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Report on Field-work in the Fremstfjell and Gaizervatn areas, July - August 1982

M. J. Ryan and Portsmouth Polytechnic Student Group

This report includes brief, preliminary field reports from the six undergraduates (Don Cawthera, Pete Davis , Jane Enderby, Jon Samson, Steve Swatton and Garry Wilcock) and a summary from Mike Ryan and Abdel Mohamed.

The group left Portsmouth on Friday, 2nd July, arrived in Grong on July 5th, left Grong on Saturday, 7th August and arrived back in Portsmouth on Friday, 13th August. About five weeks were spent in the field area, with one week more or less completely "washed out" by bad weather.

Cawthera and Samson worked around the southern end of Gaizervatn and the rest of the group worked on and around Fremstfjillet with Ryan operating in the two areas.

D. Cawthera: Field-work in the Gaizervatn-Pervatn Area

The rocks of this area comprise a series of granodiorites, "leucogranites" and greenstones which occur in an elongate NE-SW trending zone, bordered on each side by metasediments including meta-arkoses and meta conglomerates. The northern contact of the granodiorite-greenstone zone is a fault trending NE-SW and running the length of Gaizervatn-Pervatn. The southern margin of the zone is marked by the outcrop of a coarse meta-conglomerate which apparently oversteps the greenstones in the SW, indicating an unconformable relationship. The conglomerate contains phenoclasts of grandiorite, "leucogranite" and greenstones.

Greenstones consist of quartz-feldspar-chlorite-epidote- actinolite schists and it is supposed that they were originally mainly basic volcanics including some pillow lavas - possible "pillow-like" structures indicated by epidote pods and lenses etc. Epidote also occurs as thin veinlets in both greenstones and granodiorite. Pods or lenses of dark grey chert occasionally outcrop within the greenstones - probably representing volcanic hydrothermal exhalations. The largest body of this type of chert occurs in the SW of the map area as an elongate lens trending NE-SW along the regional strike direction. Associated with this body is a magnetite + pyrite rock which occurs along the margin in a narrow band. Mm-scale quartz-pyrite bands or veins are interbanded with black magnetite-rich rock. It is assumed that this magnetite-pyrite rock is of volcanic exhalative origin, although it has not been found in association with other chert occurrences.

SE of the chert locality above, greenstones pass into "leuco-granite - but the actual contact is not visible. Greenstones become more acid towards the boundary; within the 'leucogranite' are large rafts or lenses of greenstone, separated from the main body, presumably stoped in during instrusion. Elsewhere the granodiorite/greenstone contact is a shear zone or thrust - e.g. 10 m inshore from Pervatn, SE of the hytte, a series of thrusted contacts can be seen, the thrust planes dipping at 2 - 5^{0} towards NE.

The relationship between granodiorite and 'leucogranite' is difficult to define because in most cases the contacts are gradational, e.g. in the SW and on the shore of Gaizervatn - the change here may be associated with a series of shear zones. But at the stream SE of the hytte on the SE shore of Pervatn, 'leucogranites' apparently alternate with granodiorite every 10 - 20 cm. The contacts are gradational - suggesting that metasomatic processes may have operated.

The major structures in the greenstones are a series of NE-plunging isoclinal folds - deduced from outcrop mapping. Foliation/schistosity trends are invariably NE-SW and do not pick out fold closures. Thrusting and shear zones are commonly encountered, with pronounced rodding in association. Repeated thrusting etc. produces interfingering contacts between greenstone and granodiorite.

Mineralisation (excluding the possible volcanic exhalatives mentioned above) occurs in the form of patchy disseminated pyrite in a broad zone to the E, SE and S of Gaizervatn and separate individual veins of quartz-pyrite-molybdenite (± chalcopyrite) within the rusty pyritic zone. These veins vary in thickness from 5 - 8 cm to 1.5 - 2 m - the latter extreme thickness is apparently due to pinching and swelling in the "Rusty Cliff" locality. (See Ryan's summary and moly-locality map later).

