IGNEOUS GEOCHEMISTRY OF THE BLÅHØ NAPPE OF THE MIDDLE ALLOCHTHON, NORWEGIAN CALEDONIDES: A DEEPLY SUBDUCTED SEGMENT OF ROCKS GEOCHEMICALLY SIMILAR TO THOSE EXPOSED IN THE STØREN GROUP OF THE UPPER ALLOCHTHON

Kurt Hollocher[1], Maria Van Nostrand[2], Peter Robinson[3], and Emily Walsh[4]

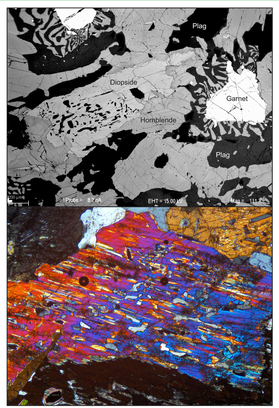
[1]Geology Dept., Union College, Schenectady, NY 12308
[2]Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409
[3]ROBINSON, Peter, Geological Survey of Norway, Trondheim, N-7491
[4]Geology Department, Cornell College, Mt. Vernon, IA 52134

Abstract

The Scandinavian Caledonides are a complex orogenic belt that was assembled in the middle Paleozoic from several tectonic segments from within and on both margins of Iapetus. Some parts of the Caledonide belt developed in the Iapetan Ocean, including volcanic arcs, that were first accreted onto the Laurentian side of the ocean. These were transferred, with parts of the Laurentian margin, to the Baltican side during the culminating Siluro-Devonian Scandian collision between Laurentia and Baltica. Caledonide architecture now includes these assembled pieces as the Lower Allochthon (Baltican margin), Middle Allochthon (Baltican rifted margin, possibly with outboard volcanic arcs), Upper Allochthon (volcanic arcs), and Uppermost Allochthon (pieces of Laurentian margin), all above autochthonous Baltican crust.

The Blåhø Nappe of Norway is an assemblage of metamorphosed sedimentary and igneous rocks, with eclogites in some places, that is interpreted to be the remnants of an outboard arc, similar to upper parts of the Middle Allochthon (Seve Nappe) in Sweden. Here, we present 95 new whole-rock chemical analyses of Blåhø igneous rocks that include metamorphosed gabbros, basalts, and sparse intermediate, dacitic, and rhyolitic rocks. Mafic rocks are generally tholeiitic, felsic rocks generally calc-alkaline. REE diagrams for mafic rocks range from somewhat LREEenriched to LREE-depleted. Multi-element and other diagrams indicate variable arc influence. Comparisons indicate derivation from an arc-back-arc system that is geochemically indistinguishable from ophiolitic and related volcanic and plutonic rocks in the Støren Group of the Upper Allochthon. Sparse Blåhø Nappe igneous ages are also similar to those of the Støren Group.

Eclogites within the Blåhø Nappe give metamorphic ages that are Scandian (based on literature), as do eclogites in the Lower Allochthon of the Western Gneiss Region. Middle Allochthon eclogites and gneisses in Jämtland, Sweden, record Ordovician 445-490 Ma metamorphic ages, from earlier subduction probably on the Laurentian side of Iapetus. Based on eclogite ages and new geochemistry, we present a model in which the Blåhø Nappe resulted from deep Scandian subduction of part of the same volcanic-sedimentary assemblage that also became the Upper Allochthon



