**Gold Exploration in the Belka Fold area, Telemark, 1984**

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**Sammandrag**


GOLD EXPLORATION IN THE BLEKA FOLD AREA, TELEMARK.

BY

O. Harpøth
J. L. Gregersen

O. Harpøth
Copenhagen 1984
SUMMARY.

The gold-bismuth bearing Bleka-type veins of the Bleka Fold area (170 km²) of central Telemark have been investigated in detail. The investigation was concentrated partly in the Bleka Mine area and in the Espelid area 2-3 km north of Bleka where the hitherto largest vein swarm of the area was found and mapped at scale 1:1000. Apart from this, reconnaissance investigations of other known vein occurrences include Ny-staul, Barstad, Blengsdalen and Gjuv.

The results of this investigation strongly indicate that all of the known occurrences including the newly discovered Espelid vein swarm have a common ore genesis and a conceptual model for the veins is proposed. This concludes that the 40°-90° striking gold-bismuth bearing quartz-tourmaline-carbonate veins were emplaced in their amphibolite host rock along ENE-WSW dextral shear faults resulting from ESE-WNW max compression during N-S to NNE-SSW folding in the Sveconorwegian orogenic period. Major ore lenses seem to be located in areas where max tension and dilation occurs e.g. merging en echelon vein segments. Pronounced hydrothermal alteration envelopes characterize the mineralization and also, together with the mineral assembly of the veins, indicate the high temperature nature of the veins. In summary, the location of the Bleka-type veins is a result of regional tectonics combined with favorable host rock lithology whereas the high temperature nature and to some degree the mineral assembly is controlled by the intrusion of underlying granite.

Due to the high-grade nature of the known ore lenses (25 ppm Au and 0.5 % Bi) and due to the significant size of the Espelid vein swarm as compared with that of Bleka the economic potential is considered good here. Furthermore, a bismuth (locally gold) halo is observed in the northern end of the vein swarm probably indicative of deeper-lying gold-bismuth mineralization. In conclusion the Espelid vein swarm is considered a prime drilling target for a small to medium sized gold-bismuth deposit.
RECOMMENDATIONS.

Prime importance - the Espelid vein swarm.

1) It is recommended to carry out drilling on the Espelid vein swarm. It is suggested that gold-bismuth mineralization is located 200-300 m below the present surface and this should be tested in a first step by drilling of two or three holes totalling in the order of 500-1000 m from one drill location provisionally situated in the northern part of the vein swarm just south of Nystaul (see enclosed Map 3). The exact position of this locality and the details of this drilling programme would benefit from the following additional investigations:

a) analysis of all remaining chip samples from the area for bismuth in order to get a more precise outline of Bi-halos.

b) fluid-inclusion studies on quartz-(tourmaline)-(carbonate) which could indicate whether the Espelid veins are located at a 200-300 m higher level than the known gold-bearing veins of the Bleka Fold area as suggested by present day position.

c) a detailed microscopic investigation of the gold and bismuth minerals and their paragenetic position in the different occurrences might also help in the interpretation of relative levels.

d) local trenching partly along and partly across the veins in the more promissing areas to identify areas of max dilation e.g. merging between en echelon vein segments.
Secondary importance - Bleka-Blengsdalen-Gjuv.

2) Further detailed geological investigations around Blengsdalen and Gjuv are recommended in order to be able to make a better estimate of the economic potential of these.

3) On a long-term basis it is suggested to investigate further the merge zone at the bleka Mine possibly by drilling. In this context the area NE of Sverveli should also be investigated.

4) The SW and NE continuation of the recognized gold-anomalous belt (outlined from stream-sediment survey) stretching from Espelid-Bleka-Blengsdalen to NE of Gjuv should be tested by supplementary stream-sediment sampling.
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ENCLOSED:
   MAP 1 - Structural interpretation of the Bleka Fold area -
            Telemark. Based on air photo mosaic.
   MAP 2 - The Bleka Vein - Telemark.
   MAP 3 - The Espelid Vein Swarm.

SEPARATE EXHIBIT MAP:

SAMPLE MAP 1 - Svartdal.
SAMPLE MAP 2 - Ambjørndalen.
SAMPLE MAP 3 - Nutheim.
SAMPLE MAP 4 - Ståldalen.
SAMPLE MAP 5 - Barstadhovi.
SAMPLE MAP 6 - Hovdejord.
SAMPLE MAP 7 - Svinom.
SAMPLE MAP 8 - Bismuten.
SAMPLE MAP 9 - Hjartdal.
SAMPLE MAP 10 - Gvammen.
SAMPLE MAP 11 - Kvikdalen.
SAMPLE MAP 12 - "Flatdal".
1. INTRODUCTION.

The investigated area covers approximately 170 km² of the Bleka Fold in central Telemark, Norway (Fig.1). The main aim of the project was to carry out detailed investigations on gold-bismuth mineralized veins in order to propose a mineralization model for the area.

The work was carried out during a seven-week period from late May untill early July. It comprises a photogeological interpretation (lineament analysis + limited photogeological mapping) of the entire area as well as five weeks of detailed field work in selected areas.

The field work comprises:

1) Detailed mapping and sampling of the Bleka Mine area (0.5 km²). This includes both surface and subsurface investigations.

2) Detailed mapping and sampling of the Espelid area.

3) Investigations of other known vein occurrences.

4) Reconnaissance for gold-bearing veins in unknown areas.

Due to the finding of a previously unrecognized vein swarm in the Espelid area approximately half of the time was spent on detailed investigations in this area.

The field work was coordinated with stream-sediment sampling for gold in central Telemark conducted by B. Sieborg. A total of 203 litho-samples (Appendix I) comprising 145 chip samples (1-10 kg according to vein thickness) and 58 grab samples (0.2-2 kg) were collected. Of these 193 have been analyzed for gold and 57 for one or more associated elements (Bi-Ag-Cu-Pb) (Appendix II).

Finally, two polished sections (one rock chip and one pan concentrate of ore) have been investigated ore microscopically. We acknowledge the fruitfull discussions in the field with P.A. Lindberg, F.D. Pedersen, L. Rasmussen, B. Sieborg and T. Vrålstad.
2. GEOLOGICAL SETTING.

In a regional context the Bleka Fold area of central Telemark belongs to the Southern Precambrian Province of Norway. This province is bounded by the coast of Southern Norway to the south, by the Cambro-Silurian of the Oslo Region to the east and by overlying Cambrian autochton or Caledonian thrust nappes to the north and northwest. Traditionally, the province has been subdivided into: the Egersund Anorthosite Province of Rogaland in the extreme southwest, the southern basement gneisses with post-tectonic granites, the Kongsberg-Bamble Complex along the eastern margin and the Telemark Supracrustal Suite of the central area.

In a semi-regional context the geology of central Telemark is dominated by the Proterozoic supracrustals of the Telemark Supergroup which comprise an up to 7 km thick sequence of felsic and mafic volcanics, quartzites, conglomerates, schists and subordinate marbles. The supracrustals of the Telemark Supergroup have been divided into four groups: the Rjukan Group, the Seljord Group, the Bandak Group and the Heddevatn Group. The Rjukan Group (predominantly felsic and mafic volcanics - up to 1000 m thick) and the Seljord Group (predominantly quartzites, conglomerates and schists - up to 4000 m thick) have been folded and eroded before the deposition of the overlying Bandak Group (dominated by a mixed sequence of felsic and mafic volcanics and clastic sediments with subordinate calcareous sediments - up to 2200 m). The western continuation of the Bandak Group called the Blåbergås Group is conformably overlain by the Heddevatn Group (predominantly andesitic flows - up to 3200 m) which comprises the youngest deposits of the area.

Fig. 2 shows a schematic representation of the stratigraphy of the Telemark Supergroup.

The last registered major geological event was the intrusion of a suite of postkinematic granitics during the period 1100–850 ma. In the central Telemark area the granites are of calc-alkaline affinity.
Fig. 2. Schematic representation of the stratigraphy of the Telemark Supergroup. From Pedersen (1984).

A tentative scheme of the tectonic development of the central Telemark area has been proposed by Pedersen (1984):

\[\sim 800 \text{ ma.}\]
- 8) Drag folding by late faults
- 7) Doming around granite diapirs
- 6) Folding around N-S axes
- 5) Granitization
- 4) Deposition of the Bandak and Heddevatn Groups
- 3) Uplift and erosion
- 2) Folding around E-W to ENE-WSW axes
- 1) Deposition of the Rjukan and Seljord Groups

\[\sim 1650 \text{ ma.}\]

The summary description of the regional to semi-regional geological setting as outlined above is mainly based on a recent comprehensive study by Pedersen (1984) who has interpreted the geology and proposed some conceptual models for the Southern Precambrian Province.
In a local context the geology of the investigated area of the Bleka Fold is dominated by a prominent NNE-SSW trending anticlinal fold structure which in the core towards NNE exposes felsic volcanics of the Tuddal Formation (Rjukan Group) and at the flanks exposes quartzites and conglomerates of the Seljord Quartzite (Seljord Group), schists of the Bondal Schist (Seljord Group and calcareous schists of the Lauvhovd Schist (Seljord Group). Furthermore, the rocks of the Rjukan and Seljord Groups have been intruded by thick mafic sills and dykes which have been folded as well. Finally, minor granite intrusions occur in the area. A geological sketch map of the area is shown in Fig.3.

A detailed description of the geology of the Bleka Fold area is given by Svinndal (1952).

Fig.3. Geological sketch map of the Bleka Fold area. Map mainly bases on Neumann and Dons' map at scale 1:100,000 and on Svinndal (1952).
3. RESULTS.

The investigations performed comprise in addition to a photo-
geological interpretation detailed field work in selected
areas as well as reconnaissance exploration throughout the
Bleka Fold area. The work was initially concentrated on in-
vestigations in the Bleka Mine area in order to achieve a
better understanding of the gold-bismuth bearing vein system,
but was later concentrated in the Espelid area due to the
finding of a significant vein swarm. The work is described
in the following order:

1) Lineament analysis of the Bleka Fold area.
2) The Bleka Mine area.
3) The Espelid area.
4) Investigations of other known vein occurrences.
5) Reconnaissance for Au-bearing veins in unknown
areas.

3.1. Lineament analysis of the Bleka Fold area.

Prior to field work a photogeological interpretation of the
area was carried out. The basis of this interpretation is a
series of air photos at scale 1:30,000 from Norsk Luftfoto og
Fjernmåling I/S (H76 1642 - Lines A-F).
A photomosaic was constructed and two types of lineaments -
major distinct lineaments and unspecified lineaments - were
interpreted. Furthermore, a few circular features were out-
lined. In addition to the lineament/circular feature interpre-
tation the amphibolite sills and dykes, which host the Au-Bi
veins, were provisionally outlined. This was possible in par-
ticular in the western part of the area where a lithologically
based vegetation difference is pronounced.
The lineament interpretation is biased in the way that more
subtle lineaments have been included from amphibolitic areas.
This is due to a hope that even the most insignificant linea-
ment could be a guide to a vein system.
The result of the interpretation is shown in the enclosed
Map 1 (scale ~1:20,000) and in Fig.4 (scale ~1:80,000).
Fig. 4.

