CONNECTIONS BETWEEN THE TRONDHEIM AND SUNNHORDLAND REGIONS, CALEDONIDES OF NORWAY

By

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The traditional view put forward in Norwegian geological discussions has been to draw the links between the Trondheim region and the coastal area south of Bergen over the Jotunheim region. On the other hand an essential difference has been claimed to exist between the Trondheim region and the Jotunheim region. In actual fact there are a number of circumstances which show that the connection between the Trondheim region and Sunnhordland does not run via the Jotunheim region, but via the Devonian synclinal area of Vestlandet.

On this view the Caledonian mountain range forms a great arc pushing into Central Norway, having its convex side towards the southeast and to southward passing over into an arc with its concave side to the southeast. Such an arcuate mountain chain would provide an explanation of the complex folding systems that we encounter in the chain. In the following paragraphs I shall discuss features which throw light on the relationship between such an arcuate mountain range and the geology of Norway.

The Trondheim Region and Vestlandet.

Th. Vogt, in his important studies on the structure of the Caledonides, pointed out the existence of a direct connection between the Trondheim region and the Devonian synclinal area of Vestlandet (1928, 1954 a, 1954 b, 1954 c). The westsouthwesterly fold system which links these two areas together occupies a prominent place in Vogt's tectonic analysis. An important feature is the syncline which he traces between the Dombås area of the Trondheim region and the Devonian

rocks of Hornelen. The axis of this syncline runs parallel with that of the more northerly situated Trondheimsfjord syncline.

This westsouthwesterly fold system is further discussed in my paper on the main stratigraphic and tectonic features along the Trondheimsfjord syncline (I. HERNES 1956 c). I concluded by saying that the Trondheim region was directly continuous into the Western Gneiss area, and that the westsouthwesterly fold system probably constituted the main line of the Caledonides in this area.

The Devonian synclinal area of Vestlandet is a most interesting region both petrographically and tectonically. N.-H. KOLDERUP (1928) has published a geological map of the area. The investigations have recently been continued and an interim report has been published (1955).

I had the opportunity to take part in these investigations on the Devonian synclinal area and I intend in the next few paragraphs to give a brief account of some of the points arising from this work which are of interest for our present study. The area is reminiscent, of the Trondheim region in character. Petrographically, for example, I would mention the occurrences of greenstone, pyrites and Caledonian intrusives.

The transition between the Devonian synclinal area of Vestlandet and the Western Gneiss area calls to mind, both in petrography and structure, the western boundary of the Trondheim region south of the Trondheimsfjord syncline. A connection between those two border areas would reach its culmination in Sunnmøre—Romsdal.

A closer study of the most western part of the Trondheimsfjord syncline would be of intrinsic interest in an evaluation of such a culmination. The Trondheimsfjord syncline, which can be followed down the Surnadal and further over Tingvoll—Molde (HERNES 1956 a, 1956 b), is described, in its westward continuation, by T. GJELSVIK (1951).

From the Trondheimsfjord syncline and northward the structurally determined westsouthwesterly trend is very pronounced. Southwards, towards the Jotunheim region, this structural westsouthwesterly trend appears to become steadily less and less dominant. We are here approaching an area where Caledonian nappes overlie pre-Eocambrian rocks, with the possibility of finding traces of a pre-Caledonian structure (K. LANDMARK 1949).

Let us now return to the Devonian synclinal area of Vestlandet. Here we are in a very complex region. In addition to the main W — E trend, which links up this region with the Trondheim region, we also find a pronounced N — S trend. This is especially prominent in the Old Red deposits which, showing a clear W — E major trend, occur in a belt trending N — S. The geological conditions further south along the coast show that the N — S trend becomes steadily more pronounced southwards, whilst the W — E trend gradually dies away.

Not the Old Red sediments alone, but also the underlying rocks, occur along the coast of Vestlandet in a N — S trending belt. The Devonian, as is known, is found as far south as the Bergen arcs. Greenstone, pyrites and Caledonian intrusives can be seen as far down as the Stavanger district. The anorthosites, near and between the Devonian of Hornelen and Håsteinen, I regard as a complex equivalent to the anorthosites of the Bergen arcs.

