ESRF	**Experiment title:** **Texture measurements of Variscan slates for the development of "Enhanced Geothermal Systems”**	**Experiment number**: ES-784
Beamline: ID22	**Date of experiment**: from: 24.11.2019 to: 27.11.2019	**Date of report**: 12.08.2019
Shifts: 9	**Local contact(s)**: Andy Fitch	*Received at ESRF:*

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Report:

Variscan metasedimentary basement rocks, widely present in Europe, might be developed as a new geothermal reservoir type and are currently under investigation in the EU HORIZON2020 project MEET [1]. The anisotropic physical properties of these rocks are crucial for developing exploration and exploitation strategies of such kind of reservoirs. Samples originate form the Western Harz Mts. in Germany and from the Havelange bore hole in the Ardennes of Belgium. Using synchrotron diffraction, we quantitatively analysed the crystallographic preferred orientations (textures) of all mineral phases of exemplary rock samples. Due to the high portion of phyllosilicate minerals in the samples and the accompagnying fragileness during surface prepraration of the samples, the high penetration power of synchrotron diffraction is necessary to measure undisturbed fabrics within the sample volume.

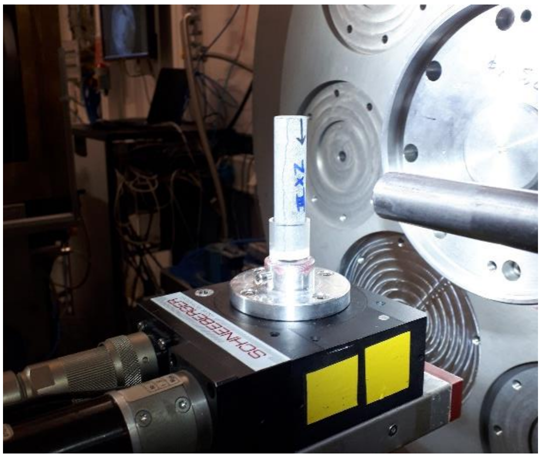

Figure 1. Mounted cylindrical rock sample at ID22 during the measurement campaign.

In our experiment we used cylindrical samples with a varying diameter of 10 to 20 mm depending on original sample size and material properties. The solid material could be directly mounted in an acrylic sample holder (Fig. 1).

The set-up of the experiment at beam line ID22 was as follows: It consisted of an X-Y-Z-stage in combination with an ω -rotation stage. This set-up was appropriate to record diffraction data in transmission mode with a Perkin Elmer 1611 image plate detector in order to calculate the Quantitative Texture Analyses (QTA). The sample-detector distance was adjusted to 1399.7 mm. For the texture measurements a rotational step width of Δω=5° and an ω -range of 180° was applied. The cylinder axes of the samples were mounted parallel to the Y-direction of the sample holder, so that the sample geometry was constant during rotation around ω and a subsequent geometrical correction is not necessary. The beam energy has been adjusted to 70 keV and the beam size to ~1 mm x 1 mm.
To avoid detector overflow, 10 single images per measurement were collected and summed up. Exposure time per frame varied between 0.04s -1s depending on the sample diameter and the material composition. To ensure that we consider possible heterogeneities of the natural material and to improve statistical data representation as good as possible, especially of the mineral phases of low portion, we run one to eight texture measurements per sample at different positions along the cylinder axis.

The textures are calculated from the data with MAUD (Material Analysis Using Diffraction [2]), a Rietveld-based code. The texture of an exemplary sample is illustrated in Fig. 2. As visible from the pole figures, quartz and plagioclase are not strongly preferred oriented, while the phyllosilicate minerals muscovite and chlorite show a strong preferred orientation determining the fabric and are therefore the physical properties-controlling minerals of these samples.

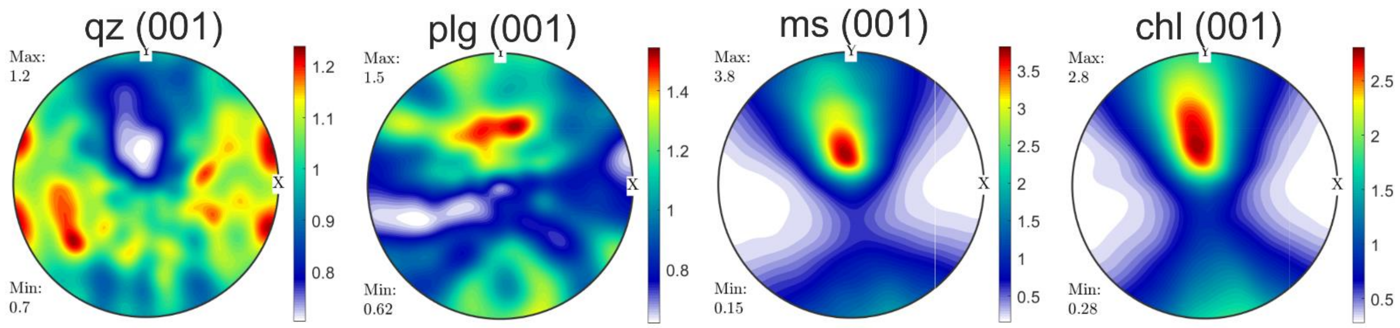

Figure 2. Recalculated pole figures for the basal planes of the different minerals of a slate from the Harz Mountains in Germany. Equal area, lower hemisphere projection. Maxima in multiples of random distribution (m.r.d.). Abbreviations: qz: quartz, plg: plagioclase, ms: muscovite, chl: chlorite.

All scheduled samples could be measured during the proposed beam time. However, the quantitative texture analyses by means of MAUD are very time consuming, also due to long computer calculation times (compare e.g. with [3]). Based on the texture results the anisotropic physical properties will be calculated and compared with the measured properties of the rocks. The results will contribute to set up a geothermal reservoir model for developing an exploitation strategy as an “Enhanced Geothermal System”.

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