It is seen that the major distinct lineaments are represented by three main directions:

a) appr. NW-SE
b) appr. NE-SW
c) appr. N-S
Including all interpreted lineaments the two directions - NW-SE and NE-SW are the dominating ones with minor directions NNW-SSE, NNE-SSW, E-W and N-S. This is in accordance with mapped faults of the Telemark area (Sigmond et al., 1984) where in particular the NW-SE faults are prominent structural features. Movement along the three prominent directions seems to be sinistral for the NW-SE and N-S faults and dextral for the NE-SW faults. The N-S faults are clearly the oldest features as they are cut by both the NW-SE and the NE-SW fractures. The NW-SE/NE-SW faults could be interpreted as a conjugate fracture system resulting from E-W compression contemporaneous with the N-S folding of the central Telemark area. If this is to hold true it means that the level in the crust in which the fracturing/shearing is observed was located somewhere close to the boundary zone between the ductile and the brittle regime since the angle between the two fracture directions in the plane of max stress is 60°-90° (Ramsay, 1980). This means that the gold-bismuth bearing Bleka-type veins which strike 40°-90° could be related to dextral shear faults associated with E-W to ESE-WNW compression. In fact, as will be demonstrated later this is the actual case.

However none of the more pronounced interpreted lineaments (40°-90°) within amphibolitic terrain which were investigated in the field could be directly related to vein systems. This is probably mainly due to the very low overall exposure (5%), but could as well be due to lack of relation as implied by the known and newly discovered veins which do not show up as lineaments on air photos.

In summary, it can be concluded that there is no direct relationship between interpreted lineaments and observed vein systems. However, the lineament analysis is a powerful means of unraveling the structural evolution of the area and as such an indirect guide to vein mineralization.

3.2. The Bleka Mine area.

The Bleka Mine area as defined by this investigation is outlined in the enclosed Map 2. It covers an area of approximately ½ km² and includes the 1100 m known strike length of the Bleka Main Vein System as well as associated veins.
The area has been covered by both surface and subsurface investigations as outlined below.

The history of the mine and the previous work carried out is reported by Vogt (1886, 1888), Kostke (1902), Wielgolaski (1918), Bugge (1935), Horvarth (1943), Hake (1943a, 1943b), Lauer (1943), Svinndal (1952) and Pedersen (1984). The work by Vogt and by Kostke is by far the most comprehensive and in particular the early work of Vogt gives an excellent description of the geology of the mineralized veins. A summary of the most important reported results is presented in Table 1.

The surface investigations carried out include mapping and detailed sampling of the Bleka Main Vein System along the known 1100 m strike length as well as mapping and detailed chip sampling of associated veins. The main results of this are presented in the enclosed Map 2. The area has been mapped at a scale of 1:1000 based on enlargement of 1:5000 maps from Økonomisk Kartverk. As the overall exposure of the amphibolite is as low as 5-10% probably only a small portion of the existing veins and veinlets have been located in the area (Vogt (1888) notes that appr. 20 veins were known in the Bleka area). The trace of the Bleka Main Vein is only mappable due to old trenching of the vein. Most of the other veins indicated on the map were also located due to trenching and blasting. As it is seen in Map 2 the Bleka Main Vein is only exposed in a few localities (less than 10) otherwise covered by filled-in material along the old trench or not exposed. The vein is estimated to exhibit an average surface thickness in the range of 20-25 cm over a total length of more than one km. From the map it is obvious that a major shift in orientation occurs along a 300 m long part centered around the old workings. This is probably due to the convergence of two en echelon fractures. This point is further elaborated in section 4. The mean orientation of the vein is 71°/73°N (43 measurements) which is in accordance with earlier results. Macroscopically, the main vein is a quartz-tourmaline-ankerite vein with minor calcite, dolomite, epidote, muscovite and chlorite. The ore minerals which in general constitute around 1%, but occasionally up
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<td>1840-1900</td>
<td>Mining</td>
<td>Small scale mining by Compagnie Francaise des Mines de Bambie. No detailed report exists on the results of the mining activity. Excellent geological description of the veins.</td>
<td>Dons (1963)</td>
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<td>1900-1935</td>
<td>Sporadic geological investigations and feasibility studies.</td>
<td>Geology: The Bleka Main Vein is an irregular vein, which has been followed along 1100 m length. The average thickness - 35 cm and the average grade 74'/70'W. The vein often exhibits a banded structure with tourmaline towards the margins and carbonates in the centre. Late often cross-cutting quartz veinslets carry bismuthinite and visible gold. There is clearly an intimate relationship between bismuth and gold. Mine data: In 1901 a total of 701 m of drifts existed. An estimate of the vein tonnage shows a minimum 3 kg gold; 525 level at approx. 50,000 t. A very thorough sampling program carried out in the mine in 1931 totalising approx. 1800 kg of vein material on split into several representative samples. This average is 150-200 kg yields an average grade of the undisturbed vein of 35 ppm Au, 43 ppm Ag, 0.88% Bi (a more realistic value according to the analysis results is 0.3-0.6%) - see Kostke and L. A. C. This average estimate is calculated on a tonnage of 16,000 t of ore. Older analyses (1860-1930) show the high grade nature of the vein as selected samples yield values in the range 50-700 ppm Au (one sample - 5.3% - possibly a sort of concentrate and 100-2000 ppm Ag.</td>
<td>Kostke (1902)</td>
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<td>1935-1939</td>
<td>Mining</td>
<td>Mining was carried out by A/B Bleke Gruber, No reports exist on this activity. According to Halvor Johnsen Sverdrem (personal communication, 1943) they found a close proximity to ore deposits (some 800 m) further to the west. As the ore contents (from footings) were sent to Germany during this period. A shaft was sunk 70 m down from from mine level 525 (drift F of Kostke (1903)) and three lower levels were investigated. According to Halvor Johnsen Sverdrem very low gold values were encountered.</td>
<td>Dons (1963)</td>
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<td>1940-present</td>
<td>Feasibility studies and geological investigations</td>
<td>During the Second World War the Germans showed renewed interest in the Bleka Mine. A report by Horvarth indicates a small-scale ore deposit of 60,000 t with a grade of 0.55% Au. Two reports by Lauer and Hake goesgrades this estimate drastically. Lauer geological investigations of the underground workings conclude the following: The gold-bismuth mineralized lenses (mainly the thicker parts of the vein) within the Bleka Main Vein in general have a strike length of 20-50 m with thin barren parts interweave. They are mostly composed of tourmaline and ankerite with only minor amounts of quartz. The upper parts of the vein as if the quartz is a distinct zone with predominantly carbonaceous material and western parts of the mineral and predominently tourmaline-ankerite in the upper and western parts. The main stoped-out level 50 (drift B) and the intersect level of level 525 (drift F) were not stoped-out level 525 (drift F) are not stoped-out level 37 representative samples (each representing 350 m of vein). A total of 1.5 t of vein material was sampled. The samples were crushed and split into 2-3 kg samples which were analysed at Kongsberg Silverslimen for Au, Ag and Bi. The average grade of this part-over part of the vein system is 1 ppm Au, 400 ppm Bi and 0.254 ppm Ag. The individual analyses and a sketch of the mine with indicated sample points are shown by Pedersen (1984, Fig.58). On the basis of this discouraging results no further recommendations are made for the Bleka Mine by the Germans.</td>
<td>Horvarth (1943)</td>
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The work by Svindel adds no new information on the Bleka Mine, but mentions that pure tourmaline veinlets are found in the area. Pedersen visited the mine on a reconnaissance basis and stresses the potential of the mineralization because of the steep dip of both the veins and the amphibolite. Furthermore, prominent stream-sediment anomalies of gold were outlined in the Bleka Gold area. |

**Table 1. Summary of the history of the Bleka Mine.**
to several per cent, comprise chalcopyrite and pyrite with subordinate bismuthinite, Bi-sulfosalts, gold, galena and scheelite. The economically interesting minerals gold, bismuthinite and Bi-sulfosalts are in particular concentrated in the eastern part of the vein, but the Bi-minerals are also quite widespread in the Sverveli area in the westernmost part (Map 2). Visible gold was only observed in two samples (2110061 and 2110062) both originating in the central mine area around drifts 560 and 580 (B + A according to Kostke (1902)). The gold grains observed are up to 1 mm in the greatest dimension and occur partly in late quartz veinlets and partly intergrown with tourmalin-quartz, in both cases associated with bismuthinite. Galena was only observed in the Sverveli area where it occurs in both the main vein and in adjoining feather veins. The Sverveli area is situated at a level approximately 100 m higher than the main ore lenses of the vein system and thus could represent a lower temperature ore assembly.

Pronounced hydrothermal alteration is associated with the veins. This alteration has been thoroughly investigated by Vogt (1888) who describes it as a zone of appr. 0.5 m's thickness on either side of the veins. Mineralogically, the amphibolite host rock increases its muscovite and calcite content towards the vein, whereas the hornblende and feldspar content decreases. This results in an overall bleaching of the rock towards the vein. Eventually, the altered amphibolite is transformed into a quartz-muscovite-calcite rock. Furthermore, development of idiomorphic pyrite cubes and magnitite octahedrons as well as occasional tourmalinization and ankeritization is a characteristic feature. Minor chalcopyrite impregnation is locally developed. This progressive hydrothermal alteration process is almost identical with alteration phenomena described by Robert and Brown (1984) who investigated gold-bearing quartz-tourmaline veins at the Sigma Mine in Canada. Figs. 5-7 exemplify the progressive alteration observed at the Sigma Mine. The processes observed are virtually identical to those identified at Bleka. However, an important difference seems to be the distribution of gold within the altered zones. At Sigma, gold enrichment is associated with intense carbonatization in the zone of visible alteration. At Bleka this has not yet been observed,
Fig. 5. Schematic representation of distribution of cryptic and visible alteration zones around veins and stringers at the Sigma Mine. Visible alteration may be absent and grade laterally to asymmetrical or to symmetrical alteration envelopes. From Robert and Brown (1984).

Fig. 6. Idealized semiquantitative distribution of minerals involved in cryptic alteration. From Robert and Brown (1984).
Fig. 7. Idealized semiquantitative distribution of minerals involved in visible alteration superimposed on cryptic alteration. From Robert and Brown (1984).

although several samples of the alteration zones have been analyzed for gold. Fig. 8 shows visible alteration around a small Bleka-type vein.

The macroscopic appearance of the exposed main vein is shown in Figs. 9-12.

The other veins found in the Bleka Mine area are probably all associated with the fracture system of the Bleka Main Vein. Most of these veins occur within a short lateral distance (<100 m) from the main vein and are relatively thin (2-20 cm). In only one of the veins visibly Bi-mineralization was observed (sample 21l0046 - Map 2) whereas the rest mainly represent quartz-tourmaline veins with minor pyrite and chalcopyrite.
Fig. 8. Visible alteration (bleaching) around a small Bleka-type vein. Locality close to sample 2110046 (Map 2).

Fig. 9. Outcropping 10-20 cm thick Bleka Main Vein at the entrance to mine level 530.
Fig. 10. Outcropping 20-30 cm thick Bleka Main Vein close to the shaft level 595. Contains locally abundant Bi-Au mineralization.