J. Samson: Field-work in the area south-west of Gaizervatn

This area contains mainly two rock types:

1. Grandiorite/leucotzondhjemite.
   Much of the area consists of the former - a hornblende grandiorite which varies from massive to highly schistose. Alteration produces a pale coloured "leucotrondhjemite" - with sericitised feldspar and chloritised hornblende, which occurs chiefly in the mineralised area (disseminated pyrite and quartz-molybdenite veins) around the south-eastern end of Gaizervatn.

2. The second major rock type is greenstone - a basic schist, originally basic lava and/or tuff. Greenstones are composed mainly of pale coloured albite, actinolite and dark green epidote - with a variety of compositions from basic through intermediate to acid, the latter possibly representing metamorphosed keratophyric lavas.

   Within the greenstones adjacent to Gaizervatn at the lake's southern end occurs a lens of quartzo-feldspathic rock with up to 50% pyrite - probably a volcanic exhalite. The unweathered rock is white and sugary in appearance; when weathered the pyrite-rich rocks are rotten, friable and easily broken.

Metalliferous mineralisation consists of:

a) pyrite - diseminated through the granodiorite
   - in veins
   - within greenstones
   - within the quartzo-feldspathic rock

b) molybdenite
   - (rarely) in spots in granodiorite
   - in veins along with quartz-pyrite

c) copper - minor chalcopyrite and secondary
- green malachite.

All the molybdenite veins were found in granodiorite/leucotrondhjemite - seven occurrences, varying in thickness from 4 - 10 cm to 1.5 m - 2.0 m, and generally associated with sericitisation and, possibly, K-feldspathisation.

The remaining rock types encountered were:

3. Deformed, metamorphosed conglomerate.

4. Metamorphosed arkosic sediment.

5. Calcareous sediment, varying from calcareous arkose to calcareous phyllite.

The deformed conglomerate contains pebbles and boulders of granodiorite varying in size from 4 cm to 30 cm, elongate in a NE-SW direction. It seems reasonable to assume that the granodiorite clasts are locally derived, with the conglomerate unconformable on the granodiorite/greenstones. The matrix of the conglomerate is arkosic to argillaceous. The whole rock proves resistant to weathering and erosion.

The meta-arkosic sediment shows cross-bedding and in some cases careous weathering indicative of carbonate content. Although the rock is highly deformed and metamorphosed, sequences such as conglomerate - coarse sand - fine sand - conglomerate .... can be recognised. Way-up criteria are difficult to determine because of the deformation.

The calcareous sediment, located to the north of Gaizervatn, is of a variable nature, from arkosic to phyllitic.

Most of the large faults in the area have a NE-SW trend, parallel with the regional cleavage/foliation. The boundary of the granodiorite may be strongly foliated - indicative of either syntectonic, forceful intrusion or, more likely, post-intrusion shearing, as many granodiorite boundaries are not marked by increased foliation.

The whole area is veined by several series of quartz veins, the majority barren of metalliferous minerals, but a small number (seven) containing molybdenite. Epidote veining occurs in limited extent.

No major folds were mapped out. It may be that the granodiorite towards the western edge of the mapped area plunges gently eastwards on a gentle fold with an E - W exis. Because this area contains the quartz-molybdenum vein concentration, this model perhaps requires further study.

J. L. Enderby: Field-work at Fremstfjellet, Skardfjellet and Gaizervatn

Most time was spent at Fremstfellet, on and around the main mineralised area. A brief one-day excursion was made to Skardfjell, where molybdenum and copper anomalies had been discovered, and a two-day visit to Gaizervatn, with the object of comparing the three areas.

Fremstfjell

Lithologies

The different rock types seen at Fremstfjell were:

1. Greenstone
2. Gabbro
3. Granodiorite (trondhjemite)
4. Leucotrondhjemite
5. Metadolerite dykes.

1. Greenstones were dark green, fine/medium-grained strongly foliated or schistose and frequently rusted, due to rich pyrite content. They represent metabasic and intermediate volcanics; relict amygdales occur 200 m SE of borehole No. 9. Elsewhere (see report of S. Swatton) the 'greenstones' consist of metasediments, e.g. NE of Olavtjern.

