Tittel

Geology of the Numedal Area, Norway

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Råstofftype	**Emneord**	
Malm/metall	Cu Ag	

Sammendrag

FOR FALCONBRIDGE NIKKELVERK A/S

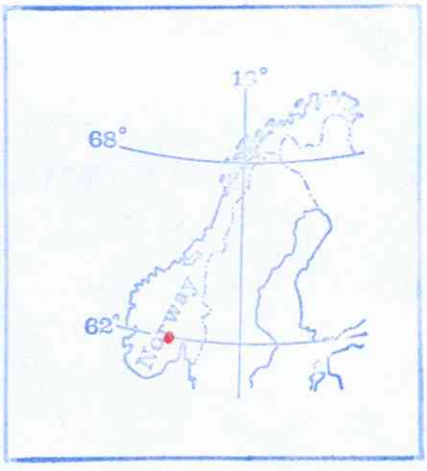
A/S SULFIDMALM

PROJECT 905-15

Geology of the Numedal Area, Norway

1974

by M. P. Annis



Matthews or Vokes

NumHov Project

Geology of the Numedal Area, Norway

Introduction

This report describes the geologic setting of seven sulfide occurences near Rødberg. All are located in, or north of, Numedal (see the accompanying map sheet). The descriptive geology is based on two relatively brief periods of field study, one of 3 weeks duration in summer 1972 and one of 3½ weeks duration in summer 1973. The study is organized as part of the NumHov Project. This project is an economic geology investigation of mineral deposits in the Numedal - Hovin region led by Professor F. M. Vokes. The primary aim of the study reviewed below is to provide a geologic description and concept of the development of the copper sulfide occurences in the Numedal area.

Very little was known about the regional geology at the outset. The Geological Map of Norway (Holtedahl and Dons, 1960) indicates Precambrian supracrustal rocks of the Telemark Formation occur in the area, with basement gneisses exposed both east, and west of the area. The map of mine and ore deposit localities for southern Norway (Foslie, 1925) shows the Numedal localities plot along a linear trend which apparently extends as much as 80 km southwards to the Hovin deposits.

Geologic mapping in the field has revealed several important features of the regional geology which help explain the linear trend of the copper sulfide localities.

Regional Geology

Greenstones, quartz schists and quartzite form a north-south trending belt through the area (see map). These rocks are thought to be equivalent to members of the Telemark Formation as shown in the stratigraphic comparison (Table 1). The north-south trending belt appears to be tightly folded; however the relation between stratigraphy and structure is not yet known with certainty, as discussed below.

Three formations have been recognized in the area. Meta-quartzite is exposed at Rødberg and elsewhere along the west side of the belt. The greenstone formation occupies the center of the belt. Muscovite-quartz schists occur to the east.

The quartzite at Rødberg is an unusually pure quartzite, and contains excellently preserved cross bedding and oscillation ripple marks. Several basic sills, ½ to 3 meters thick occur within the quartzite, and extend for distances of 1 to several kilometers. One unusually thick sill exposed along the highway west of Rødberg is layered.

The greenstone formation is a complex unit made up of several lithologies. It is mostly dark green to black fine-grained schist made up of varying amounts of chlorite, actinolite(?), and hornblende. Occasional calcite-

epidote blebs in the greenstones may be former amygdales. Vesicular structure is preserved at one or two localities. Many other lithologies occur within the greenstone formation. The most important of these are light-colored fine-grained rocks. Their overall glassy aspect, and tabular outcrop pattern suggest they are meta-tuff beds. They contain fine feldspar crystals, and on this basis have been given the field term porphyry in previous reports. Locally, graded bedding is present near the contacts of these tuffaceous beds. Other lithologies included in this formation are a pelitic bed with preserved mud cracks, and a minor lense of pebbly sandstone.

Muscovite-quartz schists occur east of the greenstone formation. In addition to quartz and muscovite, small and variable amounts of biotite and chlorite are present. Near the greenstone contact biotite is more abundant and the rock is a muscovite-biotite-quartz schist. This is shown with the label 3a on the geologic map. A conglomerate bed is exposed in the muscovite-quartz schist in a roadcut in Numedal. Its former pebbles and cobbles are now flattened disks.

The contact between the greenstone formation and meta-quartzite on the west is marked by an angular unconformity. This is particularly well demonstrated by the map relations near Groven, and by quartzite breccia near Kisgang at the base of the meta-tuff bed there. Muscovite-quartz schist is in contact with the greenstone formation along its eastern border. As mentioned above, biotite becomes more abundant near the greenstones. However the contact itself is poorly understood at present. No sedimentary structures that might indicate which of these two formations is stratigraphically higher have been identified to date.