Fig. 11. 30 cm thick Bleka Main Vein at the entrance to mine level 560. Mainly composed of ankerite and tourmaline.
Fig.12. 10 cm thick vein of the Bleka Main Vein System close to mine entrance 550. Swelling of the vein due to dextral shear movement is evident.

The subsurface investigations carried out include inspection of approximately 300 m of accessible drifts and sampling of selected vein sections. Only mine levels 610, 560, 550 and 525 were accessible for inspection. The results of the inspection are in good agreement with those of Kostke (1902) and Lauer (1943) (see Table 1). As could be expounded from Lauers descriptions there is a distinct zonation with predominantly quartz in the lower and western parts of the mine and predominantly tourmaline-ankerite in the upper and eastern parts. Figs.13-15 exemplify this.

In the upper mine levels the vein often exhibits a banded appearance with tourmaline rimming ankerite (Fig.15). No visible gold mineralization and only very minor visible bismuth mineralization was observed in the mine. However, the stope areas were not accessible thus only the poorly developed and weakly mineralized vein sections could be investigated.
Fig. 13. One metre thick quartz-tourmaline vein from stope area of level 525 (drift F). Note internal Riedel shear planes with tourmaline and sulphides. The shear planes are a result of dextral shear movement and the seeming sinistral appearance is because the photo is taken of a roof exposure.

Fig. 14. 30-50 cm thick tourmaline-ankerite vein with late quartz veinlets. From the upper mine level 610 (drift C)
Fig. 15. Quartz-ankerite-tourmaline vein from mine level 560 (drift B). Note rimming tourmaline around ankerite veinlets.

Structurally, the vein is complex. It pinches and swells over short distances and locally disappears laterally into a 5-10 cm mylonitic fault plane with abundant chlorite and calcite. The shear movement associated with the vein emplacement is clearly dextral (Figs. 16-17) and a detailed study of the geometry of the feather joints demonstrates that shear faulting took place within the brittle-ductile shear regime (Fig. 17).
Fig. 16. Major system of pinnate calcite veinlets associated with the Bleka Main Vein. The measured strike of the Bleka vein is 50° and the strike of the joints is 85° - indicative of dextral shear. From mine level 560 (drift B). Photo from roof exposure.

Fig. 17. Minor system of calcite veinlets associated with the Bleka Main Vein. Exemplifies dextral shear within a brittle-ductile shear regime. The seeming sinistral appearance is because the photo is taken of a roof exposure. From mine level 560 (drift B).
Ore microscopy. Only two polished sections have been prepared and investigated. Prior to the field work a section was prepared from litho-sample 020107A (Pedersen, 1984) with a gold content of 72.7 ppm (average of four analyses). The primary ore minerals identified include chalcopyrite and bismuthinite (both intergrown with cpy and as isolated grains) and subordinate pyrite, sphalerite, rutile and native gold. Only two small (10-20 μ) grains of gold were found isolated in micro-fractures in quartz. The observed amount of gold only corresponds to a gold content of 1-2 ppm and clearly illustrates the nugget effect of the Bleka vein mineralization even on a small scale.

A polished section of a highgraded pan concentrate of crushed ore from the jigging table of the old milling plant has also been prepared. The ore minerals identified include the major constituents native gold, bismuthinite and native bismuth and subordinate chalcopyrite, pyrite, Bi-sulfosalts (cosalite?, aikinite?, galenobismuthite?, emplectite?), maldonite?, bornite and galena? (probably galena with a high Bi-Ag content). In addition, a UV-light examination showed a high content of scheelite.

Native gold occurs mostly as anhedral grains and aggregates (Figs.18-19), but subhedral and euhedral crystals occur as well (Figs.20-23). The observed grain size (of single grains or aggregates) varies considerably from <10 μ up to 2.5 mm. The luminous golden yellow colour of the gold also varies considerably (Figs.18, 19 and 27) indicative of a great variation in the silver content. A few more reddish gold grains could be indicative for a high bismuth content. Gold is observed intergrown with native bismuth (Figs.20-23), with bismuthinite and or Bi-sulfosalts (Figs.24-26), with chalcopyrite (Fig.26), with maldonite? (Fig.21), with Bi-bearing galena? and with tourmaline (Fig.27). A genetically very interesting is the common coarse myrmekitic intergrowth between gold and bismuth (Figs.20-21). The probable occurrence of maldonite (Au₂Bi) associated with the myrmekitic intergrowth is limited to a narrow margin within the high temperature range (Ramdohr, 1980). This texture is observed at the classical occurrence of maldonite (Maldon Mine, Australia) which is a very high temperature gold-quartz vein.
Fig. 18. Photomicrograph showing anhedral gold grains. Varying Ag-content is reflected by the colour differences. Oil immersion. Bar scale 0.1 mm.

Fig. 19. Photomicrograph showing anhedral-subhedral gold grains. Varying Ag-content is reflected by the colour differences. Native bismuth and bismuthinite occur as well. Oil immersion. Bar scale 0.1 mm.
Fig. 20. Photomicrograph showing myrmekitic intergrowth between native gold and native bismuth. Oil immersion. Largest dimension of grain - 0.3 mm.

Fig. 21. Photomicrograph showing myrmekitic intergrowth between native gold, native bismuth and maldonite? (bluish). Oil immersion. Largest dimension of grain - 0.2 mm.
Fig. 22. Photomicrograph showing aggregate with euhedral gold dodecahedron and native bismuth crystal with "feathers". Oil immersion. Largest dimension of gold crystal = 0.1 mm.

Fig. 23. Enlargement of part of Fig. 22. Euhedral gold dodecahedron with trapped bismuth droplets. Oil immersion. Largest dimension of gold crystal = 0.1 mm.
Fig. 24. Photomicrograph showing intergrown gold and bismuthinite. Oil immersion. Size of gold grain 0.2–0.5 mm.

Fig. 25. Photomicrograph showing intergrown gold, bismuthinite and Bi-sulfosalts. Oil immersion. Size of gold grain 0.1–0.5 mm.
Fig. 26. Photomicrograph showing intergrown gold, bismuthinite and chalcopyrite. Oil immersion. Size of gold grain 0.2–0.5 mm.

Fig. 27. Photomicrograph showing gold with inclusions of tourmaline. Note varying Ag-content of the two major gold grains. Oil immersion. Size of major gold grain 0.2–0.4 mm.
The occurrence of native bismuth and maldonite (?) and the intimate myrmekitic intergrowth with gold has not been reported elsewhere. However, the intimate relationship between gold and bismuth minerals reported as early as 1886 is further supported by this preliminary microscopic investigation.

**Analysis results.**

In summary, the old analyses indicate the following undiluted grades:

**High grade ore lenses ( - 10,000 t) :**
- Au - 25 ppm
- Ag - 43 ppm
- Bi - 0.4 %
- Cu - 1.4 %

**Low grade vein mineralization ( - 15000 t) :**
- Au - 1 ppm
- Ag - -
- Bi - 400 ppm
- Cu - 0.25 %

Geochemically, this means that the Bleka Vein is a bismuth-gold vein as indicated by the following enrichment factors for the high-grade lenses:

<table>
<thead>
<tr>
<th>Enrichment factor</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>500,000</td>
<td>Bi</td>
</tr>
<tr>
<td>10,000</td>
<td>Au</td>
</tr>
<tr>
<td>500</td>
<td>Ag-Cu</td>
</tr>
<tr>
<td>10-100</td>
<td>W-Pb-Zn</td>
</tr>
</tbody>
</table>

The analysis results of grab and chip samples from both surface and subsurface investigations are presented in Appendix II and the gold analyses are plotted in the enclosed Map 2. Analysis of selected samples from the Bleka Main Vein confirms the mapping results. Only samples from the central mine area have high gold contents (up to 94 ppm) whereas samples from outside this area only show gold values
in the range of < 20 ppb to 1.7 ppm. Besides gold, interesting Ag-values are encountered in sample 2110061 (> 250 ppm) of the mine area, but in particular the western (and higher) area around Sverveli exhibits interesting silver values (100- > 250 ppm). Silver is clearly associated with high lead and bismuth values and is probably contained within galena (in particular in the Sverveli area) and in Bi-sulfo-salts (e.g. sample 2110001).

In general, bismuth seems to be a much more efficient element in delineating mineralized vein systems than gold. Most of the veins analyzed for both gold and bismuth in the Bleka area show distinct bismuth enrichment (10-100 ppm) without any detectable gold (< 10-20 ppb). This means that the bismuth halo within the vein system is much more pronounced and extensive than that of gold. Thus, Bleka-type veins of the fold area should preferably be analyzed for both gold and bismuth and any encountered bismuth anomalies without gold would probably be indicative for a close gold-bismuth mineralization.

3.3. The Espelid area.

The Espelid area is outlined in Fig.1 and in the enclosed Map 3. It covers an area of approximately 3/4 km² from the Espelid Farm in the NW to just north of Livsengåsen in the SE and is situated from 2-3½ km NNW of the Bleka Mine. Geologically, the setting is similar to that of the Bleka area except for one important difference - the Bleka area is situated close to the axis of the fold whereas the Espelid area is located at the western limb of the fold. This means that the 40°-90° striking veins of the area are virtually perpendicular to the strike of the amphibolite sill (Fig.28). Furthermore, the thickness of the sill is only half of that observed in the Bleka area where it reaches a max thickness around 1000 m. This may partly be a result of primary variation in thickness and partly a result of boudinage which may also have effected the degree of dilation in the Espelid area (Fig.28). However, the steep dip of both the veins and the amphibolite sill makes room for a significant tonnage at depth.
The area was investigated on a reconnaissance basis partly due to an old (1880) Cu-bearing quartz vein occurrence (Espelid) and partly due to stream sediment anomalies of Au-Bi-Pb-Zn-Co reported by Pedersen (1984). The old trenching which seemed to have been left untouched for a great many years occurs approximately 500 m SE of the Espelid Farm and only 25 m N of the Nystaul saeter cottage. The occurrence is exemplified by samples 2110033-36 on the enclosed Map 3. The Espelid veins seem to be part of a major vein swarm identified during reconnaissance exploration of the area. Due to this encouraging find the area was mapped at scale 1:1000 (based on enlargement of 1:5000 maps from Økonomisk Kartverk) and the results of this are presented in the enclosed Map 3. As it is seen in Fig.28 and in Map 3 an area of 1000·500 = ½ km² contains in the order of 10 veins with locally more than ½ m’s thickness (max observed thickness = 2 m – Fig.29), 20 veins with a max thickness of 10-50 cm and a greater number of veins with max thickness of 1-10 cm. The veins are assumed to have a strike length of 400-500 m which is the approximate thickness of the sill. One of the major veins (samples 2110116-133, Map 3 – Fig.30) could be followed more or less continuously over 250 m laterally and 75 m vertically with an average thickness of 75 cm. Due to the very low exposure (~5%) of the amphibolite the estimated amount of veins and the length of these is very uncertain, but it is assumed that additional medium sized veins occur in the area. In general, the size of the hydrothermal vein system indicates an overall dilation much greater than observed elsewhere in the Bleka Fold area.