2. Gabbro occurs as blocks up to 5 m across, and as elongate sheets or screens. These blocks etc. form a zone up to 200 m wide which runs NNW-SSE from Olavtjern to west of Bergtjern, more or less parallel with the greenstone/granodiorite boundary. Gabbro blocks were also found 200-250 m west of trig. point 689 m. Most were found in granodiorite. The northernmost outcrops appeared to be more basic/ultrabasic in character - in some places feldspathic pyroxenite was the field description used. To the south the blocks are strongly veined by

quartzo-feldspathic material and to the north epidote veining occurs in addition. When the gabbro was strongly altered it took a bright green colour.

3. 'Granodiorite' covers a wide variety of rock types varying from 'leucotrondhjemite' at one end of the scale to quartz-diorite/diorite at the other end. The rocks are medium to coarse-grained, contain dark chloritised hornblende and cream/yellowish green coloured feldspar. The granodiorites always show crude foliation and may be strongly schistose along the several shear zones that cut the intrusive. The granodiorite is often altered by epidotisation, sericitisation, silicification and/or K-feldspathisation.

4. Leucotrondhjemite formed an irregular-shaped body within the granodiorite - the interfingering boundary tending to follow the E-W trending foliation. The leucotrondhjemite was not always foliated - especially, e.g. in trench no. 3. Ideally, no dark coloured minerals were present, and the rock was frequently veined with quartz, K-feldspar, epidote etc., giving a variety of pale colours, white, grey, cream, yellowish-green, pink etc., depending on the type of alteration/mineralisation.

5. Metadolerites occurred as dykes as pale/medium greenish-grey coloured rocks, fine-grained, containing pyrite cubes - but not containing 'vein-type' mineralisation.

Relationships between lithologies

The relationship between granodiorite and greenstone is clearly an intrusive one - with a sharp boundary and dykes of granodiorite cutting the greenstone. An intrusive nature is also implied by the common presence of greenstone xenoliths.

The occurrence of gabbro blocks suggests that the igneous complex is of a zoned character, from early basic to late acid, with the gabbro clearly a solid body subsequently broken-up during granodiorite intrusion.

The relationship between granodiorite and leucotrondhjemite is less easy to comprehend. Nowhere could there be seen a sharp contact between the two. There are two main possibilities for the nature and origin of the leucotrondhjemite:

(i) metasomatic alteration of granodiorite by sericitisation/epidotisation/silicification/K-feldspathisation - the interfingering contact produced by preferential alteration along the pre-existing foliation in the granodiorite.

(ii) crystallisation of a separate, late-stage, felsic magma, again the interfingering contact being governed by the pre-existing foliation.

Metadolerites were clearly a late-stage intrusive event, cross-cutting all other lithologies, but themselves succeeded by a foliation-producing event.

Structures

There are two sets of large-scale linear features - one set trending 070°, the other 160°. It was not always possible to prove that these features were faults, but where it was possible, there appeared to be no regular sinistral/dextral movement pattern.

The present mapping has extended the outcrop areas of 'leucotrondhjemite' to the north-west and it is possible that the segmented outcrop pattern is due to faulting splitting up a formerly more linear NNW-SSE leucotrondhjemite body into the three 'bodies' seen.

ENE-trending foliation affects the granodiorite, greenstone and, to greater or lesser extent, the leucotrondhjemite - and dips steeply to the north. There is great variation in foliation intensity - sometimes it may be so strong and accompanied by, e.g. silicification/sericitisation that identification of the original rock is not possible.

Vein orientations show two main trends - 050/090° and 120/140° - but orientations of all directions were seen to occur.

Dominant fracture and joint orientations in the granodiorite/ leucotrondhjemite were 030/050, 060/080, 090/100.

The major structural trend for the above features as a whole was 060-080 - coinciding with that of the foliation.

