c. Leachable B content in grain size fractions of overbank sediment

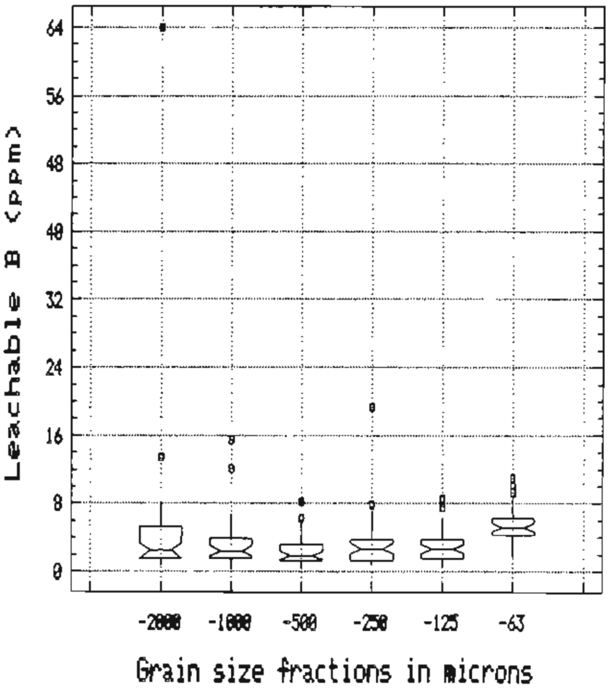


Fig. 24d. Leachable B content in grain size fractions of stream sediment

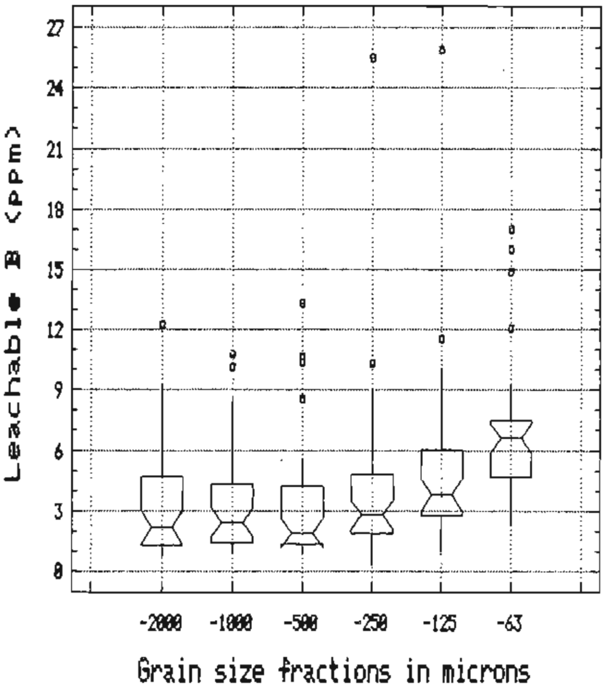


Fig. 25c. Leachable Ce content in grain size fractions of overbank sediment

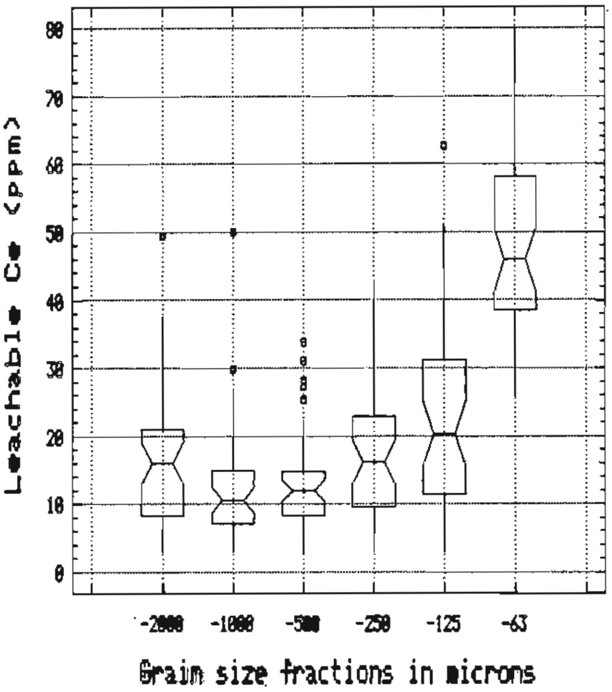


Fig. 25d. Leachable Ce content in grain size fractions of stream sediment

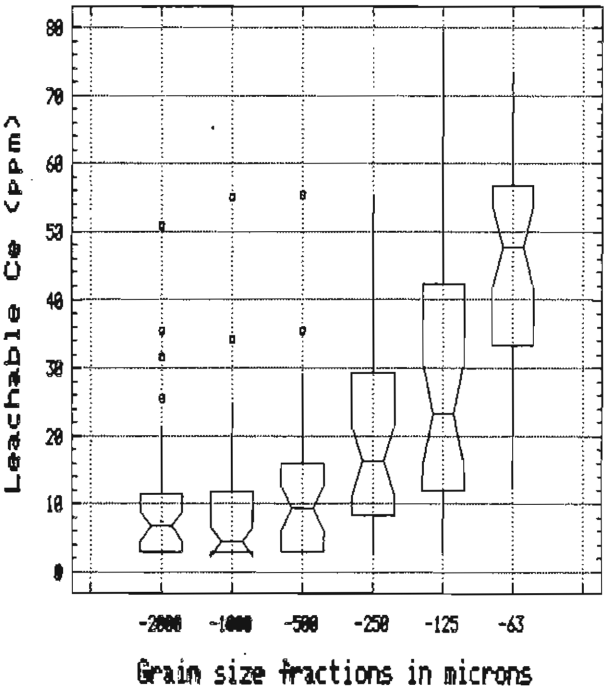


Fig. 26c. Leachable K content in grain size fractions of overbank sediment

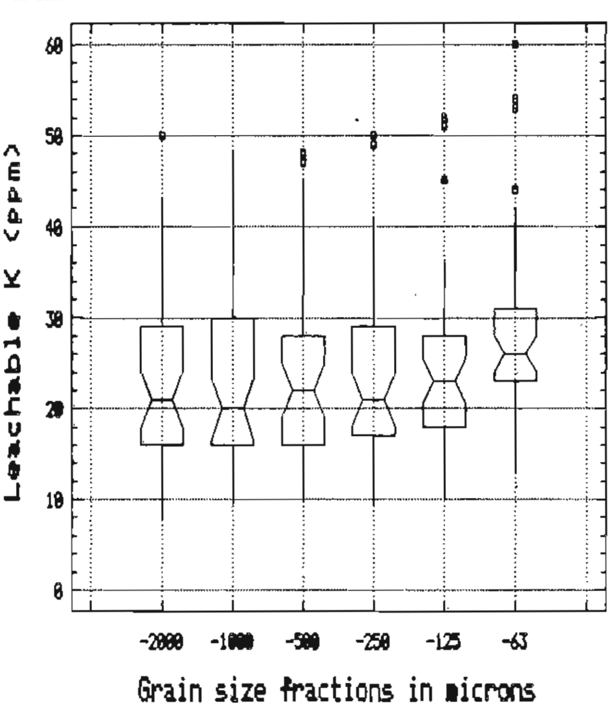


Fig. 26d. Leachable K content in grain size fractions of stream sediment

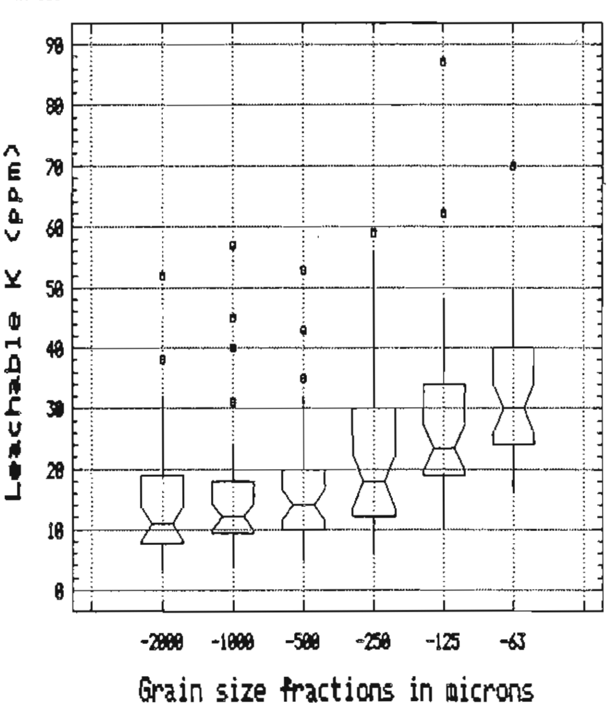


Fig. 27c. Leachable La content in grain size fractions of overbank sediment

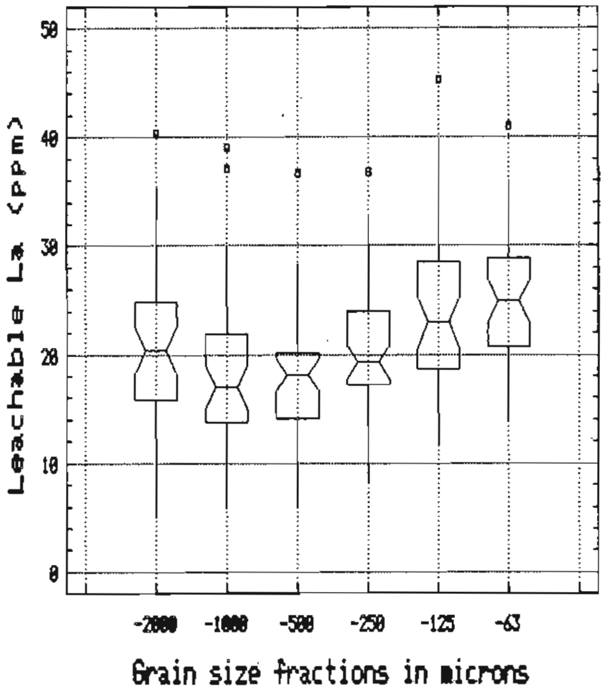


Fig. 27d. Leachable La content in grain size fractions of stream sediment

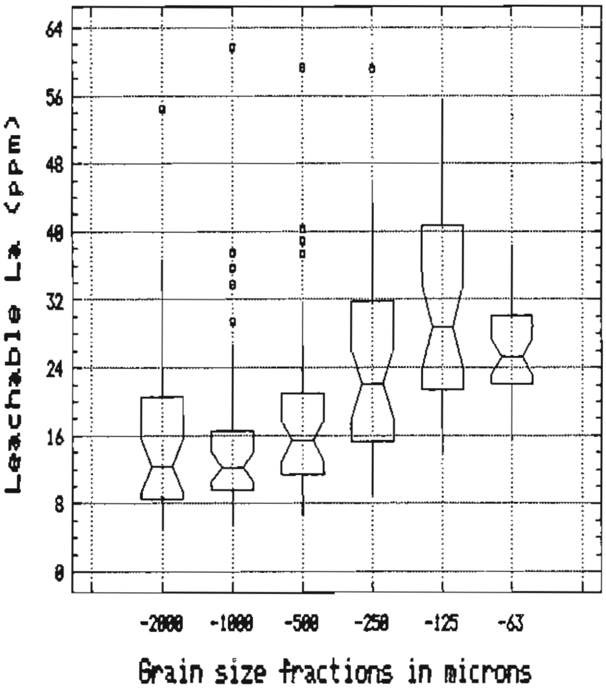


Fig. 28c. Leachable Mg content in grain size fractions of overbank sediment

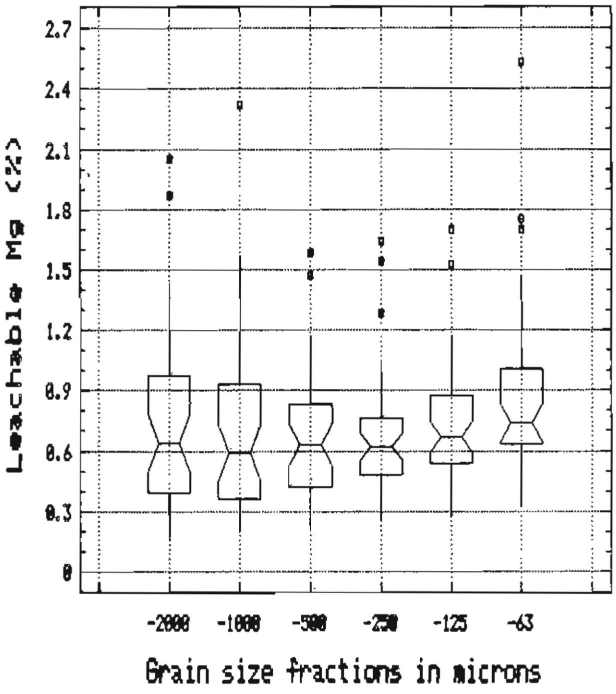


Fig. 28d. Leachable Mg content in grain size fractions of stream sediment

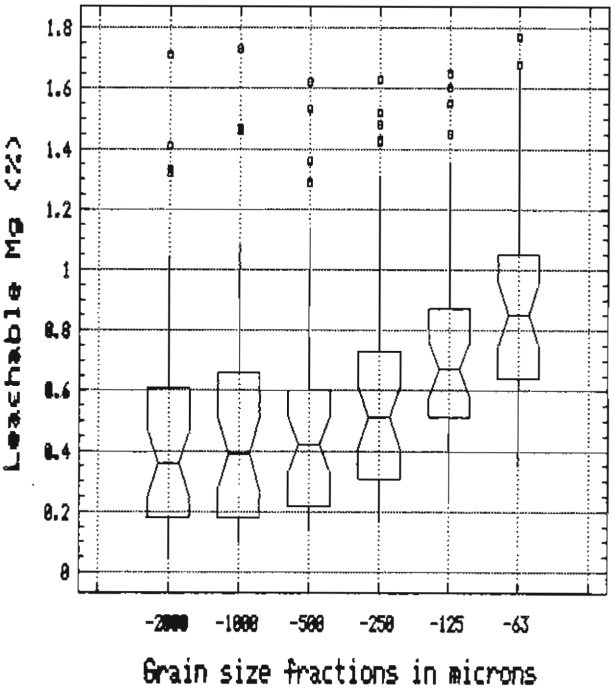


Fig. 29c. Leachable Na content in grain size fractions of overbank sediment

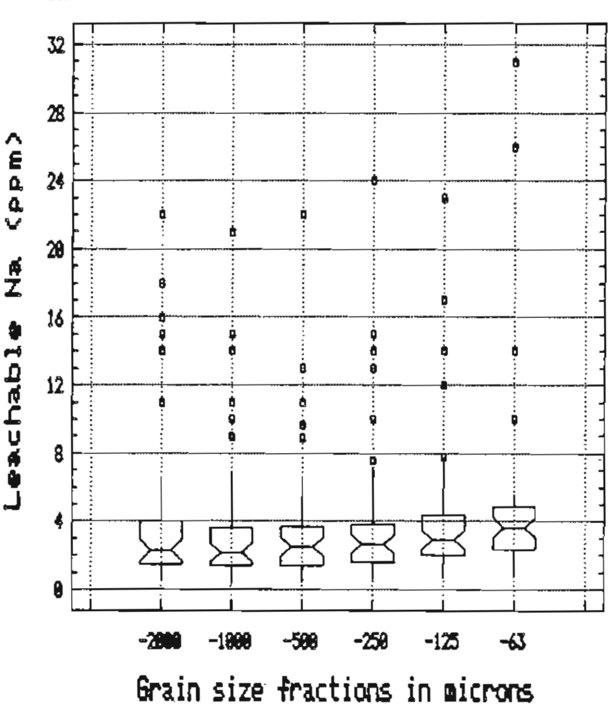


Fig. 29d. Leachable Na content in grain size fractions of stream sediment

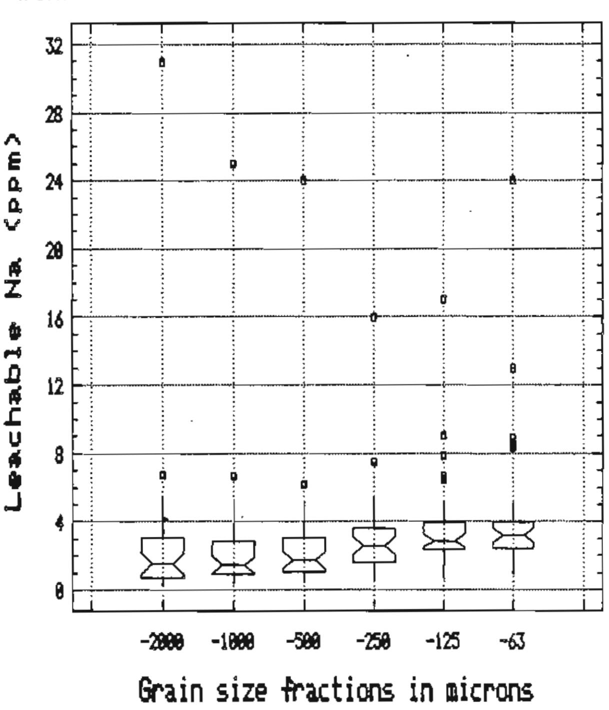


Fig. 30c. Leachable P content in grain size fractions of overbank sediment

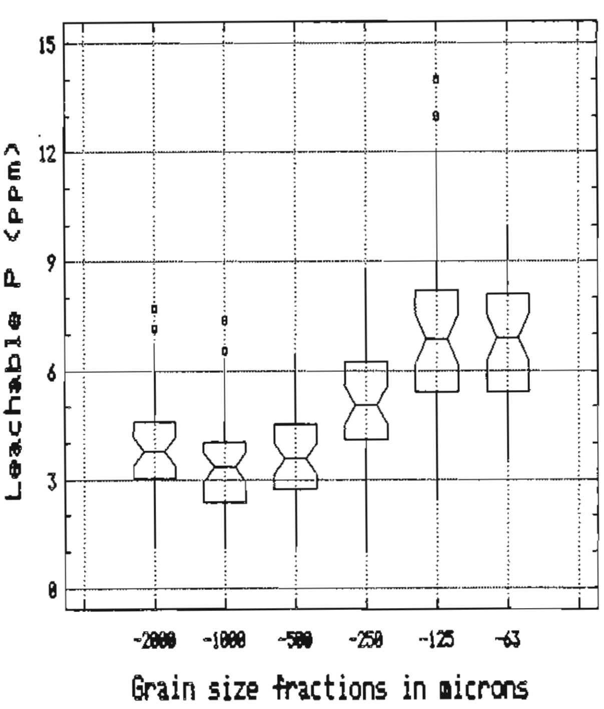


Fig. 30d. Leachable P content in grain size fractions of stream sediment

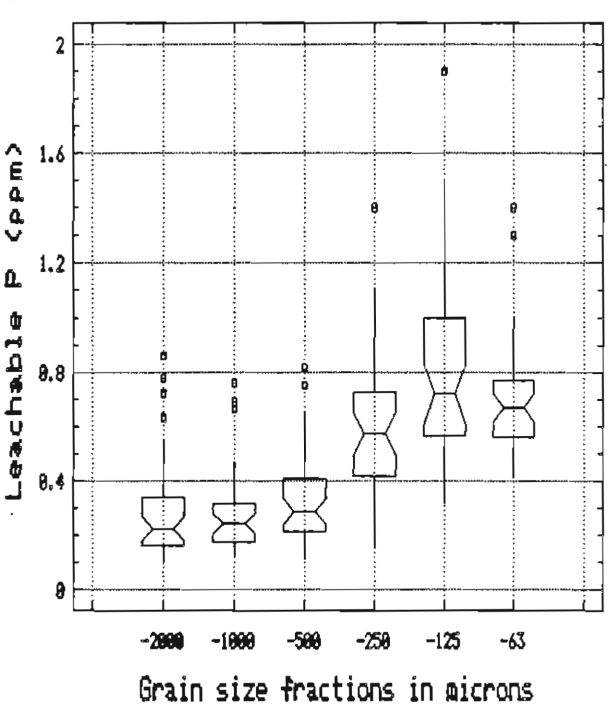


Fig. 31c. Leachable Si content in grain size fractions of overbank sediment

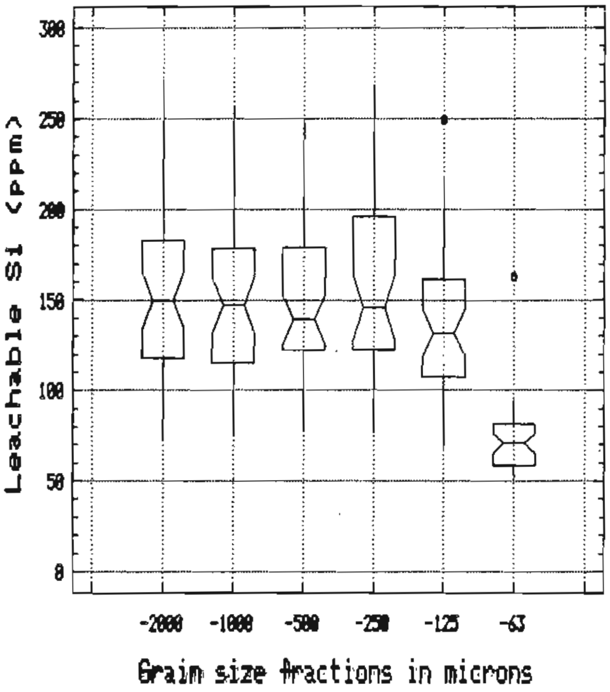


Fig. 31d. Leachable Si content in grain size fractions of stream sediment

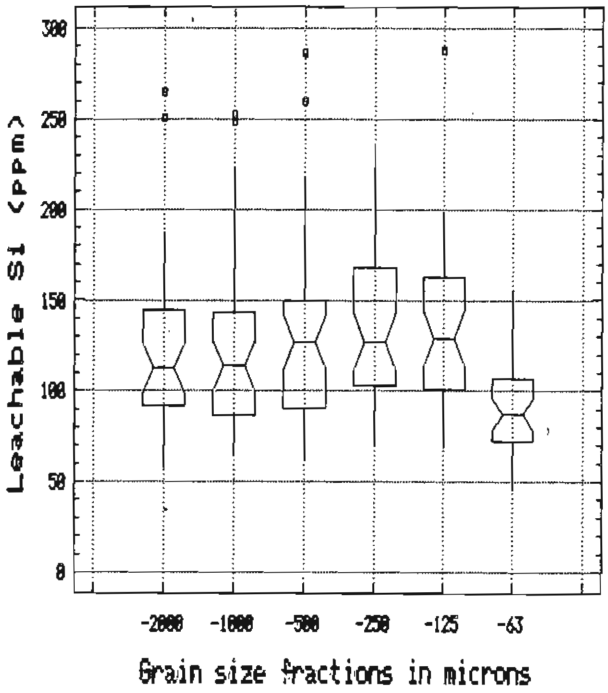


Fig. 32a. Total Y content in grain size fractions of overbank sediment

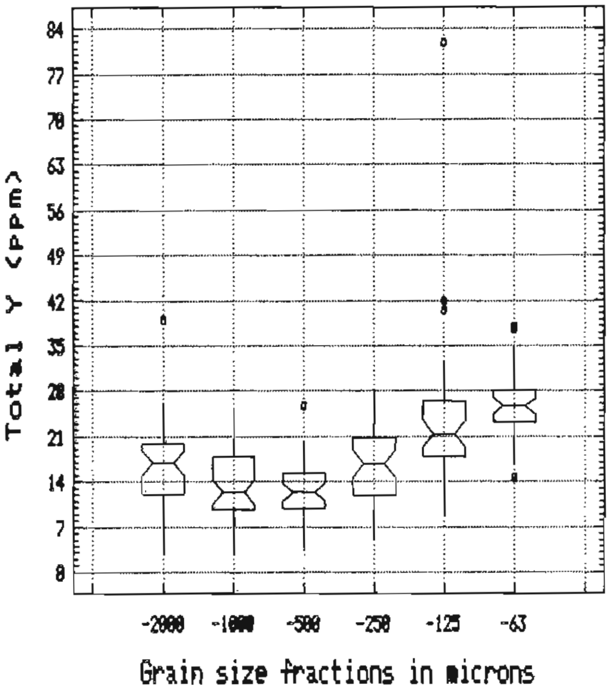


Fig. 32c. Total Y content in grain size fractions of stream sediment

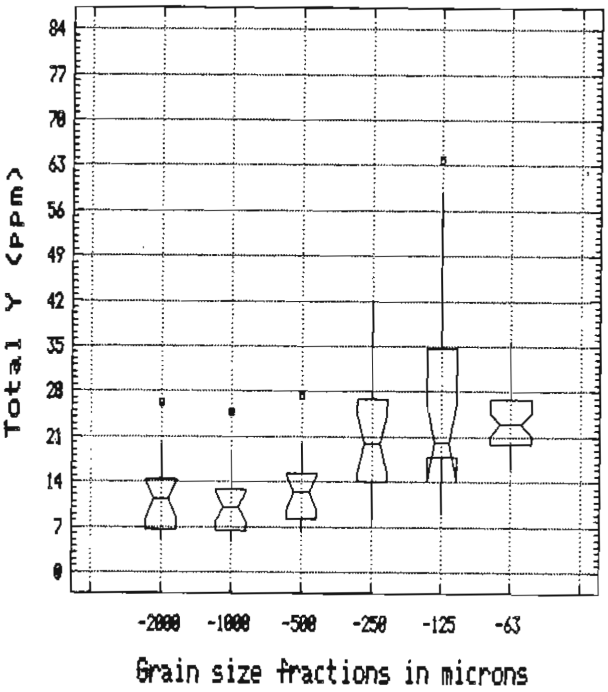


Fig. 33c. Leachable Zr content in grain size fractions of overbank sediment

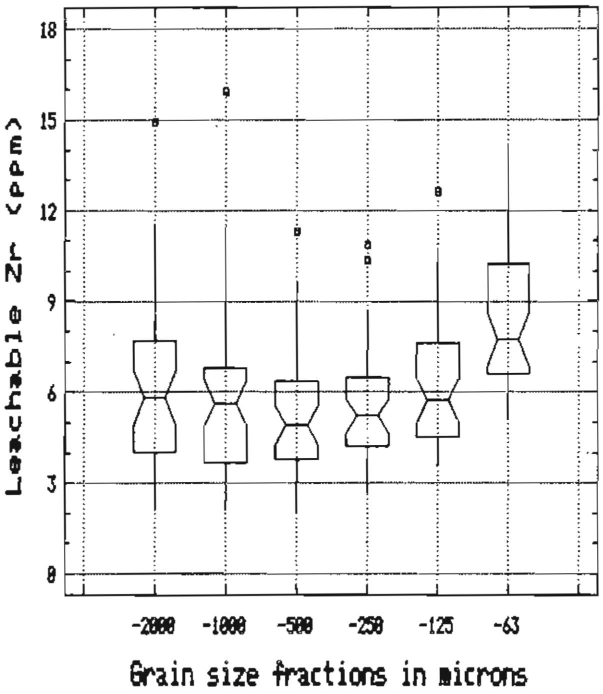
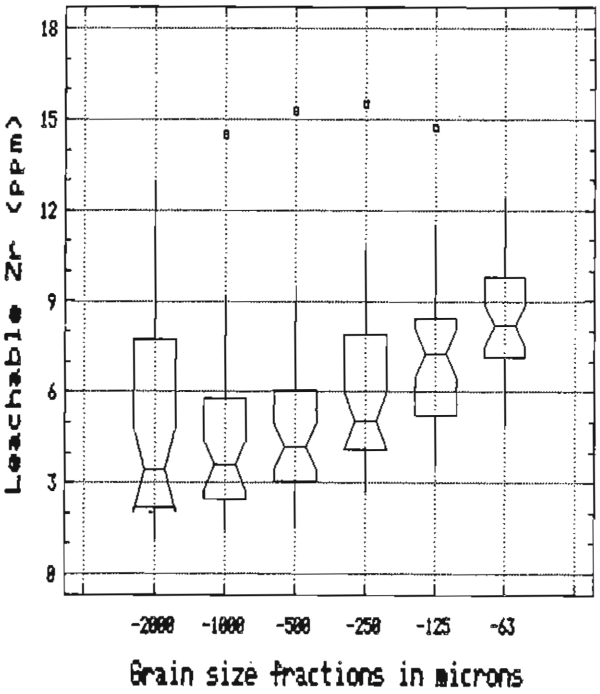


Fig. 33d. Leachable Zr content in grain size fractions of stream sediment



WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 6.3

DISTRIBUTION OF ELEMENTS IN DIFFERENT GRAIN SIZE FRACTIONS, SPAIN

Juan LOCUTURA and Enrique LOPEZ PAMO

I.T.G.E., Spain

1990

CONTENTS

1.0. INTRODUCTION

The main objectives of this work were the study of the

- grain size distribution of overbank sediment and, especially, the abundance of the -0.063 mm fraction, and
- vertical variation of elements in different grain size fractions.

2.0. STUDY AREAS

Two areas covering different morphoclimatic, geological and industrial environments have been chosen for sampling (Fig. 1).

2.1. Southern border of the Sierra de Guadarrama Mountains, Madrid (refer to Appendix report 5.8 for figures)

The Sierra de Guadarrama is a mountainous massif made up from granitic and medium to high grade metamorphic rocks (migmatite, gneiss). At its southern side, besides a narrow outcrop of Cretaceous age limestone, there is a wide Miocene basin, filled by arenaceous materials (conglomerate and sand) derived from the Palaeozoic rocks after their uplift in early Tertiary times.

Many mineralized showings of little economic significance occur in both the metamorphic and granitic terrains. It is worth mentioning the small quartz veins with Sn-W and W-As, which are closely related to peraluminous granite, and thin Sn-W placers.

2.2. Western border of the Sierra de la Demanda Mountain (refer to Appendix report 7.3 for figures)

The sampled rivers flow through a Miocene Basin, next to the mountains of the Sierra de la Demanda, where they have their source. The central part of these mountains is made up from Palaeozoic materials (schist, greywacke and sandstone), and the periphery from Triassic sedimentary rocks of continental red facies (conglomerate, sandstone and clay) and limestone of Jurassic to Cretaceous age.

Vein type Pb-Zn-Ag, Cu-Ag or Sb mineralization is known to occur in the Palaeozoic rocks, and was mined about forty years ago.

The overbank sediment is well developed in the river basins over the argillaceous Miocence basin (>1.20 m), but is less developed over the Palaeozoic formations (20-40 cms in thickness).

3.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

3.1. Sampling

Overbank sediment samples, each weighing between 5 and 15 kgs were taken over the total thickness of the profile at 20 cms intervals (except the top first 10 cms). The overbank sediment section was cleaned prior to sampling.

3.1.1. Southern border of Sierra de Guadarrama, Madrid

Ten sample sites were selected in the Jarama and Manzanares rivers, which drain the granitic and metamorphic terrain of Sierra de Guadarrama and the Miocene sedimentary basin.

3.1.2. Sierra de la Demanda area

Three sample sites (1, 2 and 3) were chosen from third or fourth order rivers coming from the mountain range of Sierra de la Demanda.

3.2. Sample preparation

All the samples (overbank and stream sediment) were dried in an oven at a temperature of 40-45°C. The dried samples were disaggregated in a porcelain mortar, and afterwards sieved through different nylon screens (0.063, 0.125, 0.250, 0.500, 1 and 2 mm) obtaining, therefore, 7 grain size fractions, i.e.,

+2.000 mm
-2.000 +1.000 mm
-1.000 +0.500 mm
-0.500 +0.250 mm
-0.250 +0.125 mm
-0.125 +0.063 mm
-0.063 mm

All grain size fractions were homogenized, and subsamples of over 0.063 mm were ground in porcelain mortar till the whole material pass through a 0.063 mm nylon screen.

3.3. Analytical methods

The total element contents were determined on the -0.063 mm fraction by the Analytical Service of the I.T.G.E., whereas N.G.U. has undertaken to analyse all the samples for hot nitric and water soluble elements. The latter analyses are not yet available.

The total element contents were determined on all the grain size fractions of the samples, i.e., the natural -0.063 mm component, and the ground -0.063 mm material of the coarser size fractions.

The sample was homogenized prior to the taking of a 1 gm aliquot for analysis. Major and trace elements were determined by ICP after hot digestion in a mixture of HNO_3, $HClO_4$ and HF acid.

Sn was determined by D.C.P. after a two stage attack on a 1 g subsample by Na_2O_2 at 45°C, and followed by a mixture of ClO_4H, and HF.

F was determined by colorimetric methods, and Au on a 50 g subsample by A.A. graphite furnace.

The lower detection limits of the elements are tabulated below (all values in ppm except Au in ppb):

Cu	Pb	Zn	Ni	Co	Cr	Ba	V	Y
5	5	5	5	5	5	5	5	5
Mn	As	Sb	Nb	W	Ag	Cd	Be	Mo
10	10	10	10	10	1	1	1	2
Fe	Al	Ca	K	Na	K	Mg	Ti	Li
20	20	20	20	20	20	20	20	50
Sn	F	Au						
10	200	5						

The concentrations in Au, Cd, Nb, Sb, As and to a lesser extent Co were in all the samples below the lower detection limit. Therefore, these results were not considered in this study.

4.0. DATA PRESENTATION

The data are presented essentially in graphical form, i.e., in cumulative plots of weight and in cumulative weight % plots, both plotted against sample depth, and plots of element contents versus grain size fractions.

5.0. DISCUSSION

The grain size distribution analysis in overbank sediment shows that the -0.063 mm fraction is a minor component of the spanish overbank sediment samples, i.e., varying between 1 and 5% with an average of 2 to 3% (Figs. 2 to 11). This feature means that it would be necessary to take samples of at least 80 to 100 kgs to obtain the required 2 kg weight of the -0.063 mm fraction. This would cause severe problems of economic and logistic character during the routine sampling in Spain.

The -0.125+0.063 mm fraction is comparatively more abundant (Figs. 2 to 11). Therefore, the selection of the -0.125 mm grain size fraction would reduce enormously the above problems.

The element distribution in the different grain size fractions shows that the -0.063 mm fraction is the most suitable, though coarser fractions show similar minor element contents (Figs. 12 to 18). A little dilution is expected in the -0.125+0.063 mm and -0.250+0.125 fractions. High element contents in the coarser fractions may be indicative of coatings or fragments of polluted materials.

6.0. CONCLUSION

The conclusion of this study is that it will be more practicable and cost effective if the -0.125 mm grain size fraction is selected for analysis and storage.

ACKNOWLEDGEMENTS

We thank S. del Barrio (ITGE) for the analysis of the samples, A. Olias (ITGE) for the delineation work, and M. Martinez for the preparation of the samples.

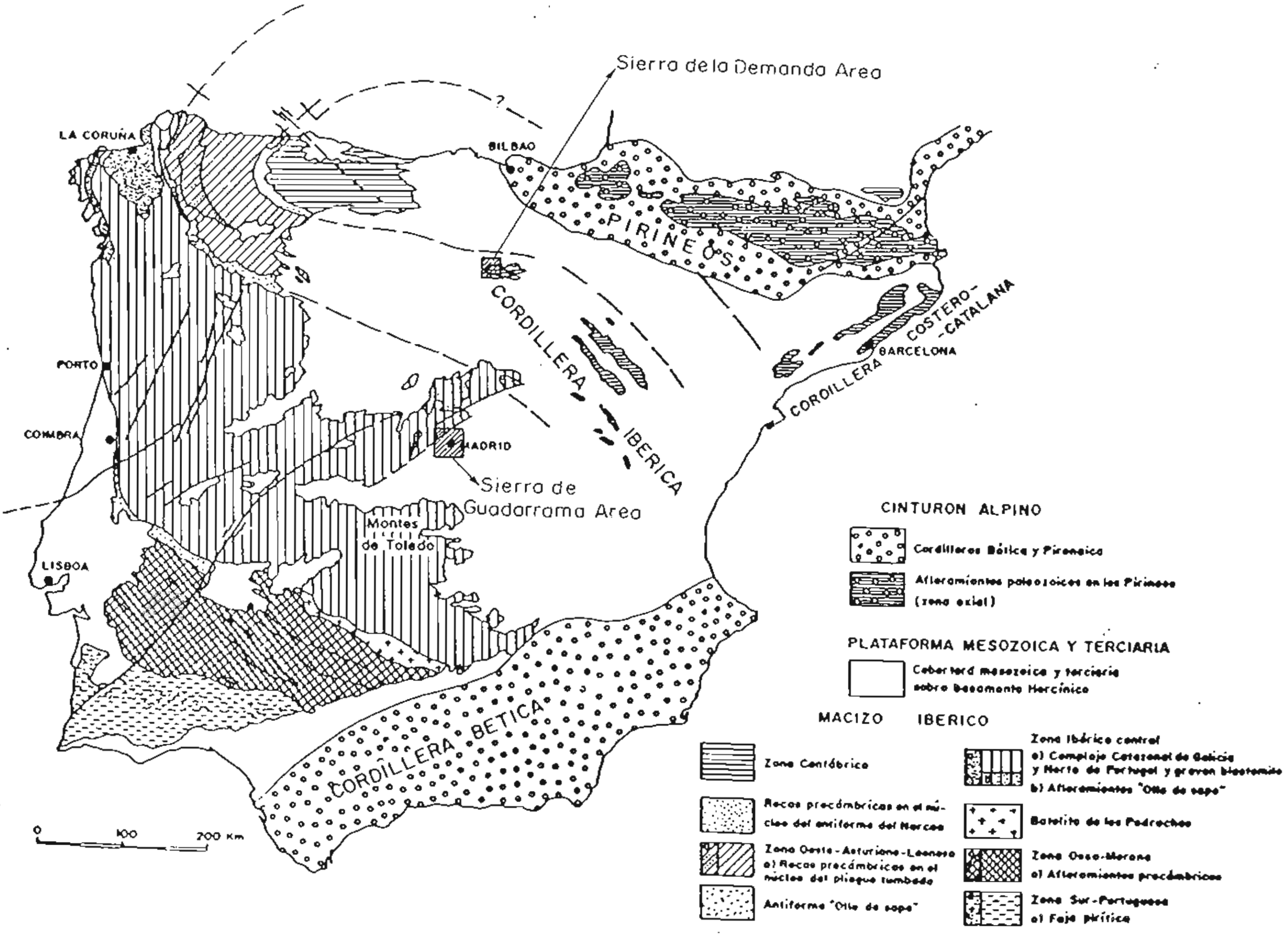
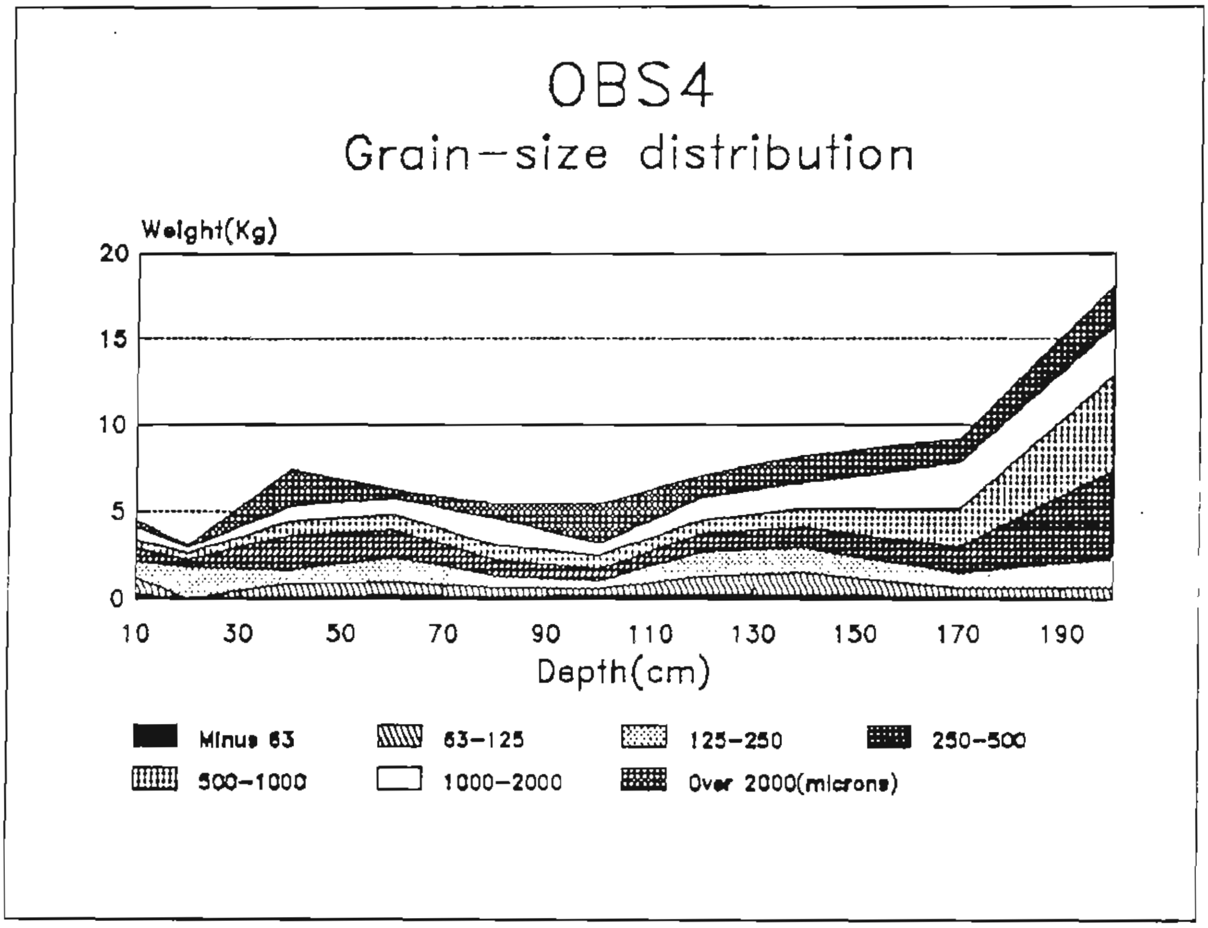


Fig. nº 1.- Sampling Areas


OBS4
Grain-size distribution
Weight(Kg)
20
15
10
5
0
10
30
50
70
90
110
130
150
170
190
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

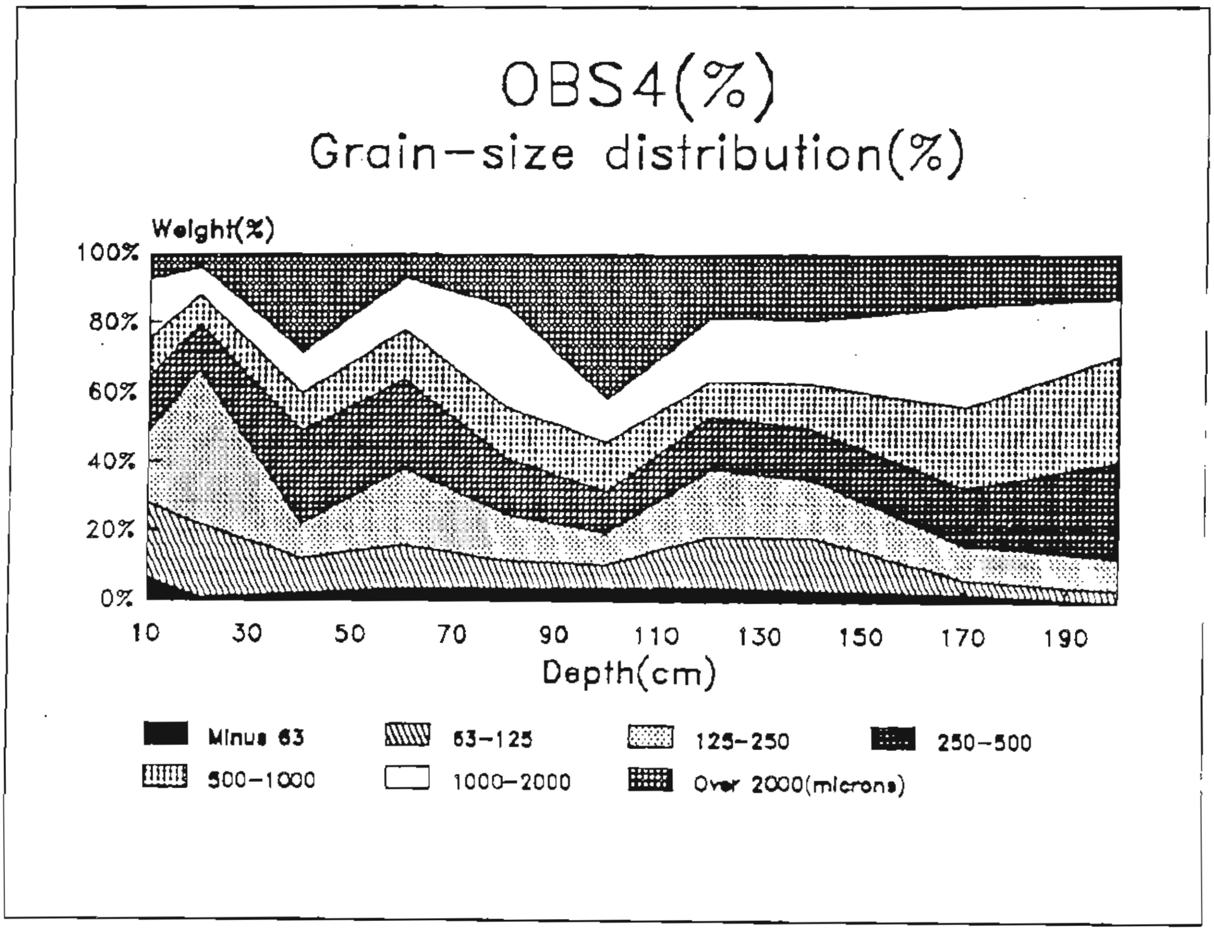
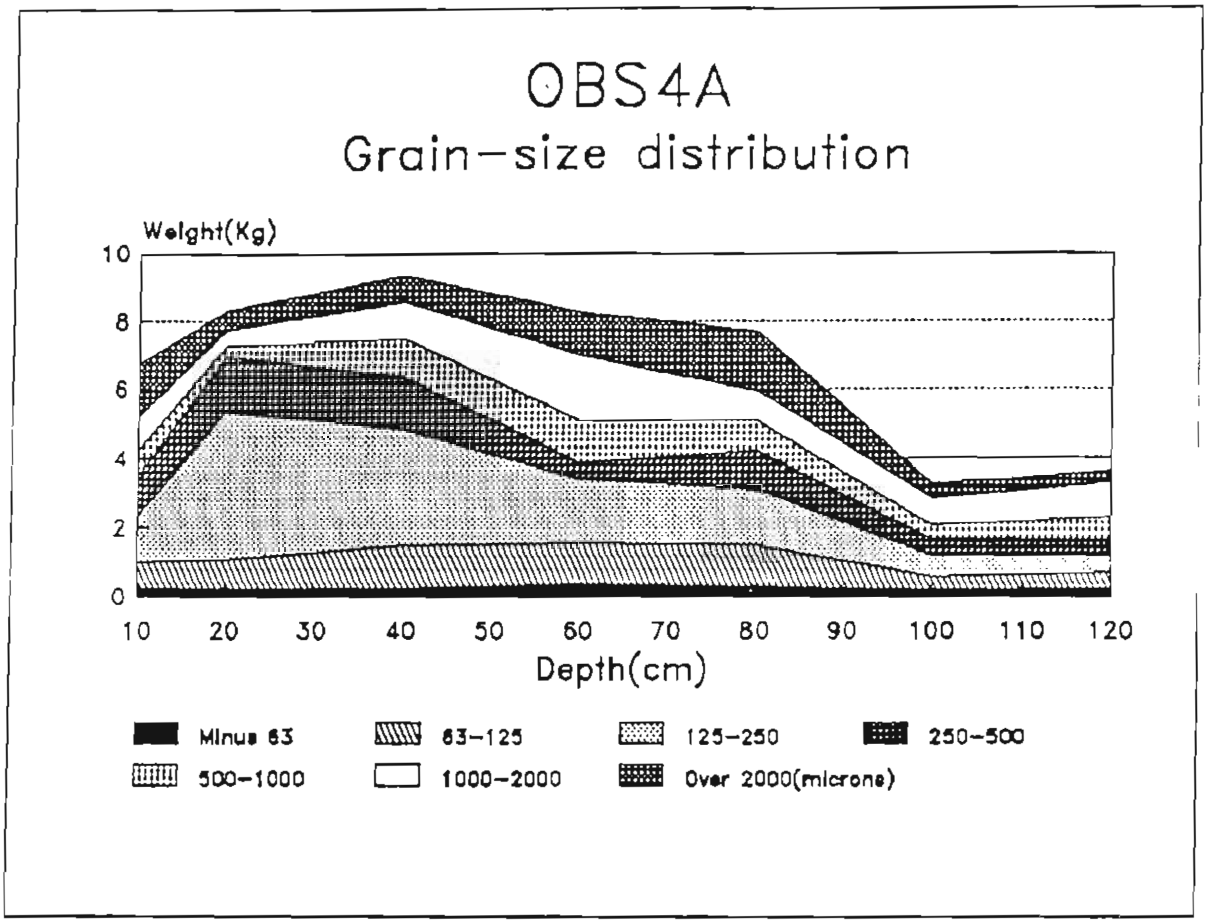

OBS4(%)
Grain-size distribution(%)
Weight(%)
100%
80%
60%
40%
20%
0%
10
30
50
70
90
110
130
150
170
190
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

Fig n° 11


OBS4A
Grain-size distribution
Weight(Kg)
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

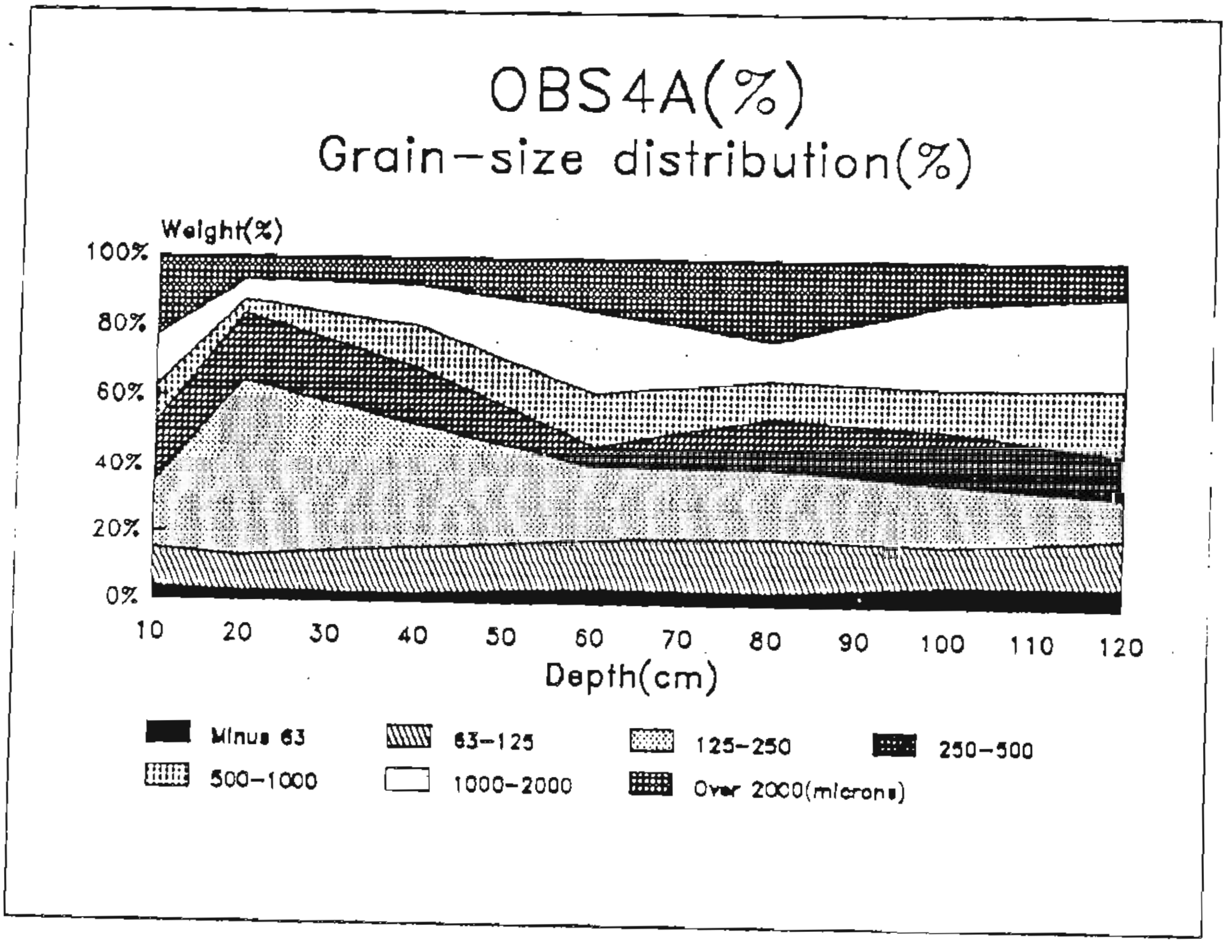
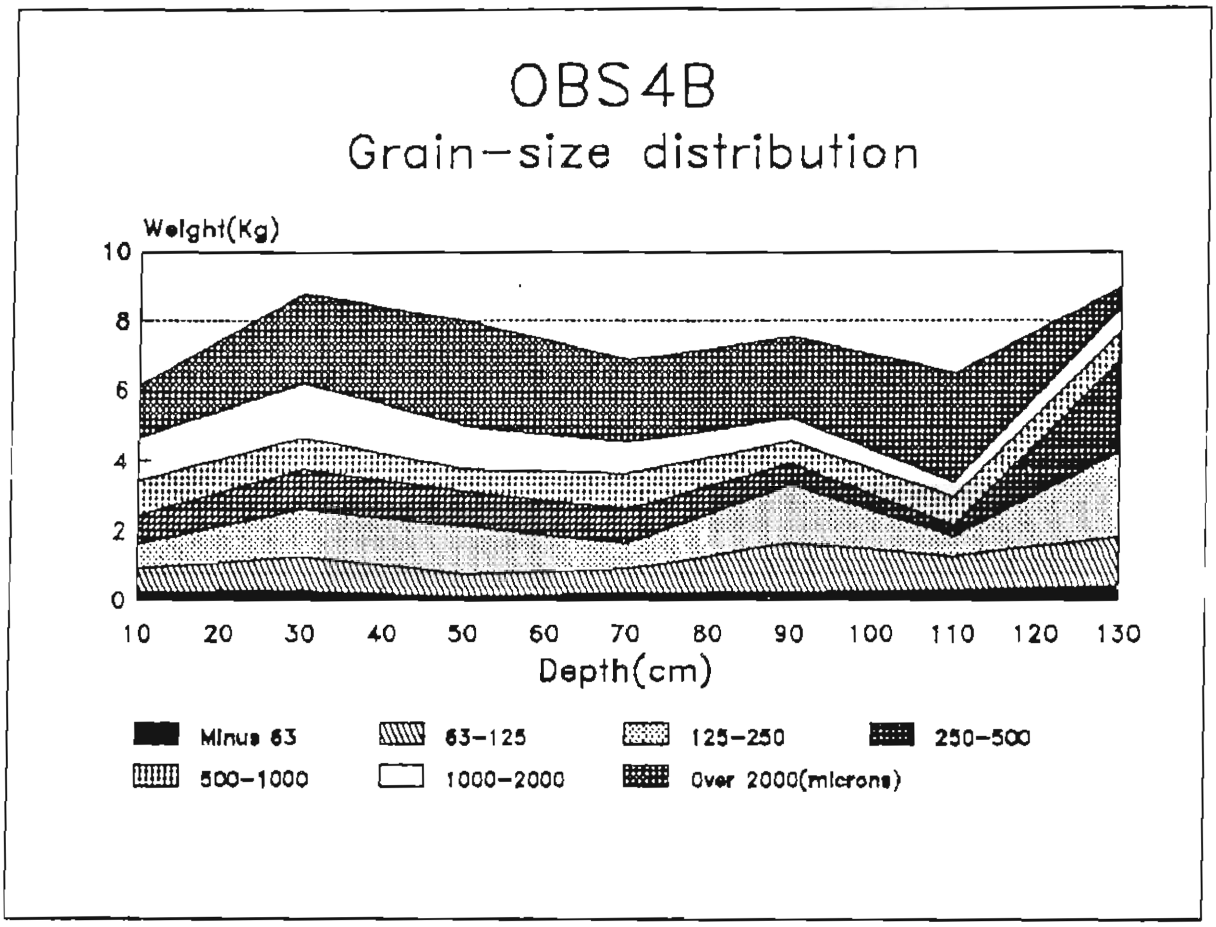

OBS4A(%)
Grain-size distribution(%)
Weight(%)
100%
80%
60%
40%
20%
0%
10
20
30
40
50
60
70
80
90
100
110
120
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

Fig n° 12


OBS4B
Grain-size distribution
Weight(Kg)
0
2
4
6
8
10
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

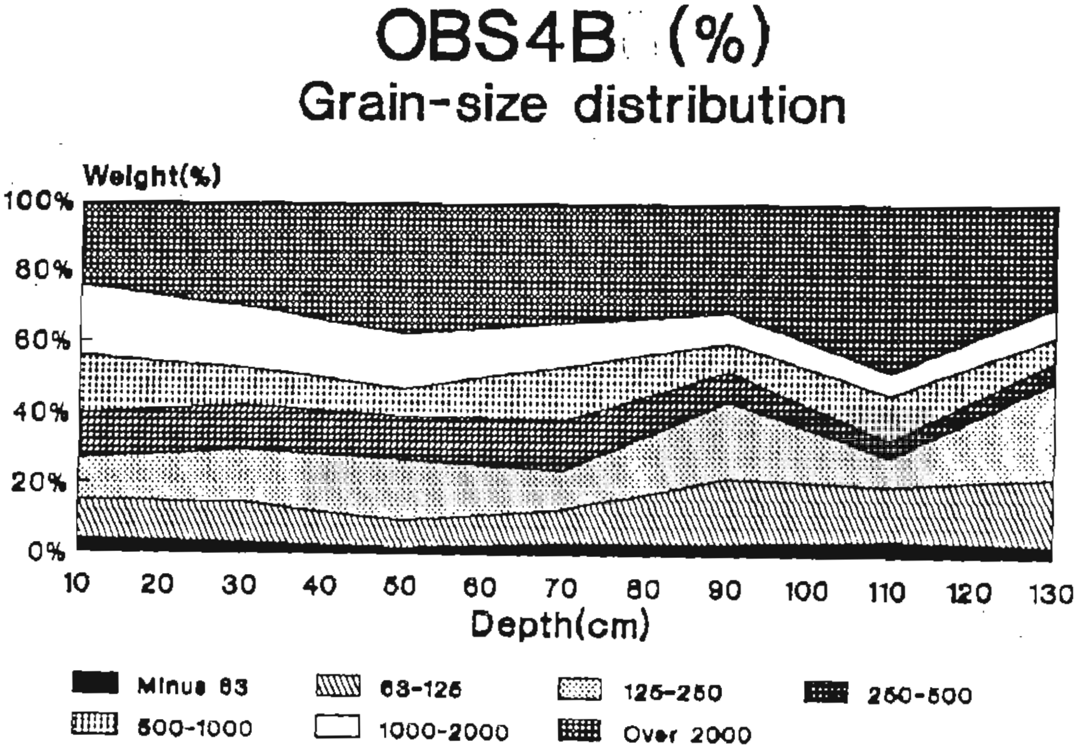
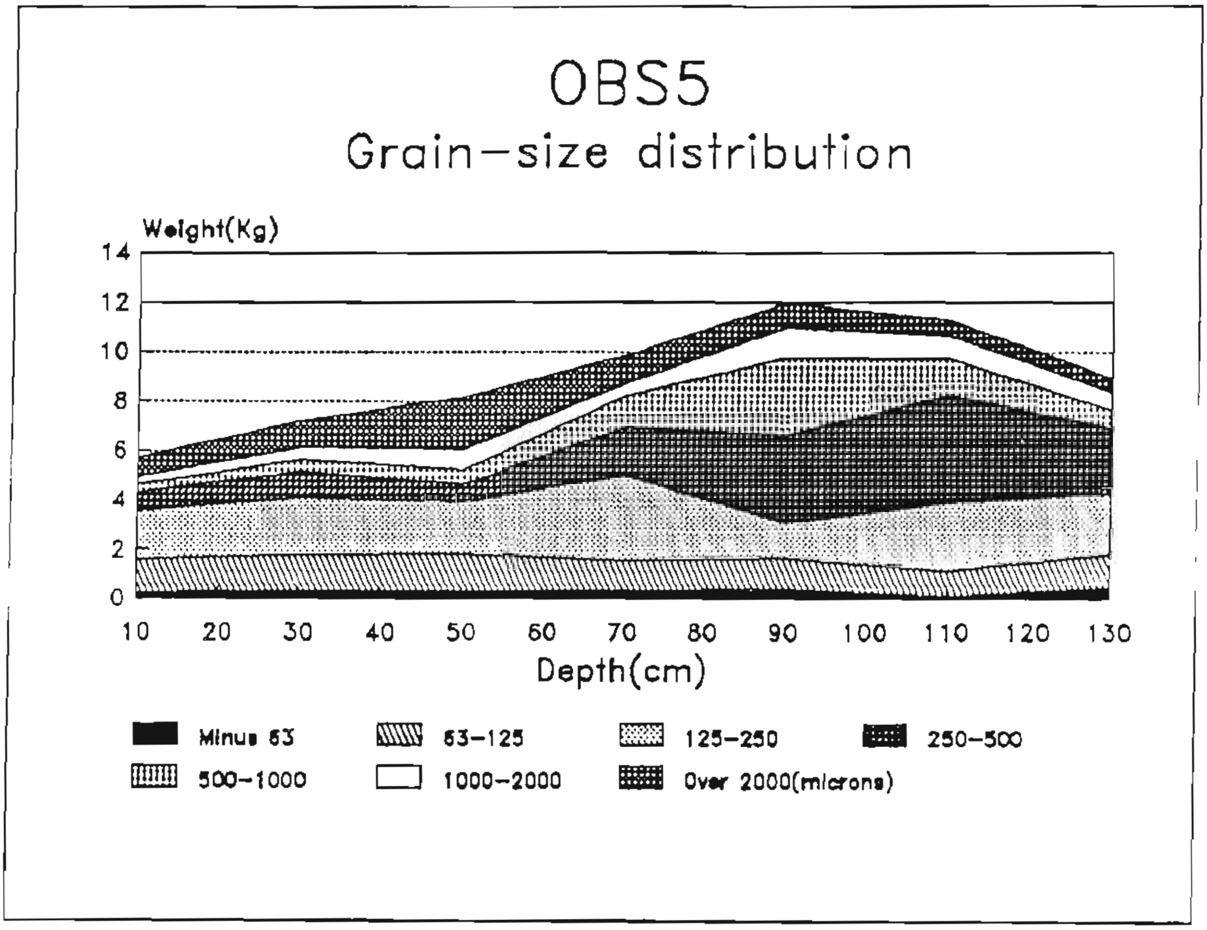

OBS4B (%)
Grain-size distribution
Weight(%)
0%
20%
40%
60%
80%
100%
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

Fig n° 13


OBS5
Grain-size distribution
Weight(Kg)
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

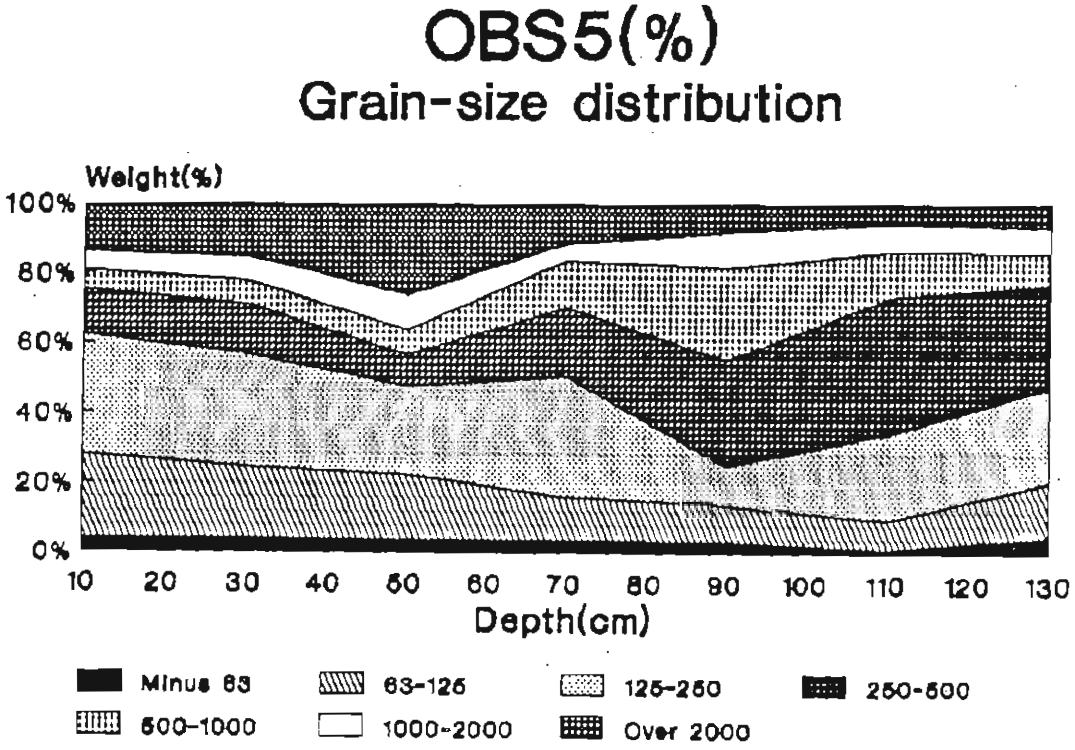
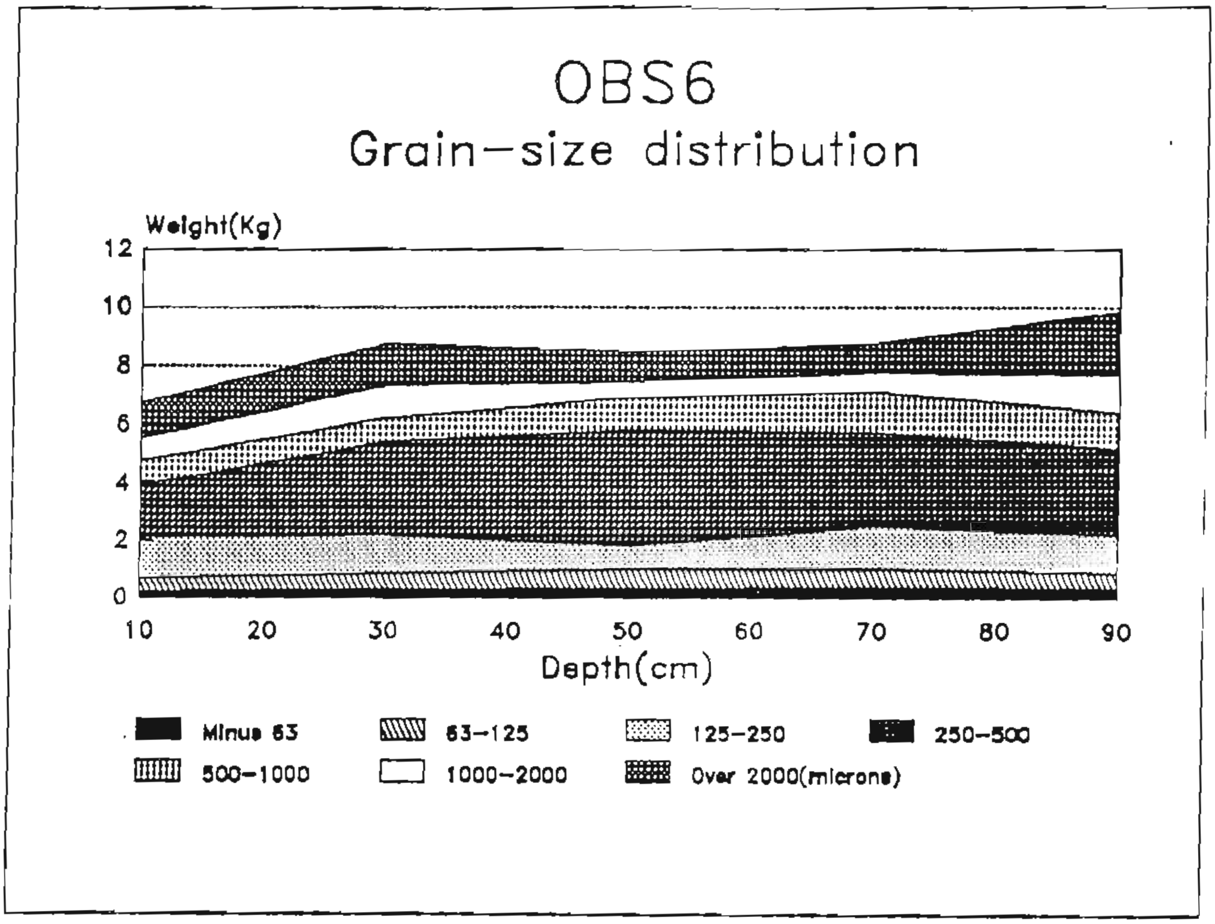

OBS5(%)
Grain-size distribution
Weight(%)
100%
80%
60%
40%
20%
0%
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

Fig n^{O} 14


OBS6
Grain-size distribution
Weight(Kg)
0
2
4
6
8
10
12
10
20
30
40
50
60
70
80
90
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

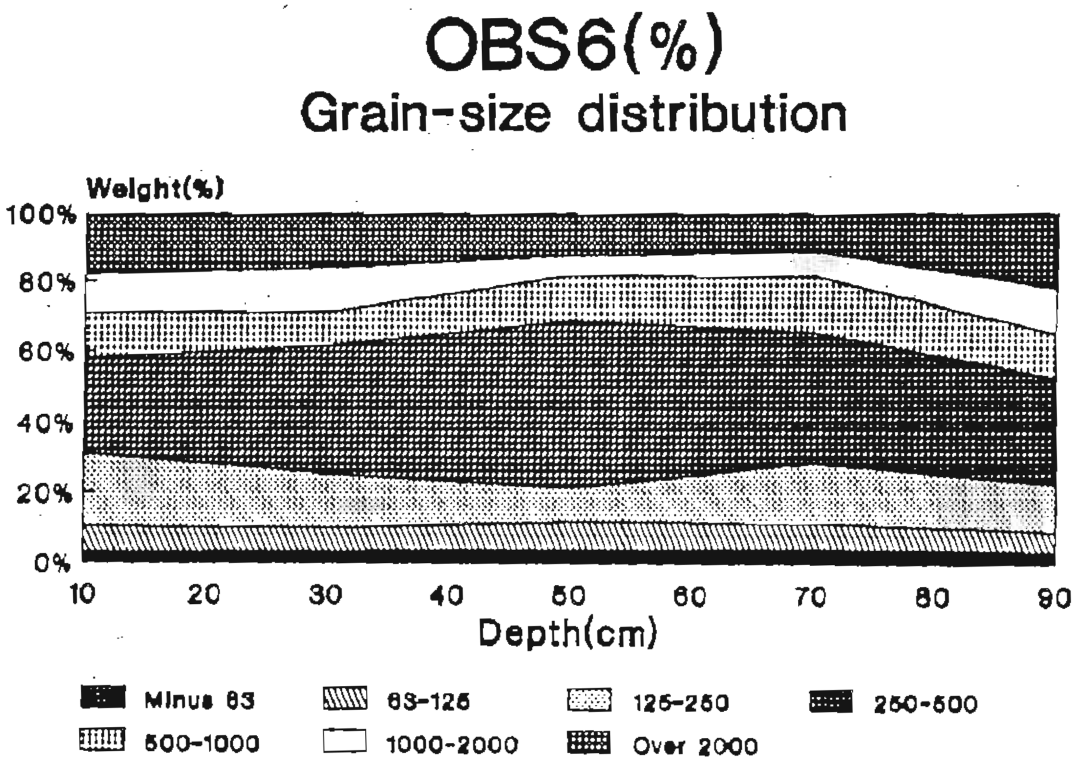
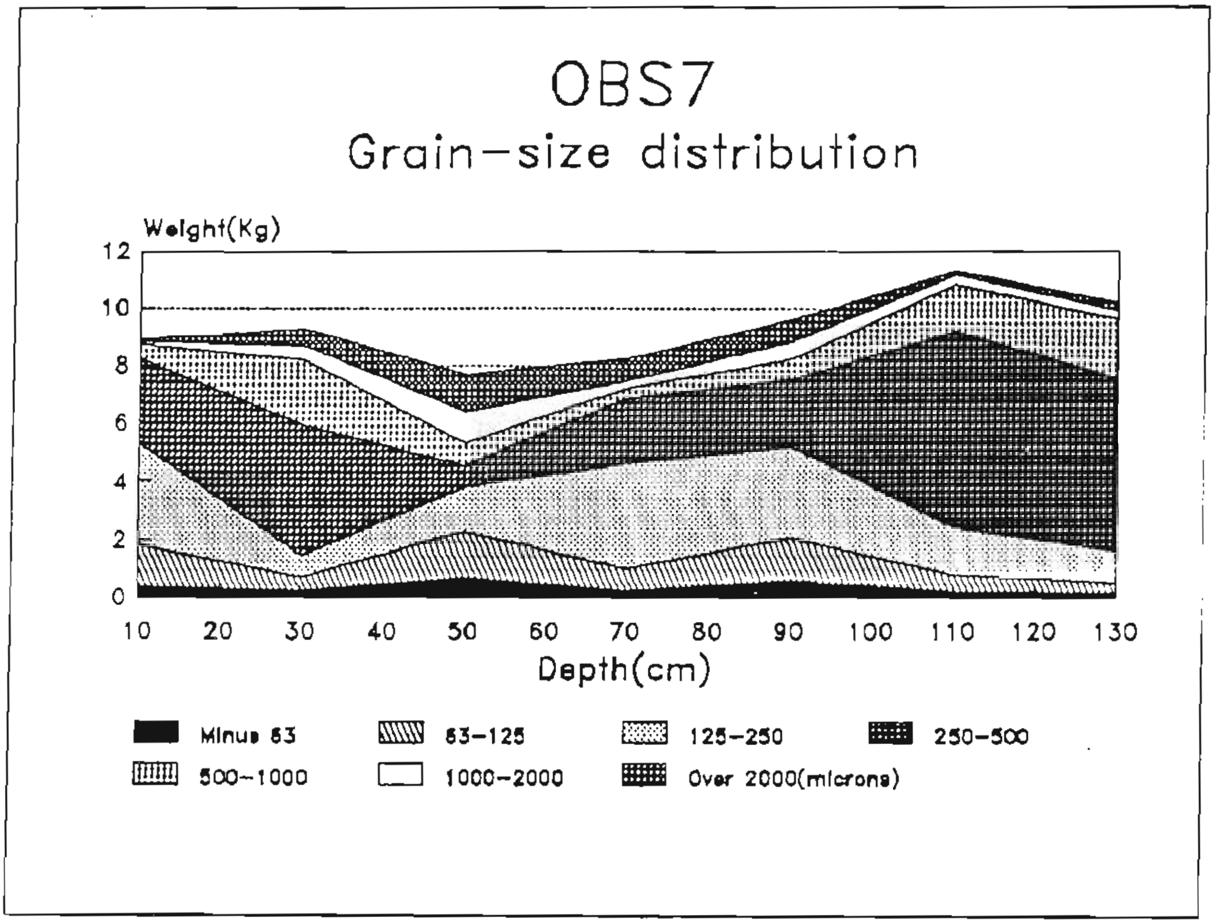

