AMS Fabric of Acid Alkaline Volcanics and Implications to Flow Mechanisms and Emplacement Mode: Examples from České Středohoří Mts. – North Bohemia

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The trachytes and phonolites are abundant in the SW-NE trending Ohře (Eger) Rift area, corresponding to reactivated first--scale Variscan tectonic boundary separating the Saxothuringian and Moldanubian terranes. It was a location of intense intraplate alkaline volcanism in Cenozoic times. Volcanic rocks of the Eocene to Miocene age (nephelinites, basanites, trachybasalts, trachytes, tephrites, phonolites) penetrate crystalline basement, Cretaceous and Tertiary sediments.

The AMS and microstructural studies were performed on several volcanic bodies of variable ratio between diameter and thickness, bulk chemistry and mineralogy (phonolites and alkaline trachytes). We investigate the degree of AMS, mean susceptibility and magma composition to show the relationship between magma viscosities and flow fabric. The highest degree of AMS is shown by alkaline trachytes enabling structural mapping of flow fabrics on the volcanic apparatus scale. In detail we have studied the trachytic dome of Hradiště located 14 km SE of the town of Teplice. This elliptic dome, elongated in the E-W direction, is formed of the sodalitic trachyte with nepheline admixture. The structure of the rock is porphyric and its matrix shows fluidal texture marked by alignment of sanidine phenocrysts, phenocrysts of aegirinic augite and sodalite are also present. The matrix of the rock is composed fine-grained laths of sanidine. Plagioclase, nepheline, amphibole and magnetite are less abundant.

The flow foliation of the studied trachytic extrusion is formed by strong preferred orientation of the sanidine tabular crystals. This allows us to map the main flattening directions across the dome. However, the mineral lineation cannot be depicted in the field and consequently, it is impossible to determine the flow direction. The mesoscopic foliation patterns enhance the elliptic form of the dome, which is nearly symmetrical in shape. However, the flow foliations are not always parallel to the margins of the dome. The dip of the foliation is very weak (10–20°) at the apical part, and becomes progressively steeper (45–80°) towards the margin of the dome. The dip is sub-vertical or even reversed in the southwestern, western and eastern parts of the dome. These data can be used to depict the shape of the dome, i.e., the ratio of diameter to thickness of intrusion.

The anisotropy of magnetic susceptibility (AMS) of trachyte samples were measured by the KLY-3S Kappabridge in the laboratory of Agico, Ltd. Brno. Although paramagnetic pyroxene is present in the rock the only one carrier of AMS was identified as Ti-magnetite from thermomagneetic curves (Curie temperature ca. 500 °C), it belongs to Ti-magnetite with around 10 % of illmenite component (Nagata, 1961). Mean susceptibility lies in order of 10–3 [SI], which is in range typical for young volcanic rocks. Low variability of Km could answer to nearly homogeneous distribution of magnetic minerals within the rock. The AMS was measured on about 40 samples and the directions of principal axes ($K1 > K2 > K3$) of magnetic susceptibility were identified. The results plotted in the map show that the magnetic foliation (K3 pole) is in good agreement with the foliation pattern measured in the field. Higher degree of AMS in trachyte (comparing to basaltoids, Pj par. from 1.25 to 1.35, Pj and T parameter according to Jelínek, 1981) is related to relatively high viscosity of trachytic magma (~105 Pas) and high degree of crystallinity of this volcanics. Magnetic ellipsoids show mostly oblate shapes (T par. ranges from 0.6 to 1). Only several samples from SW part of the dome exhibit negative T and low Pj parameter. These shapes of flow ellipsoid and degree of fabric could be interpreted in terms of magmatic feeder. Most of measured samples show strong planar fabric, where minimum principal axes are well grouped and maximum and intermediate axes lie within the girdle. The second most common pattern shows symmetry of triaxial ellipsoid – all three axes are well grouped. The last group of fabric is rather scarce and is characterized by well-grouped maximum principal axes and consequently by prolate ellipsoid. Magnetic lineations (K1 direction) are distributed symmetrically around the apical part and become oblique and finally parallel to the margin in the outer parts of the dome. Only at the SW part of the intrusion the lineation shows steep plunge. In general, the fabrics show higher degree of AMS and lower parameter T along the margins, whilst apical part exhibits lower degree of anisotropy and very high shape parameter (0.95–1).

