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A revew of the available geological and geochemical data on the Sanddøla - Nesåvatn Mo-Cu prospects i the Grong district. (Tronhjemitt-prosjektene 1974 og 1975).

Oppdrag:

SANDDØLA - NESÅVATNA PROSJEKTET I GRONGFELTET

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NORGES GEOLOGISKE UNDERSØKELSE

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Preface

This report presents a slightly modified version of the note of 31 May 1976 by D.C. Smith entitled "Note on the available geological and geochemical data on the Sanddøla - Nesåvatna Mo - Cu prospects, Grong, (Trondhjemitt-prosjektene 1974 og 1975)".

Contents

Tables

Sketches

Maps

1. Introduction.

Geological and geochemical information concerning the Mo + Cu occurrences and anomalies in the Sanddøla - Nesåvatna area, Grong, resulting from the two small field projects in 1974 and 1975 led by this author has so far been presented in two reports:

a) "Follow-up of copper and molybdenum geochemical anomalies in the southern part of Grongfeltet : Field work and analytical results for Cu and Mo". NGU report 1289/1, D.C. Smith, October 1974.

b) "Regional and detailed stream sediment surveys over the Sanddøla trondhjemite and associated rocks in southern Grongfeltet : Maps and frequency distributions for Mo, Cu, Pb, Zn and Ni". NGU report 1289/2, D.C. Smith, May 1975.

Further information has been provided as follows:

c) "Notat om muting i Sanddøla - Nesåvatna området i Sør-Grongfeltet med hensyn til Mo- og Cu-mineralisering". D.C. Smith, 20. november 1975.

d) "Rapport feltarbeide i Grongfeltet sommeren 1975 (Foreløpig rapport Trondhjemittundersøkelsen)". T.H. Tan, December 1975.

e) "Sanddøla, the correlation of altitude and the tree line with Pb in stream sediments". D.C. Smith, December 1975.

f) "Gaizervatn, moss-trapped stream material as a prospecting medium". D.C. Smith, December 1975.

g) Diverse proposals for future work, mostly concerning field work plans for 1975.

h) Diverse maps available with preliminary geochemical data.

a) to h) have all been sent to Grong Gruber A/S. e) and f) have been sent for publication in the Journal of Geochemical Exploration during 1976 with the name "Sanddøla" replaced by "Grong", the name "Gaizervatn" replaced by "Storvatnet", and the contours of Gaizervatn changed on the accompanying map, as requested by A. Haugen by telephone (12-2-76).

Several reports, or parts of reports, are planned which will cover the various aspects of the project - 1) Stream sediment surveys for Mo and Cu, 2) Soil and moss sampling, 3) Assaying of ore samples for Mo and Cu, 4) Major element petrochemistry of selected rock units, 5) An outline petrographical and historical geological interpretation and finally 6) An evaluation of ore potential by integrating the data from the Sanddøla - Nesåvatna area with known deposits elsewhere, in particular the Mo and Cu porphyry deposits of Canada and the USA. Some of these aspects (e.g. 1) are nearly ready for the stage of report writing whilst studies of certain other aspects (e.g. 4) have not yet begun.

Work on other investigations of relevance to the project (for example studies of the effects of stream order, organic content, Mn and Fe scavenging and multiple element correlations, on the significance of stream sediment anomalies) is partly complete but completion and report writing is postponed.

2. Notes on progress.

2.1 Stream sediment surveys.

Map 1270 - 02 provides an up to date review of the districts so far covered by stream sediment surveys, including the 360 samples collected in 1975 in order to fill up important spaces left by previous surveys.

Since the 1:50 000 map series inconveniently covered the Sanddøla - Nesåvatna area and the scale was too small for plotting the stream sediment anomalies, a new 1:20 000 map based on the air photograph mosaic over Grongfeltet has been constructed. This has been designed for field use and includes as much useful information as possible (e.g. the air photograph series 357 grid, the mosaic grid, geographical coordinates, altitudes, roads, huts, bridges, paths, muting grids (1-1-76), principal geological contacts and known prospects prior to this project) in addition to the conventional topographic features on stream sediment maps. Furthermore since two elements are of interest and their geographic interrelationship is of geological significance, a new special method of plotting has been developed which simultaneously provides data for both Mo and Cu. Draughting work has reached the stage of completing map 1368 - 08 (enclosed here). The next stage could be drawing contours of metal concentration, for example of Mo and Cu combined, in an attempt to delineate metal provinces.

Map 1368 - 08 clearly displays the various Mo and/or Cu anomalous districts and indicates a correlation of these with the major trondhjemite + greenstone unit which contains three of the muting districts - Gaizervatn, Nesåpiggen and Fremstfjellet. The fourth district - Finnbuvatn - lies within a separate greenstone unit further south. Also shown within the major trondhjemite - greenstone unit are five other Mo and/or Cu anomalous districts which were recommended for muting in the letter of 20-11-75 (reference 1c) (south-west of Langløftvatna, east of Skarfjellvatnet, west of Reinsjøen, north of Tjernrøle and north-east of Gaizervatn).

The stream sediment data from the 1974 detailed survey in the Fremstfjellet district has been redraughted in an identical fashion so that both the Mo and Cu results can be examined on map 1289 - 28. Thus the one kilometer wide N. W. - S. E. zone of high Mo + Cu samples mentioned in report 1289/2 is more clearly visible. The muting areas of 1-1-76 have also been superimposed such that it is easy to identify those of most interest from the stream sediment point of view, i.e. particularly numbers 68 and 69.

2.2 Soil and moss sampling.

The enclosed map of the results of moss sampling at Gaizervatn is taken from reference 11. Moss was sampled by the author in 1975 in addition to new stream sediments to clarify the relationship between the distribution of Mo and Cu anomalies and the underlying bedrock. This yielded a consistent picture of high Mo and/or Cu districts at particular localities within the major trondhjemite - greenstone unit with low districts over the conglomerate unit. Thus it was deduced that the high Mo and Cu stream sediment anomalies over the conglomerate as indicated on maps 1289 - 18 & 19 in NGU report 1289/2 are incorrectly located or are in error for some other reason. This does not, however, rule out economic possibilities in the conglomerate since this unit is derived from the mineralized trondhjemite and greenstone units.

Soil samples were taken nearby to a few mineralized outcrops to provide information on the magnitude of Mo and Cu contents in secondary media. One result at a stream known as Nålbekken (map 1289 - 28) was the discovery of 1000 ppm Cu in soil (sample 1368 - 3007) adjacent to Mo mineralization. This is a further example of the curious inverse relationship between Mo and Cu mineralization and anomalies in secondary media mentioned in report 1289/1. This again suggests an intimate mixture of Mo- and of Cu-mineralization in bedrock obscured by vegetation, swamp, water or by chemical weathering, but which is picked up by the secondary media.

Other interesting results were the Cu contents of a plant, believed to be Viscaria (240 ppm), growing in moss (950 ppm) overlying soil (560 ppm) in a dry rusty gully at the south-west end of the small lake which drains into Gaizervatnet from the south-east. Hence one can expect Cu mineralization in unweathered bedrock at this locality (Kobberbekken).

Altogether 37 samples of moss, soil and other secondary media were collected in 1975.

Kartet?

2.3 Assaying of ore samples.

Selected samples have been analysed for Mo and Cu either by optical emission spectrography (O. E. S.) or by atomic absorption spectrometry (A. A. S.). All of the analyses by O. E. S. are listed in the accompanying tables(18 from 1974, 29 from 1975). The analyses by A. A. S. are not yet complete, and those samples which have been analysed have not yet been thoroughly controlled. However, one set of data for 71 rocks from 1974 (oppdrag 1289, Fremstfjell-feltet) is presented here as an indication of the magnitude of Mo and Cu contents in the bedrock samples.