OBS6(%)
Grain-size distribution
Weight(%)
0%
20%
40%
60%
80%
100%
10
20
30
40
50
60
70
80
90
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

Fig n^{0} 15


OBS7
Grain-size distribution
Weight(Kg)
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

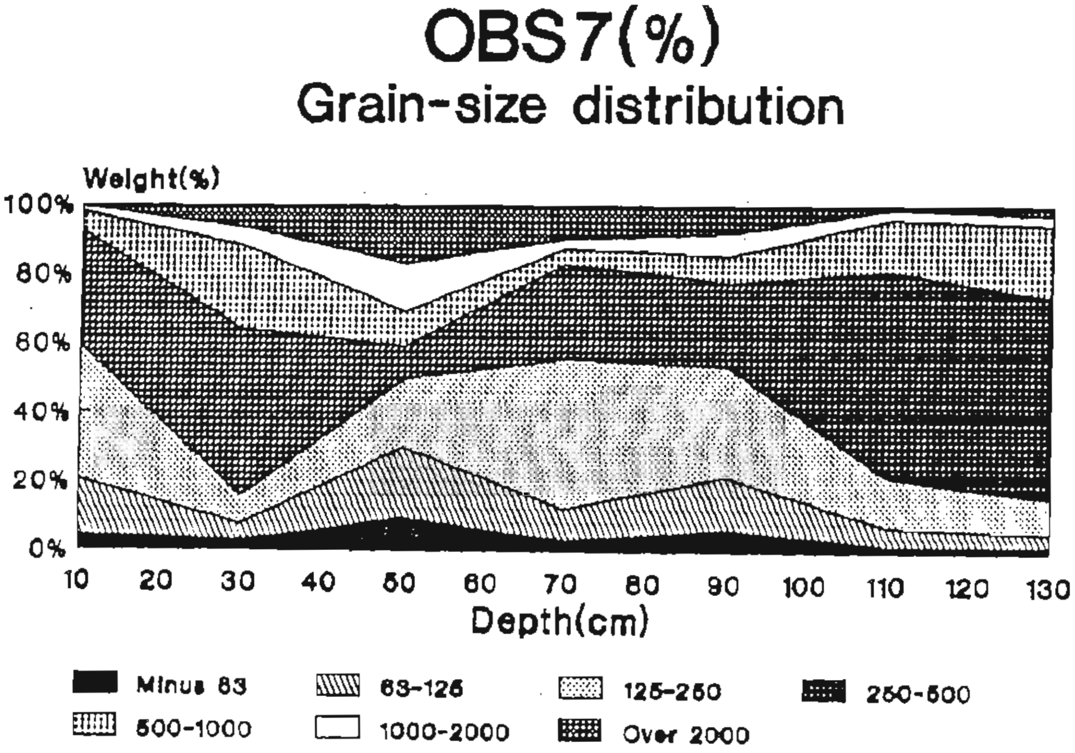
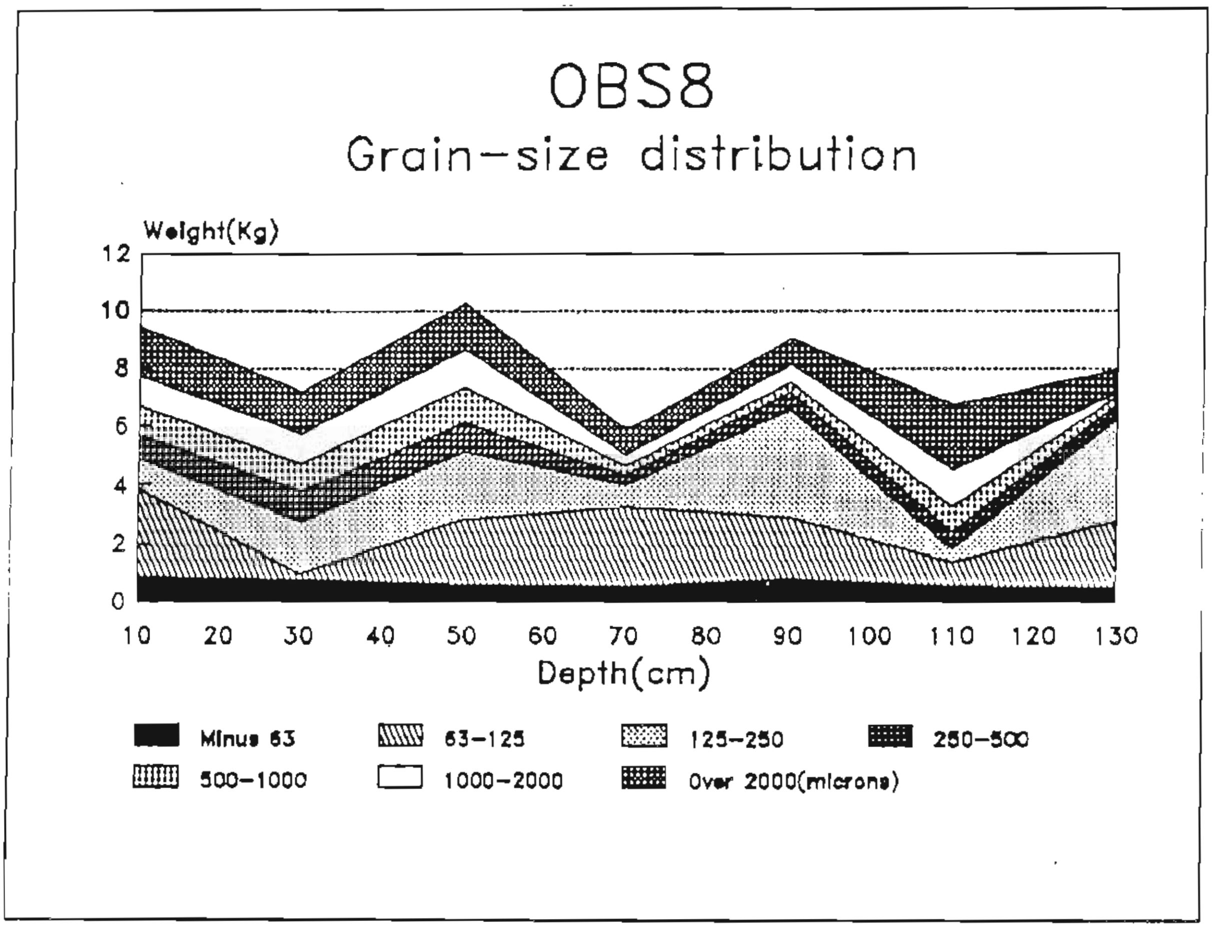

OBS7(%)
Grain-size distribution
Weight(%)
100%
80%
60%
40%
20%
0%
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

Fig nº 16


OBS8
Grain-size distribution
Weight(Kg)
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

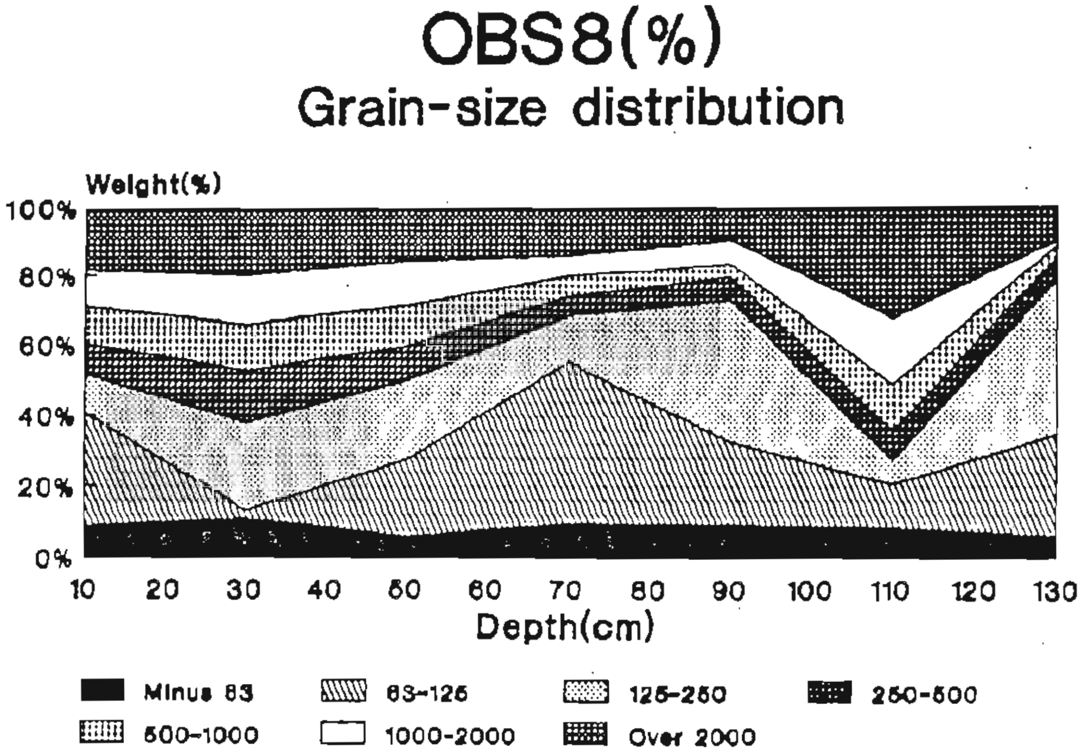

OBS8(%)
Grain-size distribution
Weight(%)
100%
80%
60%
40%
20%
0%
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

Fig n^{o} 17

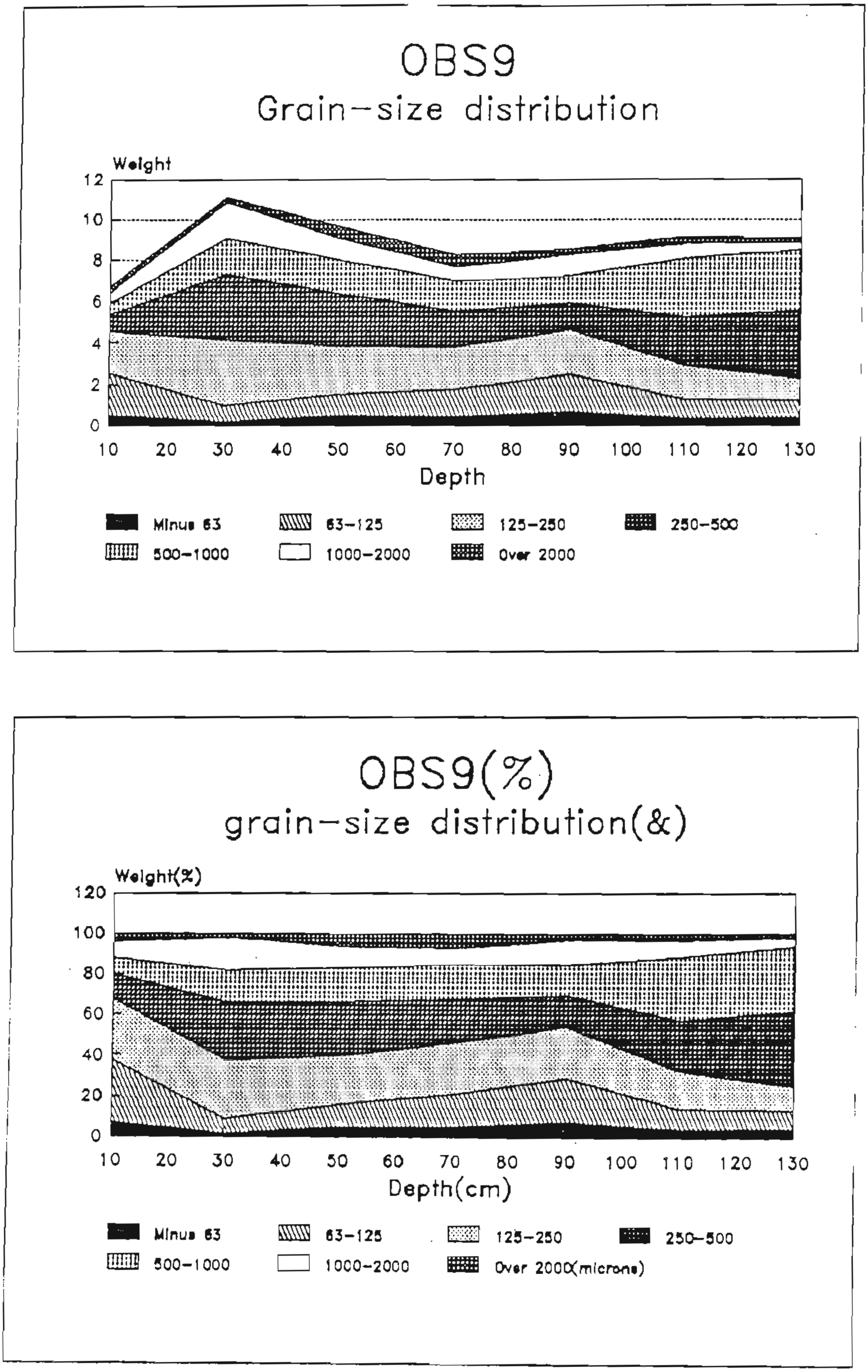
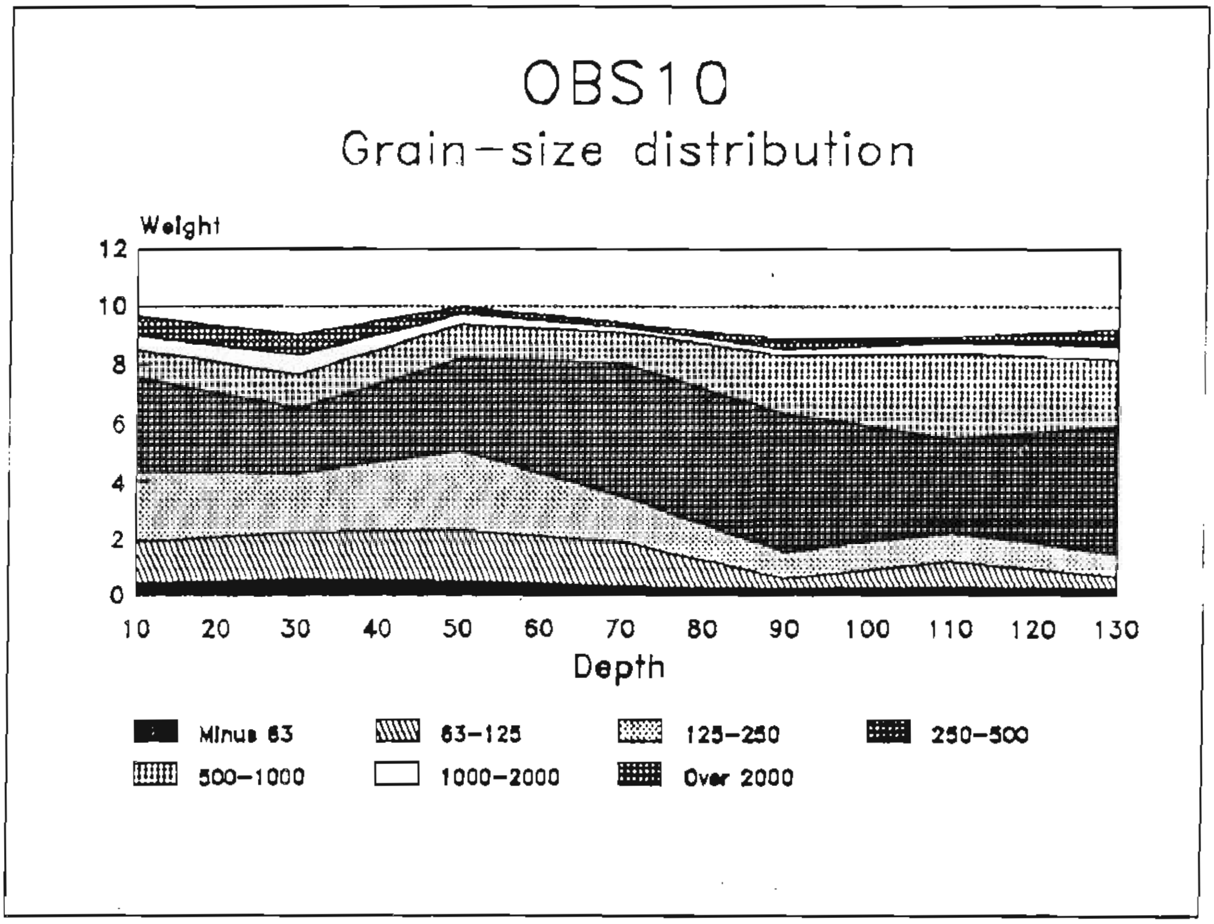

OBS9
Grain-size distribution
Weight
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000
OBS9(%)
grain-size distribution(&)
Weight(%)
120
100
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

Fig n° 18


OBS10
Grain-size distribution
Weight
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000

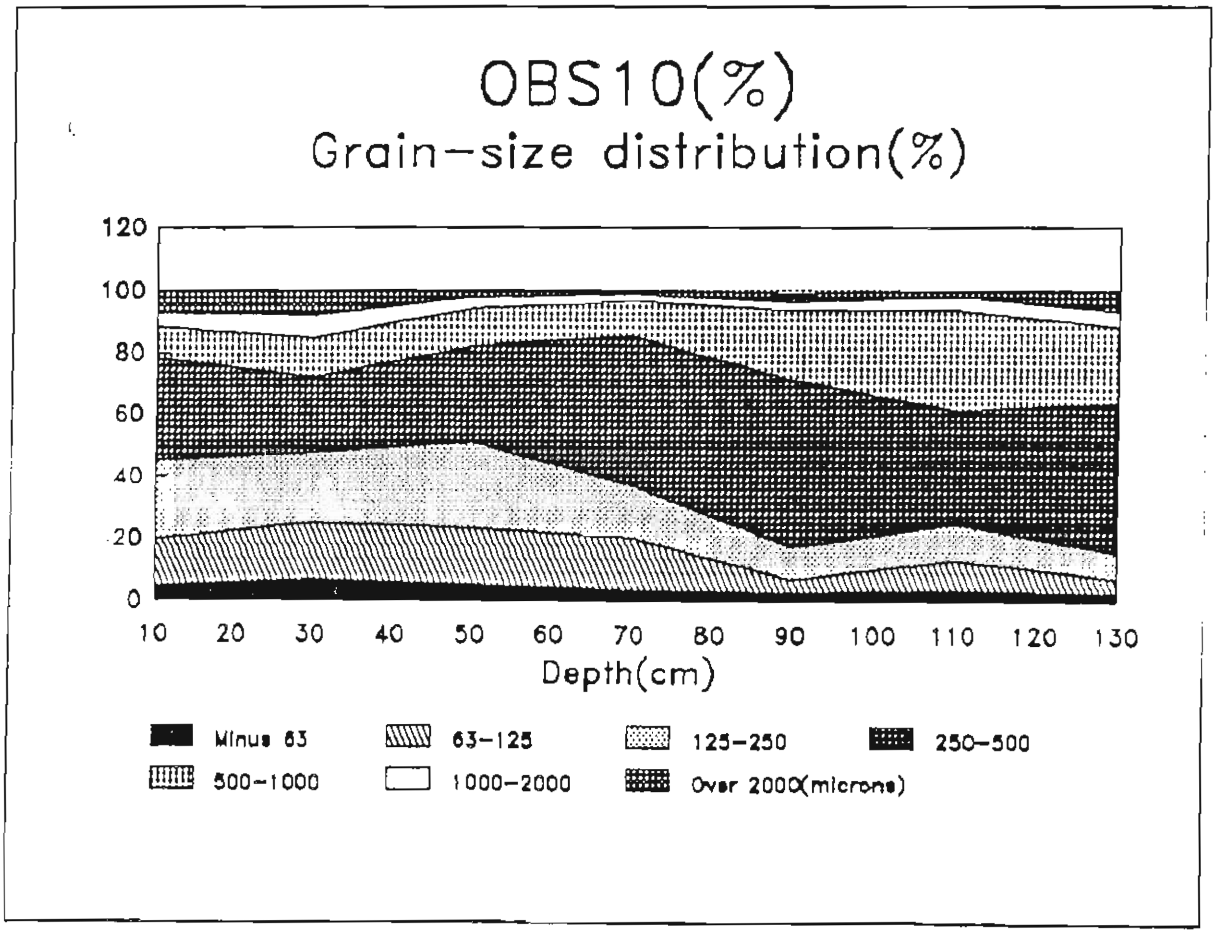
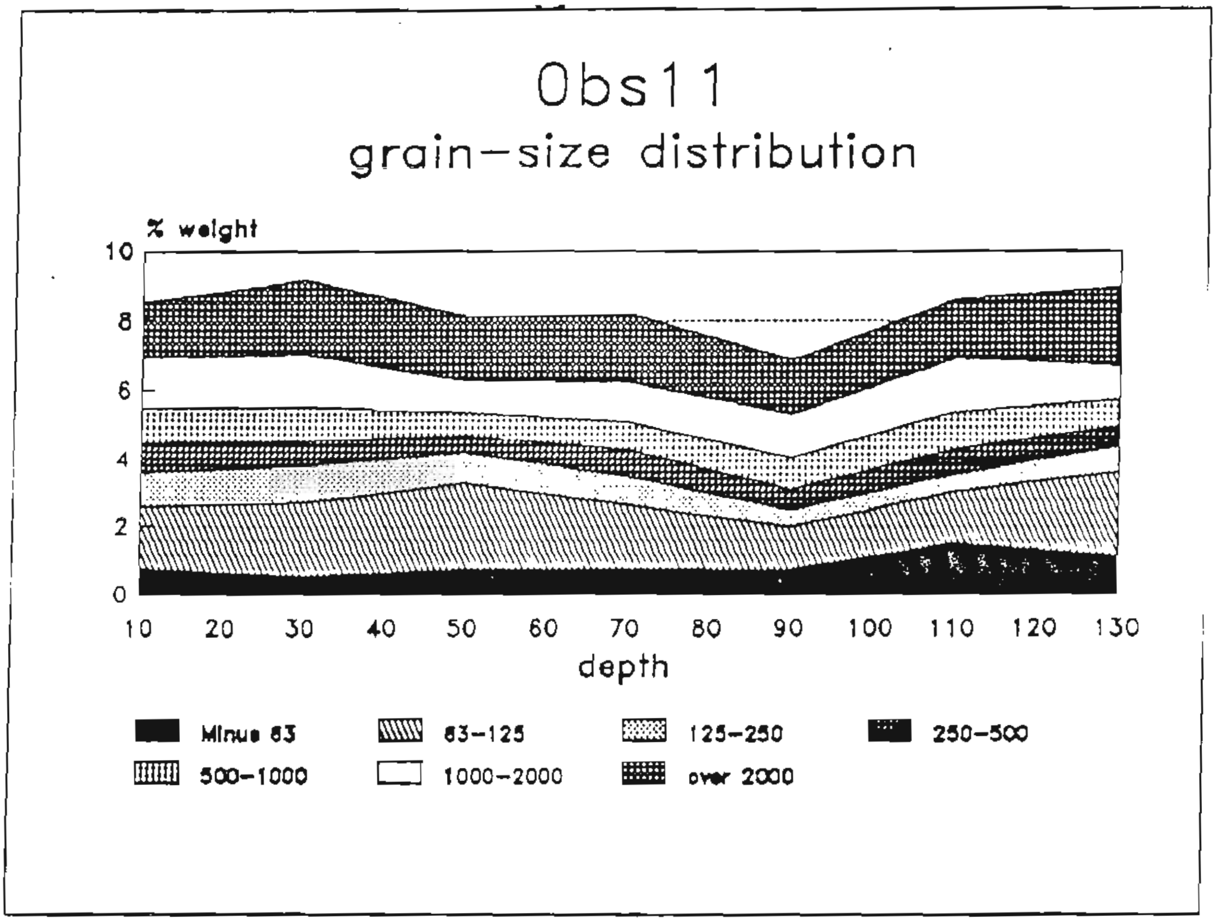

OBS10(%)
Grain-size distribution(%)
120
100
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

Fig n° 19


Obs11
grain-size distribution
% weight
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
depth
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
over 2000

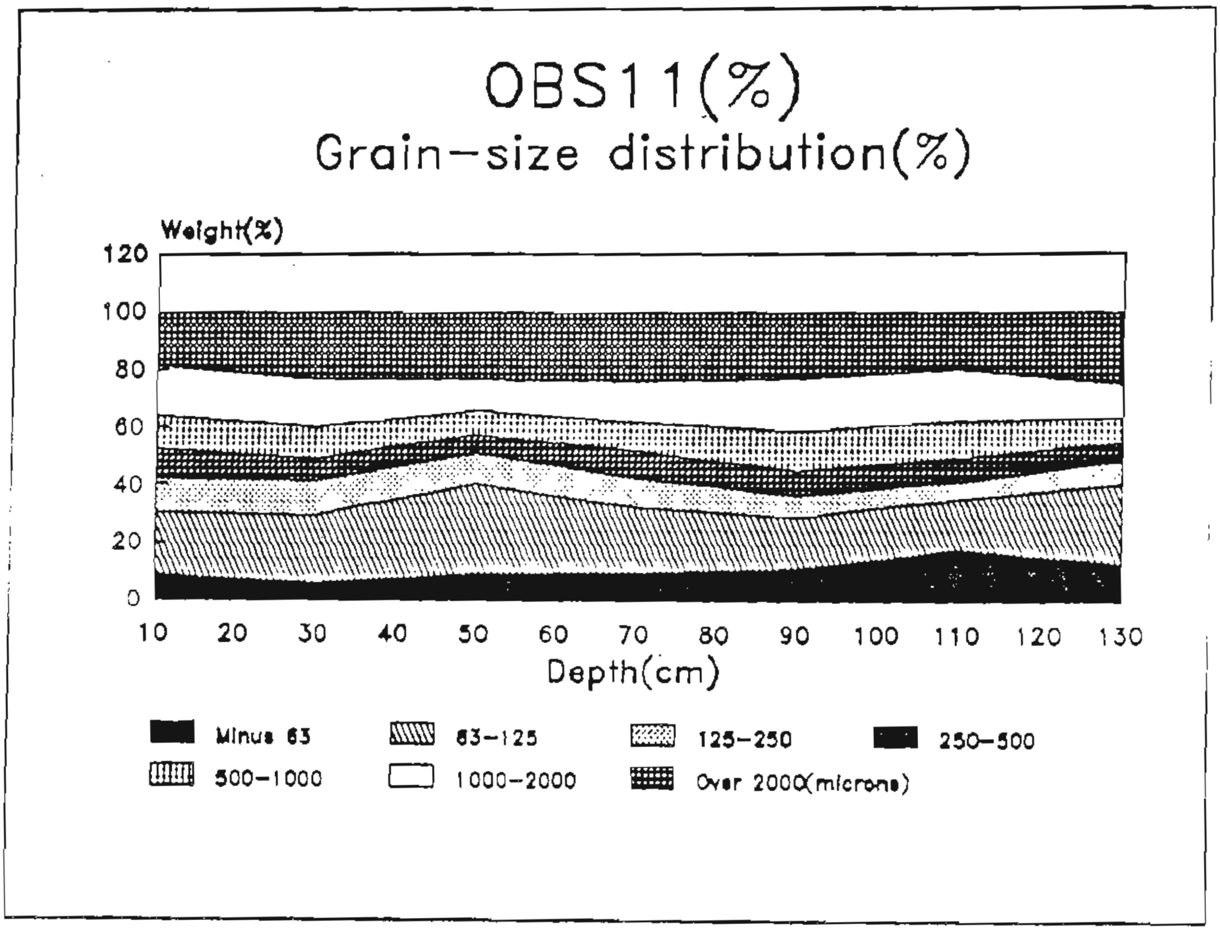
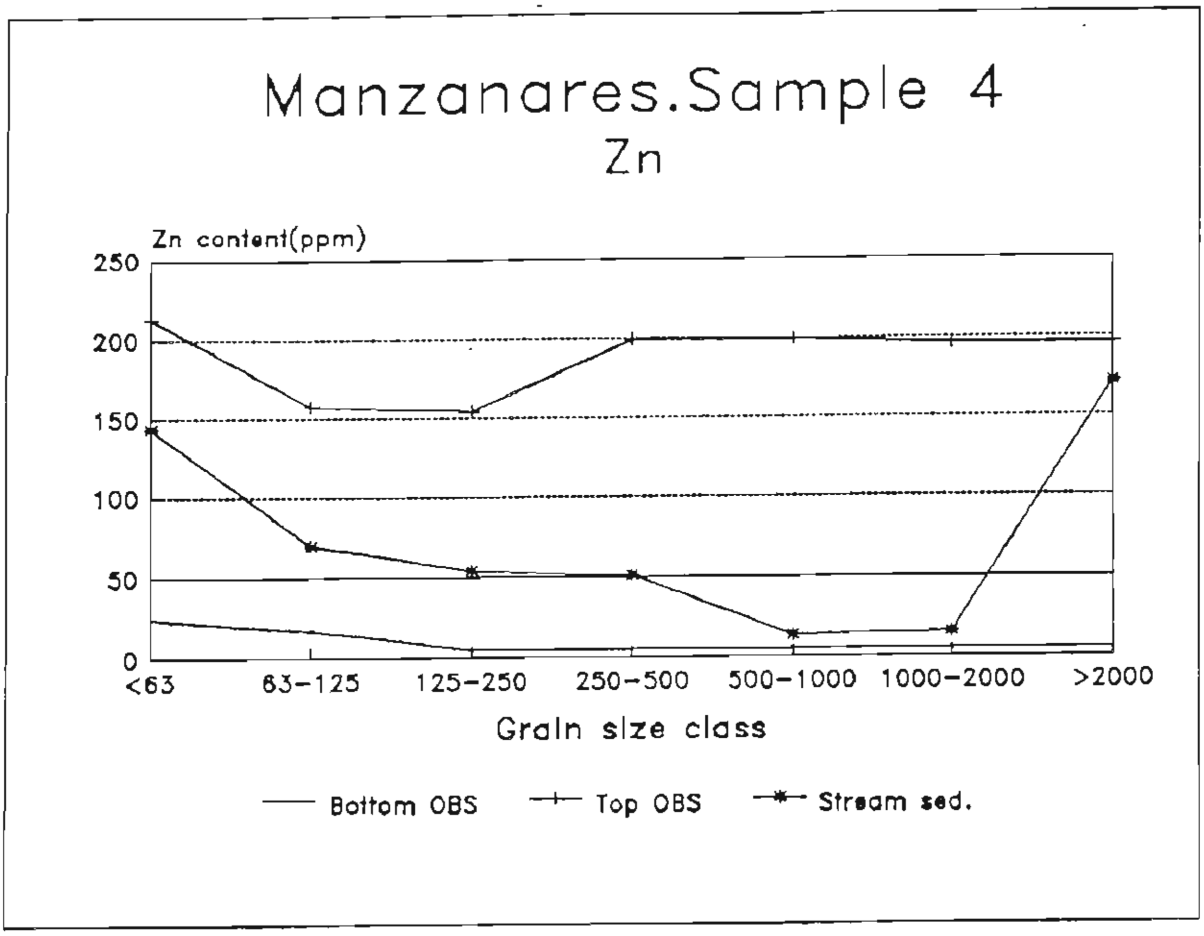

OBS11(%)
Grain-size distribution(%)
Weight(%)
120
100
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Depth(cm)
Minus 63
63-125
125-250
250-500
500-1000
1000-2000
Over 2000(microns)

Fig n° 20


Manzanares.Sample 4
Zn
Zn content(ppm)
250
200
150
100
50
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

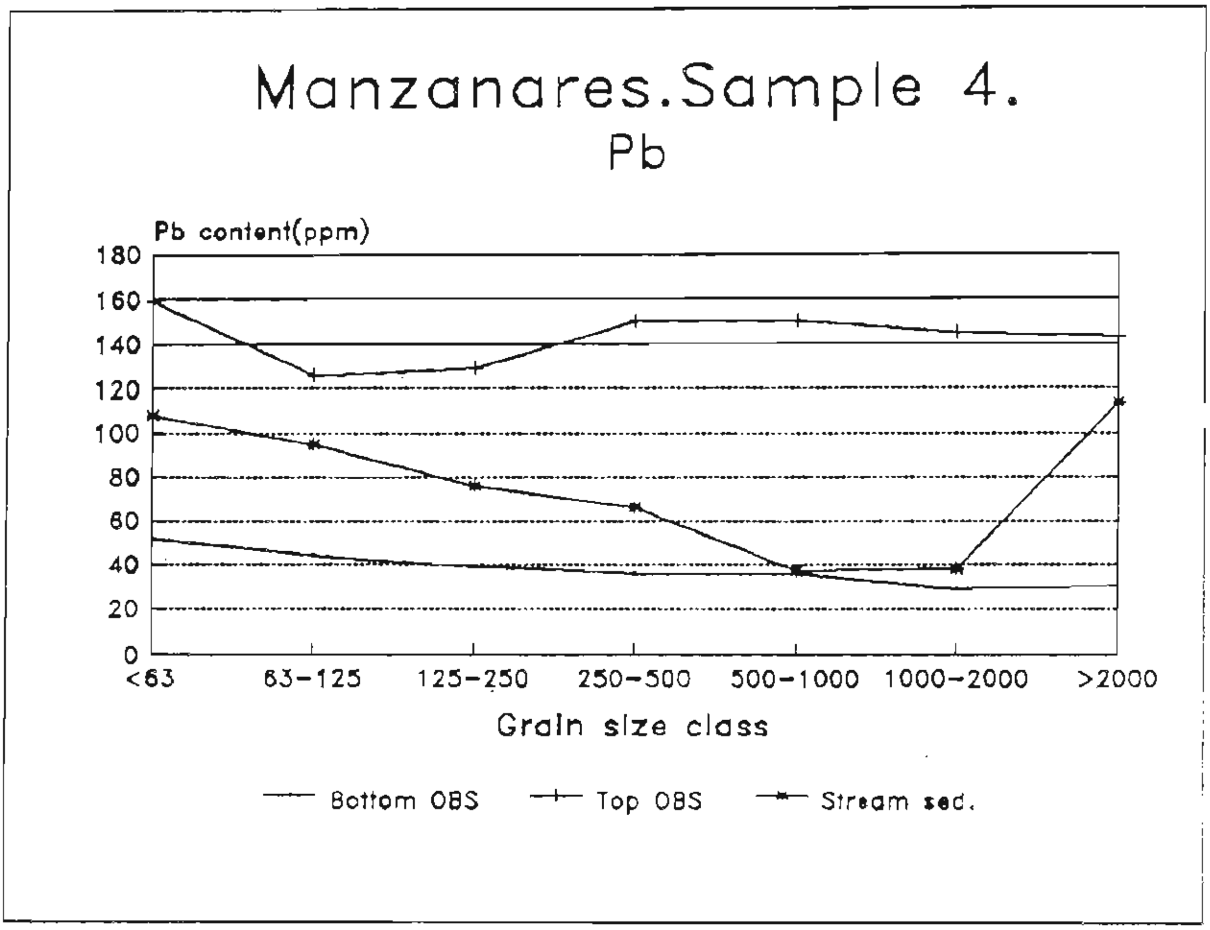

Manzanares.Sample 4.
Pb
Pb content(ppm)
180
160
140
120
100
80
60
40
20
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig n^{o} 26

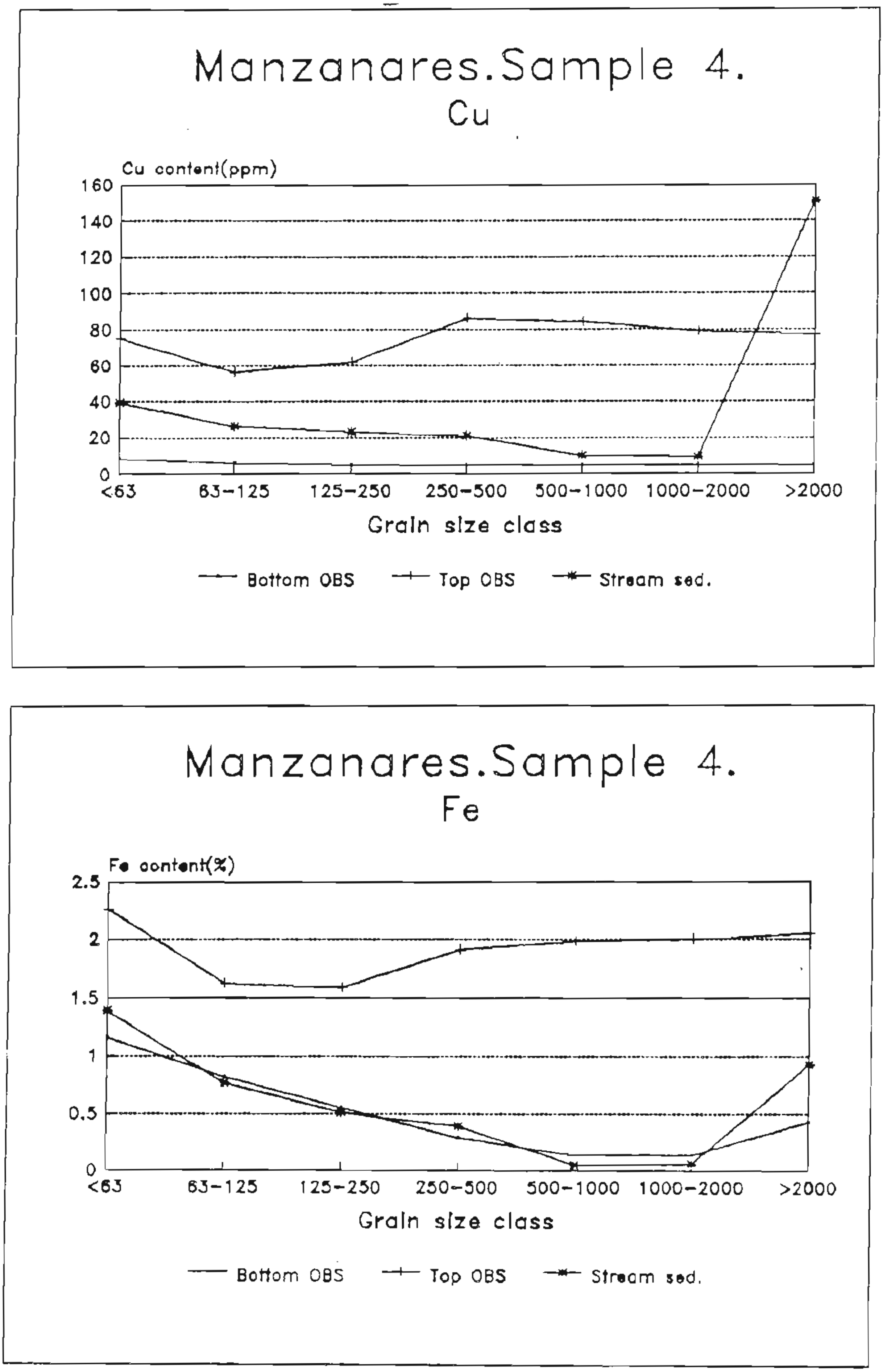
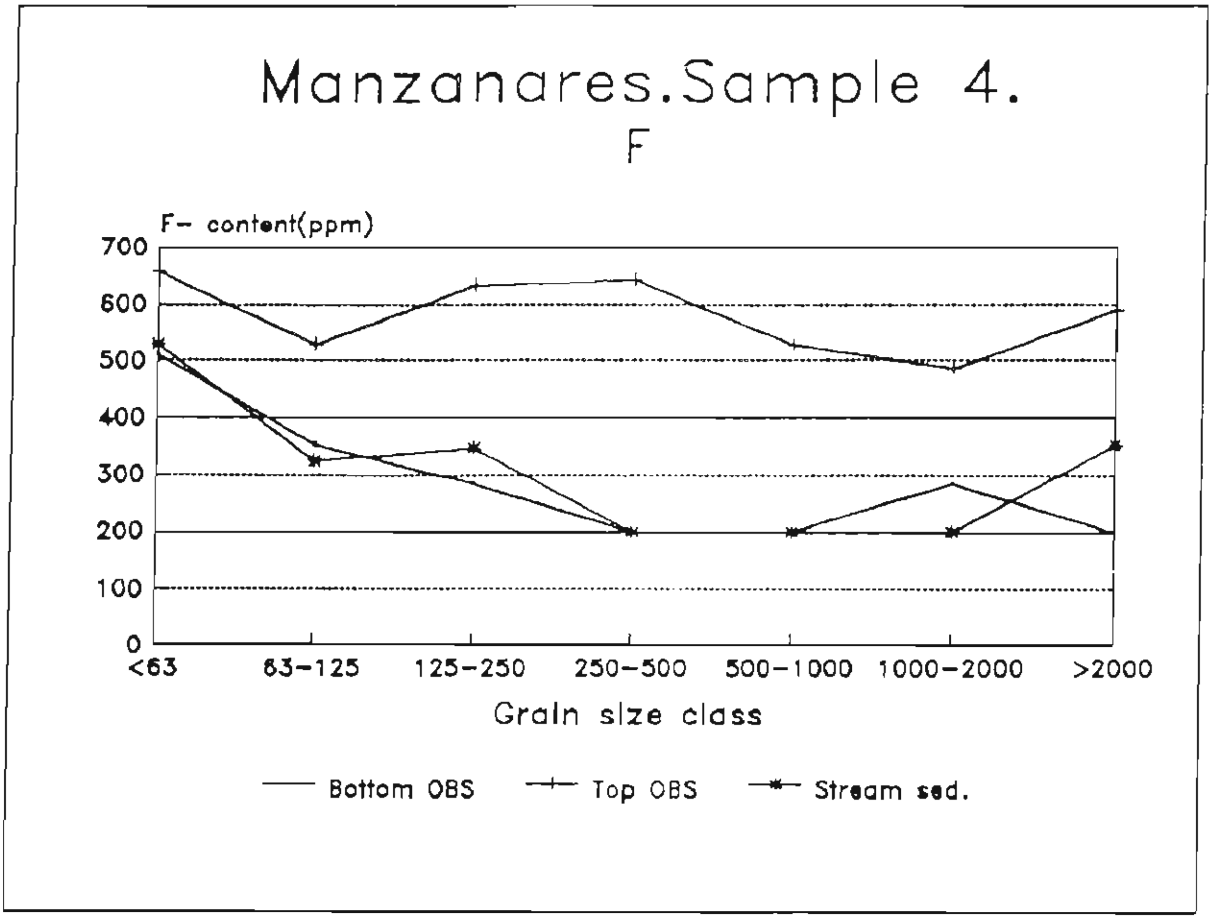

Manzanares.Sample 4.
Cu
Cu content(ppm)
160
140
120
100
80
60
40
20
0
<63
63–125
125–250
250–500
500–1000
1000–2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.
Manzanares.Sample 4.
Fe
Fe content(%)
2.5
2
1.5
1
0.5
0
<63
63–125
125–250
250–500
500–1000
1000–2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig n° 27


Manzanares.Sample 4.
F
F– content(ppm)
700
600
500
400
300
200
100
0
<63
63–125
125–250
250–500
500–1000
1000–2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

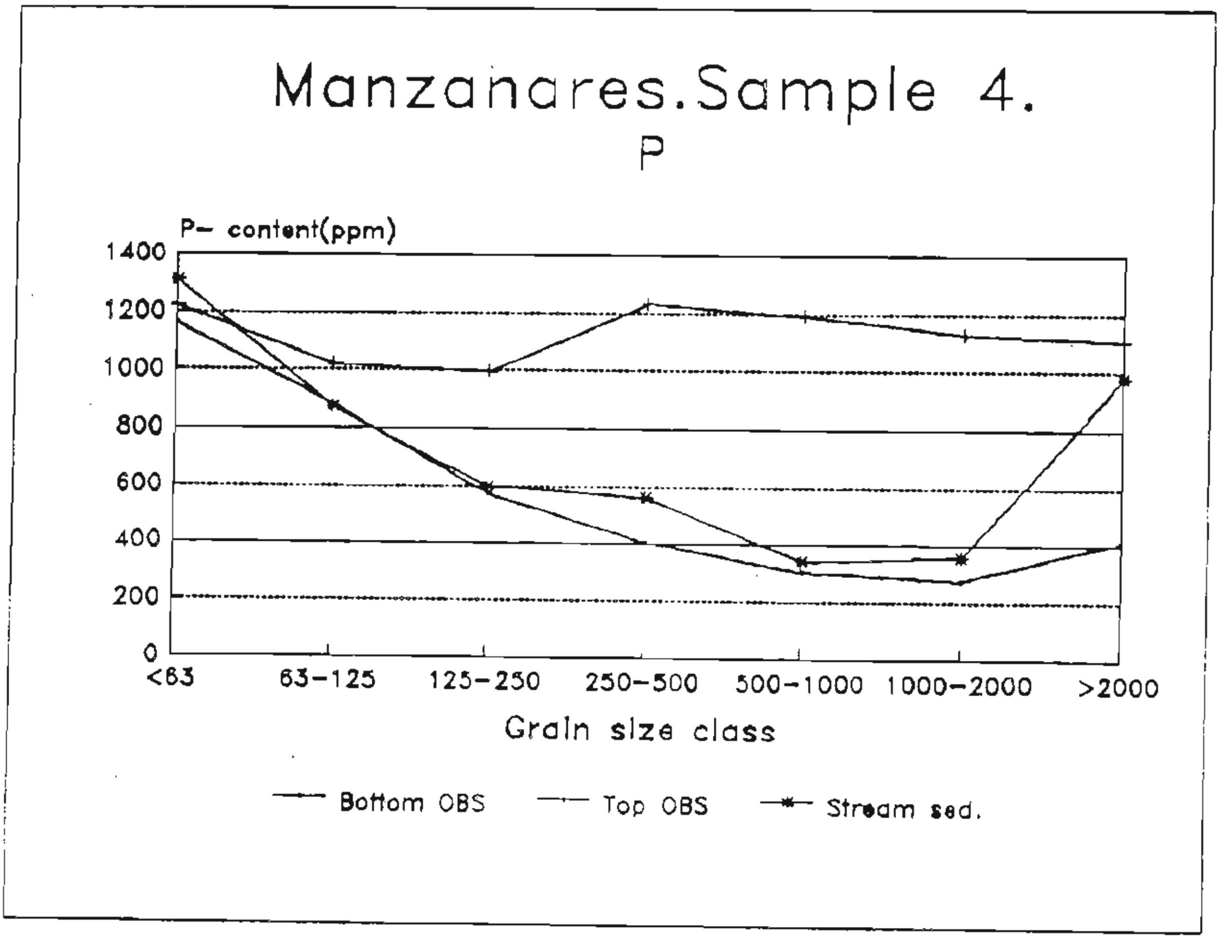

Manzanares.Sample 4.
P
P– content(ppm)
1400
1200
1000
800
600
400
200
0
<63
63–125
125–250
250–500
500–1000
1000–2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig n^{o} 28

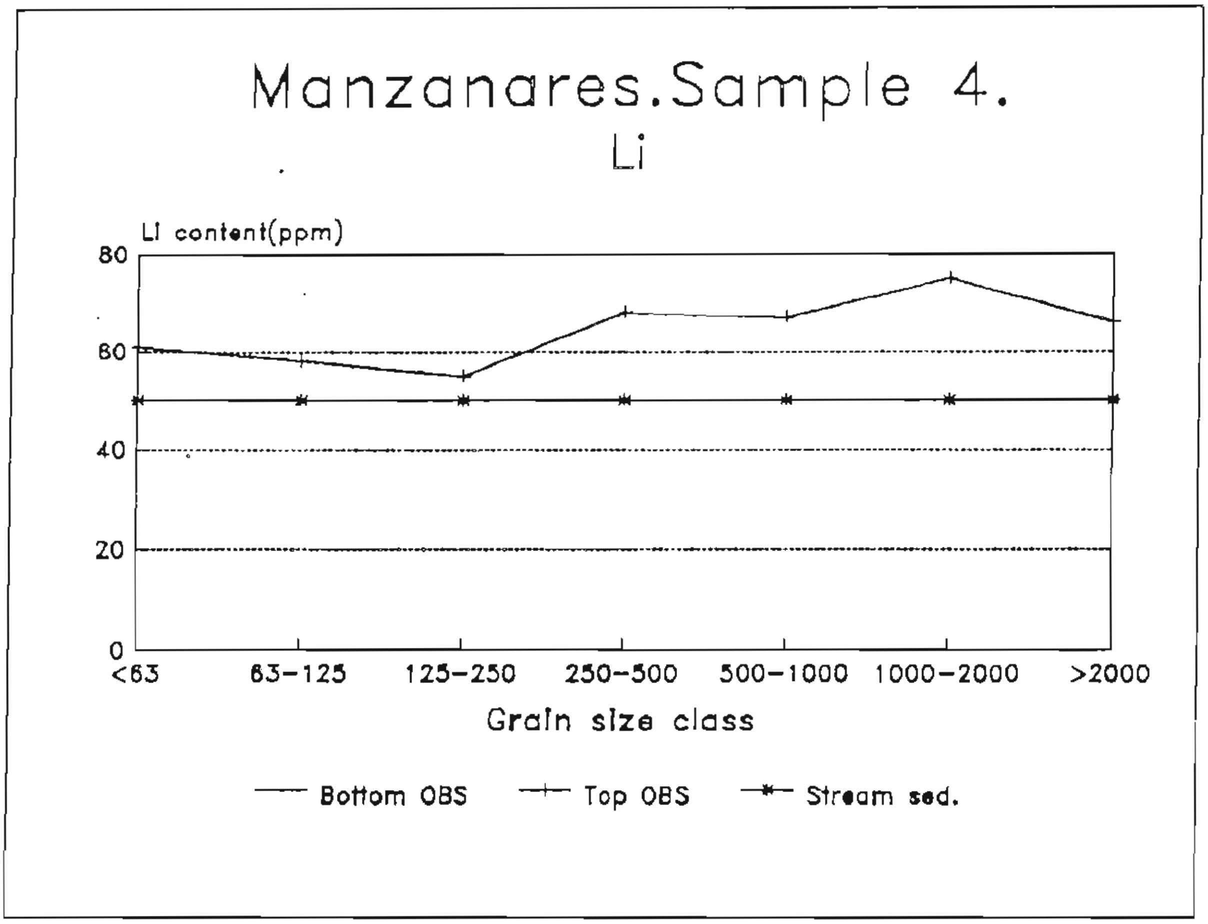
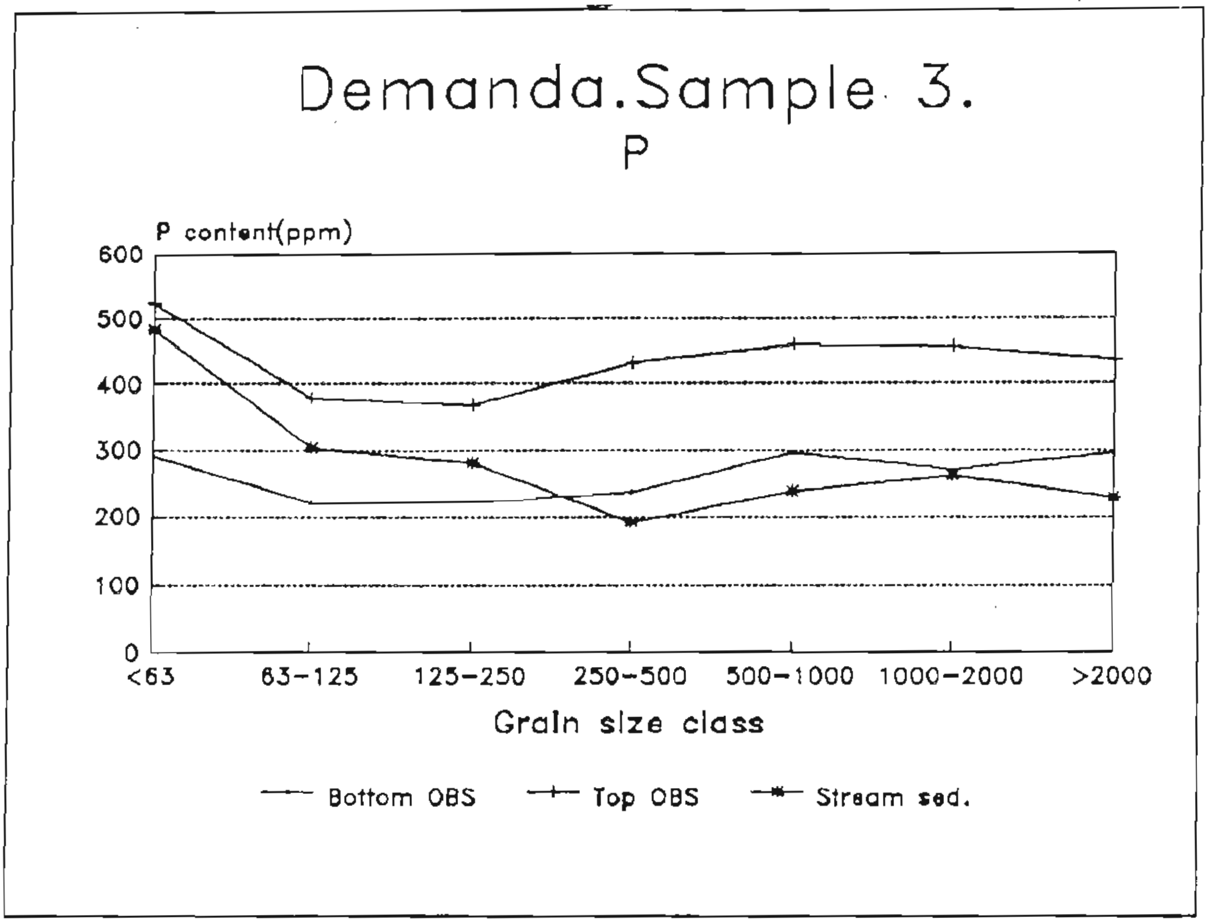

Manzanares.Sample 4.
Li
Li content(ppm)
80
60
40
20
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig nº 29


Demanda.Sample 3.
P
P content(ppm)
600
500
400
300
200
100
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

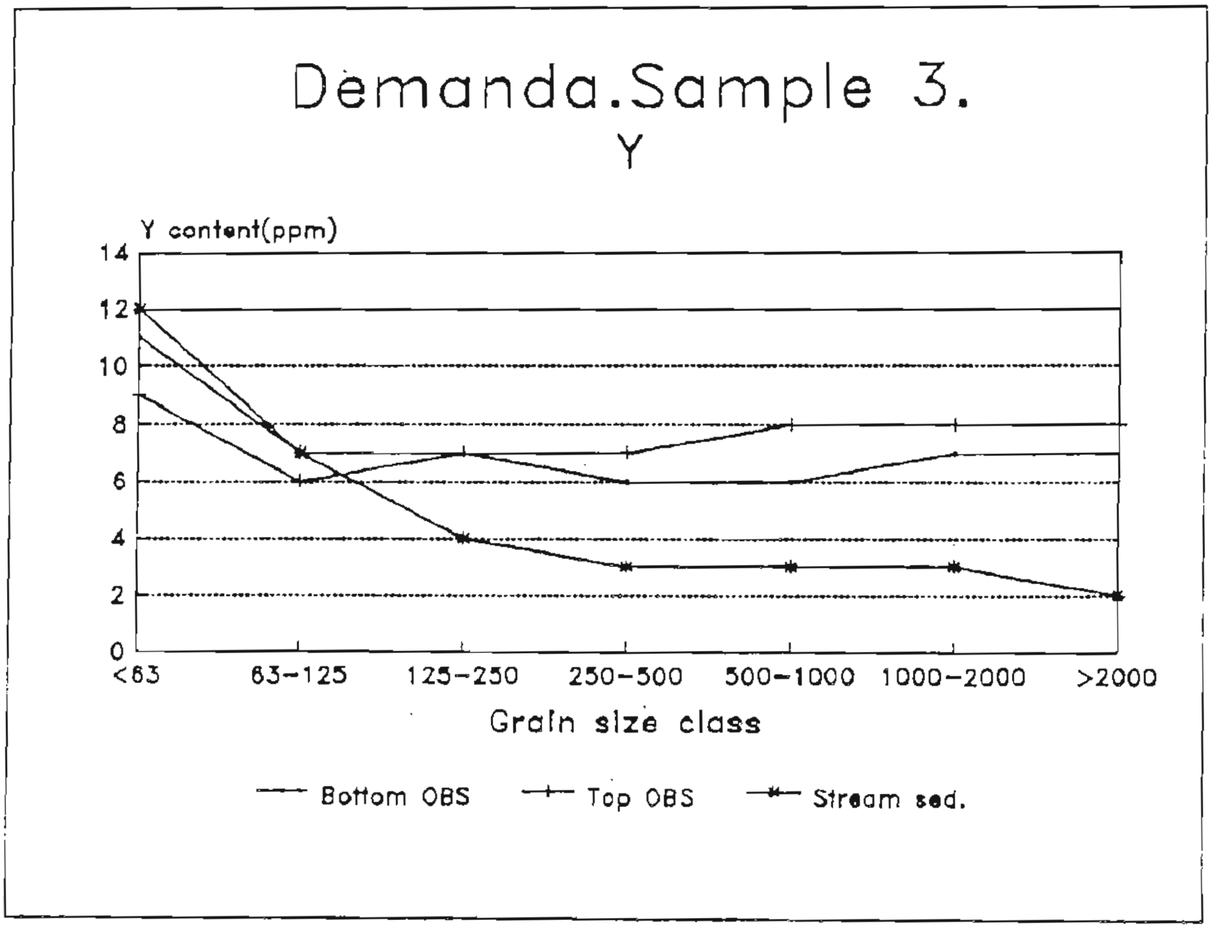
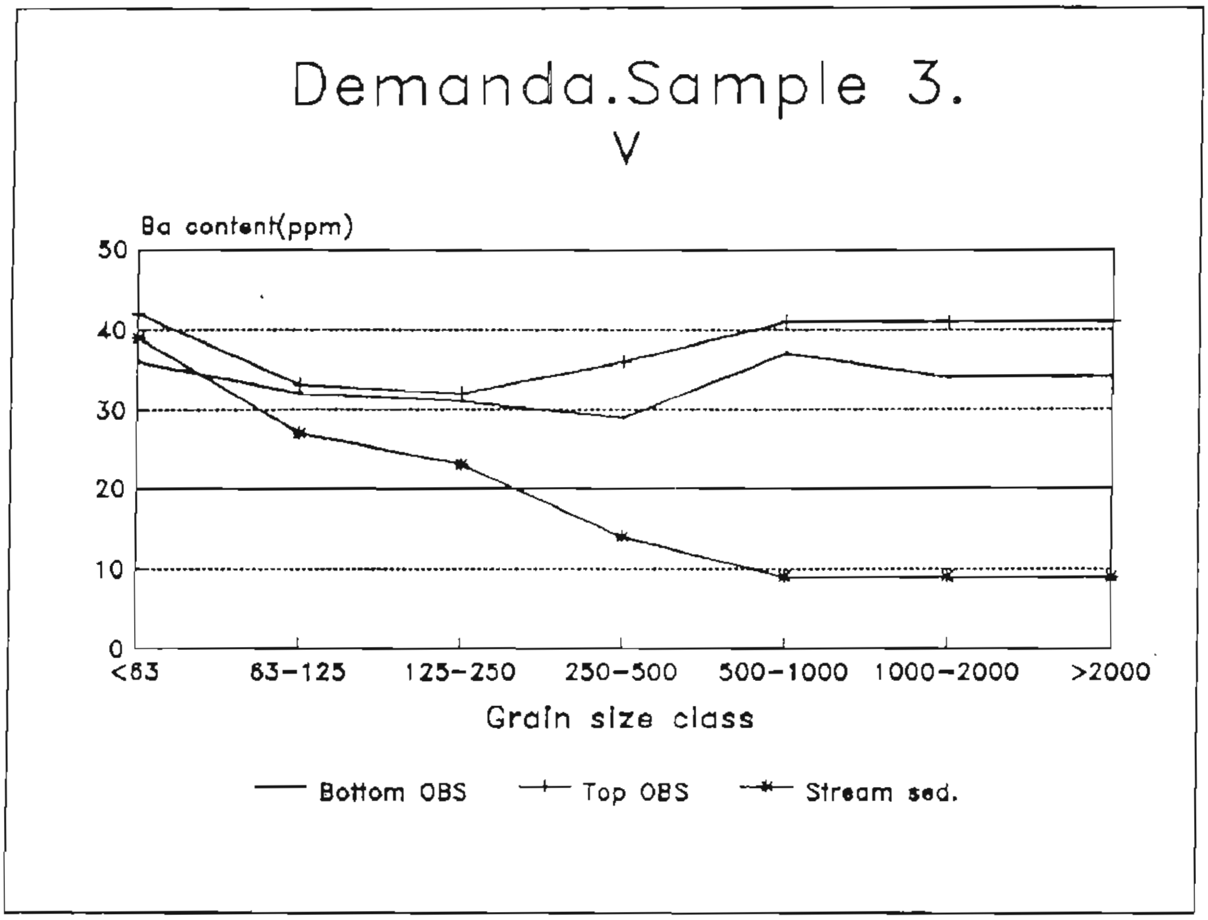

Demanda.Sample 3.
Y
Y content(ppm)
14
12
10
8
6
4
2
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig n° ~~34~~ 36


Demanda.Sample 3.
V
Ba content(ppm)
50
40
30
20
10
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

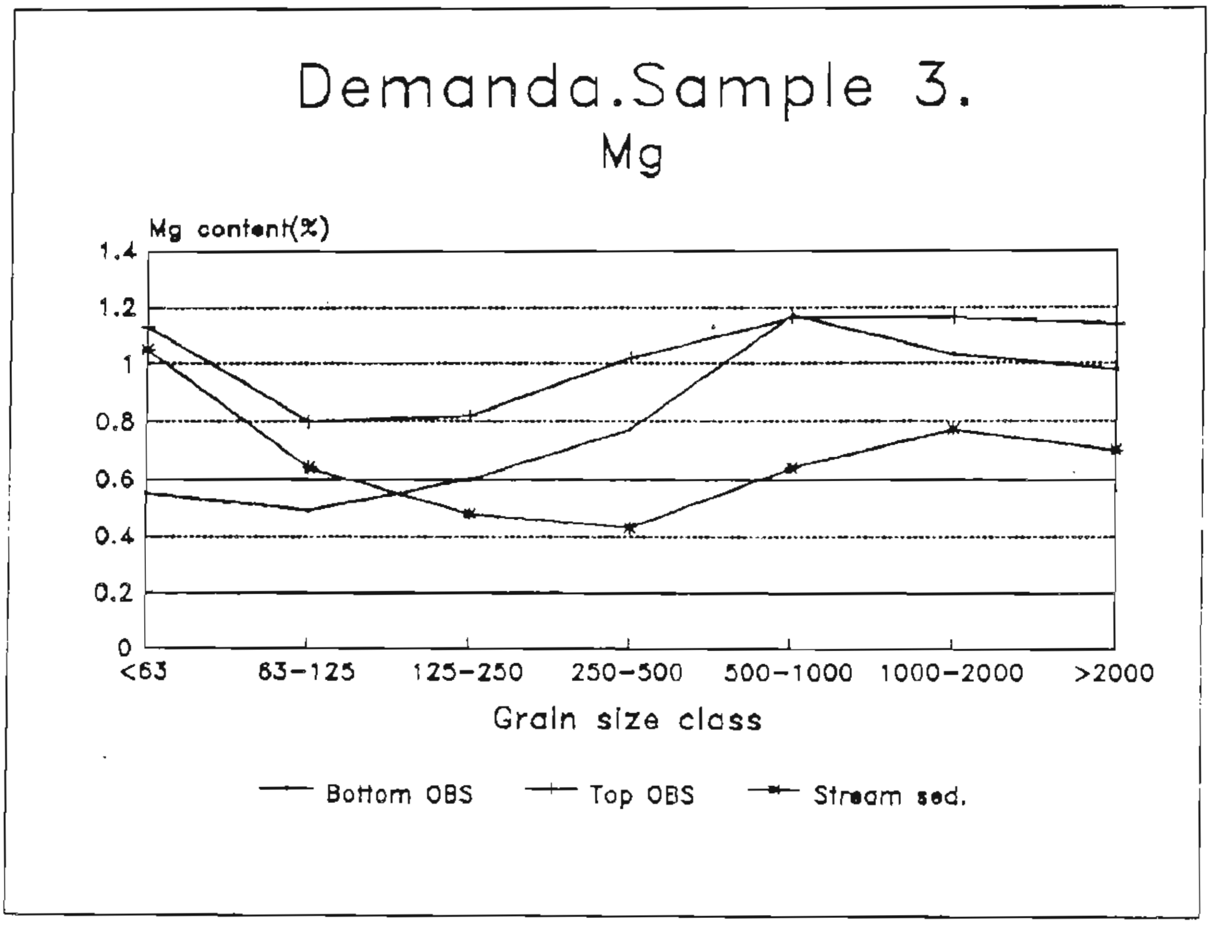
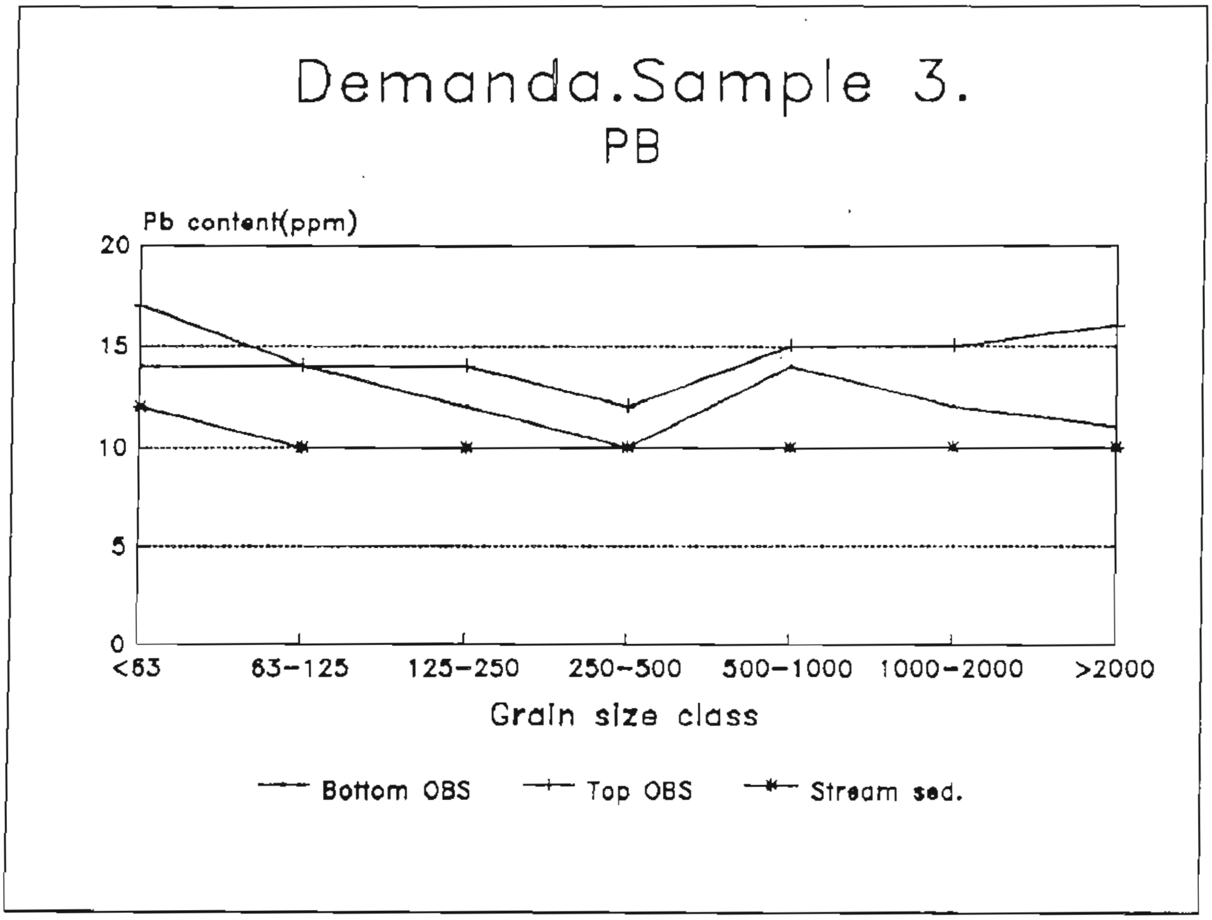

Demanda.Sample 3.
Mg
Mg content(%)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
<63
63-125
125-250
250-500
500-1000
1000-2000
>2000
Grain size class
Bottom OBS
Top OBS
Stream sed.

Fig n° 35


Demanda.Sample 3.
PB

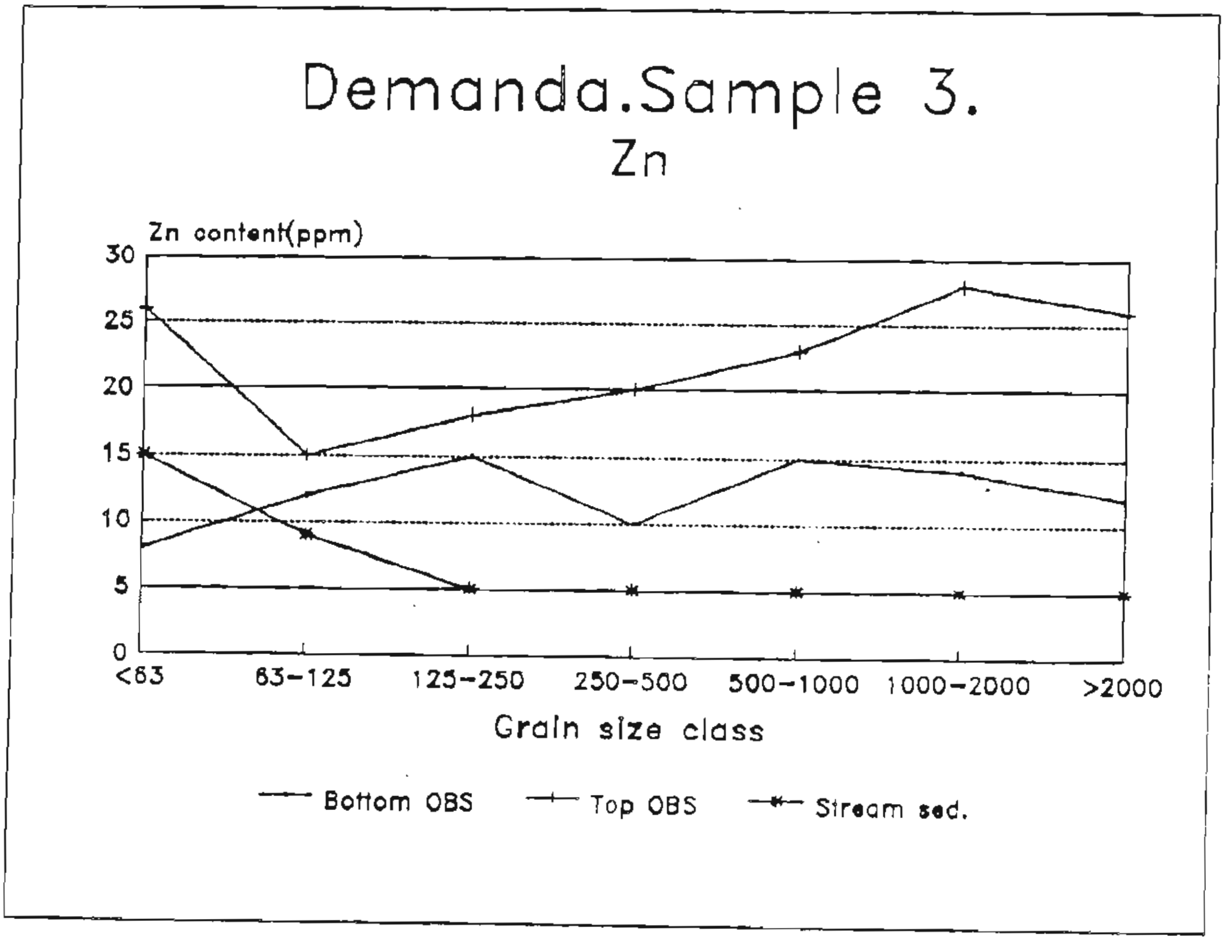

Demanda.Sample 3.
Zn

Fig n^{0} 37

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 7.1

OVERBANK VERSUS ACTIVE STREAM SEDIMENT

Rolf Tore Ottesen
Norway

1990

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

As a part of the Pilot Project, it was decided by the WEGS Working Group on Regional Geochemical Mapping, to carry out a comparison study where data from active stream sediments where compared with data from overbank sediment. In this Norwegian study a Fennoscandian denudation model is presented together with data on occurrence, composition and properties of stream sediments and overbank sediments. The study is ending up with a section of comparison of regional geochemical data from three different areas in Norway.

The main conclusion is that under Norwgian conditions overbank sediments are more representative for the drainage basin than the active stream sediments are. Overbank sediments consists mainly of minerogenic matter and are easier to interpret than stream sediments which consiste of varying mixtures of minerogenic matter, organic substances and oxydates.

2.0 FENNOSCANDIAN DENUDATION MODEL AND ORIGIN OF STREAM AND OVERBANK SEDIMENT

2.1 Denudation model

The derivation of Fennoscandian stream sediments is not usually mentioned in the prospecting literature. However, Brinck and Hofman (1964) desribe the stream sediments from the Oslo region Norway, as mainly fresh weathering products from the bedrock. Stendal (1978) investigated heavy mineral concentrates from stream sediments in south west Norway. He believes that the heavy minerals are of local bedrock origin and that the content of reworked glacial material is negligeable. Wennerwirta (1968) states that in addition to material from the bedrock, stream sediments also obtain matter from mechanically disintegrated moraine. Vartiainen (1976), Malmqvist et al. (1978) and Salminen (1979) claim that the stream sediments originates from the quaternary deposits.

