

the high-grade migmatites, orthogneisses and paragneisses of the Moldanubian Zone crop out. Based on geochemical and petrological data, most of intrusions of the batholith are interpreted as magmatic arc granitoids with involvement of mantle derived mafic magmas situated above subduction zone. Late stages of magmatism are represented by abundant dike swarms cutting through both granitoids and host rock. In the present study, we use geometry, macroscopically determined as well as anisotropy of magnetic susceptibility fabric patterns and likely emplacement mechanisms of individual plutons to interpret the polyphase tectonic evolution of the Variscan magmatic arc and we demonstrate how internal fabric patterns of plutons may be used for reconstruction of temporal evolution of strain and stress fields in magmatic arcs and convergent orogens.

Based on field relationships, geometry, fabric patterns and inferred emplacement mechanisms, we have recognized four main types of plutons making up the Central Bohemian Plutonic Complex, we describe each of these in detail below. (i) Plutons emplaced in supracrustal level during regional transpression (~ 350–346 Ma): these plutons are exposed along NW margin of the batholith and comprise strongly elongate and sheet-like (Vltava granodiorite, marginal and Milín granodiorite, Kozárovice intrusion) to more elliptical and irregular bodies (Sázava pluton – aspect ratio 2/3 in map view) emplaced during transpressional deformation. Their common characteristics are elongate shape in map view (with longer axis parallel to the margin and trend of regional structures) and strong internal fabrics, entirely coupled with Barrandian host rocks (NE-SW striking steep foliation and sub-horizontal NE-SW trending lineation determined by mean of AMS, mostly oblate to plane strain fabrics). Mechanisms which may have accommodated pluton emplacement during transpression involve multiple material transfer processes, large-scale pressure solution, ductile shortening of host rock and magmatic stoping. (ii) Nearly circular plutons with coupled or partially decoupled fabric patterns (Požáry and Nečín trondhjemites, ~350 Ma) emplaced during regional transpression in higher crustal levels have typically very weak magmatic fabrics, commonly parallel to margins and subhorizontal in central part of the plutons. We interpret this partially decoupled internal fabric pattern as a result of higher ascent velocity in contrast with strain rate of regional transpression. Little field evidences, except the presence of stoped blocks

near pluton roofs, do not allow us to interpret emplacement mechanisms of these plutons in detail. (iii) Intra-arc, younger irregularly shaped plutons emplaced into earlier magmatic bodies as well as into high-grade migmatites and paragneisses are represented by high-K granodiorites (Blatná and Červená granodiorites) and minor granitic sheets along southern margin of the batholith. Fabric pattern of the Blatná granodiorite is more complex, showing both steep transpressional magmatic fabric trending mainly NE-SW and younger magmatic fabric dipping at moderate angles to NNW in the SE part of intrusion. The SE margin of the Central Bohemian Plutonic Complex was overprinted by up to 10 km wide zone of sub-solidus to solid-state deformation displaying extensional SE-side-up kinematics with moderately dipping stretching lineations being associated with exhumation of the Moldanubian Zone. Emplacement of these granitoids was probably related to gravitational collapse and exhumation of the orogenic root domain. (iv) Tabular plutons: tabular shape was proposed according to gravity measurements for porphyric durbachites (Čertovo Břemeno, ~343 Ma). This pluton has elliptical shape in map view with E-W longer axis; our initial fabric study revealed flat to moderately dipping magmatic fabrics, which may reflect the tabular shape of this body. In the Votice area, durbachites also occur as moderately dipping sheet-like bodies displaying highly localized sub-solidus deformation and S-side-up kinematics resulting from exhumation of the Moldanubian Zone. Floor depression or roof uplift due to relaxation of vertical component of stress field may explain the emplacement and tabular shape of the pluton. All the above described plutons are cut by E-W dike swarms of variable composition reflecting late N-S extension. The dike swarms testify for stress regime reversal under still high magma pressure, established after gravitational collapse.

By summarizing structural, fabric and emplacement characteristics of individual plutons making up the Central Bohemian Plutonic Complex and adjacent host rocks, we show that magmatic processes and internal fabrics of plutons may record complete structural history and evolution of magmatic arc from the early crustal thickening to subsequent collapse and exhumation of deep rocks and re-establishment of original stress regime. Our data along with precise geochronology may serve as an example of reconstruction of temporal evolution of ancient strain and stress fields in transpressional magmatic arc.

