Discussion

A comment: Alternative to the Finnmarkian–Scandian interpretation on Magerøya, northern Norway

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Krill et al. (1988) present a re-inpretation of the geology on Magerøya. Their revision is based on radiometric data from the Honningsvåg Igneous Complex (HIC), Geul's map from 1958, and field observations by the authors. The dated samples from the HIC gabbros, collected approximately 30 years ago by Geul (1958), have been analysed at the Mineralogical-Geological Museum in Oslo and have provided the Rb–Sr and Sm–Nd isochrons. The best isochrons (Sm–Nd on cpx, plag and whole rock) give overlapping ages of 475 ± 22 and 508 ± 18 Ma from two gabbros, and are considered to represent intrusion ages for the gabbros (Krill et al. 1988).

The new ages suggest that the HIC was emplaced in the time span between the Upper Cambrian and the Middle Ordovician. Hence, the previous interpretation that the HIC is intrusive (Føyn 1967; Curry 1975; Ramsay & Sturt 1976; Andersen 1979, 1981) into the fossiliferous Silurian rocks (Henningsmoen 1961) must be in error. Provided that there can be no doubt about the filing system in the NGU rock store, and that the dating of these rocks really represents their crystallization or cooling age, it is obvious that the geology on Magerøya requires a critical re-evaluation.

The contribution by Krill et al. (1988), however, does not provide the necessary documentation for an alternative explanation, which is needed if these ages from the HIC are correct.

The present author will only comment on conclusions concerning the local geology on Magerøy. This is because the regional model presented is oversimplified, as shown by the accumulating geochronological data from the Seiland Province and elsewhere in the Middle Allochthon in Scandinavia (Dallmeyer & Gee 1986; Daly et al. 1987; Mørk et al. 1988; Mørk & Stabel 1988; Pedersen et al. (1989)). This has also been the topic in several recent discussions in this journal (Krill & Zwaan 1987, 1988; Roberts 1988; Sturt & Ramsay 1988).

The main objection to the paper by Krill et al. (1988) is the presentation of a major revision of the regional geology with limited field and textural/structural data. In this they present a number of new interpretations for which little supporting field evidence has been presented. Some of these interpretations are listed and will be discussed below.

(1) A fault appears to separate gabbros of the HIC and their hornfelses from the fossiliferous rocks along a line shown in Fig. 1, p. 173 from Krill et al. (1988).
(2) Hornfelsed rocks have not been regionally deformed until after the intrusion of the HIC.
(3) The HIC may represent intrusions of Early Ordovician oceanic crust.
(4) The Sardnes synform and its continuation in the north are true synclines, i.e. F-1 folds, and the greywackes on western Magerøya are older than the Nordvåg Gp. The interpretation of two early synclines on either side (of the Nordvåg Gp. on central Magerøya) is not needed and no mushroom fold exists.

Discussion

Point 1

A fault contact between the Honningsvåg Unit and the Nordvåg Gp. has been indicated on Krill et al.'s (1988) Fig. 1 (p. 173). The fault is necessary in order to explain the geochronology of the HIC. The problem, however, is that it is unclear whether the postulated faults have been located. In the Kjelvik area Krill et al. (1988) support Geul's observation of a tectonic contact between gabbros and low-grade metasediments. However, low-grade rocks may also be produced during contact metamorphism. No detailed descriptions of the structural relationships between the fault, its fabric or its relationship to the metamorphic textures of the area are provided. The identification of a major tectonic contact of the type indicated by Krill et al. (1988) would normally require better documentation.

Geul's map (Fig. 2 in Krill et al. 1988) shows the hornfelses very unsystematically. In eastern Magerøya, it is mainly the areas where pyroxene-rich hornfelses have developed from the calcareous greywackes which have been distinguished as contact metamorphic. Obviously, the more remote parts of the envelope would be less affected by the contact metamorphism, and these areas have not been shown as contact metamorphosed. One area where spotted slates and low-grade metagreywackes occur is the headland between E & F (Krill et al. 1988, Fig. 2). Field observations and a thin section of spotted slate from this area (UTM 642750) indicate that these rocks may have been affected by contact metamorphism. The development of characteristic spotting as well as static crystallization fabrics may well represent textures developed in more distal and low-grade parts of the aureole. Thus the fault shown at E, and which is claimed to exist at F where beds on either side are parallel and both younging to the W, cannot comfortably be accepted as the major tectonic contact required by the model based on the contradiction between dates and fossils.