The removal of inorganic sediment from streams has been measured by the sedimentologists in connection with their denudation studies (Bogen 1980). Investigations of sediment load in Finnish rivers has been made by Mansikkaniemi (1974, 1975, 1982). Sediment yield from a number of Norwegian glacier outlets has been obtained from Østrem et al. (1971), Ziegler (1972, 1973, 1974), Østrem (1975) and Kjeldsen (1977, 1980, 1981). Sediment load investigations in Norwegian streams either not or only partly fed by glaciers has been carried out by Foster and Heiberg (1971), Ziegler (1973), Nordseth (1974,1976), Bulgurlu (1977), Relling (1977) and Bogen (1981). Investigations of the sediment

load in Swedish rivers has been made by Nilsson (1972, 1976), Calles (1980) and Brandt (1982).

To summarize the data from these sediment load investigations it may be stated that: 1) The largest annual specific inorganic yields is due to subglacial erosion, usually several tousand tons/km2 year. 2) The typical plateau surface of western Norway gives only approximately 5 tons/km2 year. 3) High erosional activity is met with in the clay districts below the highest postglacial marin limit and in area with a large percentage of farm fields. 4) The sediment supply to streams draining forested till deposits above the marine limit is rarely higher than 2-6 tons/km2 year.

The traditional denudation model based on supply and removal of fresh weathering products failes to describe the overall denudation activity in Fennoscandia (Nilsson 1972, Bogen 1982 per.comm.). The reason for this is that the present regional pattern of the sediment yield closely coincides with the distribution of quaternary deposits. Only subglacial erosion may keep pace with the reworking of the quaternary deposits.
Thus Fennoscandian inorganic stream sediment and overbank sediments consists of different form and mixtures of quaternary deposits which commonly are both transported and reworked before the fluvial process takes over.

The genesis of the glacial overburden will thus have a strong influence on how the inorganic part of the stream sediments reflects bedrock and mineralizations.

2.2 Sediment sources

Under Fennoscandian conditons, true sheet erosion can be observed only during seldom occurring rainstorms, generally the major part of the stream sediments originates from sources confined to areas of limited extension within the drainage basins (Bogen 1982 pers. comm., 1986, Ottesen et al. 1989). Table 1 lists some of the sediment sources in different environments in Fennoscandia. One very important point source developes when a stream undercuts an adjacent slope containing fine fractions. Mass movement may be induced during rising water discharges (Bogen 1980). Differences in soil use, for instance intensive cultivation, also provides important point sources (Mansikkaniemi 1982). It may be concluded that the most typical Fennoscandian drainage basins recieve inorganic sediments from sources of limited extent, only occational is the whole drainage system represented through sheet flow.

Thus active inorganic stream sediment represent the quaternary deposits only from parts of the catchment area.

A vertical section through overbank sediment reflects the history of sedimentation back through time, and a composite sample of such a section will give an integrated picture of the chemical and mineralogical conditions from a large number of sediment sources opened during many floods. Thus overbank sediment represent the quaternary deposits from the whole catchment area.

3.0 STREAM SEDIMENT: OCCURRENCE, COMPOSITION, PROPERTIES AND ABILITY TO REFLECT BEDROCK

The term stream sediment refers to unconsolidated material mainly composed of mineral grains, rock fragments, organic matter and oxidates in varying mixtures.The material are transported by, suspended in, or that have been precipitated from water. Active stream sediments are thosebeing transported and reworked during present-day stream flow.

Generally, inorganic stream sediments are ubiquitous in Fennoscandia although there are great regional differences in the supply of active sediments to the streams (e.g. Nilsson 1972, Nordseth 1976, Mansikkaniemi 1982). The present regional pattern of sediment yield closely coincides with the distribution of quaternary deposits (Nilsson 1972). The inorganic fragments range in size from boulders to colloidal size. Knowlegde about grain size distribution of fine grained or suspended load in Fennoscandian stream are meagre. Rock fragments, quartz, feldspars and micas are the main components in the streams. Other minerals on average makes up less than 5% of the samples.

Nilsson (1972), Mansikkaniemi (1975), Bulgurlu (1977), Bogen (1979), and Brandt (1982) reports that on average approximately 15-20 % of the total suspended load in the stream is of organic origin, although the values varies within wide limits. Depending on the time of the year and on the geographical position of the stream, a large percentage of the suspended transport may be of organic matter.

The organic matter is a heterogenous mixture of plant, animal and organic detritus in various stages of decomposition (e.g. Gjessing 1976) with well known abilities to atach elements through complexing and ionexchange.

Oxidates, or Fe,Mn precipitates are generally believed to be rather ubiquitous as coatings on the surfaces of stream bed material in shallow, radily flowing, well-aerated segments of the streams (e.g. Goldschmidt 1954, Rose et al. 1979), as local enrichments in down stream bog areas (e.g. Nicol et al. 1967, Nowland 1982), and as deposits around springs or ground water seepages (Whitney 1981).

Even though little sustematic information exists, there are data to indicate that oxidates are not ubiquitous and that they show large scale regional distribution patterns in stream beds and lakes in Fennoscandia (Ottesen et al in prep.). The scavanging properties of oxidates are well known.

Streams are the main avenues wherby the product of weathering are carried off the land. These weathering products are believed to represent a composite sample of soil and rocks found in the area upstream from the sample point. Due to this asumption active stream sediments have been relied on heavily since the late 1950's to help delinit prospecting areas in Fennoscandia.

In geochemical prospecting in Fennoscandia the working style has been large emirical, and during the last three decades, large amounts of data on the metal content in Fennoscandian stream sediments has accumuleted. High metal values have certainly been found in sediments from streams draining ore deposits or mineralizations, but there are, unfortunately, examples where relatively large deposits or known mineralizations have remined undetected by stream sediment surveys. In other cases, geochemical anomalies which seemed to be promissing, later proved to be uninteresting from the prospecting point of view. Furthermore in areas of low topographic relief, the use of stream sediments as a sample medium for prospecting purposes has not been successful.

The metal content in stream sediments, therefore, do not always reflect the natural metal concentrations within a catchment area, but are to a varying degree modified by various factors in the environment. Even though extensively studied, geochemical stream sediment surveys are still burdened by unsolved problems connected with both sampling and the physical and chemical processes affecting geochemical migration.

4.0 OVERBANK SEDIMENT: OCCURRENCE, COMPOSITION, PROPERTIES AND ABILITY TO REFLECT BEDROCK

The term overbank sediment refers to unconsolidated material mainly composed of of mineral grains. The content of organic matter is generally less than 5 %. Oxidates are uncommon. The material have been transported in suspension by water. A sequence of overbank sediment represent material deposited during different flood event. Depending on the e.g. erosion intensity, degration history of the stream and other factors a sequence may represent a time periode of some tens to several thousand years.

Generally, overbank sediments are ubiquitous in Fennoscandia.
Often a sequence of one meter represent a time periode of one thousand years. A very large number of sediment sources will be included in such a sequence.

Experience from Norway shows that the chemistry of overbank sediments reflects compositional features of the bedrock (Ottesen et al. 1989).

5.0 COMPARISON OF STREAM AND OVERBANK SEDIMENT GEOCHEMICAL DATA FROM NORWAY

5.1 General chemistry

General chemistry of stream sediments and overbank sediments can be compared in two norwegian data sets.From 6000 wet sieved stream sediments (- 0.18 mm) 159 composite samples were made. These samples are analysed for both total and acid soluble element content. These data have been compared with dry sieved (-0.063 mm) overbank sediment data from Norway.

The results of this comparison (Table 2) shows that Si, Ti, Mn, and Zr has higher concentration in active stream sediments compared to overbank sediments. Al, Fe, Mg, Ca, Na, K, P, S, Cr, Co, Ni, Cu, Zn, Rb, Sr, Y, Zr, and Nb are enriched in overbank sediments.

The difference is probably due to the grain size effect.

5.2 Central southern Norway

Stream sediments were collected from 1333 sample stations in an 40000 km2 large area from central southern Norway. The minus 0.18 mm material was analyses for HNO3-soluble heavy metals (Ottesen et al. 1983). Copper is shown as an example in figure 1. Stream seimnets from the northern and eastern part of the survey areas has lower copper content compared to the western part.

Figure 2 shows the copper distribuition in the same area based upon analysis of 75 overbank sediment samples. The analytical methos used were the same. The distribution patterns are very similar. The copper concentration is genreally higher in the overbank sediments.

5.3 Western Norway

Throughout the field seasons 1983-84 samples of stream sediments were collected from 633 streams in the Sogn and Fjordane county of western Norway (18600 km2). (Rygaug 1986). The same area was included in the national overbank sediment programme, and covered with 37 sampls.

The same general patterns are disclosed for all element analysed. Nitric acid soluble sodium is shown as an example in figures 3 and 4.

5.5 Nordland and Troms counties

1301 stream sediments amples were collected from the 65000 km2 large area of Nordland and Troms counties of northern Norway (Krog 1987). The same area hade earlier been covered by 130 overbank sediment samples. The same gereral patterns are again disclosed. However, the more densly sample stream sediment gives more detailed information. Lanthanum is given as an example in figure 5 and 6.

6.0 CONCLUSION

Arguments in favour of sampling overbank sediment for regional geochemical mapping include:

- Overbank sediment can represent whole drainage areas, and large samples can be taken at low density and low cost per unit area.
- A small number of large samples facilitates the use of complex multielement chemical analysis.
- Overbank sediment seems to be present in all river sysytems that have fluctuating water levels or occasional floods.
- Overbank sediment may be samples at depth, but still above groundwater level, in which case possible anthropogenic pollution is a less problem than stream sedimemt.

The main conclusion is that under Norwegian conditions overbank sediments are more reoresentative for the drainage basin than the active stream sediments are. Overbank sediment consists mainly of minerogenic matter and are easier to interpret than stream sediments which consists of varying mixtures of minerogenic matter, organic substances and oxidates. For most elements the concentrations are higher in the minus 63 micron fraction of overbank sediments compared to the minus 180 micron fraction of stream sediments. The same general map patterns are disclosed in region of Norway where both stream sediments and overbank sediments have been sampled, although the number of overbank samples are 10-20 times less the number of stream sediment samples

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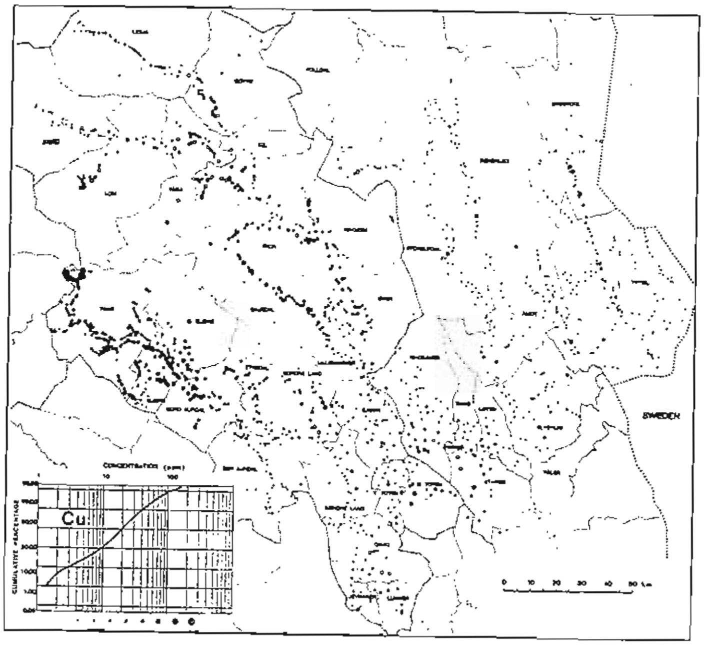

Figure 1. Nitric soluble copper in stream sediments from central southern Norway.

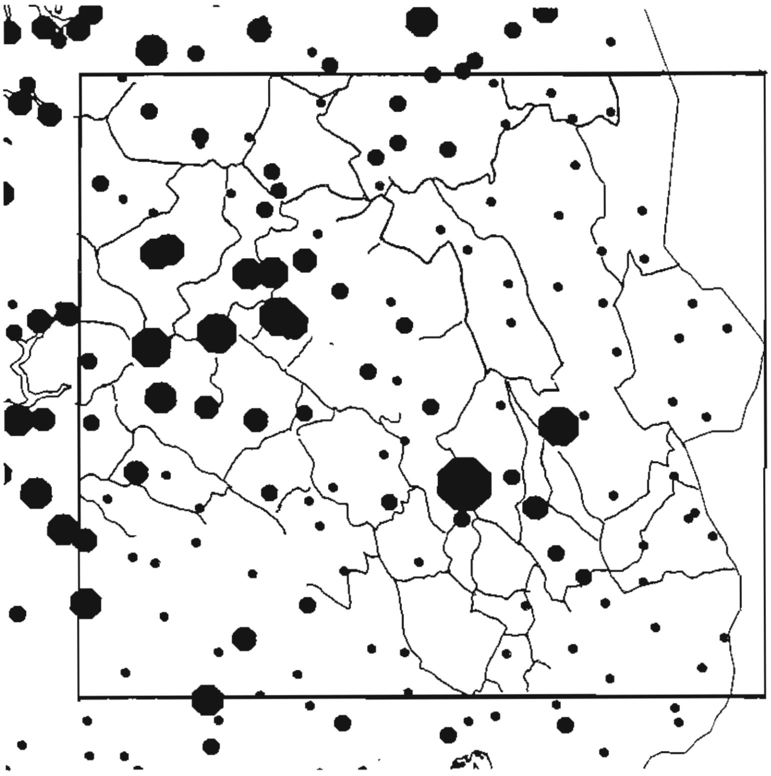

Figure 2. Nitric acid soluble copper in overbank sediments from central southern Norway.

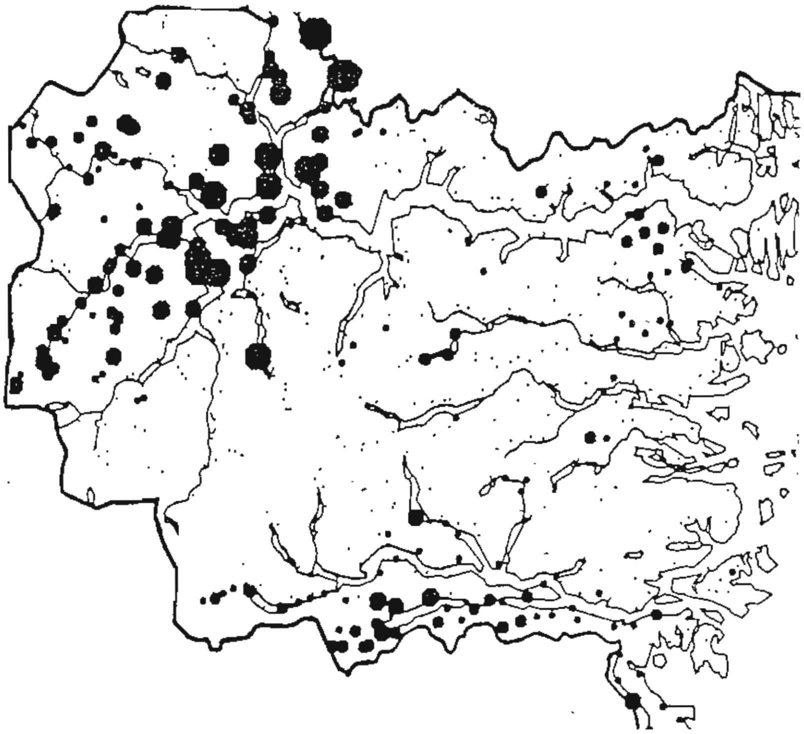

Figure 3. Nitric acid soluble sodium in stream sediments from western Norway.

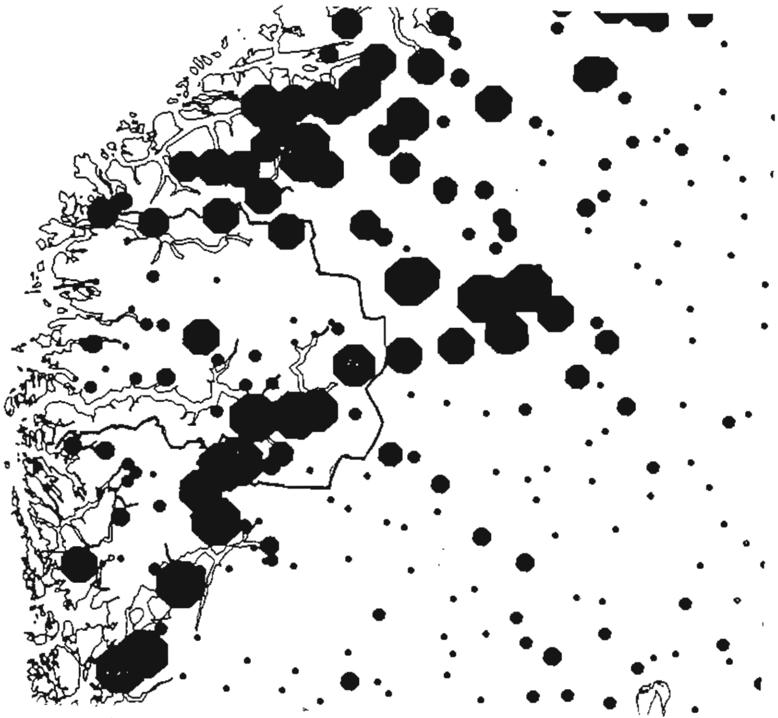

Figure 4. Nitric acid soluble sodium in overbank sediments from western Norway.

Figure 5. Nitric acid soluble lanthanum in stream sediments from northern Norway.

Figure 6. Nitric acid soluble lanthanum in overbank sediments from northern Norway.

TABLE 1. Types of sediment sources in Fennoscandinavian streams in different environments.

	Stream sediment	Overbank sediment
Origin, derivation	Mainly point sources in the catchment area	As for lake sediment
Type of dispersion	Combination of clastic and hydromorphous	Predominantly clastic
Availability to sampling	Varying depending on sediment production rate (see Table 1)	Present in all drainage systems with a fluctuating water level
Problem of sampling	Often difficult to obtain sufficiently large samples of fine fraction	Easi to obtain a large sample. Suitable sample sites can be selected from visual inspection
Susceptibility to pollution	Strongly polluted in industrialized areas	Surficial samples can be polluted, while samples at depth may be pristine
Problems of interpretation	Interpretation is complicated by varying presence of sediment sources, contents of hydrous oxides, organic material, and pollution in the drainage area.	Essentially clastic fluvial dispersion facilitates interpretation. Soil-forming processes at sampling wite may complicate the interpretation in drainage systems with rare flood events

TABLE 2 Arithmetic mean for chemical composition of wet sieved inorganic active stream sediments (- 0.18 mm) and dry sieved overbank sediments (- 0.063).

Element/component	Stream sediment	Overbank sediment	Enrichment
SiO_2	70.13	60.10	1.16
TiO_2	1.16	1.03	1.12
$Al2O_3$	10.53	12.94	0.81
$Fe2O_3$	5.35	7.45	0.71
MnO	0.14	0.12	1.16
MgO	1.34	2.60	0.51
CaO	2.70	3.10	0.87
Na_2O	2.22	2.31	0.96
K_2O	2.08	2.21	0.94
P_2O_5	0.18	0.33	0.54
SO_2	0.03	0.06	0.50
Cr	67	96	0.67
Co	11	32	0.34
Ni	21	47	0.44
Cu	13	28	0.46
Zn	81	84	0.96
Rb	70	107	0.65
Sr	217	283	0.76
Y	44	58	0.75
Nb	717	683	1.04

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 7.2

A COMPARISON OF OVERBANK AND STREAM SEDIMENT IN A LOW SAMPLING DENSITY GEOCHEMICAL SURVEY, N.E. GREECE

Alecos DEMETRIADES

IGME, Greece

1990

CONTENTS

FIGURES

TABLES

1.0. INTRODUCTION

The Rhodope Region, which is situated in north-eastern Greece, and bordered to the north by Bulgaria and to the east by Turkey, was chosen as the most suitable test area for the WEGS Pilot Project. The surveyed region is shown in Fig. 1, and covers an area of approximately 12000 square kilometres. Forty-one sample sites were selected, thus giving a sampling density of approximately 1 sample/300 km^2, although the proposed density for the WEGS regional geochemical mapping project is 1 sample site/500 km^2. The individual cells of the square grid shown in Fig. 1 are 500 km^2 in area, so one can see the sites where extra samples were taken for the purposes of a more complete coverage of large drainage basins. Additional samples were taken from (a) near the Greek-Bulgarian border, so as to monitor the input from rivers draining Bulgaria, (b) areas with known mineralization, and (c) small drainage basins of less than 60 km^2 for comparison with active stream sediment.

In this report are presented postplots of the total element concentrations in overbank and stream sediment. It is hoped that by the Orleans meeting the complete data set will be ready for presentation. Further, a comparison is being prepared between the results of the reconnaissance stream sediment survey at a sample density of approximately 2 samples/km^2 and those of the overbank sediment pilot project.

2.0. OBJECTIVES

The main objective of this study was the comparison of overbank and stream sediment results, and an assessment of the advantages of overbank over stream sediment as a sampling medium in widely spaced drainage basin reconnaissance.

3.0. GEOLOGY AND MINERALIZATION

The Rhodope Region comprises Archaean (?) metamorphic rocks of variable composition (gneiss, schist, marble), Mesozoic phyllite, greenschist, calcareous schist and marble, Tertiary sedimentary and volcanosedimentary sequences (sandstone, shale, mudstone, acid tuff, calc-alkaline intrusives and extrusives), mafic-ultramafic suites with ophiolitic affinities, felsic intrusives (granite, granodiorite), and Quaternary to Recent sediments (Fig. 2).

The mineralization types and styles are as varied as the geology (Ashworth et al. 1988; Nesbitt et al. 1988) . The most dominant type is the polymetallic sulphide (Pb, Zn, Cu, py +/-Au, +/-Ag, +/-U), but there are occurrences of chromite, manganese, scheelite, antimony, iron, molybdenum, gold, uranium and even lignite (Fig. 3). There is evidence of mining activity from ancient to recent times.

4.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

4.1. Sampling

Forty-one overbank sediment samples, each weighing approximately 20 kilograms, were collected from large third order streams over an area of approximately 12000 square kilometres (Fig. 1). At each site the overbank sediment section was first cleaned, and then the sample was taken over the total thickness of the profile. At almost every site an active stream sediment sample was taken as well (i.e., a total of thirty-nine samples). Since, the normal stream sediment of Greek rivers is relatively coarse the finest grain sample was sought and sampled.

4.2. Sample preparation

All the samples were dried in two stages, i.e., initially in a heated room at a temperature of about 35°C, and then in a thermostatically controlled oven at a temperature of 80°C. The samples were afterwards disaggregated by a porcelain pestle and mortar, and sieved to the -240 mesh (-0,063 mm) fraction with a nylon screen. The whole fraction was homogenized and subsamples were placed in 125 cm^3 plastic vials.

4.3. Analytical methods

The analysis of the Greek pilot project samples, as agreed at the Hannover meeting in November 1989, was undertaken by (a) the B.G.R. (R. Hindel) for total contents of elements, (b) the N.G.U. (R.T. Ottesen) for acid and water soluble element concentrations, and (c) BRGM (I. Salpeteur) for Au determination on only the forty-one overbank samples.

4.3.1. Analysis of total element contents

At B.G.R. major and trace elements were determined on a 500 mg aliquot after hot digestion by a mixture of HF (38-40%) and $HClO_4$ (70%) acid, and analyzed by an atomic absorption spectrophotometer (Instrumentation Laboratory - IL 951 and VIDEO 22) for the following elements: Fe, Al, Ti, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, Cr, V, Mo, Be, Sr, Ba, Mn, Sc and Y. The lower detection limits of the elements in ppm were determined on a 500 mg sample weight and a 25 ml sample solution and are tabulated below, i.e.,

Fe	Al	Ti	Ca	Pb	Cu	Zn	Cd	Ni	Co
1	5	5	5	5	3	3	0.3	3	3
Li	Cr	V	Mo	Be	Sr	Ba	Mn	Sc	Y
1	1	1	1	1	1	1	1		

Gold was determined at B.R.G.M. on a 50 gm sample by A.A. graphite furnace after a tri-acid digestion (HCl, HNO_3. HF). The lower detection limit was 5 ppb and the upper 1000 ppb.

4.3.2. Analysis of hot nitric soluble elements

One gram of the minus 0.063 mm fraction was attacked by 5 ml of 7N HNO_3 at 110°C for three hours. After digestion the solution was diluted to 20.3 ml, centrifuged and decanted. Then, 1 ml of this solution was diluted with 4 ml of a reference element solution containing 20 ug/ml of Li and Y in deionized water as internal standards. The final solution thus contained 16 ug/ml of Li and Y. The elements Al, Ag, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Si, Sr, Ti, V, Zn and Zr were determined on the solution by ICP (Odegard 1980). The lower detection limits of the elements were obtained by measuring the background signal of the element line on blank samples, and then multiplying the value by 100, which is the dilution factor of the solutions. The lower detection limits of the elements in ppm are tabulated below, i.e..

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	
0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0	

4.3.3. Analysis of water soluble elements

Two grams of fine grained material (-0.062 mm) was weighed into a screw-capped plastic bottle. Afterwards 20 ml of pure water were added, the bottle was capped and shaken up and down by slow motion for two hours at a temperature of 20°C in a specially designed apparatus. The suspension was left to stand for 20 hours, and then centrifuged and decanted through a nylon filter (20 u). The solution was acidified with one drop of ultra-pure HNO3. The elements Al, Ba, Be, Ca, Cd, Co, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Si, Sr, Ti, V and Zn were finally determined on the weakly acidified solution by ICP (Odegard and Andreassen 1986). The lower detection limits of the elements in ppb are tabulated below, i.e.,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	Cu	Zn
300	100	10	4	70	20	30	500	50	1	6
Pb	Ni	Co	V	Mo	Cd	Ba	Be	Sr	Li	
90	40	20	4	10	6	25	1	1	5	

5.0. DATA TREATMENT

Exploration Data Analysis (EDA) was developed by Tukey (1977), and subsequently elaborated by Tukey and Tukey (1981) and Hoaglin et al. (1983). It was briefly mentioned in the geochemical exploration literature by Campbell (1982), Smith et al. (1982) and Howarth (1983, 1984), but was really introduced and made popular by Kurzl (1988) and Reinman et al. (in press). The application of the EDA method to regional geochemical mapping is also discussed by O' Connor et al. (1988a, 1988b).

The effective production of geochemical maps is a subject that has been discussed since the beginning of exploration geochemistry. As it has been pointed out by Kurzl (1988) there is no accepted best method and, therefore, the application of a specific method generally depends on subjective choice or available software. EDA offers through the box-plot a method for class selection, which is independent of the statistical distribution of the data, and a choice of symbols of equal size and weight. The advantages of this technique are discussed in the above mentioned references.

The GEO-EAS software package (Englund and Sparks 1988) offers an easy and practical way for plotting geochemical exploration maps by the use of EDA-plotting symbols (Tukey and Tukey 1981), which have been combined with resistant class intervals as defined by the notched box-and-whisker plot. The principles of the box plot are discussed in Appendix report 8. The GEO-EAS postplot ascribes four EDA-plotting symbols to the four quartiles of the box-plot. EDA-symbols have the advantage of giving a balanced visual impression, and avoid the subjective weighting of special types. The combination, therefore, of the resistant class selection of the box-plot and the EDA-symbols, offers an objective display of geochemical distributions. By this way only the geochemical variability is displayed, and in the comparison of element distributions in overbank and stream sediment this is what is required.

A visual representation of the quartiles of the box-plot will be found in Appendix report 8 (Figs. 3 to 20). In addition the tables (Tables 1 to 6) show the quartiles of the box-plot and other statistical parameters.

6.0. DISCUSSION

The following discussion points only to a number of features in the element distribution of the two sampling media (overbank and stream sediment) as derived from three different analytical methods (total, hot nitric acid and water extractable). A thorough evaluation of the data set in relation to (a) geology, (b) mineralization, and (c) anthropogenic pollution is, of course, necessary and will be made in due course. Simplified geological (Fig. 2) and mineral prospects (Fig. 3) maps are included for interpretation purposes.

The anomalous concentrations of Pb (Fig. 8), Cu (Fig. 9), Zn (Fig. 10), Cd (Fig. 11), and Mo (Fig. 17) show generally mineralization. Other elements such as Al (Fig. 5), Ti (Fig. 6), Ca (Fig. 7), Ni (Fig. 12), Co (Fig. 13), Li (Fig. 14), Cr (Fig. 15), V (Fig. 16), Be (Fig. 18), Sr (Fig. 19), Ba (Fig. 20), Sc (Fig. 22), and Y (Fig. 23) are more related to the lithology. Elements such as Fe (Fig. 4) and Mn (Fig. 21) show both mineralization and lithological features.

Chromium (Fig. 15), Co (Fig. 13), Ni (Fig. 12) and V indicate the mafic and ultramafic sequences, whereas Be (Fig. 18) and Li (Fig. 14) show more the granitic rocks.

Anthropogenic pollution is indicated by the ore elements Pb (Fig. 8), Cu (Fig. 9), Zn (Fig. 10) and Cd (Fig. 11). The pollution is more evident in the stream sediment samples.

7.0. CONCLUSION

Both sampling media should be used in the proposed widely spaced drainage reconnaissance survey for the geochemical mapping of Western Europe, because the two data sets complement each other. Stream sediment is apparently more susceptible to anthropogenic pollution than overbank sediment.

ACKNOWLEDGEMENTS

I sincerely thank Roland Hindel (BGR), R.T. Ottesen (NGU) and I. Salpeteur (BRGM) for the analysis of the overbank and stream sediment samples. I also extend my thanks to the IGME General Director, Dr. V. Andronopoulos, and the Director of the Division of Exloration Geochemistry, Mr. C. Kouvelos, for their support. Finally, I thank D. Sgouros and E. Vasiliadis for their help with computer programs, N. Chrapalos, D. Voulgaroudis and C. Letsios for the computer entry of data; C. Kouvara for the drafting of maps, and G. Karianakis and his staff for the photographic reduction of maps and diagrams.

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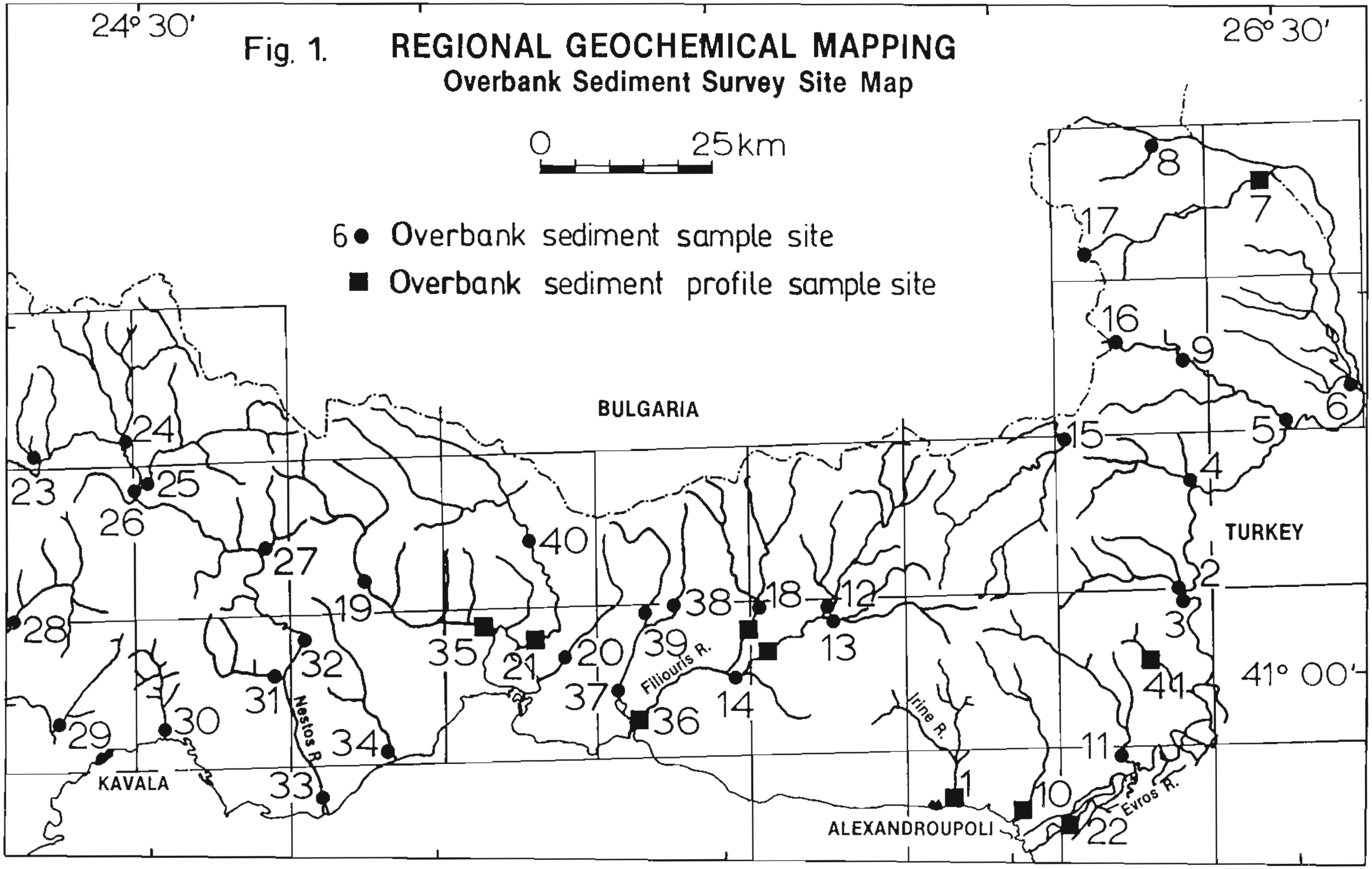


Fig. 1. REGIONAL GEOCHEMICAL MAPPING
Overbank Sediment Survey Site Map

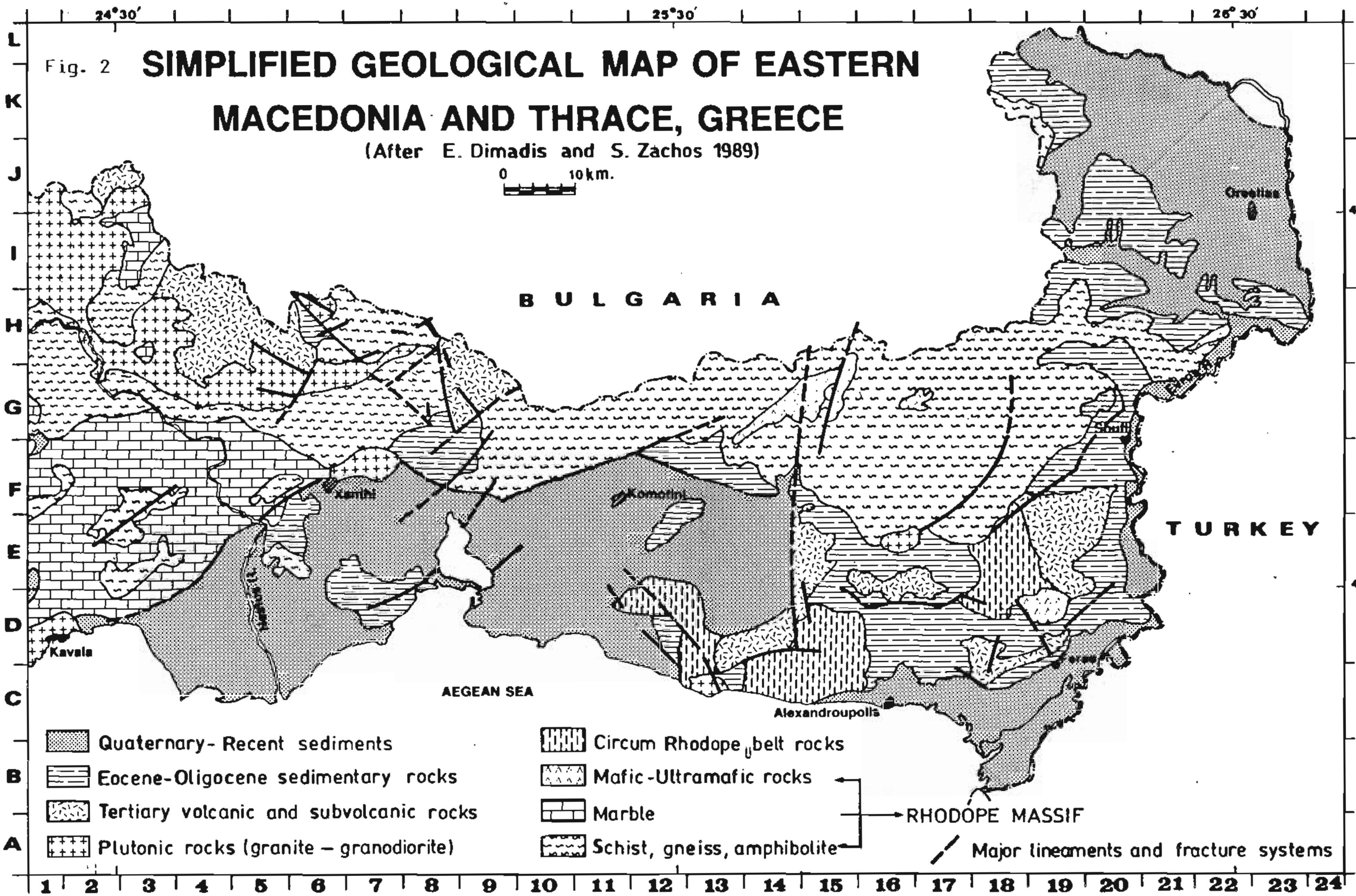
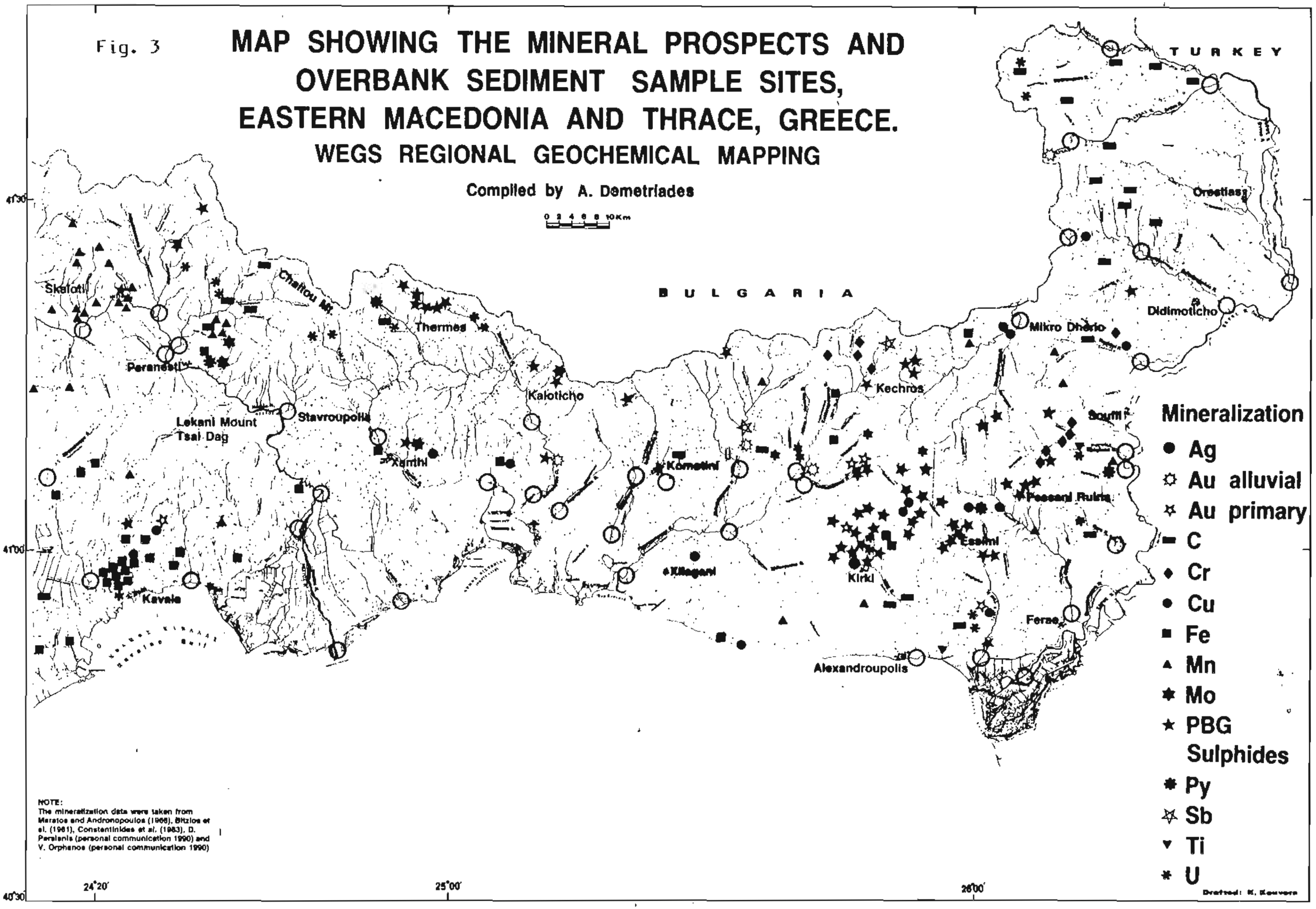


Fig. 2 **SIMPLIFIED GEOLOGICAL MAP OF EASTERN MACEDONIA AND THRACE, GREECE**

(After E. Dimadis and S. Zachos 1989)

Fig. 3



MAP SHOWING THE MINERAL PROSPECTS AND OVERBANK SEDIMENT SAMPLE SITES, EASTERN MACEDONIA AND THRACE, GREECE.

WEGS REGIONAL GEOCHEMICAL MAPPING

Compiled by A. Demetriades

NOTE:
The mineralization data were taken from Maratos and Andronopoulos (1966), Bitzios et al. (1961), Constantinides et al. (1983), D. Persianis (personal communication 1990) and V. Orphanos (personal communication 1990)

Fig. 4. Postplot of total Fe in the −0.063 mm fraction of overbank sediments, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)

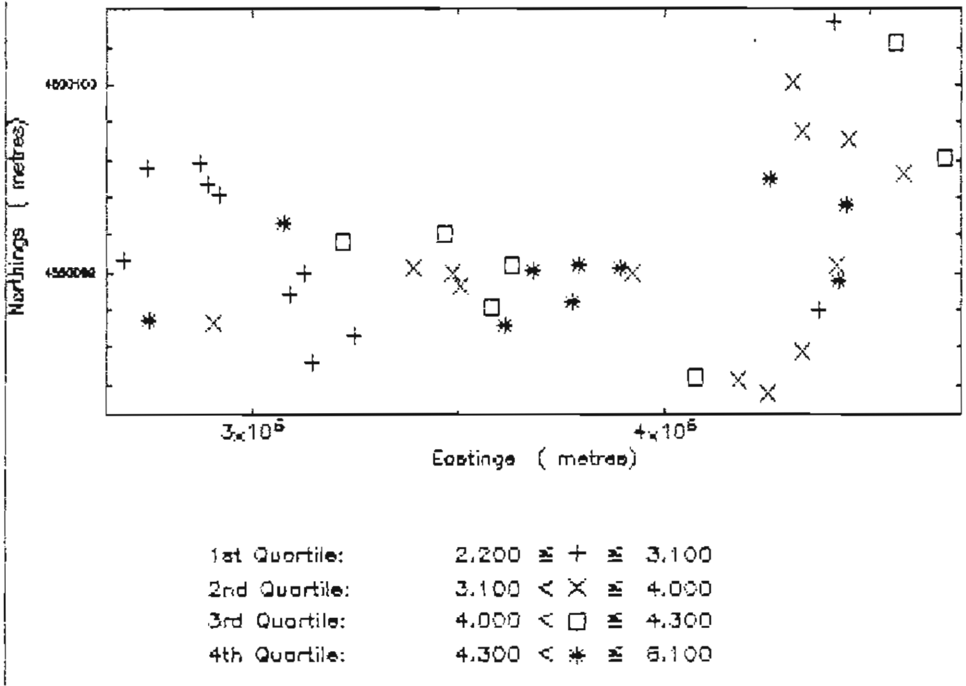


Fig. 4a. Postplot of total Fe in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)

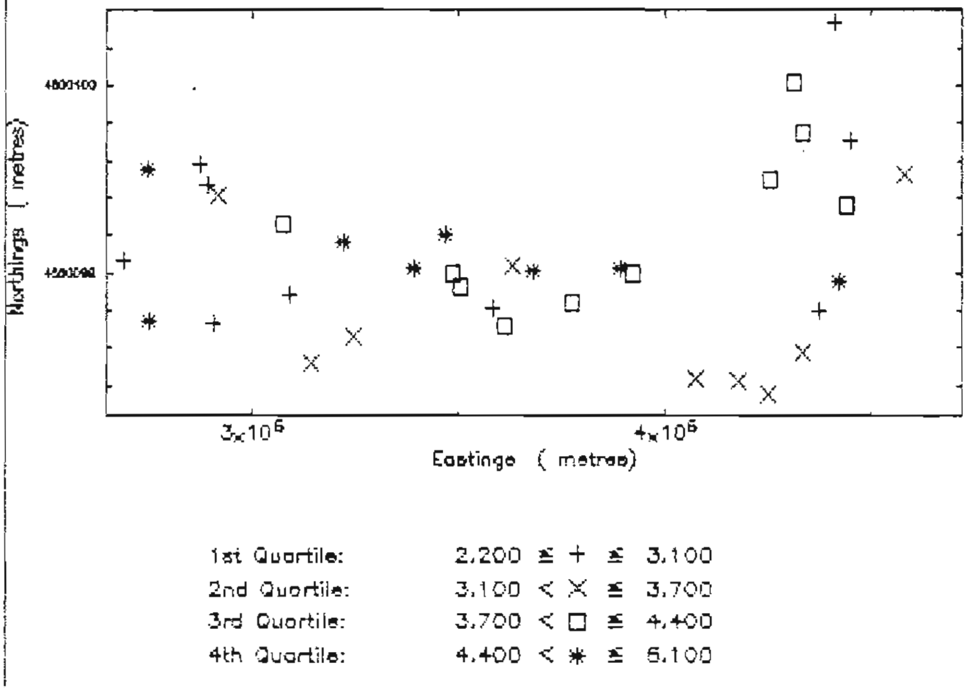
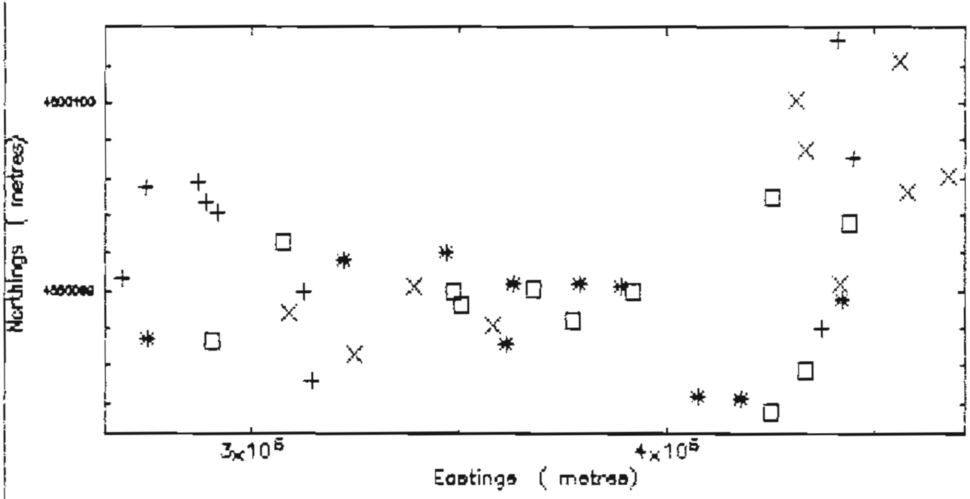
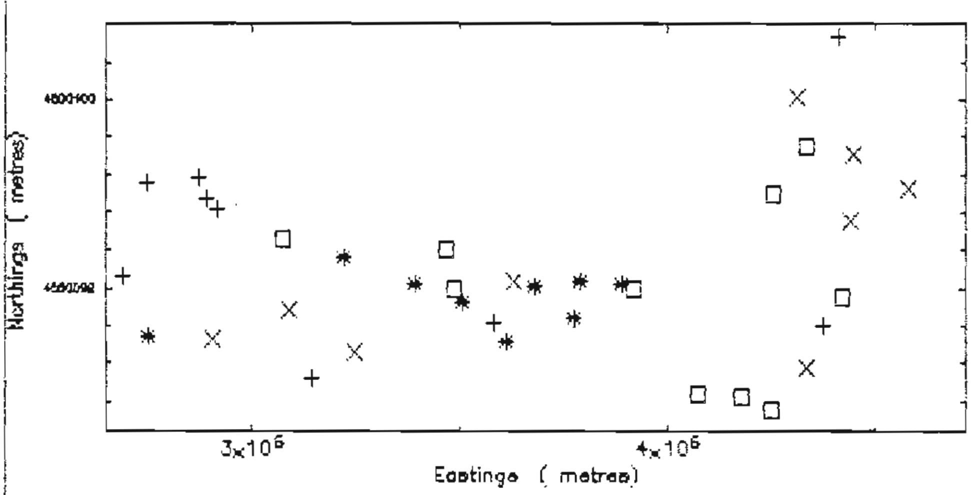


Fig. 4b. Postplot of hot nitric acid soluble Fe (pct) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



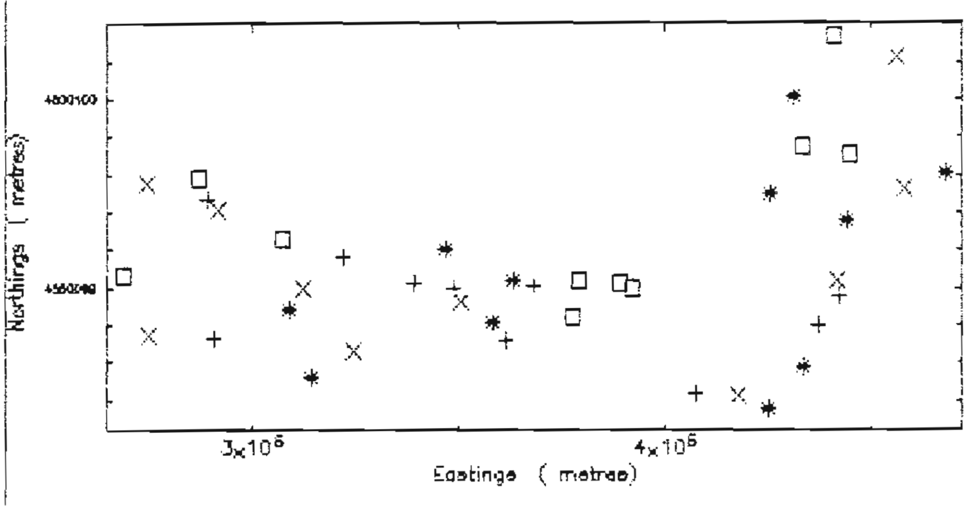
1st Quartile: 1.410 ≤ + ≤ 1.880
2nd Quartile: 1.880 < × ≤ 2.490
3rd Quartile: 2.490 < □ ≤ 2.900
4th Quartile: 2.900 < ✳ ≤ 3.970

Fig. 4c. Postplot of hot nitric acid soluble Fe (pct) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



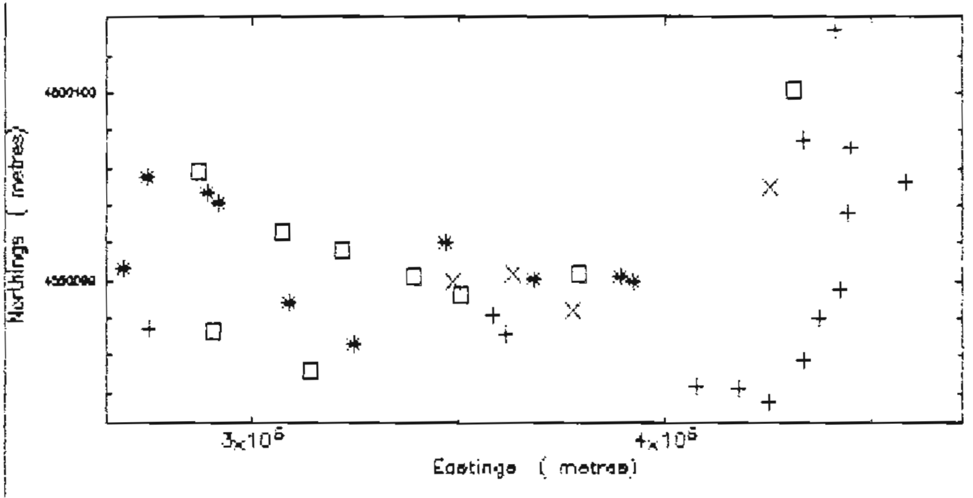
1st Quartile: 1.360 ≤ + ≤ 2.010
2nd Quartile: 2.010 < × ≤ 2.570
3rd Quartile: 2.570 < □ ≤ 3.330
4th Quartile: 3.330 < ✳ ≤ 4.540

Fig. 4d. Postplot of water soluble Fe (pct) in the
0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



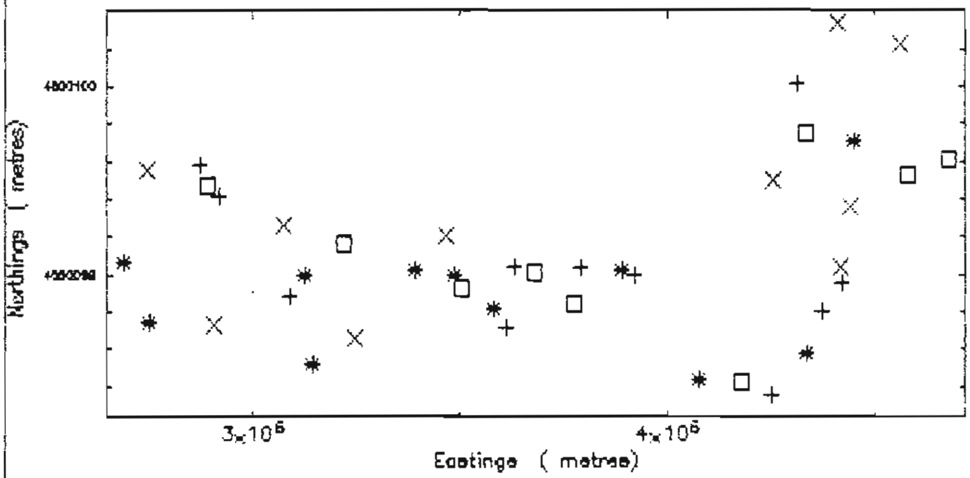
1st Quartile: .000 ≤ + ≤ .001
2nd Quartile: .001 < X ≤ .001
3rd Quartile: .001 < □ ≤ .002
4th Quartile: .002 < ✱ ≤ .007

Fig. 4e. Postplot of water soluble Fe (pct) in the
−0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



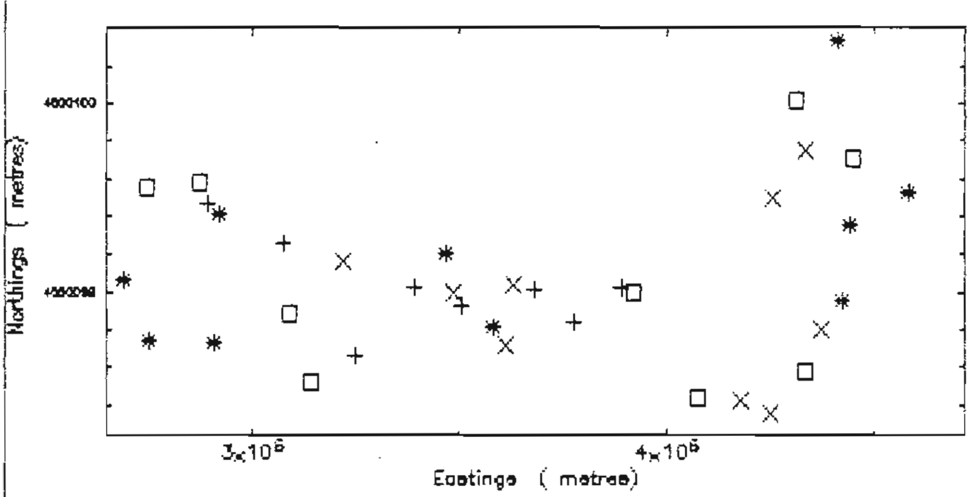
1st Quartile: .000 ≤ + ≤ .000
2nd Quartile: .000 < X ≤ .000
3rd Quartile: .000 < □ ≤ .000
4th Quartile: .000 < ✱ ≤ .005

Fig. 5. Postplot of total Al in the −0.063 mm fraction of overbank sediments, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 3.400 ≦ + ≦ 5.200
2nd Quartile: 5.200 < X ≦ 5.700
3rd Quartile: 5.700 < ☐ ≦ 6.200
4th Quartile: 6.200 < ✱ ≦ 7.600

Fig. 5a. Postplot of total Al in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 4.000 ≦ + ≦ 4.800
2nd Quartile: 4.800 < X ≦ 5.400
3rd Quartile: 5.400 < ☐ ≦ 6.200
4th Quartile: 6.200 < ✱ ≦ 7.700

Fig. 5b. Postplot of hot nitric acid soluble Al (pct) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

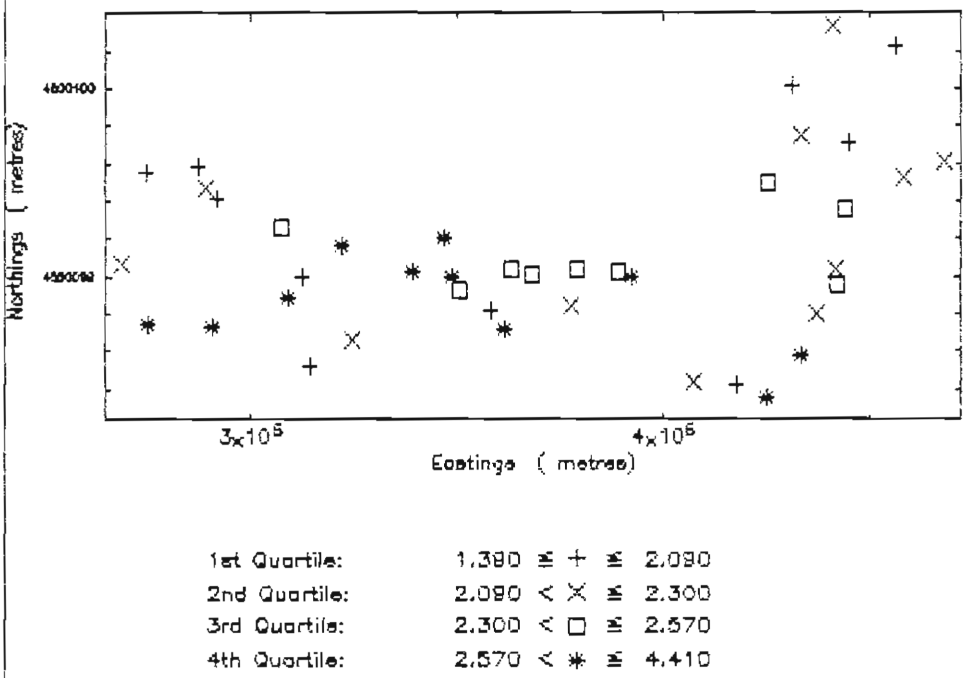


Fig. 5c. Postplot of hot nitric acid soluble Al (pct) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

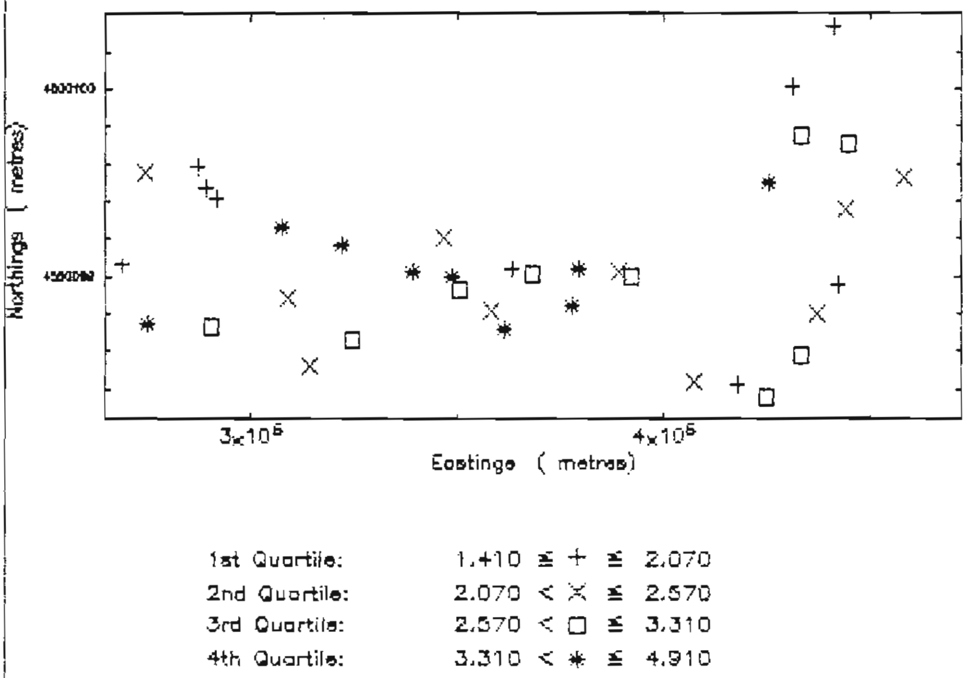
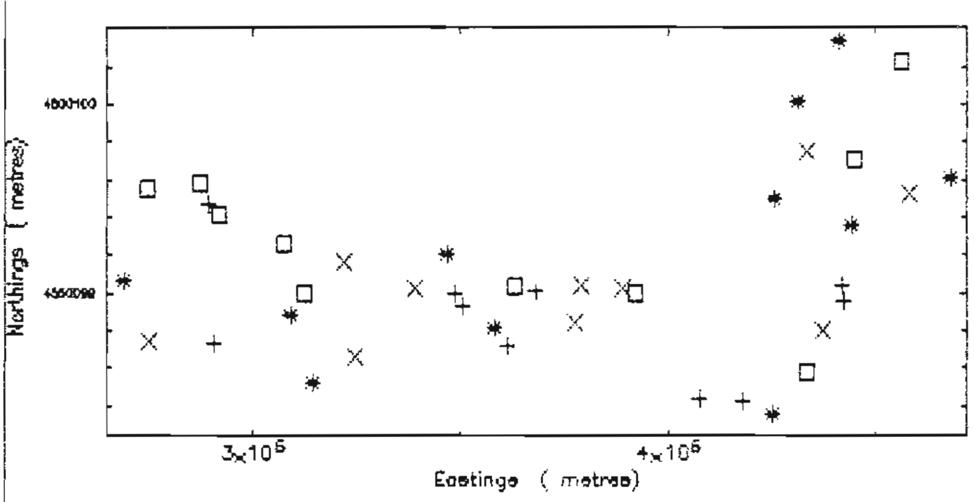
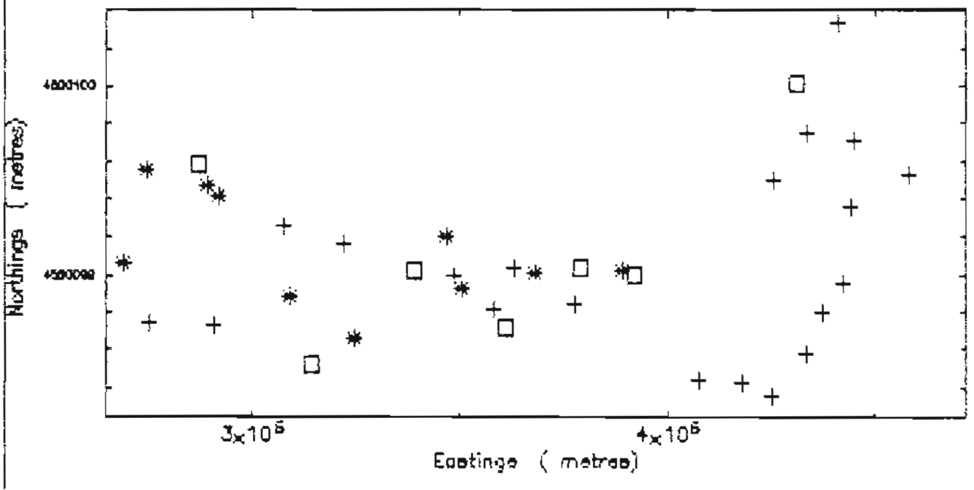


Fig. 5d. Postplot of water soluble Al (pct) in the
0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



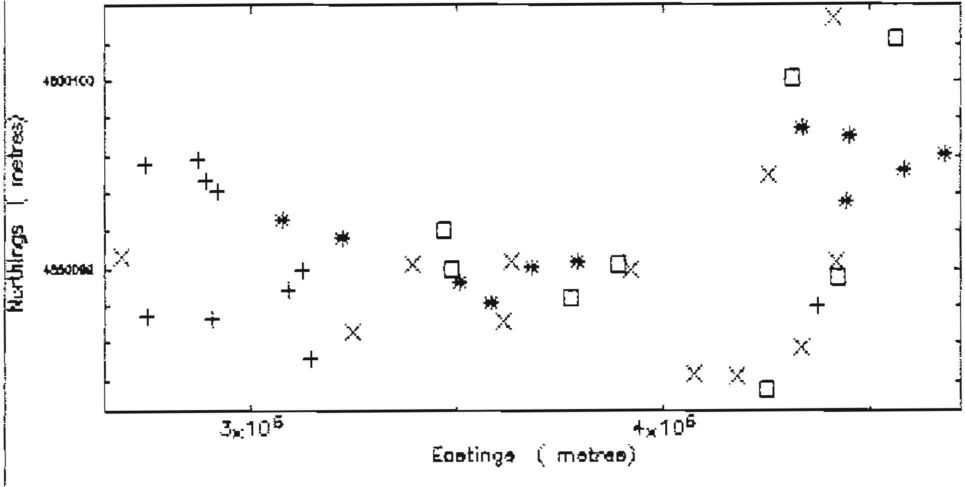
1st Quartile: .000 ≤ + ≤ .001
2nd Quartile: .001 < × ≤ .001
3rd Quartile: .001 < □ ≤ .002
4th Quartile: .002 < ✱ ≤ .010

Fig. 5e. Postplot of water soluble Al (pct) in the
-0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



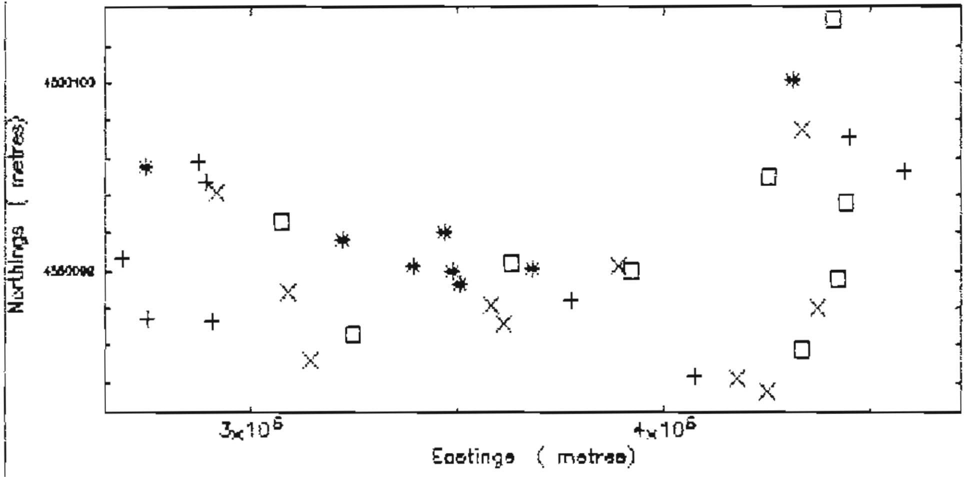
1st Quartile: .000 ≤ + ≤ .000
2nd Quartile: .000 < × ≤ .000
3rd Quartile: .000 < □ ≤ .000
4th Quartile: .000 < ✱ ≤ .008

Fig. 6. Postplot of total Ti in the −0.063 mm fraction of overbank sediments, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



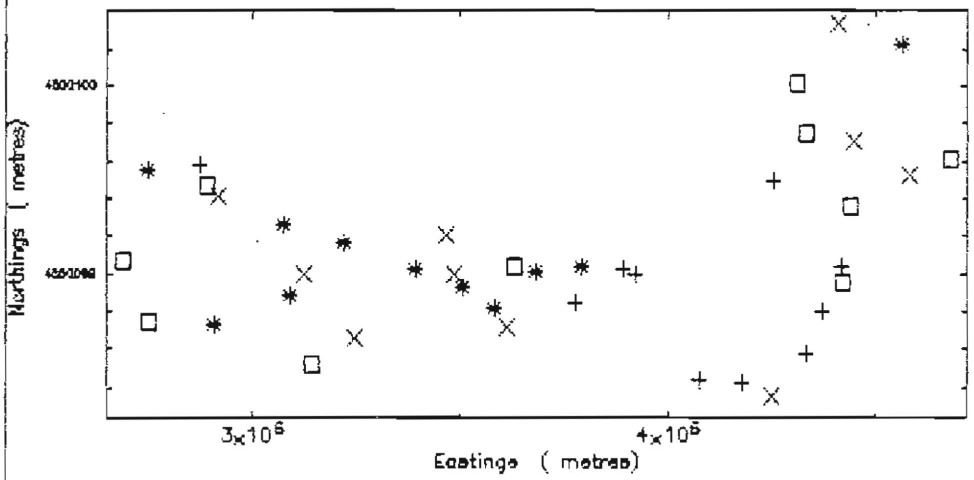
1st Quartile: .330 ≤ + ≤ .440
2nd Quartile: .440 < × ≤ .510
3rd Quartile: .510 < □ ≤ .560
4th Quartile: .560 < ✳ ≤ .730

Fig. 6a. Postplot of total Ti in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



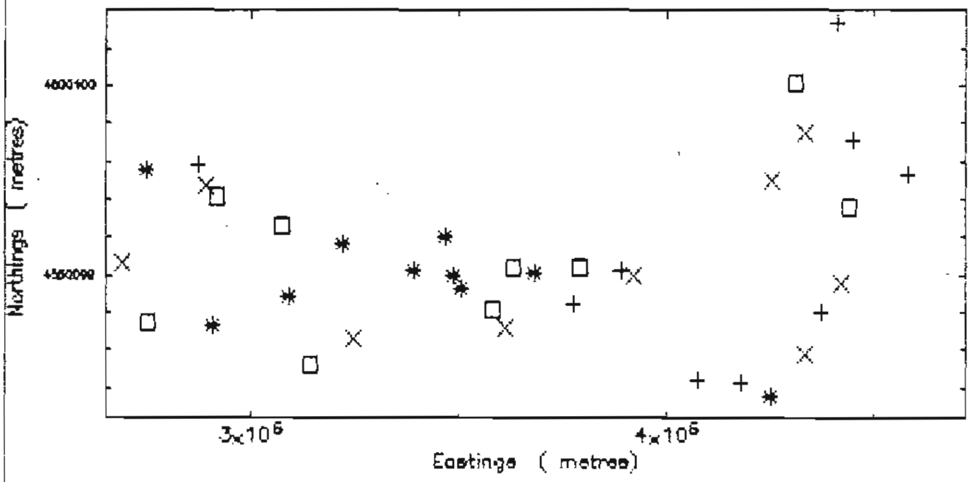
1st Quartile: .260 ≤ + ≤ .390
2nd Quartile: .390 < × ≤ .460
3rd Quartile: .460 < □ ≤ .520
4th Quartile: .520 < ✳ ≤ .720

Fig. 6b. Postplot of hot nitric acid soluble Ti (pct) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



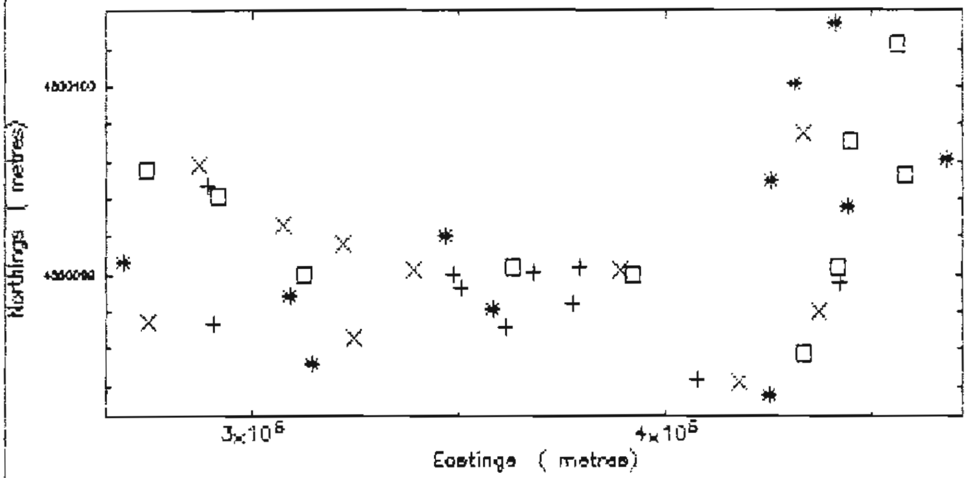
1st Quartile: .009 ≤ + ≤ .060
2nd Quartile: .060 < X ≤ .084
3rd Quartile: .084 < □ ≤ .100
4th Quartile: .100 < ✱ ≤ .220

Fig. 6c. Postplot of hot nitric acid soluble Ti (pct) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



