AN OCCURRENCE OF NATURALLY LEAD-POISONED SOIL AT KASTAD NEAR GJØVIK, NORWAY

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Abstract.

A 100 m^2 area with exceptionally sparse vegetation in the forest at Kastad, 6.5 km north of Gjøvik, Norway, is described. The area bears no signs of human activity. Determination of heavy metals in the soils of the area shows no really abnormal contents of V, Mn, Co, Ni, Cu, Mo, Ag, and Zn, but a mean concentration of 4.7 % Pb in top soil dry matter. There is a clear correlation between sparsity of vegetation and lead content in the soil, and it has been concluded that the area is lead poisoned.

Most plants normally growing in the area were not found on the lead-rich soils, although some registered species can tolerate considerable lead in the substratum. The vegetation growing on the lead rich soil has an abnormally high lead content, and might therefore have an injurious effect on fauna.

It is presumed that the lead in the soil is accumulated from natural solutions produced during chemical weathering of a galena-bearing quartzite. Registration of areas with sparse or selective vegetation might be used as a tool in lead prospecting.

Introduction.

Nearly ten years ago a program was established in Norway by the National Forest Survey, the Agricultural College, and the Geological Survey involving the investigation of forest soils for the combined purpose of general soil research and geochemical prospecting (Låg 1962, p. 111). In conjunction with its normal inventory work the Forest Survey has collected humus samples from systematically distributed plots in Nord-Trøndelag, Oppland, and Buskerud. These humus samples

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have been analysed chemically and spectrographically at the Agricultural College and the Geological Survey.

In addition to this regional work detailed investigations have been carried out, especially of methodological character. One such investigation includes a closer study of an approximately 0,1 km^2 tract in the Gjøvik district, where lead anomalies occur in the humus (Hvatum 1965). The presence of lead mineralization in the bedrock had earlier been reported (e.g. Føyn 1954, and Eriksen 1962). During a reconnaissance by the present authors on the 18th of August 1967 we observed a small, stony, barren area where sparsity of vegetation led us to suspect the presence of poisoned soil. Chemical analyses of soil and vegetation samples showed this to be the case.

Description of the area.

This stony, barren area lies in generally forested terrain on the Kastad farm (owned by Sverre Braastad) in Gjøvik township, ca. 6.5 km north of the town Gjøvik (Fig. 1). The area is fan-shaped with irregular borders, ca. 20 m long and up to 10 m wide, thus covering approximately

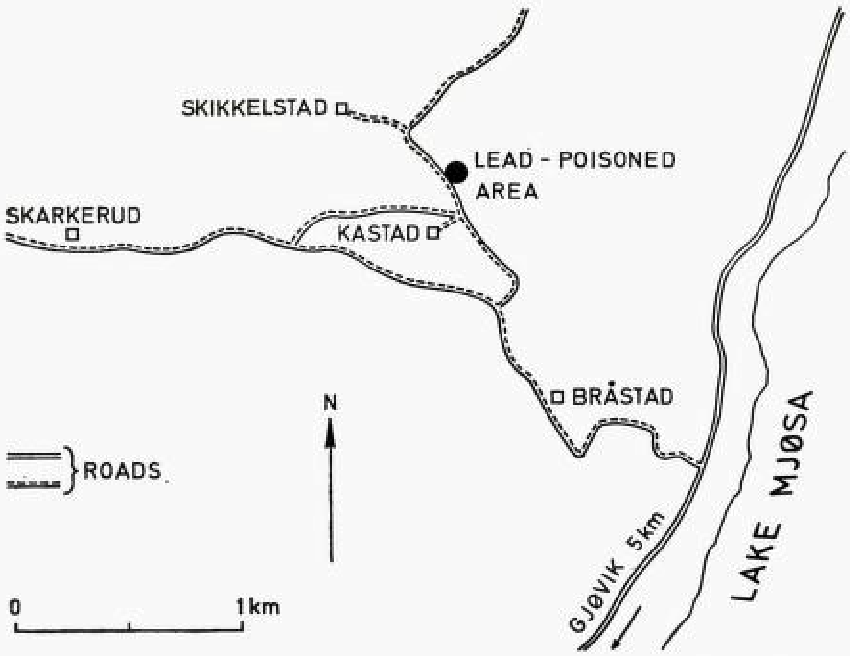

Fig. 1. Location of a lead poisoned, barren area at Kastad, near Gjøvik, Norway.