Localities are listed in the table. Sample sites for oppdrag 1289 are indicated on maps 1289 - 01 and 02 in report 1289/1. Sample sites for oppdrag 1368 are not yet draughted. Petrographical examination of the samples is not complete but the general rock type is listed in the table. Preliminary comments can be made as follows.

Mo is highest at Smaltjernet (sample 1368 - 1166, 1.44%) where about 15 narrow parallel veins of molybenite occur within a 3 cm wide quartz vein cutting trondhjemite. All other values exceeding 0.1% occur nearby to Smaltjernet in similar types of trondhjemite or occur at the chalcopyrite prospect at Amøbetjernet or in the trondhjemite specimens from Nesåpiggen. However, samples from other districts (e.g. Gaizervatnet and Langløftvatna, samples 1368 - 1223 and 1225), also indicate substantial Mo contents.

Cu is highest at Amøbetjernet (samples 1289 - 3032, 3036 and 1368 - 1250, 1256 all exceed 20% whilst 1368 - 1250 contains 30% Cu). The magnetite - pyrite deposit at Kroktjernet shows Cu contents up to 2.6% (sample 1289 - 3083 and 1368 - 1149 and 1151). Other Cu contents exceeding 1000 ppm occur in Mo-bearing samples (e.g. sample 1368 - 1166 at Smaltjernet) or at isolated outcrops at Skarfjellelva, Reinbekken and Reinsjøen (samples 1368 - 1128, 1246 and 1268 respectively).

2.4 Major element petrochemistry.

The budgets of 13-8-75 and 16-9-75 allow for major element analyses for Si, Al, Ti, Ca, Mg, Fe (tot), Na, K & Mn of 10 rock samples. Hence the 471 samples collected (151 in 1974, 320 in 1975) have to be examined from various geological standpoints before a sensible selection of only 10 samples can be made. Such a geological examination is not yet complete. For the same reason it is not possible to report on thin section microscopy of the 1975 samples.

2.5 An outline petrographical and historical geological interpretation.

2.5.1 The geology of the Fremstfjellet area.

The geological maps of Foslie and Gale indicate two rock types in the Fremstfjellet area - trondhjemite and greenstone - in addition to a conglomerate unit to the south. However, field examination by the author in 1975 revealed many different types of intrusive rocks ranging from melanocratic hornblendite through diorite, microdiorite, and perhaps gabbro to different types of leucocratic rock, including tonalite and granodiorite and perhaps mangerite or monzonite and several different porphyries and microporphyries some of which may be chilled margins of the other more equigranular rocks. Thus the area is really an igneous complex. Wherever an intrusive relationship was observed in the field, the younger rock was always more acid. Many of the rocks are strongly sheared, chloritised, sericitised, epidotised with remobilised quartz and often also pyritised, such that in many cases it is impossible to identify the original rock type, at least in the field. Thus the boundary of the greenstone cannot yet be mapped accurately.

The most reasonable hypothesis so far is that a pre-existing greenstone unit was intruded by a series of igneous rocks commencing with the most basic first and culminating in the most acid. The conglomerate was derived from the greenstone and intrusive units. The area has been subjected to tectonism and metamorphism at least once under greenchist facies conditions.

2.5.2 The mineralization of the Fremstfjellet area.

Molybdenite is normally associated with quartz in veins oblique to the schistosity. In the outcrops at Smaltjernet and Nålbekken the obliquity is only about 20°. The host rock is commonly a very leucocratic medium-grained porphyritic "trondhjemite" partly affected by what appears to be kaolinisation. Pyrite always occurs in the host rock and occasionally in the veins. Chalcopyrite is not common in this association; when it occurs it seems to be related to pyrite rather than to molybdenite.

The thickest molybdenite-rich vein so far discovered is 6 mm (specimen 1289 - 5066). Often only one narrow (1 - 2 mm) vein occurs, but at Smaltjernet a 3 cm wide quartz vein contains about 15 subparallel < 1 mm thick molybdenite veins (specimen 1368 - 1166, 1,44% Mo within the vein).

The localities of rich Cu-mineralization are widely separated and of different character. Thus the nearly pure chalcopyrite mineralization at Arnkletjernet occurs at a contact between schistose trondhjemite and schistose trondhjemite - derived conglomerate. The rich magnetite-pyrite occurrence with some Cu at Kroktjernet occurs in a dioritic rock type adjacent to a more acid unmineralized trondhjemite. Otherwise weak chalcopyrite mineralization occurs in pyritised greenstone and trondhjemite.

2.5.3 The geology and mineralization of the Nesåpiggen and Gaizervatnet areas.

The Nesåpiggen area has been described in the report of Tan (reference 1 d).

One day was spent in the Gaizervatnet area by the author in 1975. The geology is essentially identical to that of the Fremstfjellet area - trondhjemite, greenstone and conglomerate - with rust zones rich in pyrite. New Mo- or Cu-mineralization was found within the prominent rust zone, partly mapped by Gale, which strikes north-east/south-west cutting the south-eastern-most part of Gaizervatnet. This zone is directly adjacent to the contact with the conglomerate unit and is collinear with the anomalous zone detected by the VLF survey of the district carried out by Grong Gruber A/S in 1975.

The impression was gained that the Gaizervatnet and Fremstfjellet areas are very similar in size, in geology and in mineralization and therefore probably also in ore potential. The Nesåpiggen area may also be similar.

2.5.4 Geophysical surveys.

Hva er dette? Area Helimating

The electromagnetic surveys by NGU in 1974 (oppdrag 1274) do not provide much information concerning this project but the magnetic maps (1274 - 01 and - 02) are very interesting. Magnetic anomalies correspond well with the long thin outcrop of greenstone to the south passing through Langtjernet, mapped by Gale (maps 1293 - 05, - 06, - 07); the Skartjellet

district and the units joining Langløftvatna with Gaizervatnet and with Reinsjøen. However, the map suggests that the Gaizervatnet - Langløftvatna unit swings sharply north-westwards to Reinsjøen and does not continue to Skarfjellet which shows a closer relationship to the Langtjernet unit.

The greenstone units have been correlated with Cu anomalies in stream sediments (NGU report 1289/2). The Mo mineralization in the Fremstfjellet and Gaizervatnet areas occurs close to the contact of the magnetic anomalies and the magnetic background in accord with the observation that the Mo mineralization appears to occur mainly at the margins of trondhjemite against greenstone (NGU report 1289/2). The Gaizervatnet - Langløftvatna - Reinsjøen greenstone unit probably continues into Reinbekken and Månedalen giving rise to the Mo- or Cu- stream sediment anomalies and magnetite - chalcopyrite mineralization there (map 1368 - 08) but it might conceivably swing further north to account for the anomalies in the Nesåpiggen area.

A prominent rust zone, observed from a distance by the author, occurring on the north slope of Skarfjellet, corresponds with a prominent magnetic anomaly and is probably another magnetite - pyrite deposit like the one at the summit of Skarfjellet described by Pettersen in 1974.

4.5.5. A geomorphological/structural interpretation of the Mo mineralization.

A close examination of Nålbekken, a small stream with both anomalous Mo-values in stream sediments and molybdenite-quartz mineralization in bedrock, provided evidence for the author's hypothesis for the origin of the many anomalous stream sediment Mo-values in an area, Fremstfjellet, with apparently very little Mo mineralization.