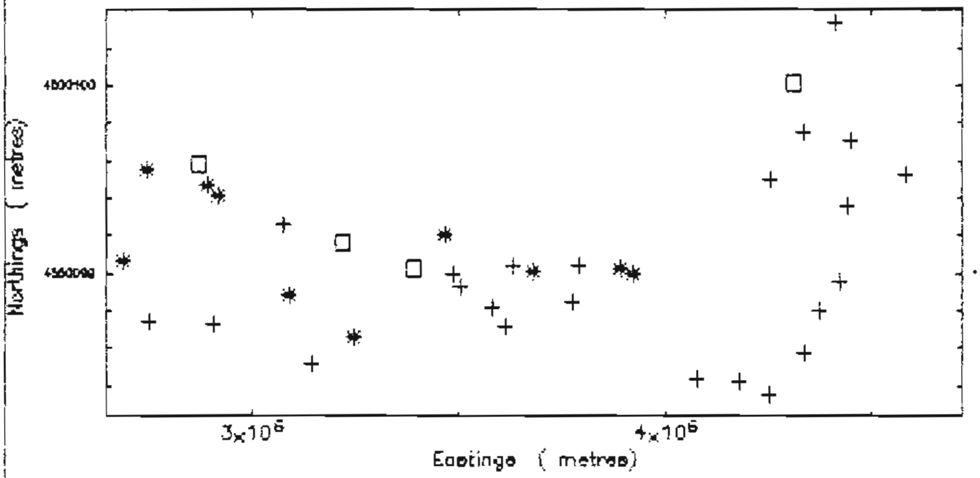
1st Quartile: .002 ≤ + ≤ .046
2nd Quartile: .046 < X ≤ .068
3rd Quartile: .068 < □ ≤ .094
4th Quartile: .094 < ✱ ≤ .170

Fig. 6d. Postplot of water soluble Ti (pct) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



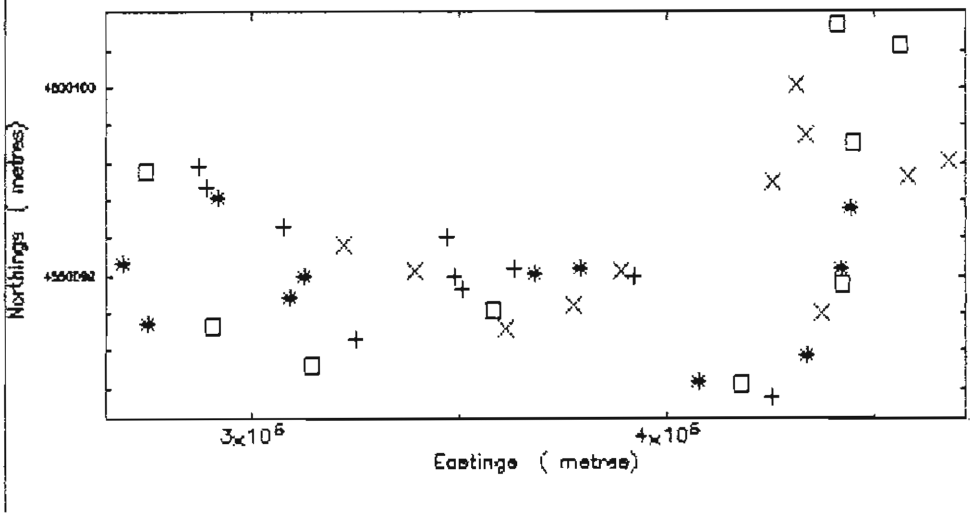
1st Quartile: .000 ≤ + ≤ .000
2nd Quartile: .000 < × ≤ .000
3rd Quartile: .000 < □ ≤ .001
4th Quartile: .001 < ✳ ≤ .007

Fig. 6e. Postplot of water soluble Ti (pct) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



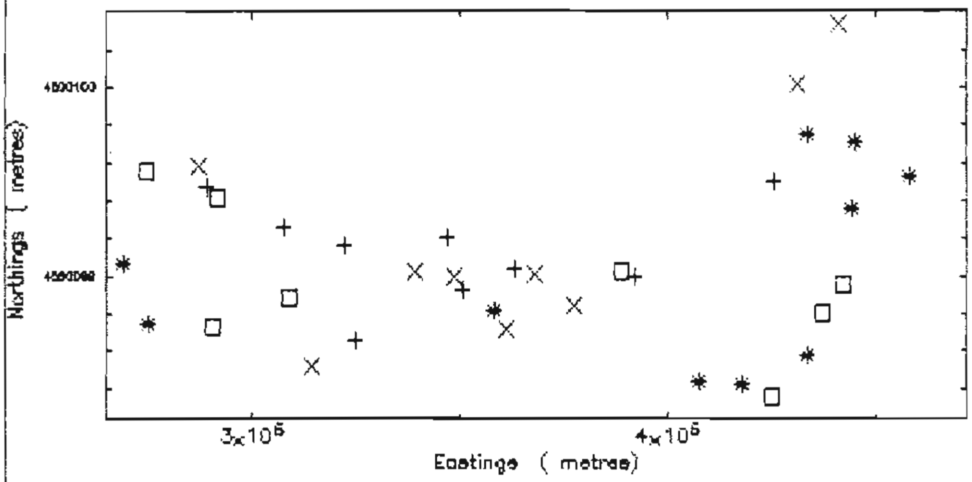
1st Quartile: .040 ≤ + ≤ .040
2nd Quartile: .040 < × ≤ .040
3rd Quartile: .040 < □ ≤ .097
4th Quartile: .097 < ✳ ≤ 3.860

Fig. 7. Postplot of total Ca in the −0.063 mm fraction of overbank sediments, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: .800 ≤ + ≤ 1.870
2nd Quartile: 1.870 < × ≤ 2.590
3rd Quartile: 2.590 < □ ≤ 3.220
4th Quartile: 3.220 < ✱ ≤ 7.480

Fig. 7a. Postplot of total Ca in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: .650 ≤ + ≤ 1.840
2nd Quartile: 1.840 < × ≤ 3.270
3rd Quartile: 3.270 < □ ≤ 4.360
4th Quartile: 4.360 < ✱ ≤ 12.800

Fig. 7b. Postplot of hot nitric acid soluble Ca (pct) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

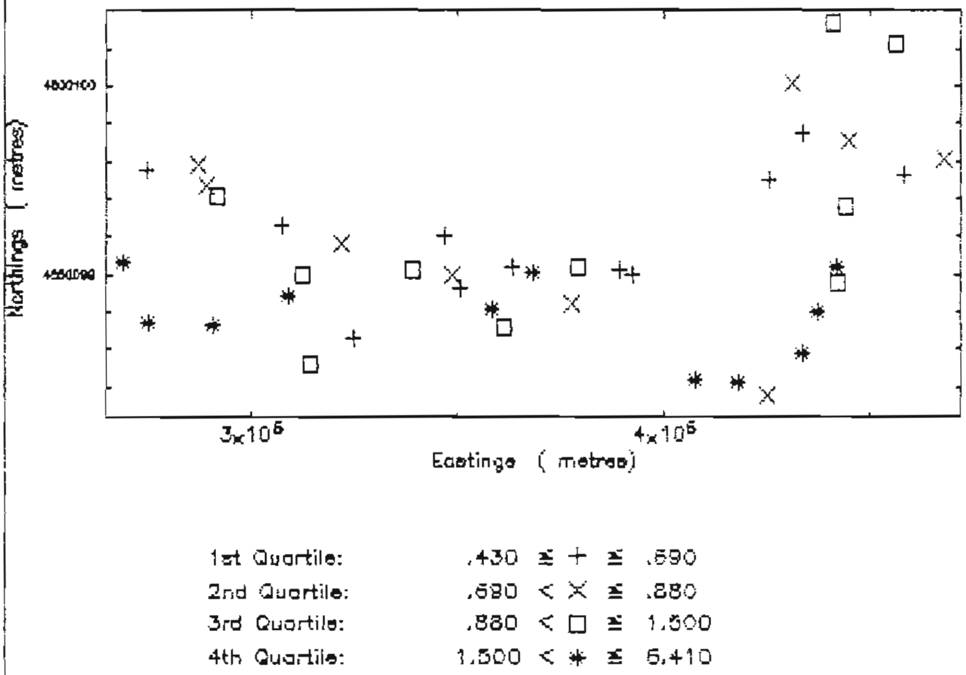


Fig. 7c. Postplot of hot nitric acid soluble Ca (pct) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

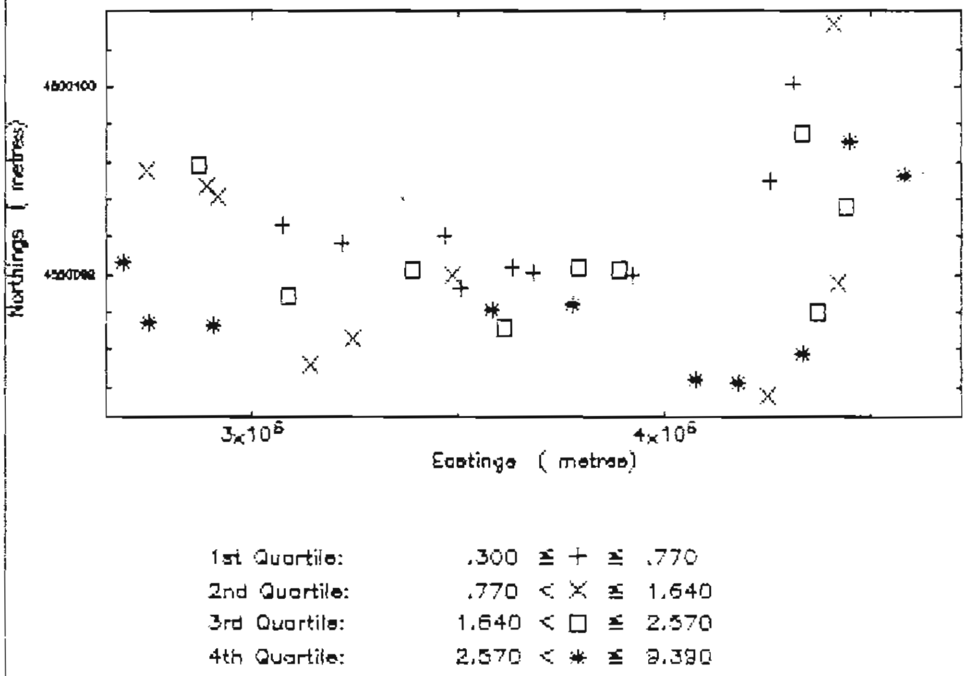
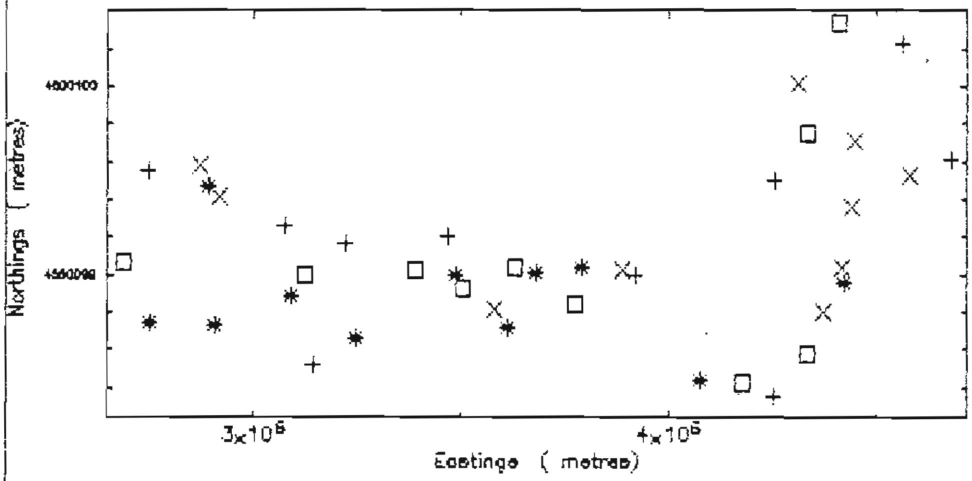
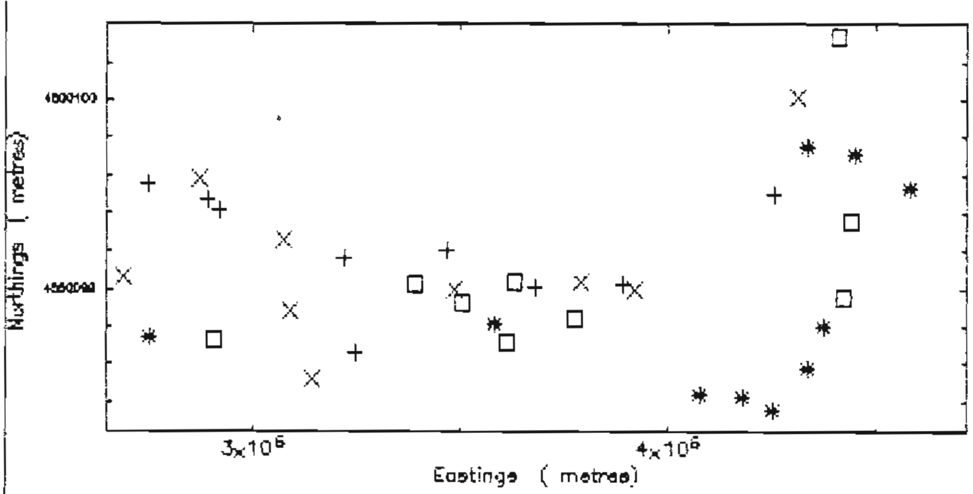


Fig. 7d. Postplot of water soluble Co (pct) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



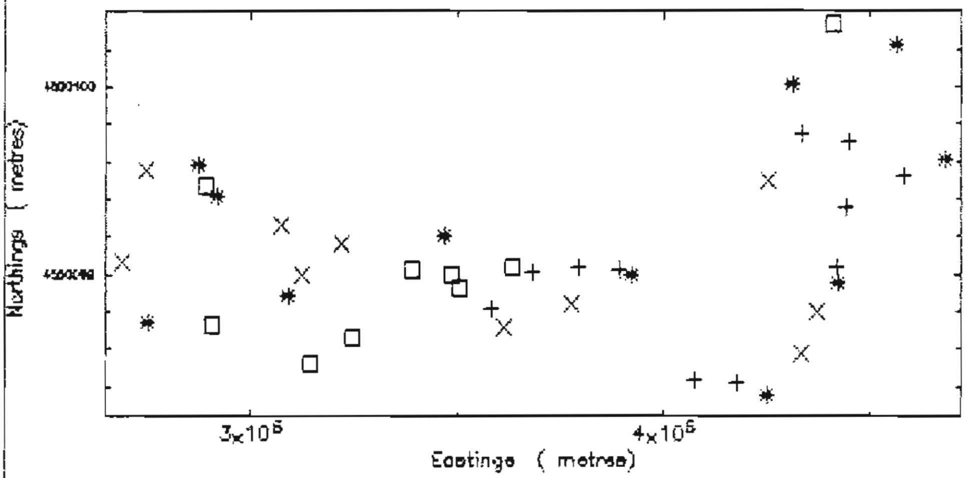
1st Quartile: .002 ≤ + ≤ .014
2nd Quartile: .014 < X ≤ .019
3rd Quartile: .019 < □ ≤ .024
4th Quartile: .024 < ✱ ≤ .100

Fig. 7e. Postplot of water soluble Co (pct) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



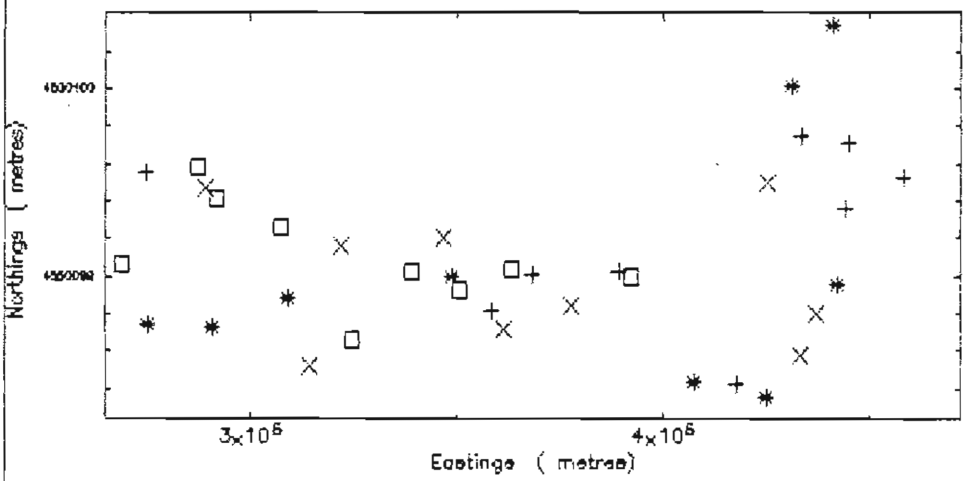
1st Quartile: .009 ≤ + ≤ .017
2nd Quartile: .017 < X ≤ .032
3rd Quartile: .032 < □ ≤ .063
4th Quartile: .063 < ✱ ≤ .120

Fig. 8. Postplot of total Pb in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



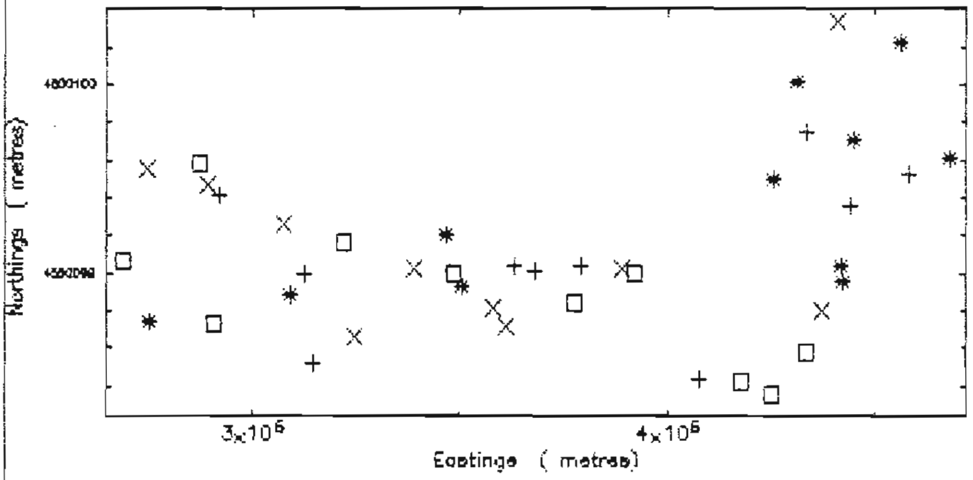
1st Quartile: 21.000 ≤ + ≤ 28.000
2nd Quartile: 28.000 < X ≤ 34.000
3rd Quartile: 34.000 < □ ≤ 42.000
4th Quartile: 42.000 < ✱ ≤ 351.000

Fig. 8a. Postplot of total Pb in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



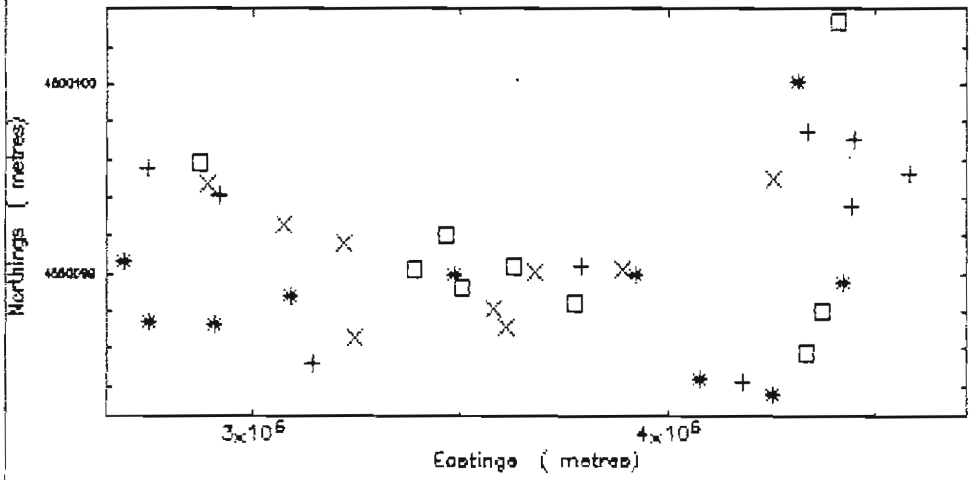
1st Quartile: 25.000 ≤ + ≤ 31.000
2nd Quartile: 31.000 < X ≤ 39.000
3rd Quartile: 39.000 < □ ≤ 46.000
4th Quartile: 46.000 < ✱ ≤ 375.000

Fig. 8b. Postplot of hot nitric acid soluble Pb (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 5.810 ≤ + ≤ 13.960
2nd Quartile: 13.960 < × ≤ 17.970
3rd Quartile: 17.970 < □ ≤ 28.350
4th Quartile: 28.350 < ✱ ≤ 423.400

Fig. 8c. Postplot of hot nitric acid soluble Pb (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 8.040 ≤ + ≤ 13.550
2nd Quartile: 13.550 < × ≤ 19.810
3rd Quartile: 19.810 < □ ≤ 27.450
4th Quartile: 27.450 < ✱ ≤ 397.700

Fig. 8d. Postplot of water soluble Pb (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

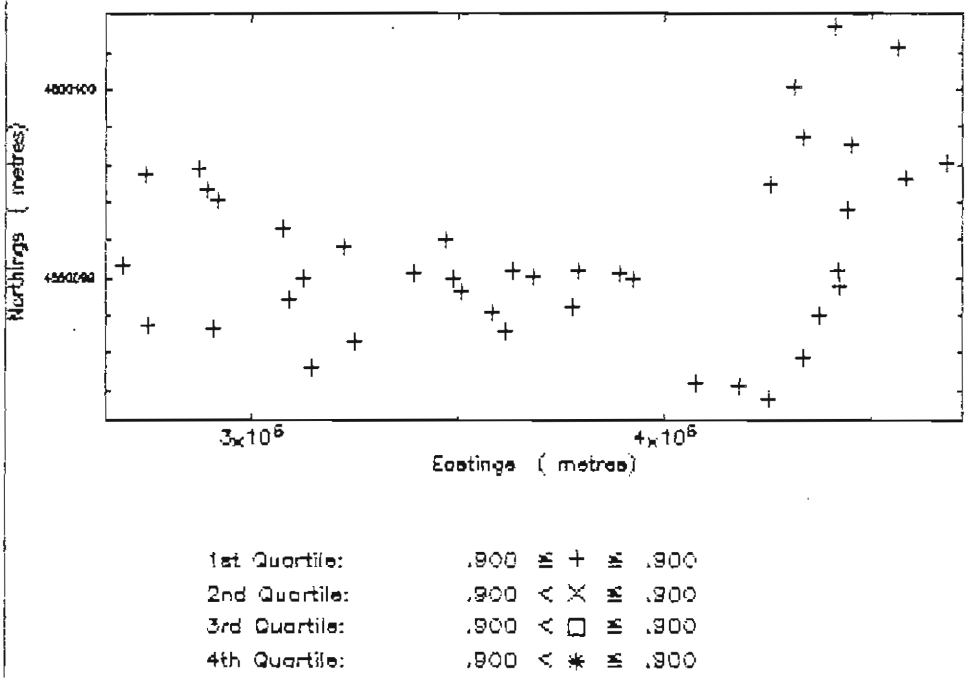


Fig. 8e. Postplot of water soluble Pb (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

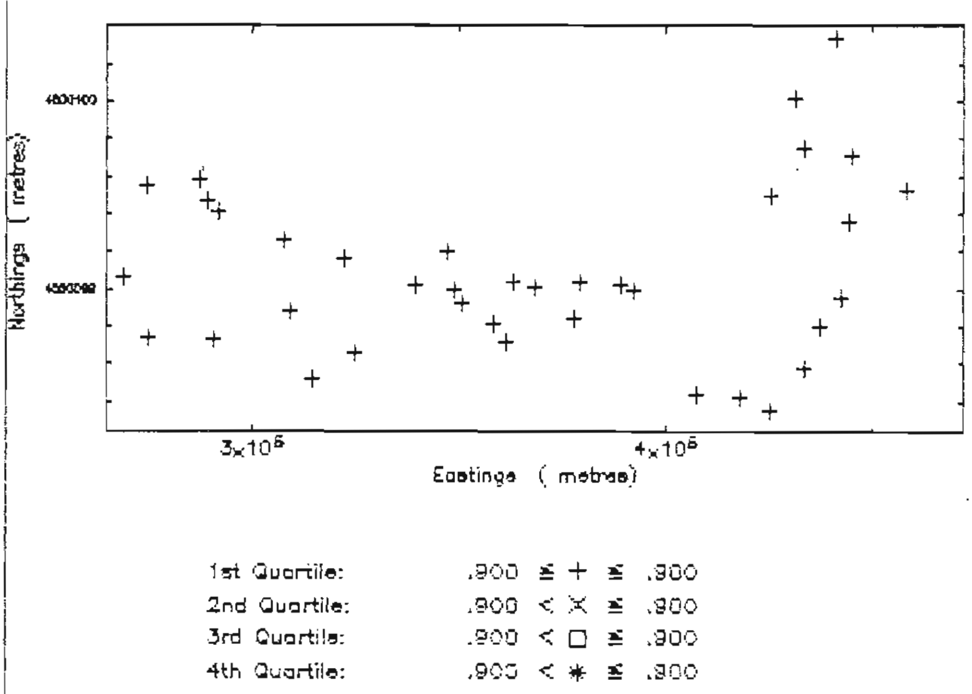
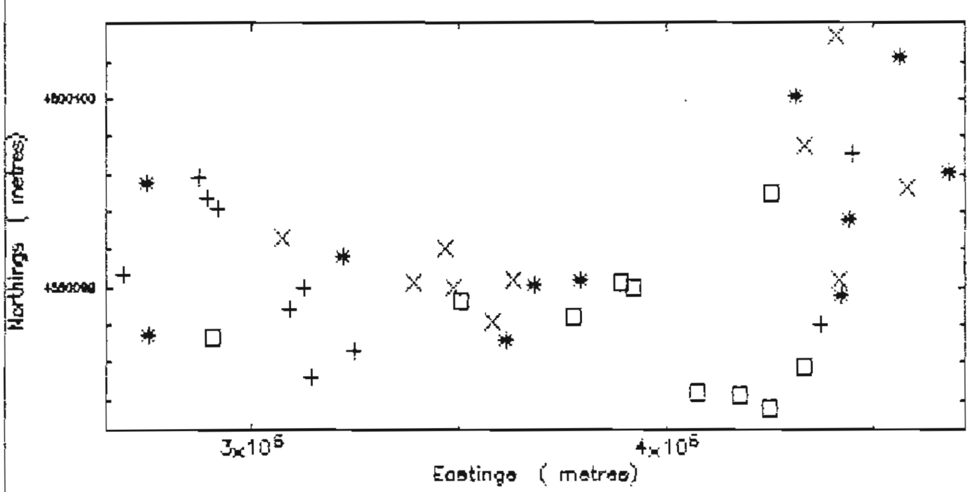
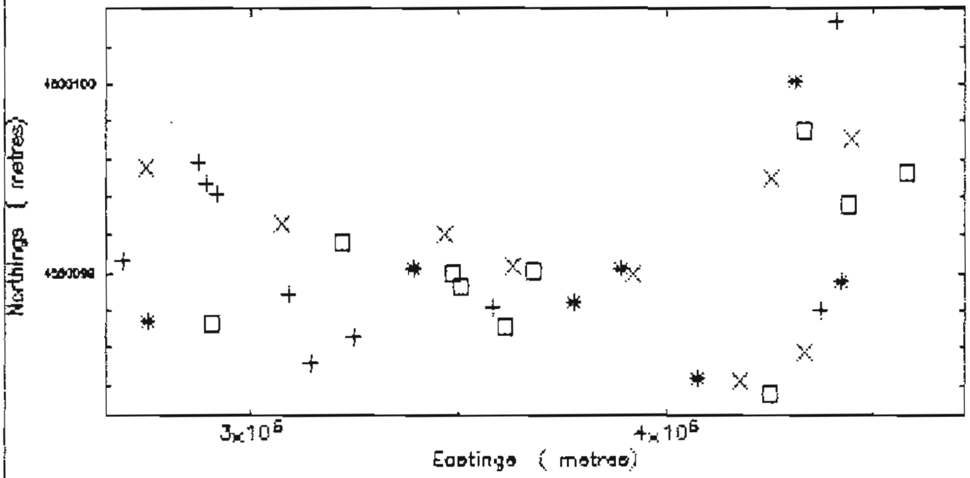


Fig. 9. Postplot of total Cu in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 10.000 ≤ + ≤ 21.000
2nd Quartile: 21.000 < X ≤ 26.000
3rd Quartile: 26.000 < □ ≤ 32.000
4th Quartile: 32.000 < ✳ ≤ 93.000

Fig. 9a. Postplot of total Cu in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 11.000 ≤ + ≤ 22.000
2nd Quartile: 22.000 < X ≤ 29.000
3rd Quartile: 29.000 < □ ≤ 35.000
4th Quartile: 35.000 < ✳ ≤ 112.000

Fig. 9b. Postplot of hot nitric acid soluble Cu (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

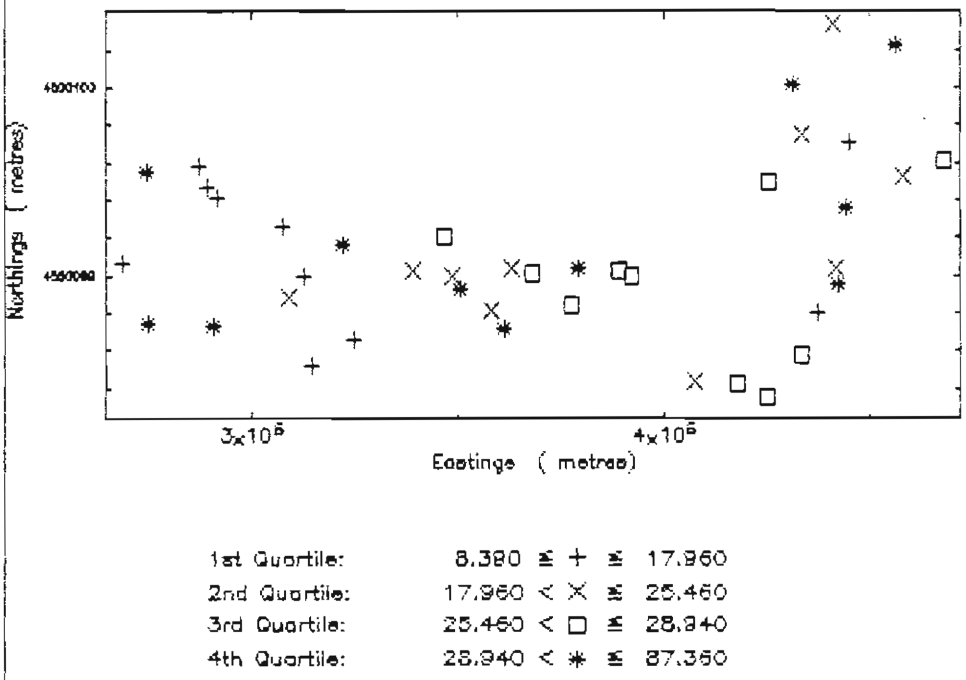


Fig. 9c. Postplot of hot nitric acid soluble Cu (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

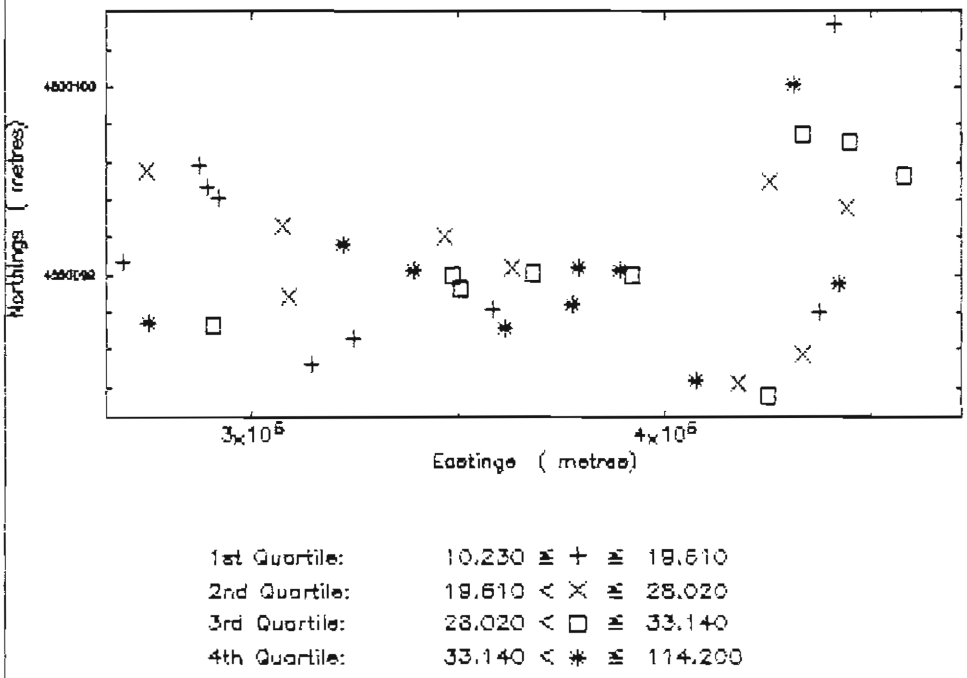


Fig. 9d. Postplot of water soluble Cu (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

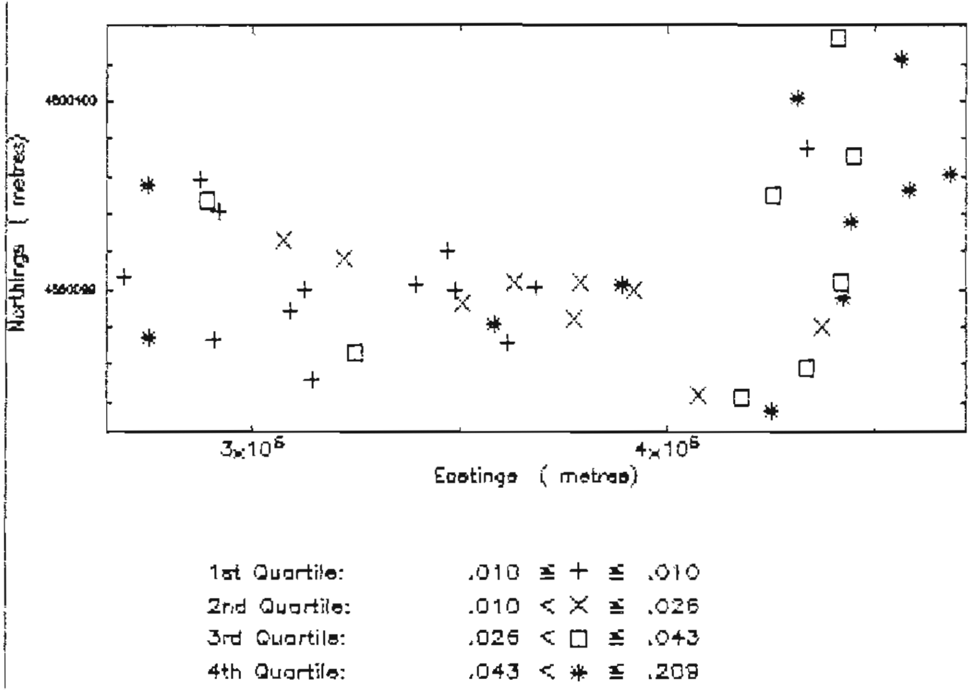


Fig. 9e. Postplot of water soluble Cu (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

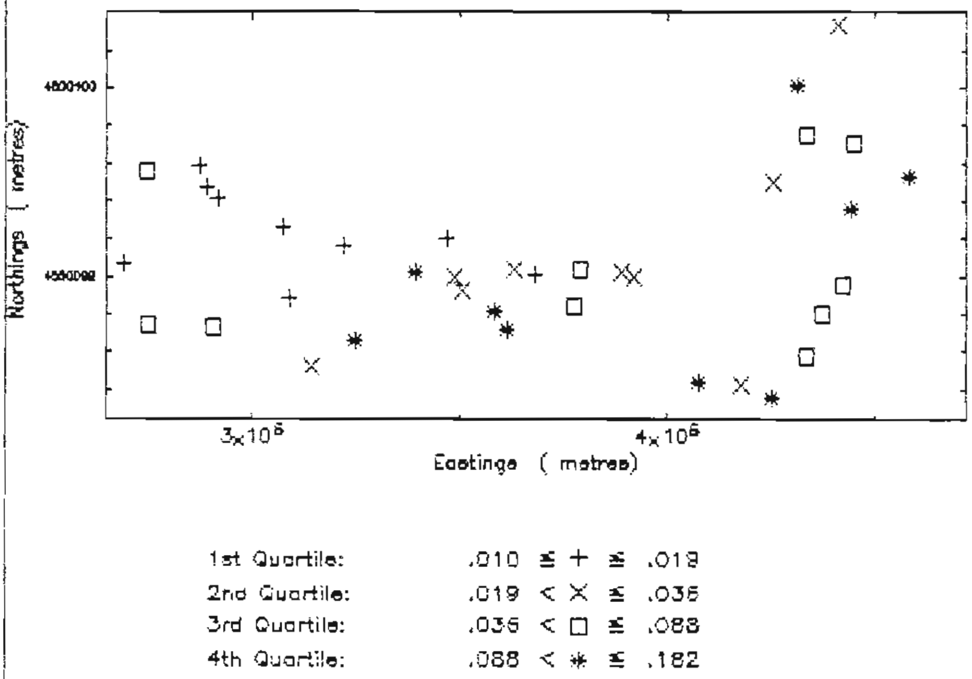


Fig. 10. Postplot of total Zn in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

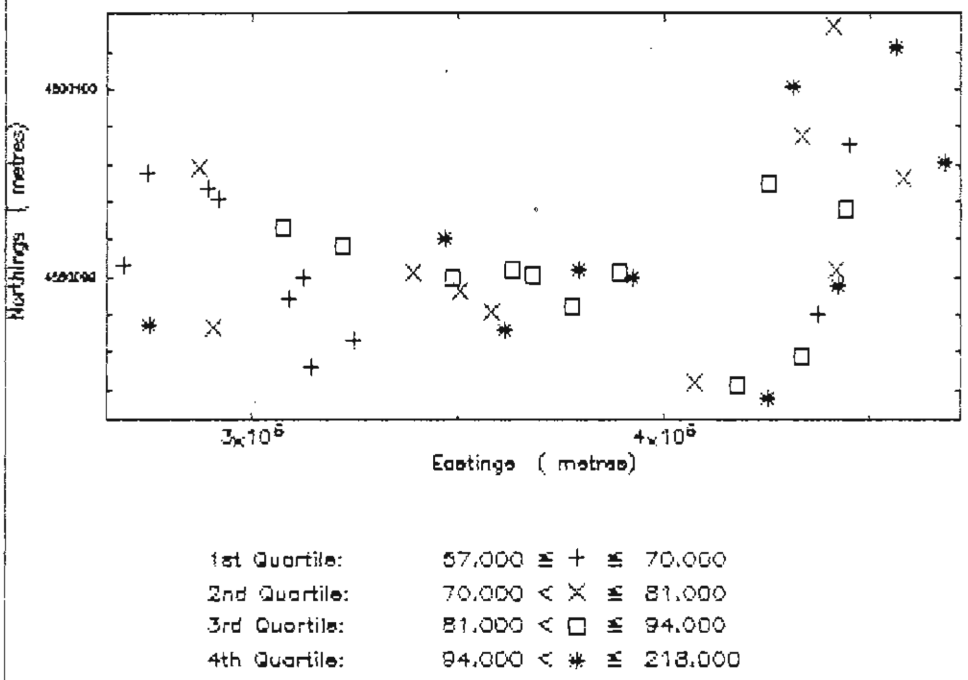


Fig. 10a. Postplot of total Zn in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

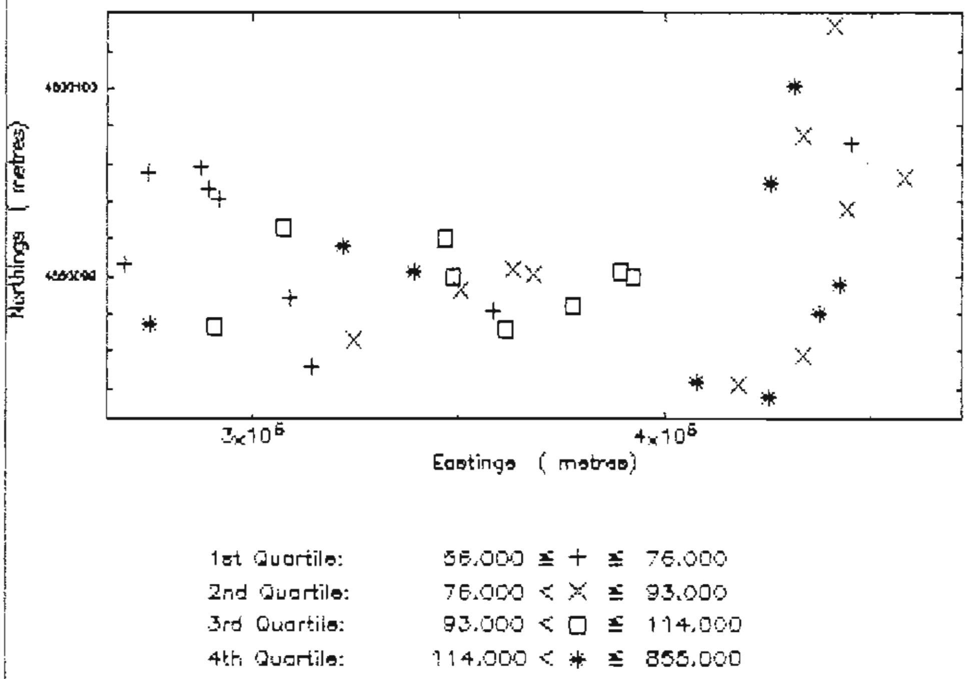
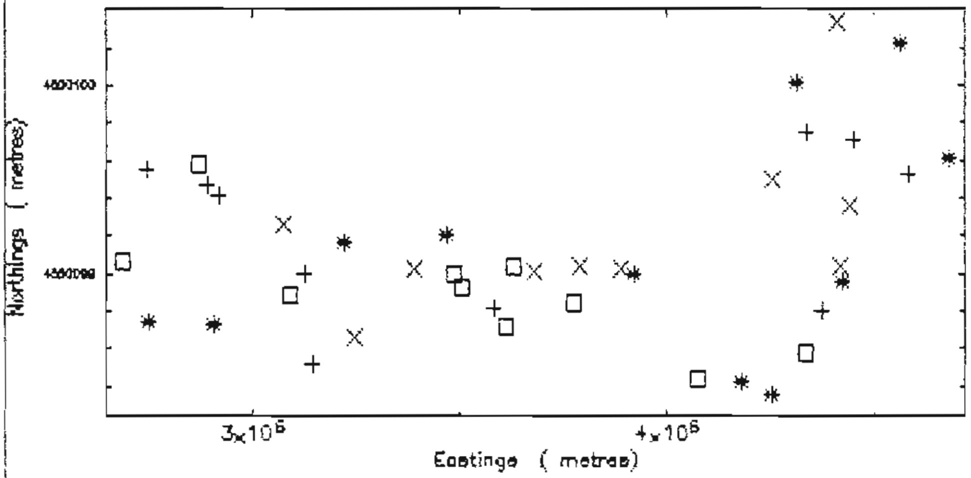
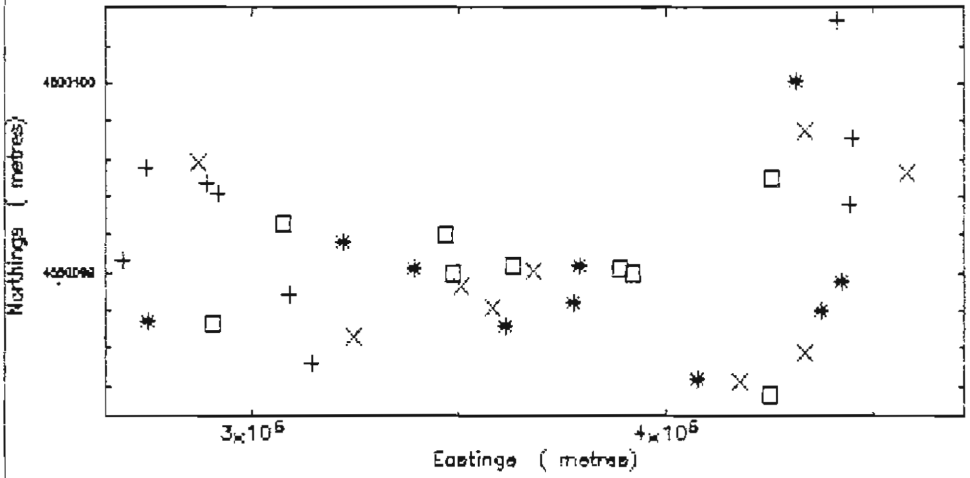


Fig. 10b. Postplot of hot nitric acid soluble Zn (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



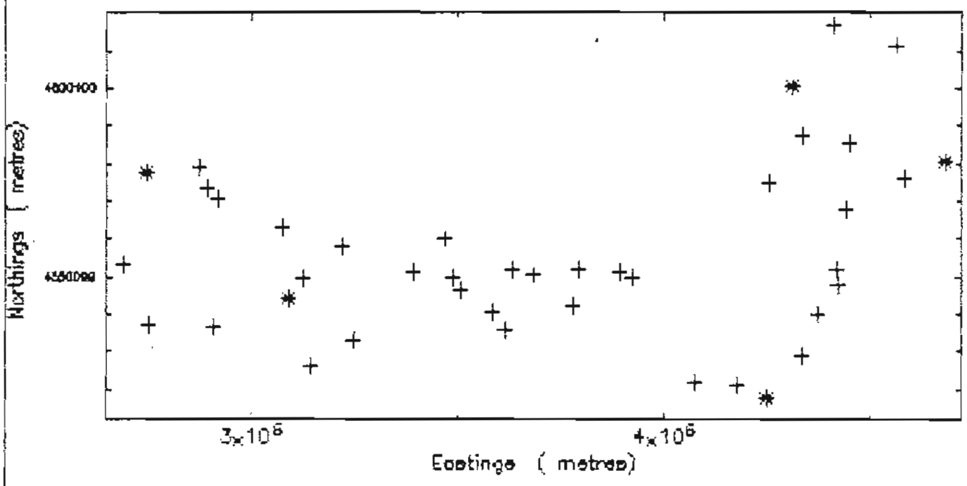
1st Quartile: 32.270 ≤ + ≤ 46.050
2nd Quartile: 46.050 < × ≤ 55.470
3rd Quartile: 55.470 < □ ≤ 64.260
4th Quartile: 64.260 < ✳ ≤ 157.600

Fig. 10c. Postplot of hot nitric acid soluble Zn (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



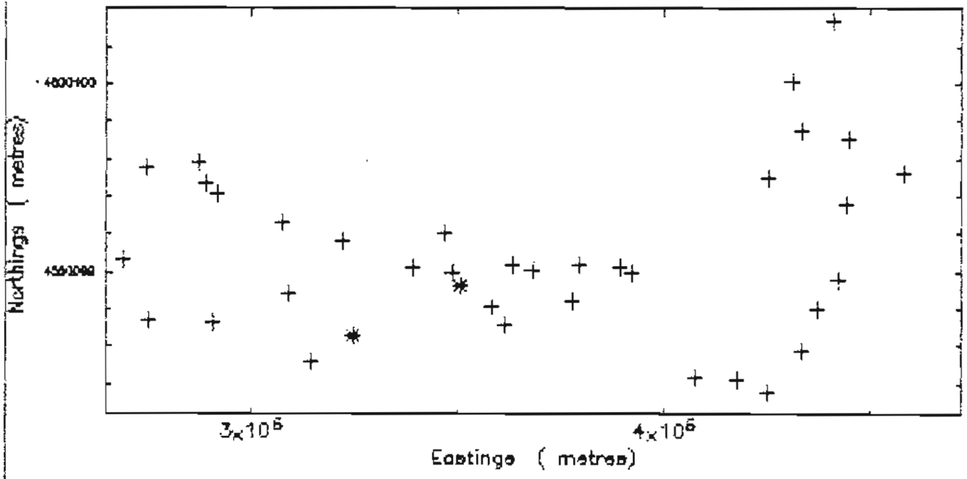
1st Quartile: 21.530 ≤ + ≤ 53.580
2nd Quartile: 53.580 < × ≤ 62.270
3rd Quartile: 62.270 < □ ≤ 77.890
4th Quartile: 77.890 < ✳ ≤ 787.300

Fig. 10d. Postplot of water soluble Zn (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



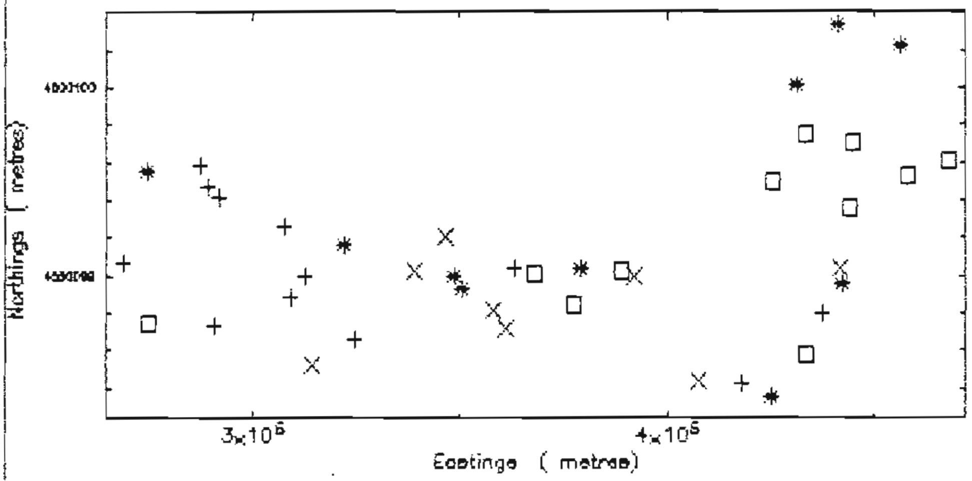
1st Quartile: .060 ≦ + ≦ .060
2nd Quartile: .060 < ✕ ≦ .060
3rd Quartile: .060 < ☐ ≦ .060
4th Quartile: .060 < ✱ ≦ .154

Fig. 10e. Postplot of water soluble Zn (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



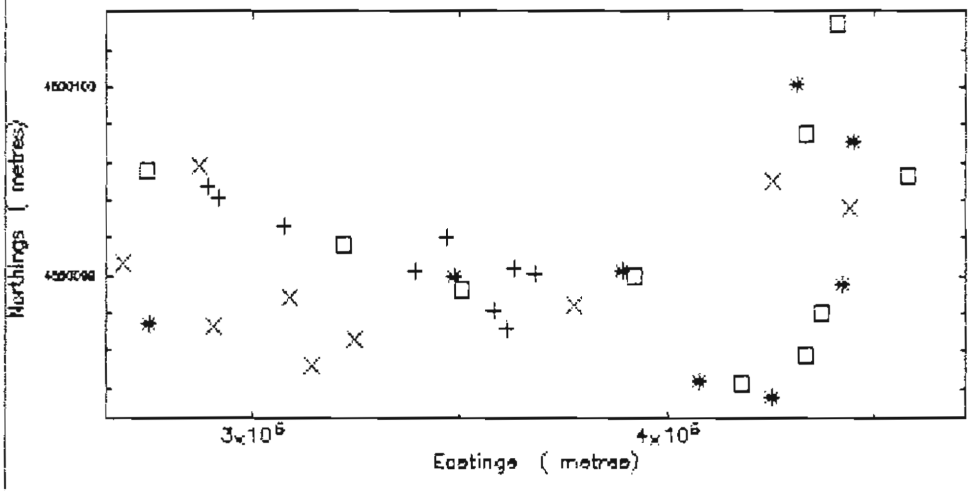
1st Quartile: .060 ≦ + ≦ .060
2nd Quartile: .060 < ✕ ≦ .060
3rd Quartile: .060 < ☐ ≦ .060
4th Quartile: .060 < ✱ ≦ .160

Fig. 11. Postplot of total Cd in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)



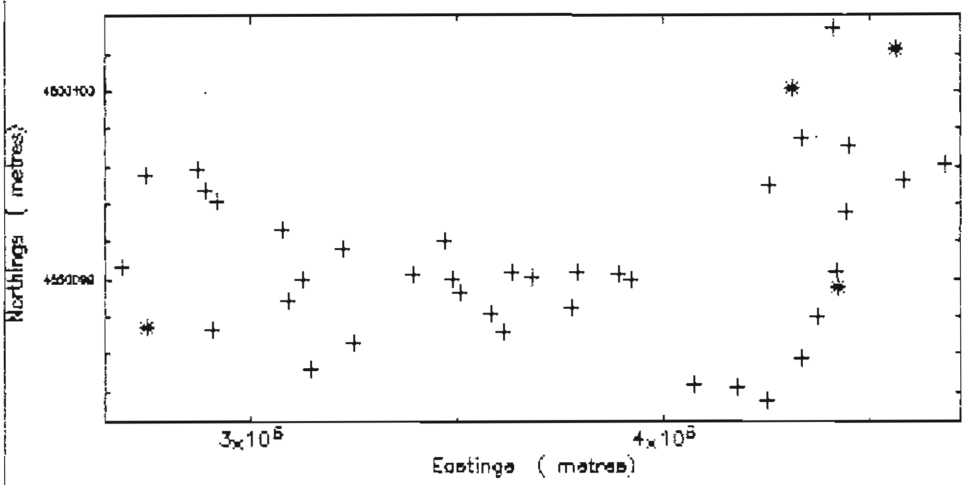
1st Quartile: 1.700 ≤ + ≤ 2.700
2nd Quartile: 2.700 < ✕ ≤ 3.000
3rd Quartile: 3.000 < □ ≤ 3.900
4th Quartile: 3.900 < ✳ ≤ 5.700

Fig. 11.a. Postplot of total Cd in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)



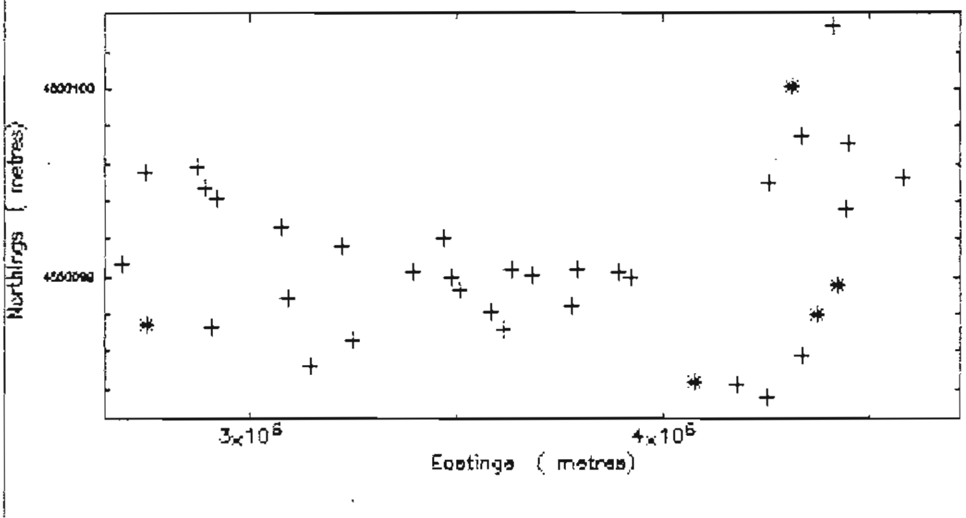
1st Quartile: 1.500 ≤ + ≤ 2.700
2nd Quartile: 2.700 < ✕ ≤ 3.500
3rd Quartile: 3.500 < □ ≤ 4.000
4th Quartile: 4.000 < ✳ ≤ 11.800

Fig. 11b. Postplot of hot nitric acid soluble Cd (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 1.000 ≤ + ≤ 1.000
2nd Quartile: 1.000 < ✕ ≤ 1.000
3rd Quartile: 1.000 < □ ≤ 1.000
4th Quartile: 1.000 < ✳ ≤ 4.650

Fig. 11c. Postplot of hot nitric acid soluble Cd (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 1.000 ≤ + ≤ 1.000
2nd Quartile: 1.000 < ✕ ≤ 1.000
3rd Quartile: 1.000 < □ ≤ 1.000
4th Quartile: 1.000 < ✳ ≤ 8.280

Fig. 11d. Postplot of water soluble Cd (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

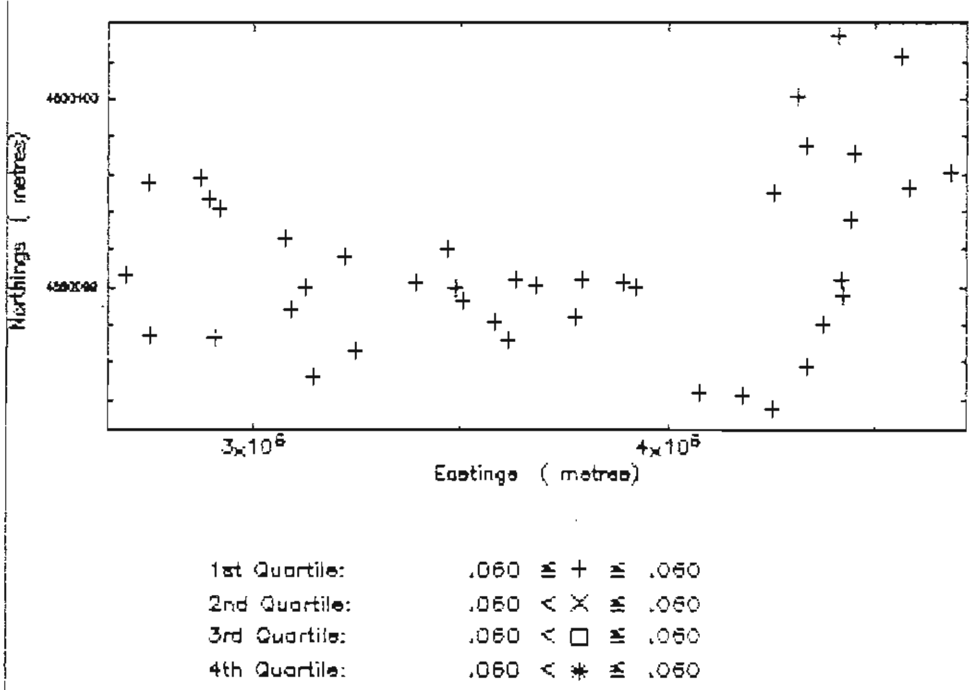


Fig. 11e. Postplot of water soluble Cd (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

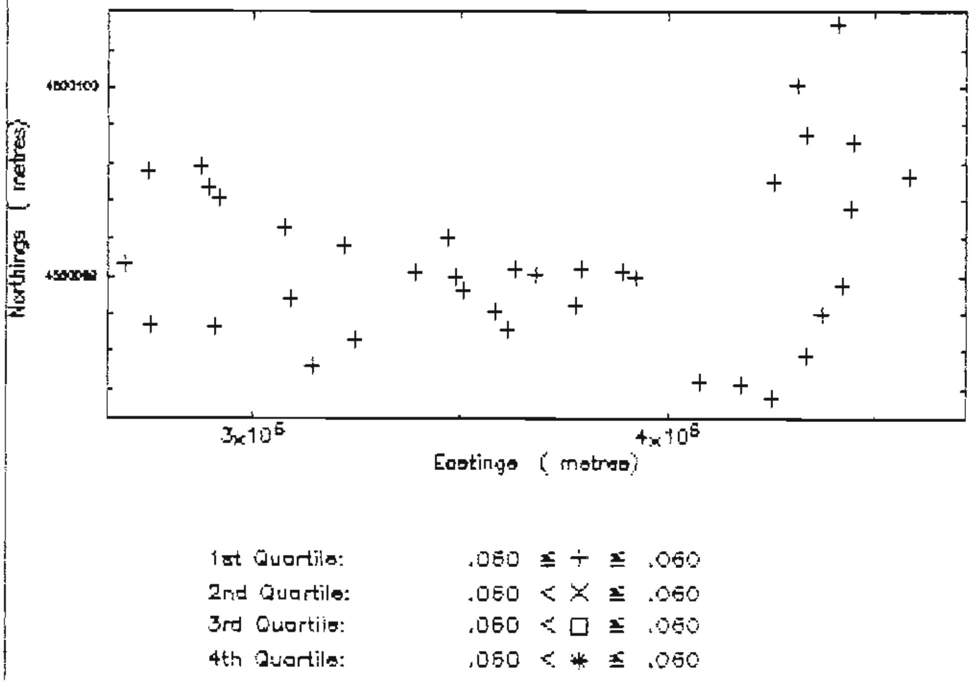
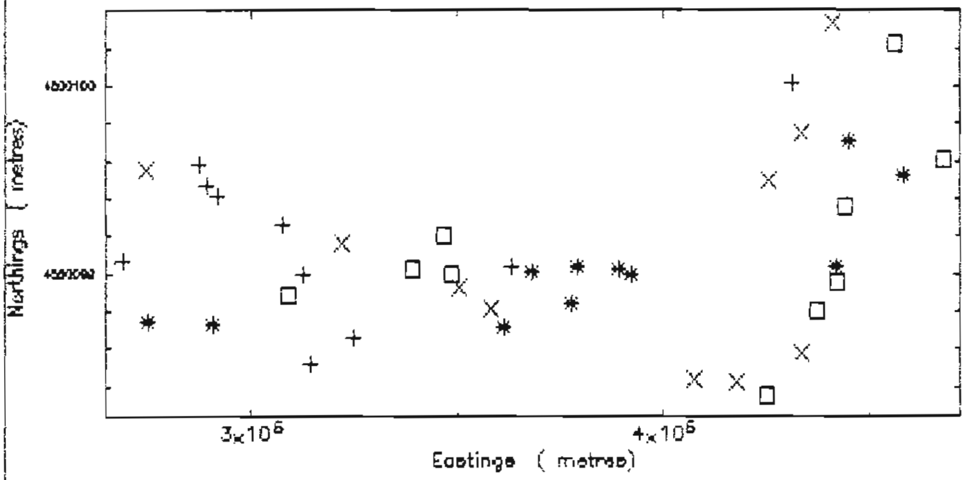
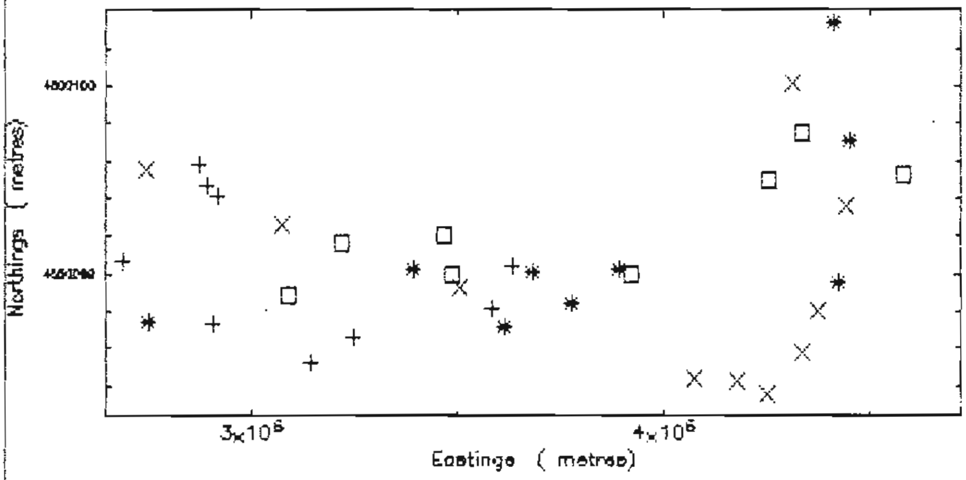


Fig. 12. Postplot of total Ni in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



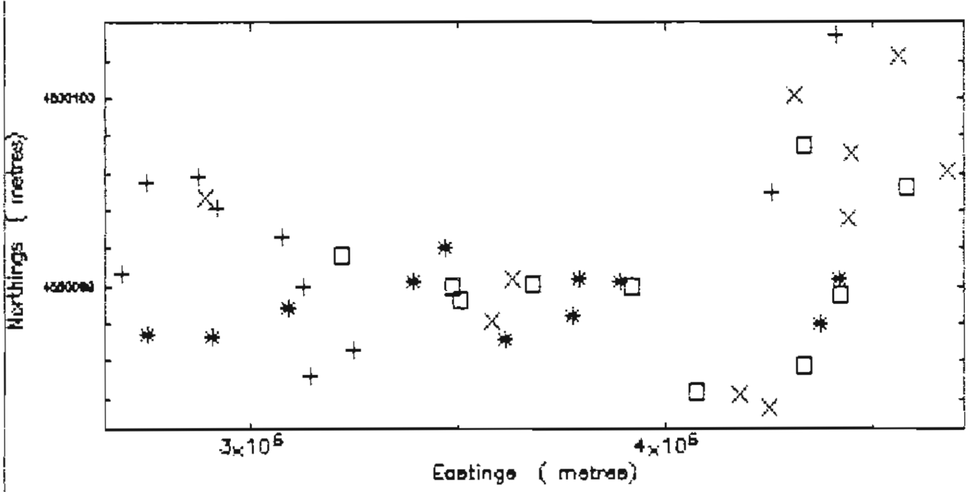
1st Quartile: 31.000 ≦ + ≦ 56.000
2nd Quartile: 56.000 < × ≦ 74.000
3rd Quartile: 74.000 < □ ≦ 85.000
4th Quartile: 85.000 < ✱ ≦ 408.000

Fig. 12a. Postplot of total Ni in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



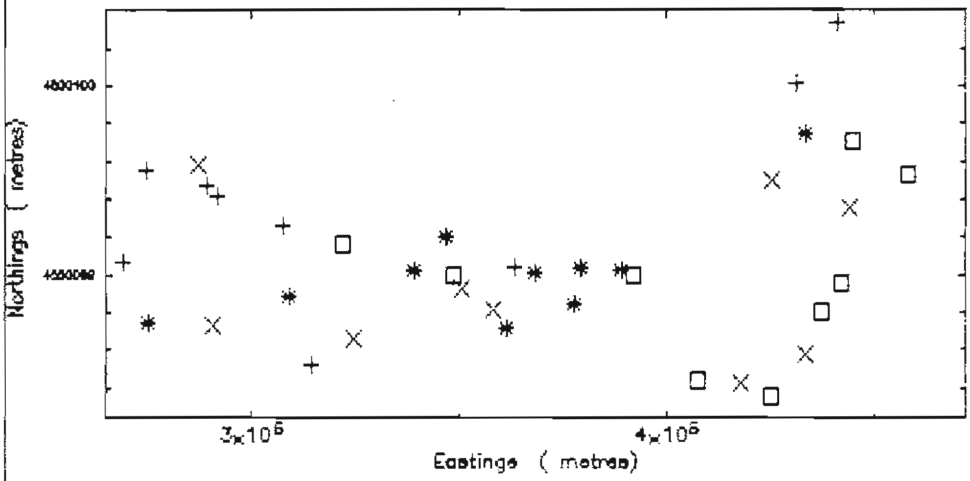
1st Quartile: 41.000 ≦ + ≦ 67.000
2nd Quartile: 67.000 < × ≦ 80.000
3rd Quartile: 80.000 < □ ≦ 100.000
4th Quartile: 100.000 < ✱ ≦ 303.000

Fig. 12b. Postplot of hot nitric acid soluble Ni (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 17.880 ≤ + ≤ 26.420
2nd Quartile: 26.420 < X ≤ 37.730
3rd Quartile: 37.730 < □ ≤ 54.870
4th Quartile: 54.870 < ✳ ≤ 295.500

Fig. 12c. Postplot of hot nitric acid soluble Ni (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 13.860 ≤ + ≤ 27.340
2nd Quartile: 27.340 < X ≤ 40.700
3rd Quartile: 40.700 < □ ≤ 52.220
4th Quartile: 52.220 < ✳ ≤ 211.600

Fig. 12d. Postplot of water soluble Ni (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

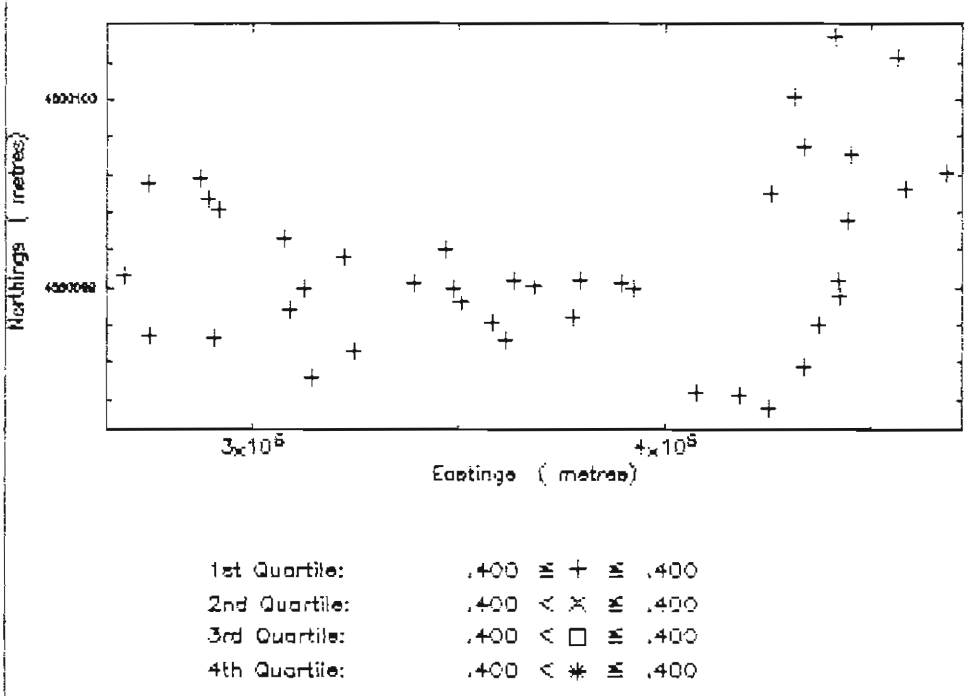


Fig. 12e. Postplot of water soluble Ni (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

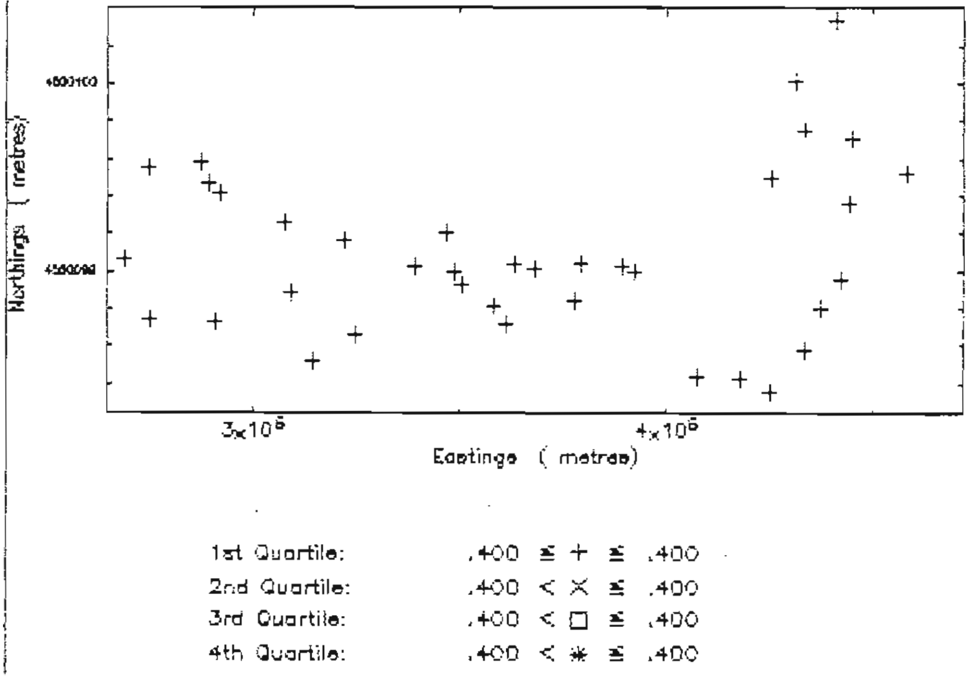
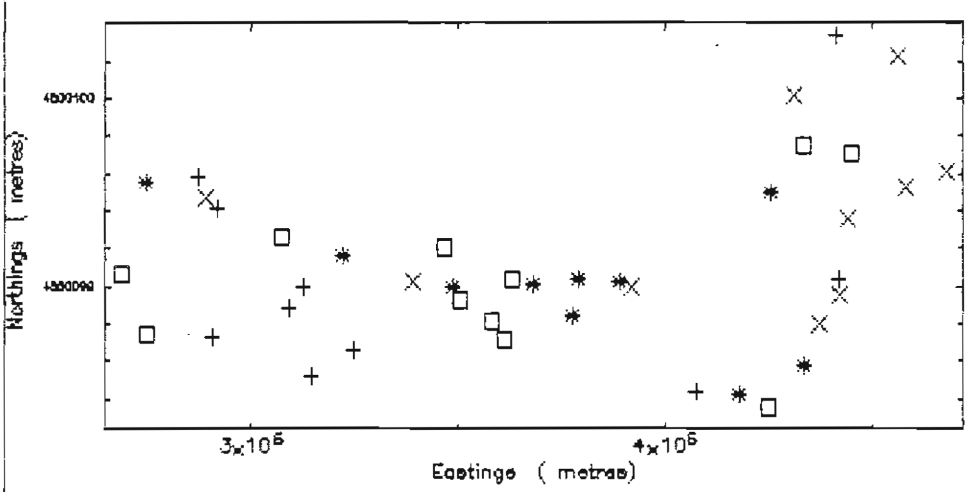
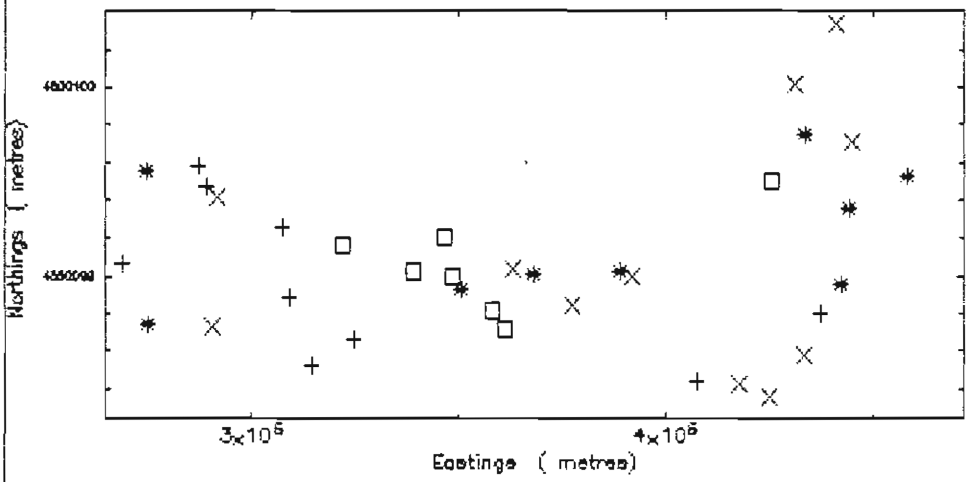


