Analogue Modeling of AMS Development During Emplacement of Shallow Level Volcanic Bodies (Extrusive Domes and Laccoliths)

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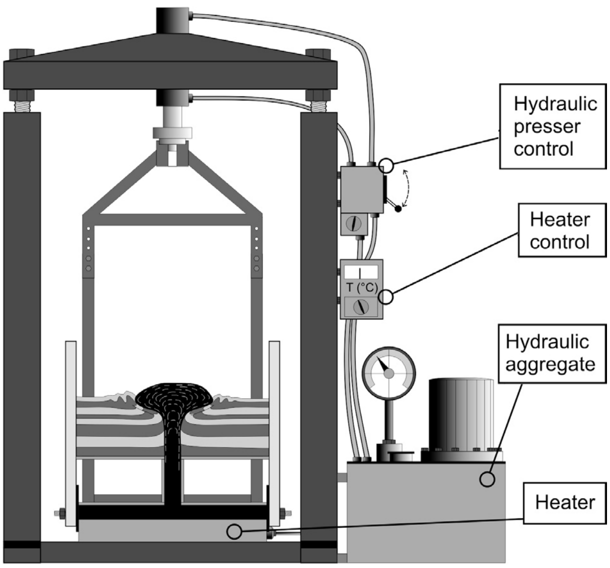
Volcanic domes and laccoliths are typical features of monogenic volcanic fields and are formed by highly viscous magmas either due to magma composition (andezites and rhyolites) and/or high crystal content (e.g. trachytes and phonolites). Although the evolution of shapes of extrusive domes and laccoliths was modelled for ideal newtonian fluids (Talbot and Jarvis, 1984, Koch et al. 1981) the evolution of internal fabric pattern during growth of such bodies is poorly understood. This is probably due to lack of good vertical cross-sections through such bodies and the microscopic nature of the fabric elements in volcanic rocks. Some aspects of the internal fabric development during viscous flow of magma within lava domes can be explained by the results of analogue and mathematical modelling of strain within lava flow and dome extrusions on flat surface (Buisson and Merle 2004). The models have shown that in the upper part of a lava flow (or flank of the dome), the maximum stretching axis is oriented perpendicular to the magma flow direction, while in the lower part lineations are parallel with the flow direction and diverge, where the flow extrudes radially. As the authors suggested, the results should be tested in field for various types of magma rheologies (e.g., shear-thickening dilatant rheology for crystal rich magmas, Smith 2002). Besides that natural magmatic domes often differ from the ideal flat based droplet geometry and their outer shape (and internal fabric) is controlled by complex interaction between the magma and host sediments.



■ **Fig. 1.** Scheme of hydraulic squeezing apparatus used for AMS modelling.

The aim of our study is to investigate the fabric generated by viscous flow within domes and laccoliths emplaced into weak sedimentary sequence by means of AMS analogue modeling. We follow a procedure of Kratinová et al. (2006) and use a hydraulic analogue apparatus (see Fig. 1) equiped with steel squeezing board and tube conduit and a perspex container filled with sand. The initial plaster and sand layers can be colored to visualize the deformation pattern within and around the model bodies. Sedimentary sequence is formed by pure sand or sand with clay layers, which induce zones of low tensile strength necessary for the emplacement of laccoliths.

Plaster still remains the most suitable analogue material for AMS modeling of viscous flow. It is cheap, easily colored and handled during the experiment; it is also easily homogenized with magnetic material. We have tested other analogue materials. Asphalt seemed promising, while it shows a range of temperature dependent viscosities, however it can not be colored and it is hardly handled in larger volumes. Silicones are expensive and can not be polymerized in order to bring them to solid state at the end of the experiment and carry out AMS sampling. Therefore we continue with rheological measurements of plaster of different mixing ratios of plaster and water with ambition to scale down our experiments for different magma rheologies, which are strongly dependent on the amount of solid particles (crystals). Flow of magma during filling of laccoliths and domes is for example typical with successive magma pulses (e.g. Mock and Jerram 2003). Such pulses penetrate discordantly the already present magma within inflating dome/laccolith and refold the surrounding magmatic fabric (Závada et al., this volume).

