



Bergvesenet

Postboks 3021, 7002 Trondheim

Rapportarkivet

Bergvesenet rapport nr BV 1212	Intern Journal nr	Internt arkiv nr	Rapport lokalisering Trondheim	Gradering Åpen
Kommer fra ..arkiv Falconbridge	Ekstern rapport nr	Oversendt fra	Fortrolig pga	Fortrolig fra dato:
Tittel Observations on work concerning the basic rocks of the Evje Iveland area (B A Sturt) Comments to Prof. B A Sturts report (F Nixon)				
Forfatter Brian A Sturt F Nixon		Dato 19	Bedrift Sulfidmalm A/S	
Kommune Iveland	Fylke Aust-Agder	Bergdistrikt Østlandske	1: 50 000 kartblad 15123 15114	1: 250 000 kartblad Mandal
Fagområde Geologi	Dokument type Notat	Forekomster		
Råstofftype Malm/metall	Emneord Ni Cu			
Sammendrag Se også: Structural observations on the Kjettevann prospect, Iveland. (B A Sturt). (i BV 999)				

Arkiv. Kjettermann
geologiske
JBS.

A/S SULFIDMALM
INTER-OFFICE MEMORANDUM

Date : December 14th 1971
To : J.B. Gammon
cc : B. Sturt, A.M. Clarke, R. Jahnsen
From : F. Nixon
Subject :

Comments to Prof. B.A. Sturt's report on observations on
work concerning the basic rocks of the Iveland-Evje area.

1) Age relationships and metamorphism of the basic rocks.

I am in agreement with Sturt that most of the basic rocks that we are dealing with have undergone metamorphism, and Sturt would seem to be correct in his comments. regarding this matter. In some places, however, intrusive relationships can still be seen as is exemplified by the enclosed photographs.

2) Structural observations

Again I must say that I am in agreement with Sturt's comments, and his conclusion that a detailed structural examination of certain critical localities would be of value in establishing the detailed relationship of the bodies of massive gabbroic rocks in the deformational metamorphic sequence.

It is hoped that Sturt and members of his faculty can initiate studies on these matters in 1972.



363

REPORT TO Dr. J. B. GAMMON

Observations on work concerning the basic rocks of the
Iveland-Evje area - By Prof. B. A. Sturt

In connection with my limmited studies of the drill-cores and thin-sections, principally from the Kjeltevang prospect, supplemented by the reading of the relevant reports prepared by geologists working for the company it is possible to make the following preliminary comments :-

(A) Age relationships and metamorphism of the basic rocks

In the report by Wiik (dated Feb. 1968) it is considered that the basic rocks are of three types representing an age sequence of emplacement viz:

- I - Pre-orogenic amphibolite
- II - Syn-orogenic amphibolite
- III - Metagabbroic amphibolite "formed through auto-metamorphism or more restricted, later metamorphism of the outer zones of late- to post-orogenic gabbros intruding the type II amphibolite".

These 'types' are distinguished by Wiik according to a number of lines of reasoning which would appear to the writer to have variable validity:

(a) The type-I amphibolites are recorded as occurring in the banded gneisses as layers, and that xenoliths of both rock types are found within the gabbros. This would appear to be a reliable criterion.

(b) The type-II amphibolites are distinguished from type-I on the basis of intrusive relationships and the xenoliths mentioned above, and this would appear reasonable.

(c) The type-III or intrusives of the late gabbro type, however, present to the writer a somewhat different problem.

These are described as "bodies of more or less unmetamorphosed gabbro". The first point at issue here pertains to the interpretation of the metamorphic relationships of these rocks. A variety of evidence is presented, by Wiik in his report, in support of the thesis that these rocks were intruded subsequent to the regional metamorphism in the area. In his discussion Wiik lays principal weight on the preservation of basic plagioclase within the variably uralitized gabbroic rocks. The writer has examined a considerable number of the thin-sections described by Wiik, and whilst agreeing with the essential points of his petrographic descriptions, is unable to accept that the petrography of these rocks represents any safe basis for the conclusion that the gabbros represent intrusions post-dating the amphibolite facies regional metamorphism :

(1) The preservation of basic plagioclase is in itself a poor indication of a post-metamorphic emplacement for the gabbros. To take as examples the Caledonian gabbroic intrusives of Connemara (W. Ireland) and in West Finnmark, it is possible to demonstrate that plutons which have obviously undergone the maximum conditions of almandine amphibolite facies metamorphism still contain well preserved relict igneous textures and mineralogy. The degree of preservation depends to great extent on the amount of post-emplacement internal strains which have been imposed upon the rocks. In many such rocks a primary mineralogy of olivene-pyroxene-anorthitic plagioclase is well-preserved with good cumulate and ophitic textures. The massive varieties are variably converted into amphibolite but often little or no alteration of the plagioclase has taken place. Indeed it is only in the more deformed varieties that any substantial recrystallisation of plagioclase with concomittant compositional change is to be observed. Statements

in Wiik's report e.g. " As in 23D9 the An-content of the

plagioclase is too high for the rocks to have undergone regional metamorphism of the same degree as that affecting the neighbouring gneiss and amphibolite" are liable to be misleading as they are based upon a false premise. The reasons for this are numerous but boil down to three main points, and the extent to which a basic intrusion develops a metamorphic fabric and parageneses would appear to be as follows:

(i) The degree of deformation to which the rocks have been subjected prior to or during the regional metamorphism. This is particularly important as gabbro in the massive state tends to possess stable grain-boundary fabrics which will resist the recrystallisation process. On the other hand deformed rocks which, although of the same composition, ~~xxx~~ have undergone complex internal strains will have unstable grain boundary configurations with high surface energy and be highly susceptible to the effects of recrystallization.