Fig. 13. Postplot of total Co in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 17.000 ≤ + ≤ 27.000
2nd Quartile: 27.000 < × ≤ 32.000
3rd Quartile: 32.000 < □ ≤ 38.000
4th Quartile: 38.000 < ✱ ≤ 59.000

Fig. 13a. Postplot of total Co in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 14.000 ≤ + ≤ 25.000
2nd Quartile: 25.000 < × ≤ 32.000
3rd Quartile: 32.000 < □ ≤ 35.000
4th Quartile: 35.000 < ✱ ≤ 61.000

Fig. 13b. Postplot of hot nitric acid soluble Co (ppm) in the -0.083 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

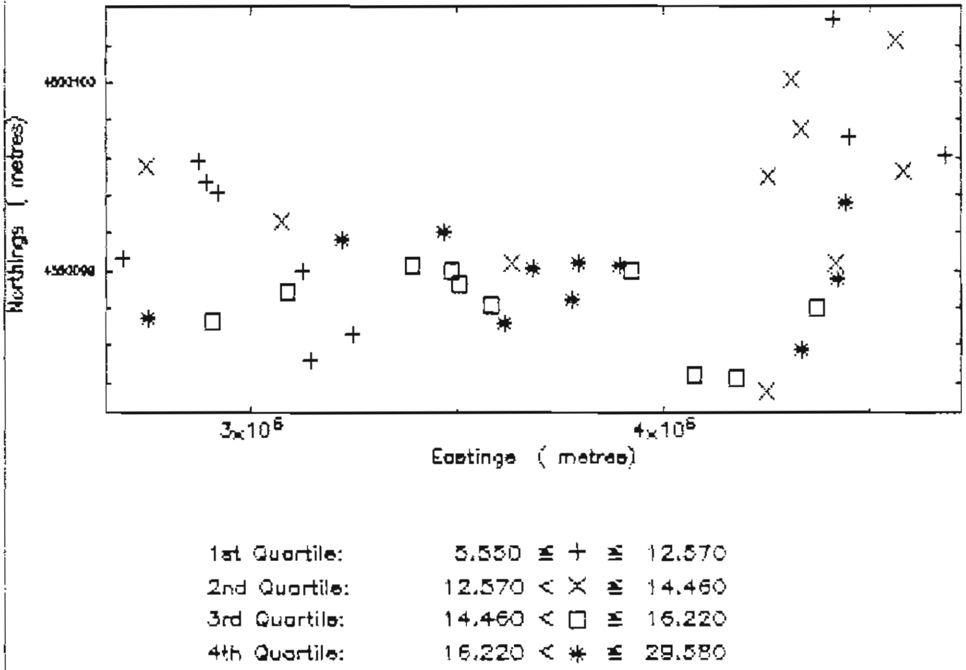


Fig. 13c. Postplot of hot nitric acid soluble Co (ppm) in the -0.083 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

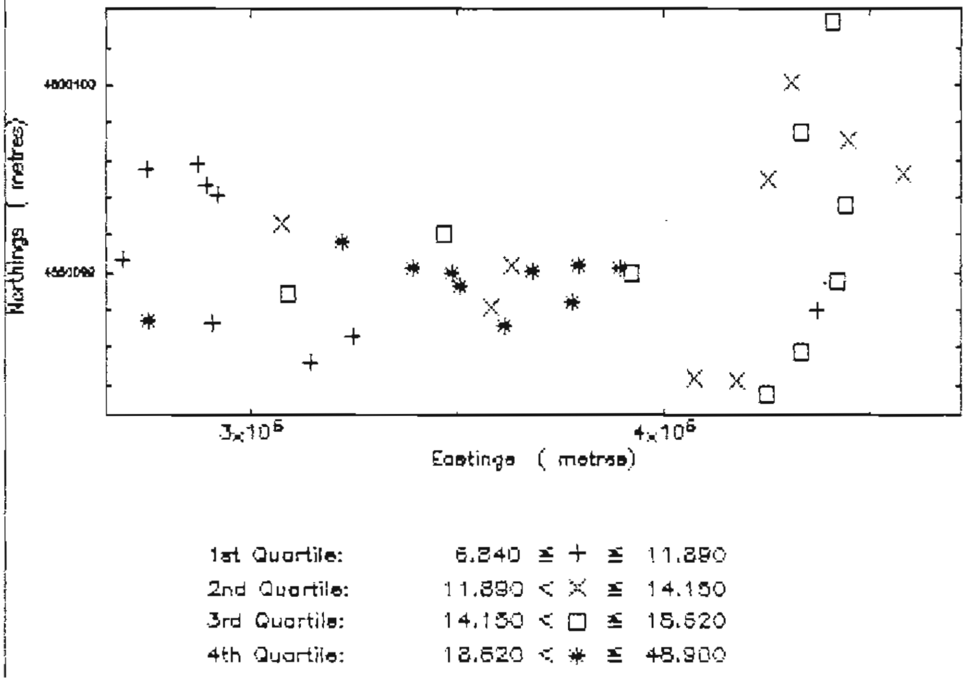
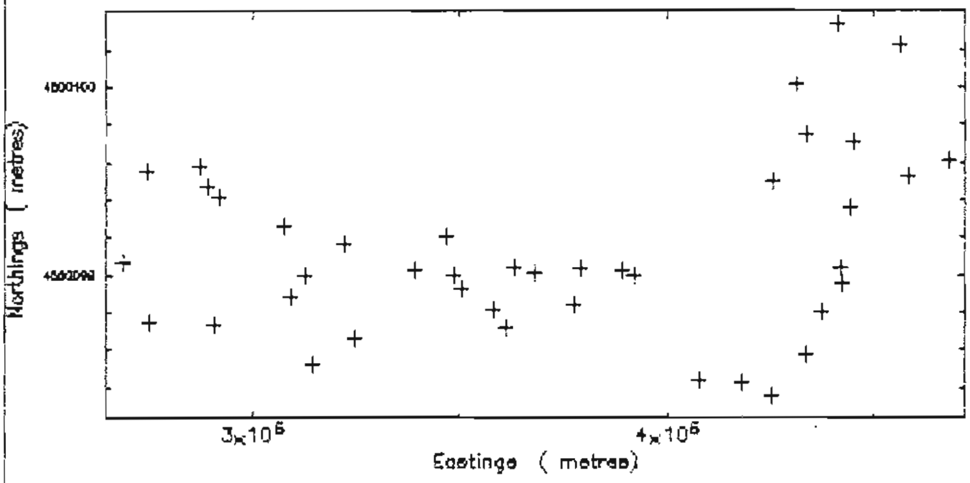
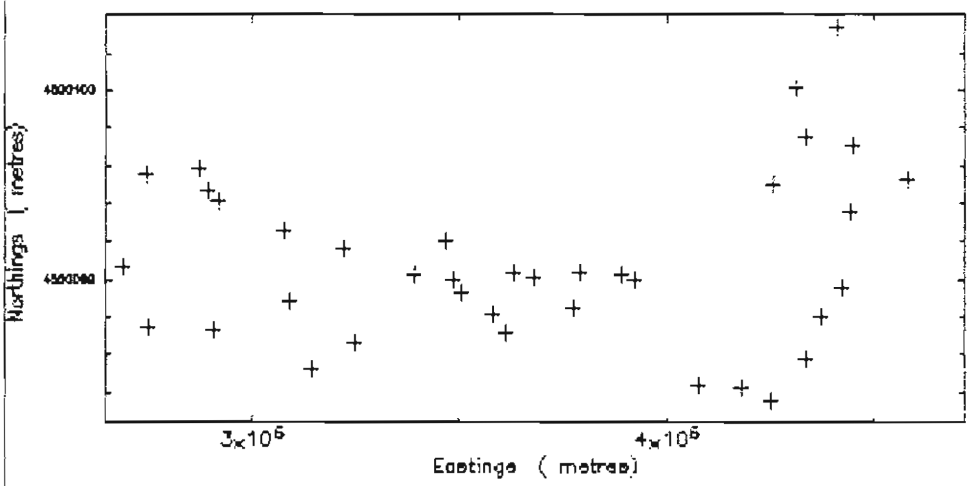


Fig. 13d. Postplot of water soluble Co (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



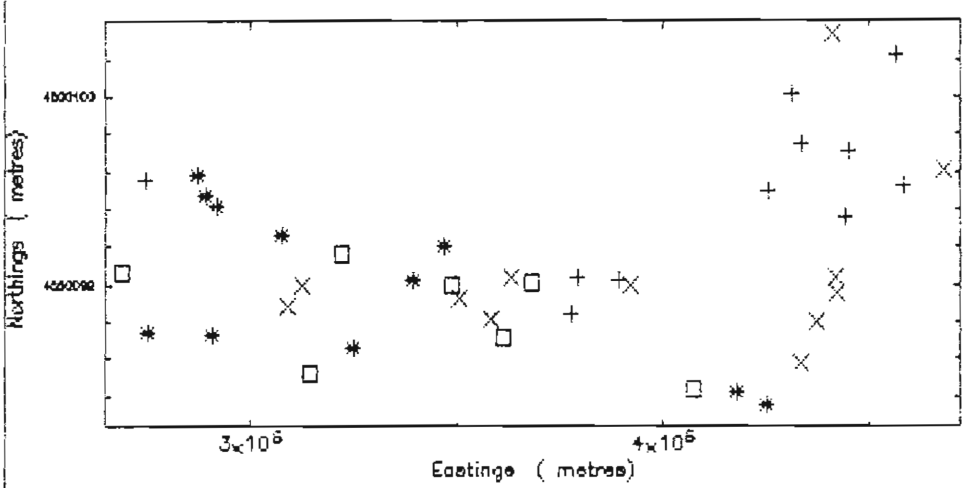
1st Quartile: .200 ≤ + ≤ .200
2nd Quartile: .200 < × ≤ .200
3rd Quartile: .200 < □ ≤ .200
4th Quartile: .200 < ✳ ≤ .200

Fig. 13e. Postplot of water soluble Co (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



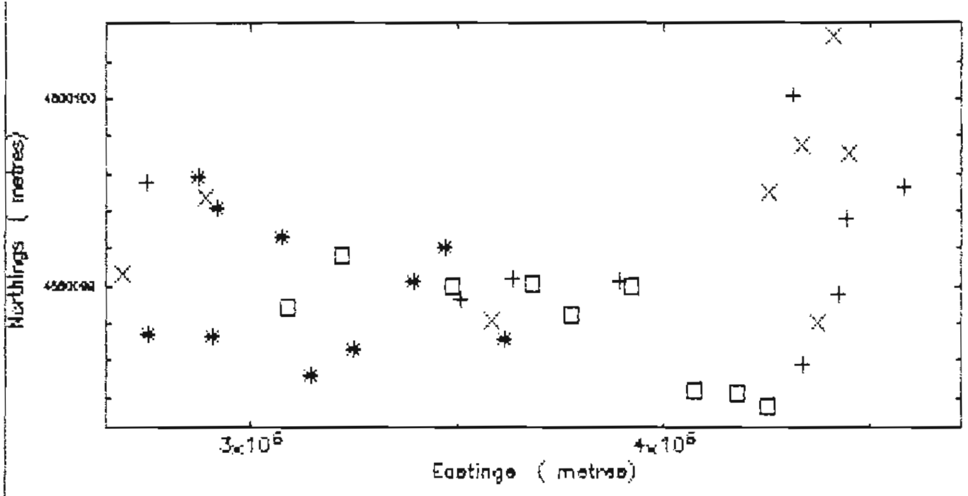
1st Quartile: .200 ≤ + ≤ .200
2nd Quartile: .200 < × ≤ .200
3rd Quartile: .200 < □ ≤ .200
4th Quartile: .200 < ✳ ≤ .200

Fig. 14. Postplot of total Li in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



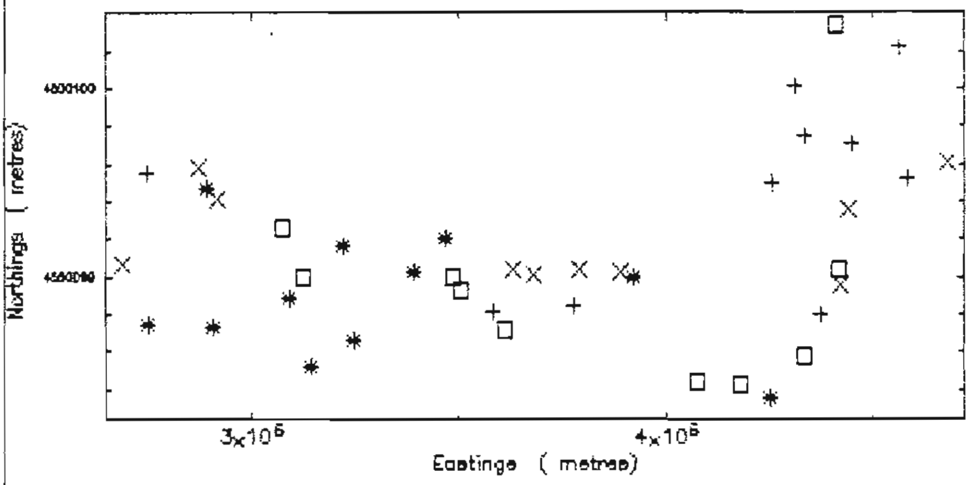
1st Quartile: 10.000 ≤ + ≤ 17.000
2nd Quartile: 17.000 < X ≤ 20.000
3rd Quartile: 20.000 < □ ≤ 23.000
4th Quartile: 23.000 < ✳ ≤ 41.000

Fig. 14 a. Postplot of total Li in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



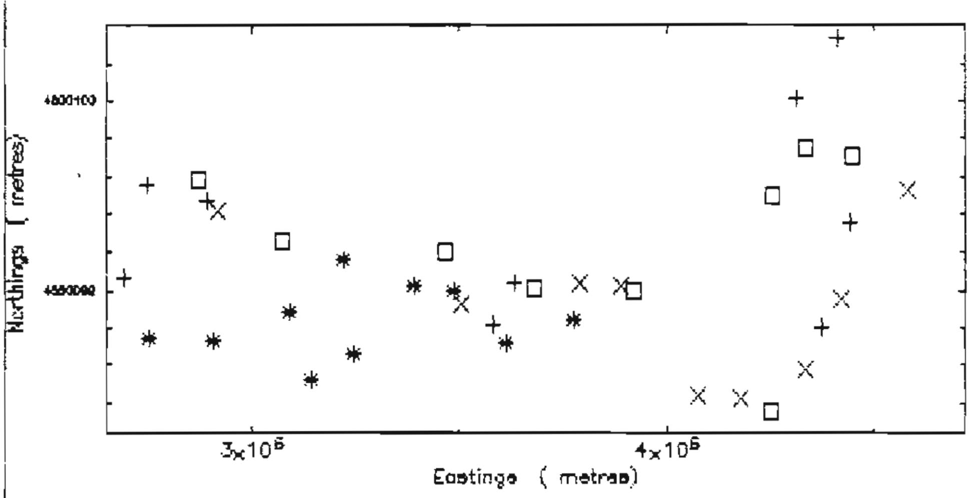
1st Quartile: 11.000 ≤ + ≤ 16.000
2nd Quartile: 16.000 < X ≤ 19.000
3rd Quartile: 19.000 < □ ≤ 23.000
4th Quartile: 23.000 < ✳ ≤ 40.000

Fig. 14b. Postplot of hot nitric acid soluble Li (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



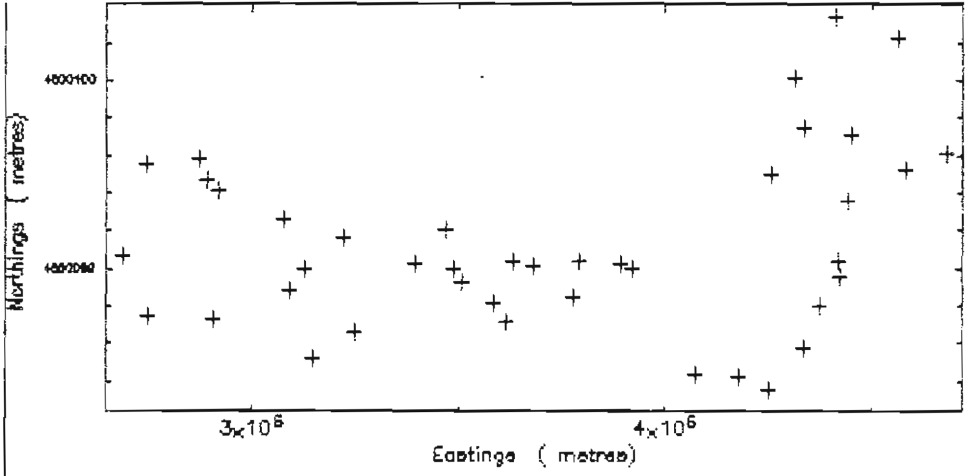
1st Quartile: 8.740 ≦ + ≦ 11.390
2nd Quartile: 11.390 < × ≦ 13.900
3rd Quartile: 13.900 < □ ≦ 16.010
4th Quartile: 16.010 < ✱ ≦ 32.930

Fig. 14c. Postplot of hot nitric acid soluble Li (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



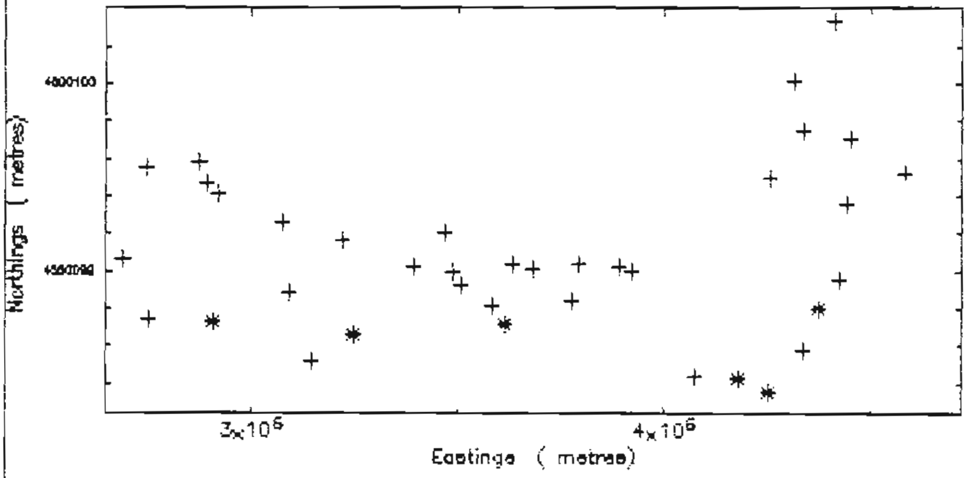
1st Quartile: 8.970 ≦ + ≦ 11.550
2nd Quartile: 11.550 < × ≦ 16.180
3rd Quartile: 16.180 < □ ≦ 18.860
4th Quartile: 18.860 < ✱ ≦ 31.370

Fig. 14d. Postplot of water soluble Li (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



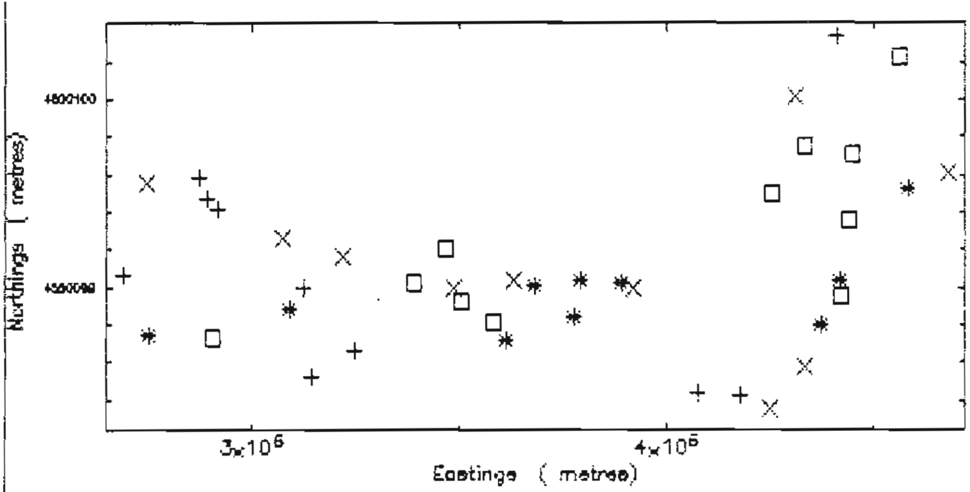
1st Quartile: .050 ≦ + ≦ .050
2nd Quartile: .050 < ✕ ≦ .050
3rd Quartile: .050 < □ ≦ .050
4th Quartile: .050 < ✱ ≦ .050

Fig. 14e. Postplot of water soluble Li (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



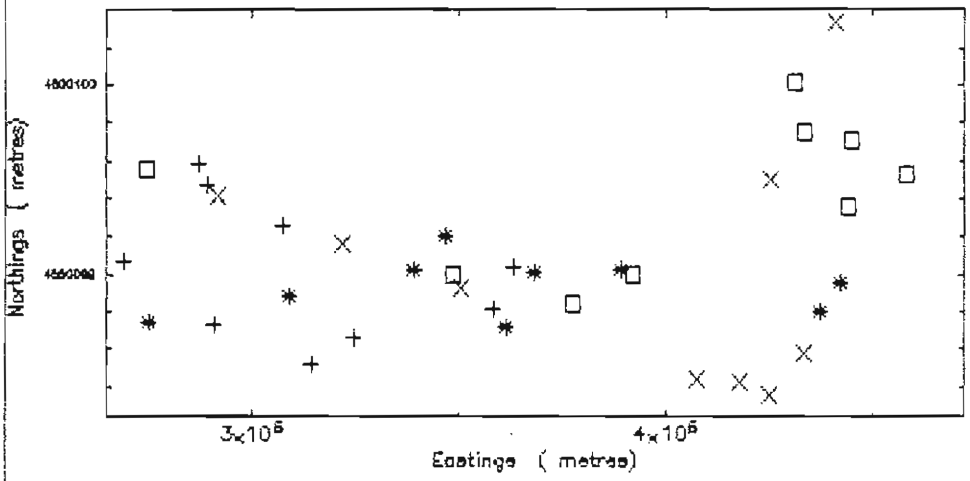
1st Quartile: .050 ≦ + ≦ .050
2nd Quartile: .050 < ✕ ≦ .050
3rd Quartile: .050 < □ ≦ .050
4th Quartile: .050 < ✱ ≦ .326

Fig. 15. Postplot of total Cr in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



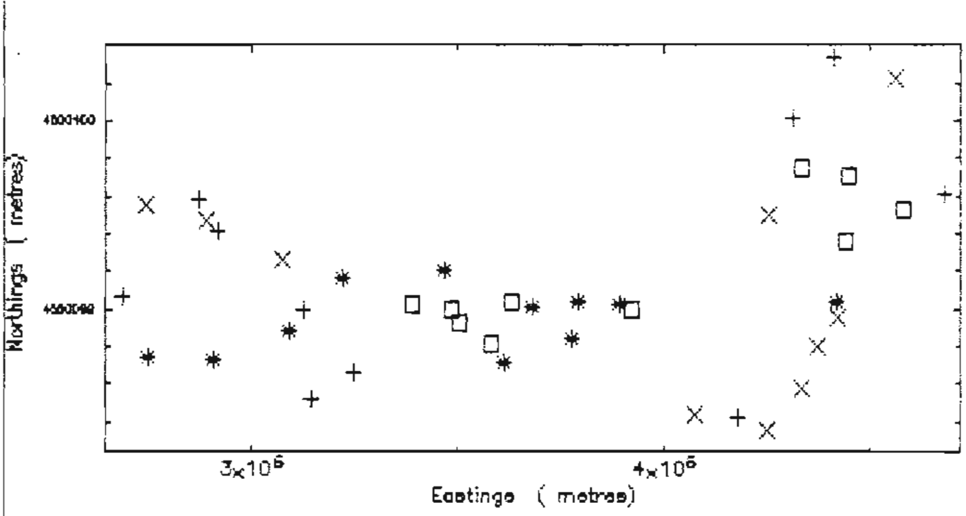
1st Quartile: 35.000 ≤ + ≤ 76.000
2nd Quartile: 76.000 < × ≤ 89.000
3rd Quartile: 89.000 < □ ≤ 132.000
4th Quartile: 132.000 < * ≤ 479.000

Fig. 15a. Postplot of total Cr in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



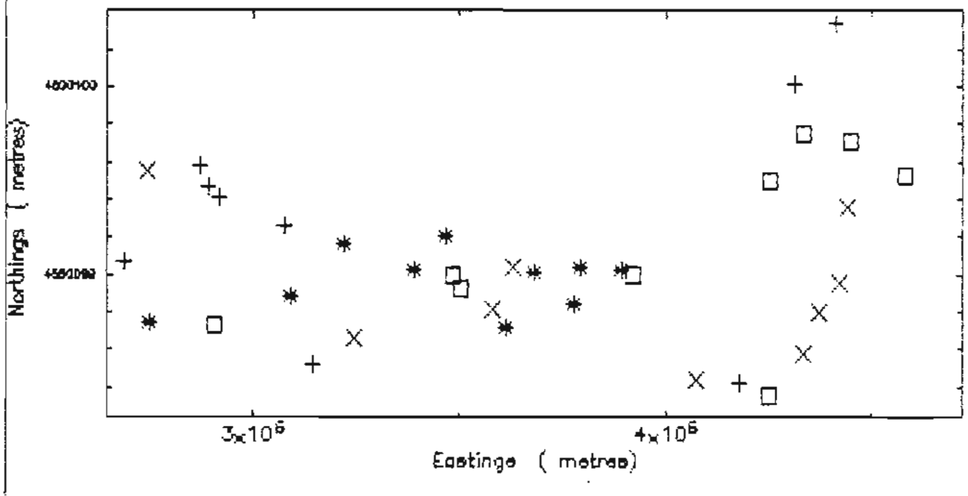
1st Quartile: 28.000 ≤ + ≤ 58.000
2nd Quartile: 58.000 < × ≤ 91.000
3rd Quartile: 91.000 < □ ≤ 114.000
4th Quartile: 114.000 < * ≤ 298.000

Fig. 15b. Postplot of hot nitric acid soluble Cr (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



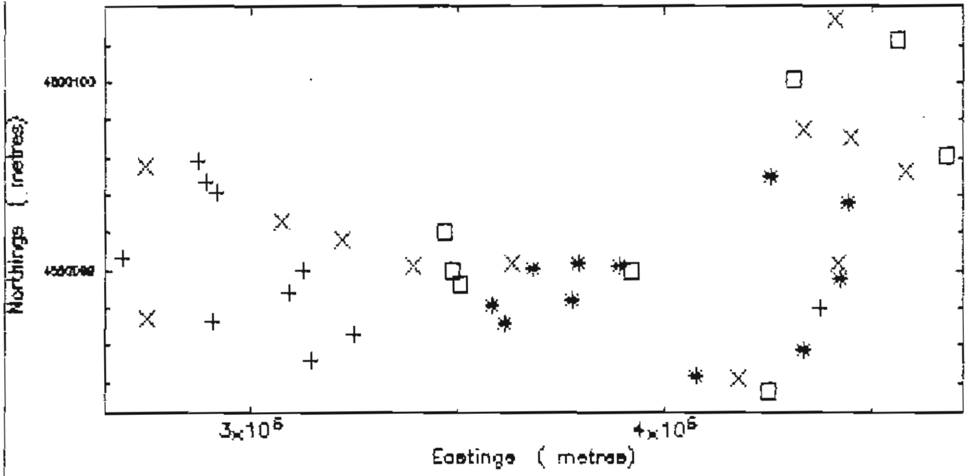
1st Quartile:	17.000 ≤ + ≤ 37.490
2nd Quartile:	37.490 < × ≤ 49.460
3rd Quartile:	49.460 < □ ≤ 61.150
4th Quartile:	61.150 < ✳ ≤ 276.200

Fig. 15c. Postplot of hot nitric acid soluble Cr (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



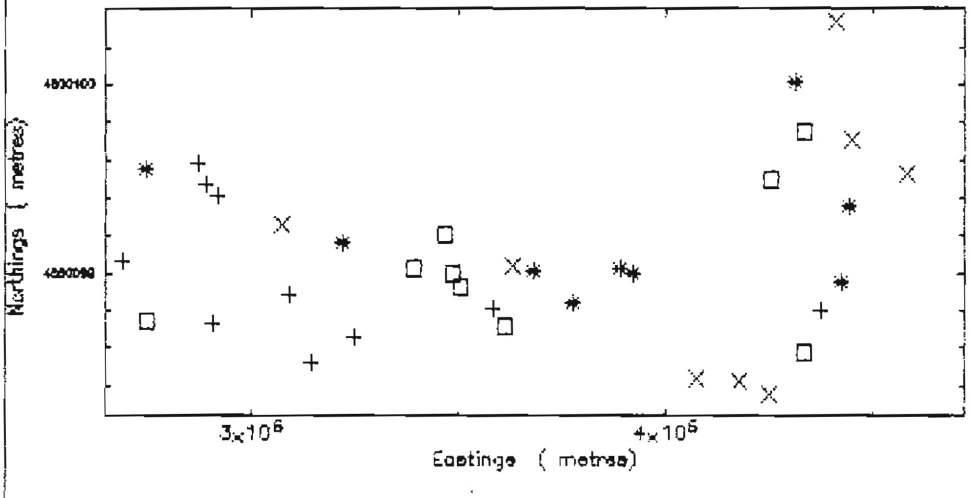
1st Quartile:	16.690 ≤ + ≤ 35.220
2nd Quartile:	35.220 < × ≤ 47.540
3rd Quartile:	47.540 < □ ≤ 69.560
4th Quartile:	69.560 < ✳ ≤ 165.600

Fig. 16. Postplot of total V in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box−and−whisker plot)



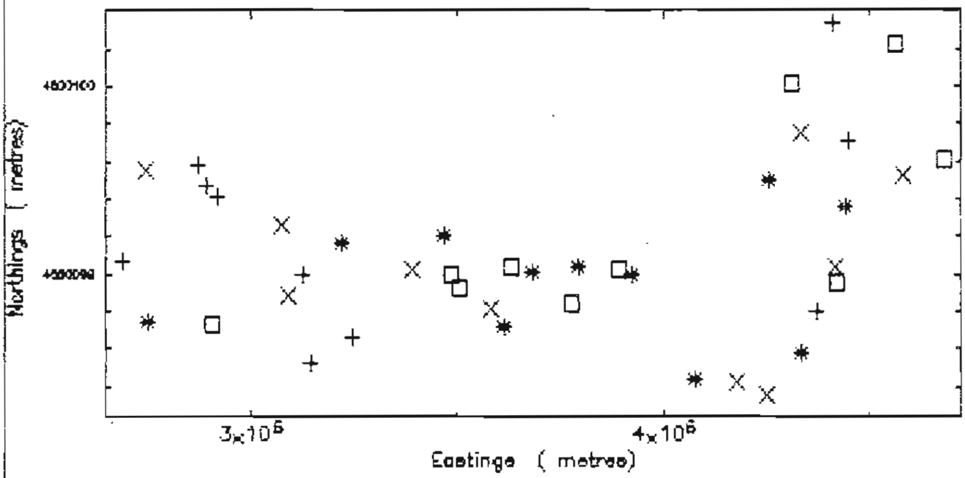
1st Quartile: 42.000 ≤ + ≤ 80.000
2nd Quartile: 80.000 < × ≤ 107.000
3rd Quartile: 107.000 < □ ≤ 112.000
4th Quartile: 112.000 < ✳ ≤ 167.000

Fig. 16 a. Postplot of total V in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box−and−whisker plot)



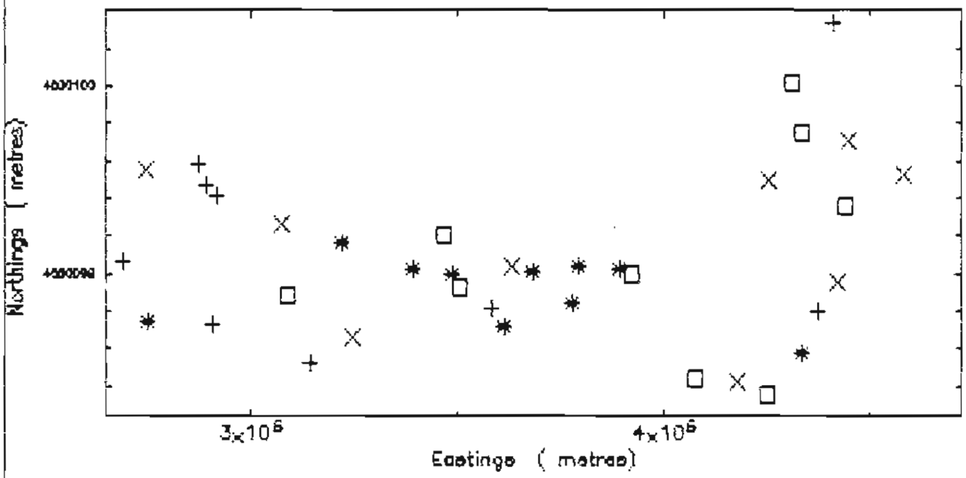
1st Quartile: 50.000 ≤ + ≤ 82.000
2nd Quartile: 82.000 < × ≤ 100.000
3rd Quartile: 100.000 < □ ≤ 117.000
4th Quartile: 117.000 < ✳ ≤ 159.000

Fig. 16b. Postplot of hot nitric acid soluble V (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 19.130 ≤ + ≤ 40.830
2nd Quartile: 40.830 < X ≤ 50.570
3rd Quartile: 50.570 < □ ≤ 55.190
4th Quartile: 55.190 < ✱ ≤ 72.930

Fig. 16c. Postplot of hot nitric acid soluble V (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 23.080 ≤ + ≤ 40.750
2nd Quartile: 40.750 < X ≤ 48.710
3rd Quartile: 48.710 < □ ≤ 60.120
4th Quartile: 60.120 < ✱ ≤ 92.630

Fig. 16d. Postplot of water soluble V (ppm) in the
0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

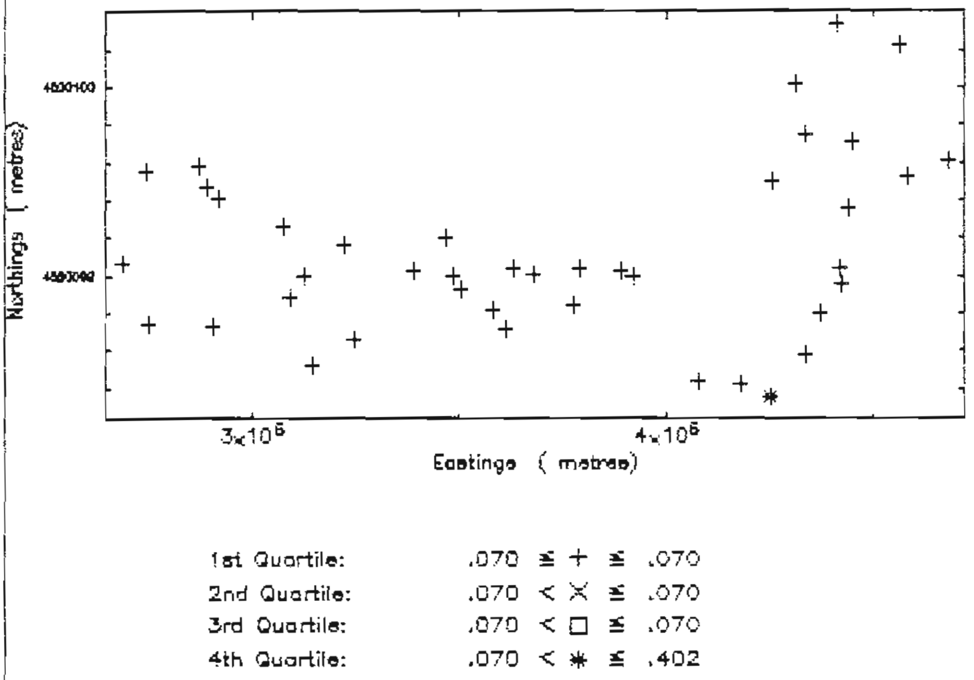


Fig. 16e. Postplot of water soluble V (ppm) in the
-0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)

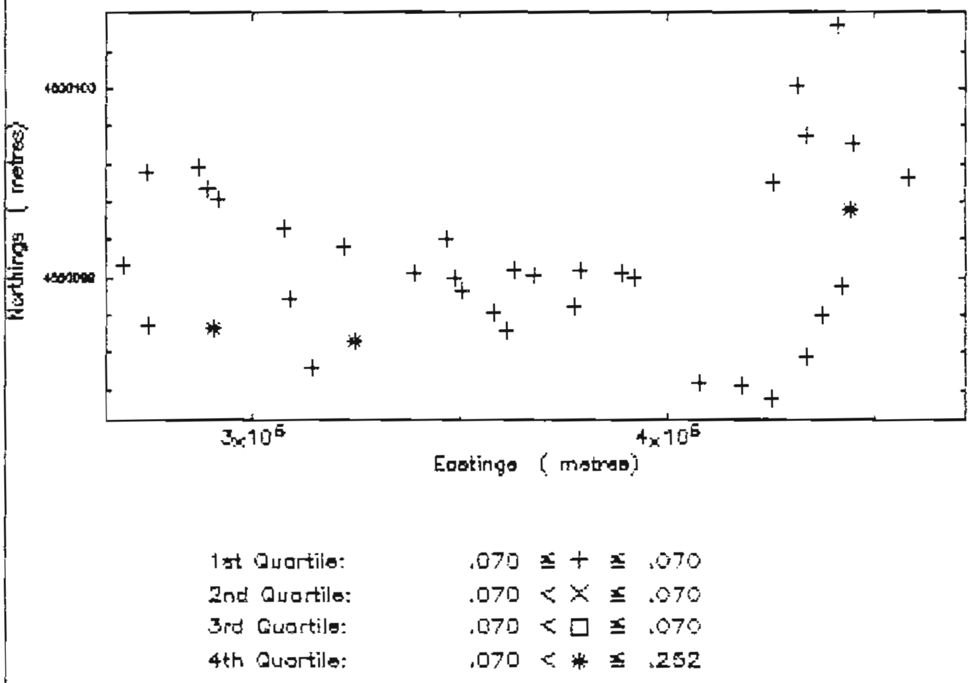
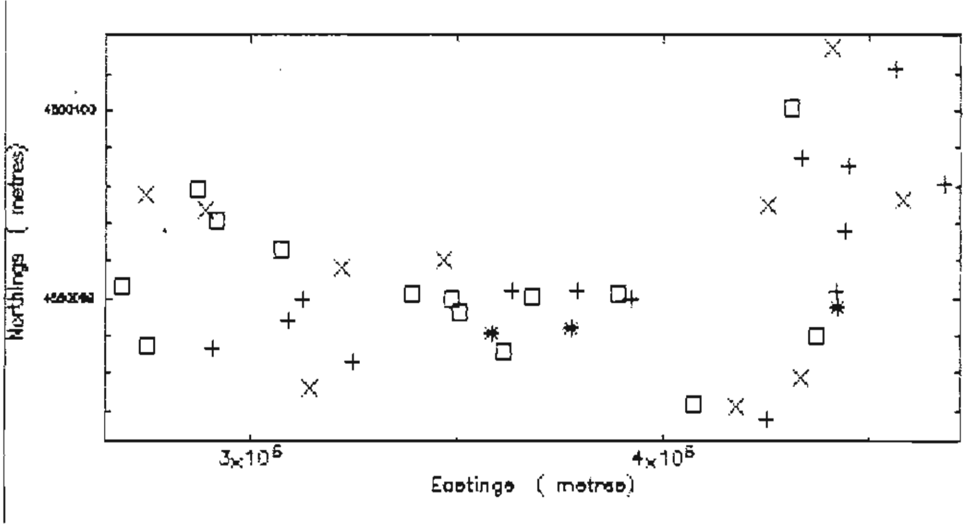
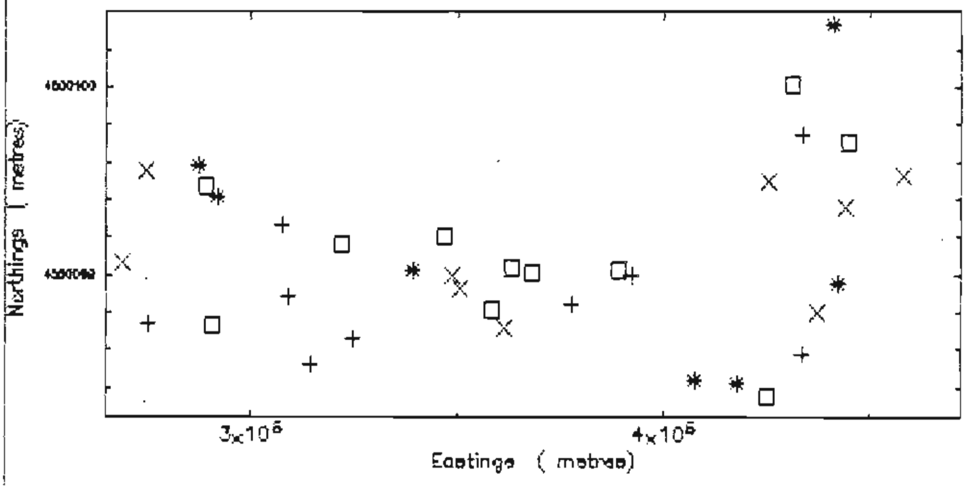


Fig. 17. Postplot of total Mo in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



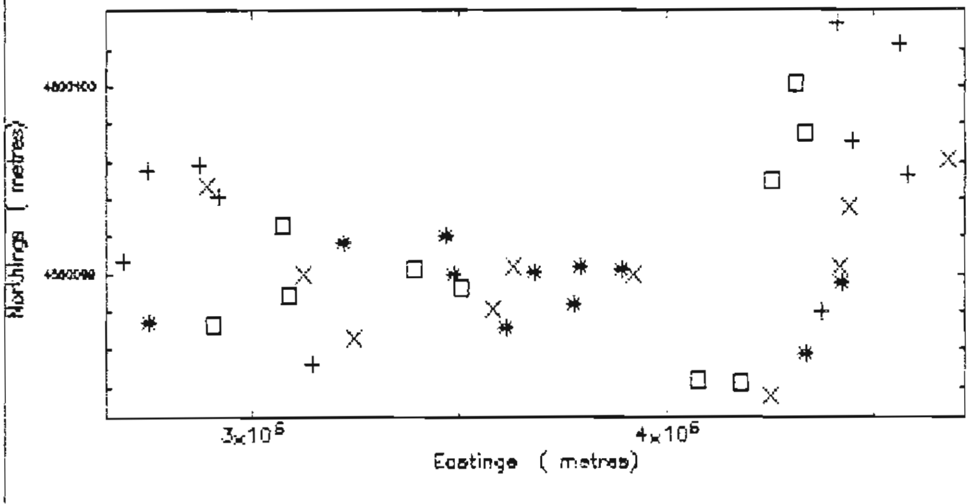
1st Quartile: 1.000 ≦ + ≦ 3.000
2nd Quartile: 3.000 < × ≦ 4.000
3rd Quartile: 4.000 < □ ≦ 5.000
4th Quartile: 5.000 < ✱ ≦ 7.000

Fig. 17a. Postplot of total Mo in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



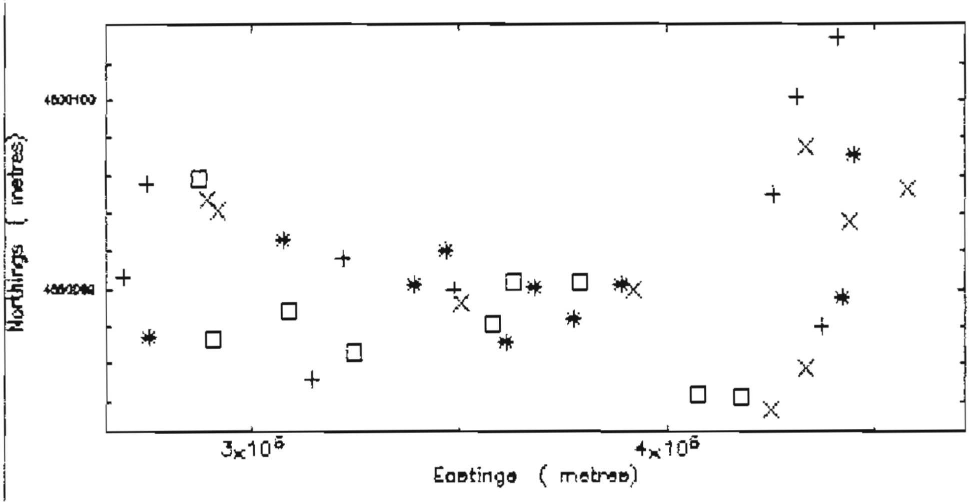
1st Quartile: 1.000 ≦ + ≦ 3.000
2nd Quartile: 3.000 < × ≦ 4.000
3rd Quartile: 4.000 < □ ≦ 6.000
4th Quartile: 6.000 < ✱ ≦ 11.000

Fig. 17b. Postplot of hot nitric acid soluble Mo (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



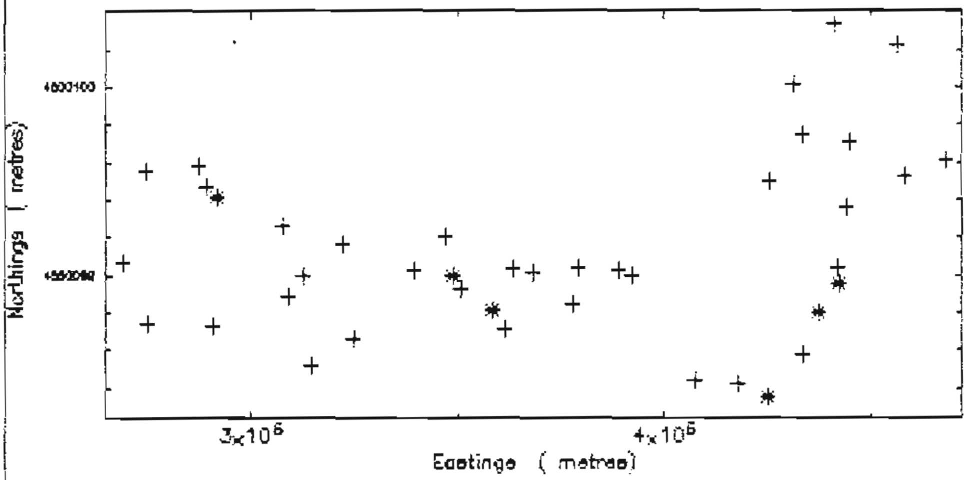
1st Quartile: 2.740 ≤ + ≤ 3.850
2nd Quartile: 3.850 < × ≤ 4.530
3rd Quartile: 4.530 < □ ≤ 5.520
4th Quartile: 5.520 < ✱ ≤ 9.980

Fig. 17c. Postplot of hot nitric acid soluble Mo (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



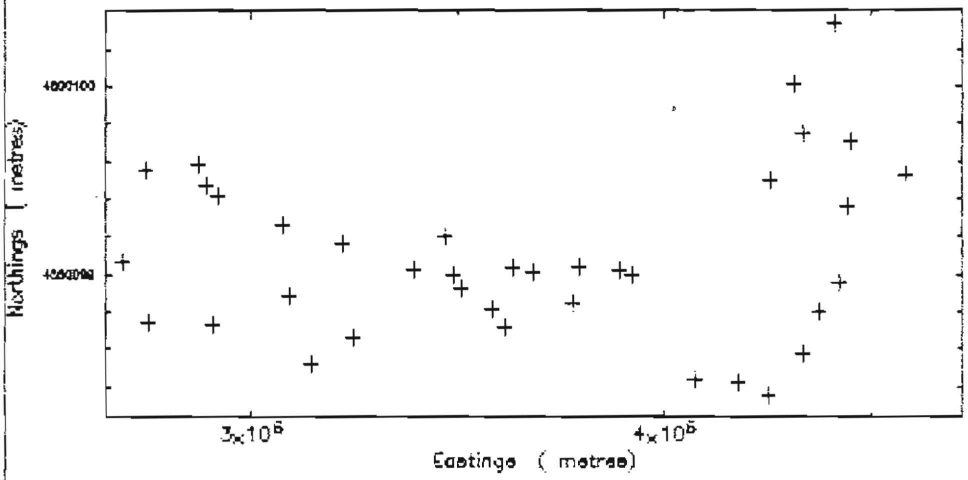
1st Quartile: 1.660 ≤ + ≤ 3.240
2nd Quartile: 3.240 < × ≤ 4.140
3rd Quartile: 4.140 < □ ≤ 5.220
4th Quartile: 5.220 < ✱ ≤ 8.970

Fig. 17d. Postplot of water soluble Mo (ppm). in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



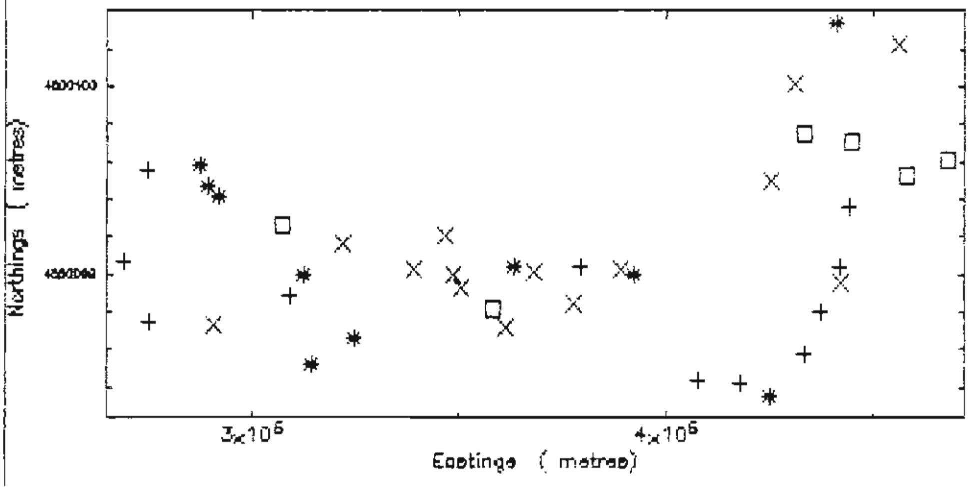
1st Quartile: .100 ≦ + ≦ .100
2nd Quartile: .100 < × ≦ .100
3rd Quartile: .100 < □ ≦ .100
4th Quartile: .100 < ✳ ≦ .317

Fig. 17e. Postplot of water soluble Mo (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



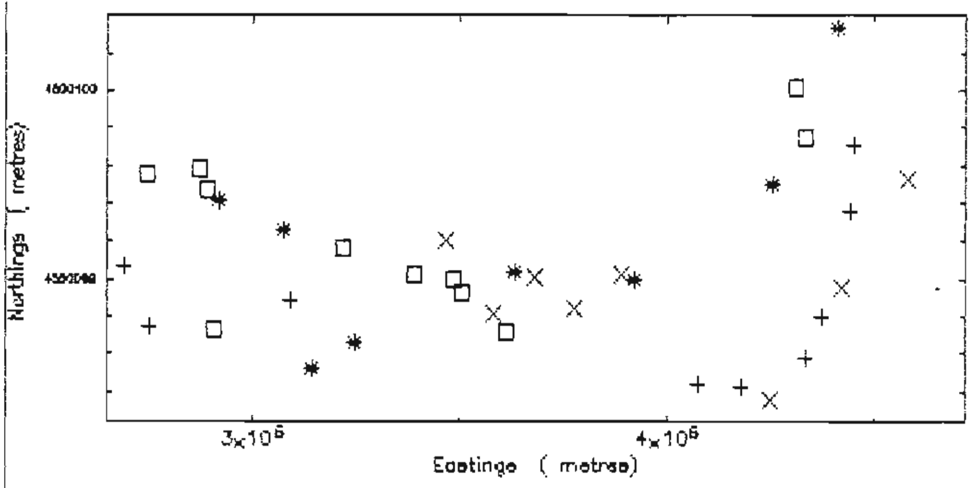
1st Quartile: .100 ≦ + ≦ .100
2nd Quartile: .100 < × ≦ .100
3rd Quartile: .100 < □ ≦ .100
4th Quartile: .100 < ✳ ≦ .100

Fig. 18. Postplot of total Be in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



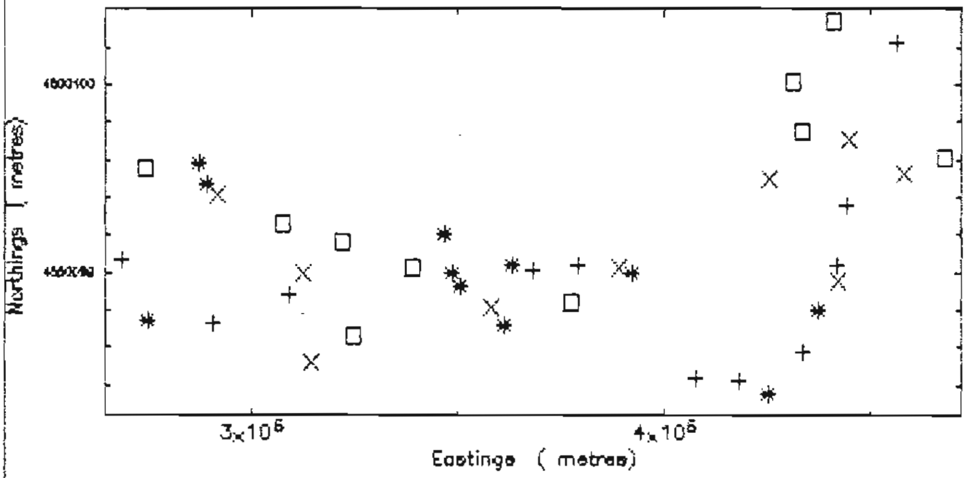
1st Quartile: 1.700 ≦ + ≦ 2.200
2nd Quartile: 2.200 < × ≦ 2.700
3rd Quartile: 2.700 < □ ≦ 3.000
4th Quartile: 3.000 < ✱ ≦ 4.400

Fig. 18a. Postplot of total Be in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



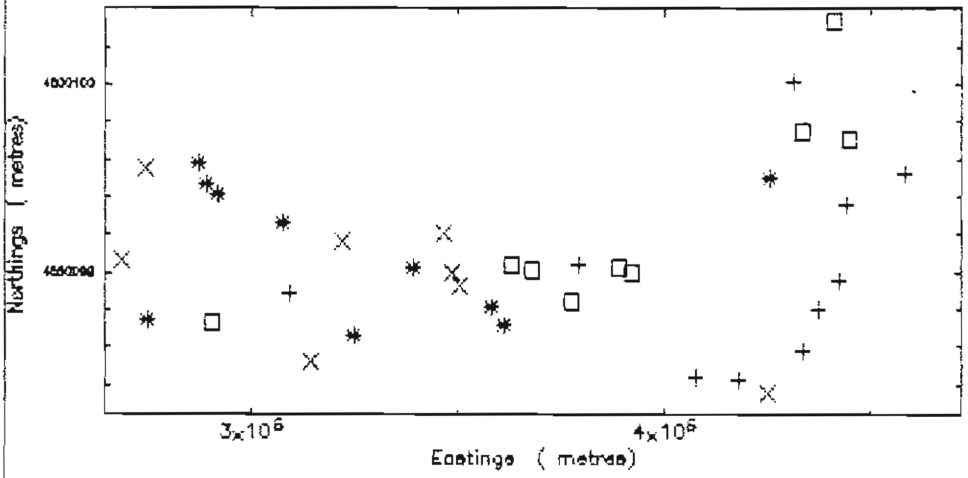
1st Quartile: 1.300 ≦ + ≦ 2.200
2nd Quartile: 2.200 < × ≦ 2.400
3rd Quartile: 2.400 < □ ≦ 3.000
4th Quartile: 3.000 < ✱ ≦ 5.900

Fig. 18b. Postplot of hot nitric acid soluble Be (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



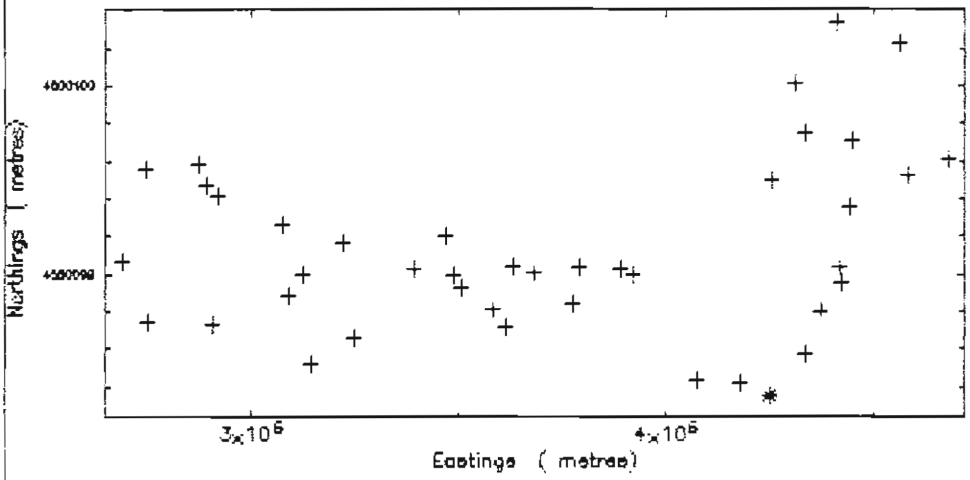
1st Quartile: .450 ≤ + ≤ .880
2nd Quartile: .880 < × ≤ 1.000
3rd Quartile: 1.000 < □ ≤ 1.220
4th Quartile: 1.220 < ✱ ≤ 1.870

Fig. 18c. Postplot of hot nitric acid soluble Be (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



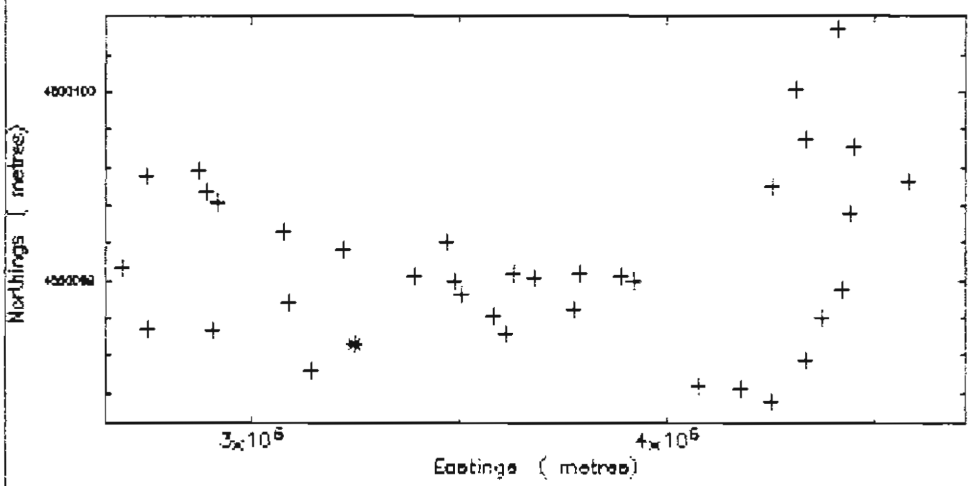
1st Quartile: .490 ≤ + ≤ .880
2nd Quartile: .880 < × ≤ 1.090
3rd Quartile: 1.090 < □ ≤ 1.470
4th Quartile: 1.470 < ✱ ≤ 3.830

Fig. 18d. Postplot of water soluble Be (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



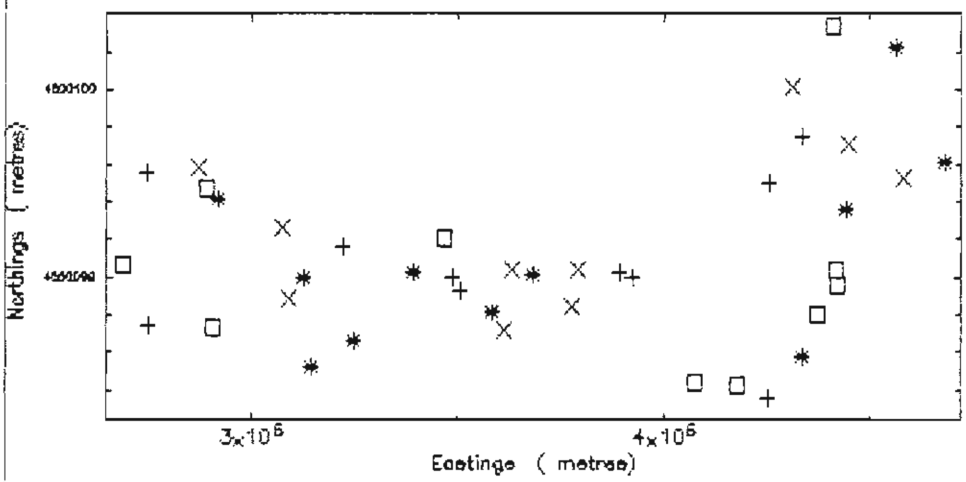
1st Quartile: .010 ≦ + ≦ .010
2nd Quartile: .010 < ✕ ≦ .010
3rd Quartile: .010 < □ ≦ .010
4th Quartile: .010 < ✳ ≦ .014

Fig. 18e. Postplot of water soluble Be (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



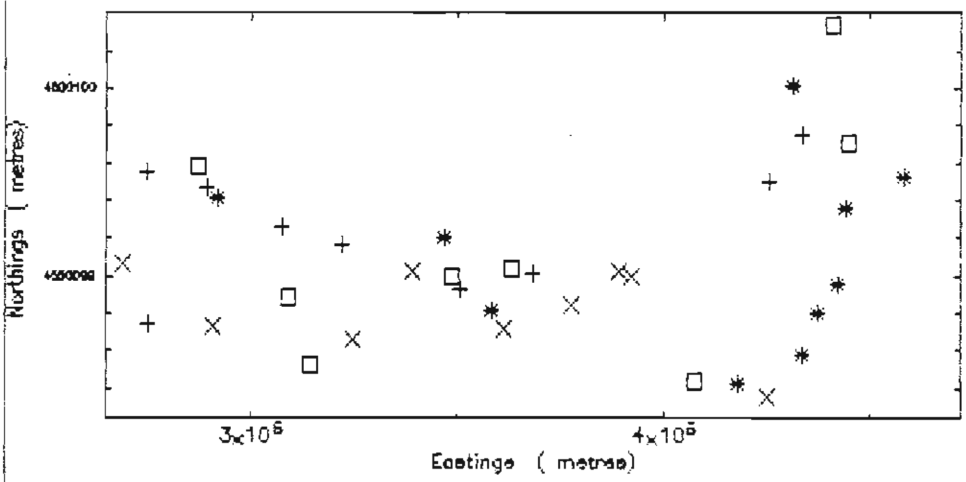
1st Quartile: .010 ≦ + ≦ .010
2nd Quartile: .010 < ✕ ≦ .010
3rd Quartile: .010 < □ ≦ .010
4th Quartile: .010 < ✳ ≦ .014

Fig. 19. Postplot of total Sr in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



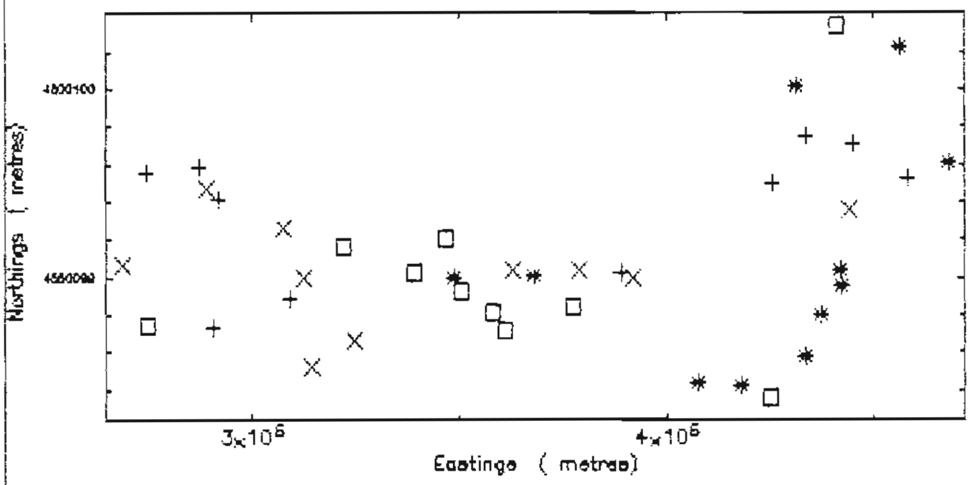
1st Quartile: 38.000 ≤ + ≤ 118.000
2nd Quartile: 118.000 < × ≤ 163.000
3rd Quartile: 163.000 < □ ≤ 201.000
4th Quartile: 201.000 < ✱ ≤ 255.000

Fig. 19a. Postplot of total Sr in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



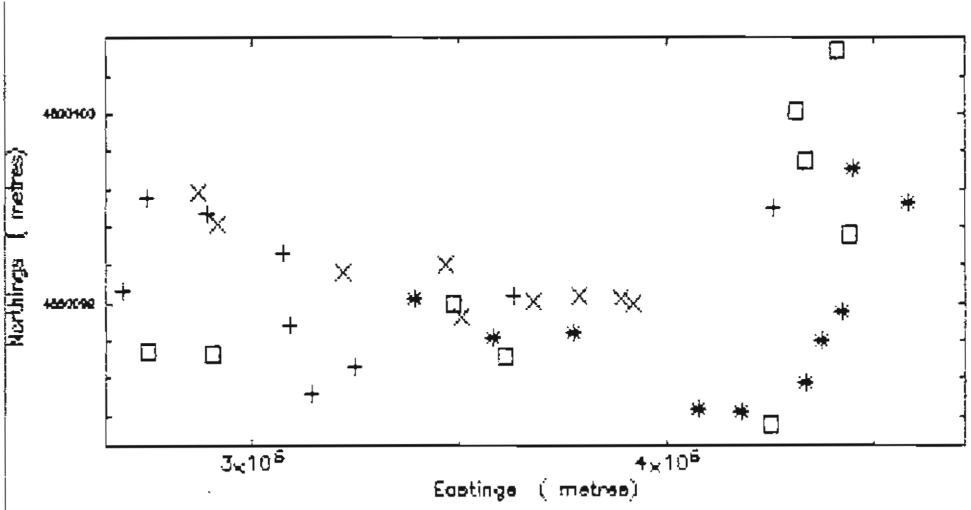
1st Quartile: 65.000 ≤ + ≤ 133.000
2nd Quartile: 133.000 < × ≤ 161.000
3rd Quartile: 161.000 < □ ≤ 189.000
4th Quartile: 189.000 < ✱ ≤ 263.000

Fig. 19b. Postplot of hot nitric acid soluble Sr (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



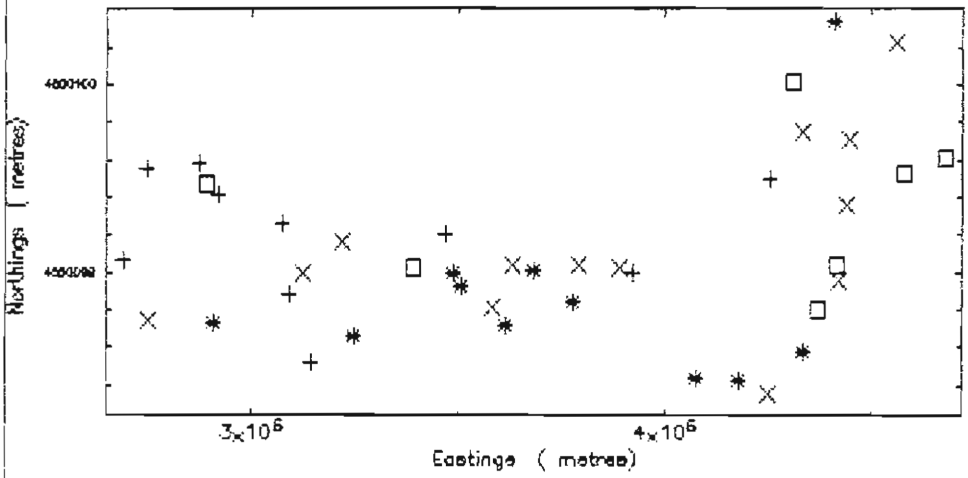
1st Quartile: 12.750 ≤ + ≤ 23.950
2nd Quartile: 23.950 < × ≤ 36.670
3rd Quartile: 36.670 < □ ≤ 53.370
4th Quartile: 53.370 < ✳ ≤ 99.680

Fig. 19c. Postplot of hot nitric acid soluble Sr (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



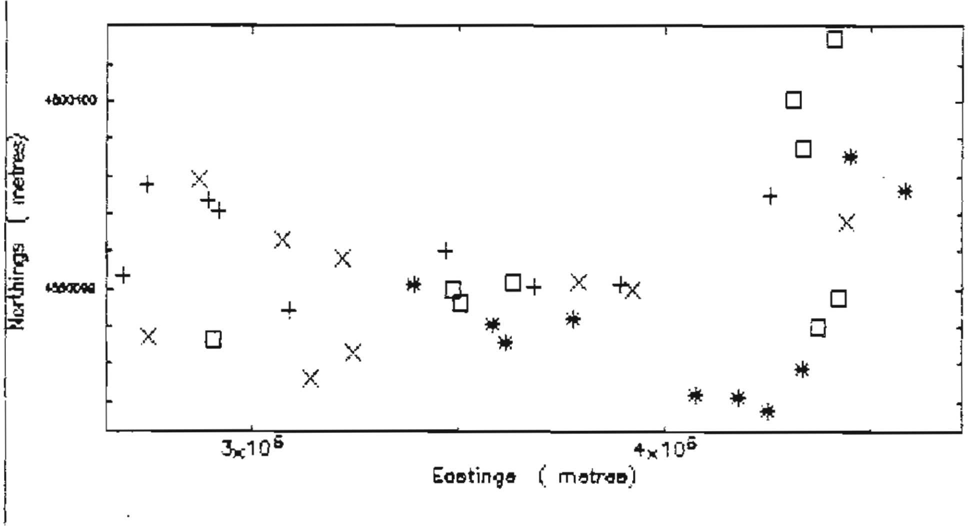
1st Quartile: 19.310 ≤ + ≤ 31.970
2nd Quartile: 31.970 < × ≤ 47.370
3rd Quartile: 47.370 < □ ≤ 72.450
4th Quartile: 72.450 < ✳ ≤ 159.800

Fig. 19d. Postplot of water soluble Sr (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



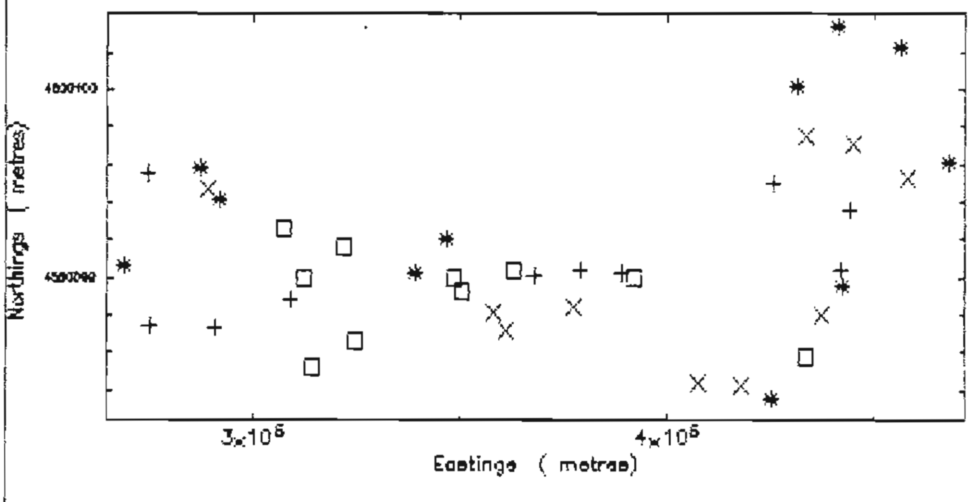
1st Quartile: .072 ≤ + ≤ .307
2nd Quartile: .307 < × ≤ .521
3rd Quartile: .521 < □ ≤ .719
4th Quartile: .719 < ✳ ≤ 3.650

Fig. 19e. Postplot of water soluble Sr (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



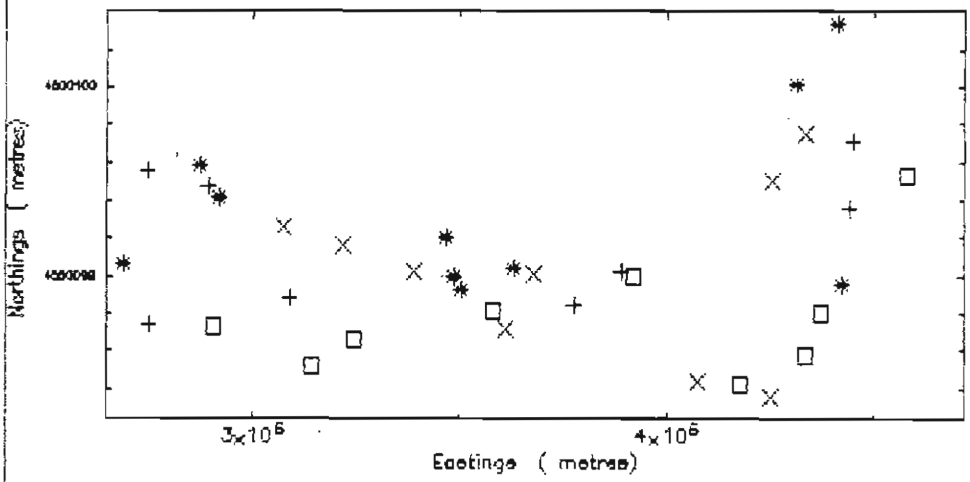
1st Quartile: .263 ≤ + ≤ .562
2nd Quartile: .562 < × ≤ 1.540
3rd Quartile: 1.540 < □ ≤ 2.900
4th Quartile: 2.900 < ✳ ≤ 6.060