The enclosed, idealized sketch of a section through Nålbekken (fig. 1) shows the following principal features observed at the surface and those inferred at depth -

a) round smooth weathered exposed bedrock (pyritised trondhjemite, in part schistose), essentially a relict surface since the last glaciation;

b) a thin cover of vegetation (grass, heather, fern or moss) occurring mainly in depressions;

c) a relatively deep, narrow, straight and overhanging small gully;

d) a low water level, due to a small drainage area, insufficient to have formed the gully since the last glaciation by only river action;

e) blocks of bedrock fallen from the overhanging wall and obscuring the stream in part.

Molybdenite - quartz mineralization occurs in the overhanging wall (f); in some of the fallen blocks (g); in loose blocks in the stream bed which are probably in situ (h); and in "in situ" bedrock in the stream bed (i). Molybdenite does not occur within the first two centimetres of exposed rock where it has been dissolved away leaving a quartz vein full of holes and stained a characteristic red-brown.

The hypothesis proposes that the molybdenite - quartz mineralization exists in a group of interwoven veins separated from other outcrops of Mo mineralization by trondhjemite, barren apart from ubiquitous disseminated pyrite. During the summers the molybdenite in the veins dissolves in the stream water by chemical action. During the winters ice action destroys the remaining quartz fabric of the veins. Thus collapsing veins leads to a relatively rapid erosion of the bedrock thus forming the gully. Hence richer Mo mineralization can be expected directly under the stream bed. In view of examples of surface weathering leaching away Mo from exposed ore (Brenda Cu - Mo deposit, Canada) and of high concentrations of Mo in stream sediments immediately downstream of the ore zone (Boss Mountain Mo deposit, Canada) and of strong absorption of Mo by organic material in certain chemical environments, an important consequence of this hypothesis is that high concentrations of Mo in secondary media may indicate hidden Mo mineralization very close, a few metres away and a few centimetres deep, rather than several hundred metres upstream.

A search for further molybdenite occurrences in similar gullies, rather than in the intervening areas, resulted in many new finds.

Examination of the air photograph 1209 (figure 2) indicated several structural lines subparallel to Nålbekken. These are provisionally interpreted as a set of shear zones with a strike around 80°. Another set of structural lines striking around 100° is provisionally interpreted as a second set of shear zones. Alternatively they may be fracture or tension zones.

A series of short structural lines striking around 160° are identified as joints since they give rise to prominent roche moutonées in the field. Two prominent lineaments which intersect just south-west of Korttjernet are presumably fault lines.

Figure 3 displays the locations of streams with high Mo-values in sediments whilst figure indicates the localities of molybdenite - quartz mineralization found to date. The interrelation between these variables can be found in the enclosed table 2.

Thus all the Mo-mineralization found to date occurs in streams with anomalously high Mo-values. The converse is not true probably since not all of the streams have been prospected.

Mo-mineralization appears in type 1 shear zones in 6 streams (Nedrebekken, Smaltjernbekken, Nålbekken, Pinnebekken, Lavtjernene and Brattbekken); in type 2 shear zones in 2 streams (Stuttbekken, Rettbekken) and in both at Smaltjernet where the richest Mo-mineralization was found. The joints are thought to be irrelevant with respect to the mineralization. The stream sediment Mo anomalies in Linjebekken are probably derived from the mineralization around Smaltjernet such that the inferred fault lines are probably also irrelevant.

2.6 Evaluation of ore potential.

The evidence so far suggests that the molybdenite - quartz - pyrite mineralization with minor chalcopyrite within the trondhjemite rock units may not be genetically related to the chalcopyrite - pyrite - magnetite mineralization with minor sphalerite and galena within the greenstone units in Grongfeltet. The close proximity of the two mineralizations and their anomalies in secondary media in the field is probably a result of tectonism and metamorphism of adjacent rock units accompanied by some remobilisation of the ore minerals. A proper evaluation of ore potential cannot be made until present studies are completed. However, certain preliminary comments can be made.

i) Ordinary prospecting with a geological hammer led to the finding of rare grains of molybdenite in Grongfeltet (NGU report 1189). Prospecting with a sledge hammer revealed several other localities. Prospecting especially in gullies revealed richer mineralization. Blasting with dynamite revealed even richer mineralization. Hence the impression from ordinary prospecting that the ore potential of this area is low because of a lack of finds is not valid. {NGU report 1289/1}

ii) Although it is obvious that a ore body does not occur exactly at the exposed surface, it is quite possible that ore lies just below stream beds, bogs and lakes and that the only bedrock exposed at present is the barren rock between the ore which has been preferentially weathered. Only drilling can disprove this hypothesis since geophysical surveys may not detect molybdenite - quartz mineralization.

iii) If the author's hypothesis of several parallel mineralized shear zones is true then the ore may nevertheless be uneconomic if the zones are only a few metres wide but tens or hundreds of metres apart. However, they may have a strike of a kilometre or more and a depth sufficient to be of economic interest.

iv) Alternatively the presently - detected mineralization may be only the weak upper part of a rich ore-body at depth, i.e. effectively a blind deposit like the San Manuel - Kalamazoo porphyry molybdenum - copper deposit in Arizona.

v) Several features indicate a similarity of the Fremstfjellet district to porphyry molybdenum - copper deposits in Canada, for example: -

- the association of Mo and Cu with leucocratic intermediate igneous intrusions, especially with volcanic rocks nearby;
- the similar petrography of the molybdenite - quartz mineralization at Fremstfjellet and in the specimens at NGU from Climax and Henderson mines;
- features at Boss Mountain Mo deposit, single and multiple molybdenite - quartz vein systems, ubiquitous pyrite, some chalcopyrite, in granodiorite adjacent to quartz - monzonite,
- features at Brenda Cu - Mo deposit chalcopyrite, molybdenite, minor pyrite, in a gangue of quartz and epidote etc. in fracture fillings (veins), and not disseminated in a quartz - diorite;

- features at Gibraltar Cu - Mo deposit;
  stockwork of veins containing pyrite, chalcopyrite, molybdenite and bornite in the quartz - diorite; subsequent cataclasis and simultaneous saussuritization.

- features at Sheslay Cu - Mo prospect,
  Cu - Mo mineralization tends to occur in linear zones of variable grade of feldspathization and silicification in volcanic and sedimentary rocks intruded by feldspar porphyry and foliated diorite.

- the concentrations of Mo in stream sediments in the Fremstfjellet area (maximum 930 ppm) compared to those near known ore bodies: Brenda, (550 ppm); Boss Mountain, (several hundred ppm Mo); Chutanli, (24 ppm); Gibraltar, (> 80 ppm); Huckleberry, (> 40 ppm); Mahoney Creek, (48 ppm), Sam Goosly, (> 16 ppm); however, climate, topographic features and analytical methods are relevant here;

- maximum length of anomalous Mo - Cu drainage dispersion is approximately 2 miles or less at Casino, Gibraltar, Huckleberry, Maloney Creek and Sam Goosly.

- the concentrations of Mo in bedrock in the Fremstfjellet area (maximum 1.44%) compared to those in known ore bodies in Canada: Chutanli (0.1%); Gibraltar (0.016%); Highmont (0.042%, 0.093%); Huckleberry (0.025% Mo); Island Copper (0.029%), however, some of these deposits are mined for Cu with accessory Mo.

Thus many of the porphyry Mo ± Cu deposits in North America do not in fact have disseminated mineralization. Rather they have veins just like at Fremstfjellet.

vi) All porphyry Mo ± Cu deposits in North America are Triassic or younger whilst the rocks at Fremstfjellet appear to be of Caledonian age. Some geologists have suggested that porphyry deposits are restricted to Mesozoic and Tertiary rocks. Even if this is true for porphyry deposits sensu stricto, because of a change in the Earths geothermal gradient or mantle convection leading to a change in crustal processes, it is suggested that processes forming Mo mineralization similar to recorded porphyry deposits probably occurred during Caledonian times.