Alteration and Mineralisation

Four types of alteration were seen at Fremstfjell:

(i) K-feldspathisation - field identification of pink feldspar.

(ii) Epidotisation - spotting the rock by alteration of plagioclase, also in discrete veins and clots.

(iii) Sericitisation - imparts a silvery sheen and good foliation.

(iv) Silicification - produces a hard, brittle, splintery or sugary textured rock.

Metalliferous mineralisation includes molybdenite, pyrite, chalcopyrite and magnetite (possibly with bornite).

Pyrite is ubiquitous, to greater or lesser degree. Greenstones are commonly rich in pyrite and the pyrite content of the granodiorite appears to show an inverse relationship with the distance from the greenstone contact - suggesting that the hot, magmatic granodiorite may have leached at least some of its pyrite from the greenstones.

The great majority of the molybdenite was found within leucotrondhjemite north of B.H.3 and south of B.H.1 - in an area of about 160,000 m^2. It occurred as quartz-pyrite-molybdenite veins, dry moly-paint on joints and cracks, disseminated throughout the rock, or as fine dust in quartz.

Chalcopyrite was found only rarely, sometimes associated with greenstone xenoliths; green secondary copper minerals formed thin films on joints etc.

Magnetite-pyrite-chalcopyrite +? bornite occurs in a small isolated pod associated with gabbro blocks north of Pistoltjern.

The apparently richer mineralisation along the Nedrebeckken shear zone and along the linear feature north of Smaltjern could be due to the 'faults' being already present before the onset of mineralisation. It is possible that the numerous faults and shear zones that cross-cut the area acted as channelways for the mineralising fluids.

Skardfjell

A brief reconnaissance of the Skardfjell area was made in an attempt to explain the molybdenum and copper anomalies in that area. Although the attempt was unsuccessful, it was useful to compare the geology with Fremstfjell and, later, Gaizervatn.

East of the Y-shaped lake (Bevertjern) east of trig. point 908 m, typically well foliated greenstones are very strongly rusted, parallel with the lake's elongation, with semi-massive pyrite-chalcopyrite. South of the star-shaped lake (Sternevatn) pyrrhotite occurs in rusty greenschists.

On the descent northwards from Sternevatn the contact with grandodiorite was crossed - typical granodiorite but strongly epidotised, with epidote and chlorite veins in a three-dimensional framework, and ? K-feldspar. Quartz- and quartz-feldspar veining increased in intensity northeastwards, where typical leucotrondhjemite was seen - but without conspicuous sericitisation, pyritisation or widespread silicification - and no molybdenum mineralisation. Only very occasional thin veins of pyrite occur. Although the rusting in the nearby greenstones was very strong, it was absent from the pyrite-free granodiorite and leucotrondhjemite. Vein orientations and joint patterns are similar to those at Fremstfjell.

From this brief comparison with Fremstfjell (and later Gaiservatn) it seems that the absence of pyrite and widespread sericitisation and silicification also marks the absence of molybdenum.

Gaizarvatn

One and a half days were spent around the eastern and southern end of Gaizervatn. Rock types were similar to those found elsewhere with, in addition, black cherty pyrite-magnetite rich rock - probably volcanic exhalative within greenstones.

The granodiorite was again of varied composition - probably silicified to a greater extent than at Fremstfjell, and also strongly sericitised. Compared with the other areas epidotisation and K-feldspathisation are only slight or absent.

Molybdenum mineralisation occurs chiefly in separate, large veins varying from 6 cm to 1.5 m in width, along with pyrite. The area of granodiorite containing disseminated pyrite and quartz-molybdenite veins measures about 800 m along the strike by 600 m across the strike - a similar size to that of Fremstfjell (but it must be remembered that only six or seven molybdenite-bearing veins have been observed within that area. On the other hand, the degree of exposure is not great and several more veins may well occur).

It seems reasonable to suppose that this area represents a different (higher) structural level than at Fremstfjellet and Skardfjell and that beneath it could lie Fremstfjell-type porphyry-type mineralisation.