Physical Processes Along Internal Boundaries In An Continental Arc Magma Chamber: Tuolumne Batholith, Central Sierra Nevada, California (USA)

Jiří ŽÁK¹ and Scott R. PATERSON²

¹ Department of Geology, Faculty of Science, Charles University, Prague, Czech republic

² Department of Earth Sciences, University of Southern California, Los Angeles, USA

Incremental growth of magma chambers by episodic assembly of magma pulses, as proposed by recent models of magma chamber construction, dramatically affects the nature of internal processes, the rates and mechanisms by which heat and

mass are transported through the crust (and therefore rheology and deformation of orogenic belts), and how we view and thus solve the emplacement problem. Understanding internal processes and their structural expression in plutons is crucial

for complex evaluation of composite magmatic systems. In the present study, we focus on physical processes operating along internal boundaries between individual magma pulses in a magmatic system, evolving from early sheeting to younger nested diapirs (Tuolumne Batholith, central Sierra Nevada, USA) and we show that structures preserved along internal contacts may record information about the rheological state of juxtaposed magma batches, complex flow along these boundaries, and late fabric formation during emplacement of progressively younger magma pulses and regional tectonic strain.

The Tuolumne Batholith is a large composite batholith exposed in the central Sierra Nevada (California, USA), emplaced as a nested diapir during Late Cretaceous into low-grade metasedimentary and metavolcanic rocks and older plutons. Successive emplacement of four main units making up the batholith (Kuna Crest, Half Dome and Cathedral Peak granodiorites, Johnson granite porphyry) produced concentric array of internal contacts between compositional domains. In detail, however, internal contacts and associated igneous features vary widely, from simple sharp or gradational contacts, sheeted domains, to very complex zones of mingling and flow. We discovered several domains of very complex magma mingling and flow in the eastern part of the Tuolumne Batholith, typically associated with geometric irregularities and deflections of the contact. These domains are characterized by the presence of complex magma mingling, complicated schlieren patterns, disequilibrium microstructures, multiple magmatic sheets, gravitational instabilities and physical accumulations of K-feldspar megacrysts. Four distinct magmatic fabrics are developed in this domain, two of which occur throughout the Tuolumne Batholith. The two earliest fabrics record strain during flow in pulses. A slightly younger NNW-SSE foliation is typically parallel to internal contacts, whereas the youngest WNW-ESE foliation runs across all internal contacts and overprints older magmatic features. Both the regionally developed foliations share a single steeply plunging magmatic lineation, defined by identical igneous minerals. These multiple magmatic fabrics record a temporal evolution of strain caused by flow during chamber construction to tectonic strain of a relatively static chambers.

Based on our field research, we reached the following conclusions: (i) simple gradational zones between two juxtaposed magma batches represent stable contacts allowing partial homogenization of magma pulses within transition zones and implying slower rates of interactions and small rheological contrasts; (ii) zones of complex magma mingling and flow, often displaying complex, but ordered patterns, develop due to multiple gradients introduced to the system during emplacement of magma surges along wall-rock irregularities; (iii) internal emplacement mechanisms recorded in domains along internal contacts in the Tuolumne Batholith involve multiple rheology-dependent processes, e.g. magma escape flow and shortening in magmatic stage, negative volume change of cooling magmas along margins with progressive accumulation of outward-younging sheets and thermal fracturing and magmatic stoping of older solidified magmas; (iv) The presence of internal contacts and spatial distribution of other igneous structures in the Tuolumne Batholith are in contrast with chamber-wide convection models, we argue for small-scale convective structures operating during final stages of magma chamber construction; (v) overprinting relationships show that the youngest WNW-ESE magmatic fabrics formed after chamber construction and represent late increments of regional tectonic strain. We emphasize that physicochemical gradients across the contact, relative rheology of juxtaposed magma pulses, geometry and spatial orientation of the interface and temporal evolution of the system, are the most important factors controlling the nature of processes along internal boundaries in magma chambers. In addition, our study provides some field constraints on dynamic forward modelling work (Bergantz, 2000) predicting the geometry of interface between juxtaposed magma pulses for various rheologies and geometries of the modelled system.

References

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Quartz and Feldspar Rheology Contrasts under Natural Thermal and Strain Gradients: A Comparative Study

Prokop ZÁVADA, Karel SCHULMANN, Ondrej LEXA and Jiří KONOPÁSEK

Institute of Petrology and Structural Geology, Charles University, Albertov 6, 128 43, Prague

Existing models of crustal rheology use experimentally derived flow laws described by constitutive equations, which are established for minerals such as plagioclase or monomineralic rocks like quartzites, marbles. However, the crust is commonly composed of polyphase rocks – namely granitoids, represented by mixtures of felsic minerals of different proportions, variable

grain shape and grain-size distribution. Detailed microstructural observations, textural analysis and EBSD measurements were used to estimate relative changes in strain partitioning and point to inconstant ‘relative viscosity’ under different thermal conditions and strain intensities. The study was carried out at three paleothermal levels: