NGU Rapport nr. 89.134

Geological investigations of anorthosite in Voss 1989 for A/S Polymer.

NORGES GEOLOGISKE UNDERSØKELSE

Postboks 3006 - Lade
7002 Trondheim
Tlf. (07) 92 16 11
Telefax (07) 92 16 20

RAPPORT

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Tittel:
Geological investigations of anorthosite in Voss 1989 for A/S Polymer.

Forfatter: J.E. Wanvik	**Oppdragsgiver:** A/S Polymer
Fylke: Hordaland	**Kommune:** Voss
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Sammendrag:

Based on the investigations of anorthosite in the Voss and Aurland are in Western Norway ten years ago, NGU did a shorter mapping and sampling of selected areas for A/S Polymer within the large anorthosite massif between Gudvangen and Mjølfjell. Localities that is suitable for producing the raw material of an initial test production was evaluated. Various localities seem to be suitable for this purpose. Mining areas for a permanent production phase is also available, but a more specific location can not be pinpointed until a more detailed supplemental investigation of the relevant areas is accomplished.

Emneord		
industrimineraler	anorthositt	ressurskartlegging

CONTENTS

1. INTRODUCTION

Based on the active participation of NGU (Geological Survey of Norway) in the geological and mineralogical aspects of the Anortal project 10 years ago, and the recent transferral of the Anortal archive to NGU, Per Lindbak of A/S Polymer established contact in 1989.

Polymer's project on production of aluminum-chemicals from anorthosite based on a Anortal-like leaching process has proved to be very promising, and a guarantee of an adequate and available anorthosite deposite has become imperative. The parameters now are though not equal to the ones operative in the Anortal-project, and a deposit meeting Polymer's new specifications is wanted.

The author was as an Elkem employee, Anortal geologist during the years 1977-81, and has thus last summer done a weeks fieldwork for Polymer in the Voss area.

2. SHORT REWIEW OF THE EARLIER INVESTIGATIONS.

The investigations by I/S Anortal during the years 1976-1981 included a regional survey of norwegian anorthosites -and especially the larger bodies with soluble anorthosite in the Sogn-Voss area. The aim of the investigations then was to locate a deposit of at least 100 mill. tons. Two areas with acceptable quality and volume was veryfied by detailed mapping, sampling and diamond drilling. These are the Hylland-deposit and the Kaldafjell-deposit, both located within the large Gudvangen-Mjølfjell massif as shown by fig 2.1.

3. THE NEED OF LOCATING NEW DEPOSITS NOW.

The 100 mill. ton deposits of Anortal are both situated on the mountain tops in high altitude, and somewhat too far away from existing roads. Polymer's lower tonnage demands (0.6 - 5 mill.tons) might make it possible for geographically more attractive areas to give the adequate amount of good quality anorthosite. In addition Polymer does not have as strict demans of a low iron-content (from non-feldspar minerals) as Anortal, and this also gives room for new localities.

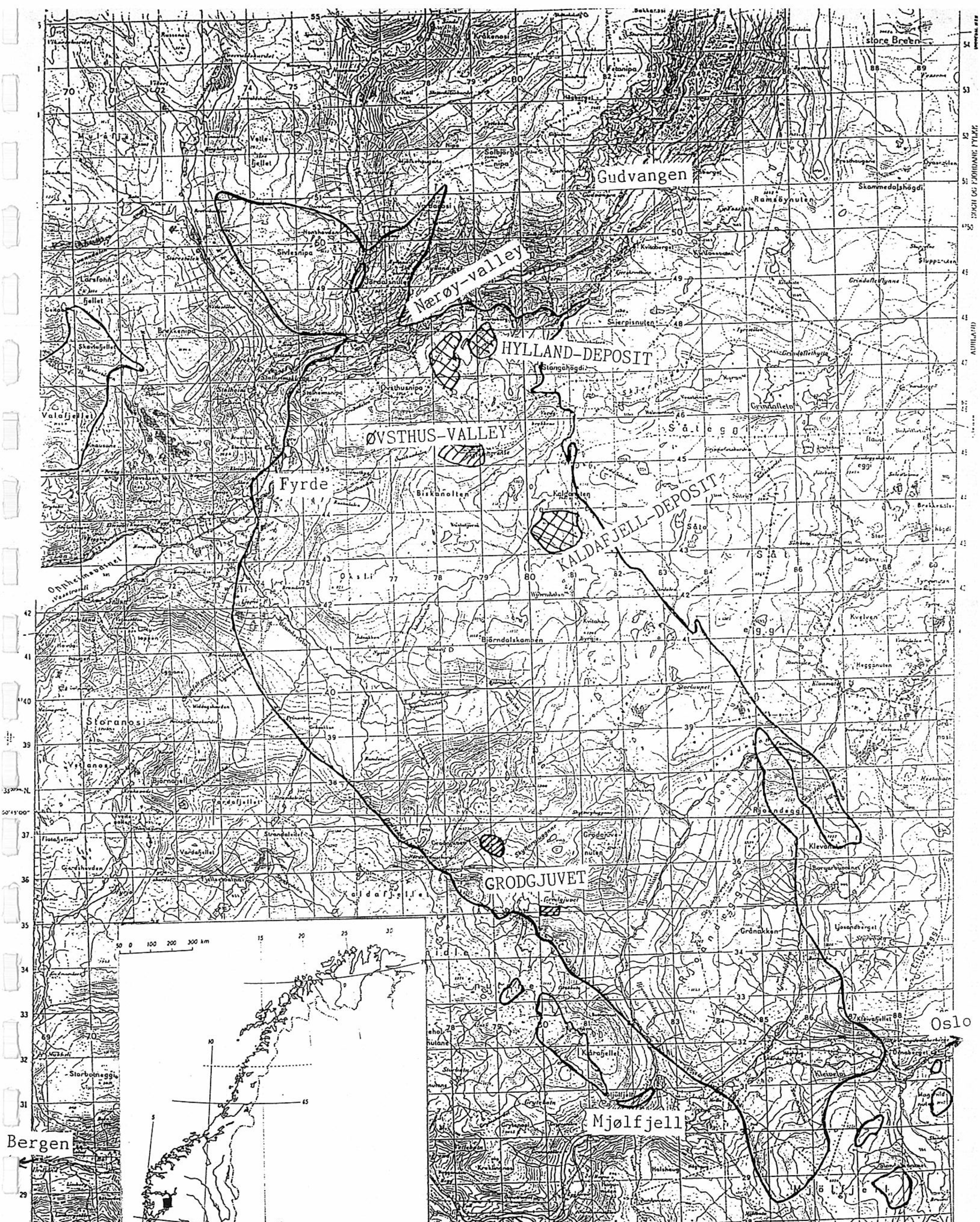

Fig. 2.1 The Gudvangen - Mjølfjell anorthosite massif. ca. 1 : 100.000

4. THIS YEARS INVESTIGATIONS.

The field work last summer by the author was only one week. This was mainly spent on fields trip together with Mr. Per Lindbak, and potential localities in Grodgjuvet and the Øpsthus valley was roughly sampled.¯ An interesting locality by the main road near the Fyrde farm was also sampled. In addition a sampling of the material of the mining operations of the Nærøy valley was undertaken.