In the north we find arcs with a W — E trending structure pattern, which southwards become progressively more and more drawn out in a N — S direction. This is in good agreement with the theory of an arcuate mountain chain showing the effects of pressures from both the north and the west. The Devonian synclinal area, on this view, would thus constitute the transition from a westsouthwesterly to a N—S primary trend of the Caledonides. O. HOLTEDAHL (1944, p. 22) also assumes a primary N — S trend of the Caledonides in the Haugesund —Stavanger district.

An interesting point about the Devonian synclinal area is that we find preserved here Caledonian nappes overlying rock complexes intensely folded during the Caledonian orogeny. The Devonian of Kvamshesten is particularly interesting, with the associated and underlying mangerite — syenite nappe, as also the overthrust gabbro on the Devonian of Solund (C. F. KOLDERUP 1925). The direction of thrust in the latter area has not yet finally been determined but is assumed to be approximately east or southeast.

A. KVALE (1953, map fig. 2, p. 58) has made a detailed structural analysis of the Bergsdalen area, just east of the town of Bergen. Kvale has distinguished two nappes here. The lineation strikes in an east-southeasterly direction and the main direction of thrust lay between east and southeast.

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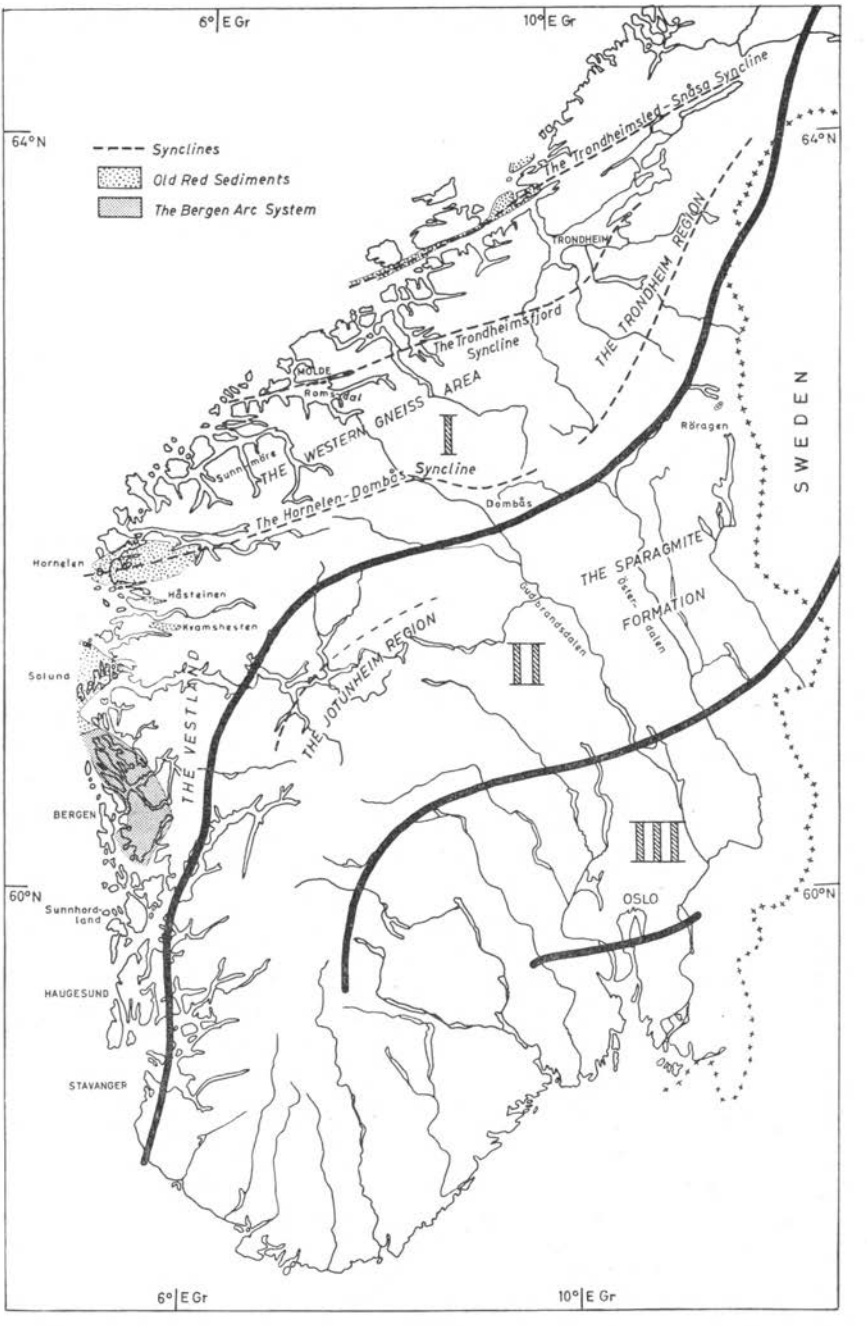
6° E Gr
10° E Gr
64°N
60°N
Synclines
Old Red Sediments
The Bergen Arc System
The Trondheimsfjord Syncline
The Trondheimsfjord-Snåsa Syncline
THE TRONDHEIM REGION
TRONDHEIM
MOLDE
Romsdal
Sunnmøre
THE WESTERN GNEISS AREA
I
The Hornelen-Dombås Syncline
Dombås
Røragen
SWEDEN
Hornelen
Håsteinen
Kramshesten
Sotuna
THE JOTUNHEIM REGION
II
Gudbrandsdalen
THE SPARAGMITE FORMATION
Österdalen
THE VESTLA
BERGEN
III
OSLO
Sunnhordland
HAUGESUND
STAVANGER