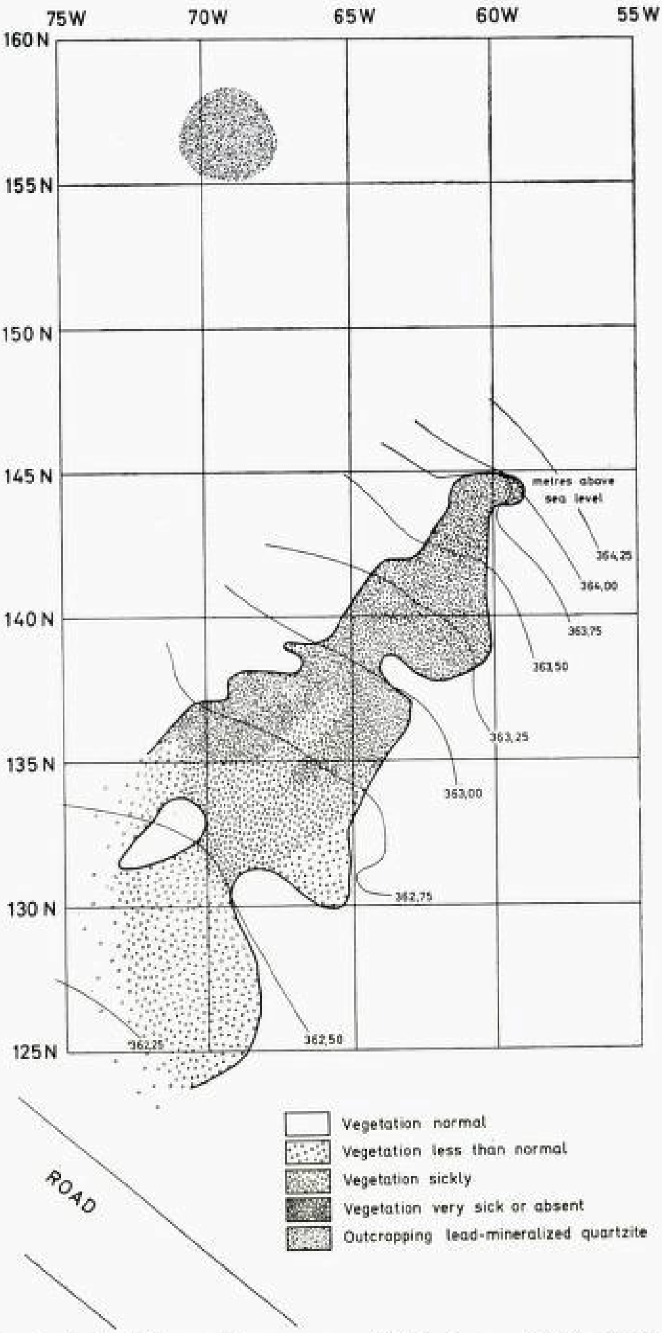

Fig. 2. A lead poisoned, barren area at Kastad, near Gjøvik, Norway.

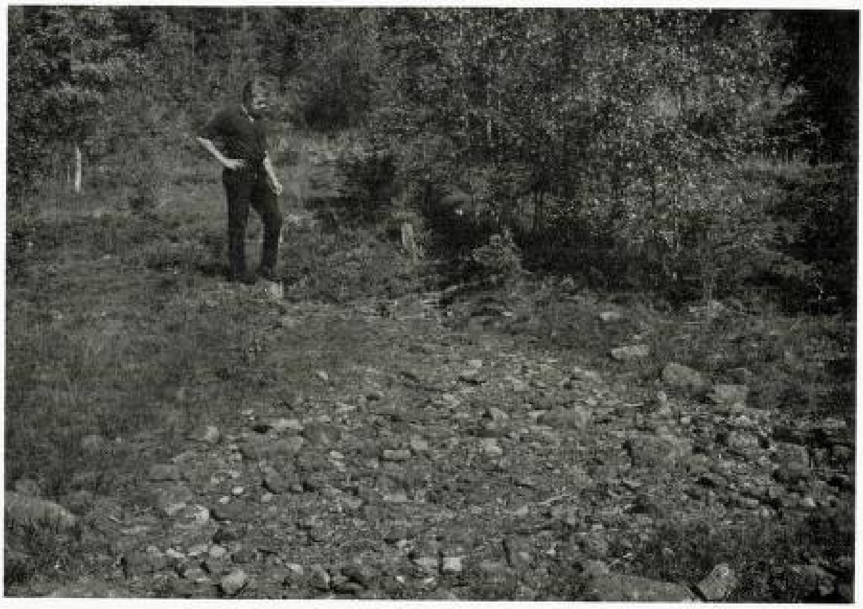

Fig. 3. A lead poisoned, barren area at Kastad, near Gjøvik, Norway.

100 m^2. It forms a slight depression in a weakly sloping field, which rises a little more abruptly NE of the narrow end of the fan (Fig. 2). As the soil between the surface stones bears little or no vegetation, the area appears in summer as a stony, dark patch in the normal green environment (Fig. 3).

