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Tittel

Preliminary report tectonic patterns of the Lyngen gabbro.

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Brian A Sturt	1973	Geologisk Institutt Univ i Bergen Sulfidmalm A/S

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Sammendrag

Foreløpig rapport uten kart kun et profil

(Feilaktig oppført i Sulfidmalms oversiktsliste med denne tittelen:
A short note on a traverse across the Hornelen Devonian district, S W Norway. Bremanger, Sogn og Fjordane, Vestlandske, 1973. F Nixon)

A/S SULFIDMALM

INTER-OFFICE MEMORANDUM

Date: 28th September, 1973

To: Falconbridge Nikkelverk A/S ✓

cc: A. M. Clarke, H. T. Berry, R. B. Band, B. A. Sturt

From: J. B. Gammon

Subject:

905-22, Structure of the Lyngen Gabbro. Report No. 259/73/22.

Please find attached Sturts report on a structural evaluation of the Lyngen gabbro. His ability to decipher this picture during his field visit to the area was of great help in planning activities connected with "Operation Phoenix".

John B. Gammon

FOR FALCONBRIDGE NIKKELVERK A/S

A/S SULFIDMALM

PROJECT NO. 905-22

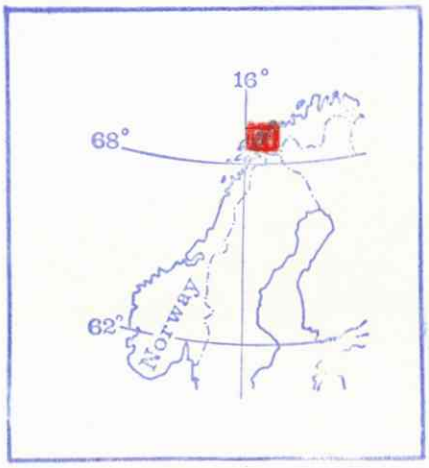
PRELIMINARY REPORT ON

TECTONIC PATTERNS OF THE LYNGEN GABBRO

by

Professor Brian A. Sturt

Geologisk Institutt,
Universitetet i Bergen



Report no. 259/73/22

Preliminary Report on Tectonic Patterns of the Lyngen Gabbro.

The only information available to the Sulfidmalm field party has been two papers by Randall (1971 a, b) which are short abstracts of work extending over a long period of time to be found in Ph.D. theses of the University of Newcastle U.K. (Randall 1958, Munday 1970/71)※. These abstracts give little clear impression of the tectonics of either the metasedimentary envelope or the Lyngen gabbro itself. Thus it was decided to make a structural reconnaisance of the gabbro and its contact zone.

Four main problems are apparent in considering the tectonic setting of the Lyngen Gabbro: -

1. In Randall's paper (1971 b) it is stated that all the contacts of the gabbro are of tectonic origin and result from thrusting, thus the problem is presented as to whether thrusting is indeed uniquely associated with the gabbro/sediment interface.

2. Randall further states (1971 b, p. 143) that there is no contact metamorphic aureole to the gabbro - this is also a point which required clarification as he draws attention to a small body the Furflaten Gabbro which possesses such an aureole.

3. Randall states that the gabbro has a "complex internal structure" resulting from folding, faulting, thrusting etc. However no clear statement is given of fold forms, wavelengths amplitudes, axial plane attitude etc. or regional pattern of the gabbro layering.

4. No attempt is made by Randall in his two papers to outline the overall structural pattern of the gabbro body.

※ Copies of these theses have not yet been obtained.

Thus the writer has attempted a rapid assessment of the tectonics of the region basically attempting to provide clarification of the points outlined above. The work was done mainly by helicopter traverse and more detailed ground investigations in selected localities. During the time available bad weather conditions severely hampered the amount of overall coverage.

A. GENERAL REMARKS CONCERNING GEOLOGY OF REGION

The Lyngen Gabbro occupies an elongated elliptical outcrop which forms a core to the Lyngen peninsular it is approximately 85 km long with a maximum width of 10 km. The gabbro is surrounded by a variable series of metasediments which form NNE-SSW strike belts (Randall 1971 b). The geophysical investigations of the body (Chroston 1972) show that the gabbro forms a relatively flat-lying plate acheiving a maximum thickness of some 1.5 km in the western crop tapering to nothing in the eastern contact zone. The published work of Randall (1971 a, b) indicates that the gabbro is detatched from its metasedimentary envelope by a major thrust, and that contact metamorphic rocks of the former aureole are not preserved.