S. Swatton: Field-work in the area north and north-east of Fremstfjell

The rocks of the area include the following:

1. Granodiorite (trondhjemite) - coarse-grained, quartz - plagioclase - hornblende rocks.
2. Leucotrondhjemite - essentially coloured mineral-free quartz - plagioclase ± alkali feldspar rocks.
3. Diorite
4. Gabbro xenoliths in trondhjemite.
5. Greenstones - metavolcanics and metasediments.
6. Calcareous metasediments.
7. Gabbro associated with diorite.
8. Magnetite rock within gabbro.

Readings and observations were concentrated along the greenstone/ granodiorite contact to determine whether the contact was of a faulted or intrusive nature.

There is strong evidence of faulting in the map area - showing a dominant NE-SW trend and predominantly sinistral sense of movement. Evidence for the faulting, beside direct observation of displacement etc, is shown by:

1) aerial photo interpretation, e.g. linear, topographic features etc.

2) increased schistosity in rocks within or adjacent to the fault zones (especially granodiorite) with re-alignment of minerals producing lineations and strong foliation.

Molybdenite was occasionally seen to concentrate along the fault zones (e.g. in the Skarsfjellet area) - which is of interest when considering the age of the moly-mineralisation relative to structures etc. Whether this simply represents re-mobilisation of pre-existing mineralisation or whether primary mineralising fluids were channelled along the faults - is unclear.

Although the faulting is widespread and an important part of the local geology, it appears unlikely that the greenstone/granodiorite contact is faulted for several reasons:

(i) none of the typical features associated with faults (e.g. slickensides, brecciation, mylonitisation etc.) occur along the boundary;

(ii) thermal metamorphism of the greenstones may possibly occur (A. R. I. Mohamed - pers. comm.);

(iii) the complex interfingering of greenstone/granodiorite is best accounted for by intrusion rather than faulting.

It is suggested that the granodiorite is the later part of a multiple intrusion, including gabbro and diorite. Gabbro xenoliths south of Olavtjern have been observed and reported previously: a new discovery of a gabbro/diorite body north of Olavtjern may give further support to the multiple intrusion model. It appears from field observations, supported by aerial photograph interpretation, that the body has a round shape and consists of either:

(i) a single basic rock, varying in grain size - possible associated with different cooling rates throughout the body, or variable volatile contents etc; or

(ii) several independent intrusions of diorite and gabbro with no direct connection between the two rock types.

At present there appears to be more evidence for the former - occasionally one rock type can be seen to grade into the other (e.g. loc. 173). This gabbro is not cut by the network of granodiorite veins that characterises the gabbro blocks south of Olavtjern, but lenses trending 140^{0} are not uncommon.

'Greenstones' can be divided broadly into metasediments north of Prawntjern, with metavolcanics to the south of that lake. The metasediments show well-preserved sedimentary structures such as slumping, water-release structures, cross-bedding etc. Compositions vary from siliceous through to honeycomb-weathered calcareous. Evidence for a volcanic origin, apart from basic composition, is not so clear-cut, but vescicular rocks and ropey, banded rocks were seen, the greenstones in general show a strong schistosity trending about 160^{0} - 170^{0}, dipping almost vertically. In the eastern part of the map-area the greenstones grade into a mixed zone of interbanded granodiorite/greenstone, trending NW-SE.

Leucotrondhjemite and granodiorite outcropped in the southern and western parts of the map-area. Granodiorite is generally foliated, strike 060 - 110/dip 45 - 85^{0} northwards.

The boundary between these two rock types is shown on the map as an inferred boundary because it became apparent during the mapping that the two lithologies grade into each other. This could be due to the leucotrondhjemite originating through metasomatic alteration of granodiorite. However, a leucotrondhjemite-type rock outcropping NE of Olavtjern may represent a separate intrusion. It was remarkably pale coloured but contained euhedral crystals (noticeably hornblende - which distinguishes it from the leucotrondhjemites to the south) and showed no veining.

