STUDIES ON THE LATEST PRECAMBRIAN AND EOCAMBRIAN ROCKS IN NORWAY

No. 7.
EOCAMBRIAN ROCKS ON THE NORTH-WEST BORDER OF THE TRONDHEIM BASIN

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Abstract.

Three occurrences of Eocambrian rocks on the north and west borders of the Trondheim basin are compared, namely in the Gangåsvann, Opdal and Tømmerås areas. It is shown that the sequence in the Gangåsvann area consists of two parts: a lower, highlyfolded succession which, in geological setting, resembles the Opdal area and an upper, lower-grade unit which closely compares with the succession in the Tømmerås anticline. The two are separated by a major tectonic break which marks the border of the "Trondheim region" proper.

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The apparent absence of Eocambrian rocks on the north-west margin of the Trondheim basin is only one of the intriguing anomalies shown by the current 1 : 1 million geological map of Norway. But since the publication of the revised edition in 1960 new work south-west of Trondheim, in the Gangåsvann area (Peacey, 1963), and around the Tømmerås window (Springer-Peacey, 1964) suggests that the search for these earliest Caledonian sediments is a rewarding study because they can provide a marker horizon by means of which the complex geological history on the edge of the "Gneiss region" may be elucidated.

Descriptions of the two areas mentioned were published in the chronological order that they were mapped but, by chance, the results of the second piece of work throw light on the first. Thus it is now possible to understand the tectonic position and setting of Eocambrian rocks in the Gangåsvann area better than previously and, in turn, this knowledge illuminates the problem of how the rocks of the Trondheim basin relate to the high-grade "Gneiss region" lying to the west.

(a) The Tømmerås area.

Geological relationships in the Tømmerås anticline hold half the solution to the puzzling association of Eocambrian rocks seen farther south. Here, in an area with simple structure and low metamorphic grade, a number of features appear which seem to characterize the Eocambrian in a particular geological setting, and which can again be recognized in the upper part of the rocks of this age in the Gangåsvann area.

At the northern extremity of the Trondheim basin the Precambrian basement is domed up to form a long ridge trending north-east. Upon this lie greenschists and mica-schists which belong to the Cambro-Silurian and beneath them a thick sequence of sandstones and siltstones, presumably Eocambrian in age. Along the south-western flank of the ridge the cover rocks thin towards the substratum and finally the Eocambrian and the lowermost Palaeozoic units wedge out against it (Fig. 1). As the rocks are only weakly metamorphosed, sedimentary features, such as cross-bedding and grading, are well preserved, particularly in the Eocambrian. In the Palaeozoic rocks thin horizons can be traced for long distances as they taper against the basement and there seems no good reason to doubt that the junction between basement and cover represents a primary discontinuity with overstep of the younger horizons over the older. (Springer-Peacey, 1964.)

The Eocambrian rocks, named in this area the Leksdalsvann Group, comprise two characteristic units: a lower one of dark, sandy siltstones with pale calcareous lenses, and an upper unit of pale, microcline-bearing, graded and false-bedded sandstones. Another diagnostic feature of this group is the scarcity of basic igneous material, either volcanic or intrusive. Only rarely do thin amphibolite sheets occur in it and this provides striking contrast to the rocks above and below. In the Pre-Cambrian basement the basic rocks are principally intrusive igneous bodies. They represent a swarm of dolerite and gabbro sheets in which the original ophitic textures, the lensoid shape and primary cross-cutting relationships can sometimes be observed. The Palaeozoic rocks seem, from their composition, to be liberally mixed with volcanic débris; the thick amphibolites present may be flows or water-laid effusive material. But truly igneous textures have never been observed even in the most massive amphibolite horizons. Thus, before the deposition of the Eocambrian in this area, the basement rocks were already fractured

