NOTES – *NOTISER*

A Discussion. Sulphide Mineralization and Wall Rock Alteration at Rødhammeren Mine, Sør-Trøndelag, Norway

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The sulphide deposits of the Rødhammeren Mine, Sør-Trøndelag are reinterpreted as regionally metamorphosed, volcanogenic ores of the Kuroko type. The sequence in the mine is thought to have been inverted during the Caledonian orogeny. Proposals for the use of this concept during subsequent stratigraphic-structural studies and base-metal exploration programmes are forwarded.

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The recent paper on the nature and genesis of the Rødhammeren ore deposits by Nilsen (1971) constitutes a most useful contribution to our understanding of the ores of the Folldal-Røros sulphide belt. However, one has the impression that the author failed to provide the student of Norwegian geology with a properly balanced set of conclusions concerning the genesis of these fascinating sulphide ores.

Nilsen describes two principal sulphide ore bodies, namely, an upper pyritic body associated with metavolcanics and a lower body, richer in chalcopyrite, which is associated with massive-gedrite-anthophyllite rocks (thought to be possible lateral equivalents of a sillimanite-biotite schist horizon of the Cambrian Gula Schist Group to the north of the mine). The metavolcanics in the upper part of the Rødhammeren sequence apparently are composed of intercalated 'ore quartzites' (meta-keratophyres), amphibolites and sillimanite-rich schists, all of which are correlated with the Lower Ordovician Støren Group. Nilsen concludes that the Rødhammeren deposits are epigenetic and analogous to ores of the 'Falun' type described by Magnusson (1953). A metasomatic introduction of Fe, Cu and S is envisaged as having taken place after a sequence of Palaeozoic sediments and volcanics had been isoclinally folded, regionally metamorphosed and subjected to 'low-pressure Mg-metasomatism'.

Alternative interpretations of the evidence

Nilsen in his discussion of the origin of the gedrite-anthophyllite (± quartz,

cordierite, kyanite, staurolite, garnet, chlorite) lithologies concludes that ... 'Iron-magnesia metasomatism is now generally accepted as a mechanism for the formation of cordierite-anthophyllite/gedrite rocks', citing the work of Eskola (1914, 1920) in the Orijärvi district of Finland and that of Bugge (1943) and Jøsang (1966) in the Kongsberg-Bamble sector of the Fenno-scandian shield. The author also concludes that the precursors of such rocks must have been of a pelitic character rather than altered ultrabasic rocks. Such an interpretation does however seriously neglect the conclusions of other workers such as Akella & Winkler (1966), Vallance (1967) and Morton et al. (1970) on the possible origin of such magnesium-rich rocks. All of these authors have forwarded the thesis that cordierite-anthophyllite/gedrite rocks such as those encountered at Rødhammeren may be generated isochemically from pre-existing, altered basic volcanic rocks during regional metamorphism.

It is therefore proposed that the gedrite/anthophyllite-bearing rocks at Rødhammeren be reinterpreted as simple members of the metavolcanic sequence which is already known to contain meta-basaltic and meta-keratophyric members. Such Mg-rich rocks, it is felt, were probably derived from strongly-altered basaltic pyroclastics analogous to the 'Green Tuffs' of Japan (Kenichiro et al. 1970). In such case the Rødhammeren sequence would be almost totally volcanogenic and all rocks, including the ores, may then be compared directly with other occurrences described by Kenichiro et al. (1970), Tatsumi (1970), Hutchinson & Searle (1970) and Hutchinson & Hodder (1972). If this comparison is made, a most striking analogy emerges between the Rødhammeren sequence and that associated with the volcanic, exhalative ore deposits of the Kuroko type in Japan as described by Kenichiro et al. and Tatsumi. The disseminated and massive chalcopyrite ores (0–1.5 % Cu) associated with the meta-pyroclastic anthophyllite/gedrite rocks are clearly analogous to the classic Oko (yellow ore) which carries an average of 1.8 % Cu and is closely associated with highly altered, basaltic pyroclastics. The overlying pyrite-rich ore body of Rødhammeren is then too clearly comparable to the Keiko or pyrite ore which is associated with silicified dacite lavas in a typical Kuroko deposit, e.g. the Shakanai mine in Akita Prefecture, Japan.

If one accepts the alternative interpretation of the evidence presented by Nilsen, then the following points must be emphasized:

The Rødhammeren ores are actually metamorphosed volcanogenic deposits, probably developed under eugeosynclinal conditions during effusive activity of a spilitic-keratophyric affinity.

In view of the present stratigraphy, where pyritic ores associated with felsic metavolcanics overlie chalcopyrite-rich ores, the sequence in the mine is most probably inverted. For in the Kuroko deposits of Japan the Cu rich ores always *overlie* the pyritic-siliceous ores. (This observation might therefore invalidate correlation of the anthophyllite/gedrite rocks with any mem-

ber of the Cambrian Gula Schist Group if the lower members of the sequence are equivalents of the Lower Ordovician Støren Group.)

The local evidence of replacement and veining recognized by Nilsen is most probably a minor effect due to regional metamorphism.

Conclusion

The Rødhammeren ore deposit is thus reinterpreted as a classic example of a 'meta-Kuroko' or 'meta-volcanogenic' sulphide deposit which was deposited, together with a basaltic-rhyolitic volcanic suite, during the Lower Palaeozoic. The sulphides and their associated lavas, pyroclastics and sediments have subsequently suffered high-grade Barrovian regional metamorphism and inversion during the Caledonian orogeny. Despite their metamorphism and overturning, however, the deposits appear to have retained many of their original characteristics, a fact which might prove invaluable during subsequent investigations in the region. In the future it might clearly be possible to utilize data on such deposits in the stratigraphic interpretation of the nappes in the Trondheim district and also to initiate a search for other base metal ores of the Kuroko type (e.g. Pb-Zn in gedrite/anthophyllite horizons?) elsewhere within the sequence.

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