The Geitvann lead–copper (-zinc) mineralisation, Porsangerhalvøya, Finnmark, northern Norway

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The Geitvann lead–copper mineralisation of Porsangerhalvøya in northern Norway occurs in shallow-marine sediments in the Kolvik Nappe, which is part of the Caledonian Kalak Nappe Complex. Lithologically, the rocks of the Kolvik Nappe consist of arkosic psammites and pelitic to semi-pelitic schists. A swarm of metadolerite dykes and sills occurs in the mineralised area. The stratabound mineralisation occurring in calcareous metasandstone beds comprises galena, chalcopyrite, pyrrhotite and sphalerite. Lead isotope data give a model age of about 940 Ma with low μ-value. The Geitvann deposit has a similar isotopic composition to that of sulphide deposits in volcanic rocks in the Grenvillian Central Metasedimentary Belt in Canada.

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The lead–copper mineralisation at Geitvann has been known since the early 1930s (Torgersen 1935). It is located on the Porsanger Peninsula (Porsangerhalvøya), 3 km SSW of Olderfjord (Fig. 1), in a region which has been mapped and studied over several years by a group from University College, Cardiff, Wales (Williams et al. 1976; Gayer et al. 1985).

Geological setting

The eastern Porsangerhalvøya area is dominated lithologically by arkosic psammites, quartzites and pelitic to semi-pelitic schists of the Kalak Nappe Complex, part of the Caledonian allochthon. Eight major nappes and some 26 thrust sheets have been distinguished within the Kalak Nappe Complex in this district (Gayer et al. 1985). The Geitvann lead–copper mineralisation south and west of the lake Geitvann is located in the Klubben Psammite Group in the Olderfjord Nappe (Table 1). The Klubben Group is the oldest unit in the allochthonous Late Precambrian to Cambrian successions in the region, and is generally assumed to be of Late Riphean to Vendian age (Roberts 1985). The sedimentary thickness of the group is difficult to estimate because of complex thrusting and internal deformation within each nappe, but a minimum thickness of 2.5 km would seem reasonable.

In the Geitvann area the psammites have variably undulating to low-angle dips. Gayer et al. (1985) have mapped an open NNE–SSW trending synform in this area. In a narrow belt parallel to the fold axis the psammites are intruded by metadolerite dykes and sills. Whereas Gayer et al. (1985) locate this belt in the western limb of the synform, Barkey (Trøften 1963) positioned it in the axial zone of the fold. The latter interpretation seems to fit best with the present detailed work. The mineralisation, however, is concentrated in the eastern limb of this open fold structure (Fig. 1).

The mapping for the present investigation was carried out on an established net at a scale of 1:2000. The belt with metadolerite dykes occurs in the western part of the map area (Fig. 2). The dykes generally have steep westerly dips and sills can locally be seen branching out from the steeply dipping dykes. As well as the dyke swarm indicated in Fig. 1 dykes and sills are also found elsewhere in the Geitvann area (Fig. 2). Mafic dykes and sills have also been intersected when drilling the mineralisation. Glacial cover is extensive in parts of the investigated area. The metadolerites are weathering easier than the psammites and they are therefore underrepresented on the geological map.

A gentle to open WNW–ESE trending antiform also affects the rocks of the Geitvann mineralised area (Fig. 2). The mineralisations are located

Table 1. Subdivision of the Kalak Nappe Complex into nappes and imbricate stacks (IS), simplified after Gayer et al. (1985).