The veins are very similar to those of the Bleka mine area. The average orientation of the veins is 68°/78°N (average of 141 measurements – standard deviation of strike = 15°) with most of the veins striking 40°-90°. The veins consist predominantly of quartz and tourmaline with varying amounts of ankerite-sericite-pyrite and locally chalcopyrite (Figs.31-32). In general, the overall sulphide content is lower than in the Bleka Main Vein. Pronounced hydrothermal alteration similar to that described from Bleka is ubiquitous. Characteristically, evidence of dextral shear movements are found throughout the vein swarm. As seen in Fig.34 much of the observed shear movement is lateral due to the frequent
ocurrence of horizontal slickensides. The dextral nature of the shear movement is seen as widespread feather or pinnate veins (Figs.35-37).

Due to the great similarity with the veins of the Bleka Mine area a detailed chip sampling programme was carried out covering almost all outcrops of veins with a thickness greater than five cm. The locations of the sampled outcrops are all shown on Map 3. More than 110 chip samples (1-10 kg according to vein thickness) and supplementary grab samples were collected. All of these samples have been analyzed for gold and
Fig. 29. Up to 2 m thick quartz-tourmaline vein of the Espelid Vein Swarm. Sample 2110231 – Map 3

Fig. 30. 1½ m thick quartz-tourmaline vein of the Espelid Vein Swarm. Sample 2110121 – Map 3.
Fig. 31. Close-up of 30 cm thick quartz-tourmaline vein with abundant pyrite. From the Espelid Vein Swarm. Sample 2110105 – Map 3.

Fig. 32. Close-up of a 10 cm thick quartz tourmaline-ankerite vein with pyrite-chalcopyrite and probably Bi-sulfosalts. From the Espelid Vein Swarm. Samples 2110141 and 2110201-202. Note wrong sample number!
Fig. 33. Thin tourmaline vein in amphibolite in the northern part of the Espelid Vein Swarm where these are quite widespread.

Fig. 34. ½ m thick quartz-tourmaline vein with pronounced horizontal slickensides. From the southern part of the Espelid Vein Swarm. Sample 2110220 – Map 3.
Fig. 35. 10 cm thick quartz-tourmaline vein with adjoining feather veins indicative of dextral shear. From the Nystaul occurrence. Sample 2110038 - Map 3.

Fig. 36. 80 cm thick quartz-tourmaline vein with feather veins indicative of dextral shear. From the Espelid Vein Swarm. Sample 2110228 - Map 3.
Fig. 37. 25 cm thick quartz-tourmaline vein with feather veins indicative of dextral shear. From the Espelid Vein Swarm. Samples 2110237-238 - Map 3.

approximately 20 samples for the additional elements Bi-Ag-Cu-Pb.

The analysis results indicate that a Au-Bi anomalous area covering $\frac{1}{4}$ km$^2$ occurs around Nystaul-Reiustaulhaugen (Map 3). Although the values are low compared with the contents of the Bleka Main Vein a distinct enrichment in both gold (20-210 ppb) and bismuth (2-144 ppm) is observed. Samples from outside this area are low in both elements. Also lead seems to be relatively enriched, whereas copper does not show any particular enrichment in this area.
On the basis of these results it is suggested that the gold-bismuth enrichment represents a halo-phenomena to a deeper-lying gold-bismuth mineralization. The low Au-Bi contents observed in the SE part of the vein swarm do not necessarily imply barren vein mineralization, but could as well be a result of even deeper Au-Bi mineralization.

3.4. Investigations of other known vein occurrences.

Barstad.

The location of the Barstad occurrence is shown in Fig.1. More precisely the old drift is located 150 m NW of the farm Barstad øvre close to the stream at 550 masl (samples 2110010-12 - Sample Map 5). The entrance to the drift is seen in Fig 38.

Fig. 38. Entrance to the 15 m drift at the Barstad occurrence.
The geological setting is similar to that of Bleka and Espelid.

The drift was investigated all along the 15 m length. The vein which is oriented 90°/60°N is locally up to 60 cm thick, but the average is much lower. It consist of quartz, tourmaline (locally very rich with up to 2 cm long crystals) and ankerite with subordinate pyrite, chalcopyrite and possibly bismuthinite. According to Kostke (1902) later quartz veinslets with bismuthinite and visible gold was observed during drifting. This was not observed neither in the tunnel nor in mineralized vein samples of the old dump. At the end of the drift the vein is displaced by a 145° fault.

Two chip samples and one grab sample were collected at the occurrence. Analyses show gold (up to 30 ppb) and bismuth (up to 12 ppm) enrichment.

**Blengsdalen.**

The location of the Blengsdalen occurrence is shown in Fig.1. More precisely two different veins (150 m apart) have been trenched and blasted over a composite length of 50-100 m. The **southern vein** is located close to the Blengsdalen farm and is exposed in the small road between the lower and the upper buildings whereas the **northern vein** is located 150 m NNW of the main building. According to Vogt (1888) the occurrence was discovered in 1884 and tested in 1896.

The geological setting is slightly different from the Bleka area. The amphibolite sill hosting the veins (the Kasin amphibolite according to Svinndal,1952) is only 100-200 m thick and has intruded the Lauvhovd limey quartz schists, whereas the Bleka amphibolite has intruded the quartzites. However, the Kasin amphibolite host is just a higher level sill of the Bleka amphibolite (Fig.3).

The **northern vein** has been trenched and blasted over a length of 50-60 m. Only very limited exposure is seen. The vein is oriented 70°/subvertical S and consists of quartz and ankerite with minor tourmaline, chalcopyrite, pyrite and bismuthinite. Pronounced hydrothermal wall rock alteration occurs. The vein probably pinches and swells over short distances and at the southern end a width of one metre was measured. One bulk chip sample of both visibly mineralized and unmineralized chips
was collected from the old dump. Further, two mineralized grab samples were collected. The analysis results indicate surprisingly high gold contents. The two grab samples have gold values of 103 ppm and 1.8 ppm respectively whereas the bulk chip sample shows 0.31 ppm Au, 84 ppm Bi, 0.28% Cu and 3 ppm Ag. The southern vein has been blasted at several locations over a length of 50-75 m. The vein is very irregular and has an average orientation of 70°/ subvertical. In the road cut the vein has a thickness of 20 cm and consists of quartz, tourmaline and ankerite with pyrite, chalcopyrite and bismuthinite (or Bi-sulfosalts). The wall rock alteration is very pronounced with extensive brecciation and bleaching as well as pyrite and chalcopyrite impregnation. A chip sample of the vein exhibits raised values of gold (60 ppb) and bismuth (5 ppm). A chip sample of the hydrothermally altered zone also shows raised values of gold (30 ppb) and bismuth (30 ppm).

The area just west of Blengsdalen was also investigated on a reconnaissance basis. The area mainly consists of quartzitic and arkosic rocks, but an amphibolite dyke or sill has intruded the sediments. A minor area with widespread quartz-tourmaline-ankerite-pyrite veinlets was located (samples 2110073-74 - Sample Map 2). Analysis of these showed no gold enrichment. 200 m NE of this area abundant boulders of quartz-tourmaline veins (2-5 cm) were located (sample 2110075 - Sample Map 2). Analysis of these shows a content of 0.1 ppm Au, 7 ppm Bi, 3 ppm Ag and 620 ppm Cu.

Gjuv.

The location of the Gjuv Mine (occurrence) is shown in Fig.1. More precisely the old drift is located 100 m SE of the farm nedre Gjuv (sample 2110003 - Sample Map 10). According to Dons (1963), the occurrence was found before 1862. It has been described by Bagstevold (1918), Busvold (1919), Dokken (1943) and Pedersen (1984). In summary, the old workings (Fig.39) consist of an open pit with a lower 50 m long drift. The quartz-tourmaline-calcite veins have reported orientations of 0°-20°/ subvertical, 135°/weakly NE dip and 90°/30°-40°N which seems to reflect a complex vein pattern. The N-S veins seem to be the Thickest ( > 1 m) whereas the NW-SE veins (up to four pa-
Fig. 39. The mine dump and old workings of Gjuv.

Parallel veins (~30 cm) over a width of 15 m) seem to be thinner. The ore minerals are mainly bismuthinite and associated Bi-sulfosalts (cosalite, galenobismuthite etc.) and subordinate chalcopyrite, pyrite and gold. Pronounced hydrothermal wall rock alteration of the amphibolite similar to that of Bleka occurs.

The grade of the ore lenses seems to be 1-2% Bi, 5-10 ppm Au and minor Pb-Cu-Ag-Te. All of the mined vein ore has been thoroughly hand sorted and a total of 5-10 t of concentrated ore have been produced. This should amount to 300-500 kg of bismuth.

The veins all occur in a 100 m thick amphibolite (the Kasin amphibolite) occurring parallel to and at a level above the Bleka amphibolite. It is possible that the complex vein pattern is a result of the position close to a major fault.

The old workings are now more or less inaccessible, thus only a single grab sample from the mine dump was collected. It contains 0.16% Bi and 19 ppb Au.
3.5. Reconnaissance for Au-bearing veins in unknown areas.

Reconnaissance exploration for Bleka-type veins was also carried out in the Bleka amphibolite outside areas with known vein mineralization. The reconnaissance was mainly concentrated in areas with stream-sediment anomalies or in important lineament areas. A more or less continuous area of the Bleka amphibolite stretching from Skjesvatn in the NW to Hjartdal in the SE was traversed. In addition to the known vein occurrences, Bleka-type quartz-tourmaline veins were found in the area between Barstad and Bleka (Steinsruddalen - samples 2110083-85 - Sample Map 5), NE of Bleka (Ormemyre - sample 2110088 - Sample Map 6), in the area between Svervei and Hjartdal (Møllerømmen - sample 2110226 - Sample Map 2 and Vrestebakken - sample 2110225 - Sample Map 6), in the Hjartdal area and in the Blengsdalen area west of the known occurrences. Only the veins of Ormemyre and Steinsruddalen are of important size. At Steinsruddalen a 20 cm thick quartz-tourmaline vein (55°/70°N) composed of quartz, very abundant tourmaline minor ankerite, pyrite and chalcopyrite is located. Very pronounced brecciation with quartz fragments in a tourmaline matrix as well as very strong hydrothermal wall rock alteration is observed.

Only the veins west of Blengsdalen are enriched in gold (0.1 ppm).

Apart from samples of Bleka-type veins, sampling of a major altered mylonite zone in the Bleka amphibolite at Brekka ytre in Ambjørndalen was performed. The mylonite zone which is 50-100 m wide and of unknown strike length exhibits pronounced epidotization, chloritization, calcite veneing and pyrite impregnation. Bulk chip samples show low to raised gold contents (up to 29 ppb).

Reconnaissance for gold mineralization was also carried out in areas of acid volcanics and metasediments. No interesting alteration or mineralization was observed in the acid volcanics and no Bleka-type veins were seen in the metasediments. However, several quartz veins were chip sampled. Only one of the veins has gold values above the detection limit of 20 ppb.
This vein which has a gold content of 0.35 ppm is a 40 cm thick quartz vein with minor hematite. It occurs in quartzite and could be followed over more than 25 m (both ends open). It is located at Kåsastul north of Hjartdal (sample 2110017 - Sample Map 8).