The structural investigations of Randall (1971 a,b) indicate that the metasedimentary racks of the Lyngen peninsular have been involved in three phases of folding. The first of these producing isoclinal folds in the layering with strong axial planar clearage, no major folds of this generation are however identified by Randall. The second generation of folding (F_2) according to Randall is responsible for the obvious major folds of the region with an axial trend of (015 - 195^{o}), and that "to a large extent the internal structure of the gabbro, was associated with this deformation". Randall also identifie a third deformation (F_3) producing fold structures of similar trend to F_2.

Regarding the metamorphism of the region Randall indicates that the main high-grade metamorphic event (amphibolite facies) occurred during the first deformation (F_1), due to the fact that he observed minerals such as kyanite and diopside forming a NW trending lineation parallel to fold axes of this generation. The thrusting into position of the gabbro is regarded by Randall as an integral part of the second deformation (F_2). The gabbro also shows considerable evidence of subsequen t metamorphism with the widespread development of amphibole and attendant saussuritization of plagioclase

feldspar. Further Randall indicates that the gabbro is intensively mylonitized near its contacts producing rocks with the appearance of "phyllites".

In order to check-out the work of Randall a series of observations were made in the north-eastern contact region of the gabbro. From these reconnaisances it was immediately obvious that Randall's remarks concerning the contact relationships of the body represent a considerable over-simplification of the picture on the ground. This is particularly well-marked in the region Koppangsvatnet-Strupen-and northwards. In the region along the northern margin of Koppangsbreen it is obvious that the rocks here are part of a High-Grade-Complex (H.G.C.) of metamorphic rocks which have the field-characteristics of granulite facies rocks. These are massive compact rocks with a high-grade recrystallisation which post-dates a penetrative schistosity in the rocks and a phase of folding that has produced strongly isoclinal folds with axial trends between NW-SE and N-S. These folds would apparently correspond with F - 1 of Randall's scheme. It is also possible to observe that these folds are cut by basic dykes , and that subsequently considerable anatexial melting producing quartzo-feldspathic neozomes has occurred. These anatexial veins vary from pegmatities to medium grained and even aplitic verieties, they may also contain hornblends and/or pyroxene with occasional garnet. The metamorphic grade of these rocks is considerably higher than anything occurring the regional metamorphic envelope and their location at the eastern margin of the gabbro is strongly suggestive that the H.G.C. represents part of the original CONTACT METAMORPHIC AUREOLE to the gabbro. More detailed features of this zone are described in another preliminary report. The rocks of this zone are not of uniform type and around the NE edge of Gamvikblåisen it is possible to see that this zone is represented by an intrusive quartz-diorite complex. The coarse quartz-diorite here contains many elongated xenoliths and rafts of amphibolite and also obvious former meta-sedimentary rock types. It may be that this quartz-diorite body is related to the extensive quartz-dioritic net-veining of the gabbro which occurs so profusely in its northern most crop.

Structural Relations of the Gabbro.

As Randall states the contacts of the body are strongly tectonized indeed along most of the contacts there is a thick well developed zone of mylonites and phyllonites. These rock types are developed from both the gabbro and its surrounding envelope. Towards

the metasedimentary envelope on either side of the gabbro the mylonitic and phyllonitic structure passes transitionally into the 190° striking foliation of the metasediments. In the northern region however, along part of the eastern contact of the gabbro the main mylonite belt does not occur at the contact between the gabbro and the regional schists, but between rocks of the H.G.C. and the latter.