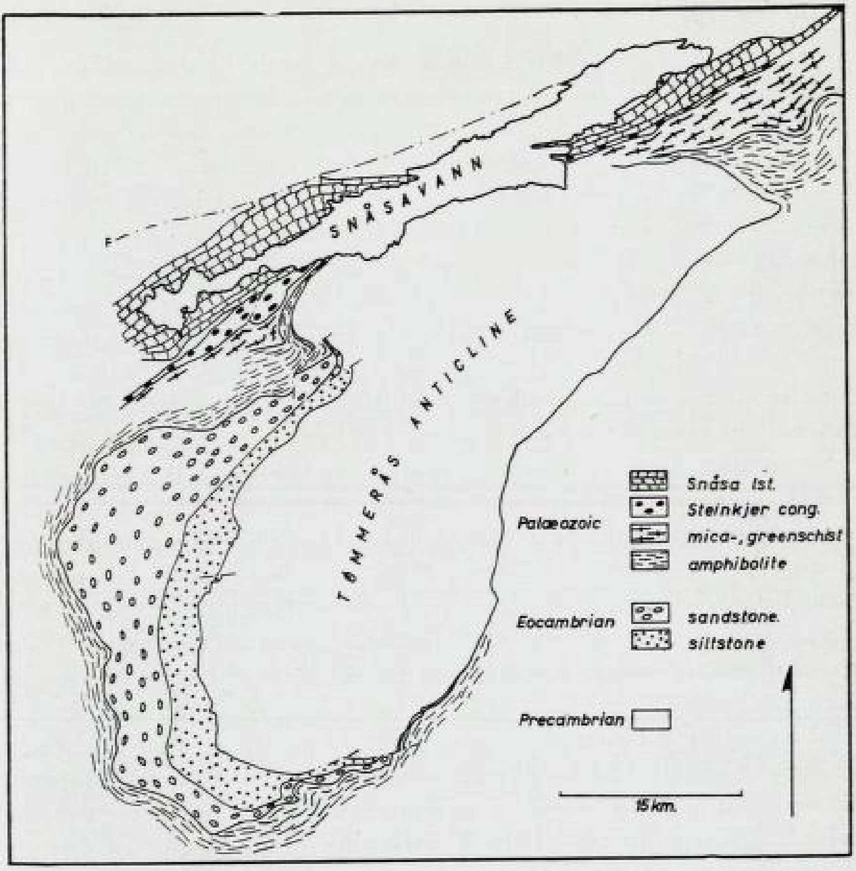

Fig. 1. Geologisk kart over Tømmerås-området.

and intruded by ophitic dolerites; the subsequent igneous activity, virtually absent in Eocambrian times and which became more pronounced later, was mainly volcanic in character.

Another aspect of the geological history which perhaps typifies the Eocambrian in this particular setting is the low metamorphic grade and the simplicity of the tectonic history. For although there are minor structures of various ages and metamorphism sufficient to induce the growth of garnet locally, these do not disguise the sedimentary nature of the rocks or their original disposition.

(b) The Opdal area.

The Eocambrian is seen in another setting in the Opdal area and this provides the second half of the solution to relationships at Gangåsvann. Although an upper series of Eocambrian rocks is missing here many other features of the two areas are remarkably similar.

The stratigraphy is often blurred by the effects of high-grade metamorphism and extreme migmatization but, despite this, in many places distinct lithological units can be recognized. The Eocambrian is represented by feldspathic flagstones with small amounts of mica-schist and above them lie mica-schists and amphibolites which are thought to be of Cambro-Silurian age.

The intense multiple folding which these rocks have suffered is obvious even from the 1 : 1 million map and it is scarcely to be expected that primary features remain. It is often difficult to tell which of the rocks represent the "basement" and the only trace of original unconformity is suggested by the fact that the flagstones rest upon differing rock types at different localities (Holmsen 1960). Both Eocambrian and Palaeozoic are cut by lenses and sills of hornblende schist which have been folded together with the rocks surrounding them. These basic sheets are interpreted as intrusions and lavas of Lower Ordovician age.