Porphyry Cu - Mo deposits are now recorded from the Scottish Caledonides, and deposits of Palaeozoic age are widespread in the Soviet Union (I.M.M February 1976.)

It is concluded that the Fremstfjellet area provides sufficient geological and geochemical evidence to infer processes of mineralization similar to those which produced typical porphyry Mo - Cu deposits in North America and hence to imply the presence (or past presence) of a Caledonide porphyry Mo - Cu deposit in southern Grongfeltet.

3. Proposals for further work.

The best available methods for locating blind deposits of porphyry Mo - Cu mineralization are probably those of alteration - mineralization zone mapping after Lowell & Guilbert (1970, Economic Geology, vol. 65 (4), p 373) or chemical element zone mapping after Chaffee (1976, Journal of Geochemical Exploration, vol. 5 (2), p 145). Both require detailed rock sampling at the surface and at depth by drilling.

Apart from one obvious drilling target (see below), an adequate zone mapping project first requires detailed petrographic studies to sort out the different host rock types and subsequently detailed structural studies to work out the structural history of the area.

Prospecting with sledgehammers, particularly along gullies may provide useful further information. In contrast to the importance of bedrock geochemistry for zone mapping, secondary geochemical media are probably of less importance now, except for very detailed studies in the Fremstfjellet area, but a continued regional stream sediment survey would be useful.

There does not seem to be a proven geophysical method capable of detecting molybdenite - quartz mineralization, though VLF or IP may detect molybdenite in continous veins or shear zones. Identification of pyrite zones by VLF or some other geophysical method may help to find molybdenite, but it may in fact hinder by yielding confusing results since pyrite occurs both associated and separate from the molybdenite mineralization.

Map 1289 - 28 and figure 3 provide useful guides to planning the areas to be covered by a VLF survey and also the first drilling target. Muting areas 68 and 69 and the northern halves of areas 77 and 78 are the most interesting and are recommended as a minimum for a VLF survey. This choice

conveniently covers many of the type 1 shear zones and some of the type 2. The lower halves of mutings area 56 and the unmuted area just south of 77 respectively include the Cu deposits of Kroktjernet and Amøbetjernet. Thus the north-south centre line of mutingsareas 68 and 77 (represented on figure 1) extended north to Kroktjernet and south to Amøbetjernet passes through most of the interesting geochemical, mineralogical, petrological and structural features of the district. Thus it would be very useful if a VLF traverse was continuous over these four muting areas, whilst extra information will be gained from surveys in the adjacent areas 69 and 78.

Since the strike of the shear zones and schistosity of the rock types is generally East - West and dips of schistosity, where measureable, are around 60^{o} to the North, a single long- or a series of short-drill holes inclined at 30^{o} to the South along this centre line would intersect many shear zones. Apart from confirming or otherwise the author's hypothesis of richer molybdenite - quartz veins at veins at depth under the stream beds, such drill holes will provide invaluable geological information, especially since continuous well-exposed sections of bedrock are unattainable at the surface. Since the logistics of taking a full size drilling rig to the Fremstfjellet district may prove very expensive, a cheaper and convenient alternative would be to use a Packsack portable diamond drill such as that at NGU which can be carried in by two men.

It is suggested that a small drilling project with the Packsack equipment will provide more useful information at this stage than the other proposed work in this district and indeed will be of great benefit prior to the proposed petrographical and structural studies, and is thus recommended as a first priority in following up this probable porphyry molybdenum - copper mineralization.

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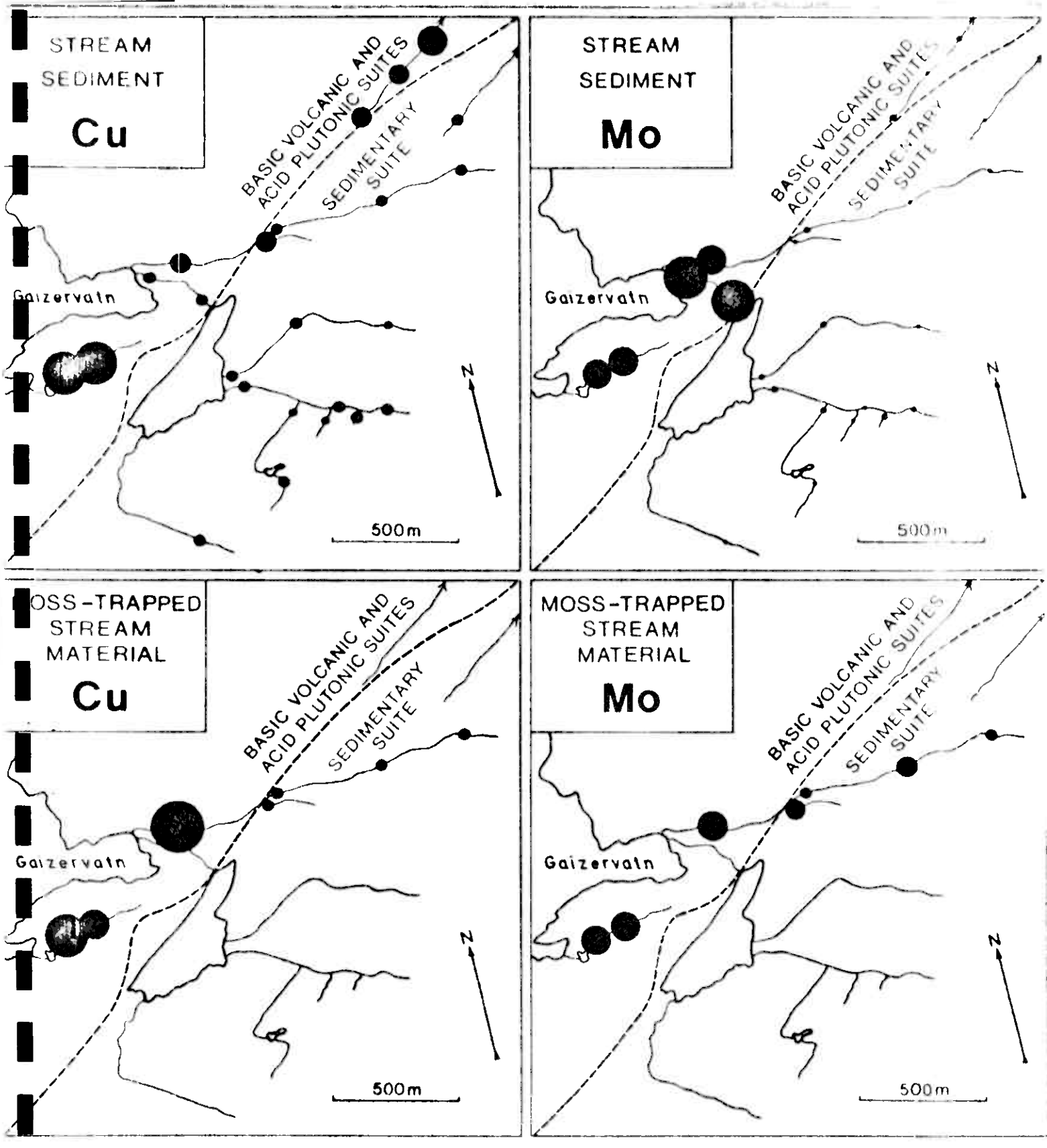
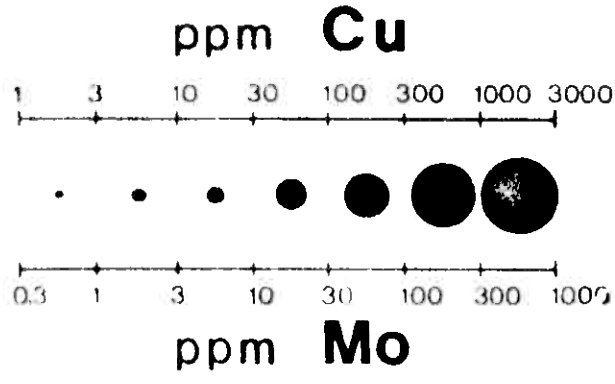




HOT HNO_3 EXTRACTABLE METALS FROM STREAM MATERIALS

GAIZERVATN AREA CENTRAL NORWAY

table 1-1

Chemical Analyses of Rocks for Mo and Cu.