4. DISCUSSION OF RESULTS.

The gold-bismuth veins of the Bleka Fold area occur geologically in a setting similar to known gold producing areas of the world. Some of the gold mines (e.g. the Sigma Mine) of the Val d’Or district, Abitibi Greenstone Belt of Canada are good examples as they are very similar to the Bleka-type veins.

The results of this investigation strongly indicate that all of the known occurrences of the Bleka Fold area (Bleka, Barstad, Nystaul, Blengsdalen and Gjuv) and the newly discovered Espelid vein swarm have a common ore genesis.

On the basis of the results from detailed investigations of the Bleka Mine area and the Espelid area a conceptual model for the Bleka-type veins of the Bleka Fold area is proposed (Fig. 40). During the Sweconorwegian orogeny, which was the last to affect the rocks of the Telemark area, the host rocks of the veins were tectonically deformed and metamorphosed to the amphibolite facies whereas the mineralized veins have not been subject to pervasive postore deformation and metamorphism. Thus, the veins were emplaced late in the geological history of the region.

As seen in Fig. 40A the late folding around N-S to NNE-SSW axes in the area is a result of E-W to ESE-WNW max compression. Assuming a level of the crust located somewhere close to the boundary zone between the ductile and the brittle regime (brittle-ductile regime) which is indicated by mapped tectonic structures (e.g. Fig. 17) and by the metamorphic grade, a conjugate fracture system with an angle of 60°-90° would develop. Actually, the lineament analysis shows a set of prominent ~NE-SW and ~NW-SE fractures to be present. The observed movement along the two prominent directions are also in agreement with the theoretical movements resulting from ESE-WNW compression. The NW-SE sinistral faults are the better developed
Fig. 40. Sketch of conceptual model for the Bleka-type veins of the Bleka Fold area. A-D show various scales.
of the two conjugate fault directions in the central Telemark area and thus have taken up most of the shear movement. However, as seen in Fig.40B gold-bismuth bearing quartz-tourmaline-carbonate veins have been emplaced along the 65°-striking dextral shear zones (faults) where these intersect the mafic sills and dykes of the area. Bleka-type veins have not been located outside the amphibolites.

The individual dextral shear zones may be developed as shown in Fig.40B consisting of merging vein segments (fracture segments). From an economic point of view these areas of merging are very attractive because max tension and dilation occurs in these zones. A very strong support for this is seen in the enclosed Map 2 which shows the Bleka Main Vein System. It is evident that the major ore lenses occur in an area of merging between two en echelon veins. No significant gold-bismuth mineralization is observed outside this 300•75 m² surface area. Assuming a depth of 150 m this implies that individual rock volumes potential for hosting high grade ore lenses are estimated to be in the order of 10 mill. t. Surface investigations indicate dilation in these zones in the order of 1-2%. In a more detailed scale (Fig.40C) the veins may exhibit pronounced pinch and swell structures and very characteristic feather fractures arranged parallel to max compression (100°) and perpendicular to max tension (Figs.35-37). These phenomena are a result of a slightly irregular fault plane and a shear movement in the brittle-ductile regime. As indicated, the shear movement is clearly dextral.

On a very detailed scale (Fig.40D) it can be observed how internal Riedel shear planes often expressed as tourmaline-sulphide veinlets occur in the main quartz vein (Fig.13). Theoretically, a set of late tension gashes should be developed. From the old reports of Kostke (1902) and Lauer (1943) it can be concluded that their observations on late cross-cutting quartz veins with visible gold and Bi-minerals can be related to these tension gashes. Other evidence of this is observed locally as open space filling of quartz crystals.

Pronounced hydrothermal alteration envelopes (Fig.40D) are developed throughout the area. Mineralogically, the amphibolite host rock increases its muscovite and calcite content towards the vein, whereas the hornblende and feldspar content decreases.
This results in an overall bleaching of the rock towards the vein and eventually, the altered amphibolite is transformed into a quartz-muscovite-calcite rock (Figs.5-8). This is indicative of percolating hydrothermal solutions causing the precipitation of the Au-Bi bearing quartz-tourmaline-carbonate veins in areas of max dilation. The mineral assembly of the veins: quartz-tourmaline-ankerite and subordinate calcite-dolomite-muscovite-epidote-chlorite-chalcopyrite-pyrite-bismuthinite-Bi-sulfosalts (cosalite?, galenobismuthite?, aikenite?, emplectite?)-native bismuth-native gold-maldonite?-bornite-galena-scheelite is indicative of a high temperature hydrothermal mineralization. In particular the symplectic intergrowths of gold and bismuth and the occurrence of maldonite indicate this. Zoning is observed both laterally and vertically. The lateral zoning is characterized by enrichment of tourmaline, carbonates and gold-bismuth minerals in the zones of merging (Fig.40B) and predominantly quartz with subordinate tourmaline and pyrite in veins outside these areas of max dilation. Vertical zoning is probably observed as introduction of galena at higher levels (Sverveli). The present relative levels of the known occurrences are so that the Espelid vein swarm occurs appr. 200 m above Bleka and Barstad and 300 m above Gjuv and Blengsdalen. As the veins were emplaced during the last period of major tectonic movements and assuming no later tilting there is reason to believe that the Espelid vein swarm contains Au-Bi mineralization at depth. This is further supported by the local enrichment of both elements which is interpreted as a halo phenomena.

The high temperature nature of the veins is probably due to underlying granite(s) which is exposed locally (Fjellstadfjell Granite N of Gjuv and a small granite plug SW of Bleka).

Thus, the location of the Bleka-type veins is a result of regional tectonics combined with favorable host rock lithology (amphibolite) whereas the high temperature nature and to some degree the mineral assembly is controlled by underlying intrusions.
**Impact on further exploration.**

On a local scale the establishment of the conceptual model implies that zones of merging or other areas of max dilation are the main targets for gold-bismuth exploration. In the Bleka area one such zone (300·75 m² surface area) has already been outlined. The area just north of Sverveli could also represent the one end of such a zone, but this would have to be investigated in more detail. In the Espelid area which exhibits a large overall dilation the low exposure (5%) impedes detailed investigations. However, two areas (A - around samples 2110091-93, 95-98 and 100-115 and B - around samples 2110231-244 - Map 3) might represent zones of merging fracture segments.

Another impact on further exploration is the rekognized Bihalo. This means that future samples should be analyzed for both gold and bismuth.

On a larger scale it should also be noted that the Bleka-type veins seem to have a low, but widespread scheelite content. This seems to hold true for many gold-quartz veins in greenstones (e.g. Sigma Mine, Canada and Ädelfors, Sweden). The occurrence of scheelite in particular in pan concentrates from areas of volcanic rocks should be checked for gold-quartz veins. This is as relevant for other areas in Norway as for the Telemark area.

Another point of interest is the result of the 1984 stream sediment sampling programme in central Telemark. In an area covering appr. 600 km², 85% of the significant gold anomalies (> 50 ppb) occur within a belt covering only 15% of the area. This belt which seems to be 5-10 km wide and has a strike similar to that of the Bleka veins runs from the Espelid-Bleka-Blengsdalen area in the SW to beyond Gjuv in the NE. The significance of this anomalous belt is uncertain, however, on a very large scale it could be postulated (mainly from interpretation of the 1:1,000,000 geological map) that a major fracture zone stretches all across the Southern Precambrian Province from the Stavanger area over Bykle-Dalen-Bleka-Kongsberg to the Oslo Rift and acted as a major channelway for hydrothermal solutions. However, this postulate is by no means supported by further investigations.
Economic potential.
The inferred reserves and metal productions from both the Bleka and the Gjuv Mines are small. The inferred original ore reserve of the Bleka Mine amounts to 50,000 t of vein material with a grade of 5 ppm gold or a diluted ore reserve of 250,000 t with 1 ppm gold. This includes a high grade part of ~10,000 t with 25 ppm, 15,000 t with 1 ppm and 25,000 t with appr. 0.1 ppm. Metal production includes 125 kg Au, 225 kg Ag, 20 t Bi and 70 t Cu from the early production period before year 1900 and 40 kg Au, 80 kg Ag, 6 t Bi and 10 t Cu from the 1935-39 production period.
Total metal production from ~7000 t of vein material:

- Au - 165 kg
- Ag - 300 kg
- Bi - 25 t
- Cu - 80 t

The figures for the Gjuv Mine are much more speculative, but only amount to 0.3-0.5 t of bismuth produced. However, the actual economic potential is considered much better for the following reasons:

a) the Bleka-type veins are known to contain ore lenses with very attractive grades - 25 ppm Au, 0.5% Bi, 45 ppm Ag and 1.5% Cu.
b) known ore lenses occur in areas of merging between en echelon veins where max dilation occurred. The bulk volume of such zones is estimated to be in the order of 3-5 mill m³ = 10-15 mill t and no drilling has been performed.
c) the located Espelid vein swarm represents a much larger hydrothermal system than the Bleka Main Vein System and exhibits a high overall dilation. 5-10 of the mapped veins exhibit average thicknesses of up to three times larger than the Bleka Vein. Assuming a similar grade the expected size of potential individual ore lenses of the Espelid vein swarm would be 50,000-100,000 t.
d) bismuth and gold enrichment is observed locally within the Espelid vein swarm. This is believed to represent a halo phenomena from deeper-lying mineralization.

e) assuming the observed high grade and minable widths for the ore lenses an ore reserve of only 150,000-200,000 t would be sufficient for a profitable small scale mining project (total revenue - 300-400 million 1984-NOK).
REFERENCES.


Busvold, W., 1919: NGU Bergarkivet.


Hake, 1943a: Bericht über die Befahrung der Bleka Grube und anschliessende Besprechungen. NGU Bergarkiv Rapport nr. 904.


ROCK SAMPLE DESCRIPTION LIST:

2110001 - Hydrothermally altered amphibolite with coarse-grained calcite/ankerite veinlets with bismuthinite, chalcopyrite and pyrite. From Bleka main vein at Suveli.

2110002 - Quartz vein with abundant chalcopyrite and minor pyrite and bismuthinite. Chlorite-bearing. From upper Bleka mine dump.

2110003 - Quartz vein with pyrite and bismuthinite. Slickensides. From main mine dump at Gjov.

2110004 - Quartz-ankerite vein with chalcopyrite, pyrite and bismuthinite. Chip sample from mine dump at Blengedalen occurrence.

2110005 - Quartz vein with chalcopyrite and minor pyrite and bismuthinite. From mine dump at Blengedalen occurrence.

2110006 - Quartz-ankerite vein with chalcopyrite, pyrite and bismuthinite. From mine dump at Blengedalen occurrence.


2110010 - Quartz-tourmaline-ankerite vein with minor pyrite-chalcopyrite. Chip sample of mineralized vein material from main dump at Barstad occurrence.

2110011 - Quartz-tourmaline-ankerite vein with pyrite and minor chalcopyrite and bismuthinite? From main dump at Barstad occurrence.

2110012 - Quartz-tourmaline-ankerite vein with minor pyrite. Chip sample of 60 cm vein in the Barstad tunnel.

2110013 - Tourmaline-ankerite-quartz vein with abundant chalcopyrite. From mine level 610 at Bleka.


2110015 - Calcareous schist with pyrite pseudomorphoses. From Kivikdalen.

2110016 - Fine-grained amphibolite with quartz veinlets. From Øygården area.