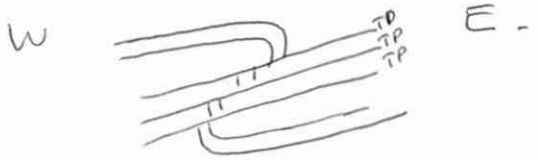
The mylonite zone is exceptionally well displayed at Strupen, where a thickness of some 2-300 m of mylonites and phyllonites are developed with the waterfall developed in them. At the top of Strupen rocks of the H.G.C. are well displayed but moving eastwards towards the lip of the waterfall cliff zones of porphyroclastic mylonites become more and more common until one is dealing entirely with a sequence of banded mylonites and phyllonitic chlorite schists. The banding is extremely regular and at first sight resembles the structure of a sequence of laminated sediments, however, in detail the cataclastic origin of these rocks can always be established, and in the more quartzofeldspathic horizens porphyroclastic textures predominate. The belt of mylonitic rocks north of Strupen is a very prominent feature and its strike (approx 190) is unwavering. Where the contact of the gabbro and H.G.C. is observed mylonitic and phyllonitic rocks are also present indicating strong movements at the interface of these units which have different competence. However, it is the writers opinion that the relations between gabbro and H.G.C. is in approximately their original position and that the mylonite belt represents the position of the thrust plane underlying the gabbro plate. Here it is considered that the thrust has cut through from the base of the gabbro into the original contact envelope to the body. Similar mylonitic rocks are found along all contacts of the body. Where possible stretching lineations in this mylonitic zone and strikewide groovings on quartz-lens have been measured. These show a distribution between 090 and 110° indicating that the direction of thrust translation has been from just north of west to slightly south of east. A similar vector for the maximum principal stress during cataclastic deformation has been obtained from an analysis of shear-joint patterns in the H.G.C. of Strupen.

The mylonite-phyllonite zone along the eastern contact has generally a fairly shallow westerly dip, though along the western contact the rocks are near vertical in their disposition. This implies that the thrust is folded into a broad synformal structure. The existence of such a general synformal structure is confirmed at Nordklubben where the

northern extremity of the gabbro body can be seen to sit in a southerly plunging synform of mylonitic rock.

The layering of the gabbro is folded into a series of asymmetrical antiforms and synforms all overturned towards the east with axial planes dipping westwards at variable angle. The largest and most persistent structure is an asymmetrical synform in the west of the body which in the Strupskardet/Stortinddalen area has a steep western limb son 3 km in thickness. This western limb of the synform is cut by the western mylonitic zone and is progressively thinned out in the southern part of the Lyngen peninsula. By projecting this synform downwards in sub-surface a maximum thickness of some 2 km below sea-level is indicated for the gabbro plate in the Strupskardet/Stortinddalen area, which conforms well with the gravity model of Chroston taken along Kjosen.

The folding of the layering in essence is by two large synforms and one large antiform in the southern area with amplitudes of 2-4 km and a number of intermediate sized folds more prominent in the northern area. One feature which is always prominent is the frequent development of westerly dipping thrusts and shear-zones in the steep limbs of the folds



which represent break-thrusts in the steep to overturned limbs of the fold-structures. It is often in association with such zones that rust-zones occur.

In the northern part of the area the folds are essentially southerly plunging structures, whereas in the southern area the folds are northward in plunge. This taken together with the different dip patterns of the mylonites on either side of the body and the obvious synformal nature of its northern crop indicate that the overall structure of the Lyngen gabbro is that of a shallow elongated, asymmetrical basin with a steep westerly limb and shallow easterly limb. Within the basin are a number of strike-persistent intermediate scale folds producing asymmetrical synform and antiforms of layering of the body. The difference in dip of the mylonite banding on the two margins of the body imply that the detachment thrust is also involved in the major structure of the basement.

Small late thrusts are also seen to affect the rocks in the mylonite belts, these are markedly cataclastic structures often producing brecciation and granulation. They generally dip westwards at shallow angles. These structures may probably be related to Randall's third deformation (F_3).

Mineralization and Tectonics

At the present stage of the investigation it is impossible to make more than a few comments.

1. There is evidence of primary sulfide dissemination in the gabbro where sulfide occurs as interstital grains in rock with good igneous texture.

2. There are local sulfide concentrations in igneous textured rock.

3. Many of the prominent rust-zones with attendant sulfide mineralization occur however in connection with shear zones in the gabbro i.e. preferentially developed in steep fold limbs and

4. In the marginal mylonite zone especially along the eastern contact e.g. mineralization at Strupen. In this latter locality it is obvious that sulfide concentrations are occurring within the mylonitic and phyllonitic rocks implying that there has been a tectonically controlled secondary sulfide migration associated with the thrusting.

