Structural and metamorphic break between the Trondheim basin and the Surnadal synform

ARNE RÅHEIM

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Recent field work shows that the rocks of the Caledonian Trondheim basin cannot be followed into the Surnadal synform as previously indicated on the 1960 Geological Map of Norway (Holtedahl & Dons 1960). The structurally complicated Surnadal synform is separated from the Støren Group (Støren nappe) by a thrust zone. The rocks of the Surna Group have suffered two metamorphic events, an earlier medium-grade event superimposed by a low-grade event, while the Støren Group rocks have only been through the low-grade event.

A. Råheim, Mineralogisk-geologisk museum, Sars gate 1, Oslo 5, Norway.

One of the larger extensions of crystalline schists from the Trondheim basin is the Surnadal synform (Ramberg 1977, Holtedahl & Dons 1960). Strand (1953) and Hernes (1956, 1967) found no structural break between the rocks of this synform and the basal gneisses. The Surnadal synform is a complex nearly 'recumbent' and isoclinal structure (Hernes 1956). According to Løset (1977) three phases of folding have affected the rocks of the Surnadal synform in the northern part of Trollheimen. These fold phases have deformed all the rock groups, including the Svecofennian (1600–1800 m.y., Priem et al. 1967) gneiss groups belonging to the basement. Løset also assigned the nearly recumbent and isoclinal development of the Surnadal synform to the first (F_1) period of folding. It was during this period of folding that the strongest metamorphism took place, where all the rocks of the Surnadal synform as well as the basement recrystallized at medium-grade metamorphism. Because the crystalline schists of the Surnadal synform were thought to be originally deposited in the early Palaeozoic, Løset logically concluded that the recrystallization at medium-grade metamorphism must be Caledonian.

Recent geochronological studies at Kristiansund (Pidgeon & Råheim 1972) and at Surnadal (Råheim 1977) suggest, however, that all the rocks between the Surnadal syncline and the coast may have been little affected by the Caledonian events. Instead, the results rather indicate that the rocks may represent the 'root' to the Svecofennian mountain chain, some 1200 million years older. The lack of any structural or metamorphic breaks between the rocks of the Surnadal synform and the basement gneisses led Pidgeon & Råheim (1972) to suggest that at least the lower part of the Surnadal synform rocks, the Røros (Hernes 1956, Råheim 1977) or Gula Group (Gee 1975), may also belong to the Svecofennian. Råheim (1972) queried a Caledonian age for the development of the Surnadal synform structure itself and suggested that the extension of the Støren Group from the Trondheim basin into the Surnadal syncline should be checked.

Rb, Sr total rock results from the Røros or Gula Group do not define a unique isochron age (Råheim 1977). The results, however, suggest that the rocks are older, possibly 1700 m.y., and that they were partially isotopically re-equilibrated during the younger Sveconorwegian and/or the Caledonian matamorphism.

Råheim (1979) has recently shown that the main metamorphic and deformational episode of the western gneiss region, including the Surnadal synform and other stripes of crystalline schists (Fosen, Oppdal) with apparent direct extensions from the Trondheim basin to the Gneiss Region, very likely did occur in the Svecofennian (1500–1700 m.y. ago). However, a metamorphic or tectonic break between these rock units which differ in age by about 1200 m.y. had not been demonstrated.

Recent fieldwork to check on the apparent extension of the Trondheim basin has now made it clear that both a structural and a metamorphic break exist at the opening of the Surnadal synform at Rindal (Fig. 1). A tectonized zone or a thrust zone separates the structurally complex sequence of medium grade rocks consisting of

garnet mica schists, amphibolites, garnet amphibolites, marbles, and associated calc silicate rocks from the much less structurally complicated low grade basic metavolcanics of the Støren Group, or indeed the Støren nappe as proposed by Gale & Roberts (1974). Previous correlations between the Røros or Gula parts of the Surnadal synform and Caledonian Støren sequences are accordingly not appropriate. In the present study the rocks of the Surnadal synform are therefore considered together and termed the Surna Group.