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The Mode of Flow and Emplacement of a Trachyte Body of the České Středohoří Mts. Studied by Means of AMS and EBSD Techniques

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The structural investigation of volcanic rocks is restricted by the small size of fabric elements, if macroscopic fluidality is not present. Therefore AMS is often employed, which is a powerful technique precisely investigating the orientation of the magnetic minerals (for review see Tarling and Hrouda 1993). The internal fabrics induced by flow of magma studied by AMS have focused mainly on the basaltic types, forming dykes or lava flows (e.g. Elwood 1978, Herrero-Bervera et al. 2001). Detailed structural analysis of more viscous volcanics due to magma composition and/or high crystal content (e.g. Smith et al. 1993) often forming domes and laccoliths was carried out much less frequently and AMS was rarely employed. The crystal-rich volcanic rocks often show conjugate textural domains (or microshear zones) interpreted to form due to extension or shear of the solidifying magma induced by "viscous drag" of still mobile magma and the bisector of conjugate shear sets indicates directions of maximum stretching and shortening (e.g., Smith et al. 1993).

In our study we have used an integrated AMS and EBSD approach to investigate the kinematics of magmatic flow within a trachyte body Hradiště u Habří and outline the style of its emplacement. We refer to the excursion guide of Šmíd et al. (2003) for the geological characteristics and petrology of the studied trachyte. The structural investigation was carried out using oriented thin-sections parallel with K_1K_3 and K_2K_3 planes of the AMS ellipsoid. The orientation of crystals within the textural domains was measured using the EBSD technique from total 12 thin-sections. The symmetry of the fabric was revealed on the basis of relative aerial representation of synthetic and antithetic microshear domains from image analysis of microphotograph sets of both perpendicular thin-sections. The correlation of the image analysis results and cluster patterns of the susceptibility directions of individual AMS specimens (8 cubes / locality) revealed three types of fabric, which form due to compression at high angle to the magmatic layering. Type I fabric shows equally developed conjugate sets of textural domains in both sections and is matched by girdle of K_2 and K_3 directions from 8 trachyte cubes measured. Type II fabric is typical with clusters rather than girdles of K_2 and K_3 directions and shows well and equally developed textural domains overprinting the primary crystal alignment exclusively in the K_1K_3 section. Type III fabric shows predominance of synthetic shear domains in the K_1K_3 section and equally developed conjugate domains in the K_2K_3 section and are characterized by very narrow clusters of the AMS directions. Type I and II fabrics are denoted as bearing orthogonal and Type III monoclinical symmetry. Since the fabric symmetry corresponds to the symmetry of deformation which caused it (Sander 1970, in Smith 2002) we can use the discrimination of fabric types to unriddle the symmetry of deformation and shear sense throughout the studied cupola using the AMS stereoplots. The interpretation of AMS clustering patterns using this classification assigns coaxial flattening and stretching parallel with the steep western margin of the body in the western rim, strong coaxial flattening in the central part resulting in intense subhorizontal fabric and non-coaxial flow on the northern margin and the eastern slope. In contrast to the rest of the body typical with strongly flattened fabric coupled with intense fabric-parallel fracturing, the southeastern part of the body exposes outcrops irregularly folded or trachytic fabric that is less clearly defined and less intense fracturing. The fabric in this area shows intense folding of the steep vertical magmatic fabric in the K_2K_3 section developing crenulation folds like in metamorphic rocks and the K_3 direction is perpendicular to the newly developed planar fabric element (c-planes). Textural domains showing regular kinks developed due to layer parallel compression of primary subhorizontal fabric are also present. The kinematic analysis revealed that compression axes inferred from several localities which show folding converge to one point and thus locate the feeding conduit. The magma flow and emplacement of the studied body is therefore also characterised by ascent of successive pulses, which cut discordantly through the already present magma and produce folds in the surrounding trachyte due to inflation of each magmatic pulse.

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