This highly-folded and metamorphosed complex of rocks, in which basement, cover and the later intrusions have been deformed together, is separated from the rocks of the Trondheim synclinorium by a thrust plane, dipping eastwards, which carries low-grade Palaeozoic deposits upon it. Not only is there a marked difference of grade across this boundary but it also appears that the tectonic history of the upper rocks has been much simpler (Holmsen 1955).

(c) The Gangåsvann area.

Whereas in Opdal the whole fabric and mineralogy of the rocks has frequently been rebuilt by the effects of the Caledonian orogeny, erasing any traces of former relationships, the process in the Gangåsvann area has not been so penetrative. Although in places metasomatism has swamped the rocks, converting all except the most quartz-rich to unremarkable granite-gneiss, elsewhere it is still possible to detect something of the former stratigraphy, tectonic pattern and even metamorphic grade.

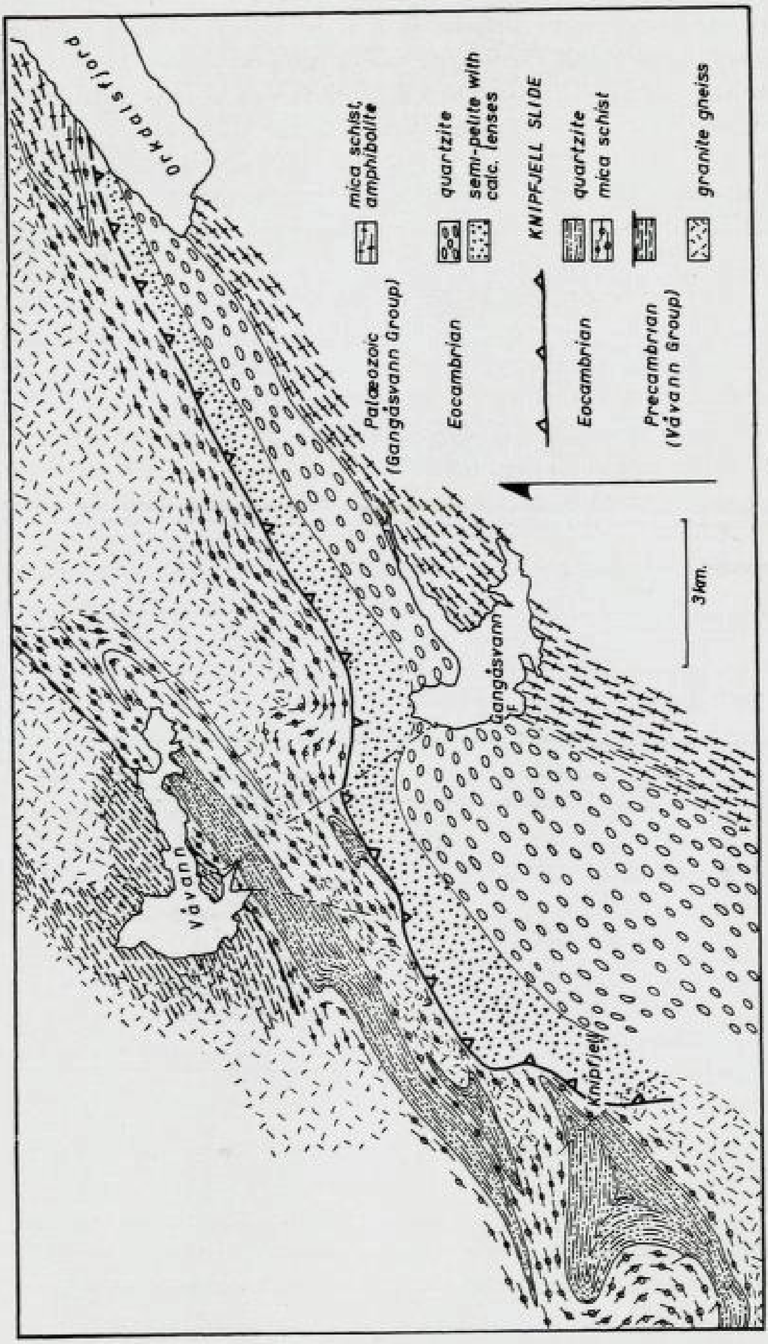

Fig. 2. Geologisk kart over Gangåsvann-området.