4.1 Grodgjuvet.

As a basis for the planning of the search for a new deposit, we have a deposit called Grodgjuvet in the southern part of the Massif. (fig.2.1 and 4.1). This deposit was mapped and sampled in detail by Anortal -together with preliminary diamond drilling. A tonnage of minimum 2 mill. tons made the deposit well suited as a potential site for the raw material in a pilot phase of the Anortal project. This deposit is situated only 2 km from existing road (military) and is easily accessable in rather flat terrain from the end of this road. This deposit is well mapped at the surface, and the next step here has to be more diamond drilling in order to know the total amount of good anorthosite awailable.

4.1.1 Lower areas of Grodgjuvet.

The more imminent need of a locality that can supply the needed 200-1000 tons of raw material for an initial test production, made it desirable to sample some areas close by the existing road in Grodgjuvet. The sampled localities are shown on fig 4.2, and the chemical analyses (G1-G5) given inn table 4.1 proves that the solubility is quite good. The analyses also shows that the contents of contaminating minerals is acceptable (table 4.1 and appendix 1).

Thus these areas by the road here in Grodgjuvet, is geologically well suited as a locality that can supply the 100-1000 tons of raw material for a test production. Quantities much larger than that is probably present in this area.

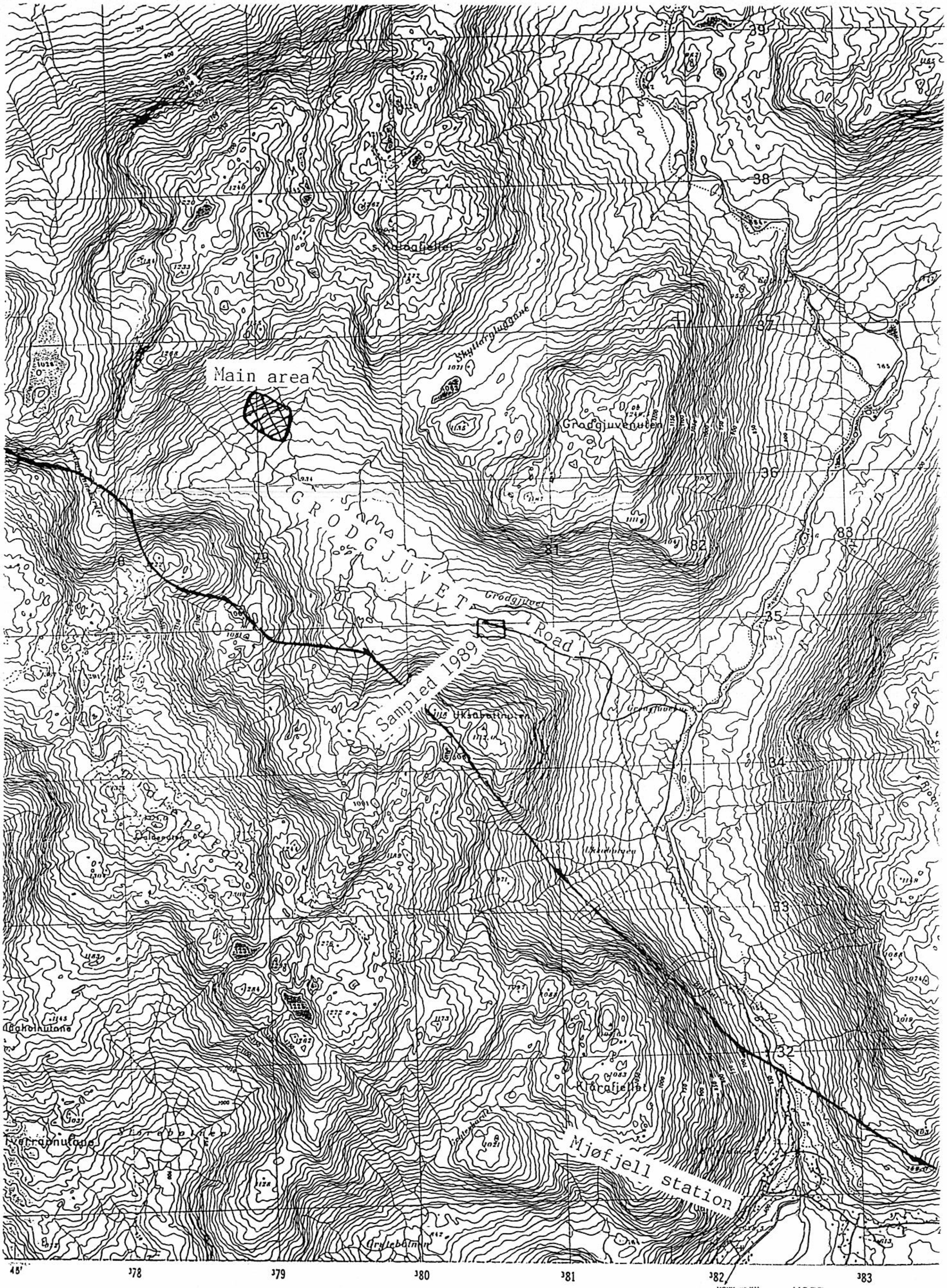

Fig. 4.1 The Mjølfjell - Grodgjuvet area. 1 : 30.000

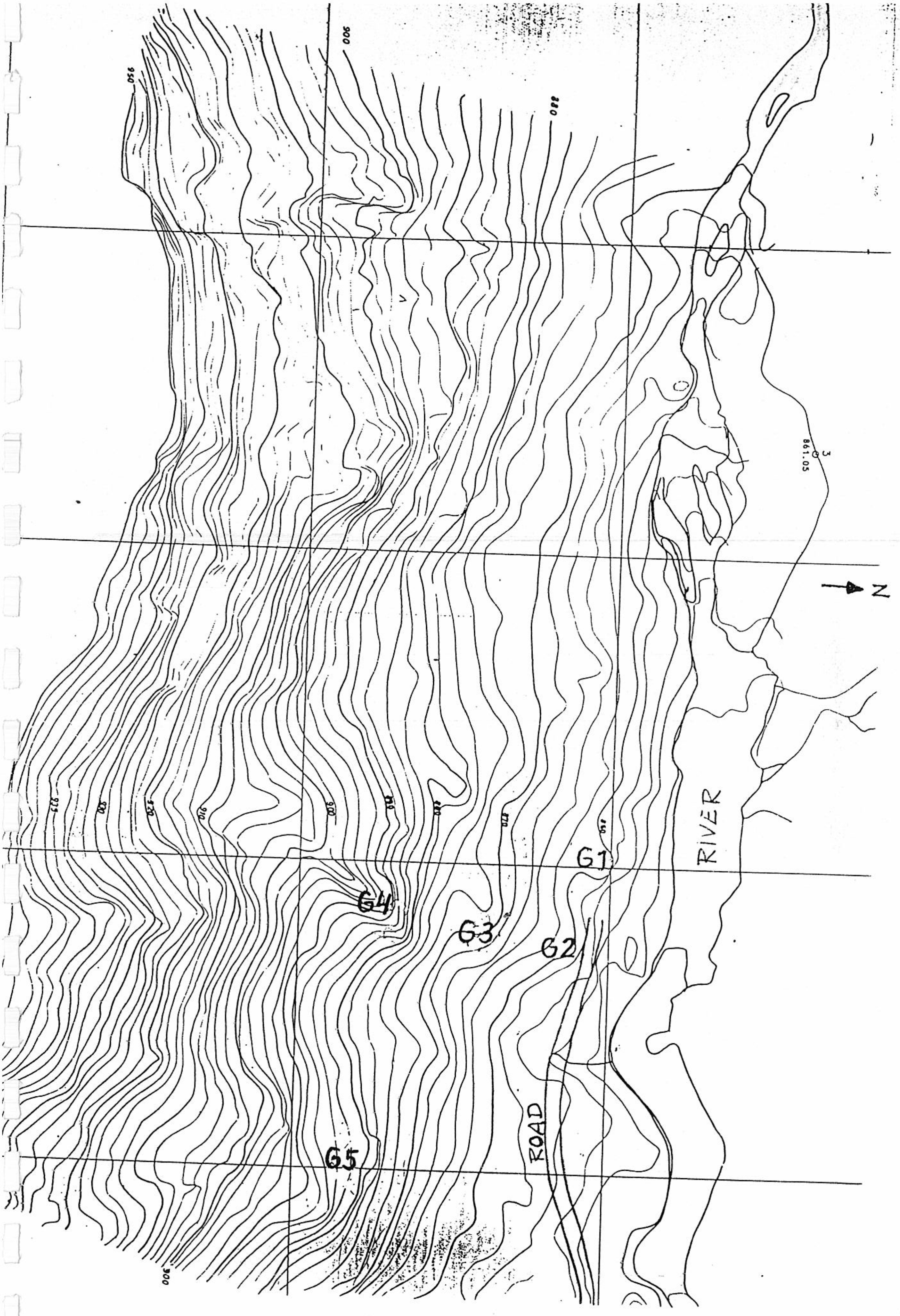

Fig 4.2. The sampled localities of the Lower Grodgjuvet area

1 : 3.300

Sample nr.	Tot. % leached	Al_2O_3 % Crude	Leached	Recovery	Fe_2O_3 % Crude	Leach.	Recov.	
G 1	44.2	30.80	94.2	29.0	0.83	52.9	0.44	G
G 2	45.1	30.69	96.2	29.5	0.95	52.0	0.49	R
G 3	44.8	31.14	96.0	29.9	0.72	50.9	0.37	O
G 4	44.4	31.32	93.4	29.3	1.06	60.1	0.64	D
G 5	44.8	30.36	95.2	28.9	0.63	48.3	0.30	G
Ø 1	42.6	30.44	92.9	28.3	1.34	58.9	0.79	Ø
Ø 2	43.9	30.45	95.7	29.1	1.47	59.9	0.88	V
Ø 3	43.2	30.07	93.7	28.2	1.27	58.9	0.75	S
Ø 4	43.7	30.62	95.0	29.1	0.82	64.3	0.53	T
Ø 5	44.8	31.13	95.5	29.7	0.71	65.0	0.46	H
Ø 6	44.9	30.97	96.3	29.8	1.05	58.0	0.61	U
Ø 7	44.5	30.75	95.6	29.4	1.03	62.3	0.64	S
Ø 8	42.8	30.37	92.8	28.2	1.10	57.4	0.63	
Ø 9	38.0	30.18	83.6	25.2	0.98	64.6	0.63	V
Ø10	38.5	30.18	84.4	25.5	0.67	64.2	0.43	A
Ø11	43.8	30.92	94.5	29.2	0.56	53.8	0.30	L
Ø12	44.9	30.70	95.9	29.4	1.29	65.0	0.84	L
Ø13	43.9	30.20	94.0	28.4	1.58	63.1	1.00	E
Ø14	36.8	29.39	80.6	23.7	1.15	67.0	0.77	Y
Ø15	43.2	31.87	91.1	29.0	0.68	55.7	0.38	
Ø16	34.6	30.47	75.5	22.9	0.66	53.4	0.35	
F-R68	35.0	30.77	74.3	22.9	0.63	56.7	0.36	
N	19.8	30.08	43.0	12.9	0.60	58.6	0.35	N
N.S.	14.3	30.36	25.4	7.7	0.63	48.3	0.30	Æ
N.K.	27.9	30.98	62.4	19.3	0.50	51.0	0.26	R
SUBB	15.3	29.40	27.9	8.2	1.46	49.5	0.72	Ø

Table 4.1 Chemical analyses of the samples collected in 1989.

4.2 The Øvsthus-valley.