2110017 - Quartz vein with minor hematite? From Kåsastul.

2110018 - Quartz-tourmaline vein with minor pyrite. From Espelid area.

2110019 - Hydrothermally altered amphibolite with pyrite and magnetite. Chip sample from Espelid area.
2110020 - Quartz vein with minor pyrite. Chip sample from Espelid area.

2110021 - Quartz-tourmaline-ankerite vein with minor pyrite and chalcopyrite. Chip sample from Espelid area.

2110022 - Hydrothermally altered amphibolite with pyrite and magnetite. Chip sample from Espelid area.

2110023 - Quartz-tourmaline vein with abundant pyrite and minor chalcopyrite. Sample from vein in Espelid area.

2110024 - Quartz-tourmaline vein with pyrite. Chip sample from Espelid area.

2110025 - Quartz-tourmaline-pyrite vein with tourmalinitized wall rock (amphibolite). From Espelid area.


2110028 - Quartz-wollastonite vein. From Espelid area.

2110029 - Tourmaline-quartz vein with pyrite. From Espelid area.

2110030 - Quartz-tourmaline-ankerite vein with minor pyrite. Chip sample from Espelid area.

2110031 - Hydrothermally altered wall-rock amphibolite with pyrite. Chip sample from Espelid area.

2110032 - Silicified breccia with quartz and chlorite veinlets. Chip sample from Nytaul area.

2110033 - Quartz-tourmaline-ankerite vein with pyrite. Chip sample from Nytaul occurrence.


2110035 - Quartz-tourmaline-ankerite vein with pyrite and euhedral magnetite octahedrons. Chip sample from Nytaul occurrence.


2110037 - Quartz-hematite-sericite vein. From Nytaul area.

2110038 - Quartz-tourmaline-ankerite vein with minor pyrite. Chip sample from Nytaul occurrence.

2110039 - Coarse-grained hornblenditic amphibolite with disseminated pyrite. From Espelid-Nytaul area.

2110040 - Amphibolite with disseminated pyrite. From Espelid-Nytaul area.
2110041 - Amphibolite with disseminated pyrite. From Espelid-Nysetaul area.

2110042 - Amphibolite with disseminated pyrite and magnetite. From Espelid area.

2110043 - Altered amphibolite with calcite-pyrite-chalcopyrite veinlet. From Haugstøl area.

2110044 - Quartz vein with abundant chalcopyrite. Chip sample from Haugstøl area.

2110045 - Tourmaline-quartz-ankerite vein with chalcopyrite and pyrite. Chip sample from Haugstøl area.

2110046 - Quartz vein with abundant chalcopyrite and minor bismuthinite. Chip sample from Bleka area.

2110047 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110048 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110049 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110050 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110051 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110052 - Chlirite-calcite mylonite. From level 610 of Bleka mine.

2110053 - Ankerite-tourmaline vein with minor pyrite and chalcopyrite. From level 610 of Bleka mine.

2110054 - Quartz vein with minor tourmaline-ankerite-pyrite. Chip sample from level 550 of Bleka mine.


2110056 - Quartz—tourmaline-ankerite vein with pyrite and chalcopyrite. Chip sample from level 525 of Bleka mine.

2110057 - Quartz-tourmaline-ankerite vein. From Bleka area.

2110058 - Quartz-tourmaline-ankerite vein with pyrite, chalcopyrite and bismuthinite. Chip sample from Blengsdalen area.

2110059 - Hydrothermally altered wall-rock amphibolite with abundant pyrite and chalcopyrite. Chip sample from Blengsdalen area.

2110060 - Quartz-tourmaline-ankerite vein with chalcopyrite and bismuthinite. From Bleka main vein.

2110061 - Ankerite-tourmaline vein with late quartz veinlets with abundant bismuthinite and chalcopyrite. One grain of native gold (1.1 mm) was observed in the quartz. From Bleka mine dump level 560.
2110062 - Quartz-tourmaline vein with abundant chalcopyrite and visible gold. Three to four grains of gold were observed (max 1 mm). From Bleka mine dump level 585.

2110063 - Quartz vein with minor tourmaline and pyrite. Chip sample from Bleka area.

2110064 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bleka area.

2110065 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bleka area.

2110066 - Quartz-tourmaline-ankerite vein with minor pyrite and chalcopyrite. Chip sample from Bleka area.

2110067 - Hydrothermally altered wall-rock amphibolite with pyrite and chalcopyrite. Chip sample from Bleka area.

2110068 - Quartz-pyrite-tourmaline vein. From Bleka area.

2110069 - Quartz vein with abundant chalcopyrite and minor pyrite and bismuthinite. From Bleka area.

2110070 - Quartz-tourmaline vein. Chip sample from Bleka area.

2110071 - Quartz vein with minor feldspar. Chip sample from Bleka area.

2110072 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bleka area.

2110073 - Tourmaline-quartz-carbonate-pyrite veinlets. Bulk chip sample from Blegnedalen area.

2110074 - Amphibolite with coarse-grained tourmaline veinlets. From Blegnedalen area.

2110075 - Quartz-tourmaline vein with pyrite and chalcopyrite. From Blegnedalen area.

2110076 - Quartz-pyrite vein in quartzitic host rocks. From Nutheim area.

2110077 - Quartz-ankerite vein with abundant chalcopyrite-pyrite and minor galena and bismuthinite. Chip sample from dump at Sverveli occurrence.

2110078 - Hydrothermally altered wall-rock amphibolite with pyrite and minor chalcopyrite. Chip sample from Sverveli area.

2110079 - Quartz-ankerite vein with pyrite-chalcopyrite and bismuthinite. From main vein at Sverveli.

2110080 - Quartz vein with abundant pyrite and galena. From Sverveli area.

2110081 - Quartz-ankerite vein with chalcopyrite, pyrite and galena. From Sverveli area.
2110082 - Quartz-tourmaline vein with chalcopyrite, galena and bismuthinite? Chip sample from Suverelli area.

2110083 - Quartz-tourmaline vein with minor ankerite and pyrite. Chip sample from Steinsruddalen area.

2110084 - Tourmaline-quartz-ankerite vein with minor pyrite and chalcopyrite. Chip sample from Steinsruddalen area.


2110086 - Quartz-tourmaline vein with minor pyrite. Chip sample from Livsengåsen area.

2110087 - Quartz-tourmaline vein with minor pyrite. Chip sample from Livsengåsen area.

2110088 - Brecciated quartz vein with minor tourmaline. Chip sample from Ormemyre area.

2110089 - Chlorite schist with ankerite and chalcopyrite-pyrite veinlets. From Blengsdalen area.

2110090 - Quartz vein with pyrite. In amphibolite sill. From north of Seljord along E76.

2110091 - Quartz-tourmaline-ankerite vein with abundant pyrite and minor chalcopyrite. Chip sample from Reiustaulhaugen area.

2110092 - Tourmaline-quartz vein with pyrite. Fine tourmaline-quartz banding. Chip sample from Reiustaulhaugen area.

2110093 - Quartz-tourmaline vein with abundant pyrite. Chip sample from Reiustaulhaugen area.

2110094 - Quartz-tourmaline vein with abundant pyrite. Chip sample from Reiustaulhaugen area.

2110095 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiustaulhaugen area.

2110096 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiustaulhaugen area.

2110097 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiustaulhaugen area.

2110098 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reiustaulhaugen area.

2110099 - Quartz-tourmaline-pyrite vein. From Reiustaulhaugen area.

2110100 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiustaulhaugen area.

2110101 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Reiustaulhaugen area.
2110102 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110103 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110104 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reiuastaulhaugen area.

2110105 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reiuastaulhaugen area.

2110106 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110107 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110108 - Quartz vein with minor pyrite. Chip sample from Reiuastaulhaugen area.

2110109 - Quartz-tourmaline-pyrite vein. Chip sample from Reiuastaulhaugen area.

2110110 - Quartz vein with minor pyrite. Chip sample from Reiuastaulhaugen area.

2110111 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110112 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110113 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110114 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Reiuastaulhaugen area.

2110115 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reiuastaulhaugen area.

2110116 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reiuastaulhaugen area.

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2110120 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reiuastaulhaugen area.
2110121 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110122 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110123 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110124 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Reistaulhaugen area.

2110125 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

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2110132 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110133 - Quartz vein with minor tourmaline and pyrite. Chip sample from Reistaulhaugen area.

2110134 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110135 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110136 - Quartz-tourmaline vein with minor pyrite. Chip sample from Reistaulhaugen area.

2110137 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bølskveven area.


2110139 - Quartz vein. Chip sample from Bølskveven area.
2110140 - Quartz vein. Chip sample from Bølskveven area.

2110141 - Quartz-tourmaline-pyrite vein with minor chalcopyrite. Chip sample from Reistaulhausen area.

2110142 - Quartz-tourmaline-pyrite vein with minor chalcopyrite. Chip sample from Reistaulhausen area.

2110143 - Quartz-tourmaline-pyrite vein. Chip sample from Reistaulhausen area.

2110144 - Quartz vein. Chip sample from Nystaul area.

2110145 - Quartz-tourmaline vein with pyrite-chalcopyrite and bismuthinite? From Reistaulhausen area.

2110146 - Mylonitized amphibolite with pronounced epidotisation and chloritisation. Pyritiferous. Chip sample from Brekka Ytre along E76.

2110147 - Mylonitized amphibolite with pronounced epidotisation and chloritisation. Pyritiferous and calcite bearing. Chip sample from Brekka Ytre along E76.

2110148 - Mylonitized amphibolite with pronounced epidotisation and chloritisation. Pyritiferous and calcite bearing. Chip sample from Brekka Ytre along E76.
2110201 - Quartz-tourmaline-ankerite vein with minor pyrite. From Nystaul area.

2110202 - Quartz-tourmaline-ankerite vein with minor pyrite. Chip sample from Nystaul area.

2110203 - Quartz-tourmaline-ankerite vein with minor pyrite. From Nystaul area.

2110204 - Quartz-tourmaline-ankerite vein with pyrite and chalcopyrite. Chip sample from Nystaul area.

2110205 - Quartz-tourmaline vein. Chip sample from Nystaul area.

2110206 - Quartz-tourmaline vein with pyrite. Chip sample from Nystaul area.

2110207 - Hydrothermally altered wall-rock amphibolite with pyrite and magnetite. Chip sample from Nystaul area.

2110208 - Quartz-tourmaline vein with pyrite. Chip sample from Nystaul area.

2110209 - Hydrothermally altered wall-rock amphibolite with pyrite and magnetite. Chip sample from Nystaul area.

2110210 - Quartz-tourmaline-ankerite vein with pyrite. From Reiustaulhaugen area.

2110211 - Quartz-tourmaline-ankerite vein with pyrite. Chip sample from Reiustaulhaugen area.

2110212 - Quartz-tourmaline vein with pyrite and mica. From Reiustaulhaugen area.

2110213 - Quartz vein. From Bølskeveen area.

2110214 - Quartz vein with minor tourmaline-ankerite-muscovite and pyrite. From Bølskeveen area.

2110215 - Quartz-tourmaline vein. Chip sample from Bølskeveen area.

2110216 - Quartz vein with minor tourmaline. Chip sample from Bølskeveen area.