	Basement	Klubben psammite Group	Kokelv Schist Group: Semi-pelite	Kokelv Schist Group: Pelite	Storelv Schist Group	Åfjord Pelite Group	Hellefjord Schist Group
Molvikfjell Nappe		×			×		×
Snøfjord Nappe	×	×			×		
Havøysund Nappe		×					
Havvatnet IS	×	×	×		×	×	×
Gardevarri IS		×	×		×		
Seivika Nappe	×						
Olderfjord Nappe		×	×	×	×		
Kolvik Nappe		×	×	×			

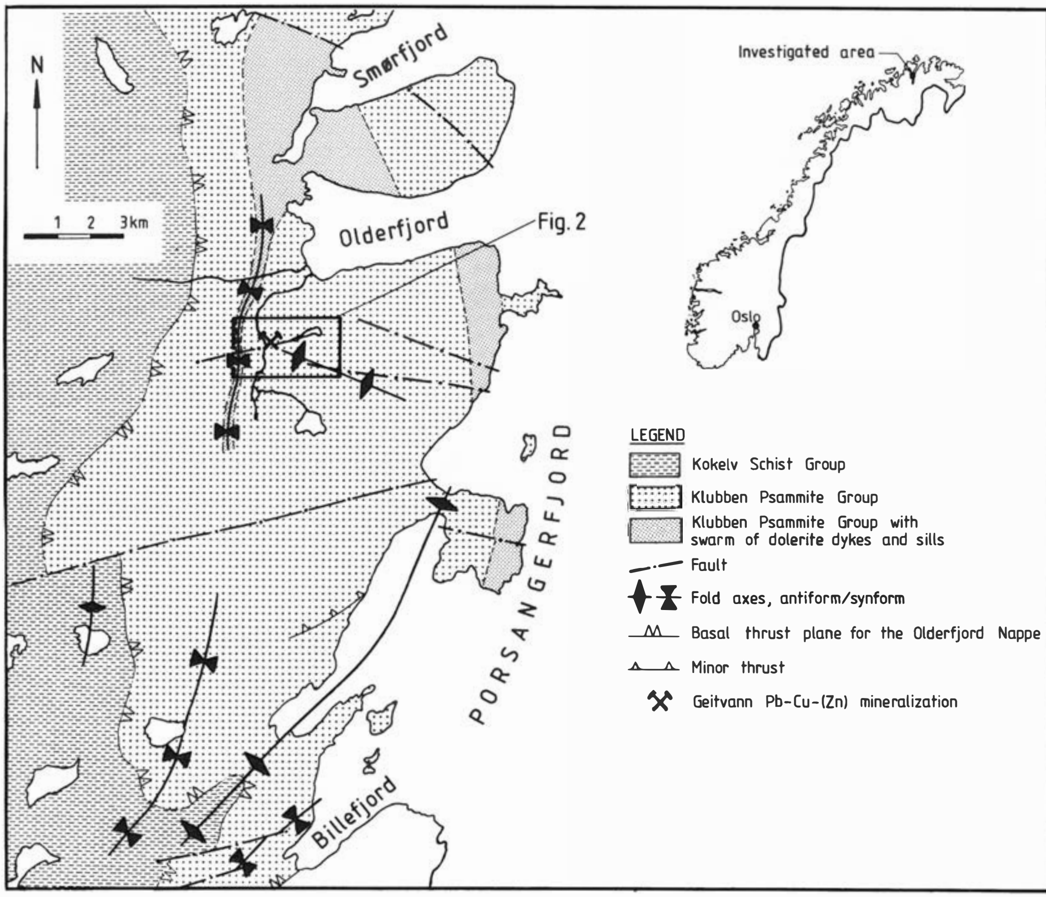

Fig. 1. Simplified geological map of the Olderfjord area after Gayer et al. (1985).