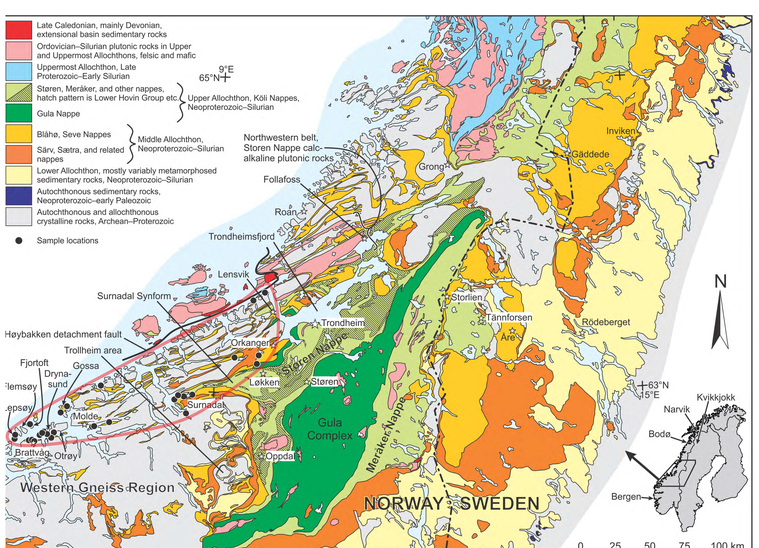
BSE image of Blåhø amphibolite: Plagioclase-hornblende symplectite surrounds garnet, with larger hornblende and plagioclase crystals, and diopside with plagiolcase exsolution blobs.

Blåhø Nappe garnet ampibolite. Some have textural evidence that they were once eclogites, including plagioclase-diopside-hornblende symplectites around garnet, and plagioclase exsolution lamellae in diopside.

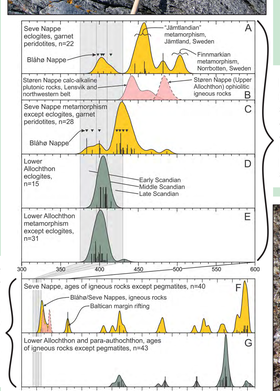
Cross-polarized light image of diopside in garnet amphibolite, with plagioclase exsolution lamellae and blobs, suggesting an omphacite precursor.

One of the relatively rare Blåhø Nappe felsic gneisses. This one has deformed leucosomes, clearly having undergone partial melting at some point, probably pre-Scandian.

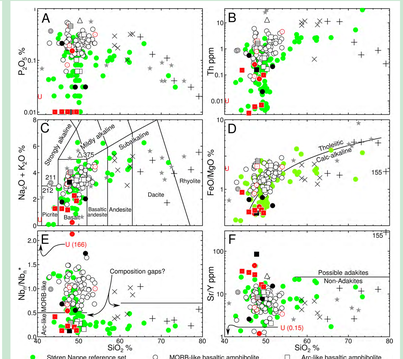
Retrogressed eclogite boudin, surrounded by garnet amphibolite and kyanite schist.



Regional map of central Norway, showing sample locations. There are 95 total samples for which whole rock data are shown in this poster. The data set includes amphibolite, eclogite, hornblendite, pyroxene granulite, and intermediate and felsic gneisses. Many eclogites and amphibolites have compositions that indicate that the protoliths were cumulate gabbros.



Age kernel density plots for Blåhø (Seve) Nappe and Lower Allochthon igneous rocks. Unfortunately, there are not enough data to reach any statistically valid conclusions about age distribution similarity. Ask me, though, about statistically invalid conclusions.

