NGU Report 96.155

Geology of the Kjøkkenbukta orebody, Bleikvassli Gruber, Nordland, Norway

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Geological Survey of Norway
P.O.Box 3006 - Lade
N-7002 Trondheim, Norway
Tel.: 47 73 90 40 11
Telefax 47 73 92 16 20

REPORT

Report no.: 96.155	ISSN 0800-3416	Grading: Open

Title:
Geology of the Kjøkkenbukta orebody, Bleikvassli Gruber, Nordland, Norway

Authors: Gleb V. Moralev, Terje Bjerkgård, Rune B. Larsen	Client: AS Bleikvassli Gruber
County: Nordland	Commune: Hemnes
Map-sheet name (M=1:250.000) Mosjøen	Map-sheet no. and -name (M=1:50.000) 1926 I Røssvatnet
Deposit name and grid-reference: Bleikvassli, UTM 449040 7312080 - zone 33	Number of pages: 33 Price (NOK): 195 Map enclosures: Five

Fieldwork carried out: April, May 1996	Date of report: April 1997	Project no.: 2543.29	Person responsible:

Summary:
The aim of the present study was to obtain more data regarding geological relations between the massive sulfide ore and wall rocks, especially the microcline gneiss, the genesis of which is a subject of discussion. Another objective was to get more data about the distribution of gold in the ore and wall rocks. The choice of mapping target was influenced both by geological relationships and interests of the mining company. Mapping of the mining level 290 meters above sea level (m.a.s.l.) was completed during two weeks in April and May, 1996. Both walls and roof along 190 m of the underground workings were mapped in the scale 1:100. The working faces of the drifts and some interesting localities on the walls were mapped in approximately the scale 1:50. The contact between the NNW part of the ore zone in the Kjøkkenbukta orebody and the microcline gneiss body is discordant and the microcline gneiss is wrapped around the ore zone. The relationship between the microcline gneiss and the surrounding mica schist is complicated by superimposed tectonic events. A single observation of an angular unconformity between the schist and microcline gneiss can be interpreted in two ways: either as a primary intrusive, or a tectonic contact. Massive ore and wall rocks in the NNW ore zone have discordant relationships to each other, and the ore cuts through schistosity and the hinge zones of small F_3 folds. This is probably a result of tectonic emplacement of the ore along a shear zone. Microscopic recognizable native gold or electrum have not been found in the massive ore of the Kjøkkenbukta orebody. This is in agreement with previously obtained data for the Bleikvassli deposit in general (Moralev et al., 1995). Native gold and electrum have been found in veinlets of remobilized ore and deposition of gold and electrum can be correlated temporally with carbonate-chlorite veinlets.

Keywords: Ore geology	Bleikvassli Pb-Zn deposit	Gold
Structural geology	Microcline gneiss	Scientific report

CONTENTS

INTRODUCTION.......... 4

GEOLOGY.......... 5

ROCK AND ORE TYPES.......... 5

DETAILED OBSERVATIONS.......... 12

The SSE drift. *12*

The junction between the SSE and NNW drifts. *14*

The NNW drift. *16*

OCCURRENCES OF GOLD. 22

CONCLUSIONS.......... 26

REFERENCES.......... 27

APPENDIX

Appendix 1: 1/1, 1/2, 1/3. Map sheets in the scale 1:100 for the junction between SSE and NNW drifts in Nisje 10/7.

Appendix 2: 2/1 and 2/2. Map sheets in the scale 1:100 for the NNW drift in Nisje 10/7.

Appendix 3: Structural observations presented in stereographic diagrams (Schmidt net - projected to lower hemisphere)

INTRODUCTION

The Bleikvassli deposit is hosted by the Kongsfjell Group, which is a part of the Rödingsfjäll Nappe Complex (Fig. 1, 2). The deposit comprises a number of massive sulfide lenses which can be grouped in three main parts: the southern (Hovedmalmen), northern (Nordmalmen), and northernmost part which is called the Kjøkkenbukta orebody (Fig.3).

The position of the massive ore within the Bleikvassli mine is controlled by the "primary" stratigraphy and is complicated by several stages of folding and high grade metamorphism (Vokes, 1963, 1966).

The structural footwall of the massive ore is commonly comprised of microcline gneiss. Some bodies of microcline gneiss are also present in the hangingwall of the ore zone. This rock type was suggested to be a metamorphosed, primary potassium alteration halo in the primary footwall of the massive ore by Skauli (1993). Later, the microcline gneiss has been interpreted as an intrusive syenite body that was emplaced later than the formation of the massive ore, but before the main Caledonian deformation and metamorphism (Larsen et al., 1995).

The aim of the present study was to obtain more data regarding geological relationships between the massive sulfide ore and wall rocks, especially the microcline gneiss. Another objective was to get more data about the distribution of gold in the ore and wall rocks.

Preliminary data had been obtained in 1995 (Fig. 4, 5) from the mining level 290 m.a.s.l. in the Kjøkkenbukta orebody. Mapping of this level was completed during two weeks in April and May, 1996. The choice of the 290 level as the mapping target was influenced by:

(1) geological relationships, (2) interest of the mining company because the production had commenced in this part of the deposit[1], and (3), water supply for cleaning of the underground workings.

Both walls and roof along 190 m of the underground workings were mapped in the scale 1:100 (Fig. 6 and Appendix 1/1-3 and 2/1-2). The working faces of the drifts and some interesting localities on the walls were mapped in the scale 1:50 (Fig. 6 and 7). Thirty-five samples were collected for the microscopic control of the ore and for classification of the wall rocks.

GEOLOGY

Rock and ore types.

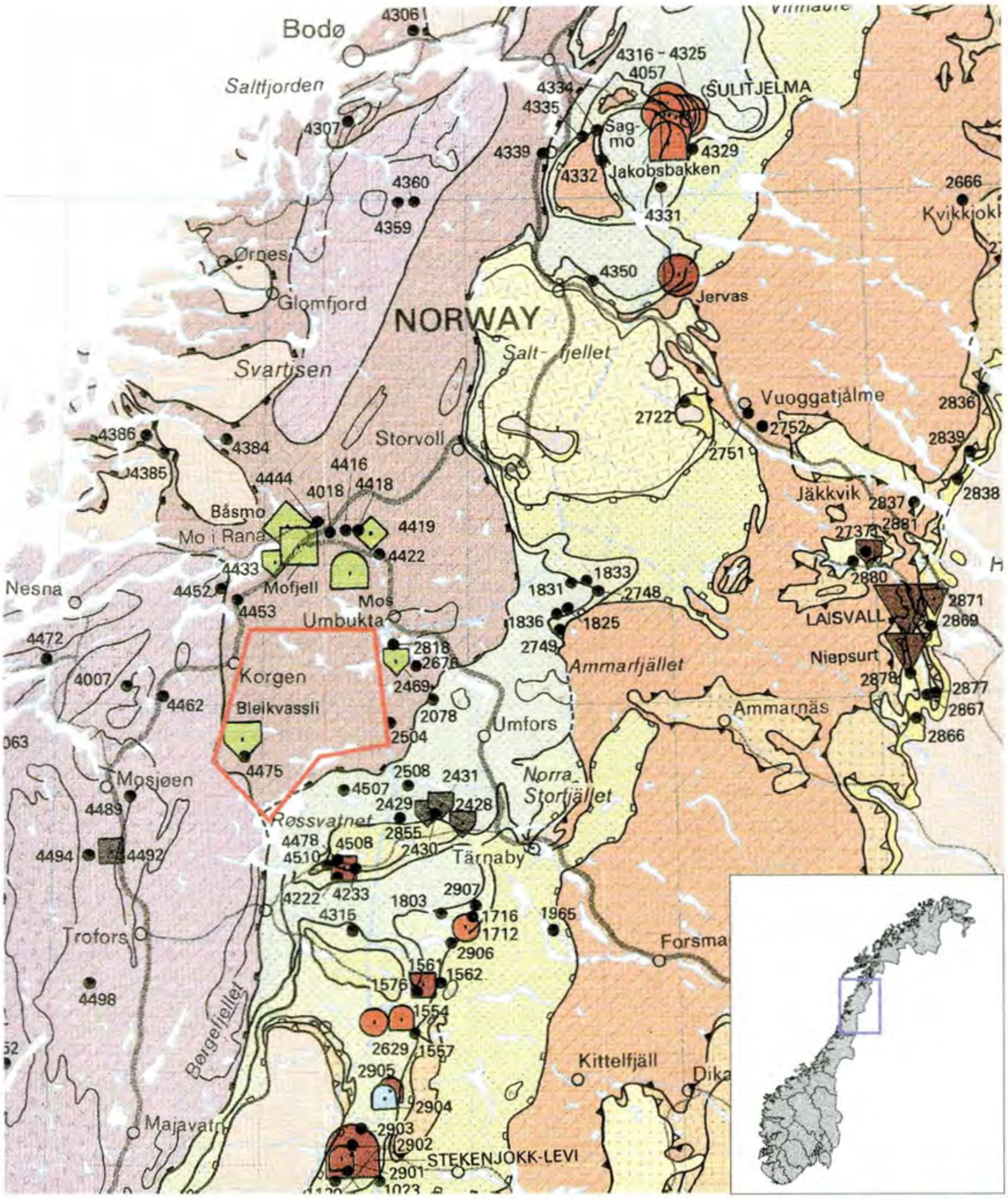
Main rock types adjacent to the orebody are microcline gneiss, two-mica schist (muscovite, muscovite-phlogopite and muscovite-phlogopite-biotite bearing varieties), quartzite and «quartzite-like» rocks. The «quartzite-like» rocks are composed of potassium feldspar, plagioclase and quartz with subordinate mica and sulfides, especially pyrite.

Distinction of the ore types was based upon the classification of Vokes (1963): Massive pyrite ore, massive pyrrhotite ore, mobilizate type veinlets and mobilizate type disseminated sulfide mineralization enriched in galena, fahlore and sulfosalts. In addition, it was possible to distinguish biotite-pyrrhotite tectonites as well as two varieties of the massive pyrite ore.

The massive pyrite ore was divided into two subtypes: coarse grained pyrite ore and medium grained, banded pyrite ore. Coarse grained pyrite ore is composed of large pyrite cubes (up to 2-3 cm in size) that occur in a pyrrhotite-rich matrix with subordinate sphalerite, galena and minor chalcopyrite. This ore type contains numerous rounded fragments of the wall rocks. This "durchbewegung" is a characteristic texture and is always present (Fig. 7, 8).

---

[1] As a result of mining the geological work at the underground workings became somewhat difficult due to the heavy traffic and air pollution after the diesel engines.



(from Zachrisson 1986)

Fig. 1. Geographic and tectonostratigraphic setting of the Bleikvassli deposit in the Rödingsfjäll Nappe Complex (brown color). The position of Fig. 2 is outlined.

Medium grained banded pyrite ore contains much smaller pyrite crystals (3-5 mm in the largest dimension) set in a sphalerite-rich matrix. A banded structure is marked by sphalerite-rich and sphalerite-poor bands commonly running parallel to the contacts of the ore body (Fig. 7, 8).

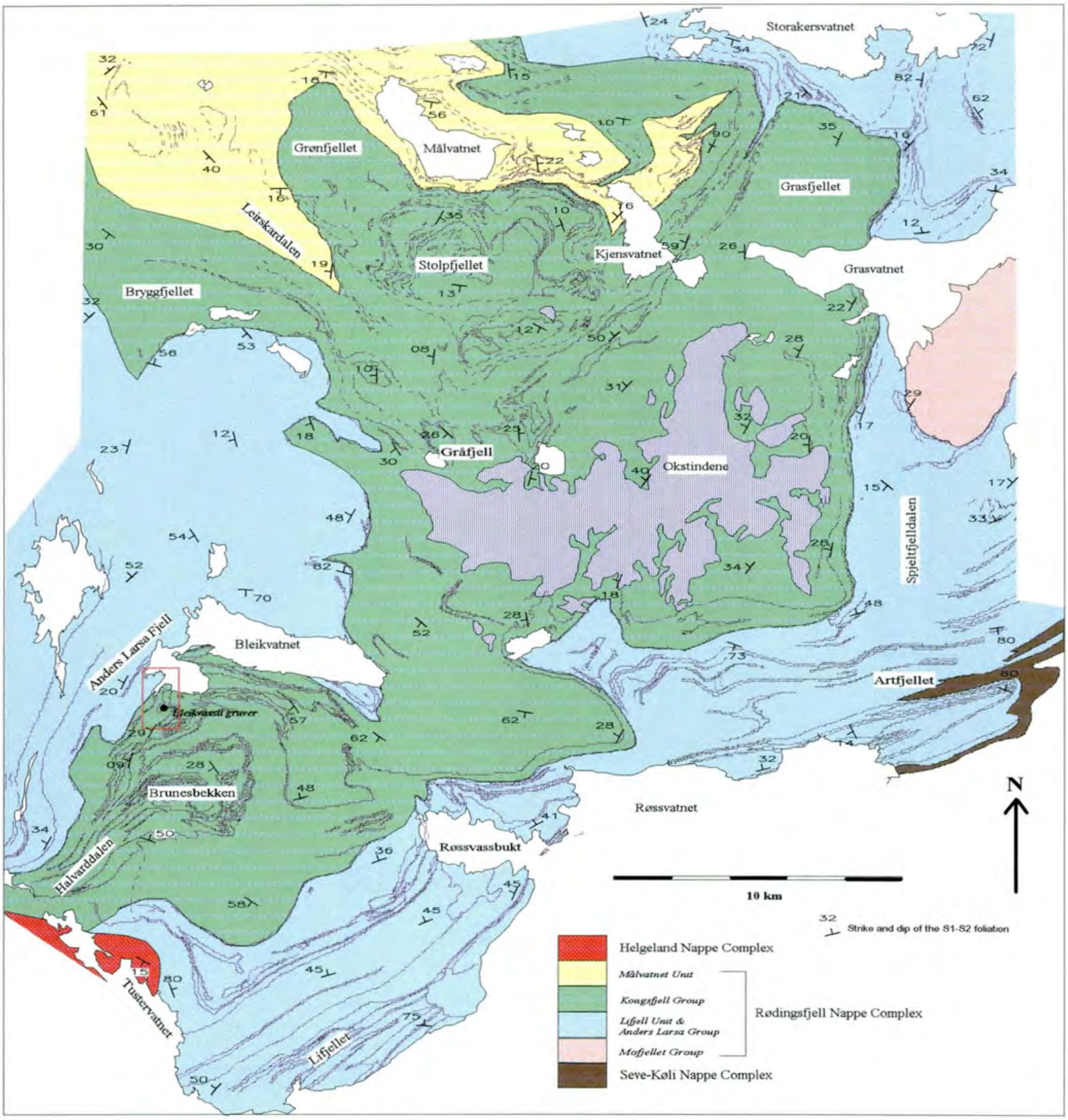


Fig. 2. Geological map of the Bleikvassli region (from Bjerkgård et al., 1995) The position of fig. 3 is outlined.