Molybdenite only occurred in the south of the map-area occurring in a vein network or stockwork (measurements available in later report) principally in the leucotrondhjemite. Copper in the form of chalcopyrite and/or malachite was often associated with molybdenite, but in small amounts, in leucotrondhjemite, e.g. N of Smaltjern. Occasionally it was found in dolerite dykes (possibly the cause of the Cu-anomaly E of Skarfjellet Lake, N of Olavtjern) and in greenstones.

A small showing of magnetite-pyrite - ?? bornite (Loc. 71) was found in gabbro approximately 85 m N of the western end of Pistoltjern. The occurrence is very localised and its origin remains problematical. It is close to a small shear zone but probably not directly connected with this structure. It is assumed that it represents iron -? copper concentration within the formerly more extensive gabbro body - now broken up into gabbro blocks etc. by granodiorite intrusion.

P. J. F. Davis : Report on field-work south-east of Fremstfjellet

The object of the field project was to map the area south-east of the main mineralised area at Fremstfjell, paying particular attention to the greenstone-granodiorite contact, along which minor mineralisation and geochemical anomalies were known to occur.

Lithologies

(a) Granodiorite - overall white or pale grey colouration, tinged yellowish-green when fresh. The rocks varied from massive, poorly foliated (almost non-existent) to highly schistose - which rendered it brittle and splintery, especially in linear zones such as along Skarfjellbekken. The Granodiorite appeared most heavily epidotised near the contact.

(b) Leucotrondhjemite - overall creamish-pink colour. May be strongly foliated or massive; generally sericitised and/or epidotised. This rock carried noticeably more quartz veining than the granodiorite and the bulk of the mineralisation.

(c) Greenstone - variable composition and colour from basic, bottle-green coloured to intermediate, pale green to acidic, pale grey/white with greenish tinge. Along Skarfjellbekken, cm-scale banding of basic and intermediate types occurred.
South of the granodiorite, the composition changed gradually

from intermediate at the contact to basic at 200 m from the contact. This change was gradational and no banding was observed. East of the granodiorite, banding was frequent with overall basic composition. The greenstones often contain quartz veins and epidote veins - the former up to 2 m thick and the latter generally as a fine network but also up to 16 cm thick.

(d) Boulder conglomerate - granodiorite boulders up to 3 m across occur in a dark, basic, chloritic matrix - usually strongly foliated. This rock unit varied in thickness from 40 m to 200 m. It cuts across the granodiorite-greenstone contact unconformably, e.g. NW of the delta at Langtjern.

(e) Gabbro - occurs as small isolated blocks up to 5 m ocross, poorly foliated and unmineralised.

(f) Diorite - occurs rarely in small rafts and lenses. It seems to be a kind of granodiorite hybrid-type rock; variably foliated and poorly mineralised.

(g) Calcareous-siliceous metasediments - overall bluish-grey colour, generally micaceous or with a cherty appearance, weathering to a light grey colour. Pressure solution cleavage develops in the calcareous rocks. This unit has a strike length of 1 km, width of outcrop up to 100 m.

Relationships between the different lithologies

(a) Granodiorite/Greenstone: appear to show three types of contact. The first is where interdigitation occurs, e.g. along the eastern margin of the granodiorite body. Elongate fingers of both rock types give this effect.
The second is where rafts of greenstone occur within granodiorite and sheets of granodiorite within greenstone.
Thirdly, the contact may be faulted.

(b) Granodiorite/leucotrondhjemite: show no clear-cut boundaries apparently one rock merging into the other, with interfingering relationships.

(c) Granodiorite/Boulder Conglomerate: this contact runs parallel with the regional foliation strike for the most part - with the exception of the 'kinks' in the outcrop N of the Langtjern delta and S of Storfisktjern. No evidence of major faulting or thrusting was seen; the boulders appear to be derived from the granodiorite itself, ruling out an intrusive contact.

(d) Boulder Conglomerate/Greenstone: in the south of the map-area, north of Litltjern, the contact appears faulted with the rocks highly foliated. North of Langtjern, however, these two units appear to have a conformable relationship.