Geologically the area belongs to the southeast edge of the Caledonian mountain chain. Cambro-Silurian sediments resting on the Sub-Cambrian peneplain have been overthrust during the Caledonian orogeny by Eo-Cambrian and Cambro-Silurian rocks, producing an imbricate structure with beds of varying composition and age (Skjeseth 1963). Lead mineralization occurs as finely distributed galena with accessory sphalerite and pyrite predominantly in Eo-Cambrian quartzites (e.g. Bjørlykke 1967, with bibliography). Similar mineralization is exploited in Sweden and described among others by Grip (1960, 1967).

Fine sandy morainic material in the order of a meter or so covers much of the bedrock in the Kastad district. The soils surrounding the small barren area of study have podzol profiles. Within the area higher vegetation is patchy, scant or absent. Where the vegetation is scant, weak podzolization with 0—5 cm of bleached horizon occurs. Where vegetation is absent, no real soil development is found. Iron precipitation is weak in the area's narrowest portion (144 N — 61 W), while in the middle of the area (139 N — 64 W) it extends to a depth of ca. 50 cm, and in the widest portion (129 N — 70 W) somewhat deeper. The humus layer varies in thickness from one to six centimeters.

Investigation of the soil.

Within the investigated 1 km^2 tract 90 soil samples were taken in 1966—67 from plots spaced at intervals of 50 m E-W and 25 m N-S. The sampling was carried out in conformity with the procedure used by the Forest Survey (Låg 1968, p. 337). At each plot ten sub-samples were taken within a circular radius of 5.64 m and combined into one sample for analysis.

In 1967 soil samples from the barren area were collected from 35 points at 1—2 m intervals. At each point two samples were taken, one at a depth of 2—4 cm, the other at 5—20 cm. In 1968 three additional samples were taken at a depth of 50 cm (Fig. 4, points B, C, and D). All samples were analysed chemically and spectrographically, and the results are presented in Figures 4 and 5, and in Table 1, 2, and 3.

Investigation of the vegetation.

A study of the distribution of vegetation in a number of 100 m^2 areas within the 1 km^2 tract was made in the summer of 1966. Registrations of the main plant species were made by two students, Kjell Ivar Flatberg and Asbjørn Moen. The plant species found in one such area lying 30 m north of the barren area are listed in Table 4. In the autumn of 1967 samples were taken of the vegetation of the barren area and grouped according to degree of apparent health. Where sufficient substance was available, the samples were analysed chemically (Table 3). Vegetation samples from the barren area were also collected in the autumn of 1968. Determination of the occurring species was made by Professor Eilif Dahl of the Agricultural College of Norway (Table 4).