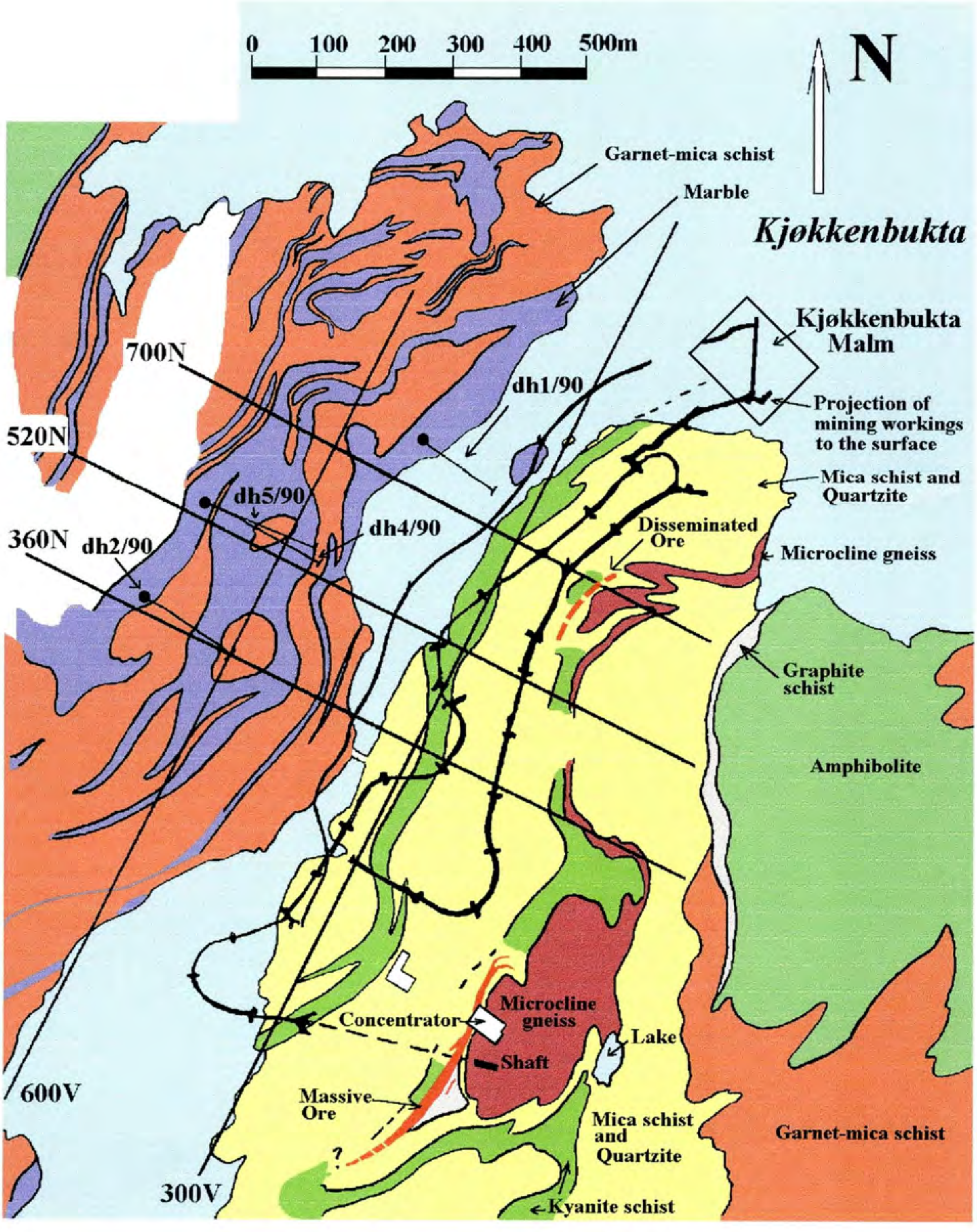


Fig. 3. Geological map of the Bleikvassli deposit (simplified from I.Rui, 1991). The box outlines the studied part of the Kjøkkenbukta orebody projected to the surface.

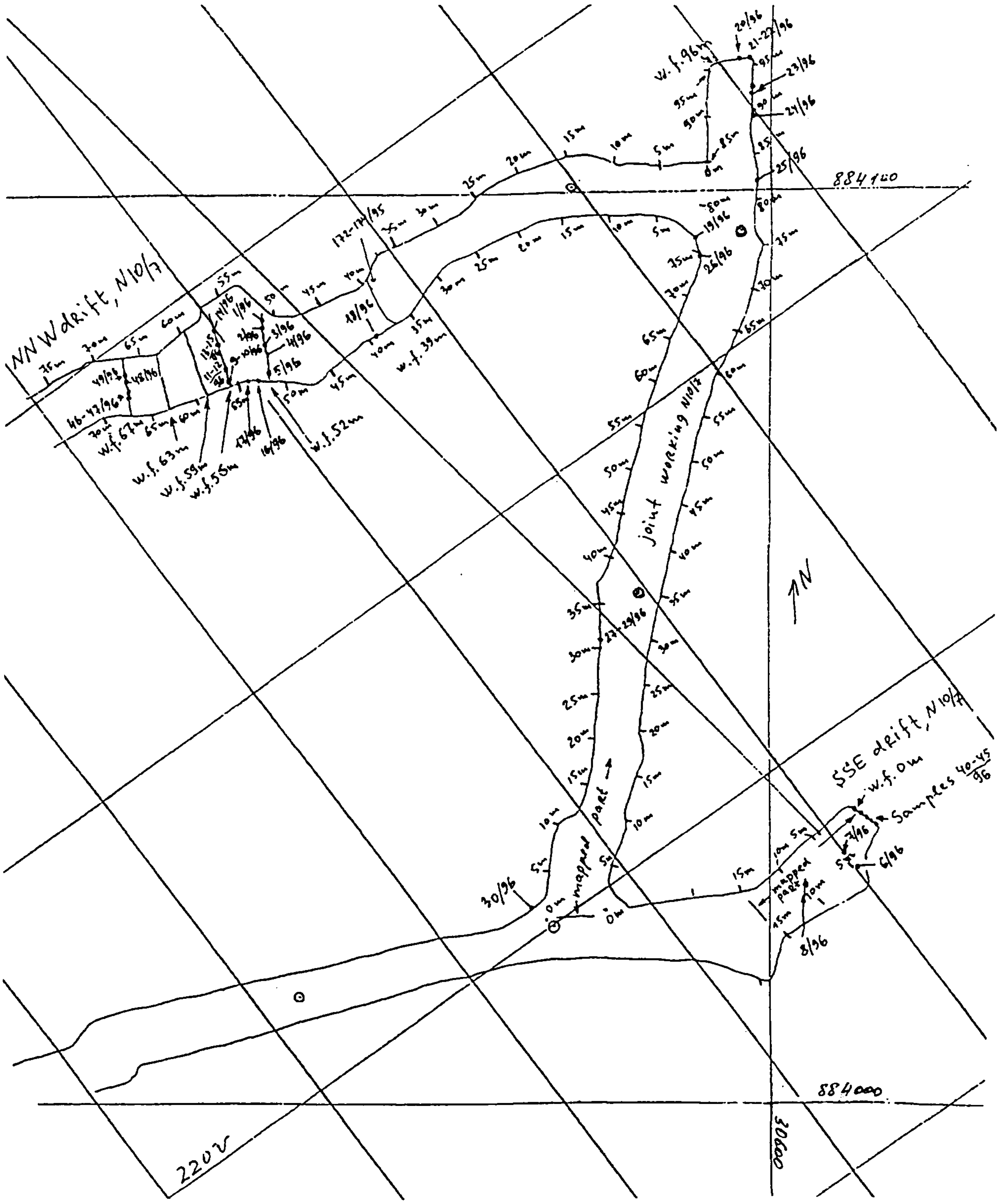


Fig. 4. Topographic map of the mining level 290 m above sea level (Nisje 10/7) in the scale 1:500 with location of the mapped workings, working faces, and sampled points.

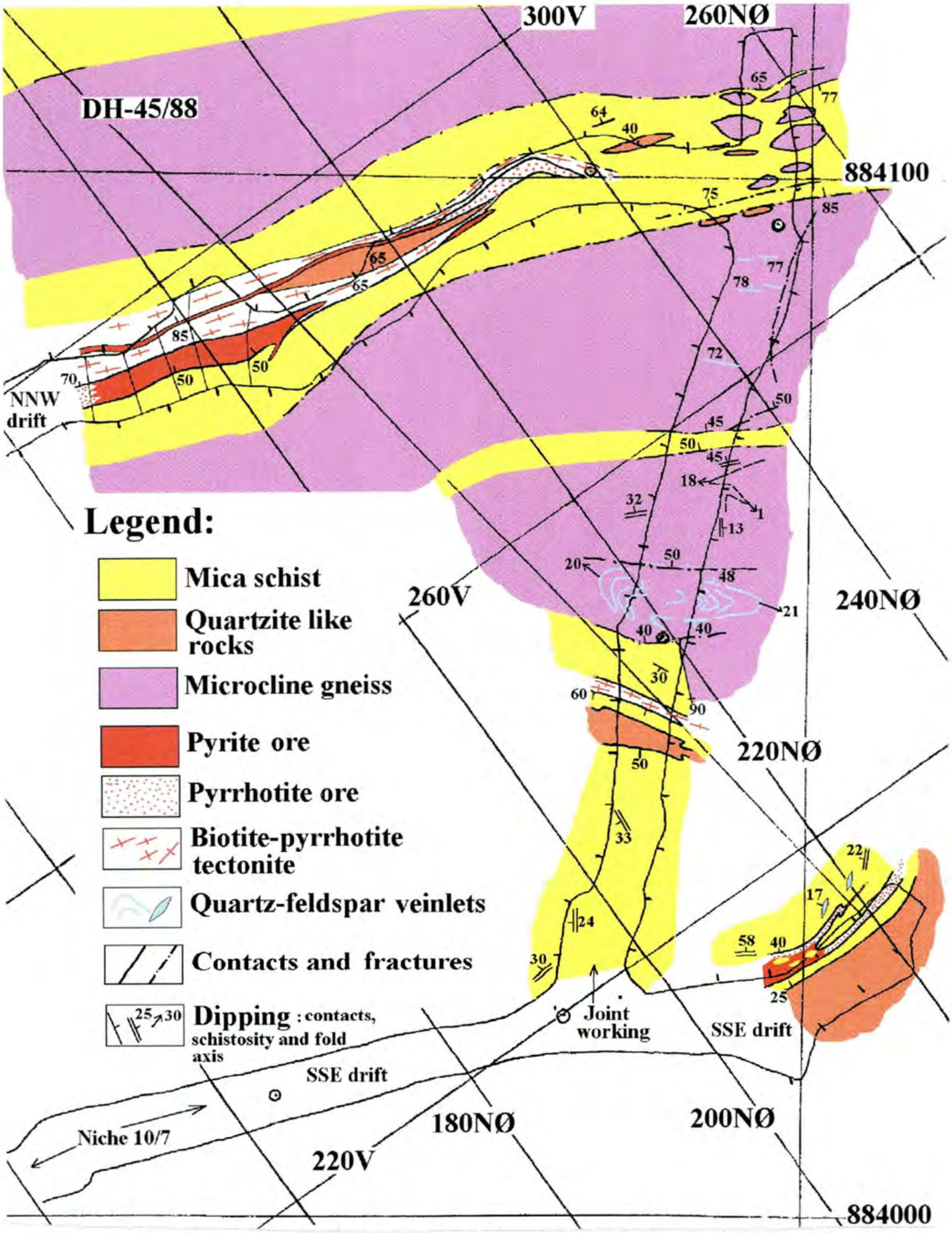


Fig. 5. Geological map of the Kjøkkenbukta orebody, level 290 m.a.s.l. Distance between NW-SE profiles (marked by NØ) is 20 m, and the distance between NE-SW profiles (marked by V) is 40 m. Note: the position of the ore-wall rock contacts was projected along its dip from the roof of the workings to an elevation 1.5 m above the floor of the workings, following the practice of the mining company. There is also a 5 m shift to the NW in the position of the same rock contacts on this map and along the drill hole 45/87 due to deviation of the drill hole.

Pyrrhotite ore can also be subdivided into two subtypes: pyrrhotite ore with "durchbewegung" texture and biotite-(chlorite)-pyrrhotite tectonites.
Pyrrhotite ore with "durchbewegung" texture was first described by Vokes (1963). Biotite-pyrrhotite tectonites are widespread not only in the Kjøkkenbukta orebody, but also in other parts of the Bleikvassli mine. This sub-economic ore type contains 5 to 30 vol.% of pyrrhotite and approximately 50 vol.% of phlogopite and/or later formed chlorite (Fig. 10). Large crystals of garnet are common and comprise up to 10 vol.% of the rock. Tourmaline was occasionally recognized in this oretype in the southern part of the Bleikvassli deposit. Chalcopyrite is the most common sulfide next to pyrrhotite. Sphalerite and galena are also present, but are usually not seen in a hand specimen. The biotite-pyrrhotite tectonite has a strongly developed schistosity and «durchbewegung» with pyrrhotite and mica wrapped around rounded fragments of wallrocks is often present. Biotite-pyrrhotite tectonites are clearly related to the pyrrhotite ore and are interpreted to represent a strongly deformed variety of the pyrrhotite ore.

Mobilizate type mineralization includes veinlets and disseminations enriched in galena, fahlore and sulfosalts of Pb-Cu-Sb-As-S composition.

So-called alpine-type lenses and veinlets composed of potassium feldspar and/or quartz, seem to have formed before the mobilizates. These were followed by later chlorite-carbonate bearing veinlets which contain large crystals of pyrite and galena. Chlorite, galena and sulfosalts are found in disseminations around these veinlets and strongly suggest a close temporal relationships between mobilizate type sulfide mineralization and carbonate-chlorite veinlets.

Post-metamorphic, hydrothermal feldspar alteration of microcline gneiss, similar to that previously recognized in Nordmalmen (Moralev et al., 1995), is only locally present in the Kjøkkenbukta orebody. Two elongated bodies (3.7x0.6 m and 3.2x0.4 m in size) with this alteration were found in the roof and western wall of the junction between the SSE and NNW drifts (Appendix 1/3, at 78 m). Both these bodies are shown as «quartzite like» rocks in Fig. 5. They occur in the footwall of the NNW ore zone, within the body of microcline gneiss. They are pale gray and composed of feldspar and brownish mica. Local banding, marked by biotite in the microcline gneiss, can be followed within the bodies. Feldspar veinlets cut through their contacts (Appendix 1/3). The blocks were inaccessible for sampling, thus details of their composition and the nature of the contact with the microcline gneiss remain unknown. Similar potassium feldspar ± mica alteration halos were also found as very small patches (few cm) along the hinges of some of the boudins of microcline gneiss in the northern part of the NNW ore zone.

In the northern part of the mapped area the microcline gneiss occasionally contains large inclusions of garnet (up to 3 cm in size). Since garnet is very uncommon in this rock, it is possible that the inclusions represent metamorphosed xenoliths.

Detailed observations

The SSE drift.

In the SSE drift of Nisje 10/7 only 15 m could be mapped in detail (Fig. 4-6). The orebody wedges out in the mapped area. About 10-15 m from the working face it has a thickness of 2.2 m, and its contact dips 40-50 ° towards NNW. The ore body contains numerous elongated boudins of mica-schist and quartz-veins. The main ore type is pyritic ore, but a thin part at the hangingwall is composed of pyrrhotite ore. Schistosity and banding in the wall rocks are conformable with the strike of the ore zone. In the structural footwall, the ore is underlain by two-mica schist (0.5-1 m in thickness), followed by white, banded quartzite with pyrite (5-10 vol.%). In the structural hangingwall the ore is overlain by the two-mica schist with minor sulfide impregnation (<1 vol. %).