In addition to the deposits in Grodgjuvet, Polymer wanted a second deposit in the more northern part of the massif. The two large deposits here Kaldafjell and Hylland, is situated somewhat too high, and the areas of the inbetween valley Øvsthus became interesting. See fig. 2.1. There has been no detailed mapping and sampling here earlier.

A rough survey and sampling of the most interesting part of the valley (for Polymer) was done.

This sampling has primarily taken place at a relatively higher altitude of the valley, since the lower parts have almost no outcrops of rock. Even along the river one has to go higher than 675m a.s.l. to find outcrops in the valley. The main sampled area this summer has an altitude of 800-900 m.a.s.l. Samples Ø1-Ø8. Map appendix 8.

Some samples taken at roadcuts above the Fyrde farm (Ø13-Ø16) indicates that the quality in this area close to the lowermost part of the valley is variable, with only some areas of good quality rock. The scarcity of outcrops here makes it impossible to map the quality variations without extensive diamond drilling, and although geographically interesting, detailed investigations in this area is not very relevant to undertake.

4.2.1 Anorthosite quality and contaminating zones.

The chemical analyses of the samples Ø1-Ø8 shows that this upper- and main part of the sampled areas has anorthosite with good quality (appendix 9). This correlates vith the visual observations in the field that showed mainly a fresh, coarse-grained anorthosite with variable but mostly acceptable contents of dark minerals.

It must be noted however that zones of gabbroic anorthosite and dikes of amphibolite occur in this area to a somewhat larger extent than in the main Grodgjuvet deposit and Kaldafjellet. These contaminating zones are very difficult to include representative in a sampling, and in the rough sampling undertaken this summer, they are not fully included. Thus the chemical analyses here give a somewhat better picture of the quality than the real average.

When it comes to actual mining of an area, some selective quarrying is possible, and the amount of such contaminating zones might not be critical.

Detailed mapping and sampling is needed to verify the qualities of the outcrops here. And diamond drilling is the only way to establish an actual picture of the third dimension - and even the continuity of the horizontal dimension at the surface, that today is partly concealed by overburden. Our experience in the former detailed investigations with diamond drilling actually showed that poorer quality feldspar of saussuritized shear-zones have a tendency to be eroded, and thus to lie under overburden.

4.2.2 Volume and tonnages.

At this stage of the investigations one can not say much about volumes, but the areas here in the middle and upper part of the Øvsthus valley seems mainly to have an easily dissolvable anorthosite. The restrictions when it comes to mining, is in case the zones of dark amphibolites and gabbroic anorthosites.