Fig. 20. Postplot of total Ba in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



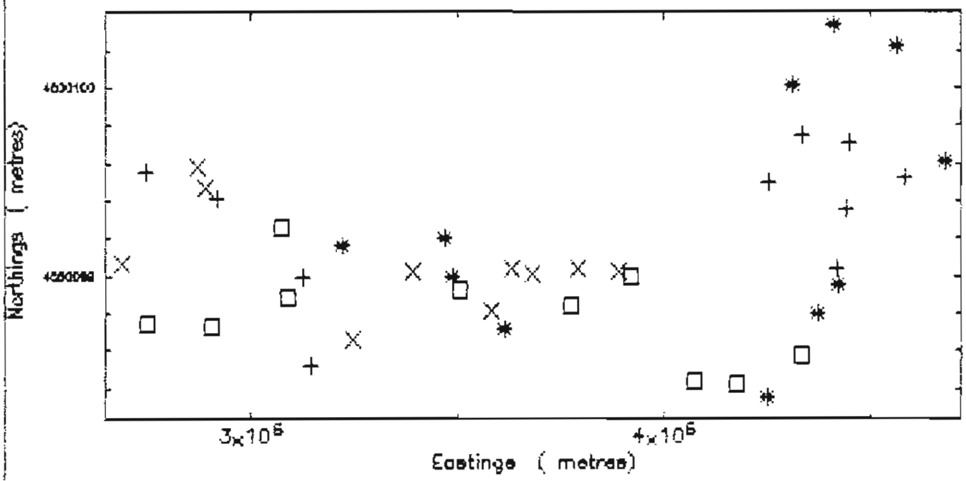
1st Quartile: 130.000 ≤ + ≤ 322.000
2nd Quartile: 322.000 < X ≤ 444.000
3rd Quartile: 444.000 < □ ≤ 527.000
4th Quartile: 527.000 < ✳ ≤ 732.000

Fig. 20 a. Postplot of total Ba in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



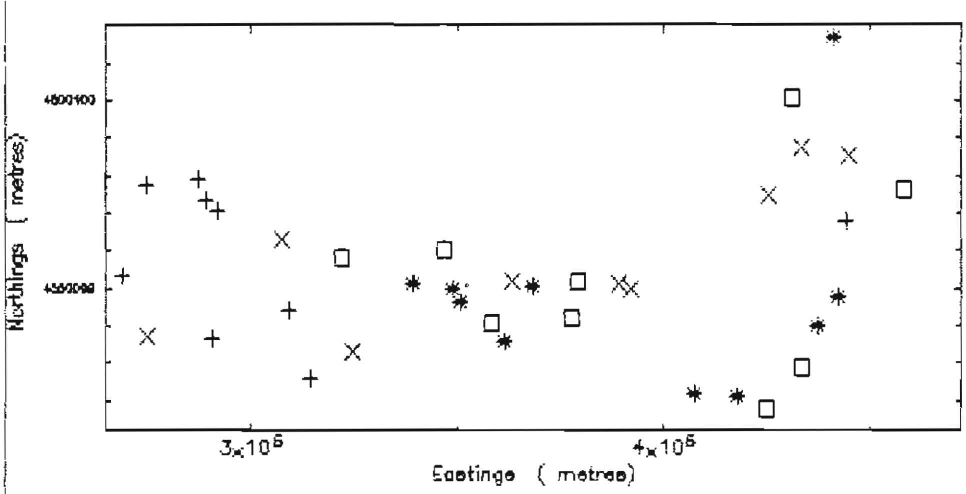
1st Quartile: 208.000 ≤ + ≤ 316.000
2nd Quartile: 316.000 < X ≤ 411.000
3rd Quartile: 411.000 < □ ≤ 490.000
4th Quartile: 490.000 < ✳ ≤ 521.000

Fig. 20b. Postplot of hot nitric acid soluble Ba (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



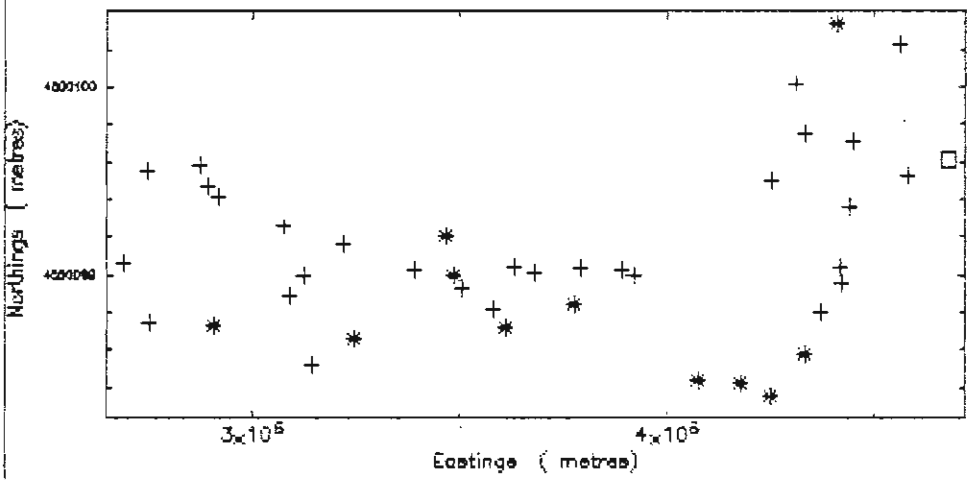
1st Quartile: 36.650 ≤ + ≤ 72.020
2nd Quartile: 72.020 < X ≤ 93.250
3rd Quartile: 93.250 < □ ≤ 126.900
4th Quartile: 126.900 < ✳ ≤ 265.100

Fig. 20c. Postplot of hot nitric acid soluble Ba (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



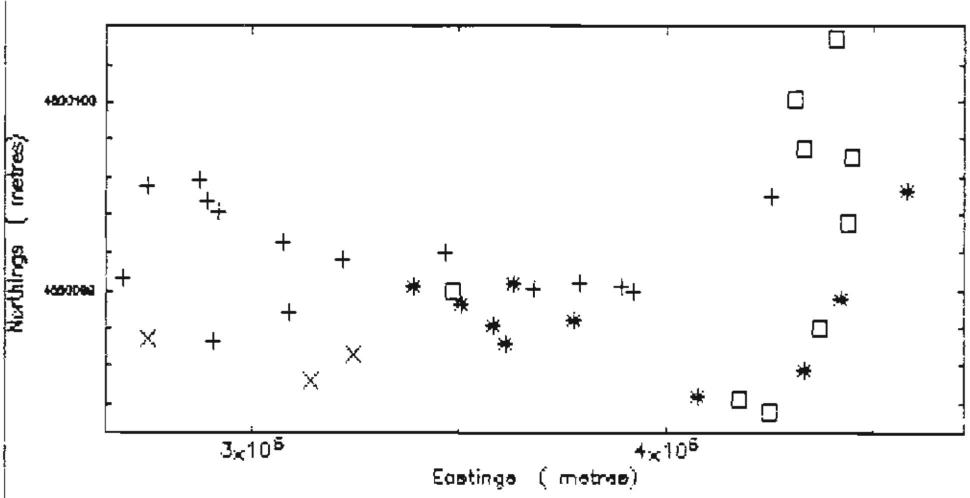
1st Quartile: 46.750 ≤ + ≤ 98.460
2nd Quartile: 98.460 < X ≤ 123.800
3rd Quartile: 123.800 < □ ≤ 172.800
4th Quartile: 172.800 < ✳ ≤ 279.800

Fig. 20d. Postplot of water soluble Ba (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



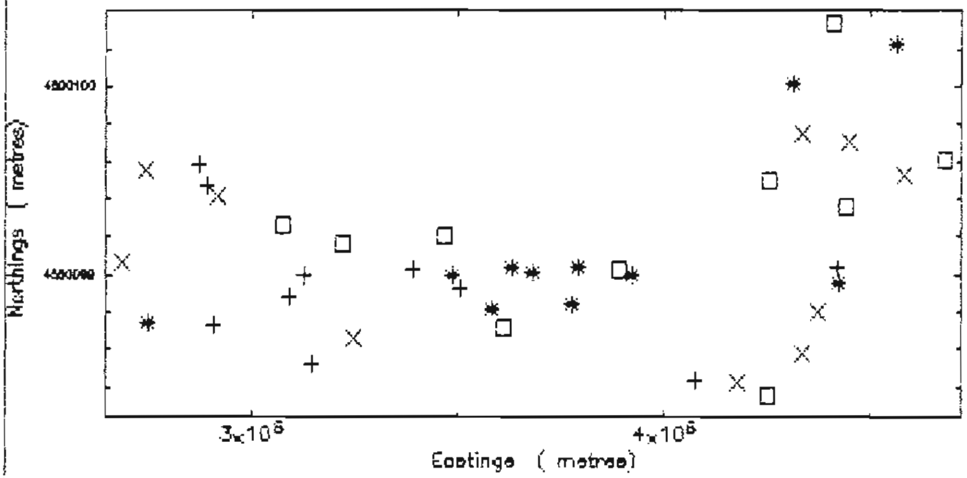
1st Quartile: .250 ≦ + ≦ .250
2nd Quartile: .250 < × ≦ .250
3rd Quartile: .250 < □ ≦ .263
4th Quartile: .263 < ✱ ≦ .329

Fig. 20e. Postplot of water soluble Ba (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



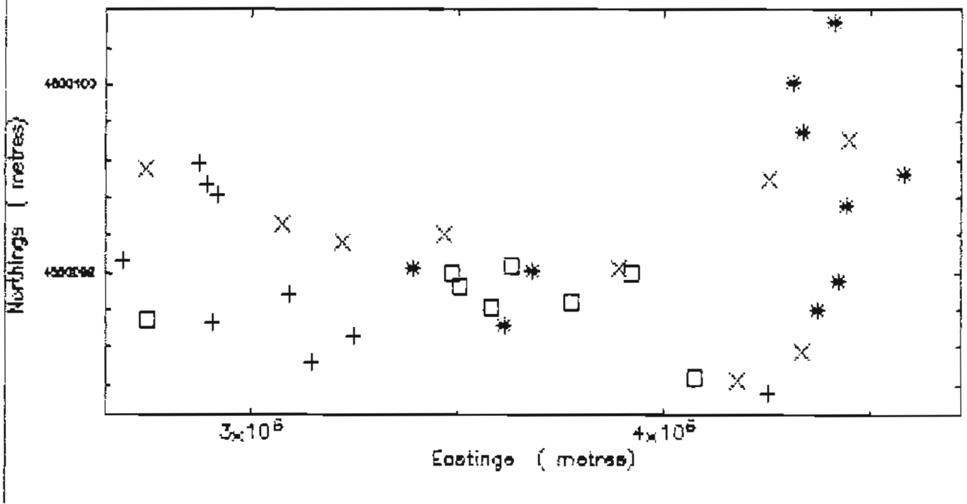
1st Quartile: .250 ≦ + ≦ .250
2nd Quartile: .250 < × ≦ .361
3rd Quartile: .361 < □ ≦ .641
4th Quartile: .641 < ✱ ≦ 1.020

Fig. 21. Postplot of total Mn in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)



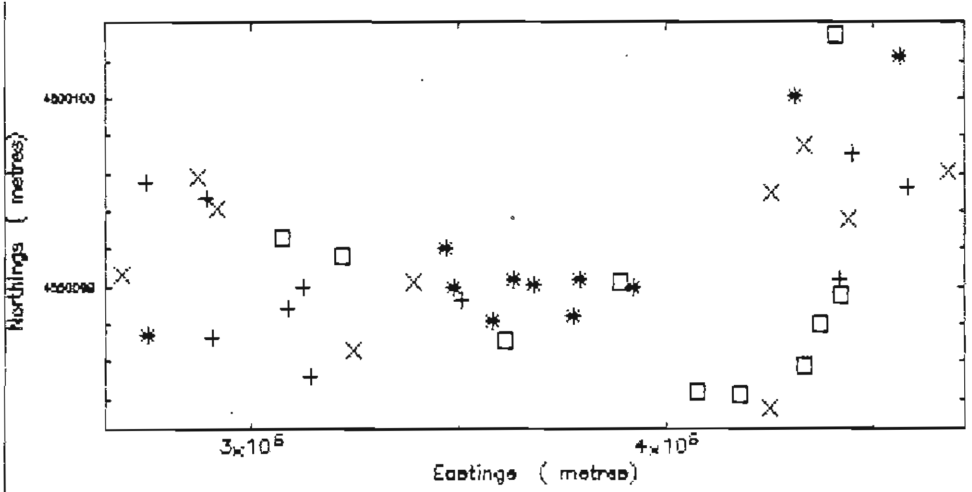
1st Quartile: 496.000 ≦ + ≦ 732.000
2nd Quartile: 732.000 < × ≦ 856.000
3rd Quartile: 856.000 < □ ≦ 965.000
4th Quartile: 965.000 < ✱ ≦ 1282.000

Fig. 21a. Postplot of total Mn in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box–and–whisker plot)



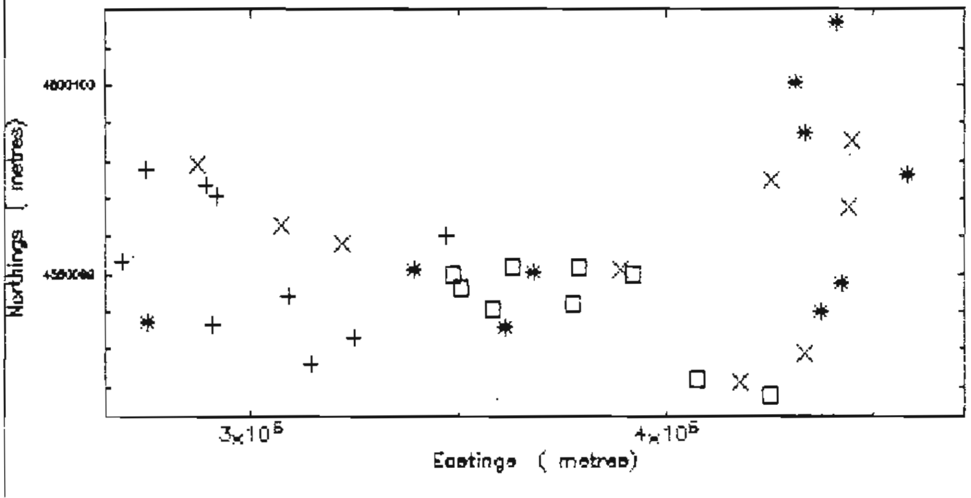
1st Quartile: 328.000 ≦ + ≦ 741.000
2nd Quartile: 741.000 < × ≦ 909.000
3rd Quartile: 909.000 < □ ≦ 1126.000
4th Quartile: 1126.000 < ✱ ≦ 3137.000

Fig. 21b. Postplot of hot nitric acid soluble Mn (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



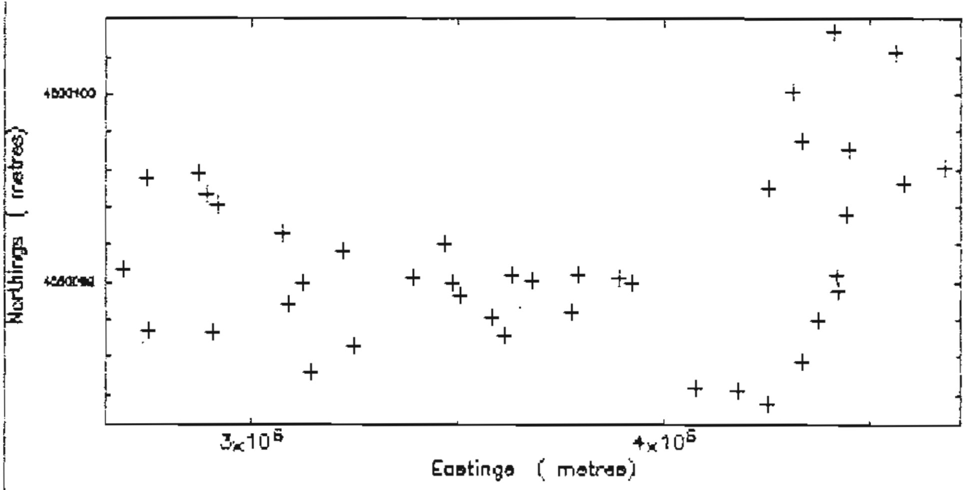
1st Quartile: 319.300 ≤ + ≤ 480.900
2nd Quartile: 480.900 < X ≤ 570.000
3rd Quartile: 570.000 < □ ≤ 656.300
4th Quartile: 656.300 < ✱ ≤ 951.900

Fig. 21c. Postplot of hot nitric acid soluble Mn (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



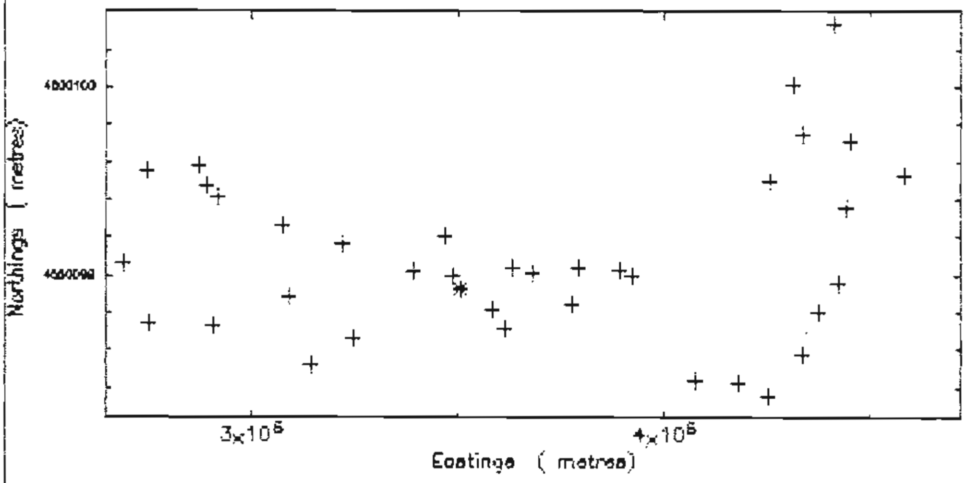
1st Quartile: 231.100 ≤ + ≤ 575.700
2nd Quartile: 575.700 < X ≤ 744.000
3rd Quartile: 744.000 < □ ≤ 916.500
4th Quartile: 916.500 < ✱ ≤ 2700.000

Fig. 21d. Postplot of water soluble Mn (ppm) in the 0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



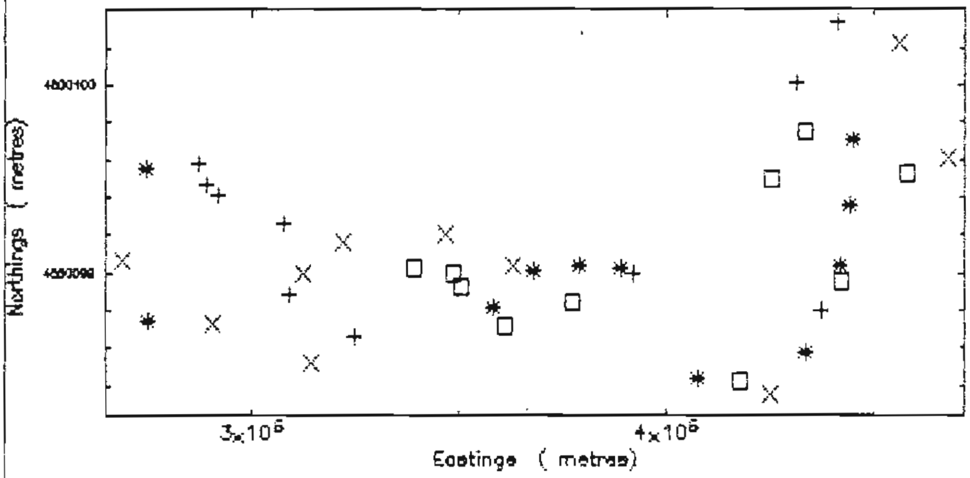
1st Quartile: .500 ≦ + ≦ .500
2nd Quartile: .500 < × ≦ .500
3rd Quartile: .500 < □ ≦ .500
4th Quartile: .500 < ✱ ≦ .500

Fig. 21e. Postplot of water soluble Mn (ppm) in the -0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



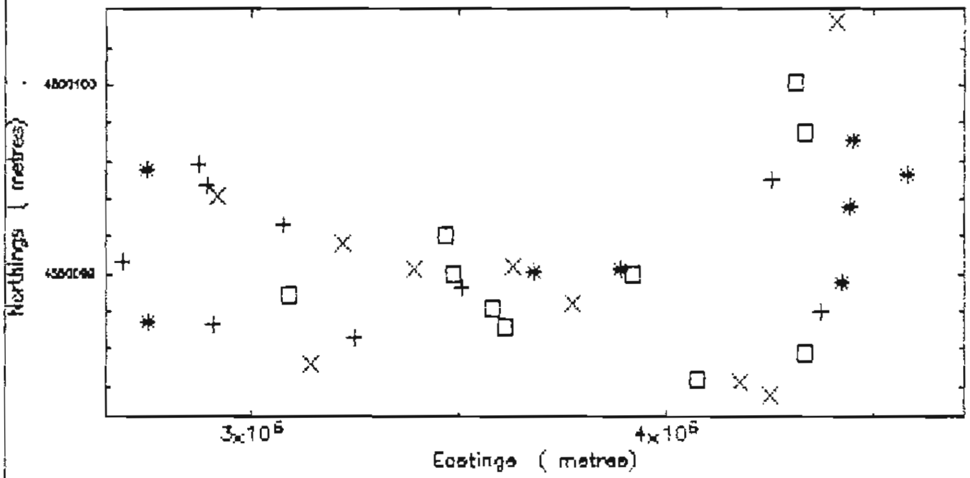
1st Quartile: .500 ≦ + ≦ .500
2nd Quartile: .500 < × ≦ .500
3rd Quartile: .500 < □ ≦ .500
4th Quartile: .500 < ✱ ≦ 29.000

Fig. 22. Postplot of total Sc in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



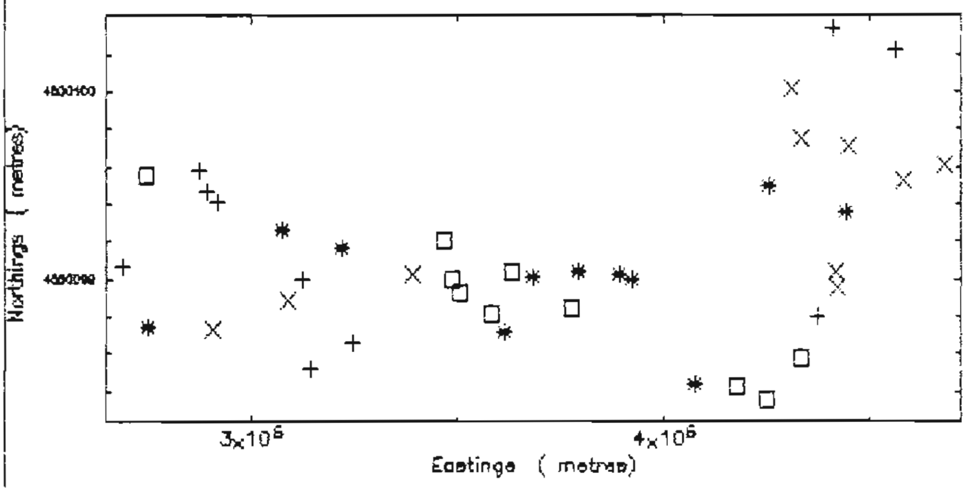
1st Quartile: 2.500 ≤ + ≤ 9.300
2nd Quartile: 9.300 < × ≤ 10.900
3rd Quartile: 10.900 < □ ≤ 12.900
4th Quartile: 12.900 < ✱ ≤ 17.600

Fig. 22a. Postplot of total Sc in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



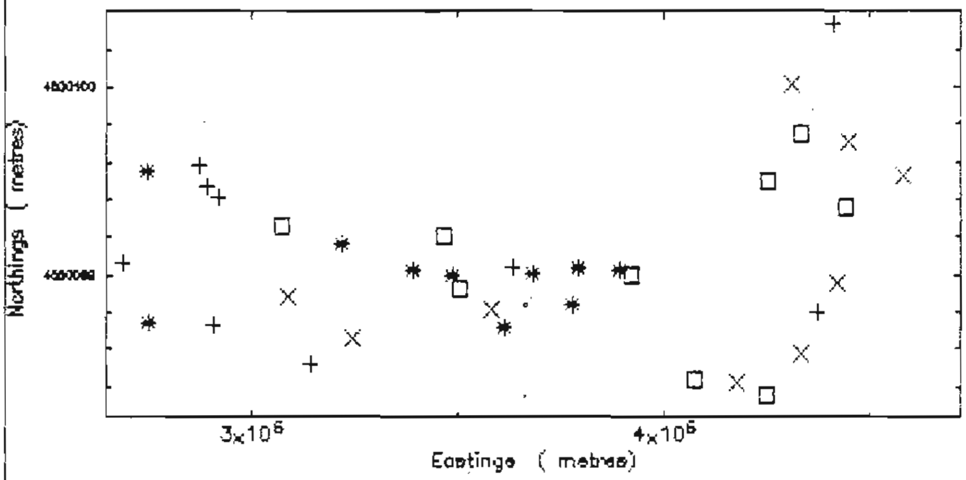
1st Quartile: 4.200 ≤ + ≤ 8.400
2nd Quartile: 8.400 < × ≤ 10.200
3rd Quartile: 10.200 < □ ≤ 11.400
4th Quartile: 11.400 < ✱ ≤ 17.100

Fig. 22b. Postplot of hot nitric acid soluble Sc (ppm) in the −0.063 mm fraction of overbank sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



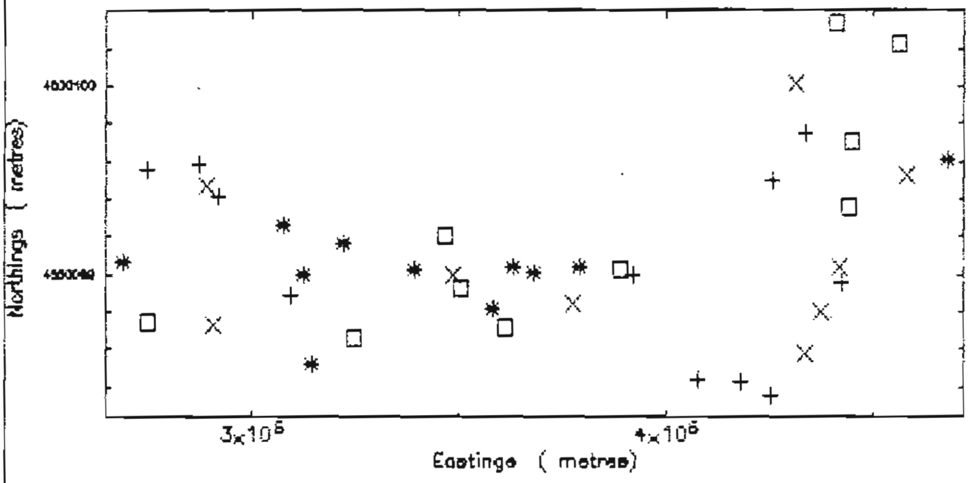
1st Quartile: 2.710 ≤ + ≤ 4.860
2nd Quartile: 4.860 < × ≤ 6.290
3rd Quartile: 6.290 < □ ≤ 7.140
4th Quartile: 7.140 < ✱ ≤ 10.440

Fig. 22c. Postplot of hot nitric acid soluble Sc (ppm) in the −0.063 mm fraction of stream sediment, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



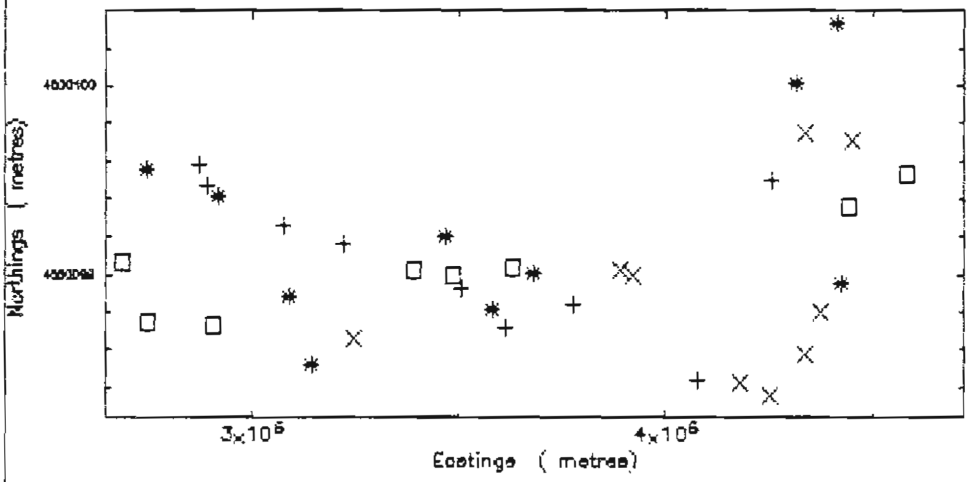
1st Quartile: 3.220 ≤ + ≤ 4.890
2nd Quartile: 4.890 < × ≤ 6.340
3rd Quartile: 6.340 < □ ≤ 7.720
4th Quartile: 7.720 < ✱ ≤ 15.250

Fig. 23. Postplot of total Y in the −0.063 mm fraction of overbank sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 14.500 ≤ + ≤ 23.200
2nd Quartile: 23.200 < × ≤ 25.400
3rd Quartile: 25.400 < □ ≤ 27.800
4th Quartile: 27.800 < ✱ ≤ 37.900

Fig. 23a. Postplot of total Y in the −0.063 mm fraction of stream sediment, Rhodope Region, N.E. Greece.
(Class values use the quartiles of the box-and-whisker plot)



1st Quartile: 16.200 ≤ + ≤ 19.400
2nd Quartile: 19.400 < × ≤ 22.800
3rd Quartile: 22.800 < □ ≤ 25.700
4th Quartile: 25.700 < ✱ ≤ 35.800

Table 1 - Statistical parameters of total Fe, Al, Ti, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, V, Mo, Be, Sr, Ba, Mn, Sc and V in the -0.063 mm fraction of overbank sediment, N.E. Greece

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	3.949	5.766	.516	2.742	54.293
Variance :	.816	.800	.009	1.502	4118.212
Std. Dev. :	.903	.895	.093	1.226	64.173
Coef. Var. :	22.877	15.515	17.928	44.708	118.199
Skewness :	.270	-.218	.179	1.427	3.438
Kurtosis :	2.760	3.103	2.599	6.737	14.435
Minimum :	2.200	3.400	.330	.800	21.000
25th %tile :	3.100	5.200	.442	1.878	28.000
Median :	4.000	5.700	.510	2.590	34.000
75th %tile :	4.300	6.275	.582	3.317	42.750
Maximum :	6.100	7.600	.730	7.480	351.000

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	29.878	93.000	3.366	86.268	33.195
Variance :	277.410	1442.400	1.020	3977.051	70.061
Std. Dev. :	16.656	37.979	1.010	63.064	8.370
Coef. Var. :	55.745	40.838	30.010	73.102	25.215
Skewness :	2.233	2.140	.447	3.667	.567
Kurtosis :	8.475	6.777	2.527	18.306	3.732
Minimum :	10.000	57.000	1.700	31.000	17.000
25th %tile :	21.250	70.750	2.700	57.000	27.250
Median :	27.000	83.000	3.100	75.000	33.000
75th %tile :	32.750	94.000	3.900	85.750	38.000
Maximum :	93.000	218.000	5.700	408.000	59.000

Table 1 cont.

	Lithium	Chromium	Vanadium	Molybdenum	Beryllium
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	20.878	119.024	103.098	3.878	2.680
Variance :	38.110	6746.725	599.890	2.160	.359
Std. Dev. :	6.173	82.138	24.493	1.470	.599
Coef. Var. :	29.568	69.010	23.757	37.896	22.341
Skewness :	1.050	2.424	.000	-.361	.508
Kurtosis :	4.810	10.367	3.584	2.424	3.239
Minimum :	10.000	35.000	42.000	1.000	1.700
25th %tile :	17.000	76.500	81.000	3.000	2.200
Median :	20.000	92.000	107.000	4.000	2.700
75th %tile :	23.750	132.000	112.750	5.000	3.000
Maximum :	41.000	479.000	167.000	7.000	4.400

	Strontium	Barium	Manganese	Scandium	Yttrium
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	163.610	434.317	867.024	11.244	25.849
Variance :	2407.944	17592.920	30854.630	9.265	22.411
Std. Dev. :	49.071	132.638	175.655	3.044	4.734
Coef. Var. :	29.993	30.540	20.260	27.071	18.314
Skewness :	-.233	-.071	.154	-.086	.346
Kurtosis :	2.597	2.555	2.791	3.624	4.004
Minimum :	39.000	130.000	496.000	2.500	14.500
25th %tile :	122.000	325.250	735.250	9.400	23.200
Median :	164.000	449.000	873.000	11.000	25.600
75th %tile :	207.000	533.750	967.250	12.975	28.025
Maximum :	265.000	732.000	1282.000	17.600	37.900

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	3.859	5.595	.466	3.865	64.676
Variance :	.780	.968	.010	7.790	7268.503
Std. Dev. :	.883	.984	.100	2.791	85.256
Coef. Var. :	22.887	17.584	21.414	72.215	131.820
Skewness :	.312	.179	.191	1.624	2.999
Kurtosis :	2.689	2.189	2.957	5.473	10.323
Minimum :	2.200	4.000	.260	.650	25.000
25th %tile :	3.125	4.825	.392	1.858	31.000
Median :	3.800	5.500	.460	3.300	39.000
75th %tile :	4.400	6.350	.520	4.480	46.000
Maximum :	6.100	7.700	.720	12.900	375.000

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	33.378	128.027	3.668	93.432	31.324
Variance :	370.908	17963.920	2.959	2151.308	66.336
Std. Dev. :	19.259	134.030	1.720	46.382	8.145
Coef. Var. :	57.699	104.688	46.902	49.642	26.001
Skewness :	2.302	4.608	2.962	2.759	.854
Kurtosis :	9.277	24.951	14.803	12.564	6.429
Minimum :	11.000	56.000	1.500	41.000	14.000
25th %tile :	22.000	77.500	2.750	67.750	25.250
Median :	29.000	93.000	3.700	80.000	32.000
75th %tile :	35.000	114.750	4.000	103.000	35.750
Maximum :	112.000	855.000	11.800	303.000	61.000

Table 2 - Statistical parameters of total Fe, Al, Ti, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, V, Mo, Be, Sr, Ba, Mn, Sc and V in the -0.063 mm fraction of stream sediment, N.E. Greece

Table 2 cont.

	Lithium	Chromium	Vanadium	Molybdenum	Beryllium
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	22.000	100.378	100.919	4.919	2.708
Variance :	56.278	2847.908	713.577	4.743	.640
Std. Dev. :	7.502	53.366	26.713	2.178	.800
Coef. Var. :	34.099	53.165	26.470	44.276	29.546
Skewness :	.985	1.542	-.005	.792	1.974
Kurtosis :	2.957	6.421	2.549	3.709	8.198
Minimum :	11.000	28.000	50.000	1.000	1.800
25th %tile :	16.250	58.250	82.000	3.250	2.200
Median :	20.000	93.000	101.000	5.000	2.500
75th %tile :	26.000	120.750	118.500	6.000	3.000
Maximum :	40.000	298.000	159.000	11.000	5.900

	Strontium	Barium	Manganese	Scandium	Yttrium
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	164.838	418.946	1139.351	10.489	23.714
Variance :	2445.751	12220.770	422126.800	8.962	25.965
Std. Dev. :	49.455	110.548	649.713	2.994	5.096
Coef. Var. :	30.002	26.387	57.025	28.540	21.488
Skewness :	.070	.057	1.604	.307	.685
Kurtosis :	2.365	2.075	4.836	3.138	2.775
Minimum :	65.000	208.000	329.000	4.200	16.200
25th %tile :	133.000	320.750	744.500	8.550	19.525
Median :	161.000	412.000	923.000	10.300	22.900
75th %tile :	191.250	496.000	1146.250	11.400	26.525
Maximum :	263.000	621.000	3137.000	17.100	35.800

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	2.472	2.378	.087	1.265	42.376
Variance :	.364	.289	.001	1.051	5786.248
Std. Dev. :	.603	.537	.037	1.025	76.067
Coef. Var. :	24.410	22.591	42.883	81.015	179.506
Skewness :	.071	1.197	.877	3.280	3.805
Kurtosis :	2.377	6.593	5.894	16.563	17.736
Minimum :	1.410	1.390	.009	.430	5.810
25th %tile :	1.903	2.092	.063	.690	13.995
Median :	2.500	2.300	.086	.920	18.180
75th %tile :	2.900	2.600	.100	1.515	30.255
Maximum :	3.970	4.410	.220	6.410	423.400

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	28.300	65.282	1.123	52.846	14.910
Variance :	277.696	1359.667	.342	2474.632	18.918
Std. Dev. :	16.664	36.874	.585	49.746	4.350
Coef. Var. :	58.885	56.484	52.075	94.133	29.173
Skewness :	2.110	2.337	5.610	3.283	.732
Kurtosis :	7.647	7.573	34.034	15.385	5.018
Minimum :	8.390	32.270	1.000	17.890	5.550
25th %tile :	18.467	46.205	1.000	26.430	12.625
Median :	25.530	55.500	1.000	38.220	14.550
75th %tile :	29.045	65.452	1.000	55.620	17.015
Maximum :	87.360	187.600	4.650	295.500	29.580

Table 3 - Statistical parameters of hot nitric acid soluble Fe, Al, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, Cr, V, Mo, Be, Sr, Ba, Mn and Sc in the -0.063 mm fraction of overbank sediment, N.E. Greece.

```
                 Lithium    Chromium    Vanadium  Molybdenum   Beryllium
------------------------------------------------------------------------
N used    :           41          41          41          41          41
N missing :            0           0           0           0           0
N .LE. 0  :            0           0           0           0           0

Mean      :       14.827      64.446      49.813       4.865       1.103
Variance  :       21.127    2413.892     136.347       2.097        .092
Std. Dev. :        4.596      49.131      11.677       1.448        .303
Coef. Var. :      31.000      76.236      23.441      29.770      27.429
Skewness  :        1.726       2.484       -.319       1.111        .623
Kurtosis  :        7.101       9.944       2.918       4.998       3.004

Minimum   :        8.740      17.000      19.130       2.740        .450
25th %tile :      11.438      37.563      40.963       3.867        .880
Median    :       13.960      49.640      51.630       4.610       1.010
75th %tile :      16.063      61.653      55.310       5.618       1.332
Maximum   :       32.930     276.200      72.930       9.980       1.870


               Strontium      Barium   Manganese    Scandium
------------------------------------------------------------------------
N used    :           41          41          41          41
N missing :            0           0           0           0
N .LE. 0  :            0           0           0           0

Mean      :       42.502     108.233     590.568       6.358
Variance  :      481.165    2304.689   19868.480       2.898
Std. Dev. :       21.935      48.007     140.956       1.702
Coef. Var. :      51.610      44.356      23.868      26.776
Skewness  :         .908       1.198        .642        .091
Kurtosis  :        3.100       4.876       3.387       2.652

Minimum   :       12.750      36.650     319.300       2.710
25th %tile :      24.340      73.160     482.750       4.880
Median    :       36.700      95.270     575.100       6.380
75th %tile :      57.675     129.375     662.075       7.267
Maximum   :       99.680     265.100     981.900      10.440
```

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	2.731	2.805	.074	2.359	48.638
Variance :	.693	.770	.001	4.959	8428.367
Std. Dev. :	.833	.878	.038	2.227	91.806
Coef. Var. :	30.483	31.284	52.013	94.385	188.755
Skewness :	.292	.645	.354	1.874	3.047
Kurtosis :	2.056	2.698	2.631	5.944	10.664
Minimum :	1.380	1.410	.002	.300	8.040
25th %tile :	2.023	2.080	.046	.777	13.630
Median :	2.680	2.570	.068	1.780	20.360
75th %tile :	3.330	3.310	.096	2.713	27.638
Maximum :	4.540	4.910	.170	9.390	397.700

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	32.770	95.430	1.395	51.715	16.139
Variance :	414.563	15675.990	1.858	1556.650	51.628
Std. Dev. :	20.361	125.204	1.363	39.454	7.185
Coef. Var. :	62.133	131.199	97.709	76.292	44.521
Skewness :	2.213	4.808	4.120	2.290	2.567
Kurtosis :	8.752	26.732	19.899	8.877	12.754
Minimum :	10.230	21.530	1.000	13.860	6.840
25th %tile :	19.888	54.022	1.000	27.493	11.935
Median :	29.020	65.870	1.000	41.740	14.430
75th %tile :	33.208	78.838	1.000	53.540	18.688
Maximum :	114.200	787.300	8.280	211.600	48.900

Table 4 - Statistical parameters of hot nitric acid soluble Fe, Al, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, Cr, V, Mo, Be, Sr, Ba, Mn and Sc in the -0.063 mm fraction of stream sediment, N.E. Greece.

Table 4 - Cont.

	Lithium	Chromium	Vanadium	Molybdenum	Beryllium
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	16.306	60.214	51.853	4.414	1.225
Variance :	24.891	1378.606	232.722	2.729	.337
Std. Dev. :	4.989	37.130	15.255	1.652	.580
Coef. Var. :	30.597	61.663	29.420	37.431	47.353
Skewness :	.832	1.549	.607	.623	2.480
Kurtosis :	3.737	4.577	3.539	3.088	12.092
Minimum :	8.970	16.690	23.080	1.660	.490
25th %tile :	11.575	35.467	40.880	3.265	.880
Median :	16.280	49.100	49.640	4.160	1.150
75th %tile :	19.108	70.152	61.507	5.407	1.485
Maximum :	31.370	165.600	92.630	8.970	3.830

	Strontium	Barium	Manganese	Scandium
N used :	37	37	37	37
N missing :	0	0	0	0
N .LE. 0 :	0	0	0	0
Mean :	64.177	139.345	901.759	6.898
Variance :	1757.791	2902.818	317466.800	6.638
Std. Dev. :	41.926	53.878	563.442	2.576
Coef. Var. :	65.328	38.665	62.483	37.352
Skewness :	1.134	.531	1.717	1.015
Kurtosis :	3.115	3.005	5.487	4.287
Minimum :	19.310	46.780	231.100	3.220
25th %tile :	32.535	99.145	576.675	4.983
Median :	52.200	134.200	754.500	6.650
75th %tile :	76.117	176.625	938.475	7.780
Maximum :	159.800	279.800	2700.000	15.250

	Lithium	Vanadium	Molybdenum	Beryllium	Strontium
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	.050	.078	.108	.010	.711
Variance :	.000	.003	.001	.000	.534
Std. Dev. :	.000	.052	.035	.001	.731
Coef. Var. :	.000	66.391	32.337	6.187	102.760
Skewness :	.000	6.166	5.567	6.166	3.030
Kurtosis :	.000	39.025	33.609	39.025	12.297
Minimum :	.050	.070	.100	.010	.072
25th %tile :	.050	.070	.100	.010	.314
Median :	.050	.070	.100	.010	.521
75th %tile :	.050	.070	.100	.010	.769
Maximum :	.050	.402	.317	.014	3.650

	Barium	Manganese
N used :	41	41
N missing :	0	0
N .LE. 0 :	0	0
Mean :	.285	.500
Variance :	.012	.000
Std. Dev. :	.110	.000
Coef. Var. :	38.639	.000
Skewness :	5.112	.000
Kurtosis :	30.094	.000
Minimum :	.250	.500
25th %tile :	.250	.500
Median :	.250	.500
75th %tile :	.274	.500
Maximum :	.929	.500

Table 5 - Statistical parameters of water soluble Fe, Al, TI, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, V, Mo, Be, Sr, Ba and Mn in the -0.063 mm fraction of overbank sediment, N.E. Greece

Table 5 - Cont.

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	.001	.002	.001	.023	.900
Variance :	.000	.000	.000	.000	.000
Std. Dev. :	.001	.002	.001	.019	.000
Coef. Var. :	96.682	110.869	129.754	79.816	.000
Skewness :	2.522	2.690	3.960	2.895	.000
Kurtosis :	11.845	12.345	21.715	11.911	.000
Minimum :	.000	.000	.000	.002	.900
25th %tile :	.001	.001	.000	.014	.900
Median :	.001	.001	.001	.020	.900
75th %tile :	.002	.002	.001	.025	.900
Maximum :	.007	.010	.007	.100	.900

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	41	41	41	41	41
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	.042	.066	.060	.400	.200
Variance :	.002	.000	.000	.000	.000
Std. Dev. :	.046	.021	.000	.000	.000
Coef. Var. :	108.099	31.612	.000	.000	.000
Skewness :	1.822	3.666	.000	.000	.000
Kurtosis :	5.979	15.133	.000	.000	.000
Minimum :	.010	.060	.060	.400	.200
25th %tile :	.010	.060	.060	.400	.200
Median :	.026	.060	.060	.400	.200
75th %tile :	.044	.060	.060	.400	.200
Maximum :	.209	.154	.060	.400	.200

	Iron	Aluminium	Titanium	Calcium	Lead
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	.000	.001	.291	.044	.900
Variance :	.000	.000	.483	.001	.000
Std. Dev. :	.001	.001	.695	.031	.000
Coef. Var. :	234.611	231.850	238.799	69.052	.000
Skewness :	3.341	3.860	4.035	.714	.000
Kurtosis :	14.848	18.744	20.265	2.415	.000
Minimum :	.000	.000	.040	.009	.900
25th %tile :	.000	.000	.040	.018	.900
Median :	.000	.000	.040	.034	.900
75th %tile :	.000	.000	.103	.069	.900
Maximum :	.005	.008	3.860	.120	.900

	Copper	Zinc	Cadmium	Nickel	Cobalt
N used :	37	37	37	37	37
N missing :	0	0	0	0	0
N .LE. 0 :	0	0	0	0	0
Mean :	.058	.063	.060	.400	.200
Variance :	.002	.000	.000	.000	.000
Std. Dev. :	.044	.017	.000	.000	.000
Coef. Var. :	76.746	26.280	.000	.000	.000
Skewness :	1.137	5.601	.000	.000	.000
Kurtosis :	3.706	33.086	.000	.000	.000
Minimum :	.010	.060	.060	.400	.200
25th %tile :	.019	.060	.060	.400	.200
Median :	.044	.060	.060	.400	.200
75th %tile :	.088	.060	.060	.400	.200
Maximum :	.182	.160	.060	.400	.200

Table 6 - Statistical parameters of water soluble Fe, Al, Ti, Ca, Pb, Cu, Zn, Cd, Ni, Co, Li, V, Mo, Be, Sr, Ba and Mn in the -0.063 mm fraction of stream sediment, N.E. Greece

Table 6 - Cont.

		Lithium	Vanadium	Molybdenum	Beryllium	Strontium
N used	:	37	37	37	37	37
N missing	:	0	0	0	0	0
N .LE. 0	:	0	0	0	0	0
Mean	:	.059	.078	.100	.010	1.920
Variance	:	.002	.001	.000	.000	2.444
Std. Dev.	:	.046	.036	.000	.001	1.563
Coef. Var.	:	76.998	45.866	.000	6.506	81.422
Skewness	:	5.614	4.152	.000	5.833	.795
Kurtosis	:	33.247	18.804	.000	35.028	2.692
Minimum	:	.050	.070	.100	.010	.263
25th %tile	:	.050	.070	.100	.010	.566
Median	:	.050	.070	.100	.010	1.550
75th %tile	:	.050	.070	.100	.010	2.945
Maximum	:	.326	.252	.100	.014	6.060

		Barium	Manganese
N used	:	37	37
N missing	:	0	0
N .LE. 0	:	0	0
Mean	:	.472	1.270
Variance	:	.059	21.953
Std. Dev.	:	.242	4.685
Coef. Var.	:	51.361	368.848
Skewness	:	.670	5.833
Kurtosis	:	2.187	35.028
Minimum	:	.250	.500
25th %tile	:	.250	.500
Median	:	.372	.500
75th %tile	:	.663	.500
Maximum	:	1.020	29.000

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 7.3

A COMPARISON OF OVERBANK AND STREAM SEDIMENT, SPAIN

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I.T.G.E., Spain

1990

CONTENTS

1.0. INTRODUCTION

The main objective of this study was the comparison of overbank and stream sediments as sampling media for low sample density geochemical mapping.

2.0. STUDY AREAS

Two areas covering different morphoclimatic, geological and industrial environments have been chosen for sampling (Fig. 1).

2.1. Western border of the Sierra de la Demanda Mountain (refer to Appendix report 7.3 for figures)

The sampled rivers flow through a Miocene Basin, next to the mountains of the Sierra de la Demanda, where they have their source. The central part of these mountains is made up from Palaeozoic materials (schist, greywacke and sandstone), and the periphery from Triassic sedimentary rocks of continental red facies (conglomerate, sandstone and clay) and limestone of Jurassic to Cretaceous age.

Vein type Pb-Zn-Ag, Cu-Ag or Sb mineralization is known to occur in the Palaeozoic rocks, and was mined about forty years ago.

The overbank sediment is well developed in the river basins over the argillaceous Miocence basin (>1.20 m), but is less developed over the Palaeozoic formations (20-40 cms in thickness).

2.2. Southern border of the Sierra de Guadarrama Mountains, Madrid (refer to Appendix report 5.8 for figures)

The Sierra de Guadarrama is a mountainous massif made up from granitic and medium to high grade metamorphic rocks (migmatite, gneiss). At its southern side, besides a narrow outcrop of Cretaceous age limestone, there is a wide Miocene basin, filled by clastic materials (conglomerate and sand) derived from the Palaeozoic rocks after their uplift in early Tertiary times.

Many mineralized showings of little economic significance occur in both the metamorphic and granitic terrains. It is worth mentioning the small quartz veins with Sn-W and W-As, which are closely related to peraluminous granite, and thin Sn-W placers.

3.0. SAMPLING, SAMPLE PREPARATION AND ANALYSIS

3.1. Sampling

At each site three samples were taken, i.e., (a) an overbank sediment sediment from the top 10 cms under the grass roots, (b) an overbank sediment from the last 10-20 cms above the gravel level, and (c) an active stream sediment.

3.1.1. Sierra de la Demanda area

Three sample sites (1, 2 and 3) were chosen from third or fourth order rivers coming from the mountain range of Sierra de la Demanda (Figs. 2 to 4).

3.1.2. Southern border of Sierra de Guadarrama, Madrid

One sample site was selected in the Manzanares river basin, which drains the granitic and metamorphic terrain of Sierra de Guadarrama and the Miocene sedimentary basin.

3.2. Sample preparation

All the samples (overbank and stream sediment) were dried in an oven at a temperature of 40-45°C. The dried samples were disaggregated in a porcelain mortar, and afterwards sieved through a -0.063 mm nylon screen.

3.3. Analytical methods

The total element contents were determined on the -0.063 mm fraction by the Analytical Service of the I.T.G.E., whereas N.G.U. has undertaken to analyse all the samples for hot nitric and water soluble elements. The latter analyses are not yet available.

The total element contents were determined on all the grain size fractions of the samples, i.e., the natural -0.063 mm component, and the ground -0.063 mm material of the coarser size fractions.

The sample was homogenized prior to the taking of a 1 gm aliquot for analysis. Major and trace elements were determined by ICP after hot digestion in a mixture of HNO_3, $HClO_4$ and HF acid.

Sn was determined by D.C.P. after a two stage attack on a 1 g subsample by Na_2O_2 at 45°C, and followed by a mixture of ClO_4H, and HF.

F was determined by colorimetric methods, and Au on a 50 g subsample by A.A. graphite furnace.

The lower detection limits of the elements are tabulated below (all values in ppm except Au in ppb):

Cu	Pb	Zn	Ni	Co	Cr	Ba	V	Y
5	5	5	5	5	5	5	5	5
Mn	As	Sb	Nb	W	Ag	Cd	Be	Mo
10	10	10	10	10	1	1	1	2
Fe	Al	Ca	K	Na	K	Mg	Ti	Li
20	20	20	20	20	20	20	20	50
Sn	F	Au						
10	200	5						

The concentrations in Au, Cd, Nb, Sb, As and to a lesser extent Co were in all the samples below the lower detection limit. Therefore, these results were not considered in this study.

4.0. DISCUSSION

Although the number of stream sediment samples taken in this project is too small, it can still be seen (Tables 1 and 2) that both samples (OBS and SS) are useful for the proposed WEGS low sampling density geochemical survey. The overbank sediment samples give more information about the history of sedimentation of a drainage basin, i.e., polluted and pristine samples may be collected, whereas the active stream sediment samples reflect the present day erosion of the river, and are more susceptible to contamination and pollution. This is clearly seen, although the trace element contents are slightly lower that in the upper part of the corresponding overbank sediment sample. The explanation for this feature may be due to many factors, such as (a) the top layers of the overbank sediment are in direct contact with man's activities (b) their different mineralogical composition, i.e., greater content in clay material, and (c) different ph-Eh conditions.

5.0. CONCLUSION

The two sampling media, overbank and stream sediment, supply complementary information. It is, therefore, proposed that both sample types should be collected by the WEGS geochemical mapping project.

ACKNOWLEDGEMENTS

We thank S. del Barrio (ITGE) for the analysis of the samples, A. Olias (ITGE) for the delineation work, and M. Martinez for the preparation of the samples.

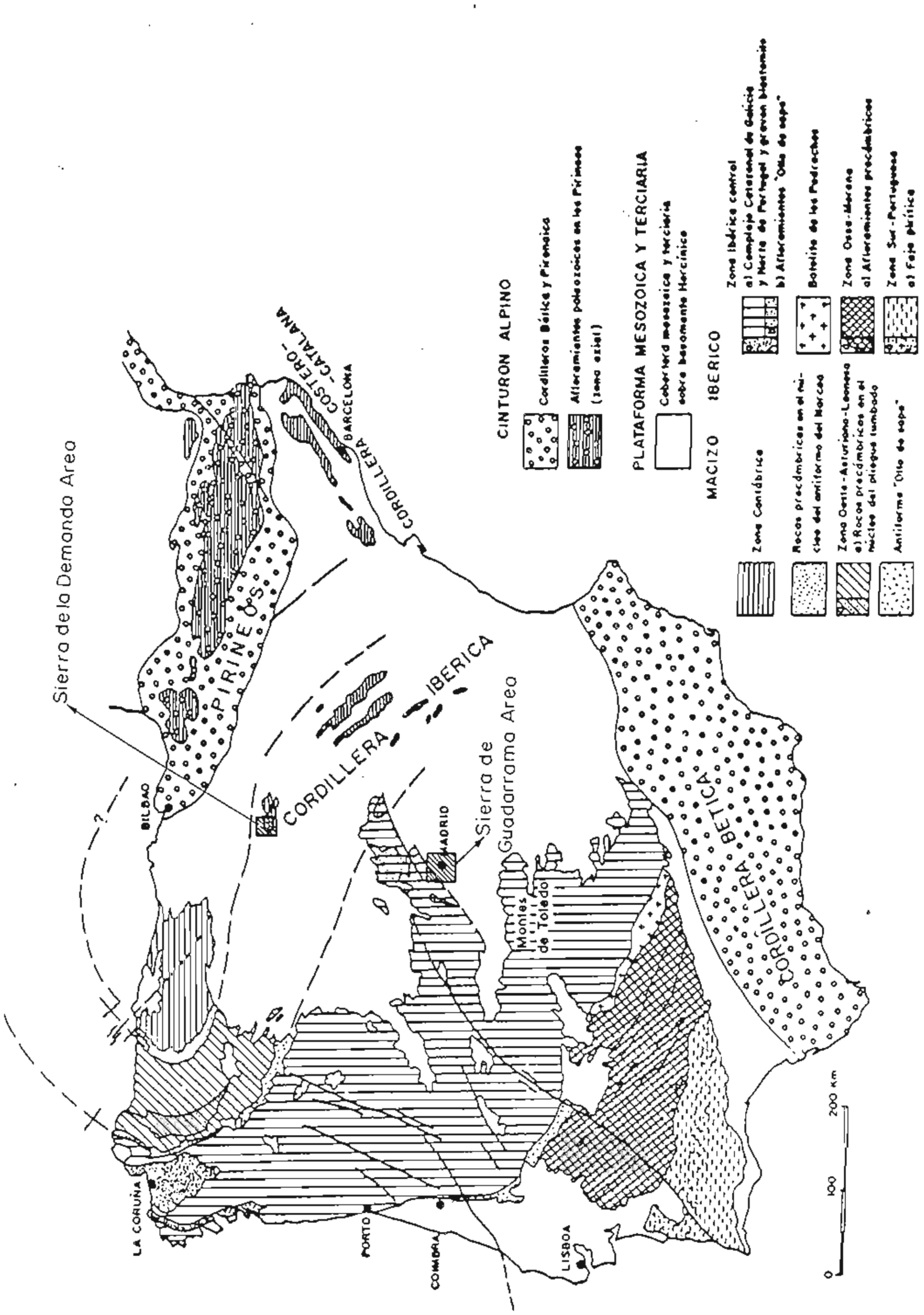

Fig. nº 1.- Sampling Areas

Fig. 2

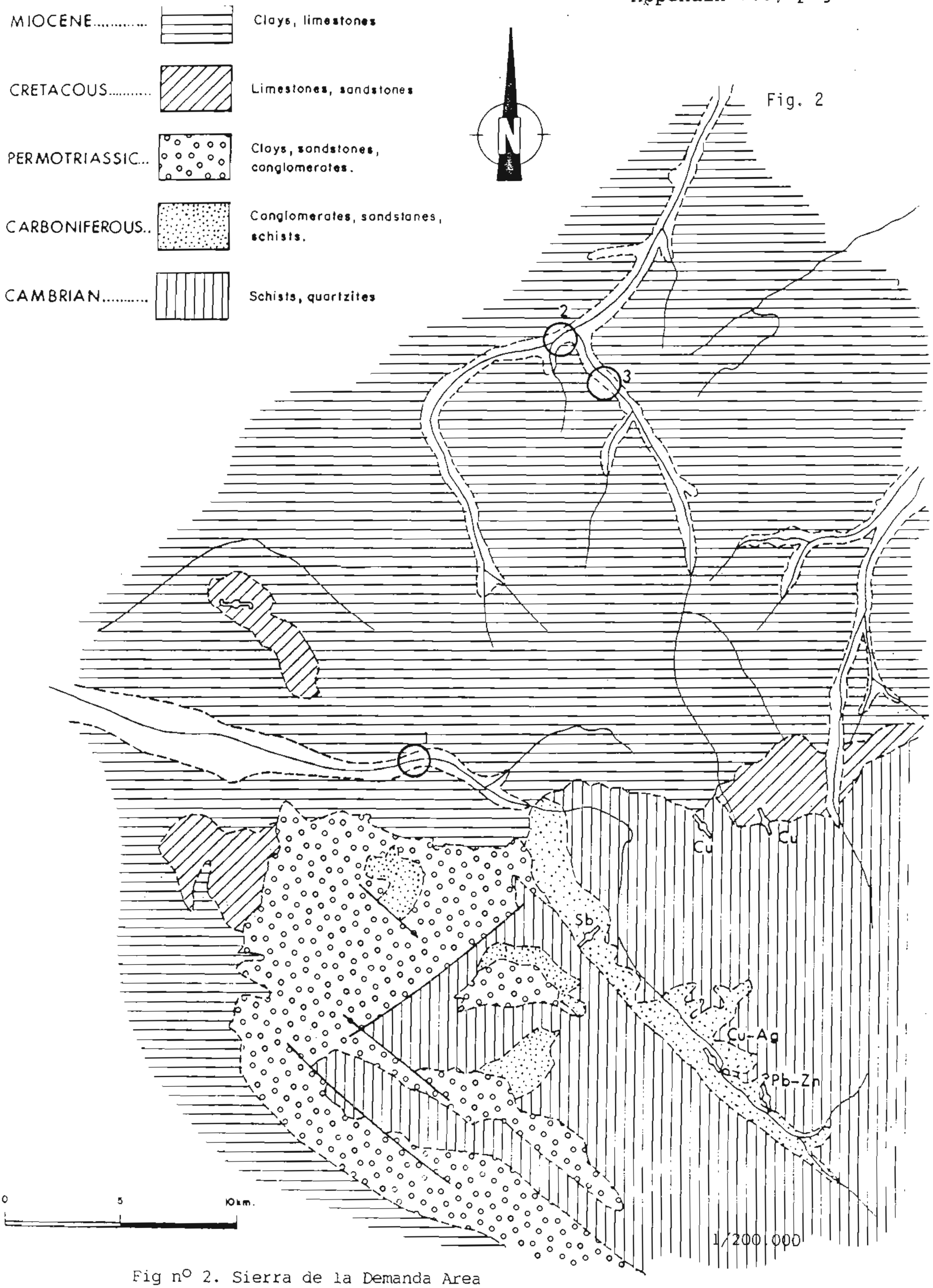

Fig nº 2. Sierra de la Demanda Area

Fig. 3.

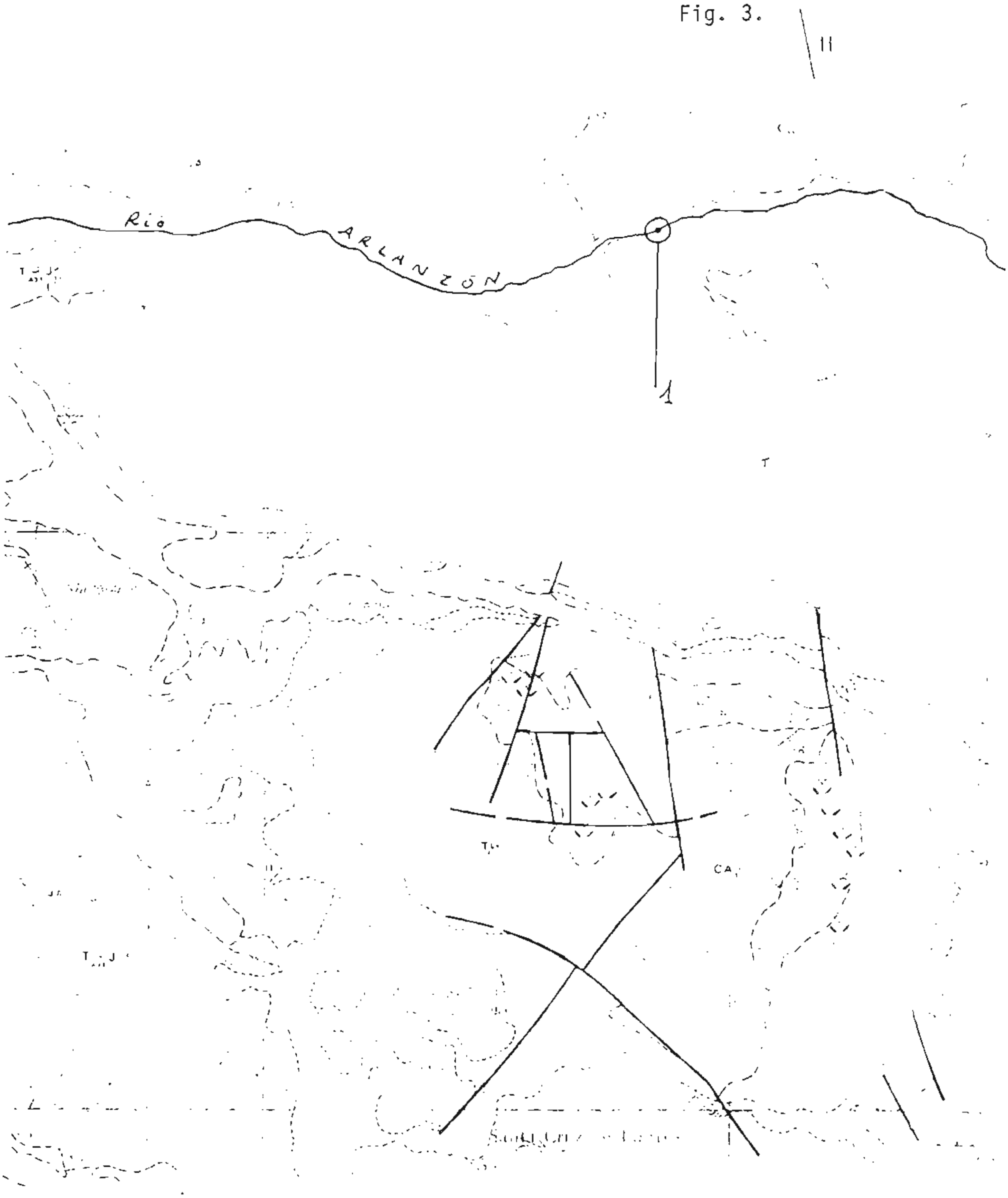

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Fig nº 5
Sierra de la Demanda Area. Site 1 (R. Arlanzón)

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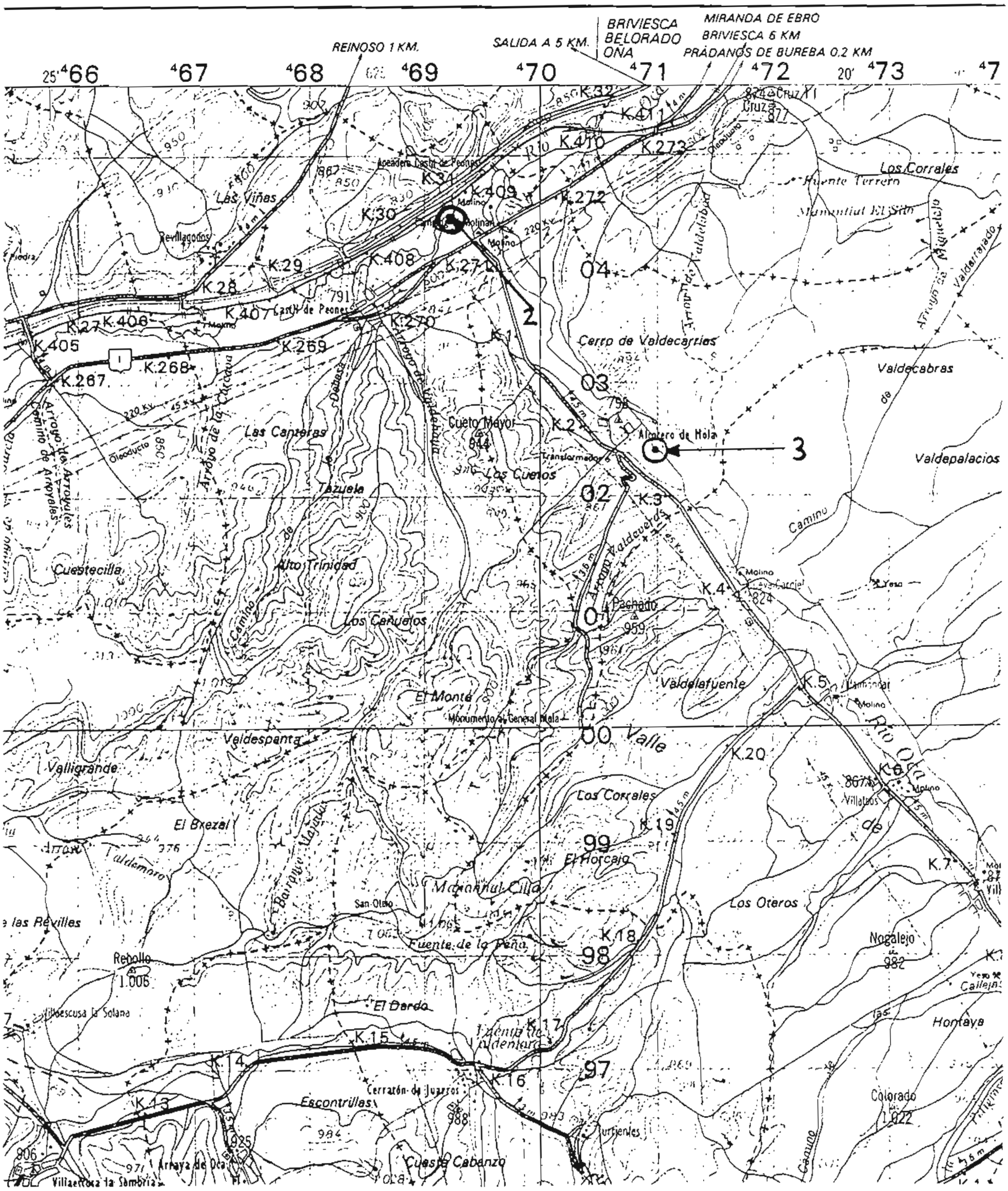

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Fig nº 64

Sierra de la Demanda Area. Sites 2 and 3 (R. Oca and R. Cerrata)

D E M A N D A   A R E A (-0.063 mm fraction)

(sites 1, 2, 3)

	TOP (OBS)			BOTTOM (OBS)			S. SED.		
	1	2	3	1	2	3	1	2	3
Cu	15	5	8	18	5	5	16	5	5
Pb	25	14	17	28	14	14	24	14	12
Zn	100	13	26	91	16	8	75	25	15
P	588	359	523	555	308	291	594	463	483
Ni	34	5	11	34	7	9	31	7	8
Co	22	5	5	22	5	5	15	5	5
Mn	1390	196	325	874	235	378	1370	176	238
Ba	479	262	353	472	307	330	435	273	316
V	65	24	42	68	31	36	61	27	34
Mg(%)	0.52	0.67	1.13	0.62	0.93	0.55	0.87	1.12	1.05
Na(%)	0.28	0.10	0.14	0.30	0.1	0.12	0.46	1.11	0.13
K(%)	2.	1.30	1.84	2.1	1.49	1.61	1.85	1.36	1.52
Fe(%)	3.15	1.08	1.85	3.18	1.34	1.65	3.12	1.22	1.45
Y	13	11	9	13	10	11	13	10	12
Ti(%)	0.28	0.28	0.25	0.28	0.26	0.33	0.30	0.3	0.34
Cr	44	15	28	44	20	21	46	19	20
Al(%)	6.02	2.63	4.11	6.12	3.30	3.48	6.02	3.	3.46
Ca(%)	0.04	10.2	5.17	--	10.	3.50	--	13.6	7.9
F	432	363	415	415	345	276	439	345	345

Table n^{o} 1 : -Comparison between OBS and SS

RIO MANZANARES SAMPLE 4

(-0.063 mm fraction)

	TOP	BOTTOM	STREAM SED.
Ag	2.5	1	1.4
Ba	687	369	455
Be	3.3	2.5	2.4
Co	5	5	5
Cr	23	7	22
Cu	121	8	39
Pb	204	52	108
Zn	240	24	143
Mn	420	399	315
Ni	14	5	5
P	878	1160	1310
V	21	17	18
Y	27	38	29
Mg(%)	0.50	0.62	0.65
Fe(%)	2.02	1.16	1.39
Na(%)	1.86	1.71	1.54
K(%)	3.44	3.10	2.96
Al(%)	7.01	6.30	6.26
Ca(%)	0.7	5.04	4.78
F	624	554	527
Li	93	64	50

Table n° 2 : Comparison between OBS and S. Sed.

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 8

A COMPARISON OF THREE DIFFERENT ANALYTICAL METHODS IN THE ANALYSIS OF OVERBANK AND STREAM SEDIMENT SAMPLES

Alecos DEMETRIADES

I.G.M.E., Greece

1990

CONTENTS

FIGURES

1.0. INTRODUCTION

The WEGS Working Group on Regional Geochemical Mapping, in its first proposal for the geochemical mapping of Western Europe in 1986, considered it important to analyze the samples by as many different analytical methods as is practically possible. At the Hannover meeting in 1989 it was finally decided to analyze the pilot project samples by at least three different analytical methods, i.e., total, partial and a weak attack by just water. The reasons for this choice are: the total method is required for information on the exact element contents of the samples; the partial method for information on the loosely bound elements in the samples, and the water extractable method will supply data on the air-borne and very weakly held elements.

The work was undertaken by (a) the B.G.R. (R. Hindel) for total contents of elements, (b) the N.G.U. (R.T. Ottesen) for acid and water soluble element concentrations, and B.R.G.M. (I. Salpeteur) for Au only.

This report presents some of the available data on the -0.063 mm grain size fraction of the Greek pilot survey overbank and stream sediment samples. It is hoped, however, that by the Orleans meeting the final version of the report will be ready for distribution.

2.0. OBJECTIVES

The study of results from different analytical methods and the evaluation of their usefulness in the proposed WEGS Geochemical Mapping Project.

3.0. ANALYTICAL METHODS

The analytical methods used in this study are described below.

3.1. Analysis of total element contents

At B.G.R. major and trace elements were determined on a 500 mg aliquot after hot digestion by a mixture of HF (38-40%) and $HClO_4$ (70%) acid, and analyzed by an atomic absorption spectrophotometer (Instrumentation Laboratory - IL 951 and VIDEO 22) for the following elements: Fe (1 ppm), Al, Ti, Ca, Pb (5 ppm), Cu (3 ppm), Zn (3 ppm), Cd (0.3 ppm), Ni (3 ppm), Co (3 ppm), Li (1 ppm), Cr, V, Mo, Be, Sr, Ba, Mn (1 ppm), Sc and Y. The values in bracket are the lower detection limits for each element, which was determined on a 500 mg sample weight and a 25 ml sample solution.

Gold was determined at B.R.G.M. on a 50 gm sample by A.A. graphite furnace after a tri-acid digestion (HCl, HNO_3, HF). The lower detection limit was 5 ppb and the upper 1000 ppb.