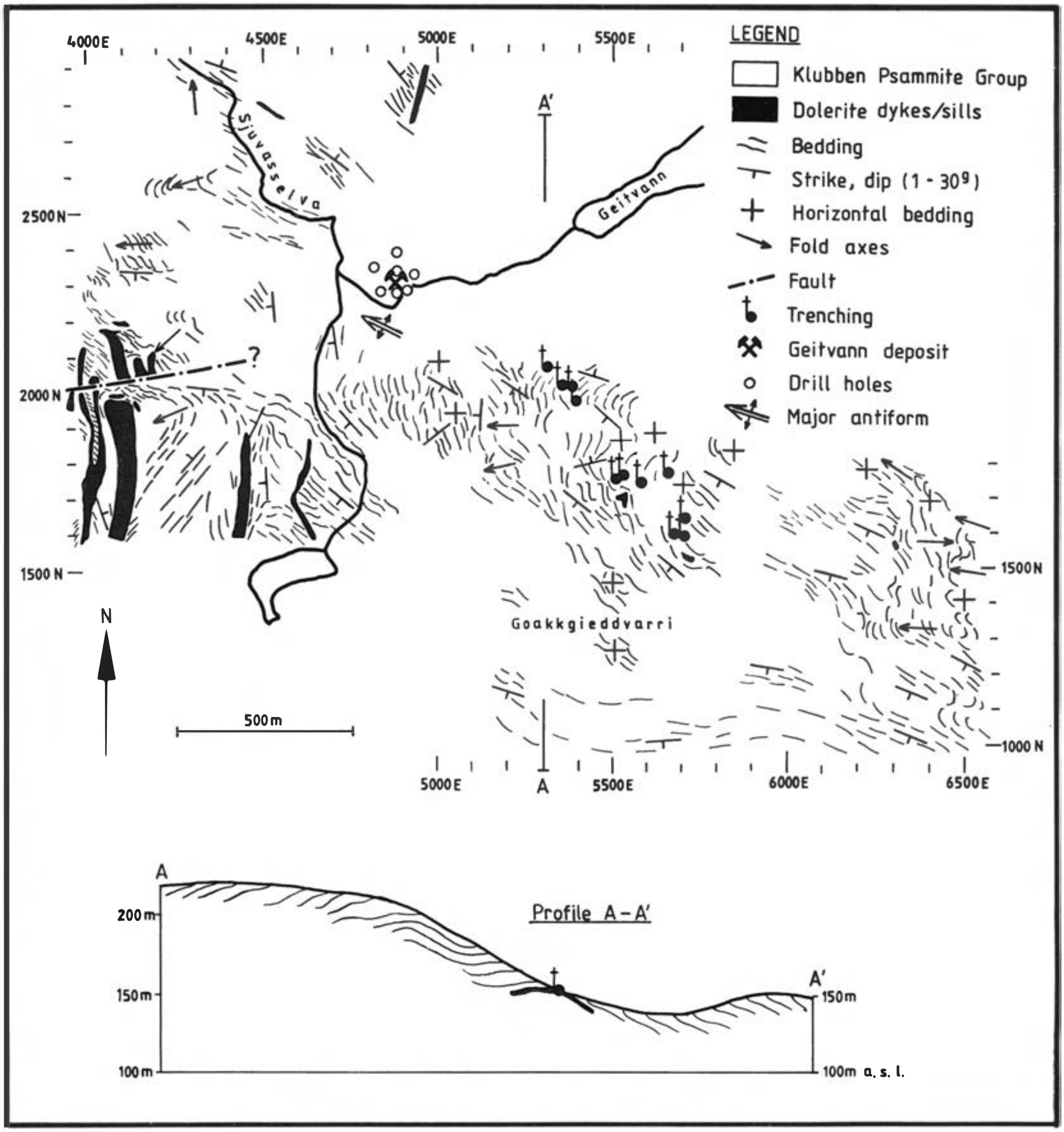

Fig. 2. Geological sketch map of the Geitvann area. The mapping (I. Lindahl) was carried out on a local grid.

along the northern limb of this fold. Trøften (1963), from mapping done by L. Barkey in the late 1950s, also described this antiform, but noted that it had an E–W trending axis. A normal fault with displacement of a few tens of metres has been mapped in the western part of the area (Fig. 2). Other faults have been recorded by Gayer et al. (1985) (Fig. 1).