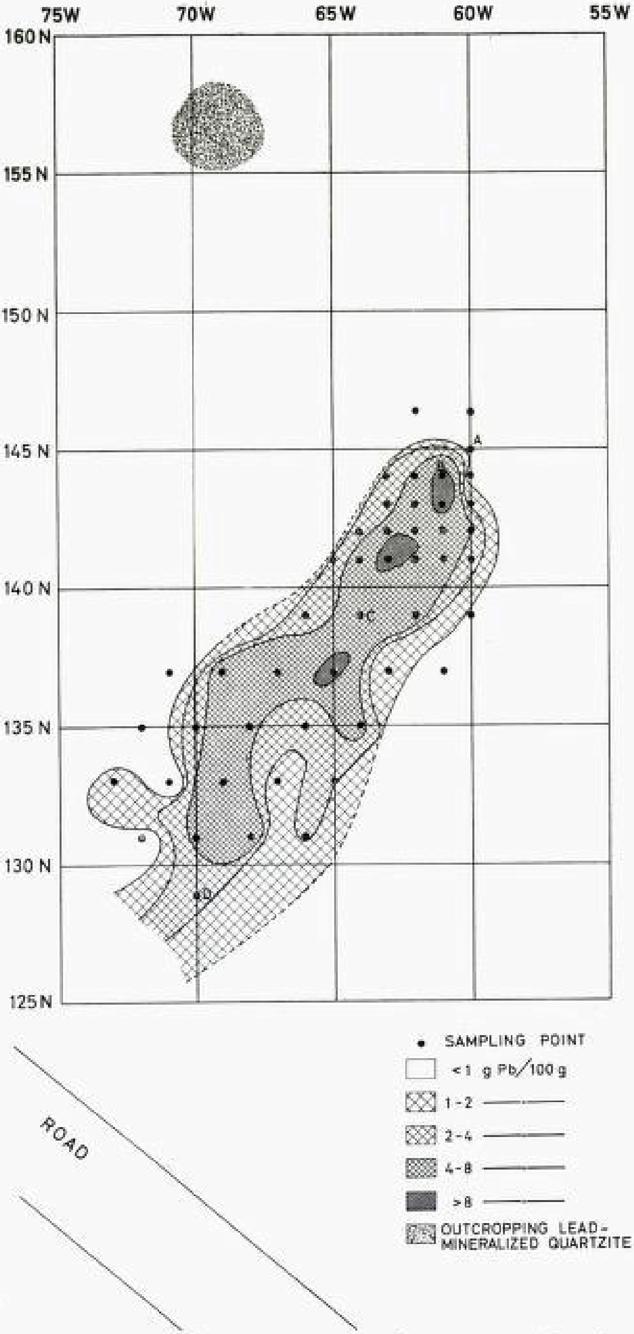

Fig. 4. Lead in top soil (depth: 2—4 cm) in a barren area at Kastad, near Gjøvik, Norway.

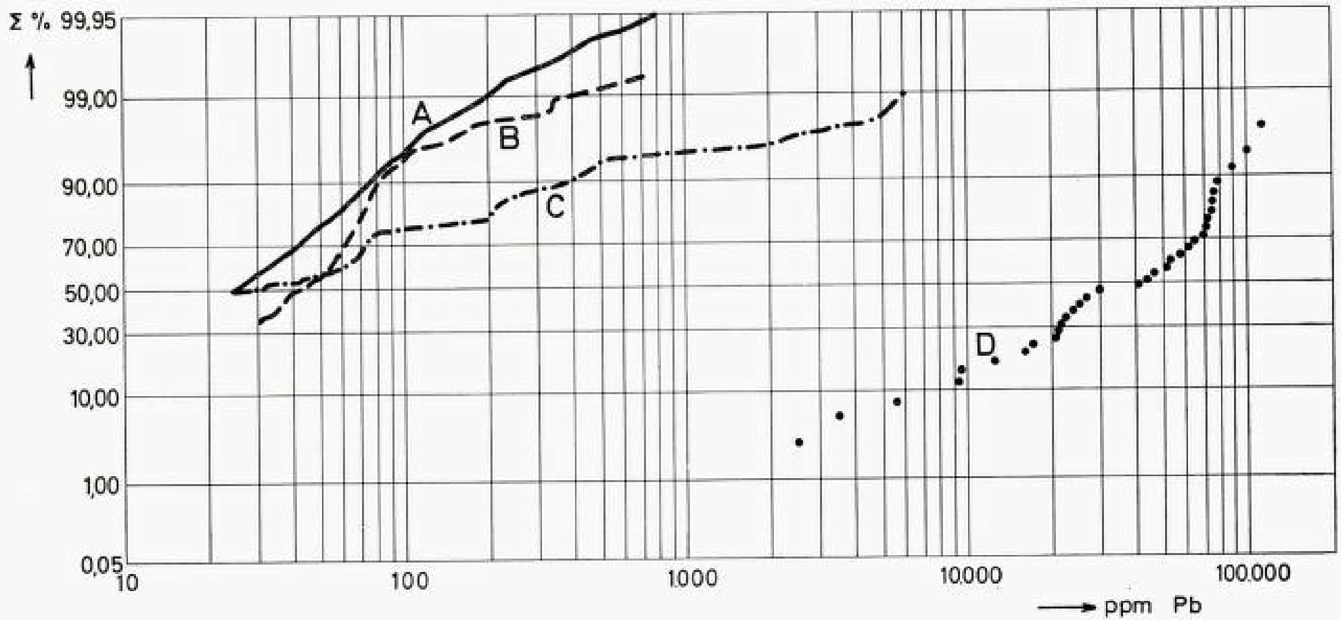

Fig. 5. Frequency distribution of total lead in top soil (mainly raw humus).

A. 2086 samples from Oppland county, Norway (40 000 km²).

B. 168 samples from Vardal, Oppland county (100 km²).

C. 90 samples from Kastad, Vardal (0.1 km²).

D. 35 samples from a barren, lead poisoned area at Kastad (100 m²).

Analytical methods.

All samples were first dried in warm air (ca. 80°C). The soil samples were then screened using 2 mm aluminium sieves, and 10 g of each fine fraction was ashed at 430°C. The vegetation samples were similarly ashed whole.

After pulverization in an alumina mill, the ash was analysed semi-quantitatively for V, Mn, Co, Ni, Cu, Mo, Ag, and Pb by optical spectrography (arc excitation of the ash mixed with carbon, visual evaluation of the spectra). The metal content in the ash is given in ppm using the concentration scale 1, 3, 10, 30, 100 etc.

Zn was determined directly in the ash by X-ray fluorescence. In addition all samples from the barren area which gave Pb-values higher than 30 ppm were re-analysed by X-ray fluorescence using Bi as reference element.

pH was determined by glass electrode in soil-water suspensions of unashed samples, the ratio soil/water being 1/2.5.