3.2. Analysis of hot nitric soluble elements

One gram of the minus 0.063 mm fraction was attacked by 5 ml of 7N HNO_3 at 110°C for three hours. After digestion the solution was diluted to 20.3 ml, centrifuged and decanted. Then, 1 ml of this solution was diluted with 4 ml of a reference element solution containing 20 ug/ml of Li and Y in deionized water as internal standards. The final solution thus contained 16 ug/ml of Li and Y. The elements Al, Ag, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Si, Sr, Ti, V, Zn and Zr were determined on the solution by a Jerrel-Ash 975 ICAP Atom Comp. (Odegard 1980). The lower detection limits of the elements were obtained by measuring the background signal of the element line on blank samples, and then multiplying the value by 100, which is the dilution factor of the solutions. The lower detection limits of the elements in ppm are tabulated below, i.e.,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
10.0	5.0	0.6	0.3	5.0	5.0	2.0	25.0	0.3	10.0
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
0.2	0.1	5.0	2.0	1.0	0.5	1.0	1.0	2.0	0.3
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	
0.1	0.3	0.5	0.3	0.1	0.2	0.2	3.0	1.0	

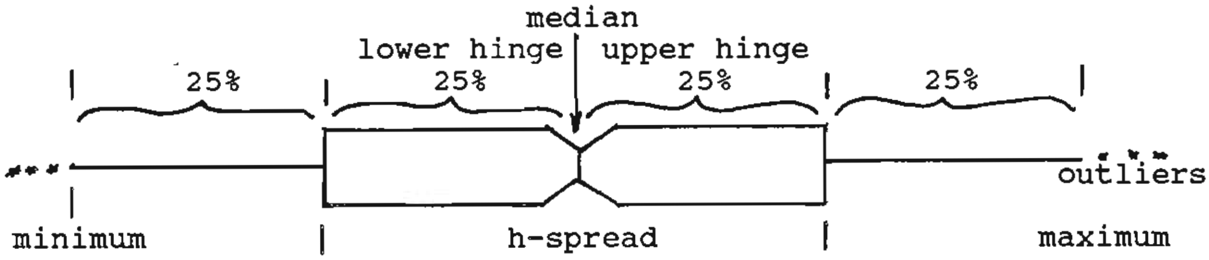
3.3. Analysis of water soluble elements

Two grams of fine-grained material (-0.063 mm) was weighed into a screw-capped plastic bottle. Afterwards 20 ml of pure water were added, the bottle was capped and shaken up and down by slow motion for two hours at a temperature of 20°C in a specially designed apparatus. The suspension was left to stand for 20 hours, and then centrifuged and decanted through a nylon filter (20 u). The solution was acidified with one drop of ultra-pure HNO3. The elements Al, Ba, Be, Ca, Cd, Co, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Si, Sr, Ti, V and Zn were finally determined on the weakly acidified solution by a Jerrel-Ash 975 ICAP Atom Comp. (Odegard and Andreassen 1986). The lower detection limits of the elements in ppb are tabulated below,

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn
300	100	10	4	70	20	30	500	50
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Ba
1	6	90	40	20	4	10	6	25
Be	Sr	Li						
1	1	5						

4.0. DATA TREATMENT

A preliminary statistical treatment was carried out on the available data set, i.e., the analysis of the -0.063 mm grain size fraction by the three different analytical methods described above. It was decided to use Exploratory Data Analysis (EDA), a powerful statistical method, which is described by Kurzl (1988). This method provides an excellent visual comparison of the studied data set. The graphical display chosen was that of the notched box-and-whisker plot, details of which are given below (STSC 1986). The following diagram shows the features of the boxplot in an ideal normal distribution:



The box represents 50% of the values (h-spread); the cutoffs define the location of the "fences" and are established by adding 1.5 times the h-spread. The whiskers extend to the two most extreme data values that are still inside the fences. All data points lying outside the fences are defined as outliers and are marked by individual points. The central line is the median; the notch corresponds to the width of the 95% confidence interval for the median, while the width of the box is proportional to the square root of the number of observations of the data set. The confidence level on the notches allows pairwise comparisons to be performed by examining whether two notches overlap.

Further, the boxplot as pointed by Kurzl (1988) and Hoaglin et al. (1983), displays the following features: (a) location, (b) spread, (c) skewness, (d) tail length, and (e) outlying data points.

In Fig. 1 an overlap is shown of the confidence level on the medians (the notches) of the OverBank Acid Extractable (OBAE) Fe and the Stream Sediment Acid Extractable (SSAE) Fe on the one hand, and the OverBank sediment TotaL (OBTL) Fe and the Stream Sediment TotaL (SSTL) Fe on the other. This overlap indicates that there is no significant difference between the median values of Fe for the same analytical method and different sample type, but there is a distinct and significant difference between the median values of the two different analytical methods.

The raw data values of the two sample types obtained by different analytical methods were plotted and compared. In some cases two plots are given for the same element, e.g., Ti (Figs. 3 & 3a). The reason for this is that significant details are lost when the plot is drawn with all the outliers.

5.0. DISCUSSION

The notched box-and-whisker plots (Figs. 1-20) show

(a) the expected fact of the water extractable method leaching only a minor amount of the total metal;

(b) there is a distinct difference between the easily extractable elements and the more resistant ones, and the elements occurring in trace amounts in minerals, e.g., (the corresponding Figs. are in parentheses) Al (2), Ti (3, 3a), Ni (9), Co (10), V (13), Be (15), Cr (12), Li (11), Cd (8), Sr (16), Ba (17), and Sc (20).

(c) the element variation of the overbank and stream sediment samples, e.g., the range of variation of the total Fe is approximately the same (Fig. 1), but the overbank sediment samples have a higher median value. The acid extractable Fe shows that the median value of the stream sediment is higher than that of the overbank sediment samples, and the former has also a bigger element variation. As was mentioned above, the overlap of the notches of the two sampling media, analyzed by the same analytical method, shows that there is no significant difference between their corresponding median values.

The Ca boxplot (Figs. 4, 4a) show another feature, i.e., (i) the bigger variation of the stream sediment samples for both the total and acid extractable methods, (ii) the higher median values, and (iii) the greater number of outlying values than the overbank sediment samples analyzed by the same method. In addition the 95% confidence notches on the medians do not coincide, showing that there are distinctive differences between the two sampling media.

The Cu boxplot (Figs. 6, 6a) shows that there is no significant difference in the median values of the two sample types with respect to the different analytical methods used.

6.0. CONCLUSION

The foregoing discussion has shown that each method supplies different information, and essentially one method complements the other. Since, the WEGS geochemical mapping project will rely on a few sample points for information, it is considered imperative to obtain as much data as is practically possible from these samples. Because, the data will be used for base line information and environmental purposes, the analysis of the samples by different analytical methods is not only essential, but a must.

A proposal must, therefore, be made by the Analytical Methods sub-project about the analytical methods to be used, the instrumentation and the laboratories that will be participating in the analysis of the samples. It is finally considered significant, for purposes of compatibility of data, that all the samples be analyzed at the same laboratory, e.g., one laboratory will undertake to analyze all the samples for total element contents, another for acid extractable element concentrations, and a third for water extractable element contents.

ACKNOWLEDGEMENTS

I sincerely thank R. Hindel (BGR), R.T. Ottesen (NGU), I. Salpeteur (BRGM) as well as the laboratory staff of the two Surveys, for the analysis of the overbank and stream sediment samples. I also extend my thanks to the IGME General Director, Dr. V. Andronopoulos, and the Director of the Division of Exloration Geochemistry, Mr. C. Kouvelos, for their support. I also thank G. Karianakis and his staff at the IGME Photographic Dept. for the reduction in scale of all the figures in this report.

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Fig. 1. Notched box-and-whisker plot of IRON, Rhodope Region, N.E. Greece

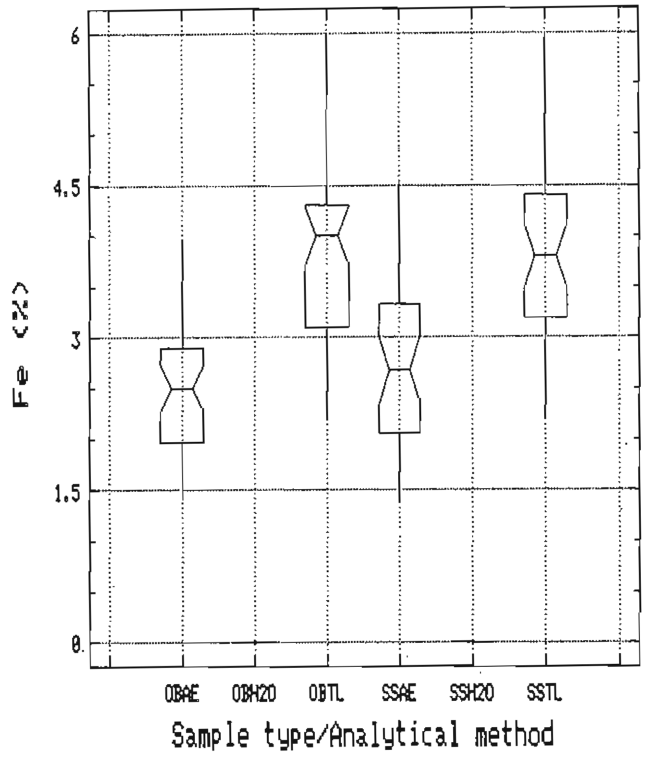


Fig. 2. Notched box-and-whisker plot of ALUMINIUM, Rhodope Region, N.E. Greece.

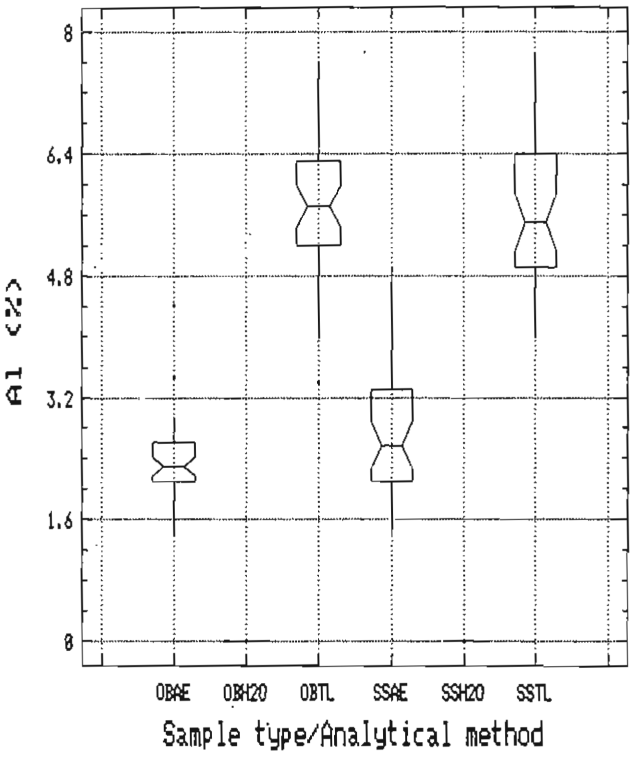


Fig. 3. Notched box-and-whisker plot of TITANIUM, Rhodope Region, N.E. Greece.

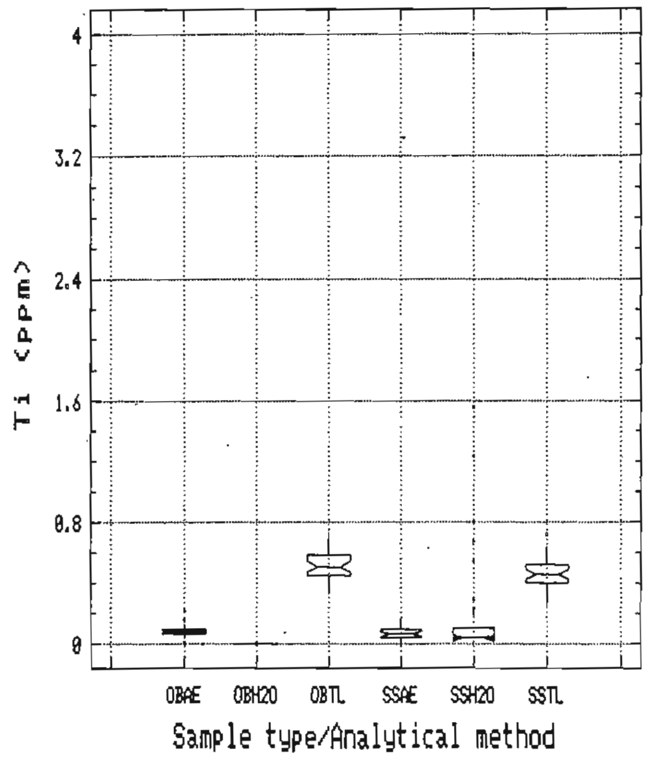


Fig. 3a. Notched box-and-whisker plot of TITANIUM, Rhodope Region, N.E. Greece.

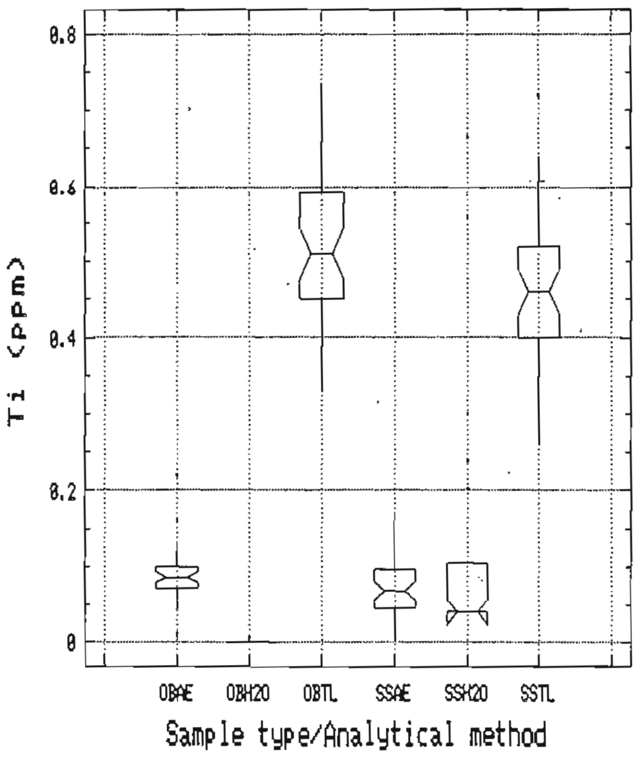


Fig. 4. Notched box-and-whisker plot of CALCIUM, Rhodope Region, N.E. Greece.

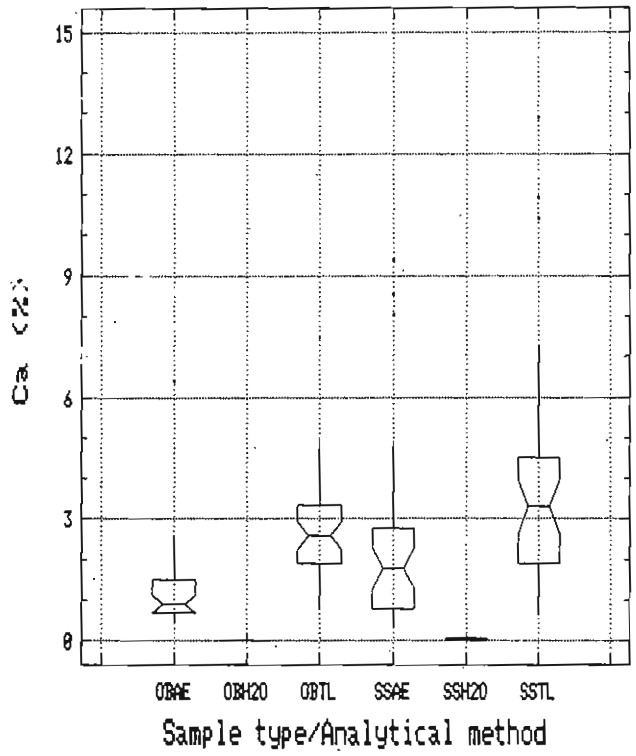


Fig. 4a. Notched box-and-whisker plot of CALCIUM, Rhodope Region, Greece.

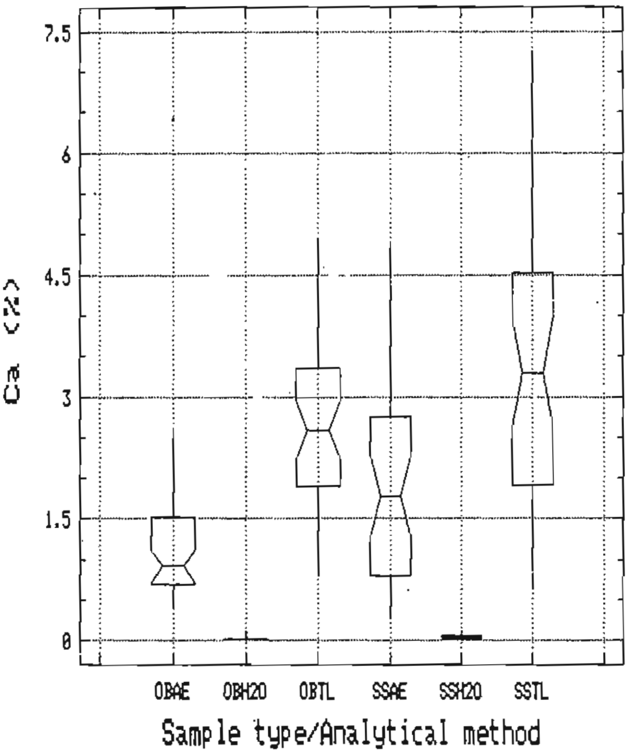


Fig. 5. Notched box-and-whisker plot of LEAD, Rhodope Region, N.E. Greece.

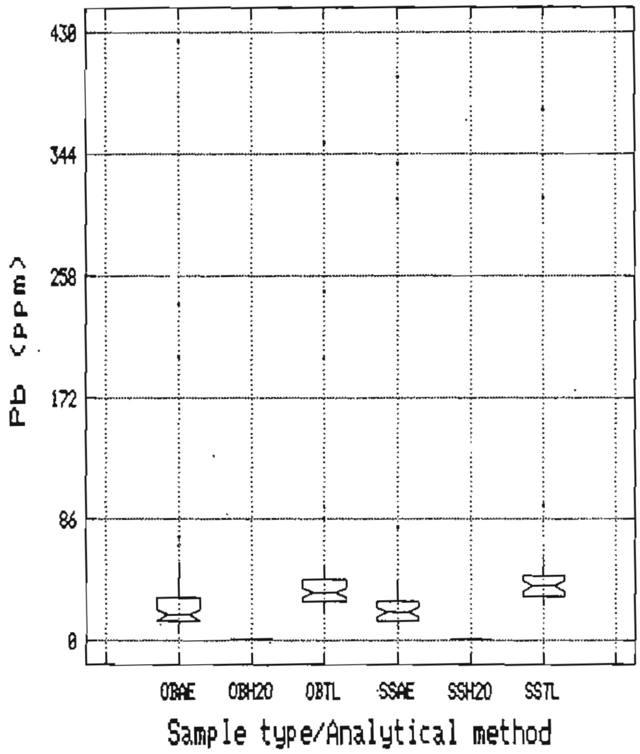


Fig. 5a. Notched box-and-whisker plot of LEAD, Rhodope Region, N.E. Greece.

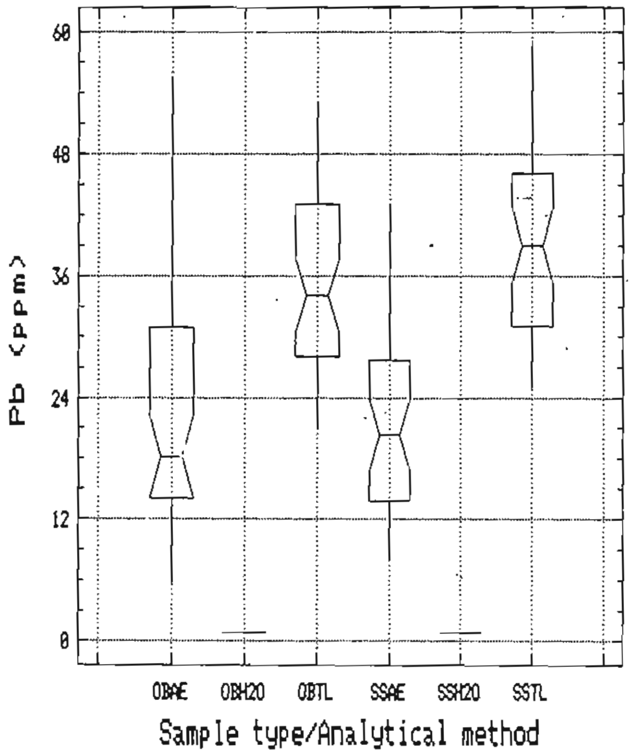


Fig. 6. Notched box-and-whisker plot of COPPER, Rhodope Region, N.E. Greece.

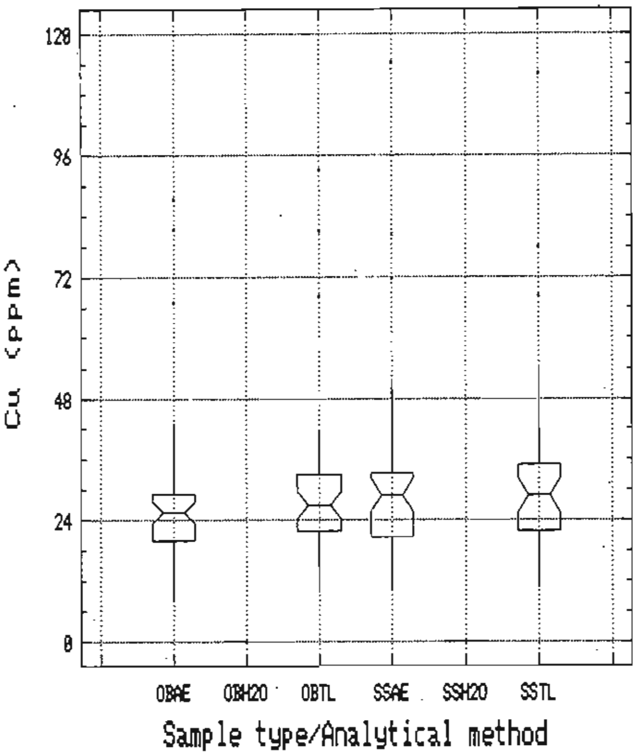


Fig. 6 a. Notched box-and-whisker plot of COPPER, Rhodope Region, N.E. Greece.

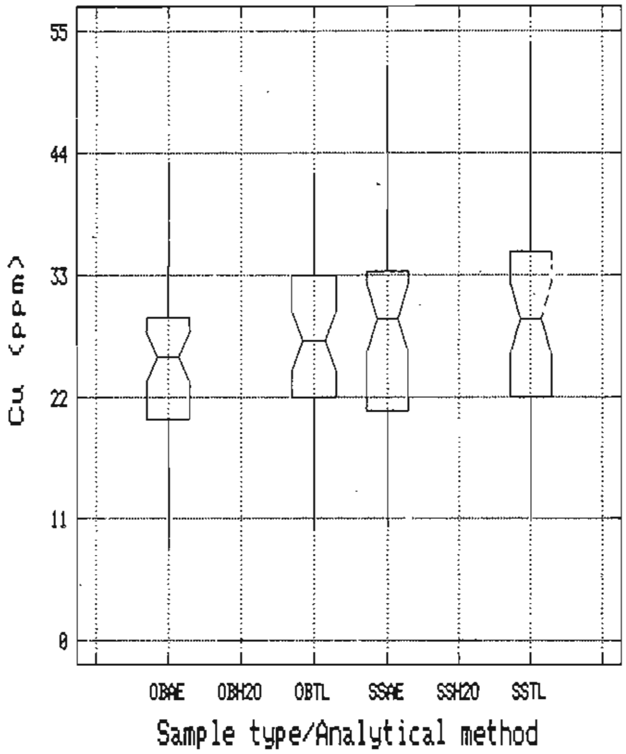


Fig. 7 . Notched box-and-whisker plot of ZINC, Rhodope Region, N.E. Greece.

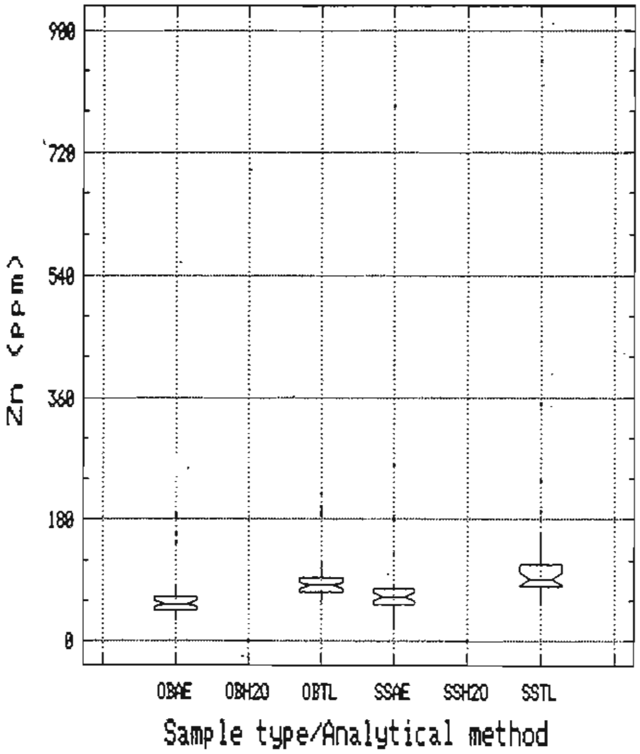


Fig. 7a. Notched box-and-whisker plot of ZINC, Rhodope Region, N.E. Greece.

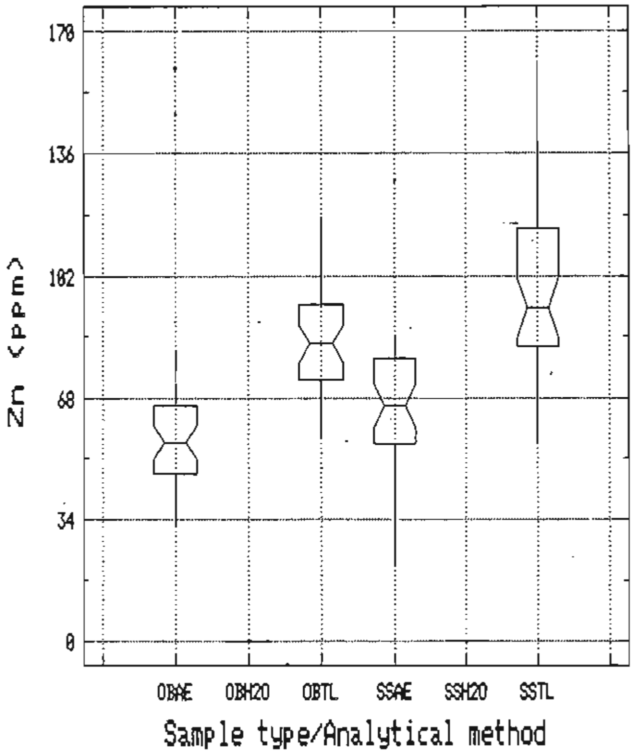


Fig. 8 . Notched box-and-whisker plot of CADMIUM, Rhodope Region, N.E. Greece.

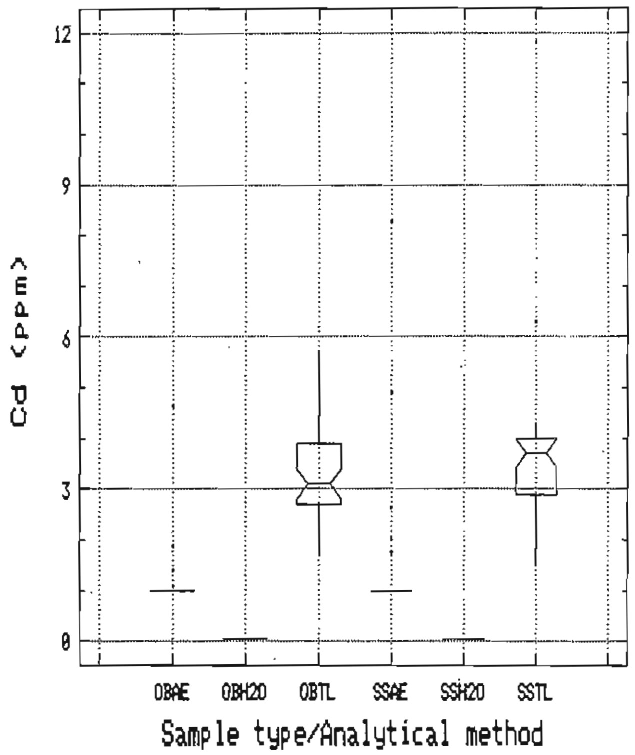


Fig. 8 a. Notched box-and-whisker plot of CADMIUM, Rhodope Region, N.E. Greece.

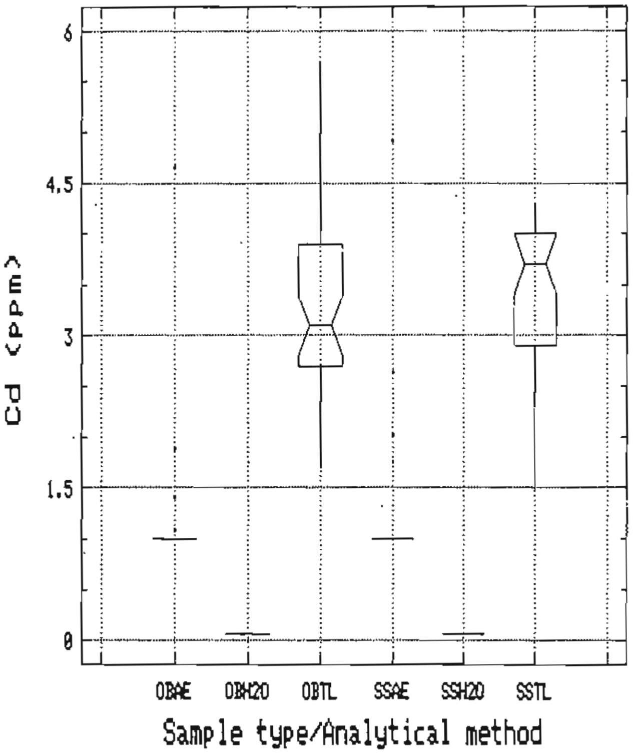


Fig. 9. Notched box-and-whisker plot of NICKEL, Rhodope Region, N.E. Greece.

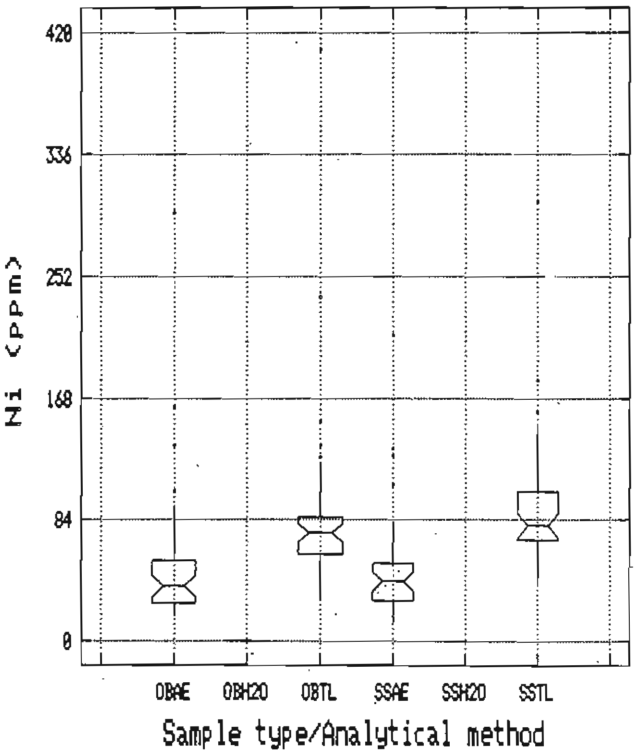


Fig. 10. Notched box-and-whisker plot of COBALT, Rhodope Region, N.E. Greece.

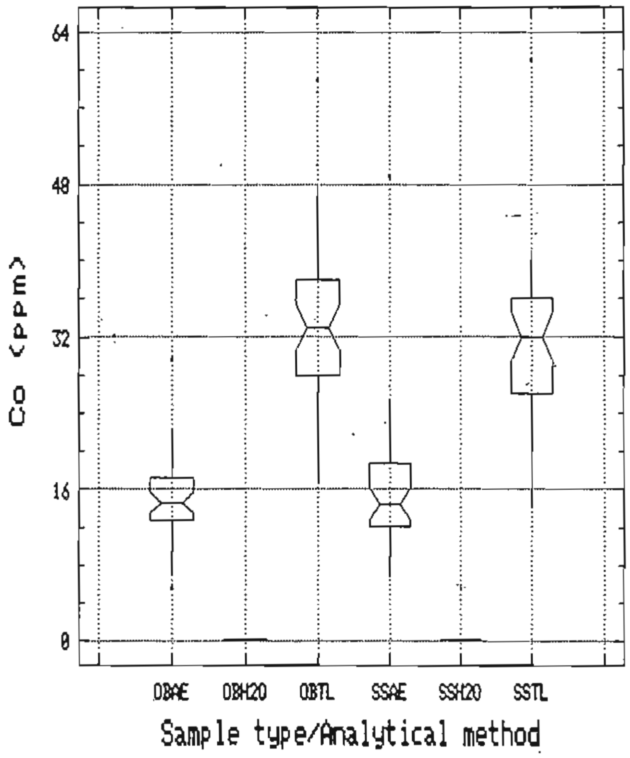


Fig. 11. Notched box-and-whisker plot of LITHIUM, Rhodope Region, N.E. Greece.

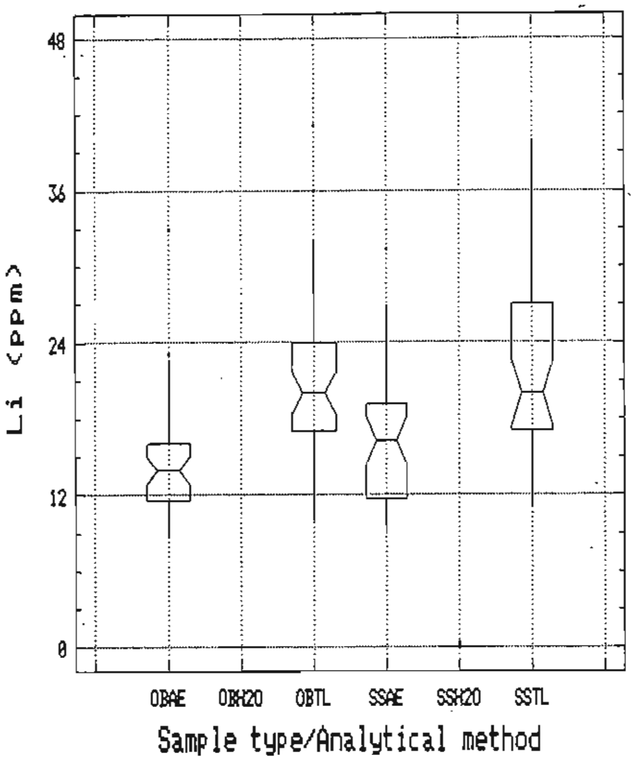


Fig. 12. Notched box-and-whisker plot of CHROMIUM, Rhodope Region, N.E. Greece.

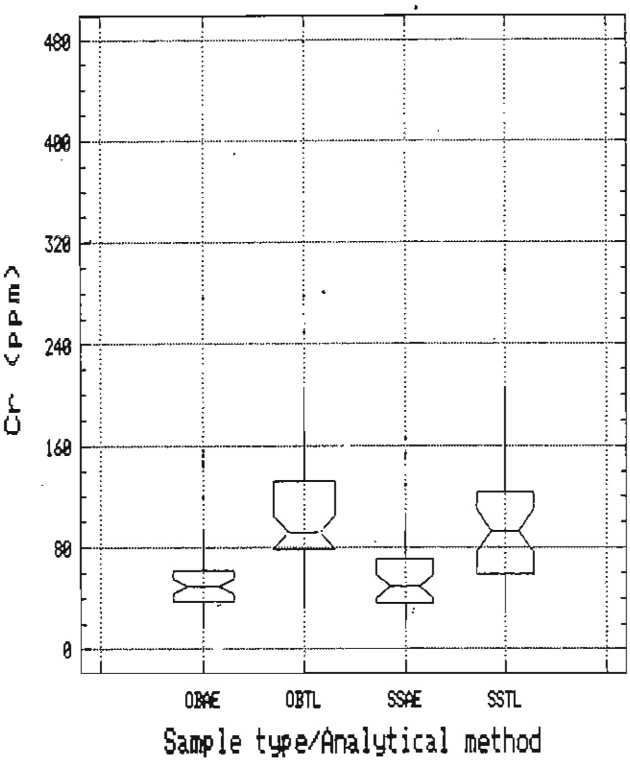


Fig. 13. Notched box-and-whisker plot of VANADIUM, Rhodope Region, N.E. Greece.

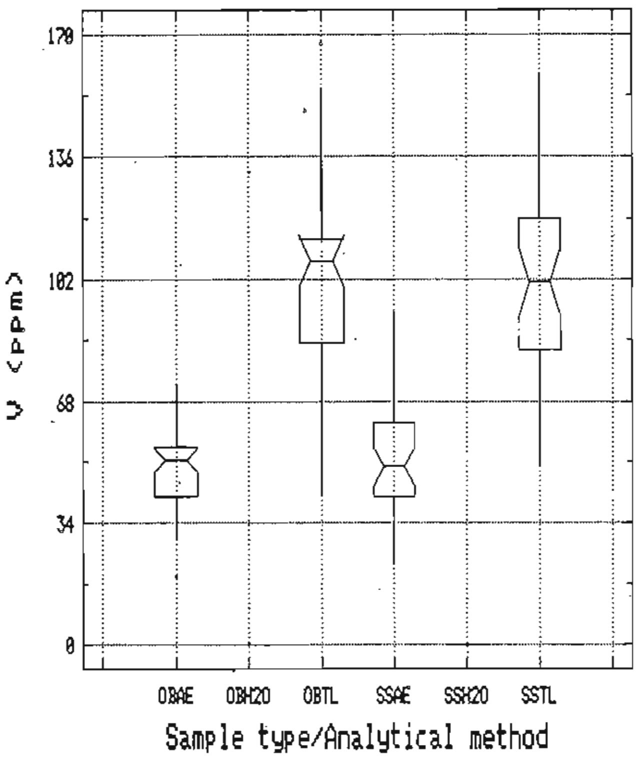


Fig. 14. Notched box-and-whisker plot of MOLYBDENUM, Rhodope Region, N.E. Greece.

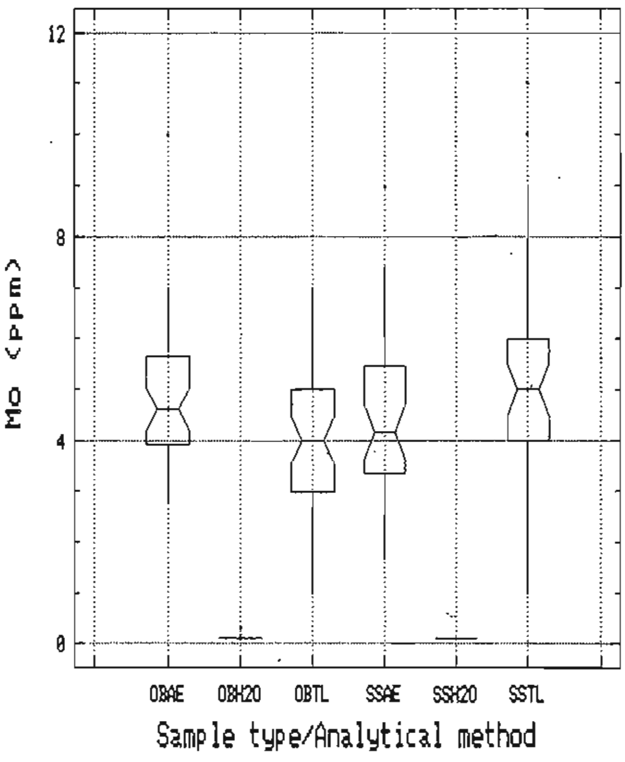


Fig.15 . otched box-and-whisker plot of BERYLLIUM, Rhodope Region, N.E. Greece.

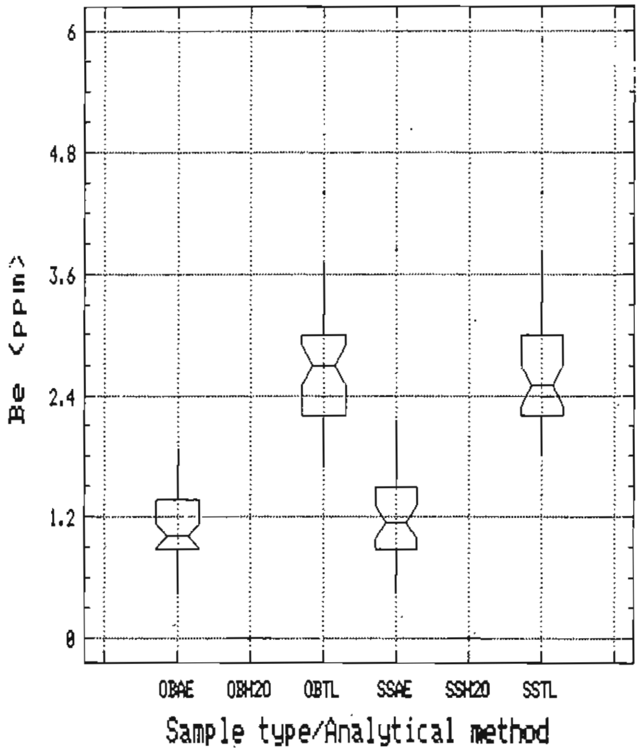


Fig. 16 Notched box-and-whisker plot of STRONTIUM, Rhodope Region, N.E. Greece.

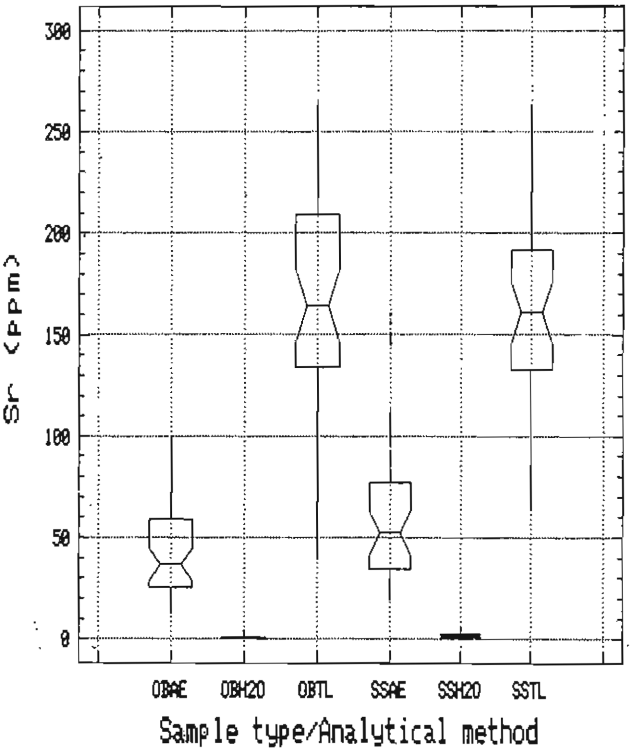


Fig. 17. Notched box-and-whisker plot of BARIUM, Rhodope Region, N.E. Greece.

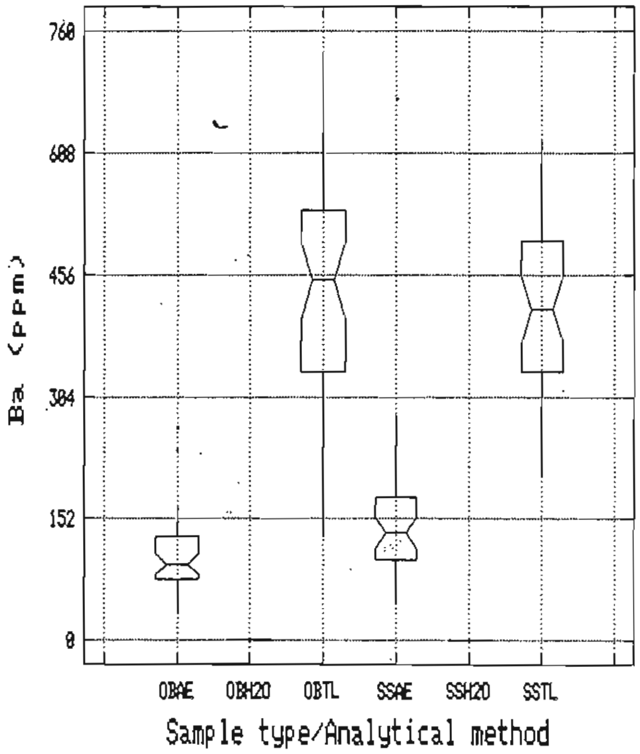
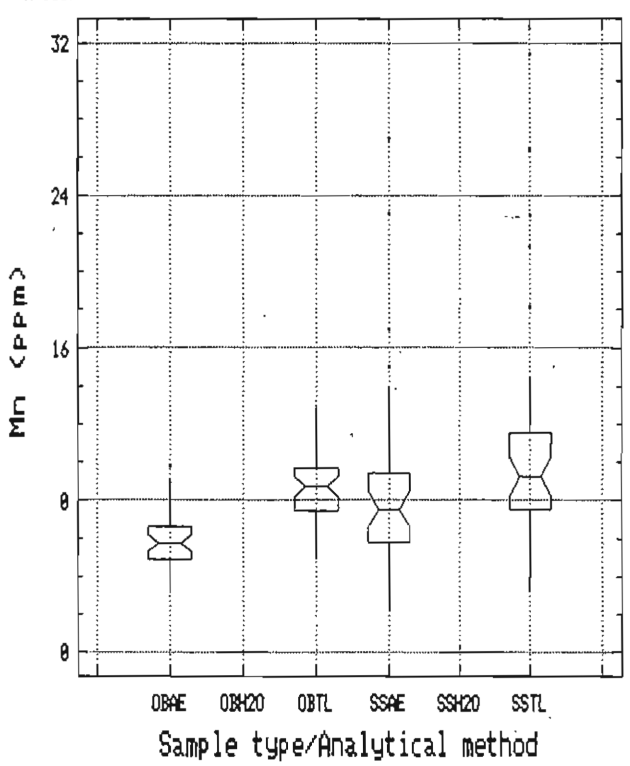


Fig. 18. Notched box-and-whisker plot of MANGANESE, Rhodope Region, N.E. Greece.



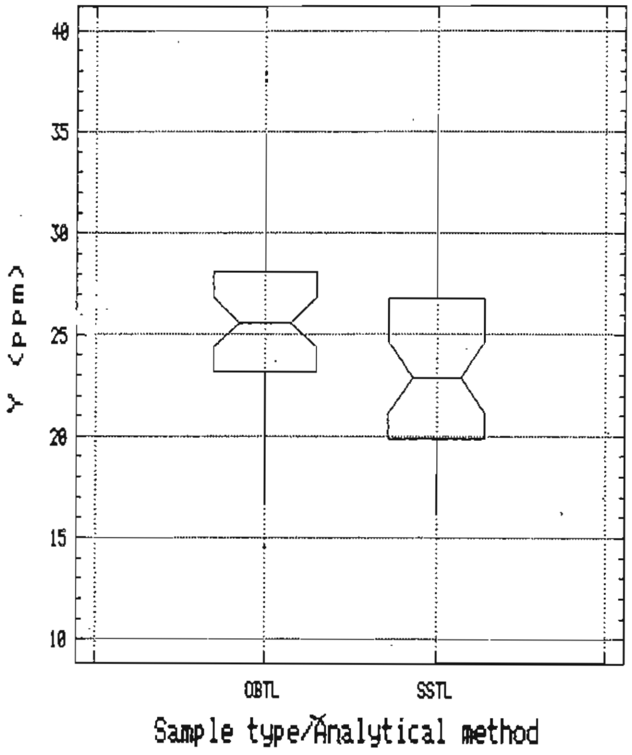


Fig. 19. Notched box-and-whisker plot of YTTRIUM, Rhodope Region, N.E. Greece.

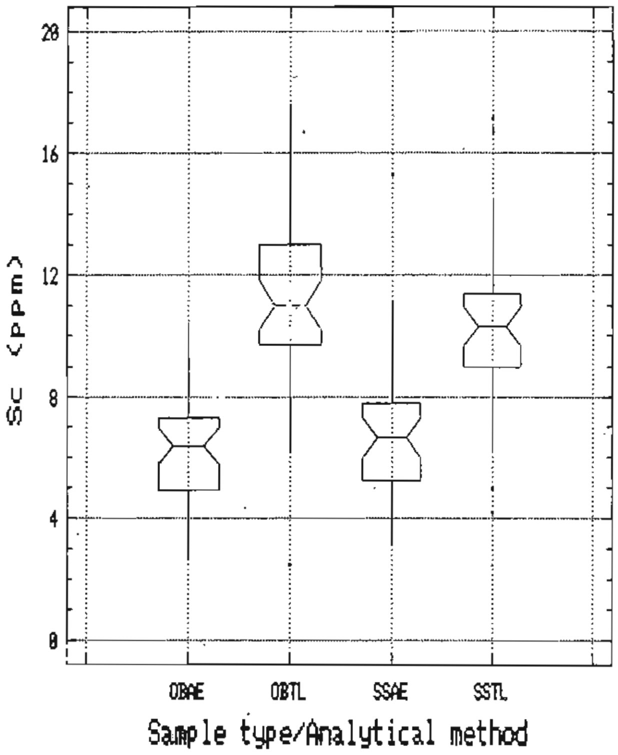


Fig. 20. Notched box-and-whisker plot of SCANDIUM, Rhodope Region, N.E. Greece.

WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 9

OVERBANK SEDIMENT: A REPRESENTATIVE SAMPLE MEDIUM FOR REGIONAL GEOCHEMICAL MAPPING

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Overbank sediment: a representative sample medium for regional geochemical mapping

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ABSTRACT

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In Scandinavia, most fluvial erosion takes place in the Quaternary glacial overburden at a restricted number of small source areas along individual drainage channels. As a consequence, a sample of active stream sediment is representative of only a very limited portion of the drainage area. This restriction makes stream sediment less reliable for regional exploration than generally expected. Overbank (levee or river-plain) sediment produced during large floods is an alternate more representative sampling medium. The sediment suspended during a flood has a much more widespread origin, and when the load is deposited upon the flood plain, nearly horizontal strata are formed and preserved at levels above the ordinary stream channel. A composite sample through a vertical section of such strata represents a great number of sediment sources that have been active at different times and forms an integrated sample of the entire catchment area. Because young sediments overlay older, the uppermost layers will be contaminated by pollutants in industrialized regions, but those at depth may remain pristine and will to a greater extent reflect the natural pre-industrial environment. In regional geochemical mapping, overbank sediment can be sampled at widely spaced sites, keeping costs per unit area low. Examples from Norway (1 sample station per 500 km^2) show that overbank sediment produces broad geochemical patterns with high contrasts reflecting the bedrock geochemistry. Some patterns agree with known geological units and metallogenic provinces, but hitherto unknown major structures have also been indicated. A large Mo-deposit missed by a traditional stream survey is readily detected in the overbank sediment. It is concluded that overbank sediment is a promising alternate sample medium that should be tested in other physiographic regions.

INTRODUCTION

The term "stream sediment" generally used for mineral exploration is active sediment from the stream bed in regular contact with the stream water (Ottesen and Theobald, in press). This material consists mainly of rock fragments

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and mineral grains with varying amounts of organic matter and secondary oxides (oxidates), all being subject to temporary deposition on the stream bed.

The application of active stream sediment as a sampling medium for geochemical mapping presupposes that its chemical composition generally reflects both the bedrock and overburden in the catchment area upstream from the sample point. This assumption is probably not always true, at least not in glaciated terrain in Fennoscandia.

Scandinavian research has shown that in Northern Europe the traditional model for denudation based on supply and removal of fresh weathering products (Holmes, 1965) fails to describe the overall denudation activity (Nilsson, 1972; Nordseth, 1976; Bogen, 1982, 1983, 1986, 1987; Bogen and Husebye, 1982; Bogen and Nordseth, 1986). By applying the concept of sediment budget (Swanson et al., 1982) it becomes clear that the present-day regional pattern of sediment yield closely coincides with the presence of Quaternary deposits available for erosion and transport (Fig. 1). Except around active glaciers, Fennoscandian fluvial sediment consists mainly of mixtures from earlier formed glacial deposits.

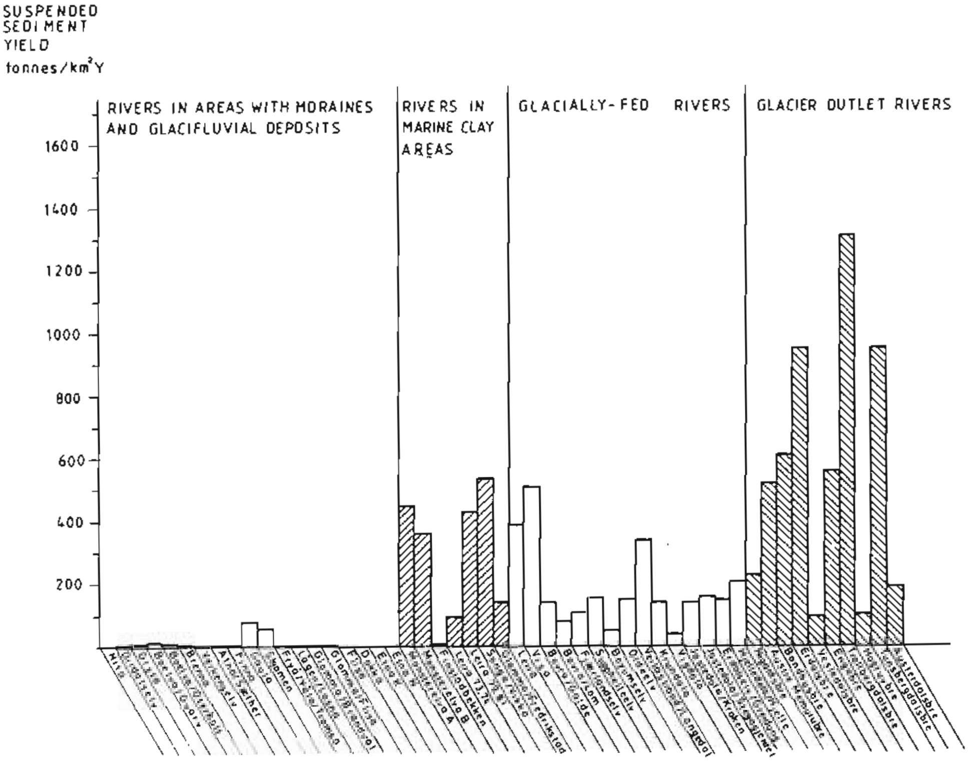


Fig. 1. Suspended sediments in Norwegian rivers. Unit: Tonnes yearly yield per km² drainage area.

True sheet erosion does not often occur. The major portion of the stream sediment originates from scattered, small source areas along a drainage channel (Table 1, Figs. 2 and 3). These point sources develop during floods through channel shifting and gullying, and under normal water conditions when a steam undercuts an adjacent slope containing fine-grained material, which induces mass movements when the water rises (Bogen, 1980) (Fig. 4).

Once a point source is established, the most significant process supplying sediment are gully erosion, channel erosion, and mass movements including slump earth flows, debris slides, and soil creep (Table 1).

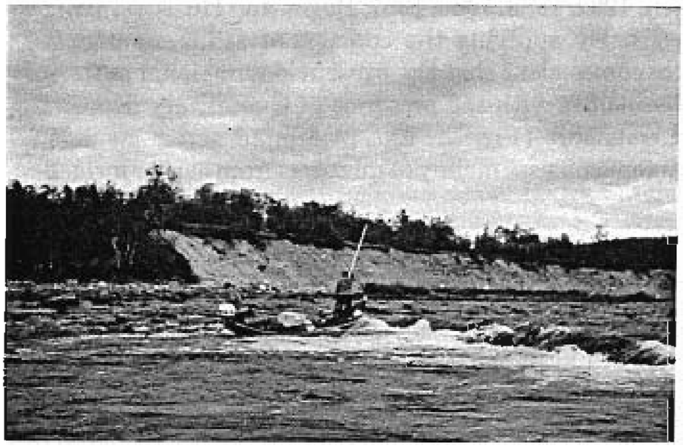


Fig. 2. Fluvial erosion from a local source on the Karasjok River, Northern Norway. The river undercuts a slope containing glacial overburden. No visible erosion is taking place from the bank with vegetation cover on the far left side of the picture. This represents the normal conditions along the river.

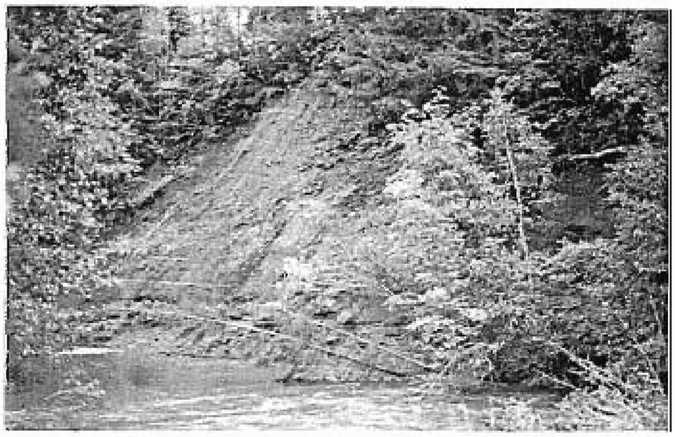


Fig. 3. A sediment source opened up during spring flooding of the Lena River, southern Norway.

TABLE 1

Types of sediment sources in Fennoscandinavian streams in different environments

Environment	Areal extent in Scandinavia	Sediment source	Representativity of stream sediments for the drainage basin
Active glaciers	Small	Sheet erosion (?)	The whole drainage basin reflected
High alpine regions	Small	Sheet erosion (?)	The whole drainage basin reflected
Alpine regions	Large	Point sources in the overburden -undercutting of adjacent slopes - channel erosion in segments of streams	Small parts of drainage basins reflected
Forested till	Dominating	Point sources in the overburden - undercutting of adjacent slopes - channel erosion in segments of streams - farmfields	Small parts of drainage basins reflected
Marine terrace clays	Small	Point sources in the overburden - channel erosion in segments of streams - farmfields	Small parts of drainage basins reflected

(Sources: Nordseth, 1974, 1976; Bogen, 1980, 1986, 1988; Mansikkaniemi, 1982).

Except for local source areas, erosion in most Scandinavian landscapes is generally minimal due to a complex of factors, of which the following three are thought to be the most important:

(1) The large amounts of sediment suspended in the stream water from an active, but restricted, local source reduces the down-stream erosion capacity of the stream and prevents homogeneous erosion along the stream bed.

(2) Bed and bank are armoured by glacial debris, which limits both the general channel erosion and the effects of scouring (Fig. 5).

(3) In the nordic climate the vegetation provides an efficient protection against erosion by promoting infiltration and counteracting surface runoff (Fig. 2). However, if vegetation is lacking or the soil becomes water saturated during snowmelt or rain, then extensive erosion may take place (Figs. 3 and 4).

Owing to the limited extent of the sediment sources, active inorganic stream sediment cannot represent whole catchment areas. Samples of active stream

Fig. 4. Sediment source opened up during a catastrophic rain storm in 1979 at the Jostedalen River, Western Norway.

Fig. 5. Bed and bank armouring of the Høverelva River, southern Norway.

sediment taken at intervals along a drainage channel are often nothing but replicates of material from the same sediment source, producing little or no geochemical information in addition to what could be obtained from a few key samples.

Apart from water and various types of sample media rich in organic material (which are not discussed in this paper), inorganic lake sediment is an attractive alternative to stream sediment. However, a serious disadvantage in using lake sediment is that a sufficient density of adequate lakes does not exist in all types of landscapes. Other drawbacks include:

(1) the sediment cannot be inspected visually before sampling;

(2) the deposition rate and the grain size of inorganic lake sediment supplied from inflowing rivers can be subject to large variations within short distances on the bottom causing corresponding variations in sample composition;

(3) the genesis of inorganic lake sediment may occasionally be complicated, due to slumping;

(4) interpretation of data for the composition of lake sediment may be difficult because of varying contributions from organic matter and oxidates; and

(5) certain strata of lake sediment are susceptible to contamination from anthropogenic sources.

In this paper we suggest overbank (floodplain, river plain, or levee) sediment as an alternative drainage sample type devoid of some of the drawbacks of active stream sediment and inorganic lake sediment. Earlier accounts of the use of overbank sediment in geochemical mapping include those given by Ottesen et al. (1986),Ottesen (1987), Bølviken et al. (1988), Ottesen and Volden (1989) and Ottesen and Bølviken (1987).

OVERBANK SEDIMENT

Overbank sediment is produced when major floods occur in a river system. During such floods the water discharge exceeds the quantity that can pass through the ordinary stream channel (bankful discharge). Even in streams of moderate size, the water level can reach several metres above normal, thereby covering large areas. At these times many new sediment sources open up (Figs. 2, 3, and 4), and the origin of the load suspended in the stream is manifold. Throughout the flood – and especially during its last phases – some of the load will be deposited on the flood plain at levels well above those of the ordinary stream channel (Figs. 6 and 7). In this way, nearly horizontal strata of overbank sediment are built up over long periods of time. In Norway, the thickness

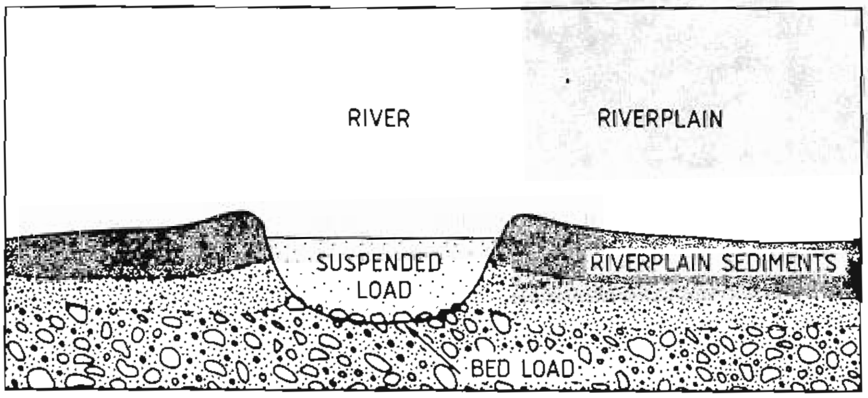


Fig. 6. Water discharge of a river under ordinary conditions with normal amounts of water.

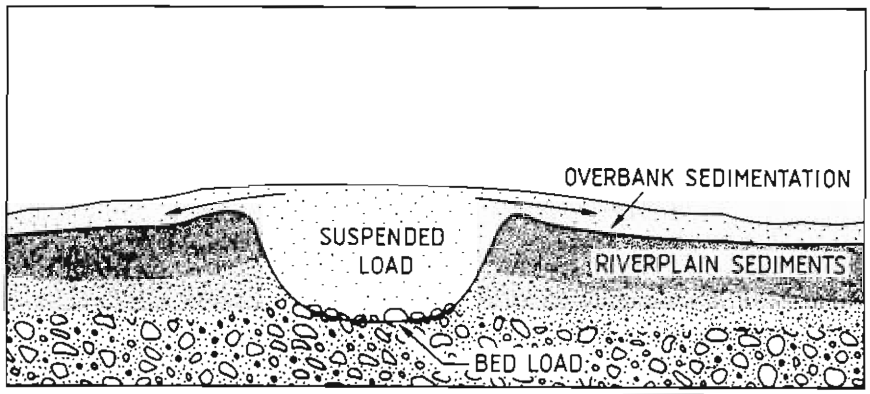


Fig. 7. Water discharge of a river during a major flood. Overbank sedimentation takes place on the river plain.

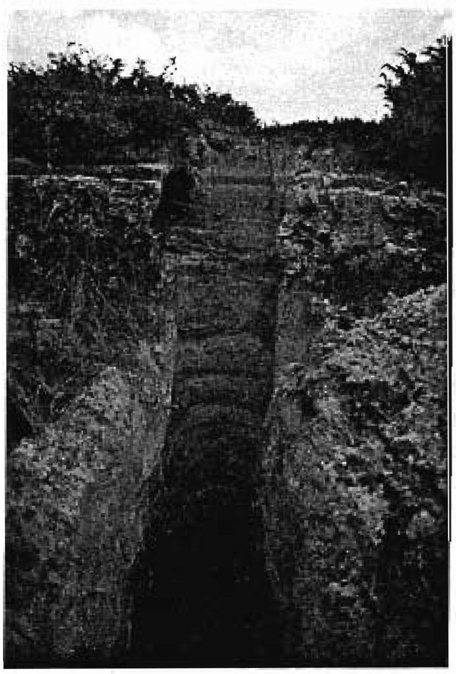


Fig. 8. A section through overbank sediment at the Atna River, southern Norway. Carbon-14 dating has indicated that the middle part of the section was deposited about 400 years ago.

of the layers from individual floods may vary from a few millimetres to several decimetres, while the total thickness of overbank sediment strata could be up to a few metres (Fig. 8).

A vertical section through overbank sediment reflects the history of sedimentation back through time, and a composite sample of such a section will

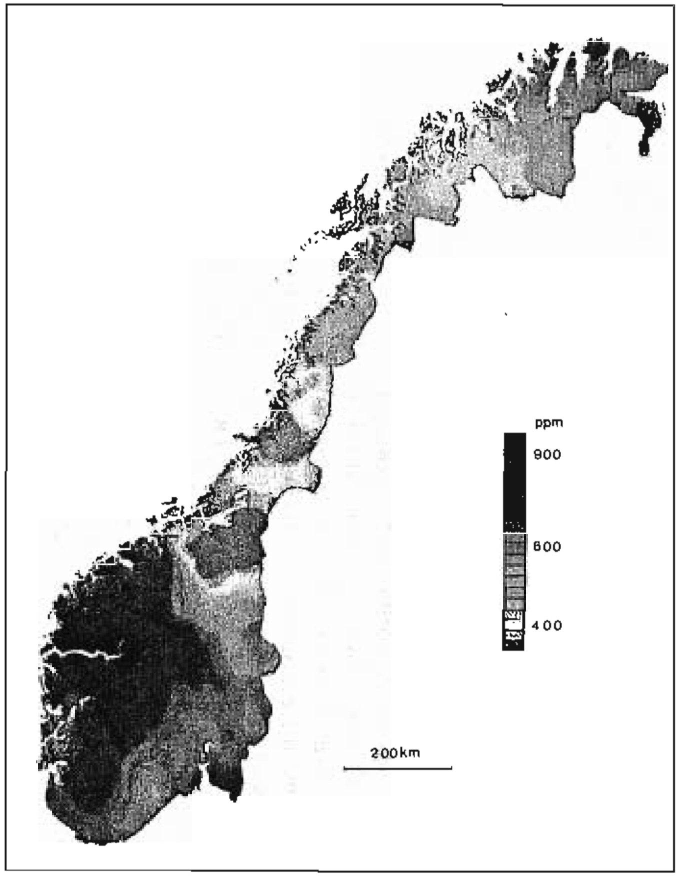
Fig. 9. Paleosediment sources at the Høverelva River, southern Norway. The sources are recognized by (1) the location near the present stream and (2) the inclination of the regular slope facing the river (exposed through logging), which corresponds to the angle of repose.

give an integrated picture of the chemical and mineralogical conditions from a large number of sediment sources opened during many floods. As active sources eventually become paleosources (Fig. 9) due to exhaustion or shifts in the river channel or other conditions affecting erosion, it is possible to characterize a large drainage area with data from one sample.

It should again be noted, however, that the above discussions deal only with clastic transport. Chemical dispersion, including precipitation and dissolution of secondary oxide coatings on grain surfaces, complicates the picture.

EXPERIENCE USING OVERBANK SEDIMENT IN NORWAY

Overbank sediment has been collected from 690 sites uniformly scattered over Norway (320,000 km^2), each site representing large drainage areas of 60–300 km^2. The sample stations were preselected by searching each of the 1:50,000 scale topographic map sheets of Norway for a suitable floodplain. In the field the samples were collected at distances of 2–200 m from the present-day stream, depending on the circumstances. Sites close to the active channel were avoided in order to reduce the possibility of obtaining polluted samples. A vertical section through the sediment was cut with a spade, and after excluding the upper 5–10 cm, approximately 5 kg of bulk sample were taken from the rest of the section. In the laboratory the samples were dried and sieved to obtain a minus 0.062 mm fraction, which was analyzed for total element amounts by X-ray Fluorescence (Faye and Ødegård, 1975), and acid soluble elements by Inductively Coupled Plasma Spectrometry (Ødegård, 1981) and Atomic Absorption Spectrometry (Kuldvere, 1988). The analytical results were plotted as single



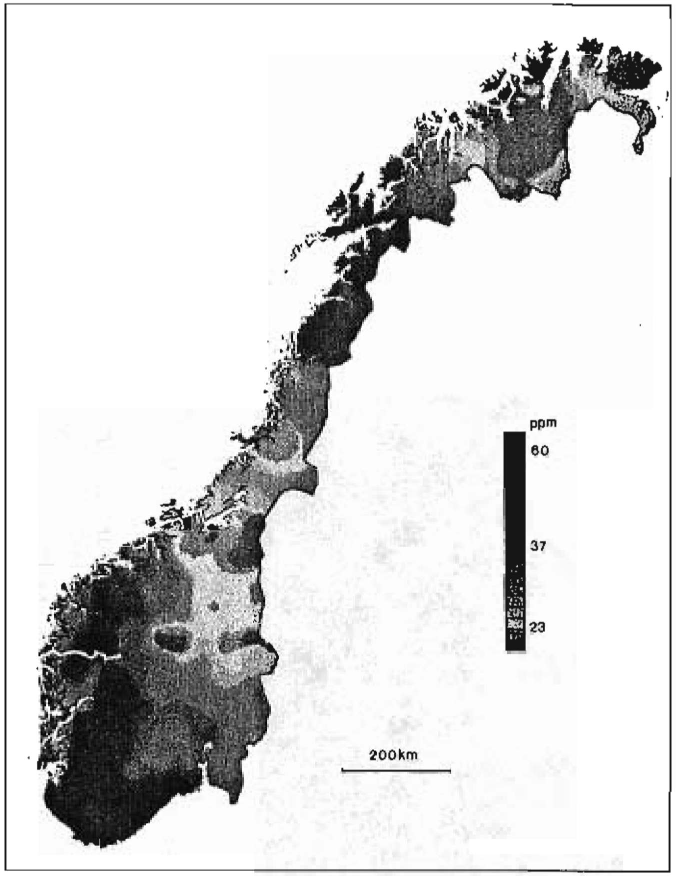


Fig. 10. (left) Total contents of Ba in overbank sediments, Norway. The map is based on the analysis of 690 samples (see Fig. 12) and shows the rolling median within a window of diameter 100 km. The cartography was done at the Geological Survey of Finland (see also Bjørklund and Gustavsson, 1987).

Fig. 11. (right) Hot nitric acid soluble La in overbank sediment, Norway. For explanation and references, see Fig. 10.

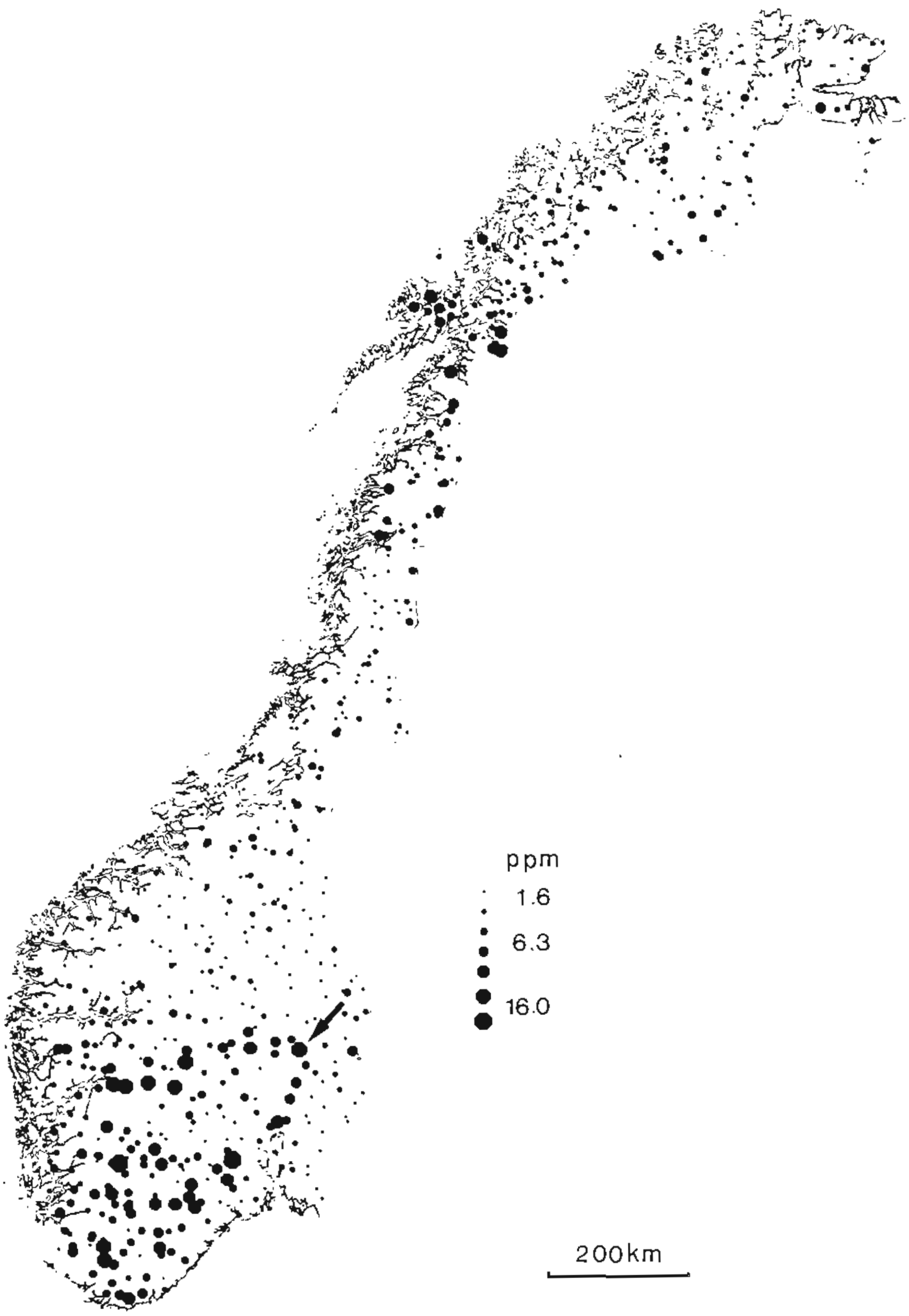


Fig. 12. Hot nitric acid soluble Mo in overbank sediment, Norway. An anomalous sample down stream from the Nordli deposit (see Case Histories 5 and 6) is indicated with an arrow.

element dots or moving median maps, of which three examples are given in Figs. 10–12.