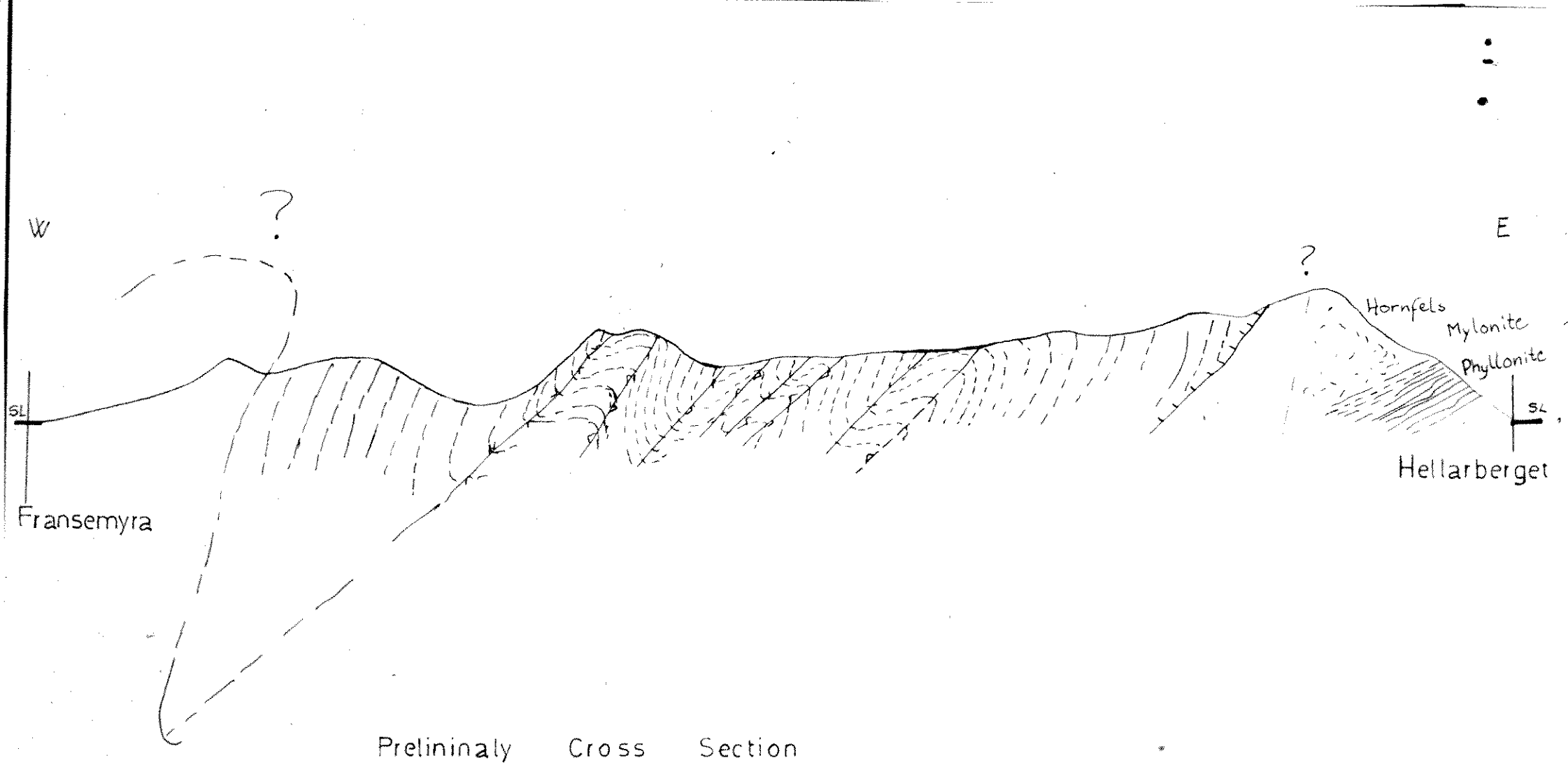
CONCLUSION

1. The overall structure of the Lyngen Gabbro appears to be a relatively shallow elongate basin with intermediate scale internal antiforms and synforms.

2. The boundaries are mylonite zones, though along part of the NE contact occur high-grade granulitic rocks which are probably part of the original contact aureole.

3. Mineralization is partly a primary dissemination in the gabbro, though secondary concentration is strong in shear-zones and the eastern mylonites.

It would appear that the thrust occurs at or near the base of the gabbro plate, in some cases cutting in to the gabbro in other instances cutting in to the high-grade contact zone.



Prelininaly Cross Section