Sample Type - selected ore-rich rock chips
Method - optical emission spectrograph
Date - 13 - 8 - 74

Number	Mo ppm	Cu ppm	Locality		Rock Type		
1289 - 3014	1	10	Svingbekken		?		
- 3020	2	60	Tynntjernet	?			
- 3022	20	100	"	?			
- 3030	1	6	"	?			
- 3038	1000	> 3000	Arnøbetjernet				M
- 3041	<1	300	Brattfjellet			Q	
- 3044	300	10	Brattbekken		T		
- 3055	3	600	Rettbekken		?		
- 3074	3	100	Smaltjernet	G			
- 3083	10	> 3000	Kroktjernet				M
- 3089	2	100	"	?			
- 3109	<1	30	Svingbekken				N

Sample Type - selected chips
Method - optical emission spectrograph
Date - 9 - 7 - 75

1289 - 3029	-	500	Tynntjernet	?			
- 3086	-	90	Kroktjernet	?			

Sample Type - selected chips
Method - optical emission spectrograph
Date - 25 - 7 - 75

1368 - 1128	<3	60	Skarfjellelva			Q	M
- 1131	<3	<3	"		T		
- 1136	<3	300	"		?		
- 1140	<3	6	"		?		

Analyses - 2.

Sample Type - whole-rocks
Method - optical emission spectrograph
Date - 30 - 11 - 75

Number	Mo ppm	Cu ppm	Locality		Rock Type		
1289 - 3005	900	5000	*Nedrebekken		T	Q	
- 3032	200	276000	Amøbetjernet				M
- 3066	10700	80	Lavtjernene		T		
- 3083	50	9800	Kroktjernet				M
1368 - 1026	<30	40	Korttjernet		T		
- 1040	<30	40	Fremsttjernet	G			
- 1117	4900	30	Nålbekken		T	Q	
- 1127	4400	40	Stuttbekken		T	Q	
- 1128	< 30	1000	Skarfjellelva			Q	M
- 1145	<30	800	Kroktjernet				M
- 1146	< 30	7000	"				M
- 1149	40	19200	"				M
- 1151	40	26000	"				M
- 1166	14400	2000	Smaltjernet		T	Q	
- 1187	300	1000	Nedrebekken		T	Q	
- 1218	40	500	Gaizervatnet			Q	M
- 1222	<30	30	Gaizervatnet		T		
- 1223	100	40	"		T	Q	
- 1225	500	50	*Langløftvatna		T	Q	
- 1237	<30	1000	Reinbekken				M
- 1246	50	3600	"				M
- 1248	<30	2000	*Kroktjernet		T		
- 1250	< 30	300000	Amøbetjernet				M
- 1256	2700	214000	"				M
- 1260	3000	16300	"				M
- 1268	< 30	11000	Reinsjøen			Q	M
- 1309	1000	20	Nesåpiggen		T		
- 1311	6700	20	"		T		
- 1320	<30	30	"			?	

* = Loose block
G = Greenstone
T = Trondhjemite
Q = Quartz vein
M = Matrix
N = Manganese-rich

Table 1-3

Analyses - 3.

Sample Type - whole-rocks
Method - HNO_3 digestion with Br_2, atomic absorption spectrometry
Date - 28 - 4 - 76

Number	Mo ppm	Cu ppm	Locality		Rock Type	
1289 - 3003	1010	580	*Nedrebekken		?	
- 3005	860	2400	* "		?	
- 3008	<10	278	Svingbekken	G		
- 3010	10	59	"	G		
- 3012	10	46	"	?		
- 3014	<10	39	"		?	
- 3016	10	20	"	?		
- 3019	<10	165	Tynntjernet	?		
- 3020	<10	79	"	?		
- 3022	40	174	"	?		
- 3024	20	201	"	?		
- 3026	10	158	"	?		
- 3028	10	38	"	?		
- 3030	<10	17	"	?		
- 3032	140	231000	Arnøbetjernet			M
- 3034	810	81000	"			M
- 3036	90	234000	"			M
- 3038	800	107000	"			M
- 3041	<10	216	Brattfjellet		Q	
- 3042	10	840	"		Q	
- 3044	480	1760	Brattbekken		T	
- 3045	40	430	"		T	
- 3047	450	2410	"		T	
- 3049	310	390	*Rettbekken		T	
- 3051	440	245	* "		T	
- 3053	20	990	"	?		
- 3055	10	243	"		?	
- 3057	10	248	*Brattbekken	G		
- 3059	60	109	Fremstfjellet		?	
- 3061	640	42	"		?	
- 3062	160	12	"		?	
- 3064	10	269	"	G		
- 3066	5100	107	Lavtjernene		T	
- 3068	90	282	"		?	
- 3070	1350	51	Smaltjernet		T	
- 3072	30	206	"	G		
- 3074	20	111	"	G		
- 3076	10	51	Høytjernene	G		
- 3078	30	280	Korttjernet		?	
- 3080	50	225	"	G	T	

Table 1-4

Analyses - 4.

Sample Type: whole-rocks
Method: HNO_3 digestion with Br_2, atomic absorption spectrometry
Date: 28 - 4 - 76

Number	Mo ppm	Cu ppm	Locality			Rock Type
1289 - 3083	40	7900	Kroktjernet			M
- 3085	20	650	"			M
- 3087	< 10	133	"	?		
- 3089	<10	225	"	?		
- 3091	10	123	Nedrebekken		?	
- 3093	10	460	Svingbekken	G		
- 3095	10	127	"		T	
- 3097	10	33	Tynntjernet	?		
- 3099	10	12	"	?		
- 3102	20	410	"	?		
- 3104	20	177	"	?		
- 3105	50	660	"	?		
- 3107	10	49	Svingbekken			N
- 3109	10	39	"			N
- 3111	10	6	Brattfjellet		T	
- 3113	10	16	"		T	
- 3115	10	18	"	G		
- 3117	30	133	Rettbekken		?	
- 3119	10	207	"		?	
- 3121	10	10	Kolitjernet		T	
- 3123	<10	6	Geittindvatnet		T	
- 3125	<10	8	"		T	
- 3127	<10	6	"		T	
- 3129	10	10	"		T	
- 3133	< 10	9	"		T	
- 3137	10	15	Geittindrumpa		T	
- 3139	<10	7	"		T	
- 3141	10	7	"		T	
- 3143	<10	7	"		T	
- 3149	<10	7	Kolitjernet		T	
- 3151	10	9	"	G	T	

