FOSSILS(?) OF PRECAMBRIAN AGE
FROM TELEMARK, SOUTHERN NORWAY

BY
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Abstract: Three nodular-rich beds occur within a sandstone unit of the Precambrian Bandak group at Haugli in Telemark, southern Norway. The nodules have ellipsoidal shapes, are 2½—4½ cm long, 1—2 cm across, are composed chiefly of fine-grained quartz, and have a central coarse-grained quartz-filled tube parallel to the long axis. The internal structure of the nodules is insufficiently preserved to permit any definite conclusion as to their origin. An organic or organic-controlled origin (e.g. some primitive sponge or concretionary development influenced by algae) seems more likely than an inorganic origin (e.g. lithophysæ, pisoliths or ooliths).

The name TELEMARKITES ENIGMATICUS has been chosen as a designation for the features.

General introduction to the stratigraphy of the Telemark area.

Geological field investigations in the Precambrian Telemark area of S. Norway are now so far advanced that an essentially complete litho-stratigraphical sequence has been established:

<table>
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<tr>
<th>Telemark suite (4000 m)</th>
<th>Bandak group</th>
<th>Seljord group</th>
<th>Vemork formation</th>
<th>Tuddal formation</th>
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<td>acid and basic lavas, quartzites, sandstones, tuffs (?), conglomerates, etc.</td>
<td>quartzites, calcareous sandstones, shales, conglomerates, etc.</td>
<td>basic lavas, tuffs, sandstones, etc.</td>
<td>acid lavas with lithophysæ and tuffs, etc. (the &quot;porphyroids&quot;)</td>
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Rocks belonging to the Telemark suite are found only below the sub-Cambrian peneplain. Because extrusive rocks are typical of the Telemark suite, and the geographically nearby Eocambrian rocks (sparagmites, youngest pre-Cambrian, “proterozoic”), which grade into Cambrian rocks, contain no traces of igneous activity, the Telemark suite and the Eocambrian formations can not be contemporaneous. The Telemark suite is of pre-Eocambrian age. Intrusive rocks of basic composition are abundant, especially as sills, in the Seljord group. The supracrustal rocks have been granitized and intruded by granite locally. Parts of the granites and gneisses surrounding the Telemark suite rocks may represent the original basement upon which the supracrustals were deposited. All the supracrustal rocks are folded.

Absolute age determinations have been performed by the Os/Re method on molybdenite occuring in hydrothermal quartz dikes that cut the Bandak group of rocks (HERR and MERZ, 1958). The results of several determinations give ages of ca. $7 \times 10^8$ years. The dikes are younger than, or contemporaneous with, folding of the Bandak group. The true age of the sediments may be 8-10 hundred million years. A communication on the absolute age determinations of various Norwegian material by several methods will be given in near future by Dr. H. Neumann.

**Stratigraphical sequence of the Bandak group at Haugli.**

The “fossiliferous”, i.e. nodular beds, which are described in this paper were found in the Bandak group in the summer 1957 by the author and his colleague Dr. A. Baer (Neuchâtel, Switzerland) during supplementary field investigations in the “Kvitei” quadrangle. This area has been mapped for the Geological Survey of Norway by Dr. H. Neumann, and the map soon will be published, together with the adjacent “Rjukan” quadrangle mapped for the Survey by the author (1947—57). A more complete stratigraphical and tectonic description of the Telemark area will accompany these maps. The stratigraphical sequence of the upper part of the Bandak group is listed in the left column of figure 1.

The word “nodule” is used in this paper as a non-genetic term. The letters $a$, $b$, $c$, etc. have no significance except for reference in this paper. They are referred to as str. u. $a$ (i.e., stratigraphic unit $a$), str. u. $b$ etc.
Field observations indicate that the sequence of alternating beds, lenses, and tongues of greenstones (str. u. a, c and f, representing basic lavas), quartzites (str. u. b, etc.), and a polymictic conglomerate (str. u. d) was deposited in a lacustrine environment, probably on the slope of a relatively flat shield volcano.

The rose to grayish quartz porphyry (str. u. e) is originally a rhyolitic lava (or welded tuff?). The presence of marble (str. u. g) is interesting owing to the extreme rarity of calcareous rocks in the Telemark suite.

Quartz sandstone (str. u. h) is a "sack name" for a great variety of rocks, such as quartz schists with some mica (quarried as high-quality whetstone since the eleventh century), shales, and polymictic conglomerates.