About 10 m from the working face, the ore body is branching out into tails of pyrrhotite ore which are 5 to 30 cm in thickness. Mobilizate-type veinlets and disseminations enriched in fahlore occur in boudins of alpine-type quartz veins and within or just at the contact to the pyrrhotite ore. Lenses of alpine type quartz are also present on the NNW wall of the drift. They have undergone boudinage and contain a number of small mobilizate type fahlore + sulfosalts veinlets. At two localities mobilizate-type veinlets

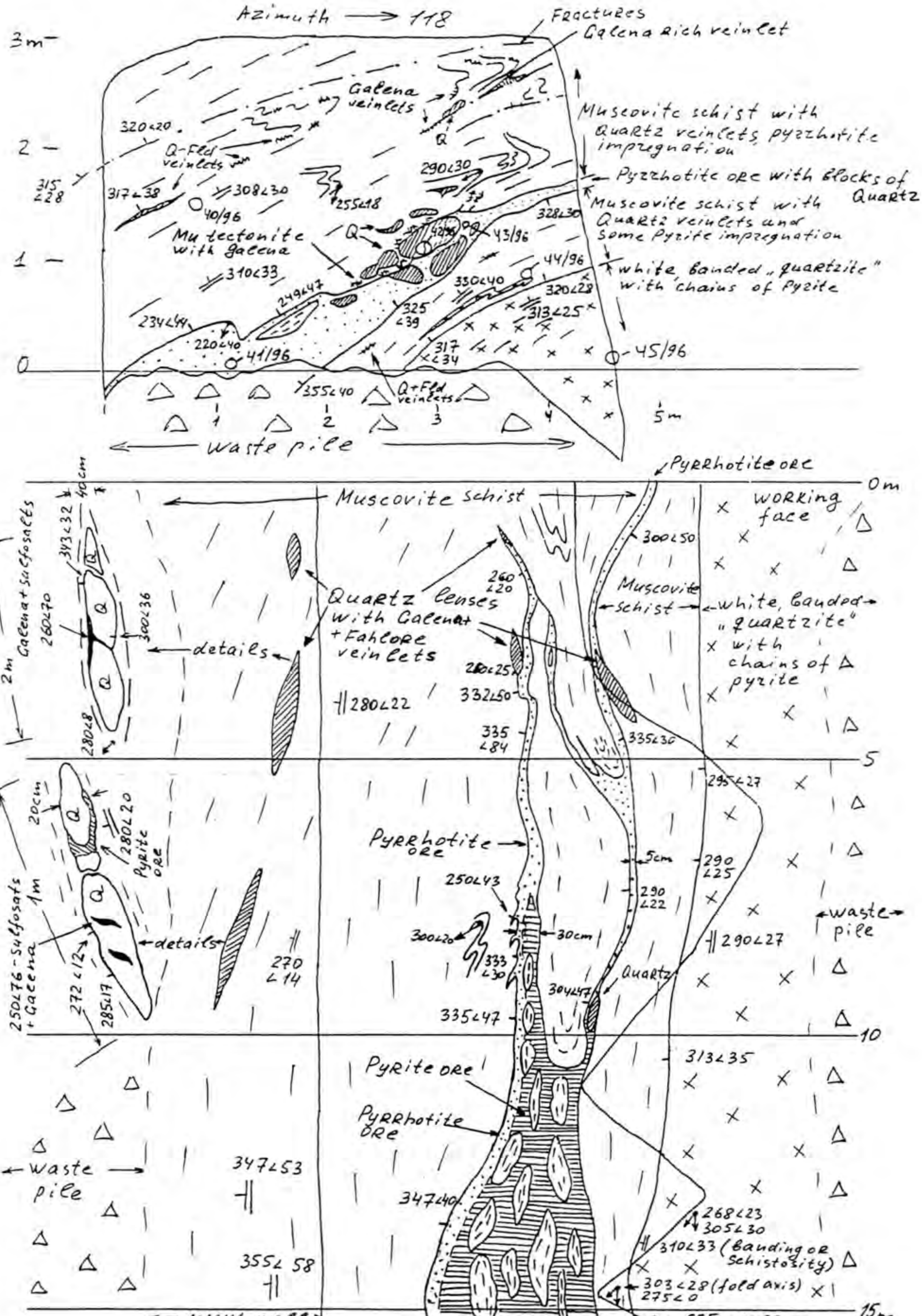


Fig. 6. Map sheet for the end of SSE drift in the Nisje 10/7 scale 1:100 (lower part) and sketch of its working face in the scale 1:50 (upper part).

occur in conjugate sets, and provide information about the strain conditions during the formation: σ_1 198°/53°, σ_2 338°/30°, and σ_3 80°/20° (Fig. 6).

Small scale folding is abundant in quartzites and mica schist. Fold axes are oriented in two directions (250-260°/20° and 290-310°/20-30°) which indicate that the ore zone suffered at least two episodes of folding. This is also in agreement with earlier studies (Rui 1991).

The junction between the SSE and NNW drifts.

Workings at the junction between the SSE and NNW drifts in Nisje 10/7 is running northwards across the main strike of the contact between the two-mica schist and the body of the microcline gneiss (Figs. 4, 5). Close to this contact, a thin bed (~1 m) of quartzite is enclosed in two-mica schist (Appendix 1/2). This bed is affected by isoclinal folding with steep axial planes parallel to its contacts and the orientations of axial traces are 295-300°/10-25°.

A thin (~1m) zone composed of weakly folded biotite-pyrrhotite tectonite occur in the mica schist between the bed of quartzite and microcline gneiss, (Fig. 5 and Appendix 1/2). Weak chalcopyrite impregnation (up to 3 vol. %) and microscopically recognizable galena and sphalerite occurs in the biotite-pyrrhotite tectonite. Chlorite is very abundant. This mineralization looks similar to that of the NNE termination of the massive sulfide body in the NNW drift where biotite-pyrrhotite tectonite is the first indication of massive ore.

The contact between the two-mica schist and microcline gneiss is very complex (Appendix 1/2). On the western wall, the schist is surrounded by microcline gneiss due to intersection of two faults. The intersection is marked by quartz and feldspar veinlets. The lower fault surface, oriented at 253°/15° is marked by a relatively sharp contact between the mica schist and the microcline gneiss. The schistosity is parallel to the fault surface. The other fault zone is oriented at 350°/40° and is marked by very abundant biotite. On the western wall it branches into many small fractures with isoclinal folds between them. The schistosity which has a dip of 285°/20° is parallel to these fractures. This second fault zone can be followed in the roof to the eastern wall where it merges into one fracture.

The contact between the two-mica schist and microcline gneiss on the eastern wall is more simple (Appendix 1/2). It strikes along the junction to the north with a vertical dip (orientation 355°/90°). The contact is sharp and is marked by quartz veinlets. It also cuts the foliation in the schist which is oriented at 205°/30°. It is clear that there is an unconformable contact between the schist and microcline gneiss at this locality. However, it is not possible to conclude whether this contact is tectonic or primary magmatic.

Near the contact to the two-mica schist, the microcline gneiss contains many thin (~1-2 cm) potassium feldspar veinlets. These veinlets outline the fold pattern along the contact which seems to be the result of two folding episodes (Appendix 1/2, 40 m). One of the folds on the eastern wall has an axis plunging gently to the ESE (111°/21°) and a steep axial plane dipping to the SSW. Another fold on the western side of the joint workings has a fold axis plunging to the NNW (306°/20°) and a steep axial plane dipping to the NNE. These are not common trends of F_3 folds, but it coincides with the plunge of some of small scale folds in the schist and quartzite close to the contact.

Five meters to the north along the junction, there are two fault zones dipping to the north (5-350°/50-45°). These zones are composed of biotite schist and contain abundant potassium feldspar veinlets. Between these zones there are internal structures in the microcline gneiss marked by dark, biotite-rich bands. On the western wall these bands dip toward NW at 340-345°/15-30°, whereas on the eastern wall they are folded. Most probably this part of the microcline gneiss was influenced by movements along the faults. Elongated feldspar schlierens ("eyes"), which are the most typical feature of the microcline gneiss, are plunging gently towards the west and north-west.

For the next 30 m northwards in the junction (Appendix 1/2-3, 50-75 m), the microcline gneiss has a massive appearance. The feldspar schlierens are shorter, and the previously described biotite banding is very weak or absent. The amount of feldspar veinlets is decreasing, and the feldspar is more white and very coarse grained. Feldspar veinlets in this interval is along fractures occasionally decomposed to thin clay-like tectonites.

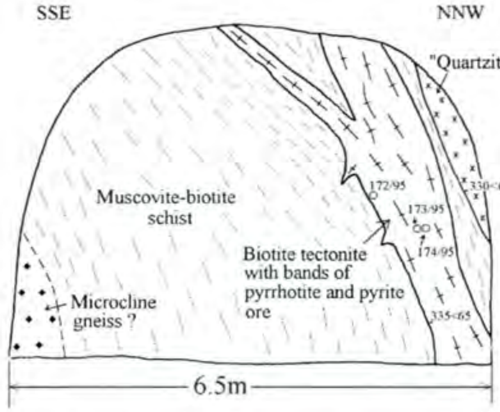
Three main systems of feldspar veinlets were recognized, steeply dipping to the north, steeply dipping to the south and more gently dipping to the NNW, respectively. The last group of veinlets are weakly folded with axes plunging gently to the west (270°/9°).

At 75 m in the junction, the body of microcline gneiss comes in contact with a new ore zone trending to the NNW (Appendix 1/3) having a thickness of 7-8 m. However, it is no massive sulfide ore in this part of the ore zone and it is composed of muscovite-biotite and biotite (phlogopite) schist. The most important features of this zone (see Fig. 5, and Appendix 1/3) are fractures filled with clay-like minerals and boudins of altered microcline gneiss surrounded by an envelope of biotite-rich schist (Appendix 1/3; Fig. 11). The boudins contain abundant quartz - feldspar bands, as well as muscovite-rich bands. Except for these bands the microcline gneiss has a mineralogy dominated by microcline and subordinate biotite, muscovite, quartz, and plagioclase.

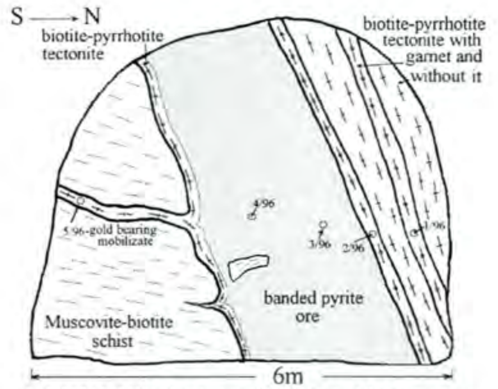
The NNW ore zone dips steeply to the NNW. In the hangingwall the ore zone is also in contact with the microcline gneiss. The ore zone displays clear discordant relations to the microcline gneiss and is itself cut by a branching tectonite, composed of biotite. A few quartz-carbonate-chlorite veinlets with galena and coarse pyrite crystals occur at the termination of such branches, or within them.

The NNW drift.

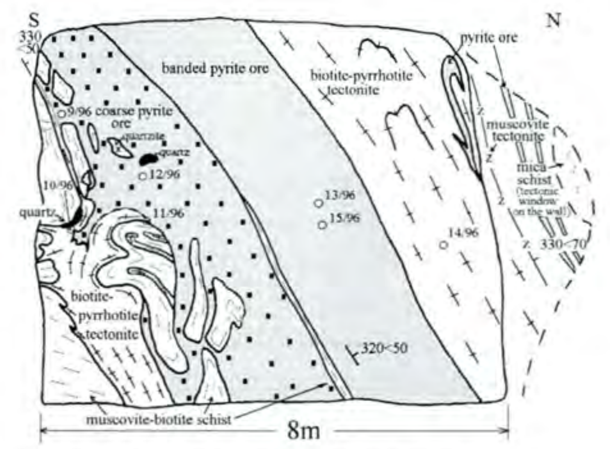
To the west, the NNW ore zone is followed by the NNW drift (Fig. 5, 7, Appendix 2/1-2). In the first 20 m of the drift, no ore is visible in the roof. The zone contains a galena-bearing mobilizate-type veinlet, boudinaged quartz veins, and some lenses and boudins of "quartzite like" rocks. Boudins of microcline gneiss are absent in the first meters from the junction of the NNW and SSE drift. Biotite-dominated schist (tectonite) becomes gradually lighter in color and on the walls of the drift muscovite-biotite schist dominates.



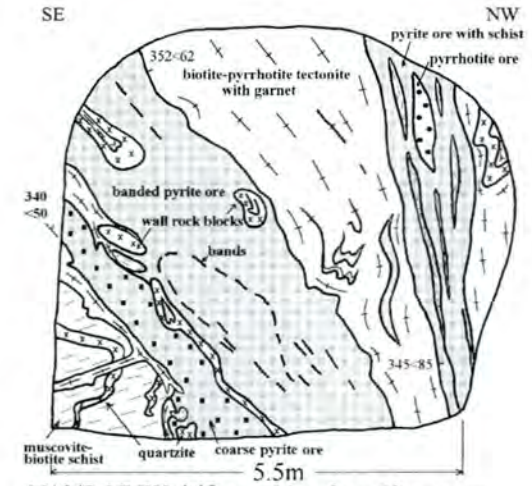
N10/7, NNW drift, working face 39m, 15.08.95



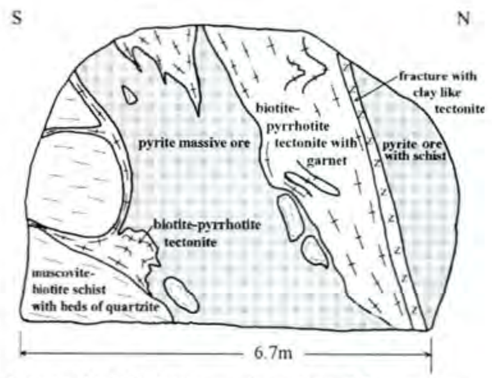
N10/7, NNW drift, working face 51.5m, 23.04.96



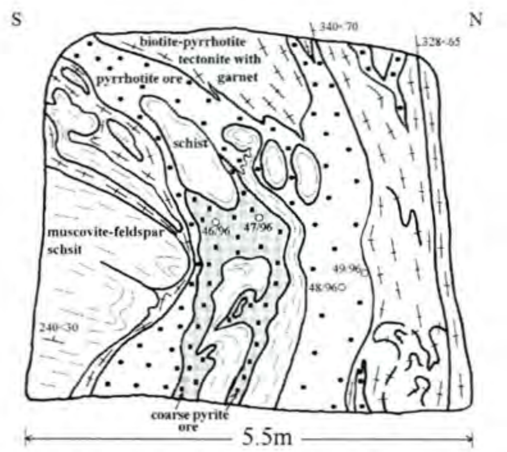
N 10/7, NNW drift, working face 56 m, 24.04.1996



N10/7, NNW drift, working face 59, 27.04.1996



N10/7, NNW drift, working face 63m, 30.04.1996



N10/7, NNW drift, working face 67m, 02.05.1996

Fig. 7. Sketches of working faces in the NNW drift.