2110218 - Quartz-tourmaline vein. Chip sample from Bølskeveen area.

2110219 - Quartz vein with minor tourmaline. Chip sample from Bølskeveen area.

2110220 - Quartz vein with slickensides. From Bølskeveen area.

2110221 - Hydrothermally altered wall-rock amphibolite with slickensides. From Bølskeveen area.

2110222 - Quartz-tourmaline vein with pyrite and chalcopyrite. Boulder from Løvengåsen area.

2110223 - Quartz veinlets. Chip sample from Langedal area.
2110224 - Quartz-sericite-chlorite-pyrite vein. Chip sample from Skuevsvatn area.

2110225 - Quartz-tourmaline vein. Chip sample from Vrestebakken area.

2110226 - Quartz-tourmaline vein with minor pyrite. Chip sample from Mølledammen area.

2110227 - Quartz vein with minor tourmaline. Chip sample from Bølskueven area.

2110228 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Bølskueven area.

2110229 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bølskueven area.

2110230 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Bølskueven area.

2110231 - Quartz vein with minor ankerite. Chip sample from Bølskueven area.

2110232 - Quartz vein with minor tourmaline and sericite. Chip sample from Bølskueven area.

2110233 - Quartz-tourmaline vein. Chip sample from Bølskueven area.

2110234 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Bølskueven area.

2110235 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Bølskueven area.

2110236 - Quartz vein with minor sericite and ankerite. Chip sample from Bølskueven area.

2110237 - Hydrothermally altered wall-rock amphibolite with abundant pyrite. Chip sample from Bølskueven area.

2110238 - Quartz vein with minor tourmaline, sericite and ankerite. Chip sample from Bølskueven area.

2110239 - Quartz vein. Chip sample from Bølskueven area.

2110240 - Quartz-tourmaline-sericite vein. Chip sample from Bølskueven area.

2110241 - Quartz-tourmaline-pyrite vein. Chip sample from Bølskueven area.

2110242 - Quartz vein. Chip sample from Bølskueven area.

2110243 - Quartz vein with minor ankerite. Chip sample from Bølskueven area.

2110244 - Quartz vein with minor ankerite. Chip sample from Bølskueven area.

2110245 - Quartz vein with minor sericite. Chip sample from Bølskueven area.
2110246 - Quartz vein with minor sericite, chlorite and pyrite. Chip sample from Bølskveven area.


2110248 - Quartz vein with minor tourmaline. Chip sample from Bølskveven area.

2110249 - Quartz vein with minor ankerite and sericite. Chip sample from Bølskveven area.

2110250 - Quartz-tourmaline-pyrite vein. Chip sample from Bølskveven area.


2110252 - Quartz vein with minor tourmaline and sericite. Chip sample from Bølskveven area.

2110253 - Quartz-tourmaline vein with minor pyrite. Chip sample from Bølskveven area.

2110254 - Quartz vein with tourmaline and pyrite. Chip sample from Bølskveven area.

### APPENDIX II:

**ANALYSIS RESULTS - LITHOSAMPLES.**

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<th>SAMPLE NO.</th>
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<th>Cu PPM</th>
<th>Pb PPM</th>
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Indledning.

På basis af feltarbejde og påfølgende mikroskopering (Schenwanndt, 1983 & Schenwanndt, 1984) blev det besluttet at foretage en mindre feltaktion i 1984 med henblik på at etablere et lithogeochemisk kort over amfiboliten (malmzone-amfiboliten i tidligere rapporter) ved Hovin Kobberverk.

Idéen med at foretage den lithogeochemiske kortlægning var primært:
i) At forsøge at verificere det på gamle analyser etablerede Cu-anomalimønster i amfiboliten (kort 4 i Schenwanndt, 1983).

ii) at undersøge om amfiboliten ved Hovin Kobberverk var anormal i metal-indhold set i forhold til de omkringliggende amfiboliter.

I anden række at få bragt klarhed over feldspat-porfyrens relation til amfiboliten, idet mikroskoperingen havde sandsynliggjort, at denne bjergart ikke havde det i feltrapporten (Schenwanndt, 1983) foreslåede slægtskab til amfiboliten.

Geologisk kortlægning.

Den detaljerede kortlægning har vist, at de tidligere 3 amfiboliter omkring Hovin Kobberverk (malmzone-amfiboliten(estligst), Næstvolle-amfiboliten og imprægnerings-amfiboliten(vestligst)) udgør én og samme amfibolit (fig. 1). Amfiboliten, der ligger i en kvartsit sekkens, er isoklinalt folde og har form som en zik-zak fold.

Alle målte småfolder her et N-3-gående aksialplan, der holder steljt mod øst (ca. 85°) og en mod nord dykkende (ca. 30°) folieakse. På basis af småfolderne må man formode, at zik-zak folden består af en østlig og en vestlig antiform med en mellemliggende synform.

Amfiboliten varierer i bredde fra 1-15 m og op til ca. 50 m. Umbøjningen i den østlige og vestlige anti-
form ligger henholdsvis 1100 m og 800 m i strøgretning fra finnsjøen (fig. 1).
Den resterende del af zik-zak folden domineres af den melanokratiske biotit-gneis, der dog stedvis bliver mindre melanokratisk. I den sydligste del af zik-zak foldens vestflanke bliver amfiboliten igen den dominerende bjergart.
Den eneste bjergart inden for amfiboliten, der klart skiller sig ud er dioriten i dagbruddet Storekaas' østlige del. Dioriten fører, som tidligere omtalt (Schøn-wandt, 1983 &1984), disseminert chalcocit og bournit. Til trods for at dioriten fører disseminerede sulfider svarende til ca. 1,5 Cu og ca. 100 ppm Ag, så er denne bjergart ikke blevet betragtet som malm, de brydning fundet sted i århundredets begyndelse, idet bjergart i det store og hele er blevet lidt tilbage i dagbruddet.
Dioriten skønnes at have udgjort et ellipseformet areal med en storakse på ca. 20 m og en lilleakse på ca. 7-8 m. Storøksen i ellipse strækker næsten N-S og er således konform med amfiboliten. Dioriten er i kontaktzonen til amfiboliten kraftig smækket og fører et gneisagtigt utseende. Dette medfører, at der er en giangre overgang mellem den gneisagtige diorit og den smækkede amfibolit, men en svag kontakt ved den smækkede stedlig del, hvor begrensset yderligere
information om relationen mellem amfiboliten og dioriten.

Ån fornyet undersøgelse af de to feldspat-porfyrr lokaliseter i det stærkt overdækkede område nord for digbruddet har sandsynliggjort, at det drejer sig om løsblækk.


Dioriten i Storekaas baggrund skiller sig ud fra de andre bjergarter i amfibolitkomplekset ved bl. a. strukturelt ikke at være konform med amfiboliten i mesoskala, hvorimod den i landstyxskala er konform med amfiboliten på grund af kontakt-zonens sterke shear deformation.

**Lithogeochemi.**

Der blev indsamlet 27 chip samples riseligt jvnt fordelt over det zik-zak foldede amfibolit. Uropekterne er markeret med en prik på fig. 2, men repræsenterer, i den udstrækning blottilapgraden tillod, et tværprofil af amfiboliten. I alle chip samples er geo-kemiske mineralisering i form af kvartsudviklet overs. I ekstermertonen varierer det afhængig af amfibolitten af de og/eller blottilapgradation af ca. 1 til 3 kg. Vær forvaret, at disse er beregnet på principiel analyse afstøningsstof til analyse procedurer for lithogruver og prøv ved
er blevet analyseret for Cu og Ag (tabell 1).

Fig. 5 viser Cu-analysen plottet på sandsynligheds-
papir. Den beskeden prøveningsde teget i. betragtning, så kan plottet tolkes som repræsentende to lognormale
fordelinger. Der er her valgt at lade de to bjærgninger
i kurveforløbet ved 80 og 1400 ppm Cu representere
henholdsvis tæskeværdien for amphibolitens normale
Cu-indhold og den nedre grænse for hvad der kan
betrægtes som diorit-mineraliseringen og dens umid-
delede mineraliserings-aureole. Værdierne mellem
80 og 1400 ppm repræsenterer i bredere forstand den
mineraliserings-aureole, der ligger omkring dioriten.

Værdierne på 80 og 1400 ppm svarer til henholdsvis
70% og 90% fraktion. Den fundne baggrundsverdi for
Cu i amphiboliten svarer til nivæuet i tilsvarende
bjærgarter andre steder.

Chip sample analysen af dioriten (større end 100 ppm Cu og
85 ppm Ag) svarer til hvad man kunne forvente på
basis af tidligere analyser af godt mineraliserede
enkelt prøver. Vigtigt i denne sammenhæng er også
at analyseresultatet bekræfter den tidligere på-
pægede korrelation mellem Cu- og Ag-indholdet i
calccosit-bornit paragenessen (Schonwandt, 1983).

| Prøve nr. | ppm Cu | ppm Ag | | Prøve nr. | ppm Cu | ppm Ag |
|----------|-------|-------| |----------|-------|-------|
| 110570   | 360   | 1     | 110571 | 27    | 1     |
| 110572   | 10000 | 86    | 110573 | 1080  | 8     |
| 110574   | 80    | 1     | 110575 | 125   | 1     |
| 110576   | 31    | 1     | 110577 | 125   | 1     |
| 110578   | 53    | 1     | 110579 | 20    | 1     |
| 110580   | 150   | 1     | 110581 | 50    | 1     |
| 110582   | 100   | 1     | 110583 | 20    | 1     |
| 110584   | 50    | 1     | 110585 | 150   | 9     |
| 110586   | 50    | 1     | 110587 | 150   | 9     |
| 110588   | 50    | 1     | 110589 | 40    | 1     |
| 110590   | 40    | 1     | 110591 | 40    | 1     |
| 110592   | 25    | 1     | 110593 | 10    | 1     |
| 110594   | 50    | 1     | 110595 | 10    | 1     |
**Fig. 3.** For nærmere forklaring se tekst.
Indsatsresultaterne er plottet på kort (fig. 2). Kortet viser fordelingen af prøverne over 1400 ppm Cu (svarende til mere end 90.6 fraktionen) og oven i 1400 og 85 ppm Cu (svarende til 90.4-70.4 fraktionen) samt prøver med et Cu-inhalte under 80 ppm (svarende til omfribolitens omdrivende grundstof). Grænsedragningen mellem de forskellige Cu-intervaller er fundet ved lineær interpolering.

Af det lithologiske kort fremgår, at der ind i for sik-zak foldens østlige flanke findes to normale områder i) et mod syd omkring store kældrag og ii) et mod nord omkring have stollen. Begge anomaliområder er bygget op af flere normale prøver og i mod til-følde er anomaliområdet svagt opbygget med de højeste værdier i den centrale del af anomalien. For det nordlige anomaliområdet vekker en sik-zak anomali sig også over på den østlige antiforms østlige flanke.