All sedimentary structures observed to date are in the western part of the belt. They indicate younger strata lie to the east. Crossbedding, oscillation ripple marks and mud cracks imply sedimentation took place in a shallow water, near shore environment; and under subareal conditions. Possible amygdaloidal texture in some greenstones, and rare vesicular structure in others may indicate subareal lava flows. Deposition and lava flow within a platform environment is inferred. Viewed in the context of the entire Telemark Formation, this may have been a platform region of considerable extent.

Metamorphism has induced recrystallization at upper greenschist, or possibly low amphibolite facies conditions. Foliation developed parallel to bedding in many places. Local superimposed foliation oblique to that parallel to bedding reflects subsequent folding.

Structurally, the formations in the Numedal area appear to occupy a down-folded synclinal trough with the major fold axis located within the greenstone unit. The foliation strikes approximately north-south and dips steeply (50° - 90°) over most of the area. A syncline occurs in the northern part of the area, between Duses and Knutstøl. It appears to plunge gently to the north, and to have a steep, nearly vertical axial plane. However, first attempts to map this were unsuccessful. The southern extension of this fold has not yet been mapped. Thus it is not certainly known whether the syncline is a local feature, or whether it tightens into an isoclinal fold which extends along the length of the belt. This latter interpretation is favored on the basis of the overall stratigraphic relations.

To summarize the general geology, it appears a section in excess of 2 km thick was deposited in the area. Pure quartzite is the oldest formation and may underlie even the eastern muscovite-quartz schist. This schist may have formed as a wedge-shaped deposit at the edge of the sedimentary basin. Alternatively, it may have been completely eroded from the area now represented by the angular unconformity. Volcanism and associated sedimentation then deposited a thick section represented by the greenstone formation. The lower strata may have entrapped unusually high metal contents, particularly copper. Subsequent regional metamorphism and deformation brought the belt to its present setting.

Copper Sulfide Occurences

The copper sulfide occurences in the Numedal area consist of quartz vein networks within particular lithologies of the greenstone formation. As shown in Table 2, mineralogic features of these veins, and replacement, vary according to which lithology forms the wall rock.

Seven prospects and former mines plus smaller, similarly mineralized localities are included in the study area. The seven are Duses, Kisgang, Hytte, Groven, Knutstøl, Lauvaasen, and Brennebekk. The quartz veins at these localities are irregular, seldom more than 25 cm thick and seldom extend more than 100 meters. They cut across foliation and occasionally include fragments of the metamorphic wall rock. In addition, the wall rock has been altered, and partially replaced at some occurences, but not at others. Magnetite is disseminated in wall rocks at each occurence. Pyrite is lacking. These features indicate the veins formed after the regional metamorphic recrystallization and its associated schistosity developed. Confinement of the quartz veins to areas where light, or siliceous, rocks are present; and variation in mineralogy according to host rock lithology probably indicates that the wall rocks participated to a significant extent in the vein formation. This encourages the inference that the greenstone formation provided at least some of the vein-forming components.

Each deposit has several unique characteristics that serve to distinguish it from the others in the district. Duses occurs along a zone of sheared rock in intensely schistose greenschist. The quartz veins here carry abundant calcite, which also fills oblique fractures. Bergarkiv 668 reports this deposit also carries silver and gold in trace amounts.

Kisgang contrasts with the other deposits in having chalcopyrite as the only important copper sulfide, and essentially no calcite, in the quartz veins. This deposit occurs in meta-tuff only a few meters from the unconformable contact with Rødberg meta-quartzite.

Hytte is partially covered by a large dump of rock from nearby tunnel excavation. It occurs in gray meta-tuff. The quartz veins are calcite bearing, in contrast to Kisgang.

There are several workings at Groven. All are located on quartz veins in the same meta-tuff bed. Some of the quartz veins have been deformed along with the meta-tuff, and now are somewhat rolled into $\int$ shaped cross sections.

Knutstøl occurs within the greenstones at an internal contact between greenschist and siliceous greenstone. The siliceous greenstone is magnetite

bearing at the deposit and at outcrops 100 to 200 meters to the southeast. Small amounts of silver and gold are present, according to Bergarkiv 668.

Lauvaasen and Brennebekk are quite similar. They are located in the same siliceous member of the greenstone formation— a gray, purplish finely laminated bed. Molybdenite is a significant ore mineral in these deposits as well as bornite and digenite. In addition, wall rock alteration and replacement is important here. This is demonstrated by samples found in the mine dumps, but could not be evaluated in situ because the mines are now closed and flooded. The altered wall rock is cream to pink colored, and contains ore minerals along foliation planes and cross fractures.

