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Structural studies in columnar basalts from crystallographic and magnetic fabrics

BOIRON Tiphaine (1,2), BASCOU Jérôme (2), CAMPS Pierre (3), FERRE Eric (4), MAURICE Claire (1), GUY Bernard (1,2), and GERBE Marie-Christine (2)

(1) Ecole Nationale Supérieure des Mines de Saint Etienne, centre SPIN, 158 cours Fauriel 42023 SAINT ETIENNE Cedex 2.FRANCE (boiron@emse.fr), (2) Université de Lyon, F-42023 ; UMR 6524 « Magma et volcans », université Jean Monet, LTL/UFR Sciences, 23, rue du Dr Michelon , F-42023 SAINT ETIENNE Cedex 02, FRANCE., (3) Géosciences Montpellier UMR 5246- CC 60 Université Montpellier 2 place E. Bataillon 34095 Montpellier cedex 5, FRANCE., (4) Department of Geology, Southern Illinois University Carbondale, IL 62901-4324, USA.

The purpose of this study is to better characterize the columnar and the associated microstructure development in basalt flows. The thermal contraction (O'Reilly, 1879) is the main hypothesis to explain the columnar formation. However, neither the structures which appear in basalt flow constituted of three levels (Tomkeieff, 1940) nor circular and radial structures within the prisms (for which weathering nor fracturing can account for) can be explained by the thermal contraction theory alone. An early structuring process during solidification (Guy and Le Coze, 1990) could play for a part that must be discussed (Guy, 2010).
We studied two recent basalt flows (75 000 years) from the French Massif Central, in which the three flow levels are clearly observed. In the first basalt flow (La Palisse, Ardèche), the emission centre and the flow direction are known. In the second one (Saint Arcons d'Allier, Haute Loire), the prismatic columns are particularly well developed.
In order to characterize the flow structure at different scales, from the flow to the grain scale, anisotropy of magnetic susceptibility (AMS) measurements were performed. The AMS data were coupled with crystallographic preferred orientation measurements of magnetite, plagioclase and clinopyroxene using Electron Backscattered Diffraction (EBSD) and image analyses from perpendicular thin sections.
Magnetic mineralogy studies of the La Palisse basalts, in particular the thermomagnetic curves, indicate that the main carrier of AMS is high-Ti titanomagnetite (Tc$\approx$130°C). AMS measurements of about a hundred samples show a higher degree of AMS (P parameter) in the middle level in comparison to the base. Inversely, the bulk magnetic susceptibility (Km) is higher at the flow base. Distinctive parameters for the different levels of the basaltic flows could be then provided by AMS measurements.. Moreover, the comparison between AMS and EBSD data indicate that the magnetic susceptibility carried by the magnetic grains is controlled by the crystallographic orientation of plagioclase and then related to the direction lava flow. In addition, an AMS study carried out on a prism section shows that Km and P magnetic parameters increase from the core to the rim of the prism. The analysis of hysteresis parameters on the same samples indicates that the magnetic grains are larger in size in the core than on the rim. This suggests processes inducing a magnetic grain size arrangement before the prism formation.

References

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