The Klubben psammite is rather monotonous in overall composition (Trøften 1963; Gayer et al. 1985). In the mineralised area at Geitvann it varies in general character from quartzitic to arkosic to semi-pelitic. This applies throughout the whole sequence which is devoid of any marker horizon except for the mineralised stratabound zone which carries a significant amount of calcite. The psammite is composed mainly of quartz, feldspar and mica. Both K-feldspar and some plagioclase are present, and small red garnets occur in mica-rich layers. The micas are muscovite and biotite in varying proportions. Accessory minerals are epidote, zircon, sphene and magnetite. The mafic dykes have a moderate green amphibole (in thin section) as the dominant mineral; biotite, zoisite (-epidote) and plagioclase are the other constituent minerals.

The mineralisation

In the area of mineralisation at Geitvann the psammite includes several dm-thick calcite-rich beds which are not typical for the Klubben psammite elsewhere. However, iron and calcium carbonate concretions in the sequence at Porsangerhalvøya (Williams et al. 1976) and Nordkynhalvøya (Roberts & Andersen 1985) have been recognised. The thickest of these carbonate-rich beds at Geitvann hosts the lead–copper(-zinc) mineralisation. In the stratabound mineralised zone, the host rock changes in character with influence of tectonism and locally developed meta-pegmatites. Banded host rock consists of quartz and feldspar (K-feldspar and plagioclase) with idiomorphic zoisite crystals and some calcite. Late mobilised calcite is deposited in veins cutting the ore horizon. In some places fluorite has been found in such veins.

The Geitvann mineralisation is the only one reported from the Klubben Psammite Group, although lead mineralisation is known from the autochthonous Dividal Group at Raufjell around the northeastern part of the Komagfjord window (25 km W of Geitvann) at Luostjåkka and Bujobæsk SE and SW of Lakselv (50 km S of Geitvann) respectively (Bjørlykke et al. 1985). Other deposits in a similar geological environment and allochthonous position are known from Håfjellsmulden in Ofoten (Bjørlykke et al. 1980), of which the Skårnesdalen deposit is the closest in character to that at Geitvann (Juve 1967). The mineralisation at Geitvann has been briefly described by Torgersen (1935), Poulsen (1940), Færden (1951) and Trøften (1963).

In the early stage of the present investigation part of the Geitvann area was trenched and drilling was carried out in 1957 (3 holes, total 70 m) and 1980 (4 holes, total 231 m). Localities where the mineralised zone has been trenched and sampled using explosives are shown in Fig. 2. It is difficult to connect the individual observations because of the flat-lying strata or where the beds are dipping at the same angle as the hillside slope at Goakkgieddvarri. The N–S profile of Fig. 2 illustrates the situation. The geophysical ground surveys (Saxhaug 1952; Dalsegg 1980, 1981) support the structural interpretation of the location of the mineralisation in the profile.

In the stratabound mineralisation the sulphides occur in several beds with a preference for the carbonate-rich ones. Sulphide banding parallel to the bedding of the carbonate-rich sediments can also be seen. Meta-ore-pegmatites consisting of quartz, feldspar, carbonate and sulphides, similar to those described by Lawrence (1967), are formed locally in the beds. Brecciation also occurs, which is probably a result of the intensive thrusting and imbrication in the region. The high-grade ore is found in the quartz–carbonate pegmatites.

The major sulphide minerals are galena, chalcopyrite, pyrrhotite and sphalerite. According to Poulsen (1940) the gold content is 0.8 ppm. The silver content from drill cores is approximately 20 ppm Ag for each 5% of lead. This correlation signifies that most of the silver is located in the galena, which again indicates a silver content in the galena of approximately 350 ppm.

Table 2. Lead isotope data from Geitvann, Gurrogaissa (Bjørlykke & Thorpe 1982) and Ofoten (Moorbath & Vokes 1963). The μ and w-values are calculated for a single stage evolution.