Det lithologiske kort (fig. 2) verificerede de to anomaliområder omkring store kæder og have stollen, som var blevet etableret på basis af gamle analyser. Siden kunne det tredje anomaliområde (se fig. 4 i chemo- udfart, 1965) ikke bekæmpes. Det lithologiske kort viser også, at omfriboliten i sik-zak foldens østlige flanke (tidligere rapporteret miks-skafbolit) ikke er normal i omfriboliten set i forhold til omfriboliten i den øvrige del af sik-zak folden. Indvist i, at anomaliområderne oplyser om udefinere parti- inden for en i Cu-indholdt evrigt normal omfribolit. Dette lithologiske lilleområder viser flere anomalier, der anføres til anomaliområdets mineralilderringsmønster (chemo- udfart, 1965).

Det fremgår af de ovenstående detaljer, at det er vigtigt at udvikle et systematisk forsøgstagelse for at sikre bestemte normale prøver i deres rel. positioner i hoved og anomaliområder.

Indsatsresultaterne og en kort areal analyse,
at chalcocit-borait findes dissemineret i dioriten og
at denne mineralisering er omdøvet af en epigenetisk
mineraliseringssærede uvis paragenese andre sig mod
afstanden fra dioriten. Dermed dioriten består
paragenesen af bornit-chalcocit, dernæst kommer en
zone med bornit-kobberkis og yderst en ren kobberkis
paragenese. Mineraliseringerne er næsten hundrede
procent knyttet til affibolit komplekset.

Der må præcisdimensioneret omkring Storekaas (fig. 2)
så viser det, at anomali er trukket ud i sydlige
retning. Denne skævhed kan have mange årsager, som f.eks.
i) at den epigenetiske mineraliseringssærede ikke
er koncentrisk omkring primemineraliseringen
(dioriten)
ii) at en begrensnet præciserside-komponeret med at
linjefungeringen har været anvendt ved grense-
dragningen mellem de forskellige (u-intervaller
iii) en topografieeffekt d.v.s. primemineraliserings
forløb i forhold til terrennet.

Det kan forestille sig andre årsager, men de nævnte
eller en kombination af disse skænhed at have været
en determined årsag til skævheden i anomaliemonsteret.

For at variere disse faktorer er der fremsat et
N-orienteret profil i aflæsningen fra Tunøen til liit
nord for Storekaas (fig. 4). I dette profil er vist
udstrekningen af de lithogigamiske særbeletter samt (u-
profilet i gennem disse forbinder. Anvinderes er vist stäl-
ler og tvevslag fra 154 m, 77 m samt 515 m niveauerne.

Sammebehold er men de gode (u-analysis fra staller og
tvevslag (schmelzt,ley 3 fig. 3) med de funne litho-
geoamaskiske særbeletter, at først med instruktet af at
arbejde med at et øje for øje. Ikonisk er så at så det
i det sydligste område i 77 m niveauen er stærke,
at de gavn kunne repræsentere den mineraliserede diorit.
Fig. 4. For nærmere forklaring se tekst.
Det skal her imidlertid, at de gamle analyser fra støller og tverslag (fig. 3 i Schouwmest, 1935) viser højere verdier, end de der er fundet ved denne undersøgelse. Dette hænger-formsådant ligge sammen med, at epigenetiske årer bevidst er undgået i denne undersøgelse. Han kan derfor ikke bruge de gamle analyser til at komplimenterere denne undersøgelses aureolemønster med. Imidlertid må så store verdier, som det sydligste tverslag i niveau 774 m viser, enten henføres til dioriten eller til en usædvanlig stor koncentration af epigenetiske årer.

Diskussion.

Med de oplysninger der på nuværende tidspunkt er tilgængelig så er det muligt, at dioriten har det med sydøksende forløb som der indikeret med A på fig. 4. Et sådant forløb af dioriten vil i meget høj grad give en tilfredsstillende forklæring på det fundne aureolemønster, når man tager topografiens og prægpunkterne i betragtning.

Det kan imidlertid ikke udelukkes at dioriten har det med B indikerede forløb. Et sådant forløb, med stejlt dyk mod nord, vil imidlertid ikke imidlertid kunne forklare aureolemønsteret uden samtidig at acceptere en relativ stor priser skævhed i dette mønster.

Det samme problem vil man også ind i, hvis man antager at dioriten er et meget lokalt fenomen, der ikke strækker sig mange 10-tals meter under overfladen.

Et relativt fladt dyk af dioriten mod nord, vil også kunne forklare aureolemønsteret, over som samtidig antager, at dioriten i øvrigt støder op en lille rest af et større dioritfelt, der i en stor og inde en sort stedet, som i niveau 764 ikke til for dioriten at foretage skævt i mere.

Alle dage at det er ingen for den stillinger i forklaringen, at dioriten ligger i kontakt med b. til imidlertid, at det i virkelighed er en så vel
flanke, der er intet der tyder på, at dette ikke skulle være tilfældet. Denne specielle position kan imidlertid forklares på idet mindste to måder:

i. Dioriten, der som tidligere omtalt petrografisk er mest beslagtet med amfiboliten, kan være et differentiat af amfiboliten efter dens enplacering. Dette vil, amfibolitens størrelse taget i betragtning, resultere i en meget beskedet størrelse af dioriten.

ii. Dioriten repræsenterer en selvestandig intrusion, men fra det samme magmakammer. Denne mulighed vil kunne give en betragtelig størrelse på dioriten.

Størrelsen på den lithogeochemiske aureole tyder på, at dioriten har/eller har haft en betragtelig størrelse, hvorfor det er mest sandsynligt at dioriten repræsenterer en selvestandig intrusion.

Forløbet af denne intrusion set i lyset af aureolemønsteret, kan enten være et relativt fladt dyk mod syd eller nord. Er dykket forløbet mod nord, så må hovedparten af dioriten være bort-eroderet. Har dykket været mod syd, så har dioriten formodentlig et forløb her det, der er indikeret med A på fig. 4.

Konklusion og omstilinger.

Den lithogeochemiske undersøgelse tyder på, at dioriten repræsenterer en selvestandig intrusion, der er mest beslagtet med amfiboliten. Det er mest sandsynligt at dioriten har et dyk mod syd nogenlunde svæveende til det, der er indikeret med A på fig. 4. Er fladt dyk mod nord er mindre sandsynligt på grund af de høje Cu-verdier i en sydlig tverslag i nivea af 374 m.

En mere detaljeret lithogeochemisk undersøgelse på oversflæken vil sandsynligvis give en større u-sel

med over dioriten foruden, at de i den enoplacering som diorit, fremstår, der påvirker det med en del "geochemical signal" og selv fordi stødningerne er rent ringe.
Det kan derimod anbefales:

at foretage en kortlægning og prøveindsamling af niveau 274 m. Ådgøring til niveauet vil formodentlig kunne ske gennem skråten i Storekaas dagbrud. Niveau 274 m ligger ca. 34 m under dagbrudsniveauet.

at det overvejes hvilke geofysiske metoder, der bedst vil kunne afsløre om diorit en har det med A indikerede forløb i fig. 4.

at økonomiske overslag foretages på basis af en malmværdi på 1,6 Cu og 90 ppm Ag med henblik på at få en minimums størrelse på malmen. Dette tal bør indgå i de geofysiske overvejelser.

Når prospekteringsafdelingen medarbejdere har foretaget de geofysiske og økonomiske overvejelser vil det være nensigtsmæssigt, at der i fællesskab udarbejdes et notat vedrørende disse overvejelser.

Referencer.


marts-85

mns@j postirkustaincnschønwandt
Nuten Cu-Bi skjerp.

Beliggenhed.

Nuten Cu-Bi skjerp ligger ca. 500 m SØ for Neshaug gård ved Hjartsjå på kartblad Flatdal (1614 III) i l:50000, UTM-koordinater (8635,0725). Yderligere 500 m SØ for Nuten er registreret et skjerp (Bergstul), som har været skjerpet på Cu. Bergstul skjerp blev ikke lokaliseret, men ved lokaliteten UTM (8665,0725) (se kort) blev observeret en mineraliseret kvartsære med orienteringen N 50°/85°, som blev forkastet af en mineraliseret sprække med orienteringen N 15°/15°. Denne lokalitet formodes at ækvivalere Bergstul efter de beskrivelser der forelå. Nuten skjerp nås ved at dreje til venstre ad vejen ved savværket ca. 200 m øst for Hjartsjå gård i den østlige ende af Hjartsjå. Derefter fortsættes 200 m ad vejen til den deler sig. Af den vej der går til højre fortsættes 1350 m til vejen i 350 moh deler sig: I T-krydsets SV-lige hjerne findes skjerpet, som måler 2x3 m i overfladen og 1-1\frac{1}{2} m i dybden.

Geologisk beskrivelse.

Nuten Cu-Bi skjerp sidder i en o,5-3,5 m tyk kvartsgang 350 moh i et topografisk markeret skar med samme orientering som kvartsgangen: N 82° (se kort). Området består geologisk af metasedimentære bjergarter tilhørende Rjukan og Seljord gruppen (skillelinien mellem de to grupper formodes at ligge indenfor de samme horisonter som kvartsgangen er afsat i). Stratigrafisk nedefra og op er der i området først afsat (se kort og skitse) en rhyolitisk bjergart derpå er afsat o,1-l m tyk basalt. Denne er overlejret af 1-2 m tyk rhyolit, hvorpå er afsat en ny basaltisk lava, denne er i toppen brecciert af en ca. 0,5 m tyk rhyolit som i kontakten til de basaltiske xenolither får et storkornet amphibolitisk udseende, idet rhyoliten assimilerer basaltisk materiale. Denne

Denne metasedimentære lagpakke er først intruderet af en granitisk bjergart, som indenfor det undersøgte område er set med både vandrette og lodrette kontakter til de omgivende bjergarter. Denne mellemkornede rød/grønplettede granit formodes derfor at udgøre toppen af et granitisk legeme. Op gennem disse bjergarter er intruderet en 0,5-3,5 m tyk kvartsgang som stryger N 82° og står subvertikal. Kontakten til de omgivende bjergarter er ikke skarpt diskordant, men nærmest migmatitisk af udseende. De omgivende bjergarter er stærkt omdannede og sheared i kontakten til kvartsgangen. Således optræder graniten som grøn augengnejs (2110313) med chlorit langs shearflader i en 1-2 m tyk zone nær kvartsgangen, bjergarten er desuden silicificeret i kontakten (0,1-0,5 m til kvartsgangen. Den rhyolitiske bjergart er i lighed med graniten shearet og silicificeret i en zone nær kvartsgangen. Langs shear- og sprækkeflader er afsat chlorit og af og til ses også chalcopyrit.

Mineralisering.


Udført arbejde.

Der er i området omkring Nuten udført geologisk kortlægning (se kort) samt insamlet 9 lithoprøver deraf 5 chipsamples af både kvartsgangen og sidestensomdannelser. I området ved Bergstul er insamlet 2 mineraliserede lithoprøver. Ved Nuten er desuden insamlet 2 geokemiske prøver fra bække, som drænerer kvartsgangen i hele dens længde. De 2 prøver udgøres af et bækkesediment og en vaskeprøve.
HISTOGRAM: FORDELING AV VERDIER FOR AU I TELEMARK
ANTALL PROVER: 869
PROVETYPE: BEEKSED.
DETEKSJONSGRENSE: 20 ppb
LABORATORIUM: CALIB.

PROVE FORDELING:

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  Samples represented - 2110076.

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