They might make selective quarrying nessecary, and probably to quarry in more than one area. The maximum required amount of anorthosite of 175 000 tons a year is however a big "bite", and if this production capasity has to be satisfied, mayby several areas in the middle and upper part of the valley must be quarried.

4.2.3 Potential areas in the Øvsthus-valley for pilot- and permanent production phase.

Polymer has recently concluded that Grodgjuvet is not very ideal as a mining site - partly as a consequence of the costs involved in establishing the necessary railroad transportation facilities at Mjølfjell. The areas in the Øvsthus-valley thus becomes an attractive altertative locality.

The overburden in the lower parts of the valley makes it difficult to get control of the anorthosite quality there without extensive diamond drilling. The lowermost areas in the valley with proper outcrops is therefore the natural locality for the initial phase production.

This lower area is represented by the samples Ø4-Ø6, which are taken at the southern side of the Øvsthus river as shown on appendix 8 and 10. We have here a fairly well-outcropped area of small ridges and brinks of anorthosite that topographically is relative well suited in a test production phase. The chemical analyses of the samples indicate a good quality, and the existing zones and dikes of gabbrioc rocks in this area is easy to avoid in a smaller production phase.

When it comes to the permanent production phase, the location of the mining area will be dependent on the size of the annual production volume. With large tonnages, selective mining is more difficult to handle, and probably more than one area in the valley must be mined. The areas here are not detailed mapped and sampled - and spesific sites can not be pinpointed at this stage. Most likely areas further up in the valley will be suitable, and maybe on both sides of the Øvsthus river. Appendix 10 shows the interesting areas for mining. In addition to mapping and sampling, a drilling program has to be undertaken to find the most suitable areas for a permanent production phase.

The annual mining tonnages are at this stage estimated with a minimum of 30.000 tons and a maximum of 175.000 tons. This equals a rock volume of 11.000 m3 to 65.000 m3, and an area of 5 to 30 acres of surface area if an average of some 2 meters depth is quarried each year.

The needed surface area will then be something between 50x100m and 300x100m. The size of these areas are indicated at the map of appendix 10.

4.3. Sampling by the main road Rv68 near Fyrde and in the Nærøy-valley

Looking for localities to supply an initial neeed of raw material, an anorthosite hill by the main road near the Fyrde farm was sampled. Although ideally situated the average solubility of Al2O3 is only 75.5%, which is probably a little too low. (Sample F-R68). Appendix 8 and 9.

As a part of the investigations this summer, the qualities of the anorhosite of the mining operations of the company Gudvangen Stein L/L in the Nærøy-valley was of interest. A sampling of the fine-grained waste material of the operations stored close by the road was done. This is named SUBB in the chemical analyses, and is proved to have a very low solubility -only 27.9% of the Al2O3. This product thus unfortunately seems unsuitable as a raw material for Polymer.

Likewise a sampling of the new "quarry" at the outside of the Glashammar was done. The sample N represents an average collection of the anorthosite varieties of the slope of blasted rocks. N.S. is a sample of completely saussuritized bands at the top of this quarry, and N.K. is from a seemingly fresher variety at the same site.

An average solubility of aluminium below 50% here, makes mining at this area less interesting.

5. COMMENTS ABOUT THE CHEMICAL ANALYSES.

The samples have been analysed with XRF (x-ray fluorescence), given at Appendix 1.

The crushed and pulverized samples have been leached for 2 hours in boiling 6N HCl. The amount leached is given in table 4.1 (total % leached). The residue is analysed with XRF, appendix 3. The amount leached Al and Fe is therefrom calculated, and is given in table 4.1, together with the calculated recovery (crude x leached).

In addition the solution is analysed with a plasmaspectrometer (ICAP) and appendix 4 gives the results, where the values of the various elements is given in weight % related to the crude material. Thus each elements solubility can be found when comparing with the values of the crude samples in appendix 1.

6. CONCLUSION.

The former investigations by Anortal guarantees that larger amounts of easily soluble anorthosite favourable in an acid process is present in the Gudvangen-Mjølfjell massif. The topographically best situated of the deposits that was investigated in detail by Anortal - Grodgjuvet - has a proven reserve of at least 2 mill. tons. This would supply the maximum production capacity for about 12 years. Beyond question, more reserves is present in this area of the massif, shown for instance by the small sampling done this year, and there should be no problems finding several million tons in adition in the Grodgjuvet area as a whole.

Localities for the wanted raw material in an initial test production was found this summer conveniently by the end of the military road.

However a second deposit area is wanted, and the sampling of the lower outcrops in the middle part of the Øvsthus-valley this summer, gave promising results. All the samples of the most relevant area here had good solubility (93-96% Al2O3, Ø1-Ø8). The content of contaminating elements from dark minerals in the samples also seems to be within an acceptable level.

The problem in this area, might however be occurences of gabbrioc dikes and zones that is present. These probably makes selective mining necessary to be able to supply the needed raw material for a larger production. Several areas within this middle and upper part of the valley might be necessary to quarry if production will be large.

Detailed investigations is of course needed to establish a solid picture of the quality variations and quantities in this valley. Based on the informations that we have today, one can however conclude that a second deposit area is available here in the Øvsthus-valley, and that even the larger production alternatives somehow should find the needed supplies here.

Trondheim febr. 22th 1990.

Jan Egil Wanvik
(senior geologist)

11-AUG-89 10:15

HOVEDELEMENTS ANALYSE MED GLØDETAP


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*  Resultater fra NGU'S XRF LAB. Instrument: Philips PW 1404  *
*  Prøvene er isoformert med LI2B407 i forholdet 1:7          *
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NGU BERGGRUNNSAVD.V/J.E.WANVIK
OPPDRAGSNR: 141/89 PROSJEKTNR: 23.2473.14