During the metamorphism and thrusting of the Støren nappe the medium-grade rocks of the Surna Group suffered pronounced superimposed low-grade effects, particularly at the thrust contact. Considerable amounts of chlorite formed in the Surna Group rocks during this event; amphibolites were transformed partly or completely to green schists or green stones, and even metapelites took on a very similar 'green appearance'. In the Surna Group rocks, however, pockets of the earlier medium-grade amphibolites, garnet amphibolites, and garnet micaschists are still preserved, showing that these rocks have been through two separate metamorphic events. The Støren Group rocks have on the other hand, suffered only one; the latter low-grade metamorphic event. The similar 'green appearance' on both the retrogressed Surna Group rocks and the Støren Group rocks made it difficult to distinguish them in the field, and prevented recognition of the break by earlier workers. The rather few outcrops in the critical areas also obscure the thrust contact, which is therefore marked with a 'thrust zone' in Fig. 1. Another zone of strong retrogression of the Surna Group rocks also occurs nearly parallel to the structural trend of the Surnadal synform (Fig. 1). It is this retrogressed zone in the Surnadal syncline which has wrongly been taken for the Støren Group equivalent, because of the general green appearance of the rocks. However, 'pockets' of medium-grade rocks, amphibolites, and garnet micaschists are preserved in this zone together with the strongly retrogressed rocks with low-grade mineral assemblages (chlorite, albite, serrisite, actinolite, and quartz). The so-called Støren-Bymark Group (Hernes 1956) of the Surnadal synform has thus been through at least two metamorphic events, while this is not the case with the Støren Group proper. The map of Goldschmidt (1915) showing metamorphic zones of the southern part of the Trondheim Region is not correct with regard to the Surnadal synform. During the first and major metamorphic event of the Surna Group no significant metamorphic zonation existed within the Surnadal synform rocks. Instead Goldschmidt's biotite zone marks the zone of retrogression, where even the biotites are relicts from the previous metamorphism.

The Surna Group rocks south of Rinna in Rindal have the same structural elements as reported by Løset (1977). However, the general trend of the main foliation has been pushed or bent subparallel to the foliation of the Støren nappe rocks. The hinge for this 'bending' is a marked tectonized zone (Fig. 1) at which both basement rocks and Surna Group rocks show an abrupt change in the strike direction (Fig. 1). Several shear zones with strong retrogression parallel to the general strike occur between this marked tectonized zone and the 'thrust zone' between the Surna Group rocks and the Støren nappe. The best place to observe the thrust zone and the marked change in metamorphism is at the farm Heggem, where garnet amphibolite and garnet micaschists are found only about 100 m from the rocks of the Støren nappe with low grade mineral assemblages.

A structural discordance between the main structures of the Surna Group rocks and the foliation of the Støren Group rocks apparently exist at Trønsdal. Unfortunately the actual thrust zone between the two groups is covered, but at the closest outcrop of the Støren Group at Lyngset (Fig. 1) the foliation strikes 100° (Fig. 1) and at Trønsdal the general trend of the much more complicated structures in the Surna Group is 60° (Fig. 1). At Trønsdal the Surna Group rocks are strongly retrogressed but with 'pockets' where rocks with medium-grade mineral assemblages are still preserved. A sulfide deposit occurs in the amphibolites of the Surna Group rocks at Trønsdal, and sulfides associated with amphibolites (or retrogressed amphibolites) can be followed westwards along the Surnadal synform. These sulfides have been correlated with the Caledonian sulfide deposits which are mined in the Støren Group at Løkken. However, a correlation with the sulfide deposits in the Gneiss Region, for example south on Averøya, is thought to be much more favorable. Here, sulfide deposits occur in amphibolites associated with garnet micaschists, garnet amphibolite eclogite rocks, marbles, and calcsilicate gneisses, which not only have the same structural