Discussion.

The frequency distribution of Pb in the top soil (35 samples) of the barren area is compared in Figure 5 with the distribution of Pb in the soils of the surrounding district. The soil samples from the barren area have a lead content which is a) ca. 1600 times as high as that of systematically collected soil samples from Oppland and Buskerud, and b) ca. 1000 times as high as that of the soil samples from the 1 km^2 tract surrounding the barren area.

The total content of lead in the upper 25 cm of the soil over the 100 m^2 barren area is at least one ton. There are no signs of human activity which might account for this. High natural lead content in soils, up to 20 000 ppm, occurring under similar geological conditions has been reported by Brotzen (1967, p. 211).

It appears that the Cu and Ni contents in the soil samples while varying but slightly, show a positive correlation to Pb (Table 1). The concentrations of Cu and Ni, as well as V, Mn, Co, and Ag are not abnormal (e.g. Mitchell 1955, pp. 262–263; Vinogradov 1959; Hawkes and Webb 1962, pp. 363–377; Hvatum 1963; Bølviken 1967, p. 230).

Table 3 shows a clear relationship between the health of the vegetation and the lead content of the substratum. It can therefore be concluded that the sparsity and effected state of the vegetation in the area is a consequence of lead poisoning.

Poisoning of vegetation due to high lead content in soil has been observed elsewhere (e.g. Mudge et al. 1968, p. 28).

As seen in table 5 only two species, *Deschampsia flexuosa* and *Cladonia chlorophaea*, occur in all health classes, regardless of the Pb content of the soil. The species *Betula pubescens*, *Picea abies*, *Pteridium aquilinum*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Agrostis tenuis*, *Polytrichum juniperinum*, and *Webera nutans* together with various *Bryophyta* species can also tolerate a wide range of lead concentrations in substratum. *Agrostis tenuis* and some other grasses have previously been reported as tolerant of high lead concentrations, the tolerance probably being genetically controlled. (Bradshaw 1952; Gregory and Bradshaw 1965; Jowett 1958, 1959, 1964; Wilkins 1957, 1960). Under the present conditions the following species seem to be especially competitive on lead rich soil (Pb > 1 per cent): *Linnaea borealis*, *Agrostis sp.*, *Cladonia coccifera v.pl.*, *C. deformis*, *C. mitis*, *C. ochrochlora*, *C. verticillata*, *C. pyxidata* and other species of *Cladonia*, as well as *Peltigera aphthosa* and various green and bluegreen algaes.

It is well known that lead is poisonous for animals and human beings, even in rather small concentrations. According to Bersin (1963, p. 417) dry plant material used as fodder normally contains 0.1—1 ppm Pb, however plants growing on lead rich soil may contain ten times as much or more.

Our investigation (Table 3) shows that apparently normal vegetation from the poisonous area has a lead content in dry matter in the order of 1000 ppm, and sickly vegetation 3000 ppm (maximum 9000 ppm). Evidently such concentrations of lead must also affect the fauna.

According to table 3 the ash content of the vegetation samples is 5—10 per cent, indicating that the plant material analysed is contaminated by soil. The vegetation itself might therefore contain less lead than shown in the table. However, this does not alter the general conclusions drawn. The plant material eaten by animals must also to some extent be contaminated by soil.

It is of interest to note that natural local concentrations of lead in soil and plants can far surpass that caused by artificial contamination shown by Rühling and Tyler (1968).

The manner in which the lead is bound in the soil of this area has not yet been established. However, the following observations have been made:

a) An attempt to identify lead minerals in the two richest samples (ca. 11 % Pb) under the binocular or by X-ray diffraction on untreated material was not successful. The predominance of the lead probably does not exist in crystalline form.
b) Tests indicate that the lead content in the soil samples is highest in the finest fractions. Till samples separated by heavy liquid (sp.wt. 2.8) showed similar lead content in the light fraction as in the heavy fraction. It seems probable therefore that the lead in the samples is at least in part bound to the surface of soil particles.
c) During ashing of litter from the samples richest in lead it was possible to see small beads of lead being «sweated out». A considerable amount of the lead must be bound to organic matter.

The vertical distribution of lead and pH in the soil of the barren area (Table 2) discredits an upward transport of lead as a dominating mechanism for the enrichment of lead near the surface.

A 5 m^2 outcrop of lead-mineralized quartzite occurs approximately 15 m from the upper end of the poisoned area. (Similar mineralization perhaps also occur over a larger area). Lead is thought to be leached out of the galena-bearing quartzite and transported through the soil in hydrous solution. During wet periods some of this water emerges in the upper portion of the fan (pt A, Fig. 4). Upon reaching the surface the solution loses lead to the soil. The lead accumulates in the soil, which becomes increasingly toxic to the vegetation. As the toxic soil impedes the normal growth of vegetation, the area becomes less protected from erosion. A slight depression is formed, which tends to channel the drainage, causing an increase in the poisoning effect. It is likely that the position, shape, and size of the poisoned area has varied somewhat during postglacial time. Among other factors variations in climatic condition may have led to changes in the degree of poisoning. However, one must assume that the effects of lead poisoning have characterized the area throughout the postglacial period.