The relationship of the Svalbardian phase of orogeny (VOGT 1928, p. 113) to this view of the geological evolution of the Trondheim and Vestlandet regions, is a question of prime importance. The Devonian synclinal area of Vestlandet undoubtedly took on its present character during a very late phase of folding. The same applies to the Downtonian — Devonian of the Trondheimsled district.

It is an open question how deeply the Svalbardian phase affected the Western Gneiss area. Tectonic investigations on the boundary areas of the Devonian regions will probably yield valuable information regarding this problem. Cand. mag. INGE BRYHNI, who is taking part in the investigations on the Devonian synclinal area of Vestlandet mentioned above, has carried out a very interesting structural analysis of the region lying between the Devonian of Hornelen and Håsteinen. The direction of strike and lineation is predominantly westnorthwesterly here, a result which implies a phase of folding in an arcuate mountain range, and a phase which is older than that of the Svalbardian folding represented by the Devonian synclines. Bryhni's investigations are not yet completed.

I should also like to draw attention to my discussion of the westsouthwesterly fold system in Central Norway (HERNES 1956 c). This structural line has such a constant and widespread character in that area that it is difficult to assume that the Svalbardian folding alone is responsible. I might mention in this connection, too, that H. CARSTENS (1955) assumes that the Snåsa syncline was formed quite early in the Caledonian orogeny.

The Bergen arcs have a main N — S trend and they thus fit quite naturally with my concept of an arcuate Caledonian mountain chain. With their infolded Cambro-Silurian schists these same arcs are so profound in character that it is difficult to imagine that they are due solely to the Svalbardian folding. The Devonian rocks in the most northerly part of the Bergen arcs also appear to be younger than the main phase of formation of the arcs.

Fig. 1. Main Caledonian tectonical zones.

I: Rocks intensely folded during the Caledonian orogeny. Overlying Caledonian nappes to some extent preserved.

II: Rocks thrust during the Caledonian orogeny, the pre-Eocambrian basement mainly unaltered.

III: Rocks folded during the Caledonian orogeny, the pre-Eocambrian basement unaltered.

The Jotunheim Region and the Sparagmite Formation.

The relationship of the Jotunheim region to the arcuate Caledonian mountain range described above, is an important question. Following my concept the region occupies a less central position in the mountain chain than the Trondheim region and Sunnhordland, and a better parallel can be drawn with the Sparagmite formation.