(e) Greenstone/Calcareous Metasediment/Boulder Conglomerate: the calcareous metasediment appears to have faulted contacts against the two adjacent units.

Structure

Foliation in the granodiorite-leucotrondhjemite body strikes 060^{o}-090^{o} and dips north at 60^{o}-80^{o}. In the greenstones the foliation trends parallel to the contact when close to the igneous complex, but gradually reverts to the same strike trend of 060^{o}-090^{o} as one moves away from the contact.

The Skarfjellbekken feature follows a large fault which apparently has dextral displacement. Other smaller faults occur in the granodiorite to the west, but the sense of movement of these was difficult to determine. Neither large-scale nor small-scale folds were observed.

Mineralisation

(a) Molybdenum - found mostly in the Fremstfjell leucotrondhjemite in the north-west of the map-area (see earlier reports of Ryan, Hocking etc.).

The high moly-anomalies in Rettbekken are related to loose blocks of quartz-moly-pyrite >> chalcopyrite in the elongate feature picked out by the stream. At the second small lake east of the eastern end of Storfisktjern occurs granodiorite with pyrite - green secondary copper - very fine-grained?? molybdenite with associated epidote veins and pink feldspar veins and spots plus the ubiquitous pyrite. The flat ground here contains conspicuous copper flowers.

(b) Pyrite - greenstones contain many rust zones, but all of small size - up to 20 m strike length. Pyrite was generally present in the granodiorite and leucotrondhjemite to greater or lesser extent. The boulder conglomerate contained granodiorite boulders which frequently contained pyrite.

(c) Chalcopyrite - but seen at Amoebtjern where massive chalcopyrite with secondary green and blue copper minerals malachite/azurite occur in highly schistose and altered? granodiorite (quartz-feldspar-sericite schist). No major occurrences of copper were found in the greenstones - only very minor, occasional spots.

(d) Magnetite - occurs as well-formed octahedra up to 2 mm across within the granodiorite in the Amoebtjern area.

G. Wilcock: Report on fieldwork in the area west and south-west of Fremstfjellet

The rocks of this map-area can be divided into three main groups:

(a) the large, intrusive granodiorite body;

(b) a series of greenschist metavolcanic and metasedimentary cover rocks;

(c) post-granodiorite, small-scale, intrusive basic dykes.

All three groups are metamorphosed and deformed. The granodiorite has variable chemistry, due to different types of alteration - K-feldspathisation, epidotisation, sericitisation and silification - especially at Fremstfjellet. This zonal sequence can be seen when approaching the Fremstfjell mineralised area from the west, i.e. up along Nedrebekken. Elsewhere, no regular alteration zonal scheme could be mapped out.

The cover rocks include metasediments in contact with the granodiorite north of Fremst.tjern - these show relict bedding, especially on the western side of the lake. This unit is medium- to fine-grained and contains layers of lighter coloured material, possibly tuffaceous. Overall, the group is calcareous.

The second group of cover rocks is a silica-rich Keratophyric unit which outcrops in a tapering, lens-shaped body around Fremst.tjern. It contains weak, patchy rust after pyrite and possibly relict volcano-clastic structures. Two intersecting planar structures - cleavage and ? volcanic layering - cause the rock to split into lenses. It was generally thoroughly weathered and difficult to collect large, fresh samples.

The third group of cover rocks, greenstones, outcrops along the southern boundary of the map-area. This unit is similar to unit one above, except that it does not contain conspicuous carbonate or bedded units - and probably consists of volcanogenic sedimentary material.

Metadolerite dykes occur as trains of lenses or boudins within the granodiorite, from 2 - 5 m in size. There appear to be two alignment directions - NNW-SSE and WSW-ENE.

Mineralisation

(a) Pyrite was recorded in all the rock types, especially the greenstones north of Fremsttjern, where strong rusting occurs, and in shear zones which often localise pyrite and rusting.