(ii) The availability of water for the uralitization of pyroxene.

(iii) The position of pluton emplacement relative to the deformational/metamorphic sequence of events in an area.

An inspection of Fig. 7 in Wiik's report shows the varying degree of uralitization that has been undergone by pyroxene in the gabbroic rocks of the Iveland-Evje area. An inspection of a number of thin-sections of these rocks (randomly selected) lead the writer to the conclusion that Wiik was mistaken in ascribing a possible autometamorphic origin to amphibole and biotite. It is indeed possible in many of the thin-sections to see that hornblende and biotite are undoubted products of regional metamorphism. In certain examples it can be demonstrated that hornblende and biotite develop along shear-zones defining a foliation, and frequently such foliation is observed to have developed at the expense of already formed hornblende that has replaced or partially replaced pyroxene. Along such shear-zones plagioclase feldspar has often

recrystallized into polygonal aggregates as the result of annealing recrystallization. Further the feldspars within the more massive facies of the gabbros are invariably clouded and the multiple twins less distinct than would be expected in unmetamorphosed equivalents. In some examples small incomplete coronas of sphene have been observed around titanomagnetite/ilmenite which is a sure sign of the metamorphism.

It is concluded by Wiik and by Nixon (presumably on the basis of Wiik's report) that these gabbroic rocks have possible intrusive relationships with the surrounding amphibolites. However, no details of the criteria used in forming this conclusion are given in either of the texts, and it is thus impossible for the writer without seeing the critical localities in the field to pass meaningful comment on this matter. In view of the comments made previously in relation to an apparently erroneous interpretation of the age-relationships of the gabbroic rocks with the timing of the regional amphibolite facies metamorphism, it may well be that this point is also somewhat suspect.

Studies of the core-samples from the Kjeltevaan prospect enable the writer to make the following preliminary observations:

- (1) The cores are mainly passing through a massive variably amphibolitized gabbroic body, and there are strong indications that this body was originally layered (at least in part).
- (2) The gabbro has undergone amphibolite facies metamorphism, though the original mineralogy and textures are variably preserved. There are also a number of zones where the massive gabbro passes gradually over into a coarse gneissic rock within which the pyroxene has been strongly uralitized. In other cases the degree of deformation and recrystallisation have been stronger and the rock becomes a hornblende-biotite-plagioclase schist. In other words the various stages in the conversion of gabbro to amphibolite can be observed in the core samples.

(3) Ultramafic rocks are observed with sometimes recognizable intrusive contacts into the amphibolitized gabbro, this is particularly marked in the case of small apophyses only a centimetre or so in thickness. In other cases the rock at the contact is more highly deformed and schistose, hence obscuring any original intrusive contact features. The ultrabasic rocks have been considerably recrystallized during metamorphism to predominantly amphibole bearing assemblages, though in thin-section highly corroded rests of olivene can occasionally be observed.

B. Structural observations (Based on reports by F. Nixon 1968, 1970)

The structural investigations reported by Nixon appear to have been the result of a careful and well executed study which does much to show light on the complex structural pattern in the region. There are, however, a number of questions that can be posed concerning the regional and local significance of certain of the observations:

(1) The Folding : considerable significance has been placed upon the interpretation of stereographic plots of poles to foliation planes in unravelling the various styles of folds and their possible age relationships. The interpretation of the presence of isoclinal folds in the western limb of the main 'synclinorium' is apparently based primarily on the interpretation of a number of stereographic plots. This is a slightly dangerous game as the stereograms mainly indicate the presence of a fairly uniformly inclined regional foliation and do not in themselves indicate the presence of the presumed series of isoclinal fold structures.

It would appear (from the reading of the reports) that because the Molland Gabbro occupies the centre of a wide synclinorium it has been interpreted as having been intruded into the centre of the synclinorium. An alternative view could

in fact be that the presence of the gabbroic rocks controlled the form of the developing structure. Here a knowledge of the detailed time relationships of gabbro emplacement in relation to the sequence of deformational and metamorphic events is of obvious significance.

As Nixon rightly points out information has not yet been provided to distinguish the age relationships of the fold structures. This in the writers opinion is of significance as both Nixon and Wiik conclude that much of the mineralisation is fairly late in the structural/metamorphic sequence, and Nixon also alludes to a possible relationship of the mineralisation with folding on a NE-SW trend (see also report by Huntings).

(2) Border relationships of the gabbroic rocks - Too little attention has apparently been placed on the structural features in the border zones margining the bodies with massive gabbroic character. This is naturally of some moment as such studies may have considerable importance in the interpretation of possible age-relationships within the complex.

(3) Lineations - No distinction has been made in any of the reports of the character of the various lineations that have been recorded. Many of the lineations recorded in such an area are liable to be mineral alignment lineations. These structures have a considerable importance because here it can be checked either in hand-specimen or in thin-section if the mineralization is syn-, pre- or post-tectonic in relation to any particular defined phase of deformation. It is of the writers opinion that such information could well be of value in relation to possible patterns of ore-enrichment.

In conclusion it has not been possible with the writers limited experience of the area to make more than these brief comments on the geological work so far carried out in the

Evje-Iveland area. The writer is of the opinion that a detailed structural examination of certain critical localities would be of value in establishing the detailed relationships of the bodies of massive gabbroic rocks in the deformational metamorphic sequence. The exact interpretation of these relationships is of obvious importance in relation to the possible location of sulfide minerals in the district.