* = Loose block
G = Greenstone
T = Trondhjemite
Q = Quartz vein
M = Malm
N = Manganese-rich

fig 1

IDEALIZED SECTION THROUGH NÅLIDEKRAN

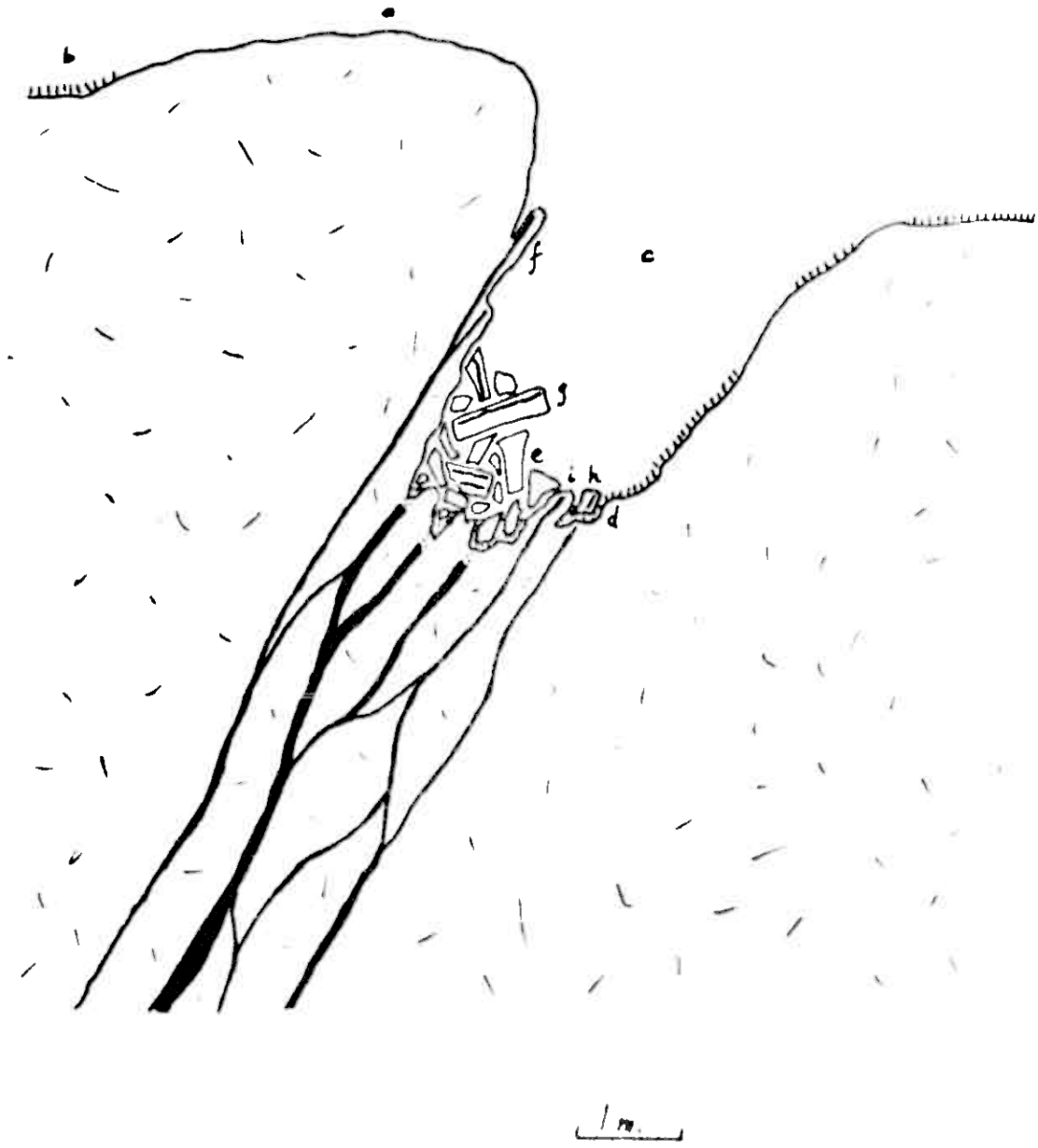
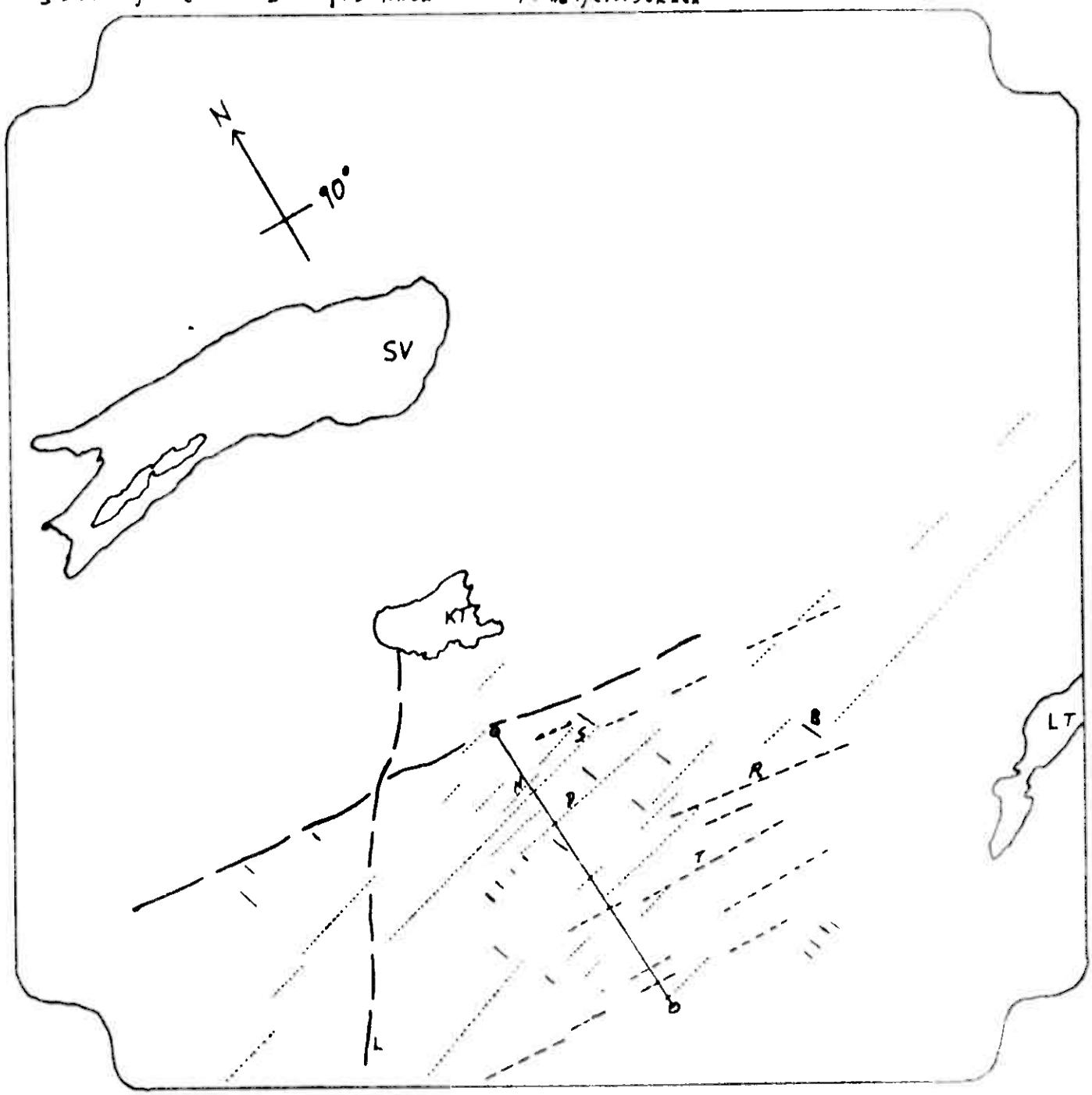


fig 2

STRUCTURAL FEATURES - FREMSTFJELLET AREA

AIR PHOTOGRAPH — WIDERØE FLY SERIES 357 NUMBER 1209 1:20,000

SV= Skarfjellvatnet KT= Korthjernet LT= Langtjernet
N = Nålbekken D= Nedrebekken R= Reinbekken B= Bjørnbekken
S = Smaltjernet L= Linjebekken T= Trollbekken