As pointed out by Krill et al. (1988, p. 179), many areas along the western side of the HIC and on the peninsula between Kamøyvær and Skipsfjorden are shown as not affected by contact metamorphism on Geul's map, also where high-grade hornfelses are present. Krill et al. (1988) have indicated (p. 179) that the tectonic contact between their Honningsvåg unit and the Silurian rocks occurs on the Nordkapp road at the garnet isograd shown on Geul's map and profile. They write (p. 179): 'we think that the "garnet isograd" represents the tectonic contact from the tail of the granite to near the coast at Sardnes'. As pointed out by Krill et al. (1988) the area under discussion is one of fairly strong fabric. Further to the south, however, and particularly in the Sardnes area, the deformation is less intense, and Krill et al. (1988) suggest that the fault swings to the east. In the Sardnes area well preserved primary sedimentary structures and trace fossils occur east of Geul's garnet isograd (Andersen 1984, Fig. 7, p. 32). Curry (1975, Fig. 33) showed the garnet isograd further to the east than shown on Geul's map. In the Sardnes–Magerøysundet area minute garnets start to appear in the metasediments without sign of an increased fabric in the rocks. Observations here do not suggest that the garnet isograd represents a tectonic contact.

It is concluded that at the present time the existence of a major structure separating the HIC and its hornfelses from the fossiliferous metasediments is required by the radiometric dates and the fossils. However, the existence of the fault has not been documented. Apart from mentioning (p. 179): 'The hornfelses are also locally foliated, and we could not always distinguish them from the schists', there is no documentation of the timing of the faulting relative to regional deformation and metamorphism. A major tectonic contact may well be present. However, the fault shown at locality E and Fig. 4 (p. 179) may represent one of several late WNW–ESE trending faults (Andersen 1981) most of which have minor displacements, and which occur on Magerøy and on the mainland. Thus the suggested location of the fault is not convincingly documented.

Point 2

Krill et al. (1988) write (p. 180): 'The sediments of the Honningsvåg unit apparently were not regionally deformed and metamorphosed until after intrusion and contact metamorphism, and we consider the HIC to be pre-orogenic.' No documentation for this interpretation has been presented even though it contradicts earlier interpretations (Curry 1975, Fig. 40; Andersen 1981). In the road section at the head of Skipsfjord (UTM 595784), 750 m north of the gabbro-hornfels contact, the turbidites have been metamorphosed in the hornblende-hornfels facies.

Prior to the static recrystallization, these rocks are folded in tight asymmetrical regular folds. These folds are quite different from the irregular 'non-tectonic' flow-folds which occur in the pyroxene-rich hornfelses and partially melted rocks which formed adjacent to the gabbro. The folds in the less ductile part of the aureole would normally be considered as evidence of deformation prior to the development of the contact metamorphism.

Point 3

The suggestion that the HIC may represent intrusions of Early Ordovician oceanic crust (p. 184) is not documented. To the present author's knowledge, the internal structure of the HIC bears no obvious resemblance to that of the oceanic crust. This point has not been discussed and appears in the last paragraph of their concluding remarks.

Point 4

Krill et al. (1988) claim that the Sardnes synform is a true syncline (p. 181) and that the greywackes on western Magerøya are stratigraphically beneath the Nordvåg Gp. Consequently, they write: '. . . the interpretation of two early synclines is not needed.' The previous interpretation was not based on a need, but on what was considered to be a reasonable interpretation of observations. Conclusion no. 4 has been reached from visiting outcrops on central Magerøy which were used in previous interpretations too. I shall first discuss the relationship between the Nordvåg Gp. and the Juldagnes Fm. in west-central Magerøy. The structural map (Andersen 1981, Fig. 4, p. 8) shows the northeasterly directed younging, very close to locality J, in general agreement with Krill et al. (1988). This interpretation by the present author was based on erosive structures at the base of conglomerate layers. The primary structures in this area and further to the north were used in defining the Duksfjord anticline as a F-1 anticline as the rocks along the axial trace of the Sardnes synform south of the Nordkapp road on the basis of primary structures were interpreted to be inverted. According to the previous interpretation the Dunksfjord anticline was refolded by the Sardnes F-2 synform. At locality K, Krill et al. (1988, Fig. 2) describe (p. 181): '. . . separate conglomerate beds clearly show sharp bases and grade upward to the east.' The present author observed grading from the same area, but as the conglomerates in the Nordvåg Gp. show reverse, normal or composite grading in its type area north of Nordvågen and west of Sardnesfjorden, grading was not regarded as good evidence of younging. Further to the south, near the Finnvik Granite, the present author found repeated Bouma sequences in turbidites apparently younging to the west, close to the stratigraphic contact (see Fig. 4, p. 8, Andersen 1981). These observations were taken as more conclusive evidence of younging than the graded conglomerates south of K, near the Gjesvær road. Krill et al. (1988) prefer to change the earlier interpretation from this area. The previous interpretation, however, was based on observations from other localities shown by younging symbols in Fig. 4 from Andersen (1981).

