Correlation of magnetic fabric and crystallographic preferred orientations of naturally deformed carbonate — mica rocks from the Alpi Apuane in Italy and the Damara Orogen in Namibia

Poster

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Scope of the correlation

The anisotropy of magnetic susceptibility (AMS) is a time-efficient method to describe crystallographic preferred orientations of rocks and has been applied in a wide field of sedimentary, metamorphic and magmatic geology. The method, however, suffers from limitations which mainly result from the interference of diamagnetic, paramagnetic and ferromagnetic fabrics (de Wall 2005) — the term ferromagnetism is used in a wider sense here, including e.g. ferrimagnetism. The AMS is an integral parameter which describes a crystallographic preferred orientation as an ellipsoid. The quantitative correlation of the AMS with the crystallographic preferred orientations should help to allow a closer view at the applicability and the limitations of the AMS analysis (see also Schmidt et al. 2006 a, b).

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Recent advances in AMS analysis through new methods for phase separation

The separation of ferromagnetic, paramagnetic and diamagnetic partial fabrics has been a subject of research in recent times and has led to several new methods. Martin-Hernandez & Hirt (2001) presented a method for the separation of diamagnetic/paramagnetic and anti-ferromagnetic from the ferromagnetic phase fabrics using high-field torque measurements and different field strengths between 0.1 and 1.7 T. While ferromagnetic magnetization saturates at high fields, paramagnetic/diamagnetic magnetization is proportional to the field strength. So the separation can be calculated from measurements at several fields.
Schmidt et al. (2005, 2006 a,b) developed a method for the separation of paramagnetic from diamagnetic fabric. It is achieved by the comparison of room-temperature and low-temperature (77 K) measurements using the high-field torque method. This method was applied and compared to neutron textures on synthetically-deformed calcite-mica samples.

Naturally-deformed rocks

To test the application of the new methods on naturally deformed rocks, mica bearing calcite marbles and mylonites from the Alpi Apuane in Italy and dolomite mylonites from the Damara Orogen in Namibia were selected. Selection criteria were varying mica contents and varying intensities/types of their crystallographic-preferred orientations (CPOs). Quantitative texture analyses were carried out by means of the 'powder and texture diffractometer SV7' at the research reactor Jülich 2 of

the Research Center Jülich (FRJ-2) in Germany. Due to a low absorption coefficient of neutrons in condensed matter, neutron diffraction allows a volume-related quantitative texture analysis of the sample cylinders which were also used for AMS measurements. Only this strategy allows a direct correlation of CPOs with the AMS. AMS measurements were performed at different field intensities (0.8 to 1.7 T) as well as at different temperatures (room temperature and 77 K) in order to separate the different magnetic phases.
Mica shows a relatively strong paramagnetic anisotropy, whereas calcite is diamagnetic.

First results

The 30 samples analysed cover a spectrum from fine-grained (0.05 mm) rocks to coarser grain sizes (max. 0.2 mm). In general, grains show isometric to elongated shapes; the grain boundaries vary from relatively straight to irregular and lobate. In the different samples, the mica content covers a range from 0 to ca. 50%.
Texture analyses reveal a large variety of texture types. The carbonate phases show single c-axis maxima, covering a range from weak to very strong intensity maxima. Other samples show distinct to weak c-axis double maxima. Furthermore, some samples show partially developed girdle distributions with moderate to weak intensity. In one case, dolomite displays a completely developed girdle distribution. The mica phases show c-axis preferred orientations covering a range of very weak to very strong single maxima.
The measured AMS tensors are found to represent the crystallographic preferred orientations of calcite and mica detected by neutron diffraction goniometry. Differing directions of the carbonate and mica phase preferred orientations are generally reflected by the directions of the dia- and paramagnetic AMS. In general, the eccentricity of the AMS ellipsoid reflects the intensity and type of the texture.
The AMS of the ferromagnetic phases was found to be often significantly different from the para-/diamagnetic AMS. Magnetite has been identified by acquisition of isothermal remanent magnetization (IRM) and thermal demagnetization of a cross-component IRM. The AMS of magnetite is defined by the grain shape rather than crystallographic orientation. Additional low field AMS measurements give results representing directions which are intermediate between paramagnetic/diamagnetic and ferromagnetic AMS.

Conclusions

The results of this study are based on a large variety of fabric types of carbonate-mica marbles and mylonites, i.e. varying mica content, grain sizes, grain shapes, types and intensities of the crystallographic preferred orientation. The presented first correlations of the AMS and CPO for the single mineral phases in general demonstrate a good matching. Regarding the comparison of texture types and the AMS, limitations are possible. While single c-axis maxima and girdle-like c-axis distributions can be also distinguished by the AMS, it is obvious that distinguishing between these types and the double c-axis type is not possible at the present stage.

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