Conclusion.

Investigation of these phases of lead geochemistry will be continued. Upon the bases of the work done, however, it seems possible to draw the following tentative conclusions:

a) Lead minerals in quartzite (mainly galena) are decomposed by chemical weathering. The products enter into hydrous solution and are transported away.
b) From this solution lead is reprecipitated in the soil, mainly in the upper humusrich layer. In the course of postglacial time (less than 10 000 years) concentrations in the order of up to 10 % Pb have accumulated in the soil.
c) Such concentration of lead in the soil has resulted in a poisoning of the vegetation. There is a great variance in the ability of different plants to tolerate high lead concentrations.
d) Since lead is toxic to many animal organisms, even in small amounts, such concentrations as found in this case may have an injurious effect on fauna.
e) Localization of areas with a conspicuous sparse or selective distribution of plant species may be of assistance in prospecting for lead ores.

Sammendrag.

En forekomst av blyforgiftet naturlig jordsmonn i Vardal.

I skogen ved Kastad i Vardal, ca. 6,5 km nord for Gjøvik by, er det funnet et nesten vegetasjonsfritt felt på ca. 100 m^2. Feltet er uten synlige tegn på kunstige inngrep. Like i nærheten finnes i fast fjell en blotning av kvartsitt med finfordelt blyglans. Blymineraliseringen hører til fjellkjederandens forekomster. Liknende mineralisering er utnyttet økonomisk i Sverige (Laisvall og Vassbo).

En mistanke om at den sparsomme vegetasjon skyldes naturlig blyforgiftning, ble bekreftet ved kjemiske analyser av jord og vegetasjonsprøver. 35 jordprøver fra rotsonen (5—20 cm dybde) hadde et gjennomsnittsinnhold på 2,4 % Pb, og 35 prøver fra de øverste jordlag (2—4 cm dybde) et gjennomsnittsinnhold på 4,7 % Pb med maksimalinnhold i enkeltprøver på over 10 %. De andre elementer det ble analysert på (V, Mn, Co, Ni, Cu, Mo, Ag, Zn), viste konsentrasjoner som ikke avviker særlig fra normalverdier for jordprøver. Fordelingen av Pb og pH i jordsmonnet tilsier at oppkonsentreringen av bly i de øverste jordlag ikke kan skyldes transport oppover i profilet. Sannsynligvis er blyet blitt frigjort fra den nærliggende blyholdige kvartsitt ved kjemisk forvitring, og deretter i fuktige perioder transportert i vannoppløsning til jordoverflaten i feltets øvre parti (se fig. 2), der det er blitt avgitt, særlig til det humus-holdige sjikt. Blyet er akkumulert i jordsmonnet, som etter hvert har fått så høyt innhold at det er blitt giftig for vegetasjonen.

Vegetasjonsprøver fra det forgiftede feltet viste et gjennomsnittlig blyinnhold på 0,22 % med maksimalt innhold i enkelte prøver på 0,9 %. Blyinnholdet i plantene økte i takt med blyinnholdet i det jordsmonn plantene vokste på.

Planteartenes evne til å tåle høye blykonsentrasjoner i jordsmonnet varierer sterkt. To arter, smyle (*Deschampsia flexuosa*) og laven *Cladonia chlorophaea* ble funnet på selv de mest blyrike deler av det forgiftede feltet, foruten under mer normale forhold i nærheten. I alt 19 arter ble påvist på jord med mer enn 2 % bly i rotsonen, mens det under tilsynelatende normale forhold på tilgrensede felter ble påvist 63 arter.

Undersøkelser over prosesser som fører til opphoping av bly i jordsmonn og vegetasjon vil bli fortsatt. Foreløpig er det konkludert med følgende:

a) Krystallinske blyforbindelser i kvartsitter (vesentlig blyglans) nedbrytes kjemisk og forvitringsproduktene transporteres bort i vandig løsning.

b) Fra den naturlige blyløsning er blyet avsatt i jordsmonnet, i størst mengde i det øverste humusholdige sjiktet. I løpet av postglacial tid (mindre enn 10 000 år) er det blitt anriket bly i jordsmonn til konsentrasjoner opp til størrelsesorden 10 %.

c) Naturlige, sekundære blyanrikninger i jordsmonnet har ført til forgiftning av vegetasjonen. Det er stor forskjell på ulike planters evne til å tåle store blykonsentrasjoner.

d) Da bly er giftig for dyreorganismer, selv i små mengder, må konsentrasjoner som påvist i dette tilfelle ventes å ha sterk innflytelse på den stedlige fauna.

e) Lokalisering av vegetasjonsfrie felter og felter med spesielt selektert vegetasjon kan brukes som hjelpemidler ved leting etter blymalm.