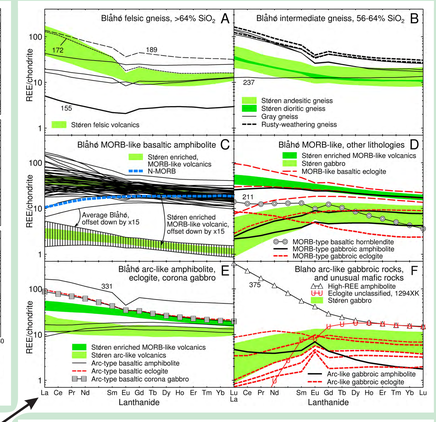


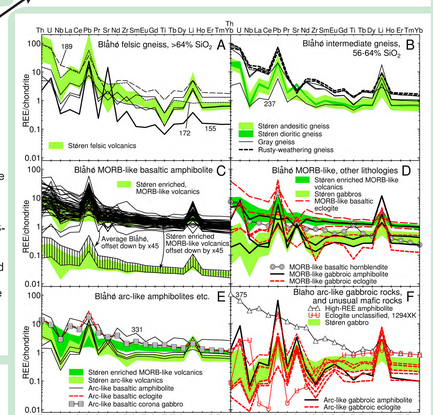
Comparison of rocks in the Blåhø Nappe, Middle Allochthon, and possibly related rocks in the locally-mapped Surna and Gula Nappes. These rocks are at metamorphic grades ranging from garnet amphibolite facies (kyanite schists) to granulite and eclogite facies. Also compared are ophiolitic rocks of the overlying Upper Allochthon Støren Nappe, which are chemically similar but at lower metamorphic grade, greenschist to epidote amphibolite facies, with no ecolgites. Both Blåhø and Støren units are dominated by MORB-like to arc-transitional (e.g., back-arc) basaltic compositions, smaller numbers of arc-like basaltic compositions, and a small numbers of intermediate and felsic rocks. Mafic rocks include compositions that are apparently cumulate gabbros. Blahø eclogites are found in all mafic types.

Metamorphic age kernel density plots for the Blåhø (Seve) Nappe and Lower Allochthon rocks. A and D show eclogites, C and E show other metamorphic ages (e.g., pegmatites). Lower Allochthon ages are about 400 Ma, matching a minority of Seve Nappe metamorphic ages, most of which are pre-Scandian, probably when near the Laurentian margin. Also shown are Upper Alochthon igneous rock ages (C).

Kyanite-garnet-muscovite-biotite schist. The kyanite-garnet-quartz-feldspar leucosome is an indication of (probably) pre-Scandian partial melting.

REE in Blåhø Nappe rocks compared to those in the Støren Group. Blåhø felsic rocks are highly variable. Intermediate rocks have patterns like those in the Støren, but more REE-rich. The mafic rocks are quite similar, including MORB-like depleted, enriched, and flat patterns, and highly-depleted patterns that are interpreted to have cumulate gabbro protoliths.

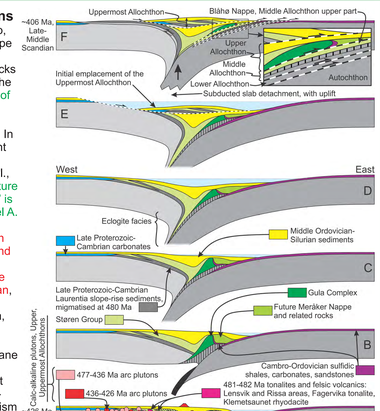




Multi-element diagrams show that Blåhø Nappe felsic and intermediate rocks (A, B) have anomalies similar in size to those from the Støren Nappe. For MORB-type amphibolites (C, D) the range of anomalies is from moderate to nonexistant, and the position of the 1σ bands, are essentially identical to those of the Støren Nappe. For the arc-like amphibolites (E, F), negative Nb anomalies are larger (by definition), and they and others are almost identical to those in the Støren Nappe. D and F also show less common lithologies and compositions, including several rocks with compositions that indicate that there were cumulate gabbros. These two figures show eclogites, which are represented in MORB and arc, and lava-like and cumulate gabbro-like types.

Conclusions

In this scenario, the Blåhø Nappe is part of the same set of rocks that make up the Støren Nappe of the Upper Allochthon. It works like this: In the bottom-right illustration (Hollocher et al., 2016), the "Future Støren Nappe" is in bottom panel A. Eclogites are associated with its formation and collision with Laurentia in the early Ordovician, and, with metamorphism, also during docking of a composite terrane in the middle Ordovician that produced calc-alkaline plutonism on Laurentia. Subduction associated with the approach of Baltica produced late Ordovician–Silurian plutonism on Laurentia. Subduction of Baltica (upper-right illustration) resulted in Scandian eclogites and other metamorphic effects. As part of the Laurentian margin was transferred onto Baltica, the "Future Støren Nappe" was split: one part remained at shallow levels and became the Støren Nappe. The other was brought to deep levels and became the higher grade Blåhø Nappe.



Acknowledgments

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