At 25 m into the NNW drift a thin zone (up to 15 cm) composed of «durchbewegt» pyrrhotite ore with an envelope of biotite-pyrrhotite tectonite appears in the roof. The pyrrhotite ore has a total sulfide content of 25 to 40 vol.%. The ore body is parallel to the schistosity in the two-mica schist and a layer of quartzite. About 35 m from the beginning of the drift the pyrrhotite ore becomes intercalated with pyrite ore and the thickness of the ore increases to 1.5 m. An envelope of biotite-pyrrhotite tectonite occur on both sides of the massive ore.

Microcline gneiss is exposed in the interval 33-43 m on the south wall of the drift. The contact between this gneiss and the two-mica schist is cut by thin fractures, but in general it seems to be conformable with the schistosity.

From this interval and to the end of the mapped area, pyrite ore is dominant (Fig. 5, 7, Appendix 2/2). Biotite-pyrrhotite tectonite occurs on the both sides of the ore body. In the structural footwall it has a thickness ranging from a few cm to a few tens of cm, whereas in the hangingwall its thickness is 1.5-3 m.

The two-mica schist which hosts the pyrite ore + biotite pyrrhotite tectonite, contains thin probably primary beds (up to 20 cm) of feldspar dominated, «quartzite like» rock. Important here is a discordant relationship between this supposed primary bedding in the host rock and the massive sulfide body, as well as between the ore and schistosity. On some of the working faces it is possible to identify discordant relationships between the footwall of the sulfide body and the schistosity in the rocks (Fig. 7). The ore also cross-cuts the hinge zones of some of the small F_3 folds in the footwall, both in the schist and in the biotite-pyrrhotite tectonite (Fig. 7, 8, 9).

In the hangingwall, the massive ore is overlain by biotite-pyrrhotite tectonite, occasionally with large garnet grains. The tectonite is characterized by complex folding and the fold axes have two main trends: due west (255-270°/20°) and SW (220-230°/20°).

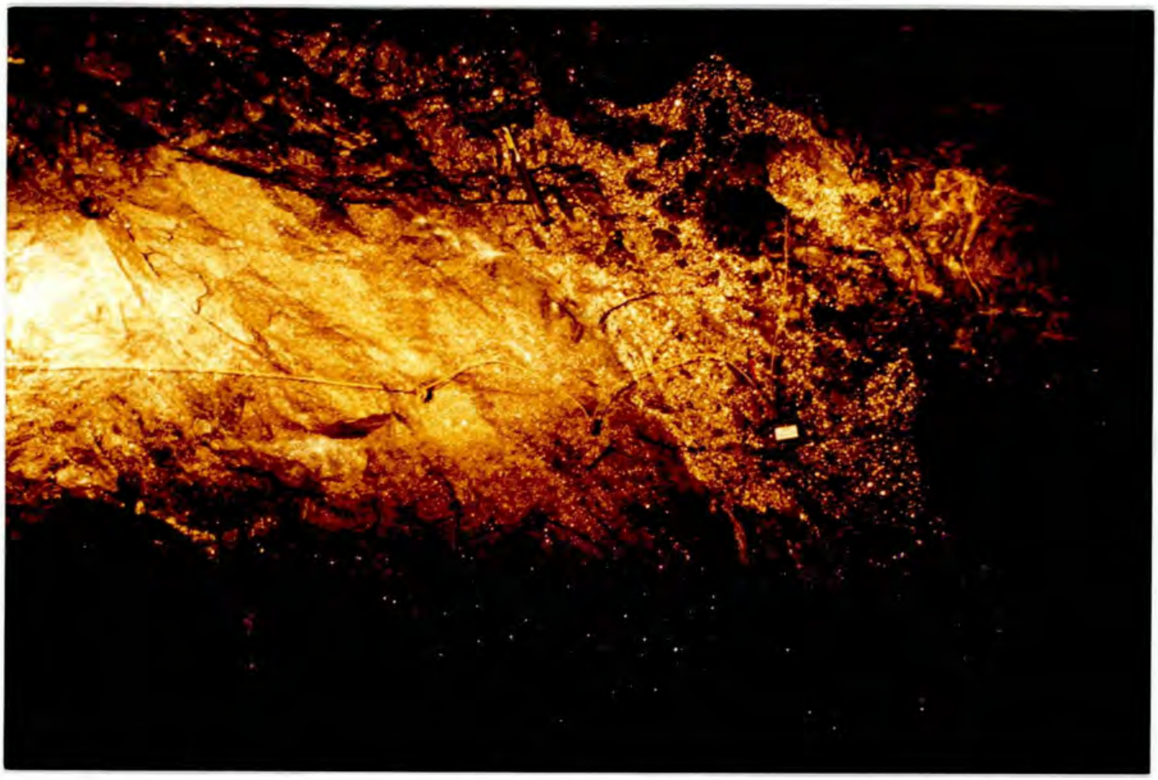


Fig. 8 Photograph of the lower part of the working face at 59 m into the NNW drift of Nisje 10/7, showing coarse grained pyrite ore with abundant rounded fragments of wall rocks in contact with medium grained, banded sphalerite-rich pyrite ore. Muscovite-biotite schist on the left side of the photo contains beds of "quartzite" (quartz-feldspar rock) which probably marks primary bedding. The length of the hammer is 33 cm.

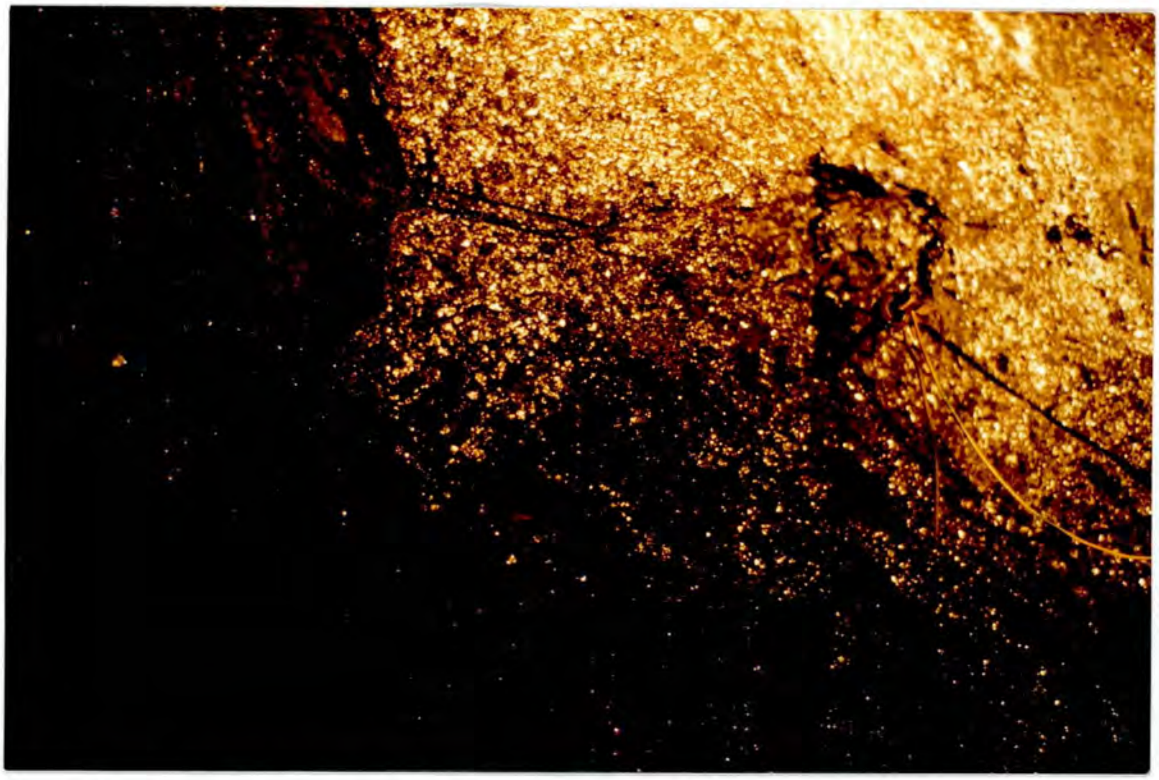
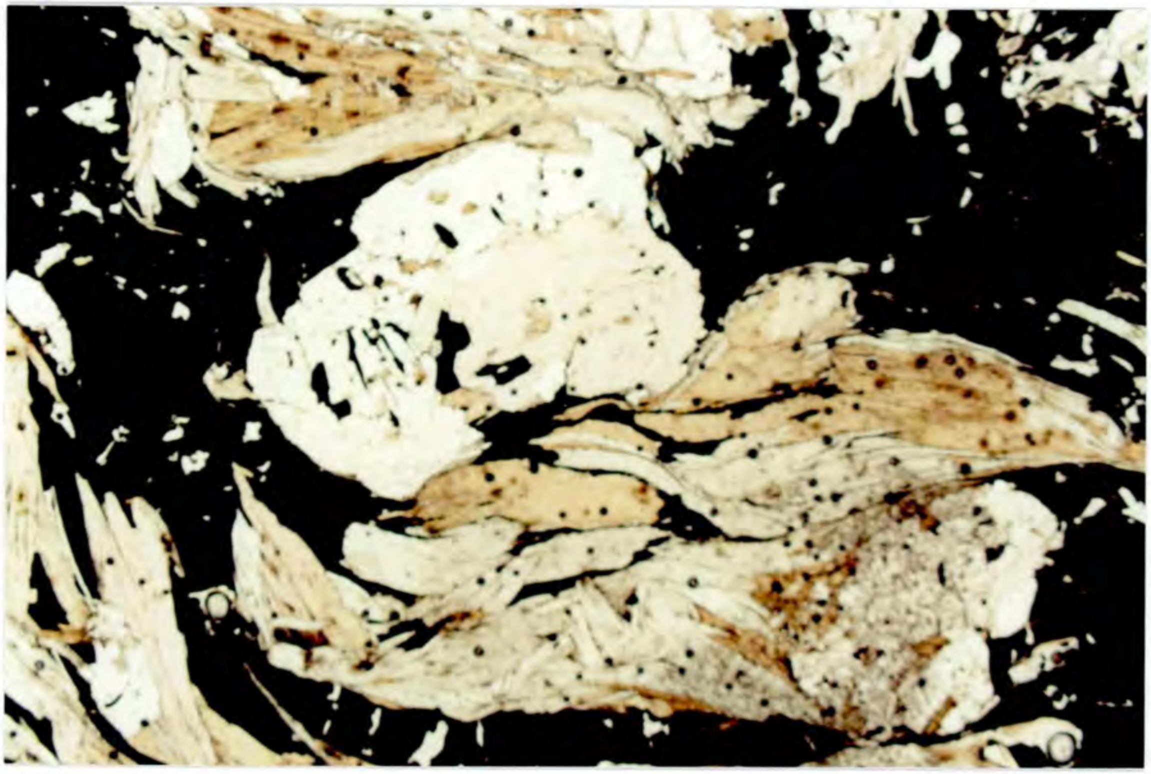


Fig. 9 Detail of the same working face as seen in Fig. 11 showing discordant contact between the massive coarse grained pyrite ore and folded biotite-pyrrhotite tectonite, which occurs between the wall rock and massive ore. The diameter of the electrode head is about 1 cm.



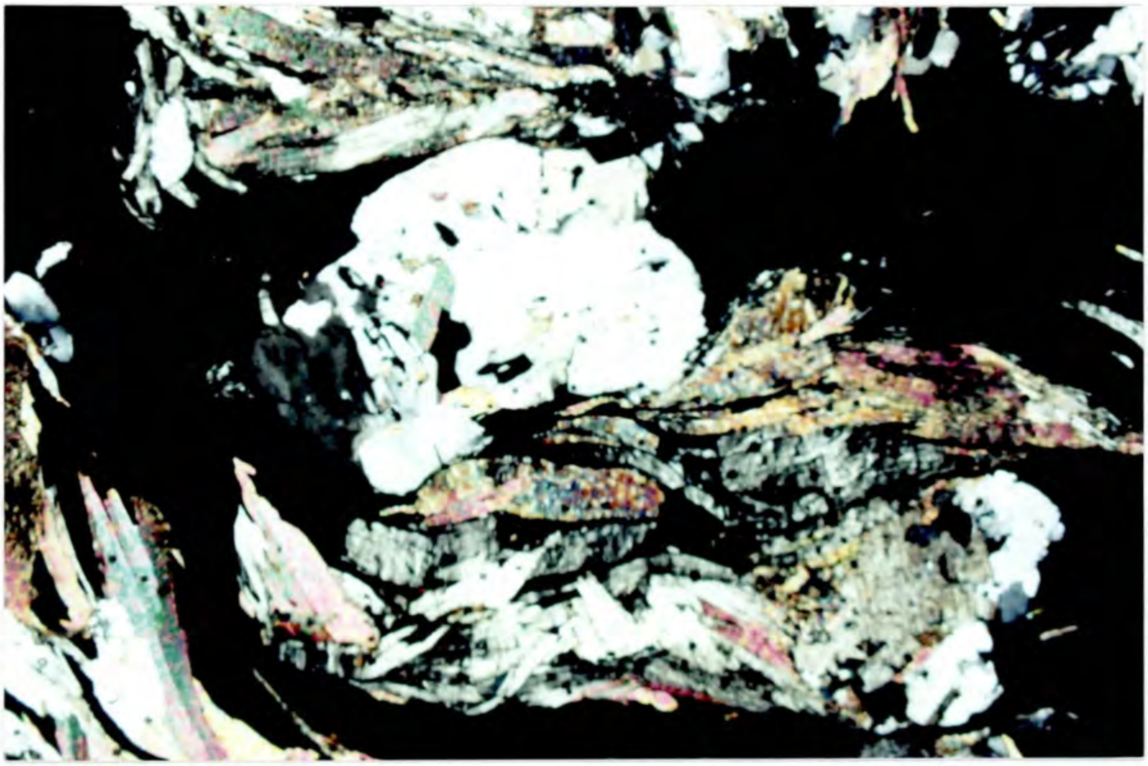


Fig. 10 (a) and (b). Microphotograph of the biotite-pyrrhotite tectonite showing brownish phlogopite, colorless chlorite, pyrrhotite (black) and a rounded aggregate of feldspar. The width of the photograph is 5.5 mm. Sample 14/96 from the working face 56 m in the NNW drift. (a) - polarized transmitted light, (b) - the same in crossed nicols.

Fig. 11. Photograph from the east wall of the junction between the SSE and NNW drifts in Nisje 10/7, interval 80-85 m showing the NE termination of the ore zone with boudins of an altered microcline gneiss within muscovite-biotite tectonite ("schist"). Note the banding in the boudins of microcline gneiss, marked by quartz-feldspar and muscovite bands. The length of the hammer is 33 cm.

The massive sulfide ore has a total thickness of up to 3.0 m. Ore types present in this interval are coarse grained pyrite and medium grained banded pyrite ore, «durch-bewegt» pyrrhotite ore and biotite-pyrrhotite tectonite. Mobilizates are rare, occurring as thin veinlets in quartz lenses hosted by the footwall schist. Some galena-rich segregations are present in the hinge zones of small folds.