An important feature of the area is the Knipfjell slide, a plane of discontinuity dipping south-east, which runs north-eastwards and divides the outcrop of the supposed Eocambrian rocks into two. (Fig. 2.) At its northern extremity the foliation in the rocks above and below is virtually parallel, making the junction difficult to locate, and at its southern end the contact is masked by later metasomatic effects. But on Knipfjell, where late-stage movements have rejuvenated the slide, an angular disjunction can be observed. On a larger scale the presence of the slide can be detected by the difference of tectonic pattern on the two sides and, less obviously, by the difference of metamorphic grade.

Above the slide the rocks are remarkably similar to those of the Tømmerås area. The metamorphic grade is slightly higher and there has been more deformation but it is still to recognize the various groups. The Cambro-Silurian, called here the Gangåsvann Group, is represented by garnet-hornblende-mica schists and amphibolites, with or without garnet, whilst in the Eocambrian two units can be distinguished. The one above comprises microcline-bearing quartzites, whose correct stratigraphic position is confirmed by grading and cross-bedding, and beneath them lies a thickness of fine, dark semi-pelitic rocks containing characteristic small lenses of paler, calcareous, sandy material. The Knipfjell dislocation follows very closely beneath this unit with calcareous lenses and it now seems logical to extrapolate it north-westwards to the shore of Orkdalsfjord (Fig. 2).

Above the slide the metamorphic grade is lower and the degree of deformation less intense than in the rocks below. In the absence of analyses and mineral phase studies it is difficult to make precise comparisons of the grade but in general terms it can be said that whilst the rocks below may develop coarse garnet-kyanite assemblages, those above never become more than medium-grained biotite-garnet schists. Several generations of minor structures exist in the upper rocks but they are only weakly developed and do not greatly disrupt the stratigraphy.

As in the Tømmerås area basic igneous material is very scarce in the upper series of Eocambrian rocks, and whilst in the Cambro-Silurian there are abundant thicknesses of hornblende schist, no evidence of intrusive igneous textures has been observed.

Beneath the slide the Eocambrian is represented by alternating quartzites and mica-schists, cut by numerous sheets and lenses of hornblende schist which occasionally show transcurrent relationships and the remnants of ophitic texture. Although no primary sedimentary features have been seen in the host rocks it is presumed that they represent a sedimentary sequence and that the hornblende schists are the altered remains of a dolerite dyke swarm.

At least one reason for the absence of primary features in the quartzites and mica-schists is the intense deformation they have undergone. Two periods of major folding have produced remarkable lunate outcrops where the axes of Early ENE-trending folds are cut by later Main NE-trending fold axial planes. This complex pattern is sharply truncated by the Knipfjell dislocation, except at its northern end where the structural lines are roughly parallel (fig. 2). It now seems likely that, rather than dying out, the slide continues north-east to Orkdalsfjord, and that the rocks above it form a separate tectonic unit. The antiformal structure (see Peacey, 1963) which lies directly above the slide is probably a shear fold formed in response to the slip north-westwards on the dislocation and it is notable that the fold is most strongly developed where rejuvenation of the slide is most marked, i.e. on Knipfjell.