	206/204	207/204	208/204	Model age	μ	W
Geitvann 1	16.970	15.436	36.526	940	9.410	34.563
Geitvann 2	16.974	15.437	36.533	940	9.416	34.585
Geitvann 3	16.970	15.438	36.525	945	9.423	34.592
Gurrogaissa 79	18.546	15.712	38.533			
Gurrogaissa 83	18.152	15.652	38.086			
Villdalsfjell, Ofoten	17.80	15.64	37.55			
Niingen, Ofoten	17.52	15.49	36.96			
Djupvik, Ofoten	17.98	15.85	38.16			

The mineralisation exhibits rather large variations in sulphide content and in proportions of the different sulphides. Galena is most abundant, but chalcopyrite and pyrrhotite dominate in some of the trenches south of Geitvann. The sulphide/silicate ratio is generally low. The intergrowths between the sulphides show a metamorphic texture (Stanton 1964). The sphalerite normally occurs as an accessory mineral and is pale-coloured with a low iron content. The ratios between base metal elements from drill cores and chip samples average Pb:Cu:Zn = 10:1:0.5. Chip samples from high grade ore have given up to 30% Pb.

Accessory minerals identified in the mineralisation include mackinawite, cubanite, arsenopyrite, graphite, pyrite, covellite and cuprite. Mackinawite occur as discrete patches in chalcopyrite. Cubanite is found in one sample as exsolution lamellae in chalcopyrite. Arsenopyrite, graphite and pyrite are also rare. Covellite and cuprite have been identified in samples from oxidation zone, where there is also an alteration of pyrrhotite (bird's-eye textures) and of galena to lead carbonates along cleavage planes.

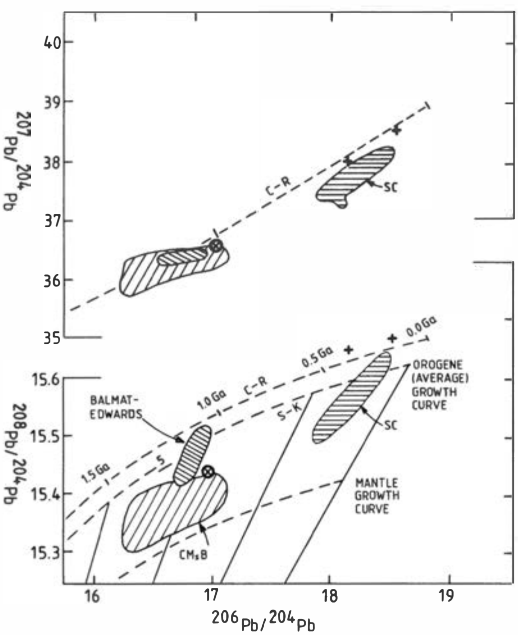

Fig. 3. Lead isotope data from Geitvann = ⊗, Gurrogaissa = + (Bjørlykke & Thorpe 1982), Swedish Caledonides = SC (Sundblad & Stephens 1983), Central Metasedimentary Belt, Canada = CM_sB and the Balmat–Edwards area, USA (Farquhar & Fletcher 1980).

The texture and intergrowth in the sulphide assemblage shows that it has undergone a medium-grade regional metamorphism. This can be concluded from the exsolution of cubanite in chalcopyrite and internal twinning in chalcopyrite (Ramdohr 1969). Locally, sphalerite shows signs of skeleton growth in chalcopyrite, and the graphite is well crystallised.

Lead isotope data

Galena from Geitvann was separated from three samples and the concentrates analysed by Geospec Consultants Ltd.

Comparison with a standard sample indicates a precision of better than 0.1% per mass unit (95% confidence limit). The 2σ errors on isotope ratios are:

$206_{Pb}/204_{Pb} \pm 0.87$‰
$207_{Pb}/204_{Pb} \pm 1.05$‰
$208_{Pb}/204_{Pb} \pm 1.44$‰

as determined from repeated analyses of NBS SRB–981 common lead standard. The correlation coefficient between ratios is 0.82. The results are given in Table 2 and in Fig. 3.

Table 2 shows model ages based on a single stage evolution for the source rock. The geological setting in a sedimentary environment with metadolerite dykes makes a single stage evolution for the lead very little likely for the Geitvann deposit, and the model ages cannot be used directly to date the ore formation or the enclosing sediments.