Some conclusions based on the results are summarized in the following six points, with reference to Figs. 10–16, Tables 2–4, and seven numbered case histories.

(a) All elements, including several of economic interest, depict broad regional patterns with high contrasts (Figs. 10–12). Some of the provinces obtained may indicate new areas with potential for mineral deposits.

(b) The chemistry of overbank sediments reflects compositional features of the bedrock. (Case History 1).

(c) The regional geochemical patterns sometimes agree with known geological structures; in other cases they indicate features not known before. (Case Histories 2, 3, and 4).

(d) Well defined overbank-sediment geochemical provinces coincide with metallogenic provinces. (Case History 5).

(e) Major mineral deposits missed by stream-sediment surveys can be indicated by the analysis of overbank sediment. (Case History 6).

(f) Overbank sediment can be used as a sample medium in heavily polluted terrain. (Case History 7).

Case histories

1. A total of 133 samples of granites from major massifs in southern Norway were collected. The samples were ground and analyzed, after nitric acid extraction, for the contents of 28 elements using ICP spectrometry (Ødegård, 1981). The analytical data, when compared with corresponding values for the minus 0.062 mm fraction of overbank sediments, showed significant correlations between the element contents in the overbank sediments and those in the granites, La and Mo being given as examples in Table 2 and Figs. 11–12 and 14–15.

2. The rocks of the Barents Sea Group, north of the Trollfjord-Komagelv fault zone (Fig. 13) on the Varanger Peninsula, have been described as a foreign element in the Caledonides of Northern Norway, supposedly being of a remote origin outside the Baltic Shield (Siedlecka, 1975; Kjøde et al., 1978; Roberts, 1985). Although the rock types are similar on both sides of the fault, the Barents Sea Group has been classified as the most distinct geochemical province found in the Nordkalott Project (Ottesen et al., 1985; Bølviken et al., 1986). Overbank sediment data also show significantly different element contents north and south of the fault, see examples in Table 3.

3. Geological mapping has revealed that the Precambrian rocks of southern Norway can be divided into two blocks by a large generally north–south run-

TABLE 2

Contents of hot nitric acid soluble La and Mo in samples from 11 main granites in southern Norway and the corresponding values for overbank sediment sampled in streams draining the granites. (See also Figs. 13, 14, and 15)

Area	Bedrock (granites)			Overbank sediment		
	N	La	Mo	*N*	La	Mo
1. Tynset	7	27	2.5	3	25	1
2. Trysil	23	60	3.5	4	35	1.5
3. Odal	7	40	4.4	3	40	2.5
4. Oslo graben, north	8	84	7.2	5	70	6
5. Oslo graben, south	5	44	2.3	7	40	2.5
6. Vassfaret	11	74	4.0	2	70	4
7. Flå	12	57	3.7	4	60	3
8. Sætesdal	32	136	6.7	16	140	10
9. Odda	11	72	5.3	4	70	6
10. Karmøy-Stord	8	33	4.5	1	30	2.5
11. Sogn	3	73	3.6	2	65	2.5

Figures for La and Mo indicate arithmetic mean in *N* samples in ppm.

ning tectonic line (Sigmond, 1985), the Mandal-Ustaoset fault zone (see Fig. 13). Overbank sediment west of the Mandal-Ustaoset line has relatively high contents of Ba and La, while those east of the line have relatively low Ba and La contents (Figs. 11–12).

4. Main structures in the bedrock in Scandinavia have been identified by airborne geophysical mapping (see Fig. 16).

Overbank sediment data show a distinct northwest-trending discontinuity in the Ba contents through southern Norway (Fig. 10), coinciding with one of the geophysical lineaments ('Jan Mayen FZ' on Fig. 16). The southeastern part of this structure ('the Mylonite Zone') is interpreted as a suture (Gaál, 1986), while the northwestern part is indicated as one Precambrian unit on the geological map (see Fig. 13). The coinciding geophysical and geochemical lineaments indicate that a revised interpretation of major geological events is warranted in the Precambrian of western Norway.

5. Several molybdenite prospects and abandoned Mo deposits, including the Knaben mine, lie within a metallogenic province in southwestern Norway (Bugge, 1983).

The map of Mo in overbank sediment (Fig. 12) shows a geochemical province embracing this metallogenic province. However, the geochemical province also includes Mo occurrences discovered more recently in the northern part of the Permian Oslo region (see Mo data on Fig. 13 and Case History 6).

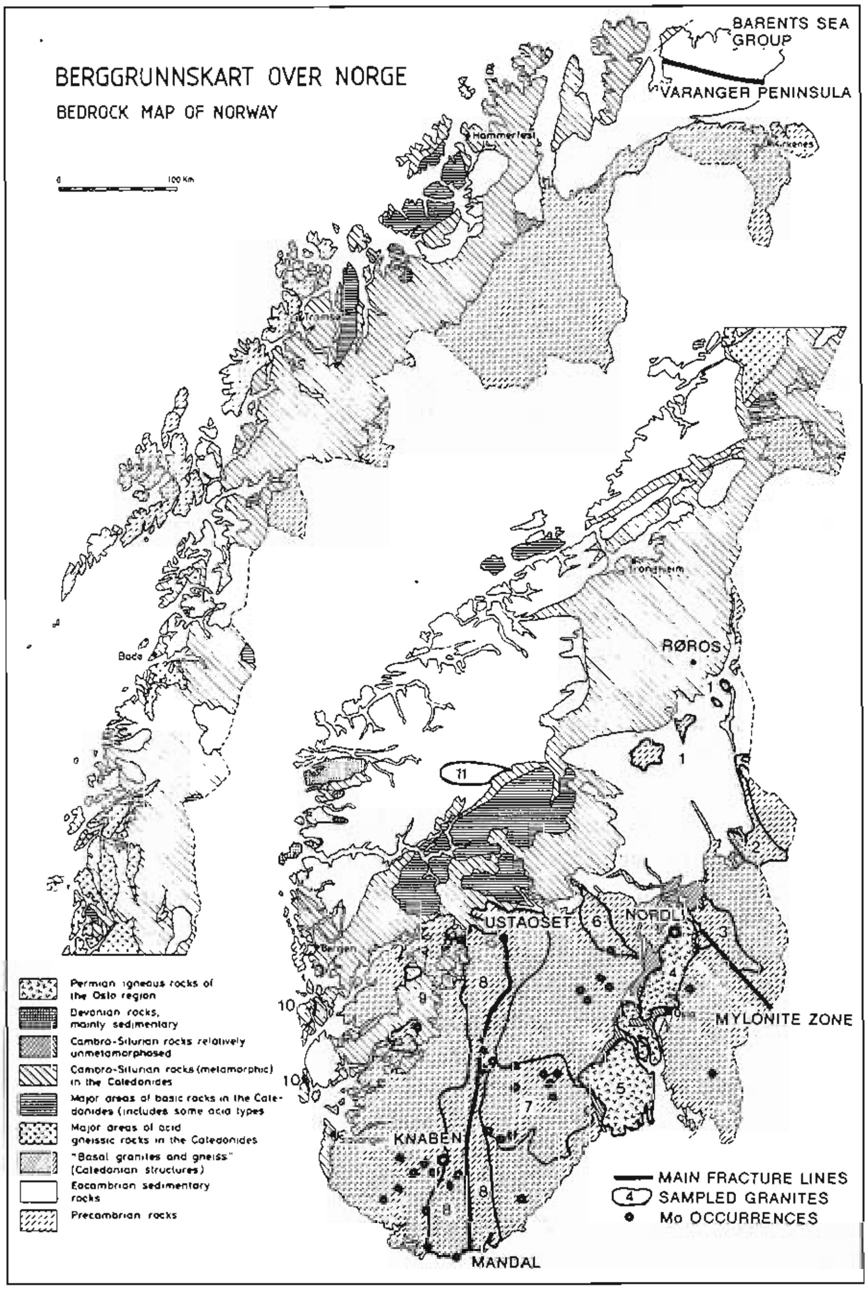


Fig. 13. Bedrock Geology of Norway (after Sigmond et al., 1983) with superposed Mo occurrences (after Juve and Gust, 1984).

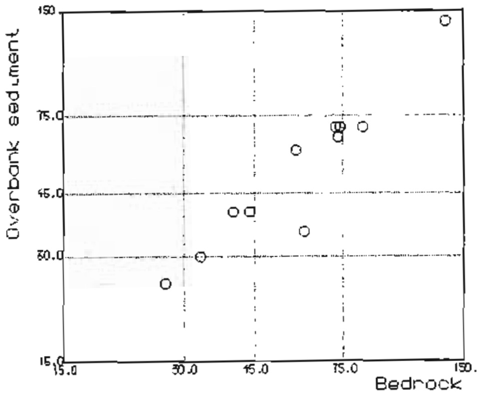


Fig. 14. Contents of hot nitric acid soluble La. Abscissa: data from main granites in southern Norway (see Fig. 13) versus ordinate: data from samples of overbank sediment taken in streams draining the granites. (See also Table 2.) $N=11$, correlation coefficient $(r)=0.97$.

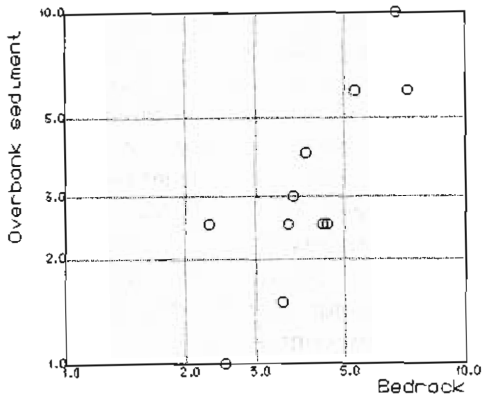


Fig. 15. Contents of hot nitric acid soluble Mo. Abscissa: data from 11 main granites in southern Norway (see Fig. 13) versus ordinate: data from samples of overbank sediment taken in streams draining the granites. (See also Table 2). $N=11$, correlation coefficient $(r)=0.83$.

6. A large Mo deposit was discovered at Nordli, in the drainage basin of the Høverelva River within the northern part of the Oslo region, southern Norway (Figs. 12 and 13). Geological prospecting, analysis of soil samples from a depth of 1–3 m, and diamond drilling delineated this rather large deposit of several tens of million of tonnes at a cut-off grade of 0.05% Mo (W. Dannow, pers. commun., 1987). However, active stream-sediment sampling failed to produce any Mo anomaly in the Høverelva River, although the stream crosses a large outcrop area of the deposit, and numerous mineralized boulders are observed in the stream bed. Strong stream-sediment Mo anomalies were, nevertheless, obtained from minor Mo occurrences elsewhere in the region (Volden, 1979, 1980).

TABLE 3

Contents of total Ba, Cu, K and Y in overbank sediment collected north (metamorphosed sediments of the Barents Sea and Løkvikfjell Groups) and south (metamorphosed sediments of the Vadsø Tanafjord and Vestertana Groups) of the Trollfjord-Komagelv fault zone, Varanger Peninsula, Northern Norway (Fig. 13)

	North of fault ($N=13$)			South of fault ($N=12$)		
	M	$\bar{X}$	SD	M	$\bar{X}$	SD
Ba (ppm)	595	598	101	478	499	112
Cu (ppm)	27	24	9.8	14	17	9.1
K (%)	3.49	337	0.65	2.44	2.39	0.60
Y (ppm)	76	71	18.4	52	56	8.2

N = number of samples; M = median; $\bar{X}$ = arithmetic mean; SD = standard deviation.
The arithmetic means of the two sets are different at $p > 0.001$ using student t-test.

The lack of a traditional stream-sediment anomaly in the Høverelva River may be explained by the long-term variability of the sediment-producing processes within the drainage basin. The existence of a large floodplain and delta of the river shows that great amounts of sediment have been transported by the river during postglacial time. Quaternary sediment sources have been active at various localities during this period (Fig. 9). Some of these earlier sources have probably been enriched in Mo, and Mo-bearing sediments have then moved through the river channel during the past millennia. At present, the stream channel in the mineralized area is armoured with large boulders (Fig. 5), and erosion is very limited. The only sediment sources now active are located further upstream, where the overburden has low contents of Mo. Toward the present time, any earlier Mo-bearing sediments in the stream bed have, therefore, been replaced by sediments with low contents of Mo.

The above interpretation is corroborated by the analysis of overbank sediment and delta sediment taken at depths of 0.6–14 m some 8 km down stream from the deposit. An average Mo content about 15 times higher than background was obtained (Fig. 12), while certain strata showed considerably higher values.

7. The Trondheim region (Cambro-Silurian rocks) is the most important Cu district in Norway (Fig. 13), where mines have been in operation for the past 300–400 years. In some of the mining areas streams are heavily polluted by mine waste, and stream-sediment data are of restricted value in exploration.

At the outlet of the heavily polluted Orva River, which drains an area of Cu, Zn and Pb-containing pyrite deposits at Røros, both active stream sediment and a vertical section of overbank sediment from polluted into more pristine material were sampled. The contents of Cu, Zn and Pb are anomalously high

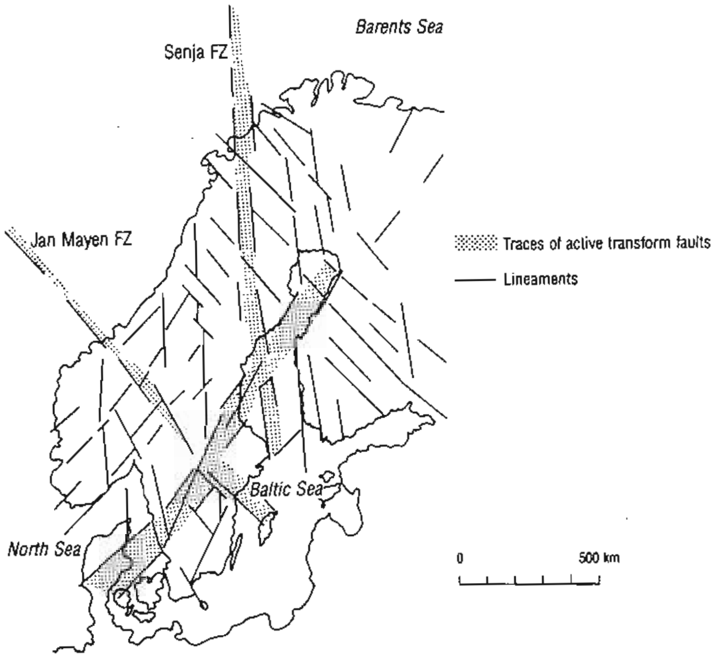


Fig. 16. Major lineaments in the bedrock in Scandinavia, as interpreted from the aeromagnetic map by Eriksson and Henkel (1983).

TABLE 4

Contents of hot nitric acid soluble elements in stream sediment, and in top and bottom layers of a hand-dug pit (60 cm deep) through overbank sediment at the polluted Orva River, Røros, southern Norway

	Active stream sediment	Overbank sediment	
		Top layer	Bottom layer
Cu (ppm)	344	3800	41
Pb (ppm)	325	229	10
Zn (ppm)	404	1300	200
Ba (ppm)	69	48	37
La (ppm)	25	17	21
Li (ppm)	6	7	12
Sr (ppm)	14	6	10
Zr (ppm)	16	15	8

in the stream sediment and in the upper part of the overbank sediment, while high background values were found in the overbank sediment taken at depth. The contents of Ba, La, Li, Sr and Zr, which are not enriched in the ore bodies, show background values in both the stream sediment and in the overbank sediment (Table 4).

DISCUSSION AND CONCLUSION

A summary of some advantages and drawbacks in the use of inorganic stream, lake and overbank sediments as sampling media is given in Table 5. The application of the stream media is also illustrated in Fig. 17, which indicates that

TABLE 5

Summary comments on the use of inorganic stream, lake, and overbank sediment as sampling media in geochemical mapping in Scandinavian and similar landscapes

	Stream sediment	Lake sediment	Overbank sediment
Origin, derivation	Mainly point sources in the catchment area	Major parts of the catchment area may be represented if vertical sections are sampled	As for lake sediment
Type of dispersion	Combinations of clastic and hydromorphous	As for stream sediments	Predominantly clastic
Availability to sampling	Varying depending on sediment production rate (see Table 1)	Large regions have insufficient density of lakes	Present in all drainage systems with a fluctuating water level
Problem of sampling	Often difficult to obtain sufficiently large samples of fine fraction	Sample sites cannot be inspected before sampling	Easy to obtain a large sample. Suitable sample sites can be selected from visual inspection
Susceptibility to pollution	Strongly polluted in industrialized areas	To a varying degree influenced by polluted ground and surface waters	Surficial samples can be polluted, while samples at depth may be pristine
Problems of interpretation	Interpretation is complicated by varying presence of sediment sources, contents of hydrous oxides, organic material, and pollution in the drainage area	As for stream sediments	Essentially clastic fluvial dispersion facilitates interpretation. Soil-forming processes at sampling site may complicate the interpretation in drainage systems with rare flood events

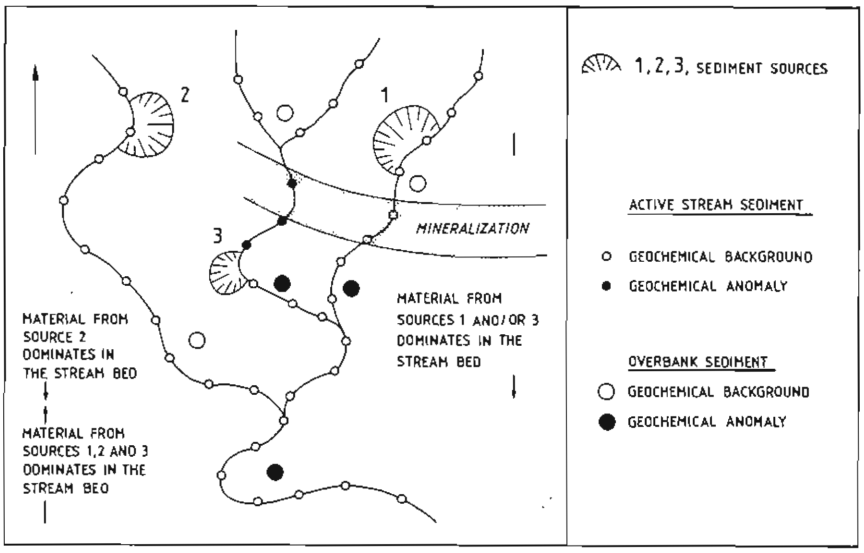


Fig. 17. A diagrammatic depiction of how geochemical dispersal patterns for active stream sediment and overbank sediment may be influenced by mineralization and sediment sources. In the stream on the right hand side, the active stream sediment is dominated by sediment source No. 1, a reason why the anomaly can be detected only in the overbank sediment. This situation is analogous to that described in Case History 6 for the Høverelva River.
In the middle river, where no active sediment sources exist in the upper part, a stream-sediment anomaly has developed where the stream crosses the mineralization due to influence from paleosources and a presently small, diffuse sediment production occurring along the stream bed. This anomaly is diluted by sediments from source 3.

significant ore deposits may still remain undiscovered in Scandinavia and possibly elsewhere, even in areas where detailed stream-sediment surveys have been conducted.

Other arguments in favour of sampling overbank sediment for regional geochemical mapping include:

– Overbank sediment can represent whole drainage areas, and large samples can be taken at low density and low cost per unit area. A small number of large samples facilitates the use of complex multi-element chemical analysis.

– Overbank sediment seems to be present in all river systems that have fluctuating water levels or occasional floods. Varying rainfall and drain-off occur in most places, and descriptions of the sedimentary environment in various parts of the world suggest that overbank sediment exists for example in Australia (Woodyer et al., 1979); Canada (Nanson, 1980; Deslodges and Church, 1987); Great Britain (Lewin et al. 1977); and the U.S.A. (Baker, 1987). Overbank sediment should, therefore, be considered as a possible sample medium suitable for a geochemical atlas of the world.

- Overbank sediment may be sampled at depth, but still above the groundwater level, in which case possible anthropogenic pollution is less of a problem than when using surface samples or sample types such as lake sediment that exist only below groundwater level.

We conclude that overbank sediment is a promising alternative sampling medium for regional geochemical mapping, and should be carefully tested in other physiographic regions.

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WESTERN EUROPEAN GEOLOGICAL SURVEYS
Working Group
on
REGIONAL GEOCHEMICAL MAPPING

PILOT PROJECT

APPENDIX REPORT 10

INVENTORY OF GEOCHEMICAL SURVEYS OF WESTERN EUROPE

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1.0 INTRODUCTION

In 1988 a proposal to prepare a modern digital geochemical database and atlas of Western Europe, as a basis for economic and environment planning in the twenty first century, was considered by the Directors of the Western European Geological Surveys (WEGS). The inventory described here was prepared as part of the WEGS Pilot Project; and was designed to determine the extent to which a geochemical database for Western Europe could be prepared by integrating available national geochemical datasets. The study was also carried out as a contribution to IGCP 259 "International Geochemical Mapping".

2.0 THE SURVEY

Information was collected using a standard form (Table 1) designed by the authors in collaboration with other members of the WEGS Working Group on Regional Geochemical Mapping. It was distributed mainly to National Survey organisations (appendix 1). Mining and exploration companies and universities were not included in the general survey because the surveys which they carry out tend to cover relatively small areas of less than 5000 km^2, the lower limit considered relevant for the purpose of the inventory. Completed forms were received from all of the WEGS countries, although the Netherlands, Iceland, Italy, Portugal and Switzerland reported that they have not conducted regional geochemical surveys over the minimum area required for the inventory.

The information is presented here in tables, maps and diagrams of summary statistics and is also available in digital format.

3.0 RESULTS

3.1 Regional Coverage

The extent of coverage of Western Europe by drainage (including stream, overbank and lake sediment, and water samples) and other sample types is listed in Table 2 and shown in Figs. 1 (a+b) and 2 respectively. Regional geochemical surveys based on rock, biological and till samples have been carried out only in Fennoscandia, and such surveys, therefore, do not provide a basis for the preparation of a geochemical map of Western Europe and are not considered further in this discussion.

The coverage of Western Europe by various types of drainage samples, especially lake and overbank sediment and water, is also limited. Lake sediment samples are restricted to eastern Finland (a total of 80,000 km^2) (reflecting the type of terrain), while the use of overbank sediment for regional surveys has been restricted to Norway and Greece (total area covered, 335,895 km^2) (probably reflecting the relatively recent introduction of this medium for geochemical surveying). Water sampling has been carried out over Finland, Denmark, West Germany and parts of Norway (total area 930,267 km^2), but the most extensive geochemical mapping coverage of Europe to date has been based on stream sediment samples (total 1,422,934 km^2). Complete coverage is available for the UK, West Germany, northern Sweden, Norway and Finland as well as significant areas of France, Austria, Greece and Turkey and to a lesser extent Spain. The stream sediment surveys have generally been conducted on a multipurpose basis (Table 2) although those carried out in France, Spain and Turkey have been mainly for metalliferous mineral exploration. Radiometric surveys are also available for Finland, Ireland, parts of the UK and those areas of France and Greece covered by stream sediment surveys.

3.2 Stream Sediment Surveys

Approximately one third of the area of western Europe has been covered by stream sediment sampling. Further analysis of the data for these surveys has therefore been carried out to study the extent to which they could provide a basis for preparing a geochemical map of western Europe. The sampling densities, size fractions and elements determined in the different surveys are summarised in Figures 3, 4 and 5.

(a) Sampling density

Sampling densities range from 8 per km^2 in parts of Finland to 1 per 300 km^2 for the combined overbank and stream sediment survey of part of Greece. Most surveys, however, employed sample densities in the range 1 per 1 km^2 to 1 per 5 km^2.

(b) Grain-size fractions

The size fractions analysed for the different stream sediment surveys range from ¾200 microns (76 BSI mesh) in the case of the survey of West Germany carried out by the BGR to ¾63 microns (240 BSI mesh) for the combined overbank and stream sediment survey of northern Greece performed by IGME. Most surveys, however, were based on the collection and analysis of the 180-177 micron fraction (approximately 80 BSI mesh)(Fig. 4).

(c) Chemical Elements Determined

There is a wide variation in the range of elements determined (Fig. 5) with only Cu and Ni analysed for all surveys (approximately 50% of the data for each of these metals is from total methods, the remaining 50% being from extraction techniques). The range of elements appears to reflect the type of analytical method available (XRF, DRS, OES, AAS or INAA) rather than the economic or environmental aims of the survey. Thus elements such as Sr and Zr, which can be determined rapidly and at relatively low cost by high productivity methods, have been included in more surveys (÷50%) than Au or U (¾10% respectively).

Elements of considerable environmental significance, such as I, have not been determined in any survey, while Se data are available for less than 5% of the surveys. The extent to which total and extractable methods have been used varies, with extractable methods being preferred for Ca, K, La, Li, Mg, Si, Ti and Zr. The methods of extraction also vary.

4.0 CONCLUSIONS

The maximum regional geochemical coverage of western Europe currently available (approximately 35%) is based on stream sediment samples; this compares with less than 15% for any other sample medium. The stream sediment data are, however, for different suites of chemical elements, determined by different (including 'total' and 'extractable') analytical methods on different size fractions. It is unlikely, therefore, that a geochemical atlas of Western Europe could be compiled using available data sets. Moreover, although there are sample archives for approximately 20% of Western Europe the size fraction stored varies so that reanalysis of this material is unlikely to provide compatible data.

The preparation of a regional geochemical atlas of Western Europe thus appears to require resampling and analysis based on standardised procedures.

Acknowledgements

The form which was used to collect information for the inventory was designed with the assistance of Dr Henry Haslam, BGS. This paper is published by permission of the Director of the British Geological Survey (NERC).

APPENDIX 1

Organisations participating in the inventory

Austria: Geologische Bundesanstalt

Belgium: Belgische Geologische Dienst

Denmark: Geological Survey of Denmark

Finland: Geologian Tutkimuskeskus

France: Bureau de Recherches Géologiques eyt Minières

Greece: Institute of Geology and Mineral Exploration

Iceland: Orkustofnun (National Energy Authority)

Ireland: Geological Survey of Ireland

Italy: Servizio Geologico Nazionale

Luxembourg: Service Geologique du Luxembourg

Netherlands: Rijks Geologische Dienst

Norway: Norges Geologiske Undersøkelse

Portugal: Servicos Geologicos de Portugal

Spain: Instituto Tecnológico GeoMinero de España

Sweden: Sveriges Geologiska Undersokning

Switzerland: Service hydrologique et géologique national
Université de Laussane

Turkey: Maden Tetkik ve Arama Genel Müdürlüğü

United Kingdom: British Geological Survey
Geological Survey of Northern Ireland

West Germany: Bundestalt für Gewissenschaften und Rohstoffe

REGIONAL GEOCHEMICAL SURVEYS

GENERAL INFORMATION

Objective of survey

Exploration ☐

Environment ☐

Multipurpose ☐

Other ☐
(please specify)

Locational information (please also show on accompanying map)

Country

Region(s) **(Name and UTM coordinates of boundaries)**

Approximate area in km^2 (minimum area 5000 km^2, except in Cyprus, Luxembourg, Lichtenstein, Monaco)

Samples and analyses (please use definitions on following sheets)

Sampling medium	*Grain size (im µm)*
Number of samples	*Heavy mineral fraction* ☐

Approximate sample density (samples per km^2)

Elements determined

Total

Extractable

Radiometric surveys **Yes** ☐ **No** ☐

Table 1: Standard information form

Other information

Year(s) of collection

Organisation responsible

Contact person responsible

Bibliographical reference Supply list, giving titles, authors and publication details

Availability of digital data/information

Yes ☐ **No** ☐
Free ☐ **Charge** ☐

(Please specify in ECUs [European Currency Units])

Comments

Contact person **Name:**
Address:

Phone:
Fax:

Availability of sample archives

Yes ☐ **No** ☐
Free ☐ **Charge** ☐

(Please specify in ECUs [European Currency Units])

Comments

Contact person **Name:**
Address:

Phone:
Fax:

Table 2: Inventory data.

Abbreviations used in the table:

MULT = multipurpose, ENV = environmental, EXPL = exploration, W = well, SP = spring, BH = borehole, MIC = micron, SG = specific gravity, RAD = radiometric survey, N = no. Y = yes, C = charge levied, F = free, COL = colorimetric, SIE = specific ion electrode, AAS = atomic absorption spectroscopy, OES = optical emission spectroscopy, (I)NAA = (instrumental) neutron activation analysis, XRF = X-ray fluorescence analysis, ICP(AES) = inductively coupled plasma (atomic emission spectroscopy), ES = emission spectroscopy, DCPS = direct current plasma spectroscopy, DRES = direct reader emission spectroscopy, SPECTPH = spectrophotometry, GUTZ = Gutzeit method, FLUO = fluorimetry

TABLE 2

COUNTRY	AREA	OBJECTIVE	AREA NAME	KM SQ	MEDIUM	FRACTION	NO. SAMPLES	DENSITY	ELEMENTS
AUSTRIA	83853	MULT.	BOHEMIAN MASS. CENTRAL E ALPS	40000	STREAM SED.	<177MIC	29717	1:1.4	Ag,Al,Ba,Be,Ca,Ce,Co,Cr,Cu,Fe,Ga,K,La,Mg,Mn,Mo,Na,Nb,Ni,P,Pb,Rb,Sb,Sc,Sn,Sr,Th,Ti,U,V,W,Y,Zn,Zr As
BELGIUM	30519	EXPL.	ARDENNES	11000	STREAM SED.	<177MIC	10205	1:1	Ag,As,Ba,Cd,Ce,Co,Cu,Fe,La,Mn,Mo,Nb,Ni,Pb,Sb,Sr,Ti,U,V,Y,Zn,pH
DENMARK	43075	ENV.	WHOLE	43000	WATER(W,SP,BH)		20000	1:2	?
FENNOSCANDIA		MULT.	N. NORWAY, SWEDEN and FINLAND	250000	TILL	<62MIC	5400	1:50	Co,Cr,Cu,K,Mg,Mn,Ni,Pb,Ti,V,Zn
							1040	1:250	As,Au,Ba,Br,Cs,Fe,La,Na,Rb,Sb,Sc,Sm,Ta,Th,U,W
					TILL HEAVY MIN.	>62<500MIC	1034	1:250	Al,Ba,Ca,Cl,Co,Cr,Cu,Fe,K,Mg,Mn,Mo,Na,Nb,Ni,P,Rb,Si,Sr,Th,Ti,V,Y,Zn,Zr
					STREAM SED.	<180MIC	5773	1:50	Ag,Al,Ba,Ca,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Ni,P,Sc,Sr,V,Zn,Zr
					STREAM SED. HEAVY MIN.	>180<600MIC	1056	1:250	Al,Ba,Ca,Cl,Cr,Cu,Fe,K,Mg,Mn,Na,Nb,Ni,P,Si,Sn,Sr,Ti,V,W,Y,Zn,Zr
					STREAM ORG. MATERIAL	<100MIC ASH	1096	1:250	Al,Ba,Ca,Cl,Co,Cr,Cu,Fe,K,Mg,Mn,Mo,Na,Nb,Ni,P,Rb,S,Si,Sr,Th,Ti,U,V,Y,Zn
					STREAM MOSS	<100MIC ASH	1095	1:250	As,Au,Ba,Br,Co,Fe,La,Lu,Mo,Sb,Sc,Sm,Th,U
					STREAM WATER		5000	1:50	Al,Ca,Fe,Mg,Mn,Na,Si,Sr,cond.
FINLAND(1)	337032	MULT.	WHOLE	337000	GROUNDWATER		8000	1:50	?
FINLAND(2)		MULT.	WHOLE	285000	TILL and HEAVY MIN.	<60MIC	71000	1:4	Au,S
							43000		Al,As,Ba,Ca,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Ni,P,Sc,Sr,Th,Ti,V,Y,Zn,Zr
FINLAND(3)		MULT.	WHOLE	337000	TILL	<60MIC	1057	1:300	Al,Au,Ba,Br,Ca,Co,Cr,Cs,Cu,Fe,K,Li,Mg,Mn,Na,Ni,P,REE,Rb,S,Sb,Sc,Si,Sr,Th,Ti,U,V,Y,Zn,Zr
									Al,As,Ba,Br,Ca,Co,Cr,Cu,Fe,K,Li,Mg,Mn,Na,Ni,P,Pb,REE,Sc,Sr,Th,Ti,V,Y,Zn
FINLAND(4)		MULT.	E. FINLAND	80000	LAKE SEDIMENT		16000	1:5	Co,Cu,Fe,Mn,Ni,Pb,U,Zn (Ag,Cd,Cr,Mo-some samps)
FINLAND(5)		MULT.	VARIOUS	80000	STREAM SED.	<180MIC	320000	8:1-1:5	Co,Cu,Fe,Mn,Ni,Fb,U,Zn (Cr,Mo-some samples)
FRANCE(1)	543965	EXPL.	MASS. ARMORICAIN	21853	STREAM SED. AND HEAVY MIN.	<125MIC	59000	2.7:1 1.5:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,Fe,Mn,Mo,Nb,Ni,P,Pb,Sb,Sn,V,W,Y,Zn
FRANCE(2)		EXPL.	VOSGES	8261	STREAM SED. AND HEAVY MIN.	<125MIC	22300	2.7:1 71:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,Fe,Mn,Mo,Nb,Ni,P,Pb,Sb,Sn,V,W,Y,Zn
FRANCE(3)		EXPL.	MASSIF CENTRAL	52767	STREAM SED. AND HEAVY MIN.	<125MIC	143000	2.7:1 1:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,Fe,Mn,Mo,Nb,Ni,F,Pb,Sb,Sn,V,W,Y,Zn
FRANCE(4)		EXPL.	ALPS-COTE d'AZUR	10127	STREAM SED. AND HEAVY MIN.	<125MIC	27340	2.7:1 71:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,Fe,Mn,Mo,Nb;Ni,P,Pb,Sb,Sn,V,W,Y,Zn
GREECE(1)	131986	MULT.	E. MACEDONIA AND THRACE	12000	OVERBANK AND STREAM SED.	<63MIC	41	1:300	Al,Au,Ba,Be,Ca,Cd,Co,Cr,Cu,Fe,Li,Mn,Mo,Ni,Pb,Sc,Sr,Ti,V,Y,Zn
							39		Ag,Al,B,Ba,Be,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,F,Pb,Sc,Si,Sr,Ti,V,Zn,Zr
GREECE(2)		MULT.	WHOLE	48000	STREAM SED.	<177MIC	83627	1.5-2:1	Ag,B,Cd,Co,Cr,Cu,Hg,Mn,Mo,Ni,Pb,Sb,Sr,U,V,Zn
GREECE(3)		MULT.	WHOLE	131944	STREAM SED.	<177MIC	12000	1:10	INCOMPLETE
ICELAND	102819	NO SURVEYS							
IRELAND	68895	MULT.	LEINSTER(PART)	6750	STREAM SED.	<150MIC	1912	1:3.5	Ag,As,Au,Ba,Br,Cd,Ce,Co,Cr,Cs,Eu,Fe,Hf,Ir,La,Lu,Mo,Na,Ni,Rb,Sb,Sc,Se,Sm,Sn,Ta,Tb,Te,Th,U,W,Yb,Zn,Zr
									Co,Cr,Cu,Fe,Li,Mn,Ni,Pb,Y,Zn
ITALY	301245	NO SURVEYS							
LUXEMBOURG(1)	2586	EXPL.,ENV.	OESLING(N. LUX)	1200	SOIL,WATER		240	1:5	Metals
LUXEMBOURG(2)		EXPL.(Al)	OESLING(N. LUX)	1200	ROCK		120	1:10	Major elements
NETHERLANDS	41160	NO SURVEYS							
NORWAY(1)	323895	MULT.	SOGN OG FJORDANE	18600	STREAM MOSS		650	1:30	Ag,Al,Ba,Be,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Si,Sr,Ti,V,Zn,Zr
NORWAY(2)		MULT.	SOGN OG FJORDANE	18600	STREAM SED.	<180MIC	650	1:30	Au,Ba,Ir,Nb,Os,Pd,Pt,Rb,Rh,Ru,Sn,Sr,Th,U,Y,Zr
									Ag,Al,Ba,Be,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Si,Sr,Ti,V,Zn,Zr
NORWAY(3)		MULT.	SOGN OG FJORDANE	18600	STREAM WATER		650	1:30	Al,Ba,Be,Br,Ca,Cd,Cl,Co,Cu,F,Fe,K,Li,Mg,Mn,Mo,Na,Ni,NO2,NO3,P,Pb,PO4,Si,SO4,Sr,Ti,V,Zn
NORWAY(4)		MULT.	NORDLAND-TROMS	53000	TILL		1310	1:50	As,Ba,Br,Co,Cr,Cs,Fe,La,Lu,Mo,Na,Pb,Sb,Sc,Sm,Ta,Th,U,W,Zn
									Ag,Al,Ba,Ca,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Sr,Ti,V,Zn,Zr
NORWAY(5)		MULT.	NORDLAND-TROMS	53000	STREAM SED. AND HEAVY MIN.	<180MIC	1209	1:50	Ag,Al,B,Ba,Be,Ca,Cd,Ce,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Si,Sr,Ti,V,Zn,Zr
						SG<2.96			Al,Ba,Ca,Cl,CO2,Cr,Cu,Fe,K,Mg,Mn,Mo,Na,Nb,Ni,P,Pb,S,Si,Sr,Ti,Y,Zn,Zr
NORWAY(6)		MULT.	NORDLAND-TROMS	53000	STREAM WATER		1204	1:50	Al,Ca,Fe,Mg,Mn,Na,Si,Sr,cond.,pH

TABLE 2 CONTINUED

COUNTRY	ANALYSIS	RAD.	DATES	DIGITAL	ARCHIVES	STATUS	COMMENTS
AUSTRIA	TOTAL		1978-81	YES/C	NO	COMPLETE	Fine ground material available
	EXTRACTABLE						
BELGIUM	TOTAL	N	1079-1980	NO	NO	COMPLETE	
DENMARK	COL,SIE,AAS		1920-PRES	YES(WELL)	NO		
FENNOSCANDIA	TOTAL(OES)	N	1980-86	YES	?YES	COMPLETE	Joint survey by Norway, Finland and Sweden - The Nordkalott Project
	TOTAL(NAA)						Combined from original 5400 samples
	TOTAL(XRF)	N	1980-86	YES	?YES	COMPLETE	Combined from original 5400 samples
	EXTRACTABLE (ICP)	N	1980-86	YES	?YES	COMPLETE	
	TOTAL(XRF)	N	1980-86	YES	?YES	COMPLETE	Combined from original 5773 samples
	TOTAL(XRP)	N	1980-86	YES	?YES	COMPLETE	Combined from original 5773 samples
	TOTAL(NAA)	N	1980-86	YES	?YES	COMPLETE	Combined from original 5773 samples
	TOTAL	N	1980-1983	YES/C	?YES	COMPLETE	
FINLAND(1)		Y	1970-78	YES/C	NO	COMPLETE	
FINLAND(2)	TOTAL EXTRACTABLE	N	1983-PRES	YES/C	?	ONGOING	
FINLAND(3)	TOTAL	N	1984	YES/C	YES/C/F	COMPLETE	
	EXTRACTABLE						
FINLAND(4)	EXTRACTABLE	N	1973-84	YES/C	NO	COMPLETE	
FINLAND(5)	EXTRACTABLE	N	1970-85	YES/C	?NO	?	
FRANCE(1)	TOTAL(ES)	Y	1976-89	YES/C	YES/C	COMPLETE	Some soils taken Radiometric survey data confidential to CEA
FRANCE(2)	TOTAL(ES)	Y	1976-89	YES/C	YES/C	COMPLETE	Radiometric survey data confidential to CEA
FRANCE(3)	TOTAL(ES)	Y	1976-89	YES/C	YES/C	COMPLETE	Radiometric survey data confidential to CEA
FRANCE(4)	TOTAL(ES)	Y	1976-89	YES/C	YES/C	COMPLETE	Radiometric survey data confidential to CEA
GREECE(1)	TOTAL	Y	1989	YES/F	YES/F	COMPLETE	
	EXTRACTABLE						
GREECE(2)	EXTRACTABLE	Y	1970-89	YES/C	NO	ONGOING	
GREECE(3)	EXTRACTABLE	Y	1970-89	NO	NO	COMPLETE	
IRELAND	TOTAL(INAA)	Y	1986-89	YES/C	NO	?ONGOING	Archives could be available
	EXTRACTABLE						
ITALY							
LUXEMBOURG(1)	TOTAL		1985-88	YES	NO	COMPLETE	
LUXEMBOURG(2)	TOTAL		1978-80	NO	NO	COMPLETE	
NETHERLANDS							
NORWAY(1)	EXTRACTABLE	N	1961-1975 1983-1989	YES/C	YES/C	COMPLETE	
NORWAY(2)	TOTAL EXTRACTABLE	N	1961-1975 1983-1989	YES/C	YES/C	COMPLETE	
NORWAY(3)	TOTAL	N	1961-1975 1983-1989	YES/C	YES/C	COMPLETE	
NORWAY(4)	TOTAL	N	1986-1988	YES/C	YES/C	COMPLETE	
	EXTRACTABLE						
NORWAY(5)	EXTRACTABLE	N	1986-1988	YES	YES/C	COMPLETE	
	TOTAL						
NORWAY(6)		N	1986-1988	YES/C	NO	COMPLETE	

TABLE 2 CONTINUED

COUNTRY	AREA	OBJECTIVE	AREA NAME	KM SQ	MEDIUM	FRACTION	NO. SAMPLES	DENSITY	ELEMENTS
NORWAY(7)		MULT.	NORD TRONDELAG	30000	STREAM SED.	<180MIC	7000	1:3	Ag,Al,Ba,Be,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Si,Sr,Ti,V,Zn,Zr Pd,Pt,Rh(1800 samples) Au(3700 samples)
NORWAY(8)		MULT.	NORD TRONDELAG	30000	STREAM WATER		600	1:5	Ag,As,Ba,Br,Ca,Ce,Co,Cr,Cs,Cu,Fe,Hf,Ir,La,Lu,Na,Ni,Rb,Sb,Sc,Se,Sm,Sr,Ta,Tb,Th,U,W,Yb,Zn
NORWAY(9)		MULT.	SE NORWAY	100000	STREAM SED.	<180MIC	4000	1:4	Al,Ba,Ca,Co,Cr,Fe,K,Mg,Mn,Na,Nb,Ni,P,Pb,Rb,S,Si,Sr,Ti,V,Y,Zn,Zr Ag,Al,As,B,Ba,Be,Bi,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sb,Sc,Si,Sr,Ti,V,Zn,Zr
NORWAY(10)		MULT.	OSLO GRABEN	10000	STREAM SED.	<180MIC	1000	1:10	Ag,Al,B,Ba,Be,Ca,Cd,Ce,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,P,Pb,Sc,Si,Sr,Ti,V,Zn,Zr
NORWAY(11)		MULT.	WHOLE COUNTRY	324000	OVERBANK SED.	<62MIC	690	1:500	Al,As,Ba,Ca,Cl,Co,Cr,Cu,Fe,K,Mg,Mn,Mo,Na,Nb,Ni,P,Pb,S,Si,Sn,Sr,Th,Ti,U,V,W,Y,Zn,Zr Ag,Al,Au,B,Ba,Be,Bi,Ca,Cd,Ce,Co,Cr,Cu,Fe,K,La,Lu,Mg,Mn,Mo,Na,Ni,P,Pb,Sb,Sc,Se,Sr,Ti,V,Zn,Zr
PORTUGAL	91631	NO SURVEYS							
SPAIN(1)	504879	EXPL.	C. PYRENEES	5105	STREAM SED. and HEAVY MIN.	<177MIC	13069 1050	2.5:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,F,Fe,Mn,Mo,Nb,Ni,P,Pb,Sb,Sn,V,W,Y,Zn
SPAIN(2)		EXPL.	GALICIA	5600	STREAM SED. and HEAVY MIN.	<177MIC	11036 900	2:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,P,Fe,Mn,Mo,Nb,Ni,P,Pb,Sb,Sn,V,W,Y,Zn
SPAIN(3)		EXPL.	CENTRAL	14500	STREAM SED. and HEAVY MIN.	<177MIC	52074 5200	3.6:1	Ag,As,B,Ba,Be,Cd,Co,Cr,Cu,Fe,Mn,Mo,Nb,Ni,P,Pb,Sb,Sn,V,W,Y,Zn
SWEDEN(1)	449790	MULT.		125000	ROCK		9000	VARIABLE	Majors+As,Ba,Cd,Cl,Co,Cr,Cu,Hg,Mo,Nb,Ni,Pb,Rb,S,Se,Sr,U,V,W,Y,Zn,
SWEDEN(2)		MULT.		115000	ROOTS,MOSSES		17500	1:7	Majors+As,Au,Ba,Cd,Cl,Co,Cr,Cu,Mo,Nb,Ni,Pb,Rb,S,Sr,U,V,W,Y,Zn
SWEDEN(3)		MULT.		55000	TILL	<63MIC	7200	1:7	Majors+As,Bi,Br,Cl,Co,Cr,Cu,Ga,Ge,Mo,Nb,Ni,Pb,Rb,S,Se,Sr,Th,U,V,W,Y,Zn,Zr Al,Ba,Be,Bi,Ca,Cd,Co,Cu,Fe,K,La,Li,Mg,Mn,Mo,Na,Ni,Pb,Sb,Se,Si,Sr,Ti,Zn
SWITZERLAND	41287	NO SURVEYS							
TURKEY	779452	EXPL.	WHOLE	150000	STREAM SED.	7	160000	1:1	As,Co,Cu,Mo,Ni,Pb,Sb,Zn
U.K.(1)	244754	EXPL./ENV.	GREAT BRITAIN	117000	STREAM SED., HEAVY MIN.,	<150MIC	66500	1:1.7	B,Ba,Be,Co,Cr,Cu,Fe,Mn,Mo,Ni,Pb,Ti,U,V,Zr
					STREAM WATER		33000	1:3	B,Ba,Be,Ca,Co,Cr,Cu,Fe,K,La,Li,Mg,Mn,Mo,Ni,Pb,Rb,Sn,Sr,Ti,U,V,Y,Zn,Zr, (Ag,As,Cd,Sb some samps)
U.K.(2)		MULT.	N. IRELAND	14140	STREAM SED.	<200MIC	4800	1:3	Al,As,Ba,Ca,Co,Cr,Cu,Fe,Ga,K,Mg,Mn,Mo,Ni,Pb,Sc,Si,Sr,V,Zn
U.K.(3)		MULT.	ENGLAND and WALES	151000	STREAM SED.	<200MIC	50000	1:3	Al,As,Ba,Ca,Cd,Co,Cr,Cu,Fe,Ga,K,Mn,Mo,Ni,Pb,Sc,Sn,Sr,V,Zn
WEST GERMANY(1)	248667	EXPL./ENV.	WHOLE	250000	STREAM SED.	<200MIC	68000	1:3	Ba,Cr,Sr,V Cd,Co,Cu,F,Li,Ni,Pb,Sn,U,W,Zn
WEST GERMANY(2)		EXPL./ENV.	WHOLE	250000	WATER		76000	1:3	Cd,Co,Cu,Ni,Pb,U,Zn

TABLE 2 CONTINUED

COUNTRY	ANALYSIS	RAD.	DATES	DIGITAL	ARCHIVES	STATUS	COMMENTS
NORWAY(7)	EXTRACTABLE	N	1984-1985	YES/C	YES/C	COMPLETE	
	TOTAL TOTAL						
NORWAY(8)	TOTAL	N	1984-1985	YES/C	YES/C	COMPLETE	
NORWAY(9)	TOTAL	N	1976-1979	NO	?YES/C	COMPLETE	Populated areas only sampled
	EXTRACTABLE	N					
NORWAY(10)	EXTRACTABLE	N	1976-1980	YES/C	YES/C	COMPLETE	
NORWAY(11)	TOTAL	N	1983-1984	YES/C	NO	COMPLETE	
	EXTRACTABLE						
PORTUGAL							
SPAIN(1)	TOTAL(DCPS)	N	1981-1983	NO	NO	COMPLETE	Digital data available in special cases
SPAIN(2)	TOTAL(DCPS)	N	1982-1986	NO	NO	COMPLETE	Digital data available in special cases
SPAIN(3)	TOTAL(ICPAES)	N	1984-1986	NO	NO	COMPLETE	Digital data available in special cases
SWEDEN(1)	TOTAL(XRF and ICPAES)	N	1978-1990	YES/C	YES/C	7	Cd and Se on selected samples only
SWEDEN(2)	TOTAL(XRF and AAS)	N		YES/C	YES/C	?	Collected over 10 year period
SWEDEN(3)	TOTAL(XRF)			YES/C	YES/C	?	Collected over 6 year period
	EXTRACTABLE (ICPAES and AAS)						
SWITZERLAND							
TURKEY	7EXTRACTABLE		1970-1989	YES/C	YES/C	ONGOING	
U.K.(1)	TOTAL(OES)	Y	1968-PRES.	YES/C	YES/C	ONGOING	Analyses for N. Scotland, Orkney and Shetland Islands
	TOTAL(DRES)						Analyses for rest of Great Britain
U.K.(2)	TOTAL(DRES, · SPECTPH., GUTZ.)	7	71970-1973?		7	COMPLETE	
U.K.(3)	TOTAL(DRES, SPECTPH., GUTZ.)	N	1969-1977	7	7	COMPLETE	
WEST GERMANY(1)	TOTAL(ES) EXTRACTABLE(AAS COL., FLUO., SIE)	N	1977-1983	YES/C	NO	COMPLETE	
WEST GERMANY(2)	(AAS, FLUO.)		1977-1983	YES/C	NO	COMPLETE	

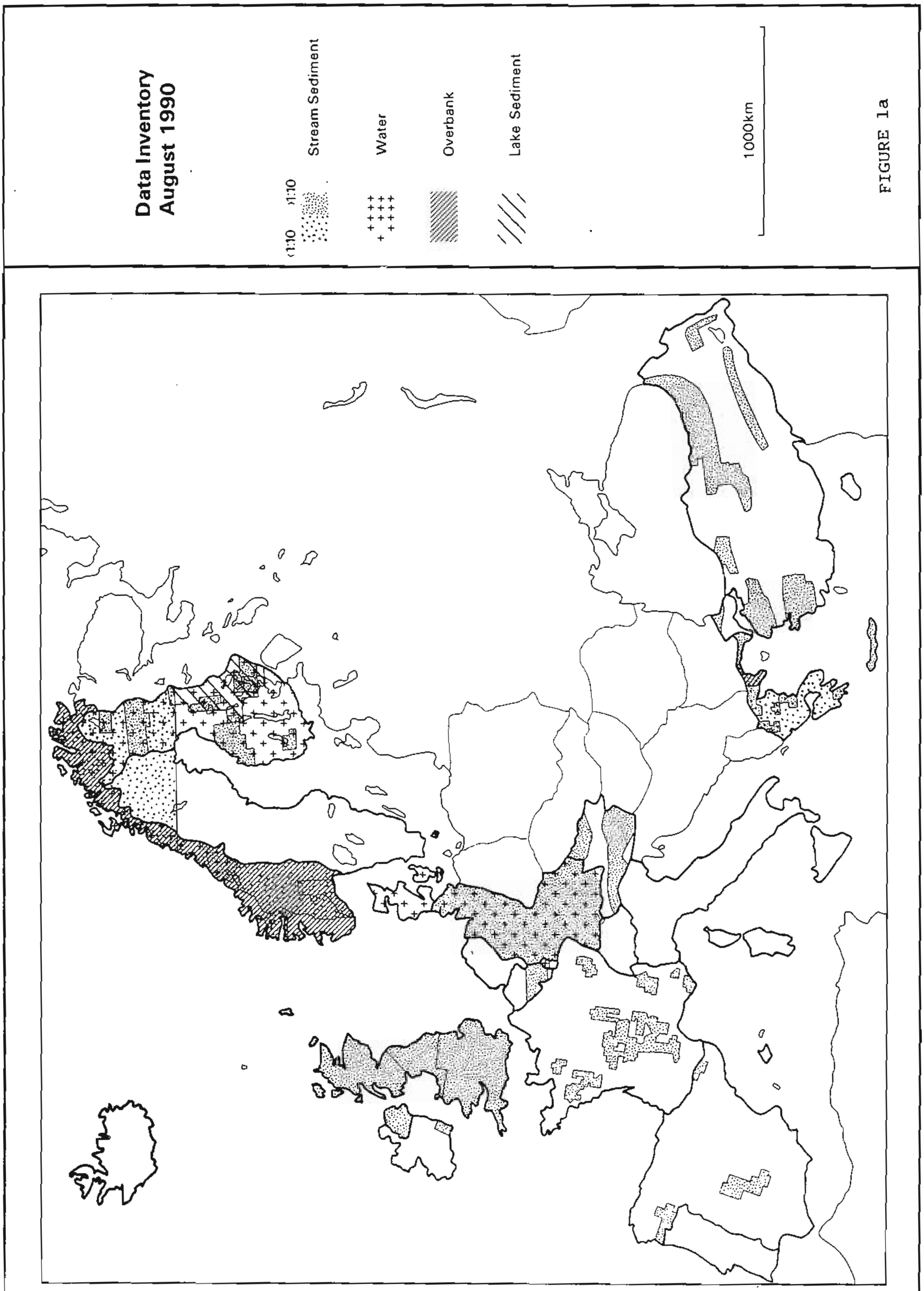

FIGURE 1a

FIGURE 1 (a+b): Areas of Western Europe covered by different types of geochemical survey. WEGS countries are shown by bold national boundaries.

Data Inventory August 1990

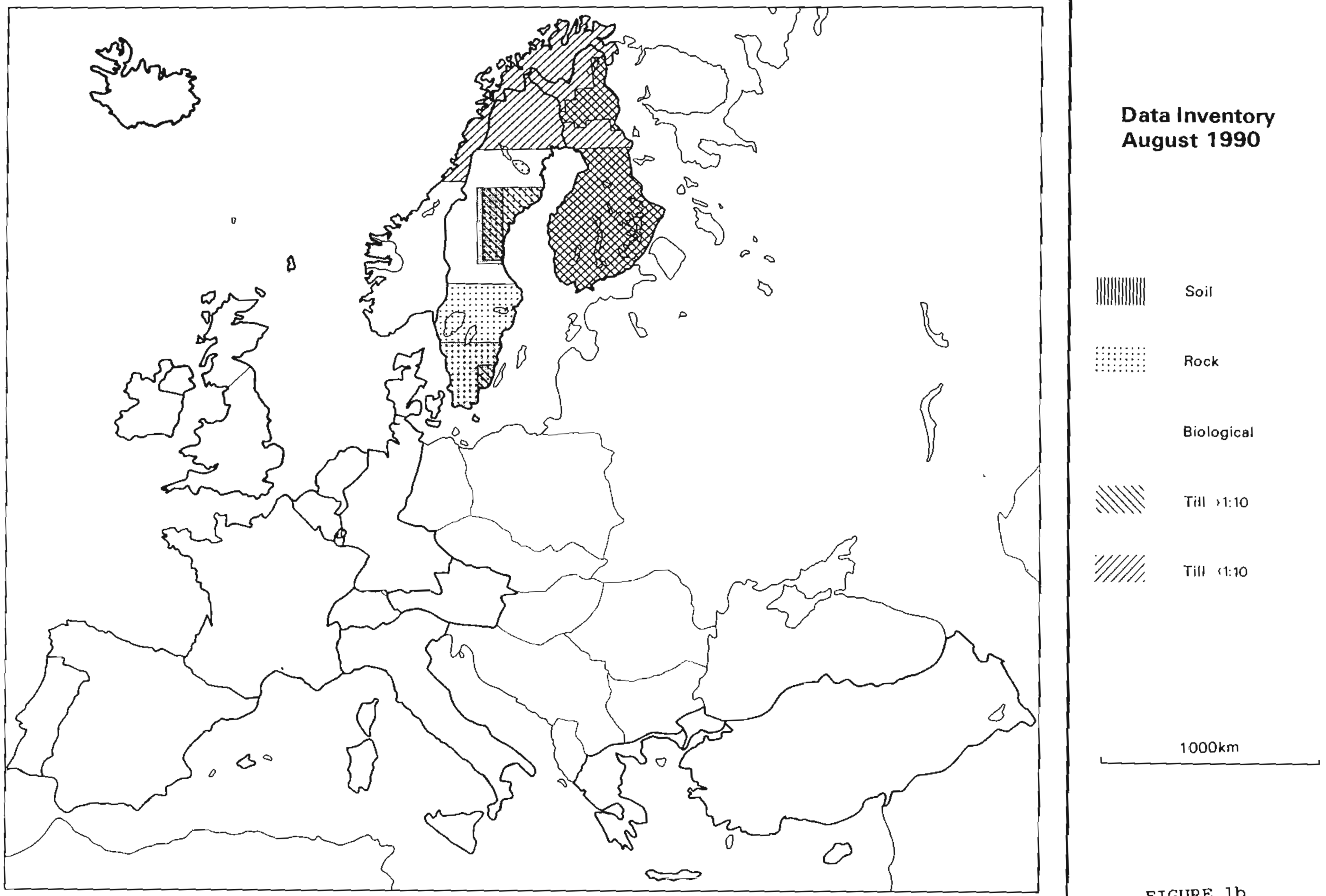

FIGURE 1b

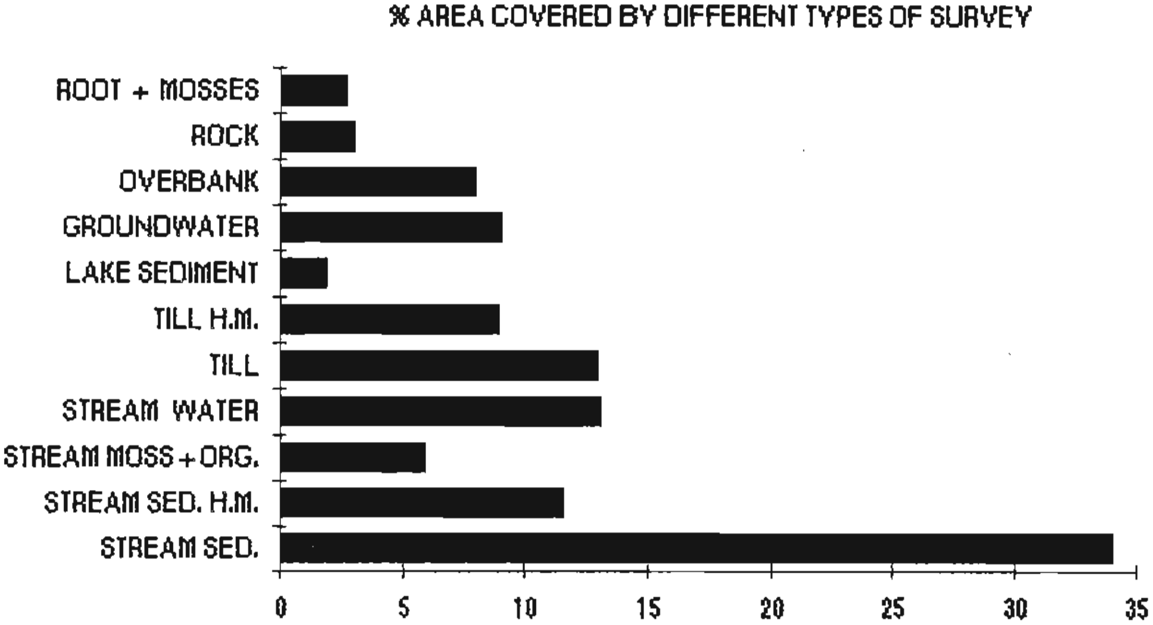

FIGURE 2: Percentage of the area of Western Europe covered by different types of geochemical survey. H.M. = Heavy Mineral; ORG = Stream organic matter.

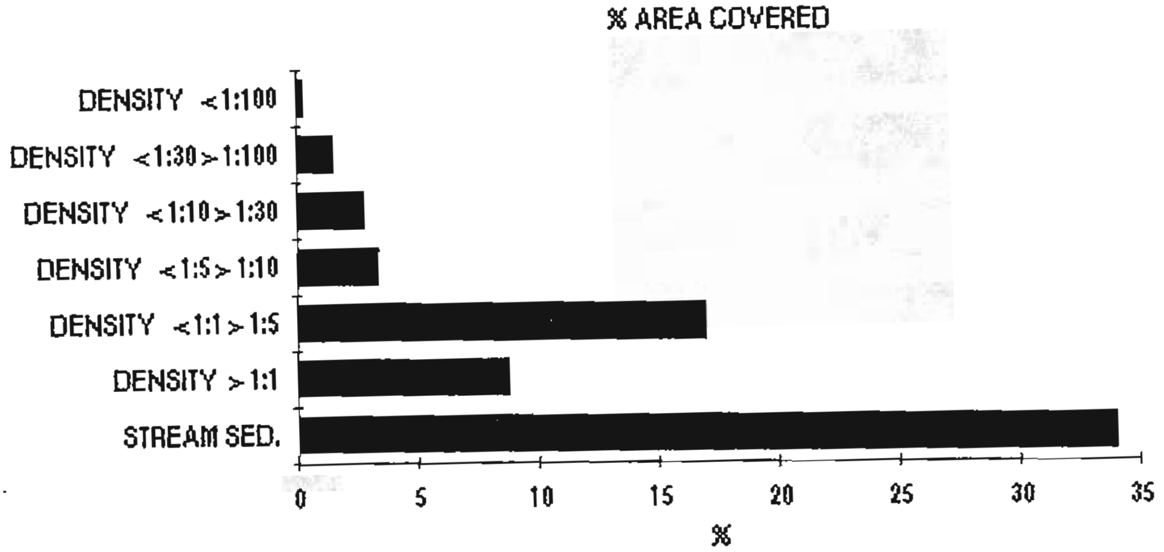

FIGURE 3: Percentage of the area of Western Europe covered by stream sediment surveys at different sample densities. The total percentage area covered by all stream sediment surveys is shown for comparison.

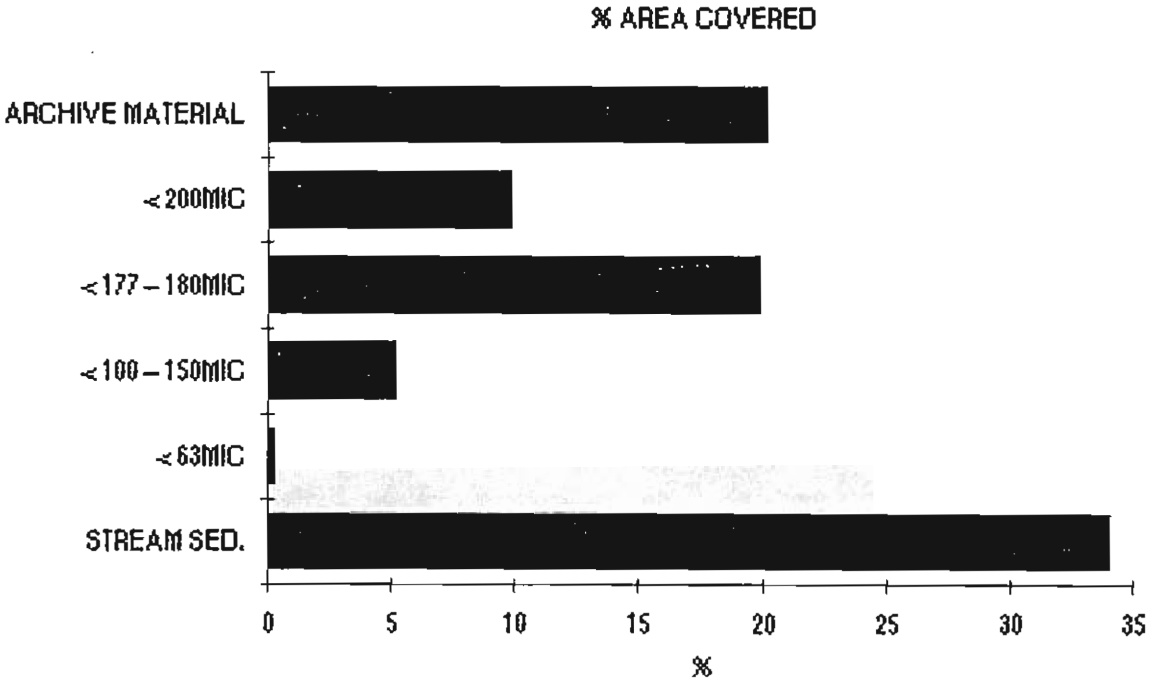

FIGURE 4: Percentage of the area of Western Europe covered by: (a) stream sediment surveys using different grain size fractions and (b) stream sediment sample archives. The total percentage area covered by all stream sediment surveys is shown for comparison.

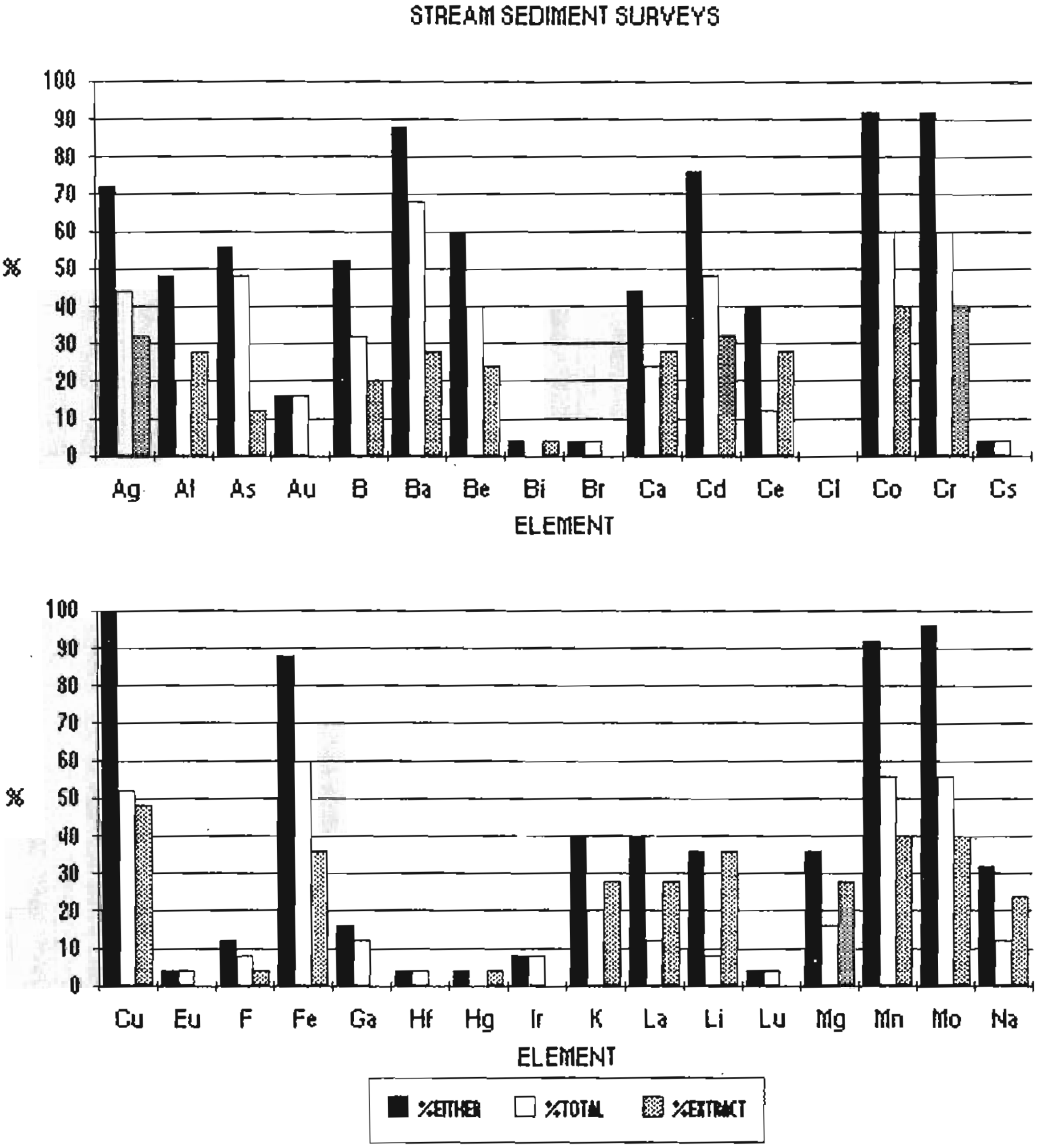

FIGURE 5: Percentage of stream sediment surveys in which various chemical elements have been determined. Percentages for "total", "extractable" and "either" total or extractable methods are shown.

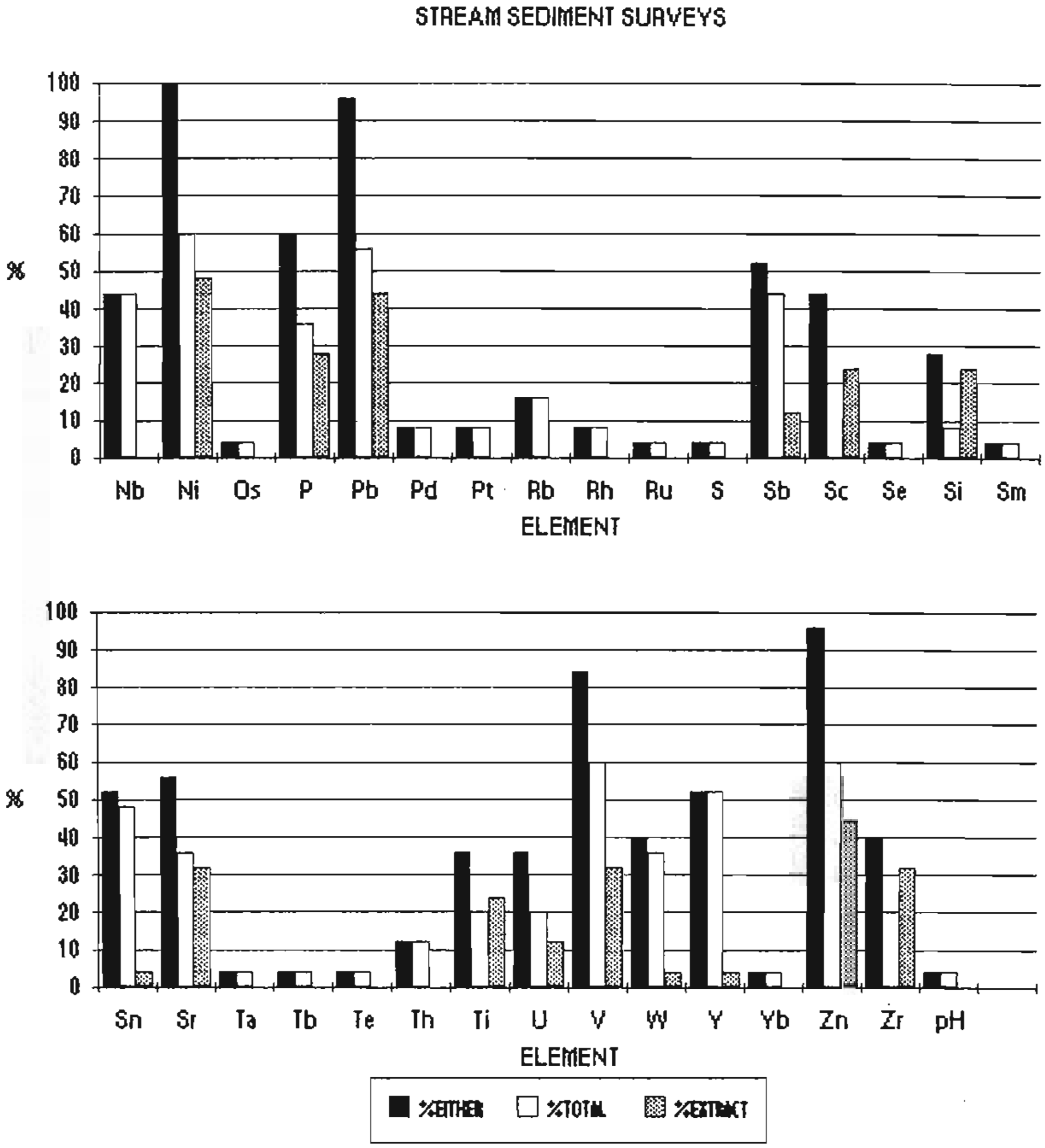

FIGURE 5 (continued).

The directors of the Western European Geological Surveys (WEGS) have appointed a Working Group on Regional Geochemical Mapping. The countries represented in the Working Group are as follows (representatives as of 1 August 1990 are given in parenthesis):

Austria (O. Schermann, G.B.)
France (I. Salpeteur, B.R.G.M)
Germany (R. Hindel, B.G.R.)
Greece (A. Demetriades,
    P. Stavrakis, I.G.M.E.)
Norway (B. Bølviken [convener],
    R.T. Ottesen, T. Volden, N.G.U.)
Spain (J. Locutura, I.G.M.E.)
United Kingdom (J. Plant,
    J. Ridgway, B.G.S.)

In addition Finland (R. Salminen, G.T.) and Ireland (P.O´Connor, G.S.I.) joined the Working Group on special matters in 1989 - 1990. J. Bogen, Norwegian Water Resources and Energy Administration, served as a sedimentology expert in the Group.

The WEGS Working Group on Regional Geochemical Mapping proposes that a geochemical mapping of Western Europe based on a low density sampling programme be carried out. This suggestion forms the conclusion of a pilot project done in 1988 - 1990. The resulting Pilot Project Report and a main Project Proposal will be presented to the WEGS directors in September 1990.

The bibliographic references are:

Demetriades, A., Ottesen, R.T. and Locutura, J. (eds.) 1990: Geochemical Mapping of Western Europe towards the Year 2000. Pilot Project Report. NGU Report 90-105, 9 pages and 10 appendices.

Bølviken, B., Demetriades, A., Hindel, R., Locutura, J., O´Connor, P., Ottesen, R.T., Plant, J., Ridgway, J., Salminen, R., Salpeteur, I., Schermann, O. and Volden, T. (eds.) 1990: Geochemical Mapping of Western Europe towards the Year 2000. Project Proposal. NGU Report 90-106, 12 pages and 9 appendices.

The Pilot Project Report as well as the Project Proposal are available from the Geological Survey of Norway (cost of reproduction NOK 900 and 90, respectively).

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