Both massive pyrite ore and pyrrhotite ore contain numerous rounded fragments of wall-rocks and occasionally of quartz vein material (Fig. 7, 8). There is generally no differences in the amount of wall rock fragments present in the pyrite and pyrrhotite ore. The wallrock fragments contain patches or bands of massive ore and of biotite-pyrrhotite tectonite which were tectonically injected or picked up during the «durchbewegung» process.

OCCURRENCES OF GOLD.

Search for gold in the Kjøkkenbukta orebody was based upon a study of 30 polished sections. Native gold and electrum were found in three samples from two localities and in both cases in mobilizate type veinlets.

The first locality was in the NNW drift in Nisje 10/7, on the working face at 51.5 m (Fig. 4 and 7, sample 5/96). In the footwall of the massive ore, there is a thin branch of biotite-pyrrhotite tectonite running concordant with the schistosity. It contains thin lenses of quartz with large crystals of pyrite and galena. Two grains of gold were found in phlogopite sourrounding one of these lenses. Gold was also observed in the porous gangue matrix near the contact to a large pyrite crystal (Fig. 12). In the latter case gold has a very yellow color, suggesting either a high gold content, or some unknown admixtures (probably Cu). Gold was also found as a rim on galena with inclusions of chalcopyrite and sphalerite (Fig. 12).

The second locality is at 91.5 m on the eastern wall of the junction between the SSE and NNW drifts in Nisje 10/7 (Fig. 4 and Appendix 1/3, sample 23/96), where electrum was found in two polished sections. On the termination of a branch in a biotite-rich tectonite, it is a thin (less than 1 cm) veinlet composed of carbonate, muscovite, quartz and chlorite containing a few large crystals (up to 1 cm) of pyrite and some galena. Disseminated galena and subordinate sulfosalts occur in the surrounding microcline gneiss. In one pyrite crystal a few small grains of electrum are enclosed in an inclusion of pyrrhotite together with chalcopyrite, galena and sphalerite (Fig. 13). A veinlet containing electrum and an unknown sulfosalt cuts through the same pyrite crystal (Fig. 14). In the same pyrite crystal there are also inclusions and veinlets of chlorite. This is an important observation, because it is the first observation of electrum together with the late formed carbonate-chlorite assemblage. From this, deposition of electrum seems to be related to the very late, postmetamorphic hydrothermal event.

Mobilizate type disseminated mineralization in the microcline gneiss also contains gold. One very small drop of probably native gold have been recognized within a grain of fahlore (Fig. 15).

Mobilizate type veinlets and disseminations are common in the SSE drift (Fig. 6) and contain abundant fahlore, Pb-Cu-As-Sb sulfosalts, pyrargyrite, but no gold has so far been found.

Neither native gold nor electrum have been observed in any of the 17 polished sections which were prepared from the massive ore and biotite-pyrrhotite tectonites. In one section (sample 14/96, collected from the biotite-pyrrhotite tectonite on the working face 56 m in the NNW drift) a lot of grains of native bismuth were recognized. They invariably occur as inclusions in galena (Fig. 16).

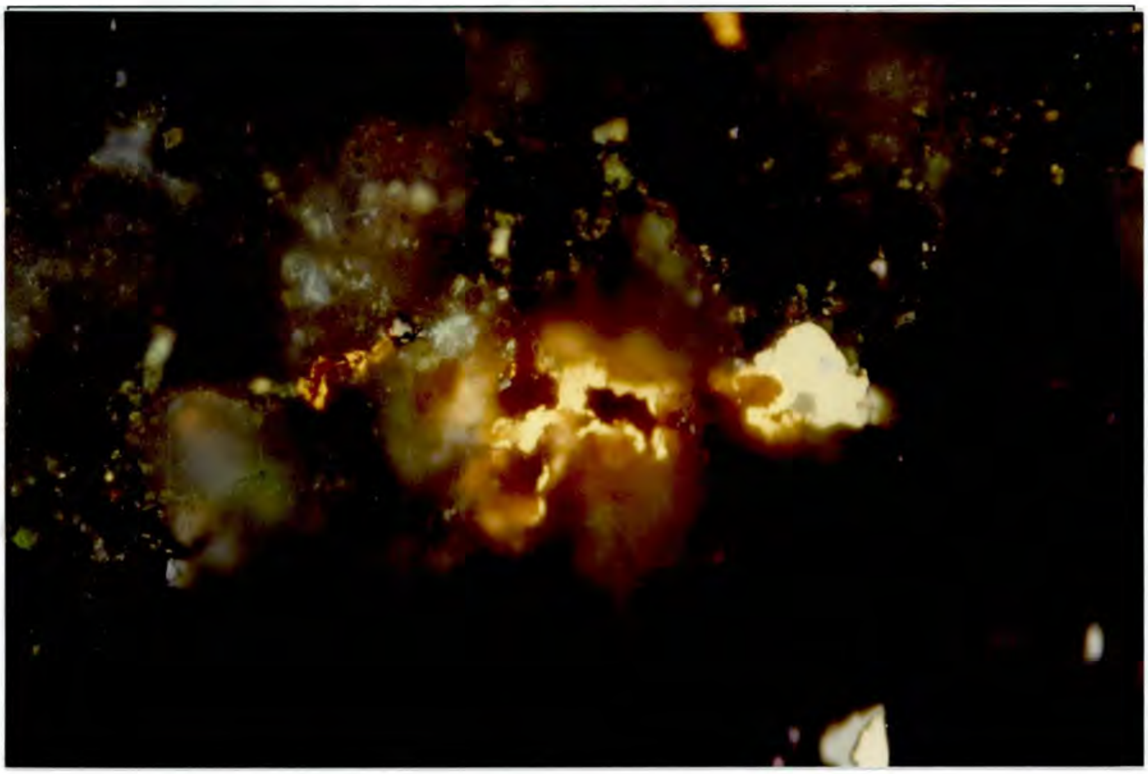


Fig. 12. Grains of very yellow gold in a porous gangue matrix (near the contact of large pyrite grain in quartz-pyrite-galena veinlet). Note the rim of gold on chalcopyrite with inclusions of galena and probably fahlore. Sample 5/96 from the working face 51.5 m in the NNW drift. The width of the image is 137 μm. Reflected light. Oil immersion.

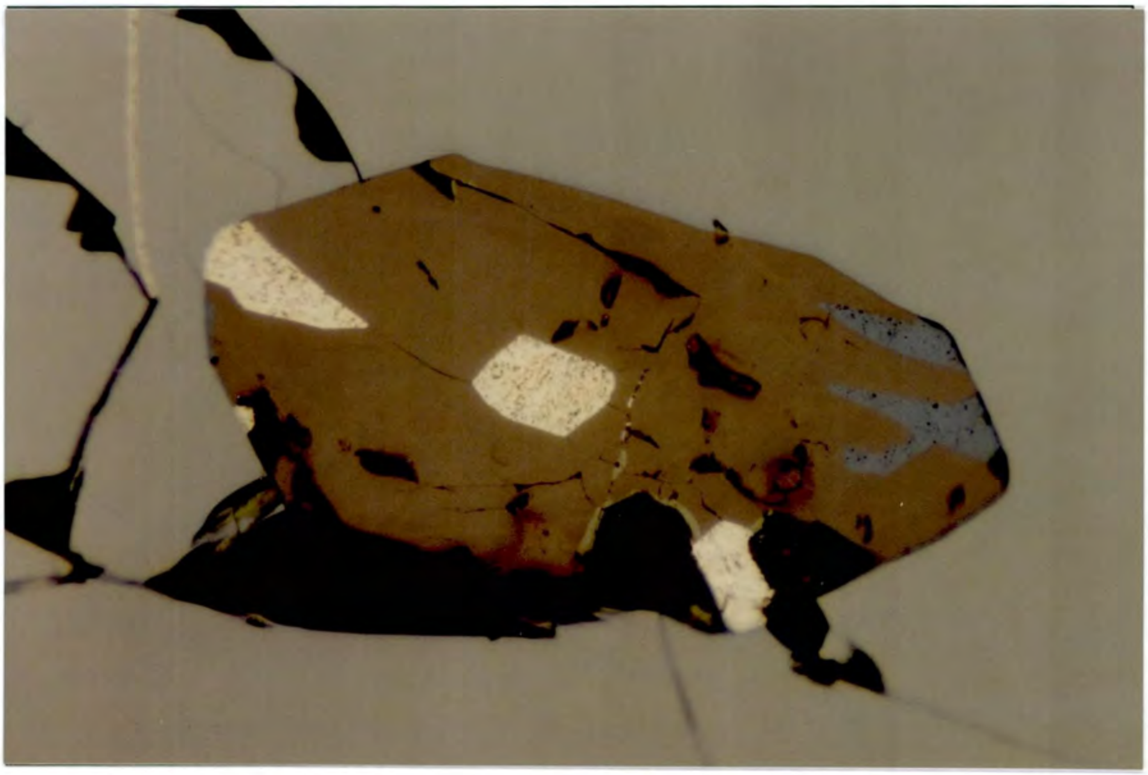


Fig. 13. Electrum locked within a pyrrhotite inclusion in a large pyrite crystal. Sphalerite, chalcopyrite and galena occur together with electrum. Sample 23a/96 from the joint working between SSE and NNW drifts, 91.5 m on the east wall. The width of the image is 137 µm. Reflected light. Oil immersion.

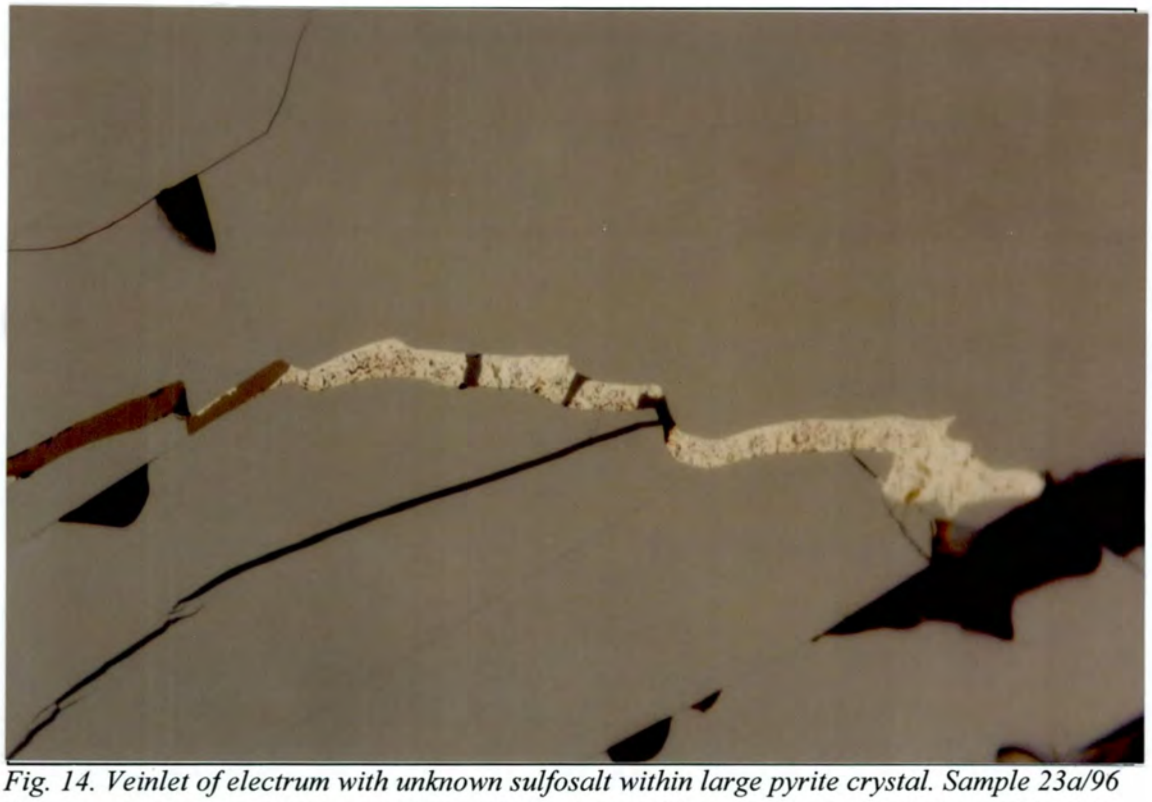


Fig. 14. Veinlet of electrum with unknown sulfosalt within large pyrite crystal. Sample 23a/96 from the joint working between SSE and NNW drifts, 91.5 m on the east wall. The width of the image is 137 µm. Reflected light. Oil immersion.

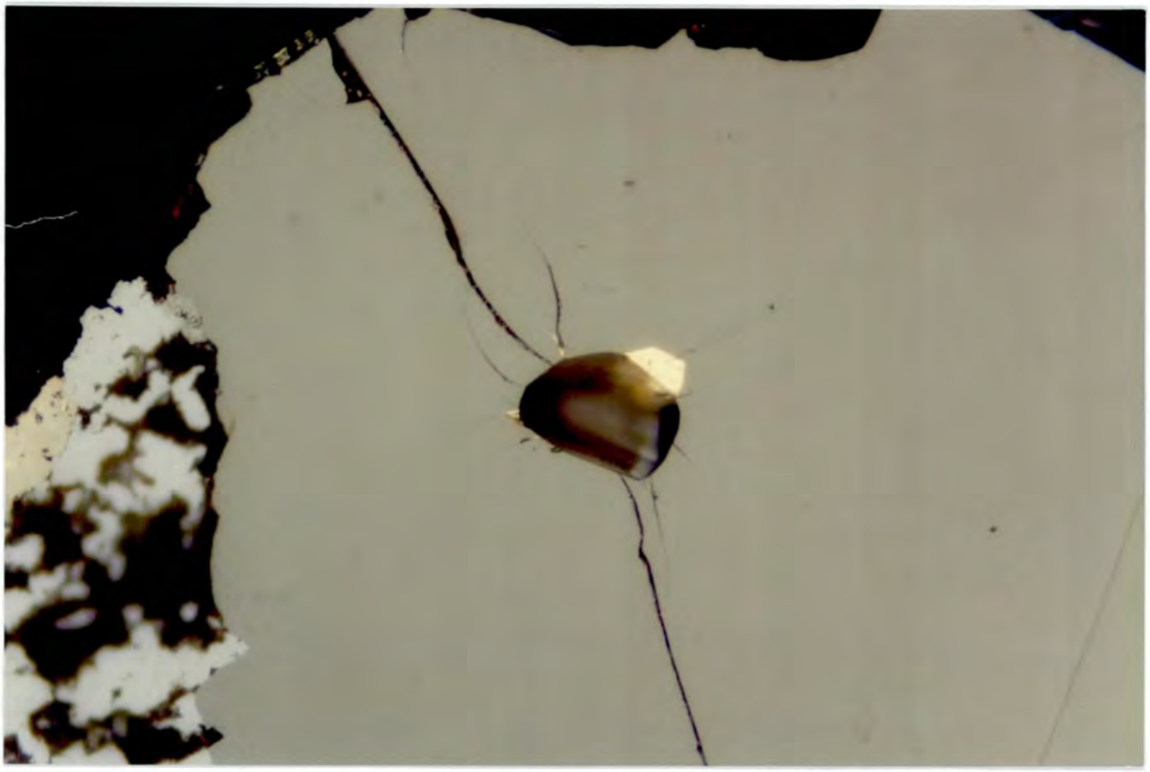


Fig. 15. Small inclusion of probably native gold and gangue in fahlore. Porous galena + pyrrhotite + sulfosalt segregation occurs to the left. Sample 23/96 from the junction between SSE and NNW drifts, 91.5 m on the east wall. The width of the image is 137 μm. Reflected light. Oil immersion.

