Report for the field and sampling campaign to Kirkenes, Norway

The aim of our field campaign at Kirkenes, North-East Norway, from 02.06. to 08.06.2022 was to sample the banded iron formation (BIF) in the Bjørnevatn Iron-ore mine, owned by Sydvaranger AS. Sydvaranger AS is an iron ore mining company that owns the BIF-hosted iron ore deposit in Bjørnevatn, approximately 7 km south of Kirkenes. Currently, the mine is not in operation, but the re-start of active mining is planned for the end of 2022.

Bjørnevatn BIF is one of the very few BIFs located in Europe and only little geological and geochemical groundwork has been done, although BIFs are the major source for worldwide Fe consumption. The few available studies estimate the age of the BIF to approx. 2.5 Ga, close to the Neoarchean-Palaeoproterozoic boundary. However, the processes and conditions during formation of the Bjørnevatn BIF were not investigated yet. Therefore, we sampled Bjørnevatn BIF in June 2022 in order to perform a detailed geochemical characterisation of this Precambrian marine archive.

Our sampling was made possible by the kind help and support of Sydvaranger AS and its employees. Especially, Ylva Wård and Eirin Hansen assisted with our pre-trip planning and throughout our onsite visit. Due to the great courtesy of Sydvaranger, we were able to sample fresh BIF material from drill core sections and from the open-pit mine, and were able to explore the local geological context of the BIF with surrounding metaclastic and –plutonic rocks within the open pit.

Sampling, Research Strategy and Analytical

We sampled drill cores and took samples from fresh break-off walls directly in the open-pit mine. The drill cores were provided from Sydvarangers AS drill core storage. Due to detailed core logs and photos of the drill cores provided by the company, we pre-selected the most interesting parts in advance of our trip. Sydvaranger AS staff members prepared the chosen core boxes and made the sampling very efficient and convenient. We screened the drill cores for pristineness, deformation, metamorphic overprint and presence of sulfide minerals and ended up with 47 fresh drill core samples from the Bjørnevatn BIF, associated gneisses and crosscutting dykes. The sampled drill core sections were logged and photographed. In addition to the drill core samples, we also took several samples of BIF, basement gneiss and basaltic dykes within geological context from outcrops inside the mine.

The research target of our collaborating research groups from the Jacobs University Bremen and the University of Vienna is to geochemically characterise the Bjørnevatn BIF based on major and trace elements and the radiogenic Sm-Nd isotope system. Depending on the purity and

pristineness of the samples, Hf, W and Cr isotopes will also be considered. Although the Bjørnevatn BIF is an iron ore deposit, which are commonly avoided due to secondary Fe-enrichment processes, the here sampled BIF still shows typical macroscopic BIF characteristics such as clean banding of alternating Fe oxide (mostly magnetite) and metachert. Individual BIF bands will be subsampled via micro drilling in order to reflect the potentially different formation conditions of Fe oxide and metachert bands. These subsamples will be milled and digested following a three-acid-digestion protocol following measurements of major and trace elements with inductively coupled plasma optical emission spectrometry (ICP-OES) and mass spectrometry (ICP-MS). Based on the major and trace element data, representative samples will be selected for Sm-Nd isotope analyses and aliquots of the sample powders are then digested and Sm and Nd separated via ion-exchange column chemistry and Sm and Nd isotope abundances are subsequently determined by a thermal ionization mass spectrometer (TIMS).

The geochemical analyses will give evidence for the pristineness and purity of Bjørnevatn BIF. If it preserved primary marine geochemical signatures (e.g., seawater-like REY distribution) and has negligible detrital contamination, the Bjørnevatn BIF will provide fundamental insights into paleoenvironmental reconstructions of the Precambrian Earth and the input from the various sources, that affect ancient seawater chemistry. Thus, the Bjørnevatn BIF has the potential to become an interesting target for future research for the Early Earth community.

From left to right: David Ernst, Ylva Wård, Sebastian Viehmann, Michael Bau. Photo taken by Eirin Hansen.

Drill core S77 of Bjørnevatn BIF.