(b) Chalcopyrite occurs mainly in two areas - in the north-east at Fremstfjell and along the southern margin of the map-area between Amoebtjern and Fremst.tjern where the copper appears to be controlled by zones of high deformation. Very minor chalcopyrite and secondary green malachite occur in the rusty rocks north of Fremst.tjern. At Amoebtj, the largest occurrence of copper in the whole area, the mineralisation may be localised by the intersection of two shear zones (one E-W and the other NW-SE) creating a zone of strong deformation. Very weak copper mineralisation was found on the western side of Amoebtjern, more or less along the strike from the main locality to the east. Whether there is even a weak, semi-continuous mineralised zone between the two is impossible to say.

(c) Molybdenite was virtually confined to the Fremstfjell main area (see earlier reports).

Summary of field results and suggestions for further work

At the main mineralised area of Fremstfjell no major new mineralised localities have been discovered. However, Jane's work shows leucotrondhjemite extending north-westwards - albeit lacking mineralisation. She has speculated that the leucotrondhjemite may have been elongate more or less N-S, subsequently split by faults into the three bodies now seen. From the 1980 geophysics and 1981 drilling, the mineralisation appears to plunge northwards - thus this possible north-westward extension of leucotrondhjemite may be of significance. In the leucotrondhjemite west and north-west of BH1 she notes "leucotrondhjemite becomes more and more barren to the north-west".

The comparison of Fremstfjell with Gaizervatn - involving the work of Jane, Don and Jon - highlights the different styles of mineralisation and different types of alteration with Skardfjell showing a third type. It was pointed out that Fremstfjell, with its porphyry style mineralisation and alteration (including K-feldspathisation, epidotisation, sericitisation, silicification, widespread pyritisation) differs from Gaizervatn, with its small number of thick quartz-moly-pyrite veins and alteration lacking conspicuous K-feldspar and epidote. Skardfjell, on the other hand, showed the presence of K-feldspar, epidote - and chlorite - veining but lacked widespread sericitisation, pyrite and molybdenite mineralisation.

From the current work and the Grongprosjektet 1974 geological mapping, the mineralised area SE and S of Gaizervatn appears to coincide more or less with the central part of a complex, elongate granodiorite body which either plunges below, or is in contact with, greenstones to the SW and NE. The 800 x 600 m dimensions of the rusty, pyritised area at Gaizervatn compare with those of Fremstfjell. If, as seems likely, we are dealing with different structural levels at Gaizervatn and Fremstfjell, it is interesting to speculate as to whether porphyry-style mineralisation and alteration lies beneath the Gaizervatn mineralised area.

The work of Steve, Pete and Garry confirms that no significant moly-mineralisation occurs outside the Fremstfjell area. Steve's discovery of a round-shaped gabbro-diorite body north of Olavtjern - along with evidence from previous mapping - lends support to the idea that the igneous complex is of multiple intrusion type. Garry's work along the southern margin of his area has led him to propose a structural control on the Amoebtjern copper mineralisation.

Suggestions for further work

1. Extend the geological mapping NW of Fremstfjellet.

2. Further trenching and drilling at Fremstfjellet to define more accurately the limits of mineralisation -

   Eg. (i) trench northwards from BH2 to Smaltjern;

   (ii) extend trench no. 2 northwards and southwards;

   (iii) trenching and/or drilling between the BH3, 4, 5, 6 and BH7, 8 profiles.

   (iv) trenching west of trench no. 1 and BH1;

   (v) trenching and/or drilling between the BH5 and BH2 profiles; more holes on the BH2 profile to N & S.

   (vi) Extend, i.e. deepen BH's 4, 5 & 6.

3. Reconnaissance of the Reinsjöen - Nesapiggen geochemical anomalies.

4. ?? Deep drilling at Gaizervatn to probe the possibility of further mineralisation at depth.

Note that size of "moly-zone", ringed below, is much less than the 800 x 600 m rusty pyritic zone mentioned in the report.

F6

Photocopy of field-slip to show Molybdenite localities.

(Don Cawthera has a possible ?? v. fine grained moly-locality to the NE – but in ? greenstone/diorite along the southern contact of the granodiorite/zone.)