Malachite is present at each deposit, and elsewhere marks outcrops in the greenstone formation which contain a few grains of copper sulfide minerals.

The geologic map for this area shows most of these occurences lie along two north-south zones. Duses, Kisgang, Hytte and Groven make up the western zone, while Lauvaasen, and Brennebekk form an eastern zone. Knutstøl lies between the projected zones to the north. The fold interpretation presented in the regional geology section implies both zones are near the base of the greenstone formation.

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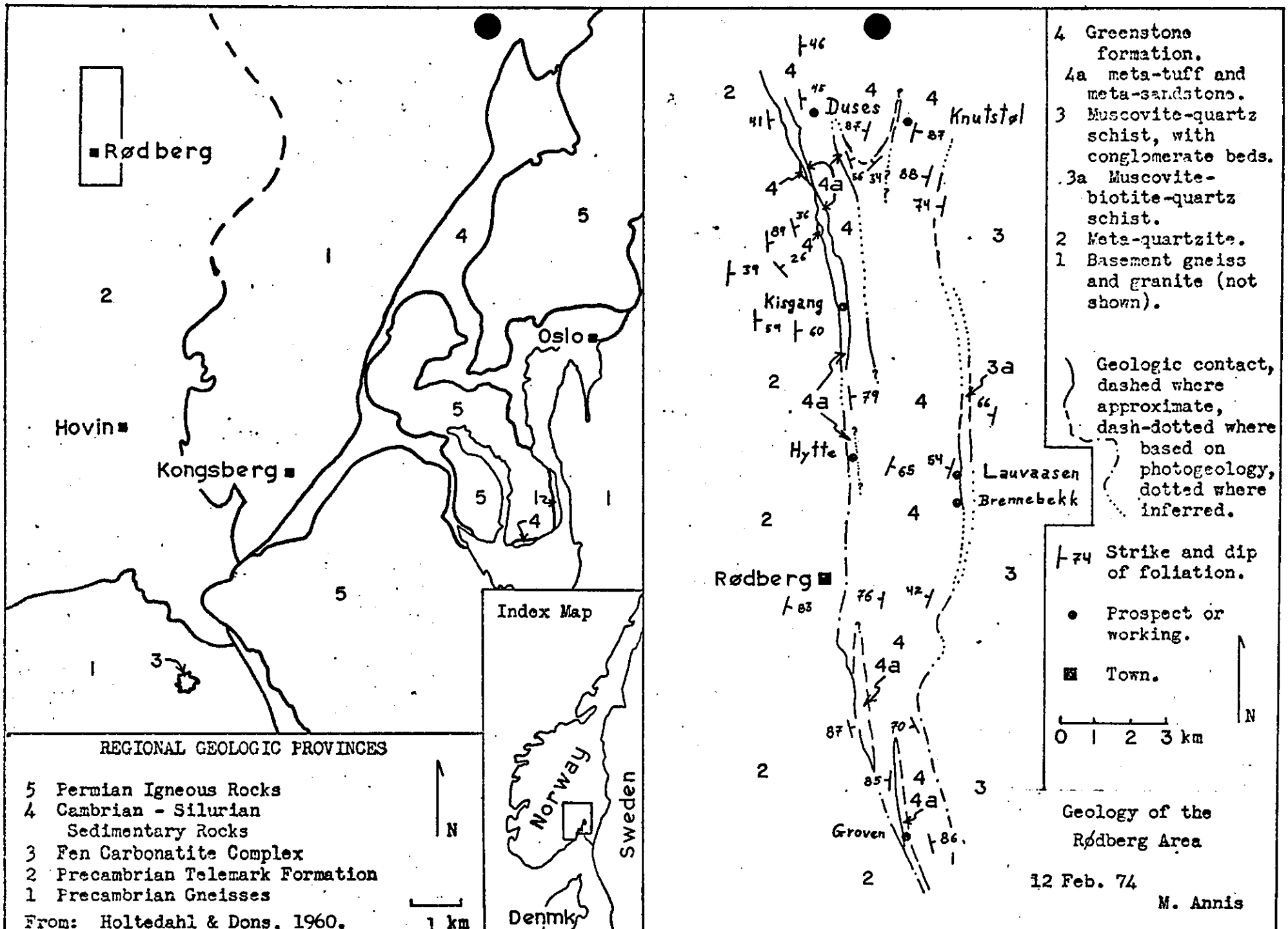
Rødberg
Hovin
Kongsberg
Oslo
Index Map
Norway
Sweden
Denmk
REGIONAL GEOLOGIC PROVINCES
5 Permian Igneous Rocks
4 Cambrian - Silurian Sedimentary Rocks
3 Fen Carbonatite Complex
2 Precambrian Telemark Formation
1 Precambrian Gneisses
From: Holtedahl & Dons, 1960.
N
1 km
Duses
Knutstøl
Kisgang
Hytte
Lauvaasen
Brennebekk
Rødberg
Groven
4 Greenstone formation.
4a meta-tuff and meta-sandstone.
3 Muscovite-quartz schist, with conglomerate beds.
3a Muscovite-biotite-quartz schist.
2 Meta-quartzite.
1 Basement gneiss and granite (not shown).
Geologic contact, dashed where approximate, dash-dotted where based on photogeology, dotted where inferred.
Strike and dip of foliation.
Prospect or working.
Town.
0 1 2 3 km
N
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12 Feb. 74
M. Annis