Shear zone 1

Major Fault

Centre line of mutingsområder 68 and 77

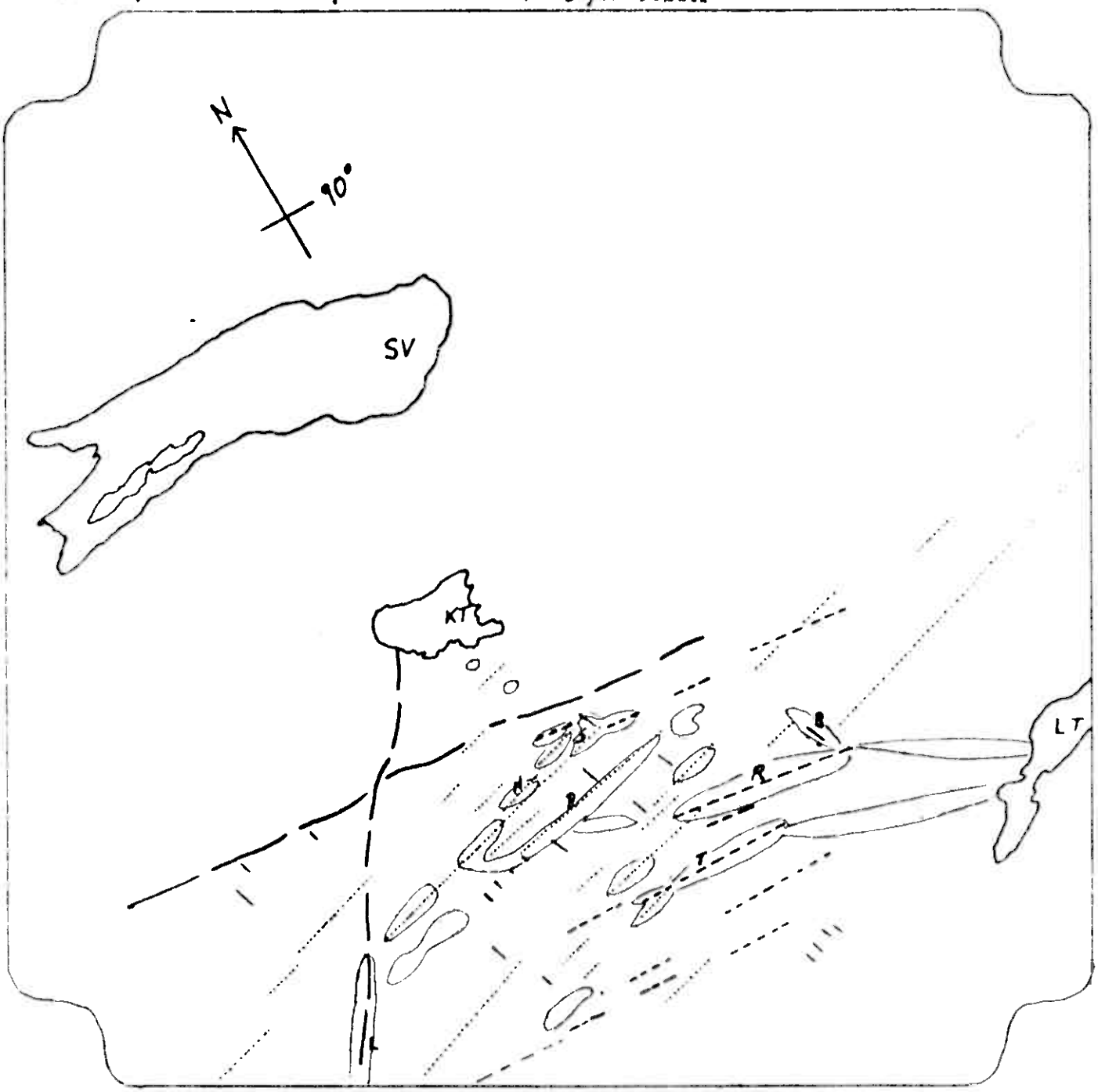
Shear zone 2

Master Joint

STRUCTURAL FEATURES - FREMSTFJELLET AREA

AIR PHOTOGRAPH – WIDERØE SERIES 357 NUMBER 1209 1:20,000

SV= Skarfjellvatnet KT= Kortkjernet LT= Langtjernet
N = Nålbekken D= Nedrebekken R= Rørbekken B= Blåmbekken
S = Smaltjernet L= Linjebekken T= Tretjernbekken