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Table 1

Heavy metals in dry matter of soil from a barren area at Kastad near Gjøvik, Norway.

		Ash %	V ppm	Mn ppm	Co ppm	Ni ppm	Cu ppm	Mo ppm	Ag ppm	Pb %	Zn ppm
Depth 2—4 cm	m	50.2	19	177	4	4	51	0.8	<3	4.7	163
n = 35	s	13.0	8	86	2	2	58	0.9		3.3	75
Depth 5—20 cm	m	91.6	39	340	7	4	35	1.0	<3	2.4	355
n = 35	s	3.2	14	225	4	2	24	0.7		1.2	138

m: Arithmetic mean $\Sigma\frac{x}{n}$; s: Standard deviation $\sqrt{\frac{\Sigma (x-m)^2}{n-1}}$

Table 2

Lead content and pH of soil dry matter from different depths in a barren area at Kastad, near Gjøvik, Norway. Sample location shown in fig. 4.

Sample location			cm depth	% ash	% Pb	pH
145 N	60 W	(A)	2—4	65.8	0.3	4.5
145 N	60 W	(A)	5—20	91.8	0.7	5.0
144 N	61 W	(B)	2—4	46.6	11.6	5.4
144 N	61 W	(B)	5—20	83.2	4.4	5.5
144 N	61 W	(B)	50	96.1	1.8	5.3
139 N	64 W	(C)	2—4	62.4	6.7	5.6
139 N	64 W	(C)	5—10	90.8	3.8	5.6
139 N	64 W	(C)	50	99.2	0.6	5.9
129 N	70 W	(D)	2—4	55.3	2.5	5.4
129 N	70 W	(D)	5—20	96.7	1.1	5.5
129 N	70 W	(D)	50	98.2	0.2	5.8

Table 3

Ash and heavy metal content of dry material of soil and vegetation from a barren area at Kastad near Gjøvik, Norway.

Type of samples	Class of Vegetation	Number of samples	Ash		V		Mn		Co		Ni		Cu		Mo		Ag	Pb		Zn	
			per cent		ppm		ppm		ppm		ppm		ppm		ppm		ppm	per cent		ppm	
			m	s_m	m	s_m	m	s_m	m	s_m	m	s_m	m	s_m	m	s_m	m	m	s_m	m	s_m
Vegetation	III Apparently normal	6	5.8	0.6	1.3	0.1	100	13	0.2	0.1	0.5	0.1	1.4	0.1	0.1	0.1	< 3	0.11	0.07	66	10
	IV Subnormal	7	8.5	1.0	2.2	0.1	107	20	0.6	0.1	0.8	0.1	2.9	0.9	0.1	0.1	< 3	0.28	0.12	99	25
	V Sickly	2	9.5	2.4	2.8	0.7	80	38	0.6	0.1	0.9	0.2	2.8	0.7	0.1	0.1	< 3	0.35	0.12	86	26
Soil at 2—4 cm depth.	III Apparently normal	9	42.3	5.3	17	3	218	35	3.0	0.5	3.5	0.4	13	3	0.6	0.2	< 3	1.69	0.72	139	15
	IV Subnormal	10	50.2	5.1	17	3	222	46	3.6	0.4	3.5	0.4	21	4	0.6	0.2	< 3	2.23	0.31	200	29
	V Sickly	10	50.3	5.5	21	3	206	36	4.8	0.8	4.7	0.8	23	3	0.6	0.2	< 3	2.87	0.53	188	34
	VI Sick or absent	16	54.9	2.7	19	2	172	18	4.4	0.7	4.7	0.4	90	17	1.2	0.3	< 3	7.43	0.57	168	14
Soil at 5—20 cm depth.	III Apparently normal	9	93.1	1.0	46	5	279	84	7.3	2.7	2.3	0.5	19	6	1.1	0.2	< 3	1.29	0.35	300	78
	IV Subnormal	10	91.9	0.7	42	5	311	79	4.9	0.7	0.9	0.0	32	8	1.0	0.2	< 3	1.99	0.39	365	49
	V Sickly	11	90.8	1.1	37	4	464	67	6.8	0.6	3.1	0.5	26	3	1.0	0.2	< 3	2.32	0.35	350	43
	VI Sick or absent	16	90.7	0.7	34	3	279	38	6.2	0.5	5.2	0.5	56	5	1.2	0.2	< 3	3.09	0.17	430	23

m: Arithmetic mean $\Sigma \frac{x}{n}$; s_m: Standarddeviation of the mean $\sqrt{\frac{\Sigma (x-m)^2}{n(n-1)}}$

Table 4

Plant registrations around and within a barren area at Kastad, near Gjøvik, Norway.