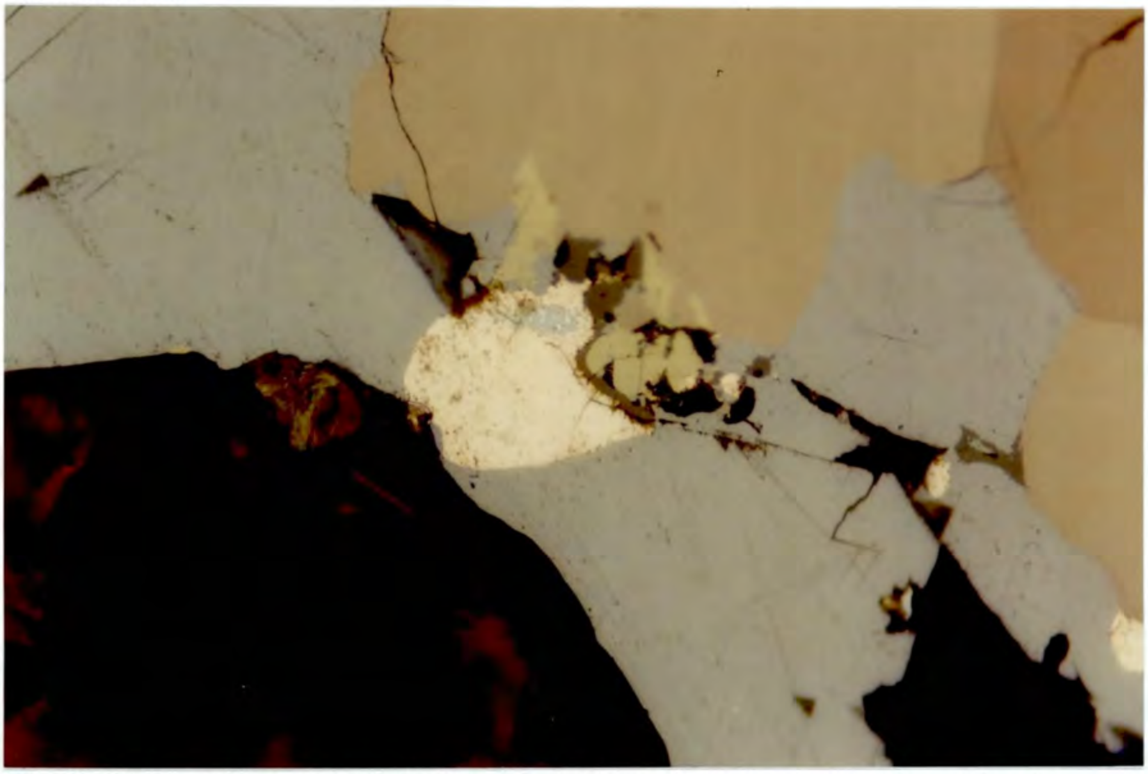


Fig. 16. Galena with complex inclusion of native bismuth, chalcopyrite and an unknown mineral. Sphalerite (with dark brown internal reflections) occupy the lower left part of the photo, and pyrrhotite occurs to the upper right. Sample 14/96 from the working face 56 m in the NNW drift. The width of the image is 137 μm. Reflected light. Oil immersion.

CONCLUSIONS

1. The NNW ore zone of the Kjøkkenbukta orebody has been subjected to strong tectonic movements. The contact between the ore zone and the microcline gneiss body is discordant and the body of microcline gneiss is wrapped around the ore zone. Primary relations between the microcline gneiss and two-mica schist are complicated by superimposed tectonic events. An observation of an angular unconformity between the two-mica schist and the microcline gneiss can be interpreted either as a primary intrusive or as a tectonic contact.

2. The exotic, large inclusions of garnet in the microcline gneiss may represent metamorphosed xenoliths, however their origin are difficult to assess with certainty.

3. The massive ore and wall rocks in the NNW ore zone show discordant relationships and the ore cross-cuts schistosity and the hinge zones of small F_3 folds. This is probably a result of tectonic emplacement of the ore along a shear zone.

4. Native gold and electrum have been found at two localities of mobilizate type veinlets. Microscopically recognizable native gold or electrum have not been found in the massive ore. This is in agreement with previously obtained data for Bleikvassli in general (Moralev et al., 1995).

5. Deposition of gold and electrum in mobilizates seems to be related to the formation of late, postmetamorphic carbonate-chlorite veinlets.

REFERENCES

Bjerkgård T., Larsen R.B. & Marker M. (1995) Regional geology of the Okstindene Area, the Rödingsfjäll Nappe Complex, Nordland, Norway. NGU Rapport 95.153.

Larsen R. B, Walker N., Birkeland A. & Bjerkgård T. (1995) Fluorine-rich biotites and alkali-metasomatism as guides to massive sulphide deposits: an example from the Bleikvassli Zn-Pb-Ag-Cu deposit, Norway. NGU Rapport 95.152.

Rui I.J. (1991) Diamantboringer ved Bleikvassli Gruber I 1990 - Sluttrapport. Unpublished report No 2185, ASPRO Prospektering A.S., pp. 4

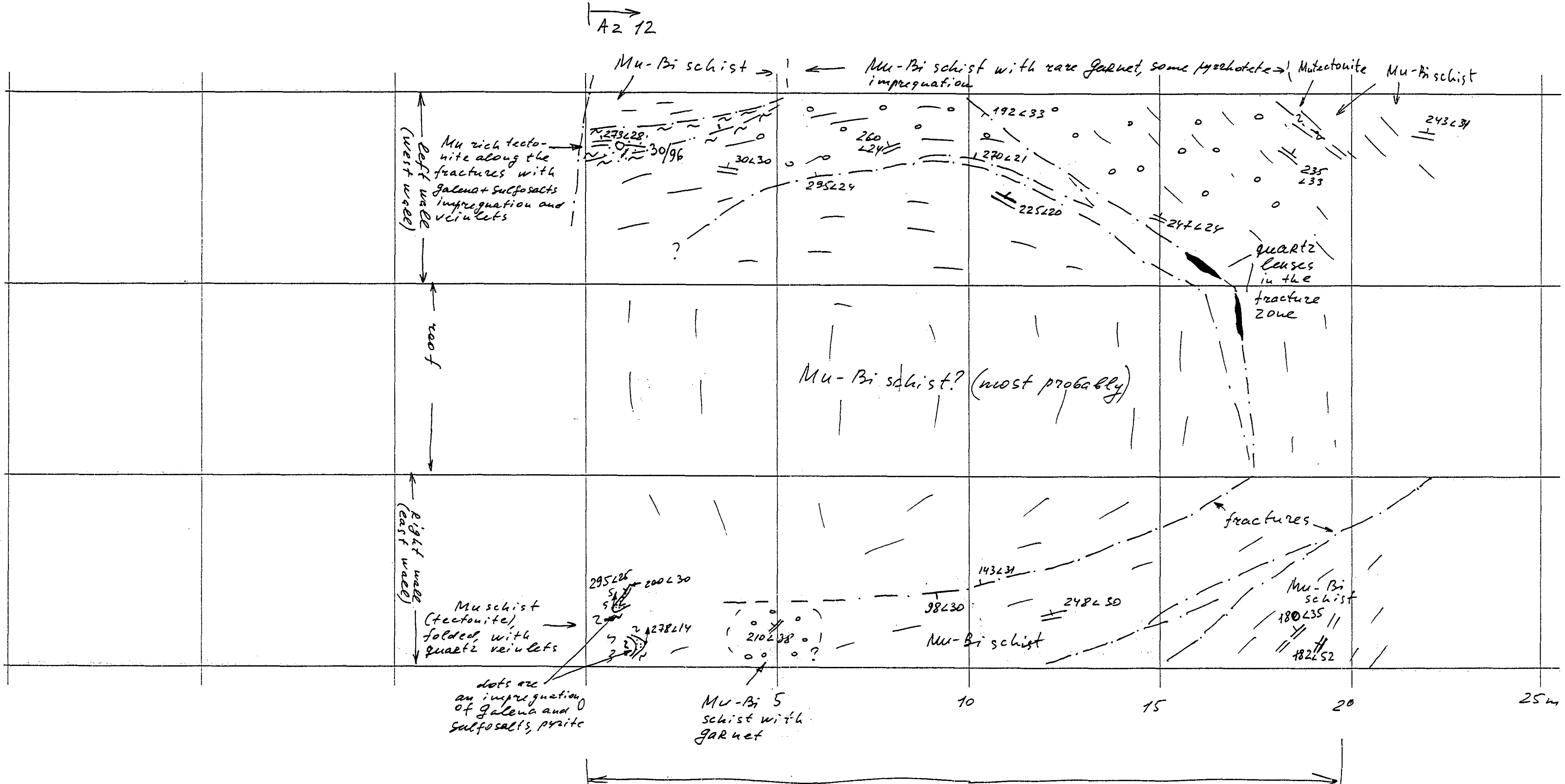
Skauli H. (1993) A metamorphosed, potassic alteration zone associated with the Bleikvassli Zn-Pb-Cu ore body, northern Norway. Lithos. 31. (1-2). p. 1-15.

Vokes F.M. (1963) Geological studies on the Caledonian pyritic zinc-lead ore body at Bleikvassli, Nordland, Norway. Norges Geol. Unders. no. 222, 126 pp.

Vokes F.M. (1966) On the possible modes of origin of the Caledonian sulfide ore deposit at Bleikvassli, Nordland, Norway. Econ. Geol. Vol. 61, No. 6, p. 1130-1139 1966.

Appendix 1/1.

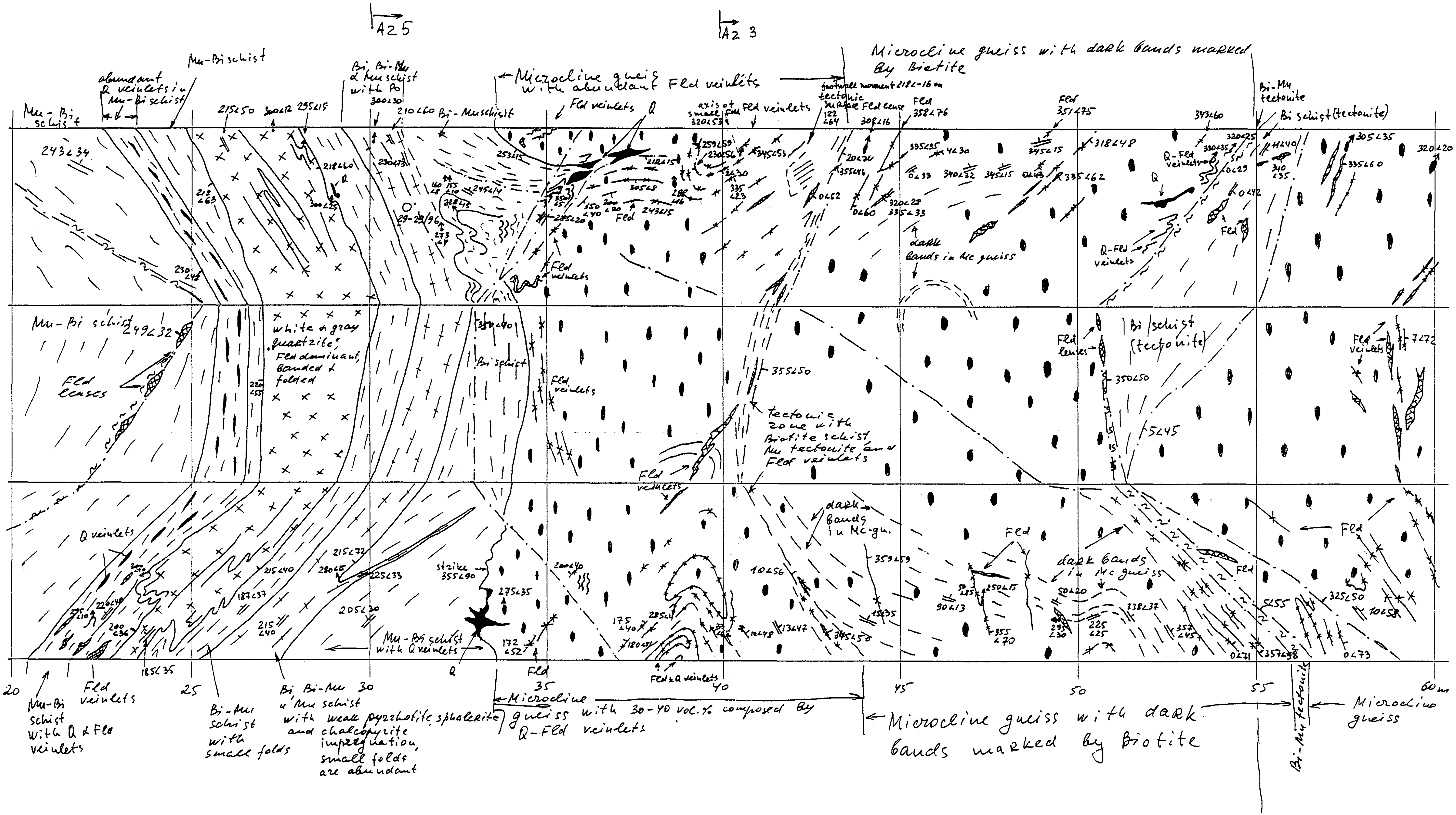
N 10/7, joint working, sheet 1, scale 1:100



This interval was mapped without washing of the walls and roof, thus the data for the roof and some contacts were not established in a proper way.