The statement that the Sardnes synform represents a 'true syncline' cannot be accepted by the present author. The reasons for this have been shown on earlier published maps (Andersen 1981, Fig. 4, p. 8). This map shows that the rocks are inverted in the entire area along the NE coast of Sardnesfjorden. The observations of younging are based on abundant primary structures in the metasediments, and show that the Sardnes synform folds already inverted strata. These observations have not been discussed by Krill et al. (1988). The primary structures, which show that the layers are inverted in the hinge-zone of the synform at Sardnes, and the type examples of refolding by the Sardnes synform of an earlier axial planar cleavage which can be studied on central and southern Magerøya have not been mentioned by Krill et al. (1988). The axial planar crenulation-cleavage, S-2, to the Sardnes synform has not been discussed. This was developed under retrograde regional metamorphism (see Fig. 9, Andersen 1981) and can therefore be distinguished with confidence from the earlier prograde S-1 cleavage. The Sardnesfjorden area lies in the hinge zone of the Sardnes synform, which is an open structure on southern Magerøya. It is also close to the hinge of an earlier recumbent syncline, the Pollneset syncline (Andersen 1981). According to Krill et al. (1988) the Pollneset syncline is 'not needed', but the primary sedimentary structures around Sardnesfjorden (south, west and north) demonstrate its existence as a major structure shown in several published and unpublished (available to the authors) figures

(Figs. 38, 41 in Andersen 1979, Fig. 7 in Andersen 1981, Fig. 4b in Andersen 1984). The fold hinge is exposed in the hills west of Sardnes-pollen, and is also shown correctly as an antiform on Geul's map (Fig. 2 in Krill et al. 1988). A photograph of the hinge is shown in Andersen (1979, Fig. 67, p. 113).

It is concluded that the interpretations in point 4, by Krill et al. (1988), concerning the geology in central and western Magerøya have not been convincingly documented. It is possible that the present author was in error when assigning the greywackes on western Magerøy to the Juldagnes Fm. as this was based on graded turbidites from a few outcrops near the stratigraphic contact (Fig. 4, Andersen 1981). If the previous interpretation (Andersen 1981) is wrong on this point, the significance of the west-vergent folds in west-central Magerøy is less important. The present author, however, maintains the previous interpretation of the Sardnes synform as an F-2 fold, which refolds the recumbent Pollneset F-1 syncline. Thus, their statement (p. 181): 'Judging from way-up data, the Duksfjord and Sardnes synforms are true synclines, the interpretation of two early synclines on either side is not needed, and no mushroom fold exists' has not been documented by their data.

It is concluded that Krill et al. (1988) have presented new geochronological data from the HIC. If these ages are correct, as they seem to be, the geology on Magerøya requires a revision. A new model for the Magerøy geology requires documentation particularly since it relies entirely on the radiometric data and involves revision of earlier interpretations. Such a model may include a structural contact between the Honningsvåg unit (Krill et al. 1988) and the fossiliferous sediments; however, this potential fault has neither been identified with certainty nor been mapped in any detail. It is surprising that the not yet documented re-interpretation of the geology on Magerøya can be claimed to support or to be supported by a model for the regional geology without more caution. The present author will accept a new model for Magerøya when the radiometric data have been confirmed by additional studies and the alternative model has been explained by detailed field observations.

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