	Vegetation normal to sick					
	I	II	III	IV	V	VI
Betula pubescens	x	x			x	
Juniperus communis	x					
Picea abies	x	x	x		x	
Pinus silvestris		x				
Populus tremula		x				
Sorbus aucuparia	x	x				
Alchemilla sp.	x					
Anemone nemorosa	x					
Chamaenerion angustifolium	x					
Euphrasia frigida	x					
Galeopsis sp.	x					
Hieracium silvaticum coll.	x					
Linnaea borealis					x	
Lycopodium annotinum	x					
Maianthemum bifolium	x					
Melampyrum pratense	x					
Melampyrum silvaticum	x					
Oxalis acetosella	x					
Potentilla erecta	x	x				
Pteridium aquilinum		x	x	x		
Ranunculus acris	x					
Rumex acetosa	x					
Rumex acetosella	x		x			
Rubus idaeus	x	x				
Solidago virgaurea	x	x				
Trientalis europaea	x					
Vaccinium myrtillus	x	x	x	x	x	
Vaccinium vitis-idaea	x	x	x	x	x	
Veronica chamaedrys	x					
Veronica officinalis	x	x				
Viola riviniana	x					
Agrostis canina v. fascicularis (?)					x	
Agrostis tenuis		x	x	x	x	
Anthoxanthum odoratum	x					
Carex leporina	x					
Carex pallescens	x					
Carex pilulifera	x					
Deschampsia caespitosa	x					
Deschampsia flexuosa	x	x	x	x	x	x
Festuca ovina	x					
Festuca rubra	x					

	Vegetation normal to sick					
	I	II	III	IV	V	VI
Luzula multiflora	x					
Luzula pilosa	x	x	x			
Phleum commutatum	x					
Poa pratensis	x					
Barbilophozia lycopodioides	x	x				
Brachythecium sp.		x				
Bryophyta sp.		x	x	x		
Dicranum bergeri	x					
Dicranum scoparium			x			
Dicranum undulatum		x				
Dicranum sp.	x	x				
Hylocomium splendens	x	x				
Hylocomium squarrosum				x		
Pleurozium Schreberi	x	x	x	x		
Polytrichum juniperinum		x	x	x	x	
Polytrichum piliferum			x			
Polytrichum strictum			x	x		
Polytrichum sp.	x					
Ptilium crista-castrensis	x	x				
Webera nutans		x			x	
Webera sp.				x		
Cetraria islandica		x	x			
Cladonia arbuscula	x	x				
Cladonia chlorophaea		x	x	x	x	x
Cladonia coccifera v. pleurota			x	x	x	
Cladonia cornuta	x					
Cladonia crispata	x					
Cladonia deformis					x	
Cladonia gracilis		x		x	x	
Cladonia mitis			x	x	x	x
Cladonia ochrochlora					x	
Cladonia pyxidata						x
Cladonia rangiferina		x	x			
Cladonia silvatica coll.	x	x				
Cladonia verticillata			x		x	
Cladonia sp.				x		x
Peltigera aphthosa					x	
Algae sp.						x

I 1. July 1966. 100 m² approx. 30 m north of the barren area.
II 5. October 1968. Around the barren area. Normal vegetation.
III 5. October 1968. Within the barren area. Apparently normal vegetation.
IV 5. October 1968. Within the barren area. Less than normal vegetation.
V 5. October 1968. Within the barren area. Sickly vegetation.
VI 5. October 1968. Within the barren area. Vegetation very sick or absent.

Table 5

Occurrence of plant species in relation to the health of the vegetation and the lead content of substratum.

Health classes, normal to sick (see tables 3 and 4) Average lead content in the root zone of the soil (per cent)	II <1.0	III 1.3	IV 2.0	V 2.3	VI 3.1	Number of species
Deschampsia flexuosa, Cladonia chlorophaea	—	—	—	—	—	2
Betula pubescens, Webera nutans	—			—		2
Picea abies	—	—		—		1
Vaccinium myrtillus, V. vitis-idaea, Agrostis tenuis, Polytrichum juniperinum	—	—	—	—		4
Pteridium aquilinum	—	—	—			1
Cladonia coccifera v. pleurota		—	—	—		1
Cladonia mitis		—		—		1
Cladonia verticillata		—	—	—	—	1
Cladonia sp.			—	—	—	1
Linnaea borealis, Agrostis sp., Cladonia deformis, C. ochrochlora, Peltigera aphtosa				—		5
Cladonia pyxidata					—	1