Shear zone 1

Major Fault

Stream Sediment Mo Anomaly

Shear zone 2

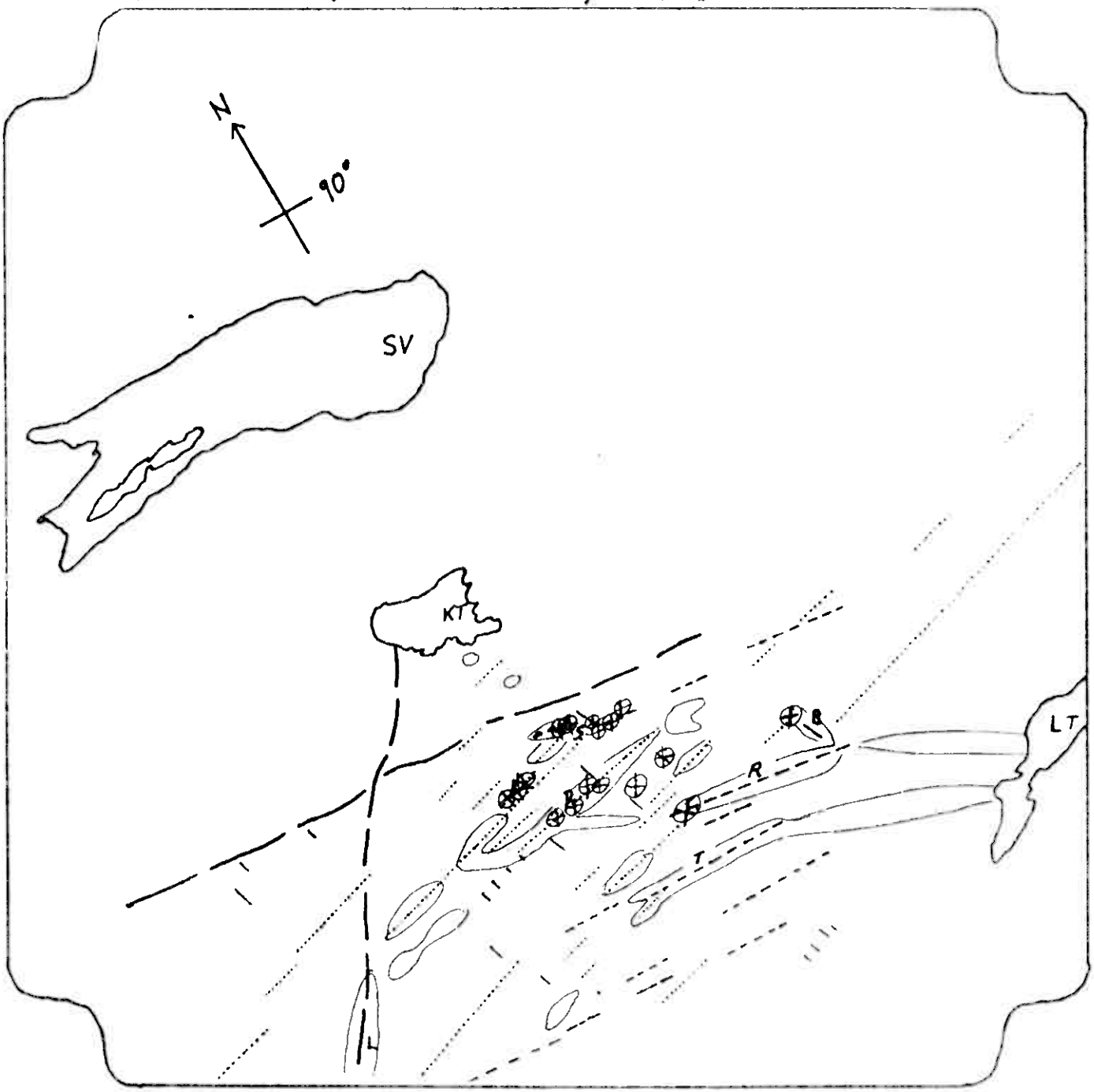
Master Joint

fig. 4

STRUCTURAL FEATURES - FREMSTFJELLET AREA

AIR PHOTOGRAPH – NOR FLY SERIES 357 NUMBER 1209 1:20,000

SV = Skarfjellvatnet KV = Korvfjernet LT = Langtjernet
N = Nålbekken D = Nedrebekken R = Reinbekken B = Bjørnbekken
S = Smaltjernet L = Linjebekken T = Trollfjernbekken



Shear zone 1

Major Fault

Stream Sediment Mo Anomaly

⊕ Mo Mineralisation

Shear zone 2

Master Joint

Table 2

Correlation between streams, stream sediment Mo anomalies, structural feature and Mo mineralization in the Fremstfjellet area, Grong.

Stream	Structural Feature			Mo Anomaly	Mo Mineralization
Linjebekken			fault	(+)	-
Kinktjernet		S2		-	-
Trappebekken	S1			+	-
Gjerntbekken	S1			-	-
Myrbekken		?		+	-
Totjernbekken	S1			(+)	-
Øvrebekken		?		+	-
Nedrebekken	S1			+	+
Smaltjernbekken	S1			+	+
Smaltjernet	S1	S2	joint	+	+
Nålbekken	S1			+	+
Pinnebekken	S1			+	(+)
Stuttbekken		S2		+	+
Høytjernene			fault	-	-
Lavtjernene	S1			+	+
Rettbekken		S2		+	+
Øvre Tretjernbekken	S1			+	-
Tretjernbekken		S2		+	-
Stortjernet		S2		-	-
Brattbekken	S1		joint	(+)	+
Svingbekken		?		-	-
Tynntjernet	S1			-	-
Sammenløptjernet	S1	S2		-	-

1825

1925

1824

1924

1823

1923

1972 (1122)
1970 (974)
1973 (1177)
1971 (1075)
1964–65 (561) (602)
1969 (905)
1970 (974)
1972 (1122)
1969 (905)
1968–71 (636/912)
1973 (1177)
TERRATEST (anal.)
1974 (1276)
1975 (1368)
1970 (974)
1973 (1177)
1971 (1075)
1972 (1122)
TUNNSJØEN
Ca. GRENSE FOR NGU's FLYBILDEMOSAIKK
1961 (407)

1823 I ANDORSJØEN
IV GRONG

1824 I BREKKVASSELV
II NAMSKOGAN
III HARRAN

1923 I MURUSJØEN
II RENGEN
IV NORDLI

1924 I HUDDINGSVATNET
II LIMINGEN
III TUNNSJØEN
IV RØYRVIK

1925 III MAJAVATN

1971 (1075) årstall, oppdragsnummer

PRØVETATT OMRÅDE
prøvepunktavstand ca. 250–500m

Prøvetatt langs vei eller fra båt 1969

Oppdrag 1289, FREMSTFJELLET, detaljert prøvetaking 1974

Oppdrag 1177/1289, orienterende prøvetaking

TILSTØTENDE BLAD

N

5 0 5 10 15 20 25 km

GRONGPROSJEKTET
Oversiktskart over GRONGFELTET
Geokjemiske bekkesediment-undersökelser

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

MÅLESTOKK		
1:250.000	OBS. J.E-DS	1964-65/68-74
	TEGN. J.E.	MARS 1974
	TRAC. J.E.	FEB. 1975
	KFR. DS-BB	FEB. 1975

TEGNING NR.	KARTBLAD (AMS)
1276-02	NQ 33-34-13 NQ 33-34-9

TRONDHJEMITT-PROSJEKTET 1974
BEKKESEDIMENTER, HNO_3-LØSELIG **Cu Mo**
FREMSTFJELL-FELTET
SANDDØLADALEN, NORD TRØNDELAG

MÅLESTOKK	ÔBS. D.S.	1974-75
1 : 5000	TEGN. D.S.	1974-75
	TRAC. J.E.	1976

KARTGRUNNLAG: DM 151-1 / DL 151-4

NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM

TEGNING NR. 1289-28
KARTBLAD (AMS) 1823 I

LIFJELLET
Heimdals-vatnet
HEIMDALS-HAUGEN
STORBERGET
Bjørnurda
Grøndals vatnet
NESÅKLUMPEN
Øverste Nesåvatnet
SVARTBERGET
nedre Nesåvatnet
midtre Nesåvatnet
øvre Nesåvatnet
ROGNBUEDALEN
NESÅDALEN
NESÅFJELLA
ROGNBUKLUMPEN
GEITTINDFJELLA
Nesåa
VEI
TRONDHJEMITT-GRØNNSTEIN
Holmvatnet
Gollervatn
Kappgroddammen
NESÅPIGGEN
BLÅMUREN
Blåmurtjerna
vestre BLÅMUREN
"Reinbekken"
"MÅNEDALEN"
Reinsjøen
GEITTINDRUMPA
Holmtjern
Langløftvatna
KOLIFJELLENE
LANGLØFTFJELLA
Skartjellvatnet
Kvittjerna
Geittindvatnet
Sisselbekken
SKARFJELL
BRYNAN
RUNDHAUGEN
Skartjellelva
GEITTINDFJELLET
LANGLØFTFJELLET
Kolitjern
FREMSTE FJELLET
Svingbekken
Langtjern
Startjern
Finbuvatnet
Finbusttjern
Berg-gård
SANDDØLADALEN
Sanddøla
VEI
FLYFOTO
TEGNFORKLARING:
BEKKESEDIMENTER 1151 prover
JORD - MOSEPRØVER - M.M.
BERGARTSPRØVER (fjell)
BERGARTSPRØVER (løsblokk)
SVOVELKIS-FOREKOMSTER
KOBBER
SINK
BLY
MOLYBDEN
JERN
NIKKEL
HYTTER
HØYDER OVER HAVET
HOVEDGRENSE FOR TRONDHJEMITT - GRØNNSTEIN
61 MUTINGSOMRÅDER 1-1 1976
N
ppm Cu
ppm Mo
KOBBER
MOLYBDEN
1151 prover
Ca 13°12'55" ØST
TRONDHJEMITT-PROSJEKTET 1975
BEKKESEDIMENTER, HNO3-LØSELIG
Cu Mo
SANDDØLA - NESÅVATNA, NORD TRØNDELAG
MÅLESTOKK 1 : 20000
OBS. DS. JE 1975
TEGN. JE. 1975-76
TRAC. JE. 1975-76
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM
TEGNING NR 1368-08
KARTBLAD (AMS) 1823 I 1824 II