The Cambro-Silurian rocks beneath the slide, which occupy the core of a narrow, overturned syncline running into Orkdalsfjord, are again garnet-mica schists and amphibolites. Farther west there is also evidence of an older basal substratum which lies structurally beneath the Eocambrian. This is a variable complex, called in the area the Våvann Group, which comprises grey, plagioclase-rich gneisses with thin bands of quartzite, mica-schist and amphibolite. The evidence of several generations of pegmatites, highly-transformed basic sheets and metastable remnants of pyroxene suggest that these are an older suite of high-grade rocks, the basement upon which the Eocambrian was deposited. One episode, however, which was common to the basement and its Eocambrian cover, but not to the Palaeozoic rocks was the intrusion of the ophitic dolerite sheets. These predate the Early folding and also apparently, the deposition of the Cambro-Silurian.

When the geological histories of the three areas are tabulated (Table 1) some interesting comparisons can be made. If information from the Opdal area is correct, then the metasomatism there predates the emplacement of the low-grade Trondheim schists, whilst at Gangåsvann the Knipfjell slide and the rocks immediately above it are, in places, engulfed by granitisation. Less significant, is the appearance of the ophitic dolerite sheets which are restricted to the basement rocks of the Tømmerås massif. At Gangåsvann igneous activity took place between the

Eocambrian and the beginning of the Palaeozoic, whilst in Opdal it apparently did not occur before the Lower Ordovician.

The history of the rocks above the Knipfjell slide is, in many respects, similar to that of the Caledonian sediments in the Tømmerås area; certainly the facies, both sedimentary and metamorphic, is comparable and the Eocambrian is not cut by a dyke swarm. It is still not possible to say what the Knipfjell slide originally represented. Certainly in its later history it has acted simply as a plane of tectonic disjunction upon which the upper rocks have slipped north-westwards. But by analogy with the stratigraphy and tectonic setting of the Tømmerås area it is tempting to imagine it as an original sedimentary unconformity which has subsequently become a plane of structural dislocation. Thus one can visualize the cover of Eocambrian and Palaeozoic rocks being loosened from its basement and finally thrust into an allochthonous position.

Below the slide the geological history of the rocks shows plainly that they belong to the "Gneiss region" proper and thus here, as in Opdal, the margin of the Trondheim basin is a major tectonic break.

The exciting task now remains to map this dislocation south as it bends west into the Surnadal embayment and also to discover how far north towards the Grong culmination it can be traced.

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Table 1.

Comparative geological histories of the three areas.

Opdal	*Lower Gangåsvann*	*Upper Gangåsvann*	*Tømmerås*
Basement rocks formed	Basement formed, traces of very high-grade metamorphism and magmatic segregation	?	Basement rocks formed
			Intrusion of ophitic dolerites
Deposition of Eocambrian and Palaeozoic	Deposition of Eocambrian	Deposition of Eocambrian & Palaeozoic, accompanying vulcanicity	Deposition of Eocambrian & Palaeozoic, accompanying vulcanicity
Intrusion of dolerites, extrusion of lavas	Intrusion of dolerites		
	Deposition of Palaeozoic, accompanying vulcanicity	Weak metamorphism ?	Gentle folding & metamorphism, doming of the Tømmerås ridge
Multiple folding	Two phases of major folding, moderate metamorphism		
Metasomatism			
Emplacement of thrust sheet of lower-grade Palaeozoic rocks	Emplacement of thrust sheet of lower-grade Eocambrian and Palaeozoic rocks	Thrusting	
	Metasomatism	Metasomatism	

Sammendrag.

Det blir gjort en sammenligning av eokambriske avleiringer i to områder som tidligere er blitt beskrevet av forfatterinnen (Gangåsvann-området og Tømmerås-området) og Oppdals-området. I Gangåsvann-området er det en øvre avdeling av lavmetamorfe bergarter, tilsvarende bergartene i Tømmerås-området, som er skjøvet over en underliggende avdeling i vest av mer høymetamorfe bergarter. I den henseende er forholdene her tilsvarende forholdet i Oppdals-området, hvor Trondheimsfeltets lavmetamorfe bergarter ligger skjøvet over de sterkt metamorfe og foldete bergarter vestenfor i selve Oppdals-området.