PR.NAVN	SiO2 %	Al2O3 %	Fe2O3 %	TiO2 %	MgO %	CaO %	Na2O %	K2O %	MnO %	P2O5 %	Gl.tap %	Sum %
G-1	49.31	30.80	0.83	0.10	0.47	14.45	2.93	0.19	0.01	0.03	0.57	99.69
G-2	48.59	30.69	0.95	0.09	0.60	14.44	2.88	0.17	0.01	0.02	0.56	99.00
G-3	49.06	31.14	0.72	0.10	0.49	14.66	2.76	0.11	0.01	0.03	0.57	99.64
G-4	48.25	31.32	1.06	0.12	0.58	14.79	2.74	0.14	0.02	0.03	1.01	100.06
N.S	48.36	30.36	0.63	0.08	0.33	14.34	3.12	0.19	<0.01	0.03	2.40	99.85
N.K	48.87	30.98	0.50	0.10	0.30	13.52	3.10	0.17	<0.01	0.02	1.98	99.55
N	48.96	30.08	0.60	0.08	0.37	13.77	3.32	0.21	<0.01	0.02	2.09	99.51
F-R-68	49.71	30.77	0.63	0.07	0.36	14.15	3.15	0.17	<0.01	0.02	0.52	99.55
SUBB	48.19	29.40	1.46	0.24	0.83	13.58	3.02	0.27	0.02	0.08	2.40	99.48
G-5	48.70	31.21	0.63	0.08	0.37	14.66	2.85	0.13	<0.01	0.03	1.38	100.06
Ø-1	49.90	30.44	1.34	0.14	0.85	14.07	3.13	0.19	0.02	0.03	0.56	100.65
Ø-2	50.50	30.45	1.47	0.22	0.95	14.05	3.07	0.16	0.02	0.03	0.53	101.46
Ø-3	49.10	30.07	1.27	0.13	0.85	13.77	3.18	0.17	0.02	0.03	0.58	99.17
Ø-4	49.08	30.62	0.82	0.11	0.54	14.22	3.20	0.15	0.01	0.03	0.68	99.47
Ø-5	49.89	31.13	0.71	0.12	0.42	14.36	3.13	0.13	0.01	0.03	0.43	100.36
Ø-6	49.25	30.97	1.05	0.15	0.63	14.52	2.95	0.13	0.02	0.03	0.41	100.10
Ø-7	49.19	30.75	1.03	0.12	0.66	14.17	3.13	0.12	0.01	0.02	0.60	99.82
Ø-8	49.15	30.37	1.10	0.15	0.64	14.09	3.03	0.14	0.02	0.03	0.52	99.25
Ø-9	48.65	30.18	0.98	0.14	0.56	13.61	3.23	0.28	0.01	0.02	1.13	98.80
Ø-10	49.54	30.18	0.67	0.10	0.35	13.87	3.27	0.19	0.01	0.03	0.79	99.01
Ø-11	48.89	30.92	0.56	0.09	0.31	14.36	3.15	0.11	<0.01	0.03	0.46	98.89
Ø-12	49.42	30.70	1.29	0.17	0.71	14.20	3.03	0.12	0.02	0.03	0.43	100.11
Ø-13	48.80	30.20	1.58	0.22	0.88	14.14	3.16	0.17	0.02	0.04	0.47	99.67
Ø-14	50.43	29.39	1.15	0.14	0.65	12.97	3.80	0.23	0.02	0.02	0.59	99.40
Ø-15	49.12	31.87	0.68	0.10	0.43	14.89	2.84	0.12	0.01	0.03	0.65	100.74
Ø-16	49.55	30.47	0.66	0.07	0.34	14.12	3.07	0.21	0.01	0.02	1.14	99.67

APPENDIX 1. Chemical analyses of the samples, by XRD.

Side 2 14.AUG 19

Prosjektnr: 23.2473.14 Oppdragsnr: 141/89

	G-1	G-2	G-3	G-4	G-5	F-R-68
Nb	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm
Zr	19.ppm	15.ppm	19.ppm	21.ppm	18.ppm	18.ppm
Y	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm
Sr	728.ppm	652.ppm	738.ppm	737.ppm	743.ppm	832.ppm
Rb	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm
Zn	11.ppm	11.ppm	11.ppm	12.ppm	10.ppm	9.ppm
Cu	10.ppm	10.ppm	10.ppm	< 5.ppm	7.ppm	6.ppm
Ni	< 5.ppm	7.ppm	< 5.ppm	6.ppm	< 5.ppm	< 5.ppm
Cr	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	13.ppm	< 5.ppm
V	13.ppm	8.ppm	8.ppm	10.ppm	7.ppm	7.ppm
Ba	102.ppm	83.ppm	92.ppm	80.ppm	103.ppm	126.ppm
Sn	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
Mo	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm
U	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
Th	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
Pb	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
Co	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm	< 5.ppm
Ce	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
La	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm	< 10.ppm
Sc	12.ppm	13.ppm	14.ppm	13.ppm	10.ppm	10.ppm

APPENDIX 2. XRF analyses of the trace elements on some samples.

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*    Resultater fra NGU's XRF LAB. Instrument:Philips PW 1404   *
*      Prøvene er isoformert med LI2B4O7 i forholdet 1:7        *
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OPPDRAG 181/89 FRA J.WANVIK PROSJ.NR.23.2474.14
LAVE SUMMER - MULIGENS P.G.A. FUKTIGHET I PRØVENE ?

PK.NAVN	SiO2 %	Al2O3 %	Fe2O3 %	TiO2 %	MgO %	CaO %	Na2O %	K2O %	MnO %	P2O5 %	SUM %
G-1	82.97	3.21	0.70	0.11	0.31	1.81	0.26	0.17	<0.01	<0.01	89.56
G-2	81.75	2.12	0.83	0.10	0.44	1.30	0.14	0.13	0.01	<0.01	86.82
G-3	82.01	2.23	0.64	0.15	0.37	1.31	0.18	0.11	<0.01	<0.01	87.01
G-4	80.54	3.69	0.76	0.14	0.27	2.07	0.36	0.14	0.01	<0.01	87.98
G-5	81.19	2.69	0.59	0.09	0.25	1.64	0.21	0.09	<0.01	<0.01	86.77
N.S	55.63	26.42	0.38	0.06	0.12	10.87	3.48	0.20	<0.01	0.02	97.18
N.K	60.78	22.63	0.34	0.07	0.12	8.62	3.24	0.24	<0.01	0.01	96.04
N	65.29	18.27	0.31	0.10	0.12	6.55	2.26	0.18	<0.01	0.01	93.10
F-R-68	72.84	12.17	0.42	0.09	0.12	4.87	1.58	0.20	<0.01	<0.01	92.31
SUBB	56.17	25.02	0.87	0.19	0.27	10.20	3.14	0.29	0.01	0.02	96.18
Ø-1	78.55	3.78	0.96	0.16	0.57	1.87	0.42	0.15	0.01	<0.01	86.49
Ø-2	81.09	2.35	1.05	0.24	0.66	1.42	0.24	0.09	0.01	<0.01	87.17
Ø-3	79.93	3.35	0.92	0.16	0.57	1.70	0.37	0.14	0.01	<0.01	87.17
Ø-4	81.54	3.29	0.52	0.12	0.27	1.69	0.32	0.16	<0.01	<0.01	87.92
Ø-5	83.49	2.00	0.45	0.15	0.28	1.03	0.19	0.11	<0.01	<0.01	87.71
Ø-6	80.26	2.07	0.80	0.17	0.45	1.06	0.20	0.08	0.01	<0.01	85.13
Ø-7	81.63	2.42	0.70	0.11	0.43	1.25	0.28	0.09	0.01	<0.01	86.93
Ø-8	80.23	3.84	0.82	0.16	0.46	1.91	0.43	0.12	0.01	<0.01	87.98
Ø-9	74.28	8.81	0.56	0.11	0.17	3.85	1.12	0.36	<0.01	0.01	89.28
Ø-10	75.51	7.65	0.39	0.08	0.14	3.34	1.10	0.22	<0.01	<0.01	88.43
Ø-11	81.31	3.03	0.46	0.11	0.18	1.55	0.28	0.11	<0.01	<0.01	87.04
Ø-12	81.72	2.30	0.82	0.18	0.46	1.21	0.21	0.09	0.01	<0.01	87.00
Ø-13	82.84	3.24	1.04	0.26	0.56	1.58	0.36	0.12	0.01	<0.01	90.02
Ø-14	73.39	9.00	0.60	0.17	0.30	3.08	1.95	0.16	<0.01	<0.01	88.65
Ø-15	80.00	4.99	0.53	0.16	0.20	2.57	0.40	0.14	<0.01	<0.01	89.00
Ø-16	72.10	11.41	0.47	0.10	0.15	4.94	1.21	0.28	<0.01	0.01	90.67

APPENDIX 3. Chemical analyses of the residuum after leaching.