In VOGT's interesting papers on the structure of the Caledonides, a syncline is shown passing through the eastern part of the Trondheim region and continuing southward via the Jotunheim region to Sunnhordland (1946, 1954 a, 1954 b). Vogt does not, however, mean that the transition between the Trondheim region and the Jotunheim region is rectilinear and marks it accordingly, *vide* his last map in particular (1954 b, fig. 1, p. 2). An anticline is also indicated on this map crossing the syncline at the transition point of the regions. This makes it clear that the connection between the two regions is not of a direct and radical type.

Vogt draws a further parallel between the gabbros of the Jotunheim and the gabbros of the eastern part of the Trondheim region, e. g. the Fongen gabbro, since, among other points, he stresses that they occur in the same syncline (VOGT 1954 a, p. 106), and in such a way that we have had, in the syncline itself, extensive break-throughs down to an underlying gabbro substratum. Most geologists today, when considering the great nappes of the Jotunheim region, would probably assent to the view that these have been thrust forward, not molten but as already solidified masses of rock, in the main from the northwest towards the southeast, and to this extent form a foreign element in the syncline.

Let us now consider the distribution of our pyrites deposits. Reference to S. FOSLIE's map of ore deposits in Southern Norway (1925) reveals the well-known feature that the area between the Trondheim region and Sunnhordland is practically sterile from a pyrites geologist's point of view. On the other hand the bordering districts, the Trondheim region and the Sunnhordland area, are characterised precisely by the multitude of their pyrites occurrences. We have here a direct connection between the distribution of the Bymark—Støren group and the presence of intrusive gabbros on the one hand and our pyrites occurrences on the other.

A study of the lineation yields an interesting picture. According to KVALE (1953, map fig. 1, p. 54), the lineation in the extensive nappes of the Jotunheim region strikes approximately northwest, the same direction that we find within the Sparagmite formation also. Within the Trondheim region on the other hand the lineation strikes more or less eastnortheast to northeast, in other words at almost 90° to the Jotunheim lineation. There appears here to be a direct connection between the strike of the lineation and the geological structure of the mountain chain; a northwesterly strike in areas characterised by nappes, the northeasterly strike in areas of folding structure.

The Jotunheim region, with its nappes overlying pre-Eocambrian rocks, with possible pre-Eocambrian rocks along its northwestern side, is markedly different, from a regional geology point of view, from the Trondheim region with its folding structure and its complicated boundary on the northwest. The formation of the Jotun fosse itself is supposed by T. STRAND (1951, p. 36) to belong to the Svalbardian phase of orogeny.

If we do not maintain the traditional view of the mountain chain, that the Jotunheim region continues directly over into the Trondheim region, it is natural to seek a continuation of the Jotunheim region in the Sparagmite formation.

In my opinion there is a striking similarity between the Jotunheim region and the Sparagmite formation. In both areas we are dealing with extensive nappes overlying pre-Eocambrian rocks, the lineation strikes in the same direction, and both areas lie for the most part outside the zone of intrusives and of ore deposits of the mountain chain.

Regarding the differences in the petrography of the two areas, there has scarcely been any deposition of Eocambrian sparagmite in the most western part of the Jotunheim region and southwards. Furthermore, the petrographic differences can be explained by the way in which the present land surface cuts the nappes. Jotunheim rock types found in the Østerdal area indicate that the Jotunheim nappes previously had a much greater extent than we find is the case today (P. HOLMSEN & CHR. OFTEDAL 1956). In the Gudbrandsdal area the rock complexes are in part found to lie horizontal, so that their extent depends in high degree upon the present-day surface topography.

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According to this view of the Caledonian mountain chain, we are dealing with a zone which extends from the Trondheim region over the Devonian synclinal area of Vestlandet to the Sunnhordland area, comprising rock complexes intensely folded during the Caledonian orogeny, a zone which has also to some extent preserved overlying Caledonian nappes. The Jotunheim region and the Sparagmite formation form a less central zone with Caledonian nappes covering little or not altered pre-Eocambrian rocks.

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