Preferred orientation of sanidine crystals studied by Jančušková et al. (1992) and their distribution into polymineralic domains were re-evaluated in this study. The fabric domains were identified under gypsum plate for 7 positions (15° step) in which characteristic sanidine orientations were measured. This allows the definition of individual slip domains, their size and spatial distribution. A kinematic model of slip system domains of Cobbold and Gapais, (1987) is applied to explain fabric variations across the intrusion and helps to model the strain regimes associated with emplacement mode. The shape preferred orientation of magnetite crystals was also mapped with respect of slip system domains. An attempt is made to establish the model of fabric acquisition of magnetite with respect to feldspar fabric pattern.

In conclusion the fabric pattern indicate that the trachyte is nearly symmetrical body and the distribution of magnetic foliation, lineation and degree of magnetic anisotropy is similar to fabrics of salt extrusions (e.g. Hormoz in Iran) rising as diapirs. High density of the interstitial crystals indicates the weak proportion of the magmatic liquid and consequently the regime of the visco-plastic deformation with significantly higher viscosity that predicted for viscous fluid (fibre slip model is suggested as the main deformation mechanisms during intrusion).

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Application of Gamma-Ray Spectrometry in Outcrop to Subsurface Correlation of Shallow-Marine Sandstones: Jizera Formation (Turonian) of the Bohemian Cretaceous Basin

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Field gamma-ray spectrometry (GRS) has the potential to objectively register small lithological changes and significant stratigraphic boundaries, which in outcrop may be difficult to recognize by standard sedimentological logging. This method is also suitable for correlation between outcrops and well logs.

In the Hradčanské stěny outcrop area near Česká Lípa (Bohemian Cretaceous Basin, North Bohemia), the Jizera Fm. is exposed in a series of outcrops of coarse-grained sandstone bodies. The degree of exposure is locally good, but the small size of most sections (between 15–20 m on average), post-sedimentary faulting, similar character of facies in different units and poor lateral correlation of sequence-stratigraphic boundaries in outcrop make it difficult to unambiguously correlate individual sequences over the area and further into the subsurface using conventional sedimentological methods. Therefore we use the field GRS to register and correlate regional stratigraphic events, in our case marine flooding events

Combination of lithological and GRS logging was used to describe individual sandstone bodies and bounding surfaces which separate them. These surfaces are characterized by abrupt decrease in grain size; however, immediately above the surfaces accumulations of gravel material (clasts size up to 10 cm) occur. These gravel layers represent a marked grain-size contrast compared to both the underlying and overlying facies. Extensive bioturbation, local cementation and high gamma-ray values characterize the bounding surfaces, interpreted as transgressive surfaces. Gravel accumulations are interpreted to have formed by wave reworking of earlier deposits during relative sea-level rise. An increase of energy in the depositional environment, coupled with a decrease in sediment supply, provided suitable conditions for passively filtering organisms and, consequently, more abundant bioturbation. Cementation at this surfaces is interpreted as of early diagenetic origin.

Individual sandstone bodies, locally less than 1 m thick in outcrop, represent building blocks, or systems tracts, of lowest-order genetic sequences (sensu Galloway). These are grouped into higher order, composite sequences which normally occur at a larger than outcrop scale and have to be delineated by regional well-log correlation. The sandstone bodies exposed in the study area comprise the following lithofacies:

(1) medium- to coarse-grained sandstones of massive appearance, with trough cross-stratification, no well-defined ichnofabric and no recognizable large-scale stratification. This facies is interpreted as strongly current-reworked deposits of shoreface environment, probably without direct sediment supply by a fluvial system.

(2) coarsening-upward successions which contain a continuum of facies ranging from fine-grained, bioturbated sandstones without recognizable stratification at the bottom, to coarse-grained to gravelly sandstones, commonly with well-defined clinoforms (foresets) of up to 10 degree slopes. These are interpreted as deposits of a deltaic system, ranging from fine-grained, pro-delta deposits to the coarse-grained foresets of Gilbert-type delta front.

The occurrence, thickness, and degree of variation of the above lithofacies define the shapes of the gamma-ray curves in both outcrop and well log, which can be divided into several electrofacies. In our correlation, the electrofacies are defined based on typical shape and overall intensity of total gamma-ray signal over a vertical interval of more than c. 5m. Typically, intervals of particular electrofacies comprise a number of individual sandstone bodies. The electrofacies, however, are dependent on local facies changes and can represent varying numbers of sequences. Therefore, individual electrofacies, as defined here, are a product of the degree of lithological variability caused by the combination of relative sea-level change and sediment supply.