Side 2 6.OCT 1989

Prosjektnr: 23.2473.14 Oppdragsnr: 141/89

	G1	G2	G3	G4	G5	F-R68	SUEB	Ø1	Ø2	Ø3
Si	274.8 ppm	341.1 ppm	309.6 ppm	336.3 ppm	209.9 ppm	219.3 ppm	787.0 ppm	280.1 ppm	326.4 ppm	253.8 ppm
Al	14.55 %	16.43 %	13.49 %	16.05 %	16.78 %	12.25 %	4.19 %	14.56 %	15.18 %	14.91 %
Fe	.29 %	.34 %	.20 %	.42 %	.22 %	.24 %	.48 %	.49 %	.54 %	.47 %
Ti	264.4 ppm	207.4 ppm	116.9 ppm	275.6 ppm	173.9 ppm	79.8 ppm	500.3 ppm	264.1 ppm	531.8 ppm	243.4 ppm
Mg	.16 %	.19 %	.11 %	.23 %	.12 %	.15 %	.34 %	.25 %	.28 %	.27 %
Ca	8.73 %	9.27 %	7.83 %	9.12 %	9.26 %	7.35 %	3.28 %	8.51 %	8.72 %	8.60 %
Na	2.12 %	2.19 %	1.74 %	1.93 %	2.13 %	1.56 %	.32 %	2.18 %	2.27 %	2.25 %
K	894.9 ppm	907.6 ppm	527.0 ppm	749.0 ppm	790.1 ppm	533.6 ppm	440.9 ppm	901.4 ppm	882.3 ppm	974.3 ppm
Mn	50.5 ppm	66.3 ppm	41.0 ppm	74.0 ppm	46.8 ppm	52.3 ppm	77.3 ppm	79.6 ppm	86.3 ppm	90.4 ppm
P	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	214.6 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm
Cu	3.2 ppm	3.4 ppm	4.4 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	16.5 ppm	6.5 ppm	13.0 ppm	11.3 ppm
Zn	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	3.8 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm
Pb	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm
Ni	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Co	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	13.5 ppm
V	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	10.8 ppm	< 6.3 ppm	9.6 ppm	< 6.3 ppm
Mo	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cd	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cr	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Ba	95.8 ppm	65.0 ppm	56.5 ppm	56.8 ppm	70.3 ppm	46.3 ppm	25.3 ppm	71.6 ppm	63.5 ppm	65.0 ppm
Sr	625.3 ppm	599.0 ppm	564.8 ppm	643.6 ppm	665.5 ppm	570.8 ppm	192.3 ppm	604.4 ppm	611.8 ppm	592.5 ppm
Zr	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm
Ag	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm
B	827.4 ppm	174.1 ppm	34.3 ppm	16.6 ppm	10.4 ppm	14.9 ppm	9.9 ppm	8.8 ppm	7.8 ppm	24.6 ppm
Be	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm
Li	4.3 ppm	3.0 ppm	3.0 ppm	3.0 ppm	3.4 ppm	< 2.5 ppm	< 2.5 ppm	2.9 ppm	< 2.5 ppm	3.8 ppm
Sc	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm
Ce	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm
La	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm

APPENDIX 4. Chemical analyses of the solution, after leaching.

Prosjektnr: 23.2473.14   Oppdragsnr: 141/89

	Ø4	Ø5	Ø6	Ø7	Ø8	Ø9	Ø10	Ø11	Ø12	Ø13
Si	227.1 ppm	263.0 ppm	140.0 ppm	<125.0 ppm	216.1 ppm	227.4 ppm	176.8 ppm	224.9 ppm	223.6 ppm	195.0 ppm
Al	15.61 %	15.98 %	14.60 %	12.60 %	15.71 %	12.84 %	13.33 %	16.05 %	15.35 %	15.10 %
Fe	.34 %	.30 %	.34 %	.33 %	.40 %	.40 %	.25 %	.21 %	.49 %	.64 %
Ti	287.8 ppm	245.4 ppm	288.5 ppm	299.9 ppm	418.2 ppm	494.9 ppm	365.9 ppm	190.9 ppm	448.4 ppm	459.5 ppm
Mg	.20 %	.13 %	.16 %	.18 %	.20 %	.25 %	.14 %	.10 %	.22 %	.30 %
Ca	8.99 %	9.19 %	8.32 %	7.28 %	9.02 %	7.47 %	7.82 %	9.11 %	8.75 %	8.85 %
Na	2.19 %	2.32 %	2.00 %	1.81 %	2.23 %	1.93 %	1.94 %	2.27 %	2.21 %	2.19 %
K	641.1 ppm	619.1 ppm	761.8 ppm	641.1 ppm	774.5 ppm	514.5 ppm	320.5 ppm	552.3 ppm	695.1 ppm	.10 %
Mn	65.8 ppm	63.4 ppm	72.6 ppm	62.6 ppm	84.2 ppm	72.0 ppm	52.9 ppm	44.5 ppm	90.6 ppm	118.4 ppm
P	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm
Cu	< 2.5 ppm	4.3 ppm	10.9 ppm	7.8 ppm	7.0 ppm	9.5 ppm	< 2.5 ppm	7.1 ppm	3.6 ppm	< 2.5 ppm
Zn	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	3.4 ppm	2.5 ppm	< 1.3 ppm	< 1.3 ppm	1.5 ppm	< 1.3 ppm
Pb	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm
Ni	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Co	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
V	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	6.8 ppm
Mo	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cd	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cr	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Ba	47.0 ppm	55.8 ppm	53.4 ppm	36.3 ppm	53.3 ppm	38.0 ppm	43.3 ppm	37.5 ppm	44.0 ppm	83.5 ppm
Sr	458.8 ppm	477.5 ppm	423.6 ppm	374.1 ppm	468.8 ppm	412.0 ppm	405.1 ppm	470.8 ppm	454.8 ppm	461.8 ppm
Zr	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm
Ag	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm
B	44.3 ppm	12.3 ppm	9.5 ppm	7.9 ppm	11.1 ppm	6.6 ppm	6.9 ppm	8.6 ppm	30.5 ppm	46.5 ppm
Be	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm
Li	3.4 ppm	2.9 ppm	3.0 ppm	< 2.5 ppm	3.8 ppm	3.8 ppm	3.0 ppm	2.5 ppm	3.0 ppm	2.9 ppm
Sc	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm
Ce	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm
La	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm

6.OCT 1989

Prosjektnr: 23.2473.14 Oppdragsnr: 141/89

	Ø14	Ø15	Ø16	N.S.	N.K.	N.
Si	167.8 ppm	151.5 ppm	355.5 ppm	382.5 ppm	185.1 ppm	456.3 ppm
Al	12.41 %	15.15 %	11.70 %	4.28 %	10.24 %	6.84 %
Fe	.48 %	.24 %	.21 %	.20 %	.17 %	.22 %
Ti	262.8 ppm	79.0 ppm	39.6 ppm	160.4 ppm	187.4 ppm	163.0 ppm
Mg	.24 %	.14 %	.13 %	.13 %	.11 %	.16 %
Ca	7.37 %	8.86 %	6.98 %	3.35 %	5.96 %	4.47 %
Na	1.88 %	1.92 %	1.65 %	.14 %	1.13 %	.64 %
K	.11 %	539.6 ppm	596.8 ppm	403.5 ppm	314.4 ppm	<312.5 ppm
Mn	92.3 ppm	50.6 ppm	43.1 ppm	30.1 ppm	31.6 ppm	34.6 ppm
P	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm	<125.0 ppm
Cu	< 2.5 ppm	< 2.5 ppm	3.9 ppm	< 2.5 ppm	< 2.5 ppm	2.8 ppm
Zn	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm
Pb	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm	<62.5 ppm
Ni	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Co	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
V	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm
Mo	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cd	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm
Cr	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm	<25.0 ppm
Ba	202.9 ppm	48.9 ppm	49.1 ppm	11.6 ppm	48.0 ppm	27.5 ppm
Sr	441.3 ppm	601.9 ppm	441.3 ppm	169.1 ppm	377.0 ppm	280.9 ppm
Zr	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm	< 3.8 ppm
Ag	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm	< 6.3 ppm
B	14.8 ppm	7.1 ppm	11.6 ppm	7.3 ppm	4.3 ppm	12.4 ppm
Be	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm	< 1.3 ppm
Li	< 2.5 ppm	3.0 ppm	3.0 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm
Sc	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm	< 2.5 ppm
Ce	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm	<37.5 ppm
La	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm	<12.5 ppm

APPENDIX 5

REWIEW OF GEOLOGICAL ASPECTS RELEVANT TO ORE QUALITY.

Anorthosite is per definition a plutonic rock with at least 90% plagioclase (a feldspar variety). The rest consists of different other minerals, mainly dark gabbroic minerals. Such pure anorthosite is not very common, on geological maps also anorthositic rocks with less than 35% dark minerals is often named anorthosite. The Gudvangen- Mjølfjell massif is though almost wholly anorthosite proper.

The quality of an anorthosite as a raw material for aluminium and aluminium-chemicals is proportional to the amount of extractable Al. Moreover, the content of contaminating elements are, of course, also of great importance.

The aluminium extracted in an acid processis, is however not in direct proportion to the contents of aluminium. The anorthosite will have to be dissolved in acids, and experiments shows that there is a close relationship between the composition and the solubility of the plagioclase.

The chemistry of the plagioclase may vary from albite (Na Al Si3 O8) through oligoclase, andesine, labradorite and bytownite to (An) anorthite (Ca Al2 Si2 O8).

Appendix 8 shows how the solubility in acids vary as a function of anorthite content. The graph shows a marked change at about An50, and it is clear that the plagioclase must have a content of at least 65-70% An to dissolve easily.

Consequently, this fact is of vital importance to the suitability of the different anorthosite varieties as a raw material for aluminium chemicals. The anorthosite from the Egersund-area for instance has An 40-50%, and is therefore unfit in a process baced on acid leaching. The deposits in Indre Sogn, however, have large areas with plagioclase rich in calcium, and in the Gudvangen-Mjølfjell massif a content of An at 70% or more is usual.

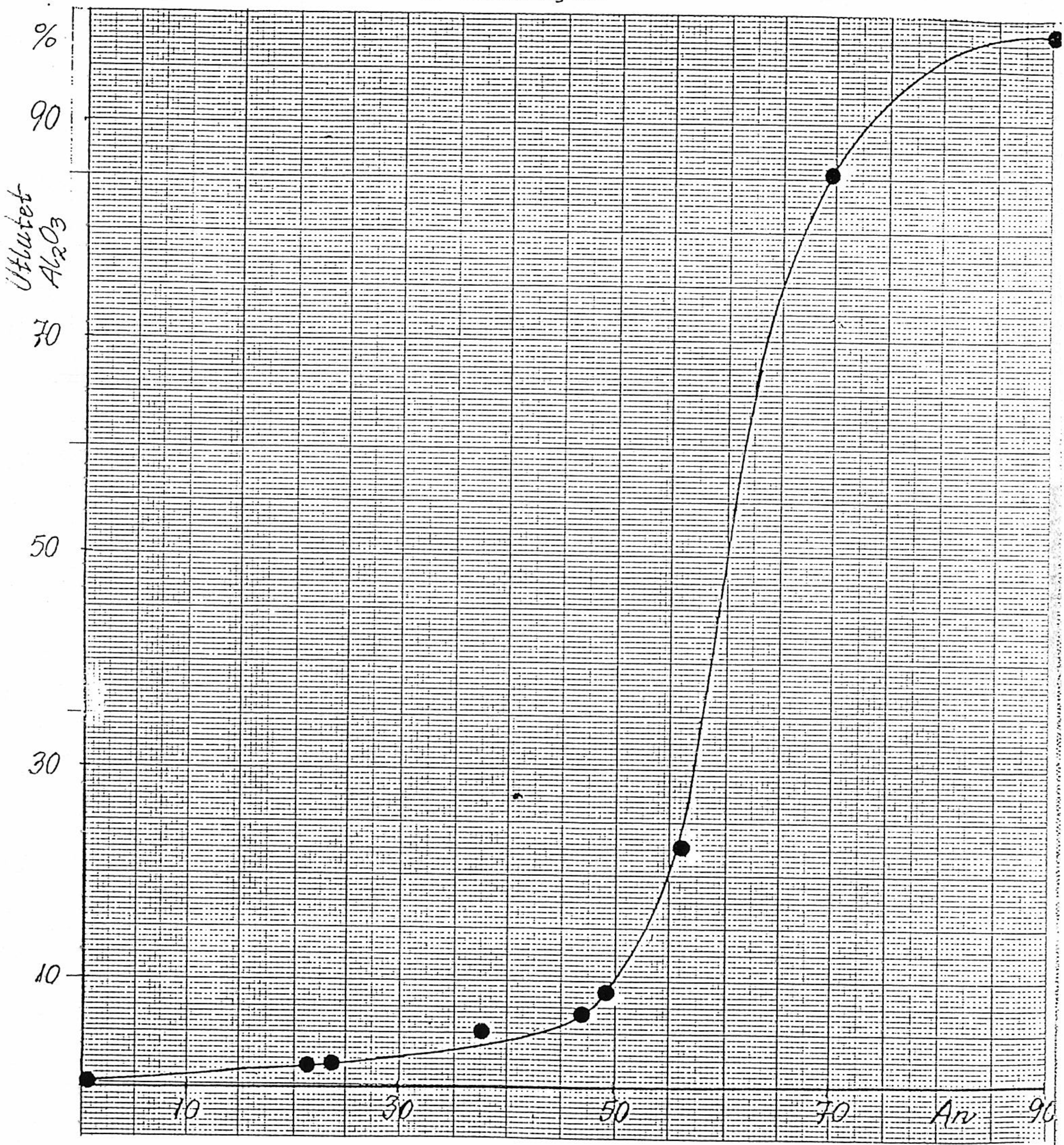
Some of the elements in the other minerals of the anorthosite will, however, also dissolve in the acid, and the amount of foreign elements tolerated in the product is limited. Due to the gabbroid dikes and spots and stripes of dark minerals in otherwise high quality anorthosite, only limited areas, even within the Gudvangen- Mjølfjell massif, are suitable as a raw material. This was especially the case for Anortal, but The Polymer product and process is fortunately not so demanding of the non-aluminum elements in the raw material.