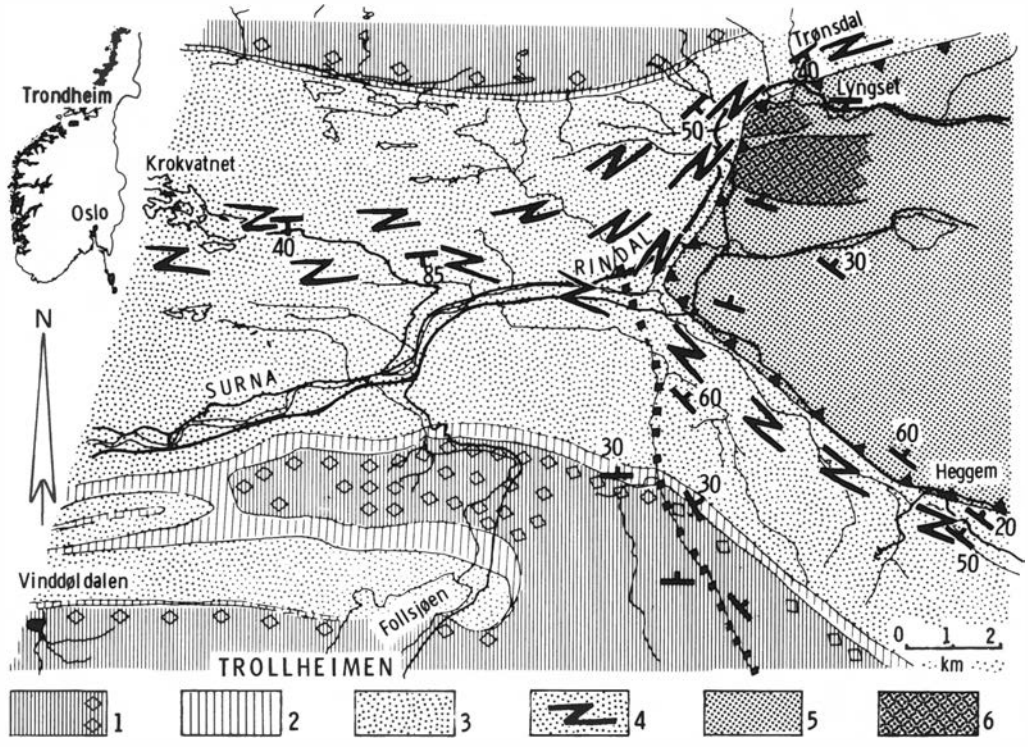

Fig. 1. Geological map showing the main rock units of the upper Surnadal-Rindal area. The map has been compiled from Løset (1977) and own observations. 1. Basement gneisses, with or without augen. 2. Quartzites and quartzschists. 3. The Surna Group. 4. Thrustzone between the Surna Group and the Støren Group (nappe) and marked zones of retrogression. 5. The Støren Group (or Støren nappe). 6. Metagabbro (low grade). The dark lense in Vindøladalen marks the location of a medium grade metagabbro, which is transformed to eclogite at the margins. The dotted line marks a tectonized zone, which acts as the hinge for an abrupt change in the strike direction. Strike and dip are given for the main foliation.

elements as the Surna Group rocks, but also have the same rock or chemical ingredients. The only difference between the rocks of the two areas is the metamorphic grade. In fact, the supracrustal rocks on Averøya and other stripes of 'supracrustals' in the Gneiss Region are much better correlated with the Surna Group rocks and with the other 'Caledonian' stripes of cover sequences at Oppdal and on Fosen (Geological map of Norway, Holtedahl & Dons 1960), than with rock units in the Trondheim basin.

The thrust-zone break at Rindal, between the Surna Group rocks which have suffered two metamorphic events, and the Støren Group rocks which have suffered only one metamorphic event, discredits the best argument in support of a Caledonian age of the major metamorphism and structures of the Surnadal synform. Instead, a Svecofennian age of the main dynamothermal metamorphism is most consistent with the metamorphic and structural situation, as well as the available radiometric age data.

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Errata

Vol. 58, 1978 Number 3.

Sturt, B. A. & Thon, A.: A major early Caledonian igneous complex and a profound unconformity in the Lower Palaeozoic sequence of Karmøy, southwest Norway. *Norsk Geologisk Tidsskrift,* Vol. 58, pp. 221–228.

P. 227, right column, 10th line from below.

It shall read: Furthermore, the Upper Ordovician metasediments of southern Karmøy rest with profound stratigraphic unconformity upon a substrate of both the West Karmøy Igneous Complex and eastern Karmøy sequence.