Model age, however, can give useful information if it is related to specific deposit types. Doe & Zartmann (1979) concluded for example that lead from stratabound sulphide deposits in shallow marine sediments deposited in a continental basin or on a continental platform, never seems to have model ages older than the enclosing sediments. Most of the deposits in this category have a high μ-value and they plot therefore above the orogen curve in the diagram of Doe & Zartmann (1979).

The model age of the Geitvann deposit (940 Ma) can indicate *minimum* age of the enclosing sediments, but the relative μ-value compared to the deposits used by Doe & Zartmann (1979) makes this interpretation a little uncertain.

The isotopic composition of the Geitvann deposit has a lower μ-value and lower 206/204, 207/204 ratios than any other sediment-hosted deposits in the Caledonides (Fig. 3). As a deposit type it can be compared with stratabound sediment-hosted deposits in the Ofoten Region, Northern Norway and with sandstone-hosted lead deposits along the Caledonian border in Sweden and Norway. Published data from three deposits in the Ofoten Region (Table 2) show a large spread in the lead isotope composition (Moorbath & Vokes 1963), but according to the authors they have model ages ranging from 730 to 830 Ma. The age of the enclosing rocks is still uncertain.

The Gurrogaissa deposit southeast of Lakselv in Finnmark occurs in a basal sandstone sequence of Vendian to Early Cambrian age above a basement of granulitic gneisses and partly as fracture fillings in the uppermost part of the gneisses. The Gurrogaissa deposit has much higher 206/204 and 207/204 ratios than Geitvann (Table 2) but has the lowest 206/204 ratio found in Late Precambrian/Early Cambrian sediments along the Caledonian front in Norway and Sweden, which reflects the low uranium content in the underlying granulitic gneisses.

Compared with stratiform and stratabound sulphide deposits in the Swedish Caledonides (Sundblad & Stephens 1983, Fig. 3), deposits in the Appalachian fold belt (Swindon & Thorpe 1984; LeHuray 1982; Kish & Feiss 1982) and Caledonian vein deposits in Sweden (Johansson 1983), galena from Geitvann have considerably lower 206/204 and 207/204 ratios.

The association of stratabound lead deposits in metasediments with metadolerite dykes is also known from the Central Metasedimentary Belt in the Grenville Province of Canada. The deposits have a similar isotope composition to the Geitvann deposit with low μ-values and the model ages range from 1.3 to 0.8 Ga, which are similar or younger than the age of the host rock. Farquhar & Fletcher (1980) suggested that the lead in the Grenville sulphide deposits was derived mainly from mantle sources because of its low μ-value. In the Geitvann deposit the metadolerite dykes could both be the heat source and partly be the metal source and provide lead with a lower μ-value.

The other possibility is a lower crust source of the lead in the Geitvann deposit, which is therefore compared with Gurrogaissa deposit occurring in and above granulitic gneisses. But, Gurrogaissa has a much higher μ-value and plots above the orogenic curve (Fig. 3).

Summary

The Geitvann deposit is situated in a sequence with mainly shallow marine sandstones intruded by a swarm of metadolerite dykes. The mineralisation which mainly consists of galena, chalcopyrite, pyrrhotite and sphalerite is stratabound in beds enriched in carbonate. In detail the richer part of the mineralisation occurs in breccias and veins. This could be due to mobilisation during the regional tectonism and metamorphism.

The Geitvann deposit is located in a region with a dyke-swarm intruding the Kalak Nappe Complex. The dyke is a probable heat source for generating a hydrothermal solution. The chalcopyrite rich paragenesis, compared to most sediment-hosted deposits in a shallow marine sediments, can be explained by a higher temperature for the hydrothermal solution near the dyke swarm, and the metals could partly have been derived from the dykes.

Low μ-values for the source of the lead in sediment-hosted lead deposits are not common but are reported from deposits in the Central Metasedimentary Belt in the Grenville Province of Canada. The model age of 940 Ma may represent a minimum age of the enclosing sediments in the Geitvann area.

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