Table 1. Comparison of Stratigraphic Units in the Numedal Area with the Telemark Formation units.

Stratigraphic Units in the Numedal Area. (This Study)	Telemark Formation Units (Dons, 1960, pp. 49-55.)
	Bandak group (acid and basic lavas, quartz-rich sediments).
	8. Quartz schist with conglomerate.
	7. Marble (locally developed).
	6. Green lava, includes one layer of sandstone containing fossils(?) (Telemarkites enigmaticus, a fossil algae.)
	5. Porphyry (acid lava) (may be missing locally).
	4. Green lava with conglomerate, 3 - 4 beds of quartzite with conglomerate, irregular and locally developed layers of quartz schists. Structures resembling pillows. Cu - Ag mineralization.
	possible unconformity
	3. Quartzite (with conglomerate) of varying thickness.
	2. Porphyry (acid lava) of varying thickness, locally missing.
	1. Basal conglomerate and quartzite, thickness decreasing eastward to zero, where no. 3 forms the base (?).
Greenstone formation (Bandak no. 4(?)). Fine-grained greenschists, amphibolites, green meta-basalt(?), siliceous greenstone, meta-tuff ("porphyry"), meta-sandstone, etc. Cu - Mo mineralization	
Muscovite-quartz schist (Bandak no. 3(?)). Fine- to medium-grained muscovite-quartz schist with variable biotite and chlorite; deformed meta-conglomerate.	
Unconformity (?)	Unconformity
Meta-quartzite (Seljord quartzite(?)). Metamorphosed pure ortho-quartzite with cross bedding, oscillation ripple marks. Basic sills are present; one is layered.	Seljord group (quartzites, conglomerates, schists). Cross bedding and oscillation ripple marks are common. Basic sills are common.
	Unconformity
	Rjukan group
	Vemork formation (basic lavas, sediments).
	Tuddal formation (acid lavas and tuffs).

TABLE 2. Wall Rocks and Vein Mineralogy of the Numedal Prospects and Workings. (1)
Sidebergarter og gang mineralogi av de Numedal skjerp og malmforekomster.

Name - Navn	Wall Rock - Sideberg art			Quartz Vein Mineralogy - kvartsgang mineralogi									
	lithology litologi (2)	replacement fortrenging	magnetite present magnetit til sted	quartz kvarts	feldspar feltspat	calcite kalkspat	chalcopyrite kobberkiss	bornite bornitt	digenite digenitt	chalcocite kobberglans	molybdenite molybdenglans	pyrite svøyelkiss	Hematite
Duses	greenstone grønnstein	-	yes-ja	+	?	+	-	+	+	+	+	-	-
Kisgang	meta-tuff	-	yes-ja	+	+	-	+	-	-	-	-	-	-
Hytte	meta-tuff	?	yes-ja	+	+	+	+	+	-	-	-	-	-
Groven	meta-tuff	trace-tegn	yes-ja	+	+	+	-	+	+	+	-	-	+
Knutstøl	siliceous greenstone kiselholdig grønnstein	yes-ja	yes-ja	+	+	+	+	?	?	?	-	-	-
Lauvaasen	siliceous greenstone kiselholdig grønnstein	yes-ja	yes-ja	+	+	+	-	+	+	-	+	-	-
Grennebekk	siliceous greenstone kiselholdig grønnstein	yes-ja	yes-ja	+	+	+	-	+	+	-	+	-	-

Abbreviations forkortelser: + = present, til sted. - = not observed or reported, ikke sett eller beskrevet.

(1) In part from Bergstøl (1972), and Bergarkiv 668. Delvis fra Bergstøl (1972), og Bergarkiv 668.

(2) All lithologies are members of the greenstone formation. Hver litologi er en del av grønnstein formasjonen.