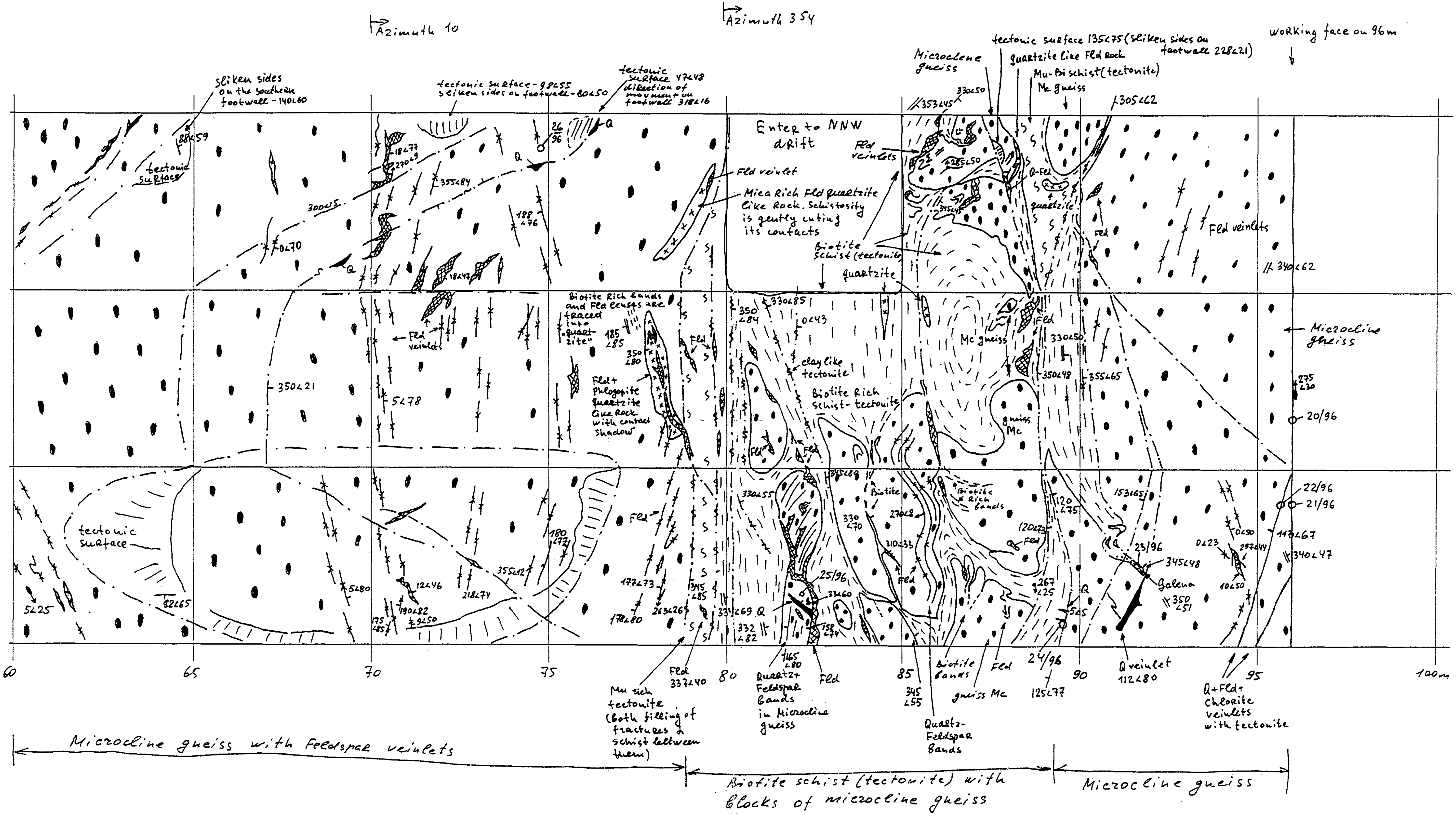
Appendix 1/1

N 10/7, joint working, sheet 2



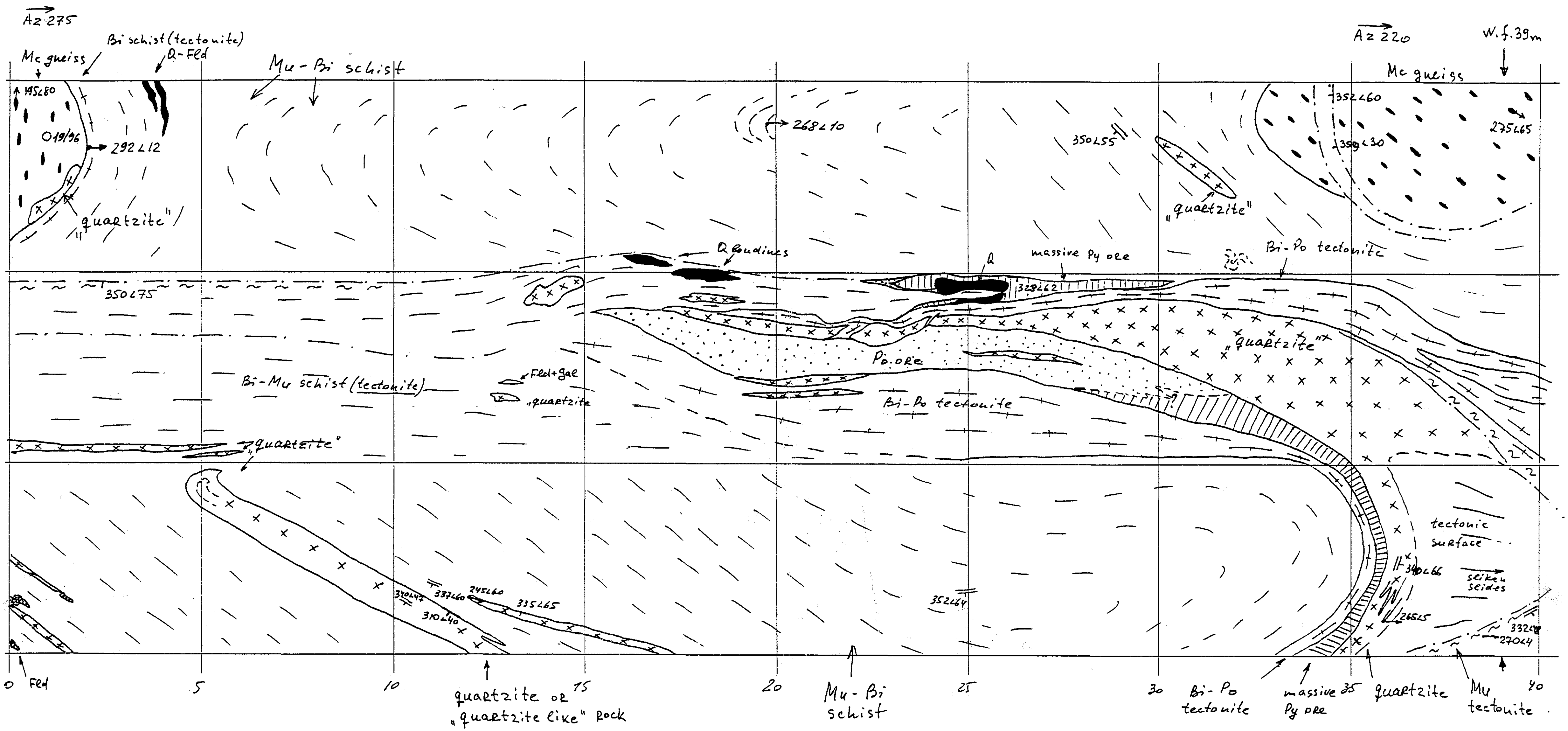
Appendix 1/2

N 10/7, joint working, sheet 3



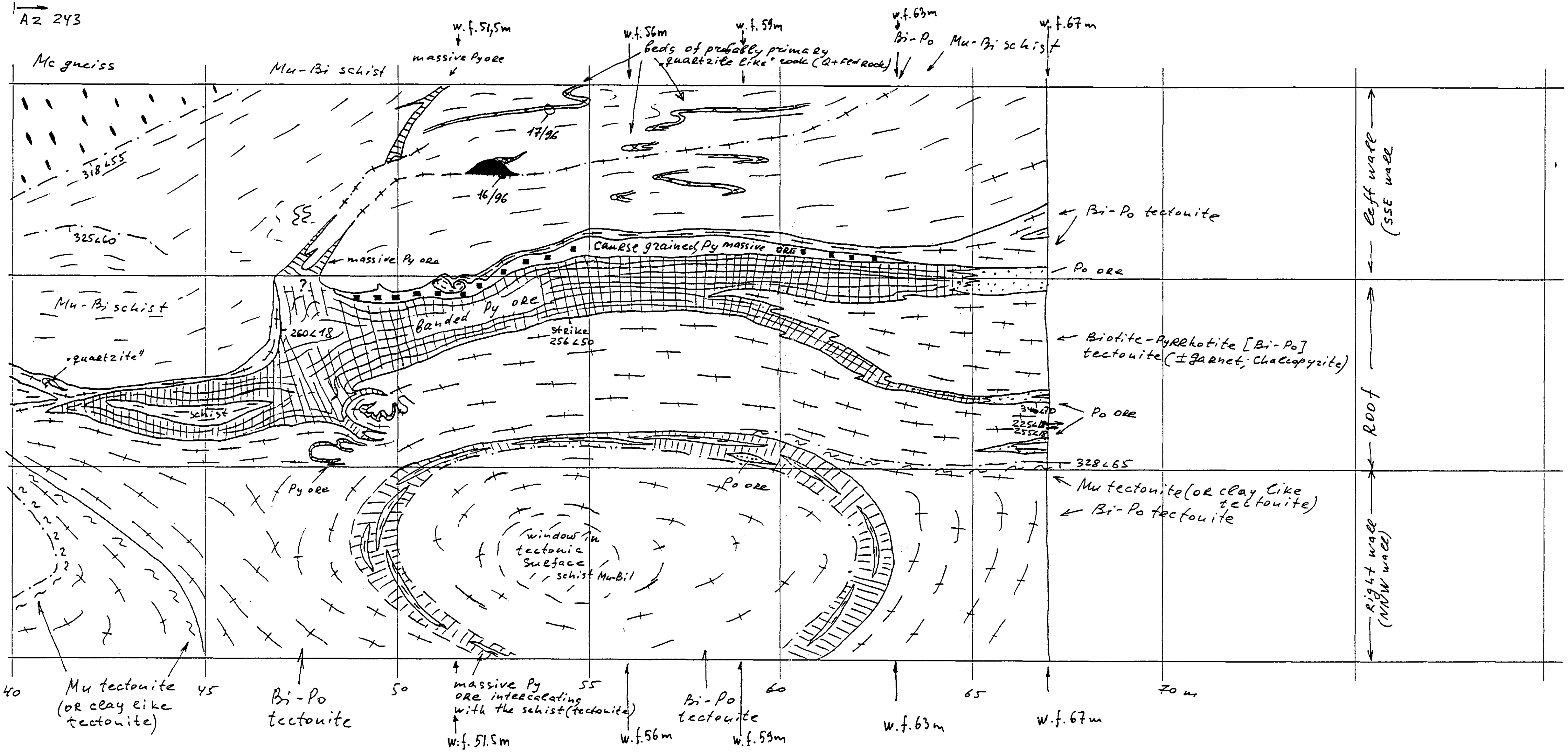
Appendix 1/3

N 10/7, NNW drift, sheet 1, scale 1:100



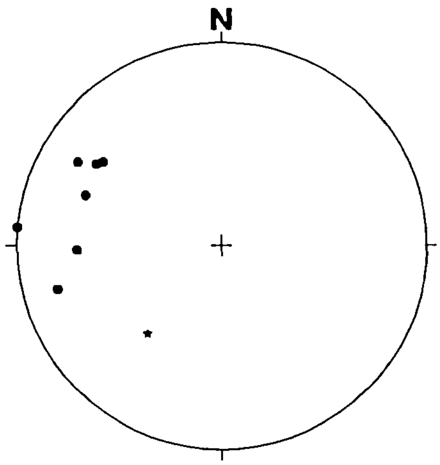
Appendix 2/1

N 10/7; NNW drift; sheet 2; scale 1:100

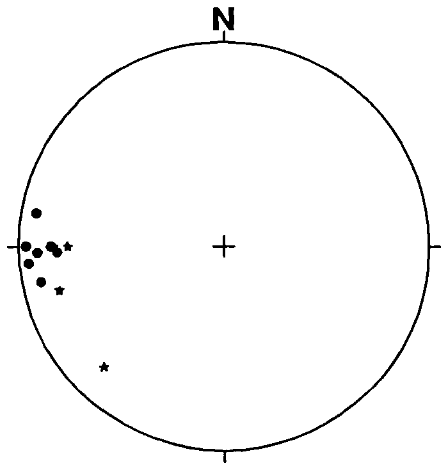


Appendix 2/2

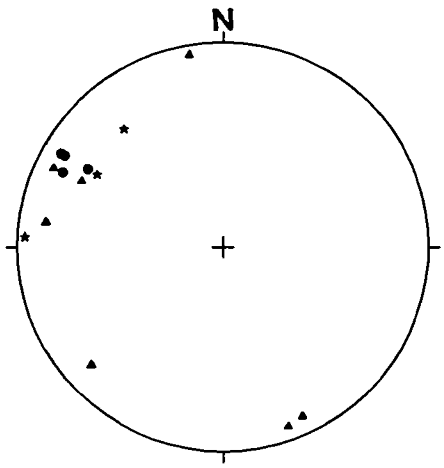
Measurements of fold axes



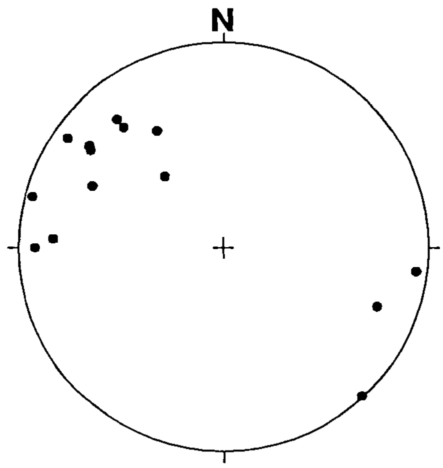
SSE drift.
Circles - fold axis in the wall rocks,
star - fold axis in the ore.



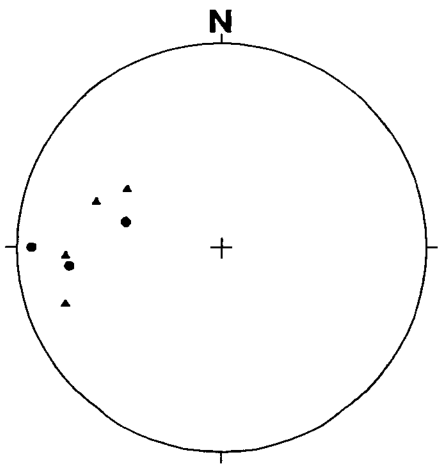
NNW drift.
Circles - fold axes in the wall rocks
and biotite-pyrrhotite tectonites,
stars - axes in the ore.



Junction SSE and NNW drifts, interval 0-42 m.
Circles - axes in quartzite like rocks,
triangles - axes in the schist,
stars - axes in biotite-pyrrhotite tectonite.

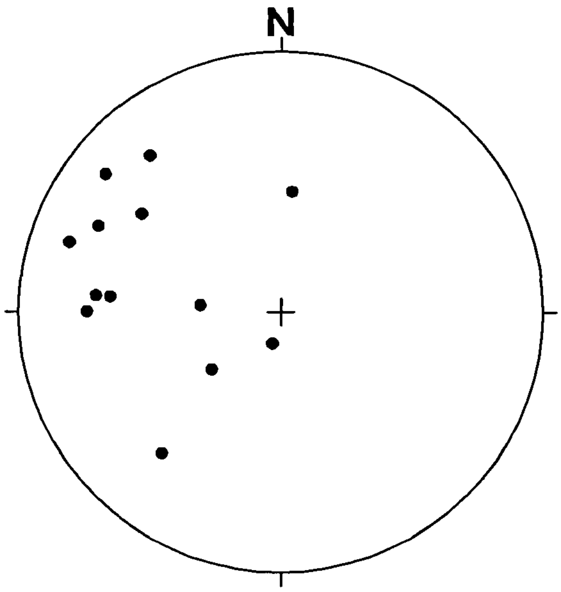


Junction SSE and NNW drifts, interval 20-77 m.
Circles - axes in microcline gneiss
marked by feldspar veinlets and
biotite rich bands.