Bedrock is exposed in nearly horizontal surfaces approximately 100 square meters in size between the road and the Dalaåi river, at the farm Haugli in the deep valley, Dalane, 10 km NW of Kviteseid (140 km WSW of Oslo). The rocks, undoubtedly sediments (fig. 1, right column), have a distinct primary bedding which now is nearly vertical and strikes generally SSW. The nodular beds were traced for about 300 meters in two directions from Haugli: — to the NE they seem to disappear rapidly; to the S they extend for a greater distance.
The nodules occur in three beds separated by greenstone or sandstone. The greenstone is a mixture of two different irregularly distributed lithologic types. One, a light variety, is undoubtedly a quartz-rich sediment, whereas the other, a deep green type, shows an ophitic texture marked by needles of epidote. Green biotite is abundant. The feldspar is cloudy and, in some sections, nearly absent. The greenstone most probably represents a thin lava flow which incorporated sedimentary material during its flow.

The dark gray sandstone between the upper two and above the upper nodular beds, contains mostly angular quartz, grainsize $< 0.1$ mm and mostly $< 0.05$ mm. The estimated mineral content of a typical specimen is 79 per cent quartz, 10 per cent sericite, 5 per cent calcite, and 5 per cent magnetite (and hematite). Untwinned plagioclase, if present, may have been taken for quartz. In some thin sections traces of sodic plagioclase, alkali feldspar (microcline and perthite) and epidote have been observed. The sandstone between the upper nodular beds shows a well marked stratification with $1-3$ mm thick darker layers spaced at $\frac{1}{2}-2$ cm intervals. The dark bands are composed of coarse-grained quartz (diameter $0.15$ mm) and laths of secondary alkali feldspar. There is no evidence of graded bedding. Large scale cross-bedding occurs in the sandstone above the upper nodular bed. Although the sandstones are recrystallized, some of the larger quartz grains may reflect original sizes and shapes. Round patches of quartz clusters $1/4-1$ cm across, occur in single rows along some of the bedding planes in the vertical beds at Haugli. The patches resemble the nodules described below and are possibly of the same origin. They may, however, be rock fragments.

The contact zone between the sandstone beds and the nodular beds is a few centimeters wide and transitional in character. The border between the greenstone and nodular beds is sharp and parallel to the general stratification.

The nodular beds.

A comparison between the nodular beds shows the following: The lower bed contains small nodules in its basal part (average diameter $9$ mm) and larger nodules in its higher part (diameter $20$ mm). In the upper bed there is a gradual upward increase in the size of nodules
Fig. 2. Specimen from the lowest nodular bed. Greatest length 14 centimeters. Both radial lines (central part) and semicircular pattern (lower middle part) are visible in the depressions. The lump to the right is nodule no. 1 in figures 3, 4, 5, and 6.

from diameter 10 to 20 mm). The diameters were measured on the natural surfaces and give the approximate average size of the short diameter(s) of the nodules. Very small nodules occur in the groundmass.
Fig. 3. One of the 21 sections from the specimen of fig. 2. Its location is shown by the a-b line in fig. 6. Nodule no. 4 shows one of the abundant quartz masses described. Nodule no. 2 cut near its end, shows an inner ring and no central tube. To the left of nodule no. 2 and above no. 4 smaller nodules can be seen in the groundmass.

There is no distinct bedding in the nodular rock layers and thus they look unstratified as compared with the sandstones.

The nodular beds are cut by quartz veins of the dilatation type. On some exposed rock surfaces, particularly of the upper nodular bed, the nodules are more or less masked by square to rhomb-shaped aggregates (sidelength 1—3 cm) of quartz and muscovite. These may be pseudomorphs after a mineral which grew in the nodules.

Oriented specimens have been studied by series’ of sections. The best results were obtained from a sample taken from the lowest nodular bed (fig. 2). The specimen was cut in 2 mm thick plates normal to the long axis of the nodules (fig. 3). The patterns on the plates, that were made clear by color differences (deep red, green, yellow, and white), were copied by drawing on 2 mm thick perspex sheets. Then, all the perspex sheets were assembled into correct position, (also taking into
consideration material removed by the diamond saw) and a transparent reconstruction of the original specimen was obtained. Figures 4 and 5 show two different parts of the perspex model placed on a rubber cast of the original specimen. Fig. 6 shows a drawing based on the perspex model — the nodule outlines were projected to a plane parallel to their long axis and also essentially parallel to the bedding-planes in the sandstones (strike NNE, dip nearly vertical). The nodules are shaped like ellipsoids of revolution, the long axis ranging in length from 2 1/2 — 4 1/2 cm and short axis, from 1 — 2 cm. A perspex reconstruction of one specimen, however, showed relatively narrower cone-shaped ends. On a weathered surface a few nodules broken across their long axis show elliptical sections. All specimens show only one axial tube, parallel to the long axis.

The internal structures of some nodules are partly destroyed by clear, white or greenish quartz masses; which have grown and made the nodules swell and partly burst. The quartz masses occupy completely random positions within the nodules.

Minerals found to occur in both the nodules and the "groundmass" are the following: quartz (main constituent), sericite (partly paragonitic?), calcite, titaniferous hematite, and a few grains of magnetite. The grain-size is typically < 0.05 mm for all except the quartz grains in the central tubes of the nodules, in the irregular quartz masses, and in the veins. These latter grains attain up to, 0.6 mm in their greatest dimension. A few grains of oligoclase, microcline, and zoisite occur in the groundmass. Calcite is irregularly distributed, but is most abundant in the groundmass. Treatment with hydrofluoric acid gave no residue thus indicating that carbon is not present. An alkali determination of the whole rock gave the surprising result: 2.04 per cent K₂O and 4.35 per cent Na₂O. The high content of Na₂O may be explained at least to some extent by the possibility that the sericite is paragonitic. Because the sericite content is fairly low, however, it seems more likely that submicroscopic or untwinned plagioclase grains do occur in considerable amounts in the groundmass. An alkali determination of material from a nodule gave 0.42 per cent K₂O and 3.88 per cent Na₂O; which shows that probably the nodules also contain plagioclase.

When studied in thin sections (parallel light, low magnification) the nodules are easily seen, because concentrations of hematite and
thin layers of pure quartz form alternating gray and white concentric bands near their outlines (fig. 7). The hematite occurs within the quartz grains as well as between them. Between crossed nicols the sections of the nodules show shades of yellowish-green colors, because of local concentrations of sericite. No well defined regular pattern is outlined by these small patches.

Some thoroughly weathered sections of the nodules show both radiating and concentric structures. A section parallel to the axial tube revealed radiating structures branching out from the end of the tube. Sections cut perpendicular to the tubes near the ends of the nodules show concentric rings (fig. 3, nodule 2), indicating termination of the nodules by at least two layers.
From figures 3 and 7 the impression is gained that certain features are common to the groundmass and to the nodules. If so, it seems possible that the radial- and concentric-appearing features in the two depressions of the specimen fig. 2 represent some sort of enclosing material (see fig. 8).

Structurally the Haugli locality is situated on the western limb of a SW-plunging anticline, a large part of which is shown in a general map published by Dr. H. Neumann (Neumann, 1944). The long axis of the nodules is parallel to the bedding planes of the enclosing sediments and plunges \( \sim 75^\circ \) SW, apparently corresponding to the poorly defined major fold axis. But 300 m SW of Haugli the long axis is vertical or plunges steeply NNE. There is, however, no geologic evidence to indicate that the anticlinal axis accordingly has reversed its plunge. Moreover, the axial tube of the nodules protrudes farther out at the ends of the nodules than could the central core of a deformed sphere. This evidence, in conjunction with the fact that in the Haugli area the pebbles of the conglomerate, str. u. \textit{d}, are nearly unde-
Fig. 6. Most of the nodules shown in fig. 4 and 5 have been projected in this figure into a plane parallel to the bedding of the adjacent well stratified rocks. Letters and numbers correspond to those used in fig. 3, 4, 5.

formed, leads the author to believe that the orientation and shape of the nodules were only slightly effected by the regional deformation which produced the folds.

**Discussion.**

One main problem remains unsolved: what is the origin of these features? Are they organic, inorganic or both organic and inorganic? Without trying to cover every imaginable possibility some main points will be mentioned below in order to initiate future discussion of the problematica.

No carbon could be identified, and there appears to be no hope of finding amino-acid or other more certain organic compounds in the rock. The present mineralogical composition of the rock (mainly
Fig. 7. Photo micrograph, parallel light. The distance between the centers of the nodules is 14 millimeters. (Nodule no. 4 to the left, no. 2 to the right.) Dark spots and lines in the nodules and along their borders are composed of hematite. White patches in the black groundmass may be related to the nodules.

quartz) does not necessarily correspond to the original composition of the sediment which contained the nodules — perhaps, for example, it was a calcareous rock which has been silicified. The rhomb-shaped “pseudomorphs” (now quartz and muscovite) that occur in some of the nodules probably indicate such replacement processes. On the other hand the marble bed (str.u. g) that is present somewhat higher within the sequence has not been silicified.