Within the massif the anorthosite in larger areas has a fresh, coarse-grained plagioclase wich easily dissolves, and contains about 70% An. This primary anorthosite has however in zones been exposed to tectonics that has resulted in a transfotmation called saussuritization. The rim of the coarse grains then are partly granulized and smaller grains of lower An plagioclase and epidote- minerals is formed. On a weathered surface, thereby a honeycomb pattern is formed, with the smaller grain protruding as mm thick rims between the coarse grains.

At the first phase of the saussuritazion process the amount of lower An feldspar is small, and the solubility of the rock as a whole is not notably reduced. When saussuritization continues, however, as in shear zones, the amount of low An plagioclase increases, and the rock's solubility reduces. During this process, one observes the rims of the honeycombs getting thicker, and as saussuritization goes on, crosscutting veins of protruding low An feldspar becomes more and more frequent.

On unweathered surfaces, this saussuritization is not so easy to observe, but where the original feldspar har a darker color as brown or violet, one finds that the coarse primary grains is unchanged in colour, while the low-An grains inbetween has a light grey-white colour.

Fig. 11. Resultatet av utlutingen.



APPENDIX 6. Correlation between content of An and solubility.

APPENDIX 7.

DESCRIPTIONS OF THE SAMPLED LOCALITIES IN 1989.

It might first be noted that each of the localities below is analysed chemically by one sample that consists of a collection of small samples that as far as possible will be representative of the whole locality.

G1-G5. Grodgjuvet, by the end of the road.

G1. Small knob of rock where the road ends. Mainly very good coarse grained, fresh grey feldspar. Dark minerals 5% in average, as there are some bands with much biotite. Eastern part of the hill has stripes and bands of dark minerals, and has lower quality - should not be used as a raw material.
Total area 10x10m gives at least 1000 tons.

G2. Small hill with violet coarse-grained good anorthosite. About 5% dark minerals in spots. 10x4x1.5m, gives about 150 tons.

G3. Small brink with light violet coarse-grained fresh feldspar. About 3% dark minerals. 10x4x2m gives 200tons.

G4. Larger ridge (30.000 t) with coarse-grained, mostly fresh feldspar. Rather much dark mineerals, 7%.

G5. Large outcrop (100x100m) with fresh, light grey-violet feldspar. Dark minerals in large spots, about 5%.

Ø1-Ø16. Øvsthusdalen.

Ø1. Just above Fyrde's hut. Fine feldspar, partly darker brown, in variation with foliated anorthosite rich in dark minerals. The sample is taken from the good variety with about 7% dark minerals.

Ø2. South of the hut and the river. Coarse-grained, brown anorthosite. Rather rich in dark minerals, about 7%. Some larger spots with corona-structure, and the dark minerals is may be a little to scarcely represented in the samples.

Ø3. South-west of the hut. Mainly fine brown feldspar. It must be noted that there are some gabbroid areas inbetween that are not included in the sampling. The fine anorthosite has about 7% dark minerals.

Ø4. Mostly brown, fresh feldspar, but also some areas with grey-white, somewhat saussuritized plagioclase. About 5% dark minerals, but some zones are more gabbroid.

Ø5. Good anorthosite, partly brown feldspar, but mostly white-grey. About 5% dark minerals, but some gabbroic dikes.

Ø6. Light whitish, somewhat unfresh. Gneissic and striped.

Ø7. Somewhat gneissic. Mainly grey-white, only here and there some relicts of brown feldspar. Probably relative good though. Some zones with narrow veins with gabbroic rocks is not included in the samples. About 7% dark minerals.

Ø8. Mainly somewhat gneissic anorthosite, about 7% dark minerals. A few zones of gabbroic anorthosite.

Ø9. Rather gneissic. Some saussuritization is evident, but the feldspar is not totally reduced. About 7% dark minerals. Some narrow gabbroid dikes.

Ø10. Rather gneissic. The rock is grey- white- greenish. Rather non-transparent. Thin dikes of gabbroic dikes is present. About 5% dark minerals.

Ø11. Rather gneissic, but seems to be slightly better than Ø10.

Ø12. Relatively fresh, brownish feldspar. About 5% dark minerals. Samples taken from outcrops by the river.

Ø13–Ø16. Roadcuts above the Fyrde farm.

Ø13. Anorthosite where the feldspar grains has a violet cores with lighter grey rims and matrix. The cliff here is steep.

Ø14. Light grey-white anorthosite that is mainly non-transparent. Represents the level just below Ø13. Layers with rather many dark minerals.

Ø15. Looks rather saussuritized, with mainly non-transparent feldspar.

Ø16. Outcrop (probably), not roadcut. Honeycomb surface-texture indicates a partial saussuritization.

Hill by main road 68 near Fyrde.

F-R68. The weathered outcrops here shows typical honeycomb-pattern similar to that observed at Ø16, with marked protruding grain rims, indicating a partial saussuritization. Even though the grain-cores have a light violet color, the chemical analyses shows a rather low solubility, almost identical to Ø16.

Samples from the mining operations in the Nærøy-valley.

N. Average sample from the blasted material of the outside of the Glashammaren. The sample collection consists of both totally saussuritized and seemingly rather fresh anorthosite.

N.K. From the top of the Glashammar "quarry", representing the apparently relative fresh, grey-violet variety occuring there.

N.S. Same locality as N.S., but this is a sample of the visuallly completely saussuritized bands of the Glashammar.

SUBB A collected sample of the fine-grained waste from the mining operation, deponated close by the main road.

APPENDIX 8

NGU - A/S POLYMER
SAMPLED LOCALITIES
ØVSTHUS-VALLEY AREA
VOSS KOMMUNE, HORDALAND FYLKE

MÅLESTOKK		
1:10 000	MÅLT	
	TEGN.	JEW '89
	TRAC.	T.G.S. FEB.'90
	KFR.	

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

TEGNING NR.	KARTBLAD NR.
89 134-01	1316 I

APPENDIX 9

NGU- A/S POLYMER SOLUBILITY OF Al_2O_3 OF THE **FYRDE - ØVSTHUS** SAMPLES VOSS KOMMUNE, HORDALAND FYLKE	MÅLESTOKK 1:10 000	MÅLT TEGN. JEW '89 TRAC. TGS FEB '90 KFR.
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 89 134-02	KARTBLAD NR. 1316 I

APPENDIX 10

NGU–A/S POLYMER RELEVANT AREAS FOR ANORTHOSITE MINING IN THE **ØVSTHUS VALLEY** VOSS KOMMUNE, HORDALAND FYLKE	MÅLESTOKK 1:10 000	MÅLT TEGN. JEW '89 TRAC. TGS FEB '90 KFR.
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 89.134-03	KARTBLAD NR. 1316 I