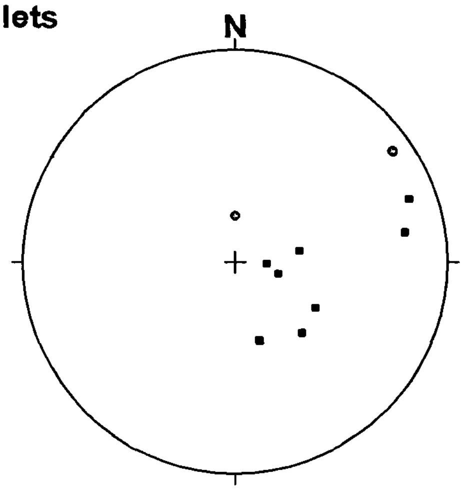
Junction SSE and NNW drifts, interval 77-92 m,
barren part of NNW ore zone.
Circles - axes marked by feldspar veinlets within boudins of
microcline gneiss
triangles - axes in mica schist around
the boudins of microcline gneiss.

Orientation of feldspar "eyes" in microcline gneiss

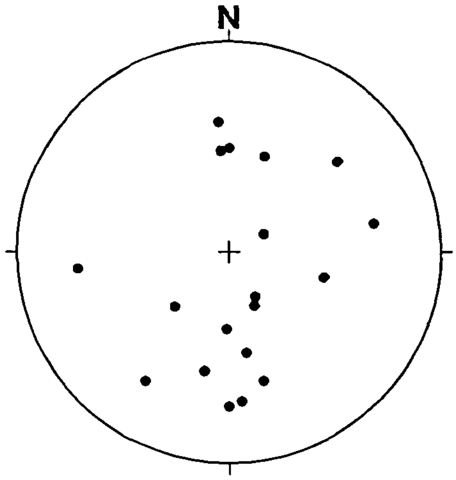


Trend and plunge of the longest axis of feldspar «eyes» in the microcline gneiss. The measurements were not precise due to difficulties in estimation of orientation of the longest axis.
Joint Working at 42-77 m and 92-96 m.

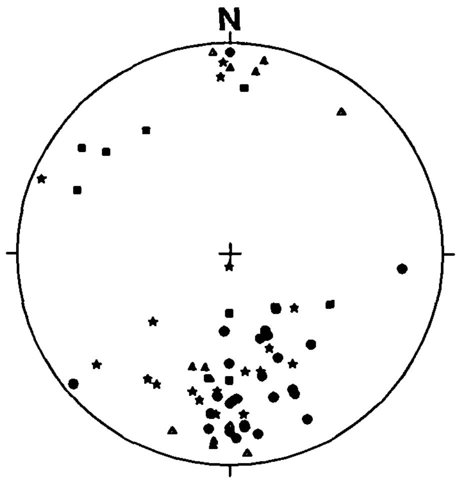
Orientations of veinlets



Rings - feldspar and chlorite veinlets
in the microcline gneiss. NNW drift.
Squares - quartz-feldspar and mobilizate type
galena-fahlore-sulfosalt veinlets in the mica schist.
SSE drift.

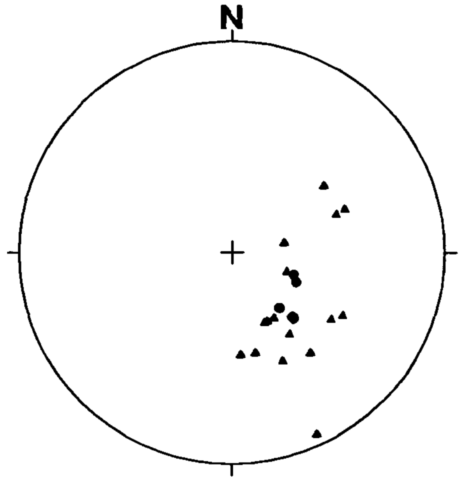


Junction SSE and NNW drifts at 0-42 m.
Quartz-feldspar veinlets in the mica schist,
«quartzite» and biotite-pyrrhotite tectonite.

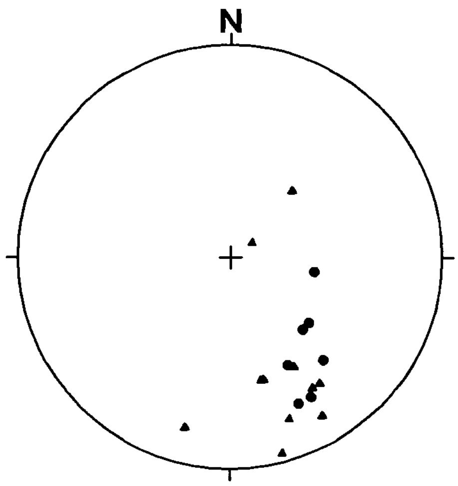


Junction SSE and NNW drifts.
Rings - interval 42-65 m, feldspar veinlets in the microcline gneiss.
Triangulars - interval 65-77 m, feldspar veinlets in the microcline gneiss.
Stars - interval 77-92 m, feldspar and quartz-feldspar veinlets in
the barren part of the NNW ore zone.
Squares - interval 92-96 m, feldspar and chlorite-carbonate veinlets in
the microcline gneiss.

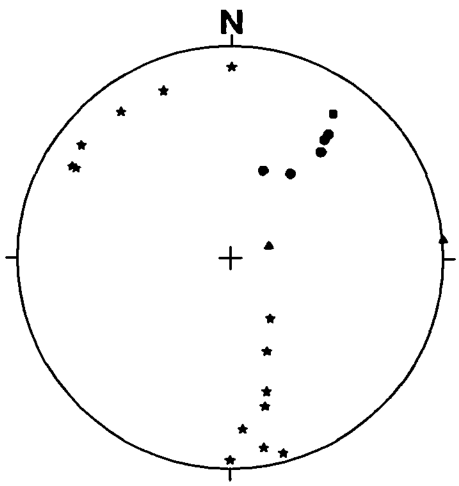
Contact relationships



SSE drift.
Strike and dip of the contacts between mica schist and «quartzite» (circles) and contacts between massive ore and mica schist (triangles).

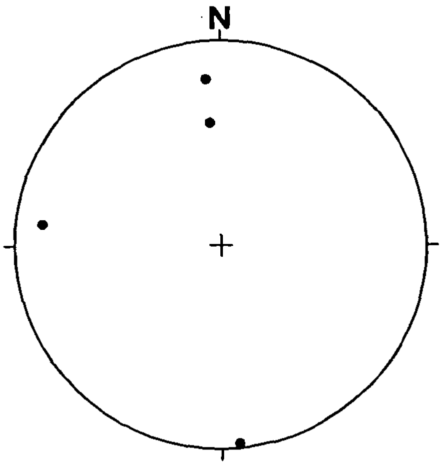


NNW drift.
Strike and dip of the contacts between different wall rocks (circles) and to the contacts with the massive ore (triangles).

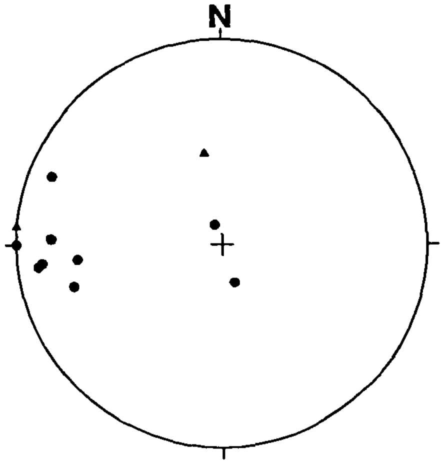


Junction SSE and NNW drifts.
Contacts between «quartzite» and mica schist (circles), between microcline gneiss and mica schist (triangles), between biotite-pyrrhotite tectonite and mica schist (squares) and contacts between biotite rich schist and boudins of the microcline gneiss in the barren part of the NNW ore zone (stars).

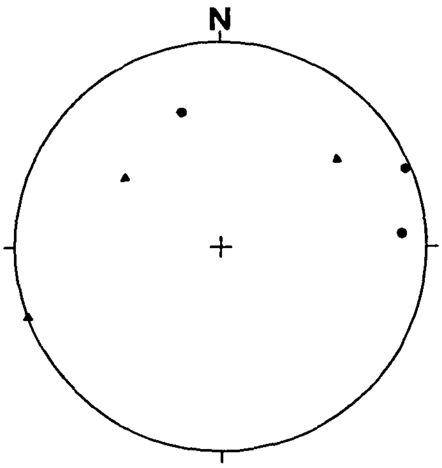
Intersection lineations



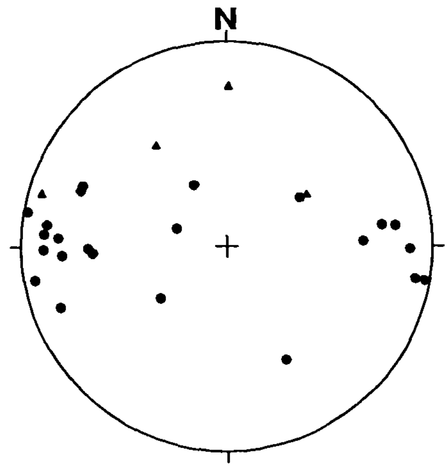
Junction SSE and NNW drifts at 42 m.
Intersection lineations between the contact surfaces of microcline gneiss and mica schist.



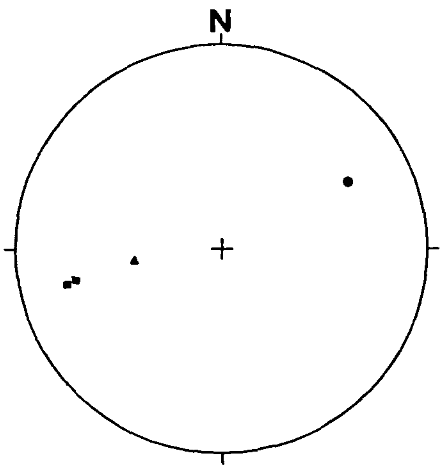
Junction SSE and NNW drifts at 77-92 m.
Intersections between variations in schistosity (circles) and quartz-feldspar veinlets (triangles) in the barren part of the NNW ore zone.



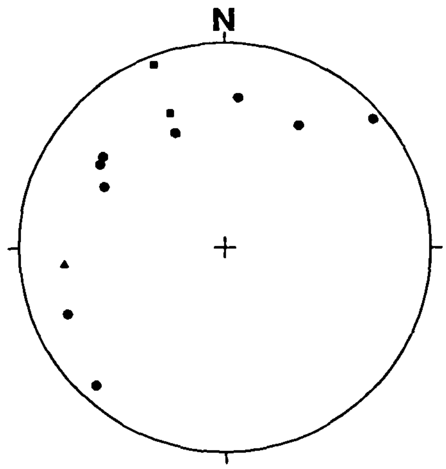
Junction SSE and NNW drifts.
Intersections between biotite bands in the microcline gneiss (circles - interval 42-77 m, triangles - interval 92-96 m).



Junction SSE and NNW drifts.
Intersections between feldspar veinlets in microcline gneiss (circles - interval 42-65 m, triangles - interval 92-96 m).

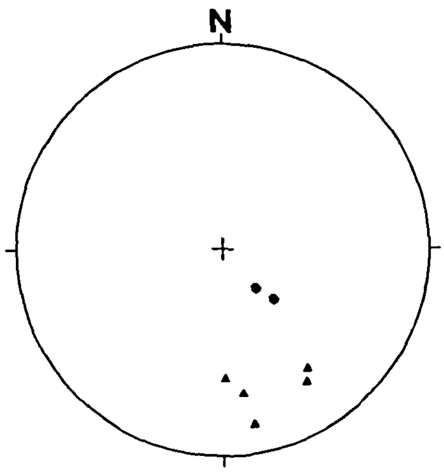


NNW drift.
Intersections between feldspar and chlorite veinlets in the microcline gneiss (circle), between variations in contacts of the massive pyrite ore (triangle) and between probably primary bedding in the wall rocks and schistosity (squares).

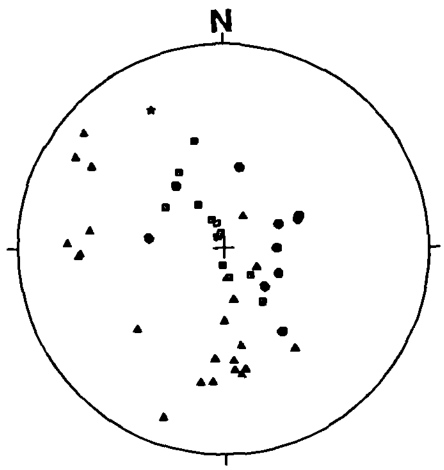


SSE drift.
Intersections between variations in the contact between massive pyrite and pyrrhotite ore (circles), variations of the mica schist - «quartzite» contact (triangle and between mobilizate type galena-fahlore-sulfosalt veinlets (squares).

Fractures

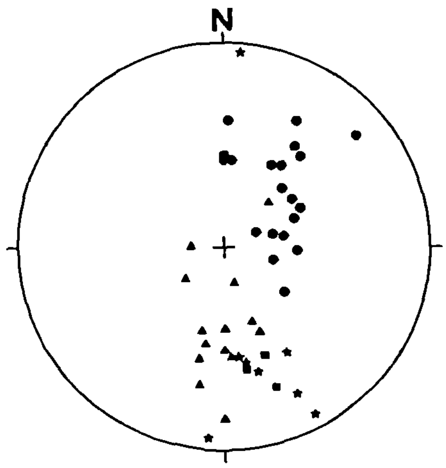


Circles: fractures from the SSE drift.
Triangles: fractures from the NNW drift.

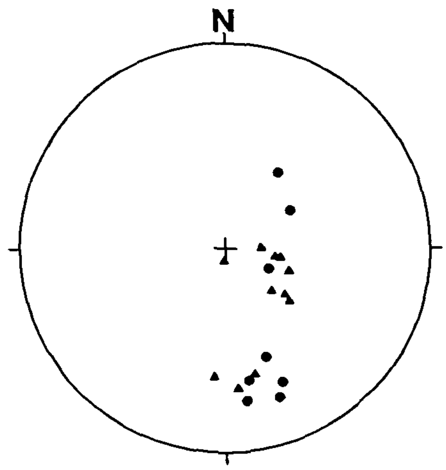


Junction SSE and NNW drifts.
Circles - fractures in the mica schist.
Triangles and star - fractures in the microcline gneiss.
Squares - fractures in the barren part of the NNW ore zone.

Schistosity



Junction SSE and NNW drifts.
Circles - schistosity in the «quartzites», mica schist and biotite-pyrrhotite tectonites (interval 0-42 m).
Triangles - schistosity in the microcline gneiss marked by biotite rich bands (interval 42-65 m).
Squares -microcline gneiss (interval 92-96 m).
Stars - schistosity in the barren part of the NNW ore zone (interval 77-92 m).



Circles - schistosity in the NNW drift.
Triangles - schistosity in the SSE drift.