The internal structure of the nodules seems to be insufficiently preserved to permit unreserved acceptance or refusal of the possibility that the nodules are purely or partly organic remains. All the nodules have the same internal structures. There is only one quartz-filled axial tube. Small nodules, probably of the same shape and construction as the larger ones, occur in the groundmass between the large nodules.
Fig. 8. A simplified reconstruction of TELEMARKITES ENIGMATICUS with the internal structures shown; surrounded by an irregular envelope of doubtful relation.

It is believed that the nodules were formed or deposited in shallow water during unstable conditions including nearby volcanic activity. The ‘‘enclosing features’’ (fig. 8) within the groundmass of the nodules seem to disprove the possibility of conglomeratic origin. If the nodules had been formed elsewhere for instance as lithophysae or ooliths and subsequently freed by weathering and erosion and transported to their present location, one should expect to find at least a few partly broken nodules. None have been found. In situ formation as lithophysae is excluded because the nodular beds are of sedimentary origin. The extremely regular and consistent make up shown by these nodules has seldom been seen in oolitic or pisolitic beds. It is believed that the nodules are practically uneffected by tectonic deformation.

There is a striking resemblance between the nodules found in Telemark and a photo reproduced by Prof. A. Hadding representing a ‘‘section through the lower part of a stromatoporoid bed showing the centra of growth, Högklint stage’’ from a Silurian reef limestone of Gotland, Sweden (Hadding, 1941). Hadding writes in a personal letter to the author, after he had seen one photo of a section of the nodules from Telemark: ‘‘Your photo undeniably shows a striking resemblance with fig. 11 in my work on Reef Limestones. The stromatoporoid, of which the basal part is figured, has the shape of a dome with diameter 200 mm. Stemlike stromatoporoids exist also, however. The Telemark-fossil I would more likely assume to be a (silicified) calcareous alga’’. (translation from Swedish).

The material was shown, described, and discussed at the III Winter
FOSSILS(?) OF PRECAMBRIAN AGE FROM TELEMARK

Meeting of Nordic Geologists in Finland (III Winter Meeting, 1958). With the hope that other geologists might have seen similar structures, a series of 7 original photo's (most of them reproduced in this paper) was sent along with a short general description to experts in Europe and USA.

The comments may be summarized briefly. Prof. L. Dangeard, Caen, France could see no definite solution of the problem, but considers deformed ooliths or pseudo-ooliths most likely. Dr. E. Flügel, Vienna, Austria, stated that there are no obvious affinities between the oldest known stromatoporoids and the nodules from Telemark. He also mentioned the possibilities of algal-structures or inorganic flattened pebbles. Prof. J. St. Jean, Jr., Chapel Hill, N.C. USA has made several thin sections of the material which was sent him, and he writes: “... I was also interested in the vermicular “septate” structures in the associated matrix which is suggestive of organic structures, but nothing appears to be identifiable. The specimen, whatever it may be, can not possibly be a stromatoporoid, though it does superficially have the general shape of the beatriceoid stromatoporoid, it has none of the internal structures of that group of fossils .......”.

Prof. O. H. Schindewolf, Tübingen, Germany also showed the photographs to Dr. Seilacher, Frankfurt a. Main, Germany. Although both men found the occurrence interesting but difficult to explain by seeing only the photos, the former proposed pisoliths formed probably by intervention of algae. Prof. R. R. Shrock, Cambridge, Mass., USA, to whom some material also was sent at request, said in a letter “... I do not have any strong feeling either for or against an organic origin for the concretionary structures ... The axial tube certainly does show up clearly and since it is always in the plane of stratification, I would be inclined to think that the structures might represent stems of some kind (provided that we can establish that stems were present at all) that were deposited on the sedimentational interface and then flattened somewhat by the consolidation of the surrounding material”.

Prof. H. Termier, Paris, thinks that they are concretions formed by the activity of schizophytes, probably cyanophyceae (blue algae).

The writer prefers not to give an opinion as this would not be based on very good positive evidence. After having worked with the material he feels, however, that the future explanation will be one
of two: 1) the nodules are concretions formed by intervention of algae, or 2) the nodules represent sponges.

The name TELEMARKITES ENIGMATICUS is proposed for the features. Telemark is a county (fylke) in southern Norway. The type locality is Haugli, Dalane in Telemark. The type specimen is deposited in the type collection of Paleontologisk Museum, University of Oslo with no. 69 586.

The author wishes to thank all persons who have taken interest and given help and suggestions during his investigations of the material.

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