Fig. 1.

Fig. 2.

A Thin Viscous Sheet Model for Weak Zone Deformation

Josef JEŽEK, Ondrej LEXA and Karel SCHULMANN

Faculty of Science, Albertov 6, 128 43 Praha 2, Czech Republic

A numerical approach is presented that enables us to simulate deformation in a weak zone surrounded by rigid or free boundaries. The approach is based on the thin viscous sheet approximation and is similar to that used by England et al. (1985) for modelling the deformation of the lithosphere. We consider a horizontal weak tabular domain subjected to viscous flow with no tractions at top and bottom surface. We assume that vertical gradients of the horizontal velocity are negligible which permits us to integrate the equations of motion over the vertical dimension and to work with vertical averages of stress and strain rate. Assuming linear relation between stress and strain rate ('Newtonian fluid'), the procedure leads to a system of elliptic partial differential equations for two horizontal velocity components. The system can be solved by the finite element method. Dirichlet and Neumann boundary condition may be applied to segments of the domain boundaries so that it corresponds to geological settings (rigid indenter, free inflow or outflow of material). The vertical strain rate and velocity are related to the horizontal velocity field by the incompressibility equation. The time development of the domain geometry is made by step by step moving the boundaries simultaneously with repeating solution of the governing equations for the velocity. At each time step we evaluate instantaneous strain rate and finite strain in a net of points in the domain. It has been described by Ježek et al. (2000) that the thin sheet model is sensitive to the angle of collision and may produce a zone dominated by lateral simple shear close to the indenter and a zone of dominant pure shear further away from the indenting boundary. Nevertheless, we show that these general features can strongly interfere with finite dimension of the modeled area and imposed boundary conditions.

References

ENGLAND P., HOUSEMAN G. and SONDER L., 1985. Length scales for continental deformation in convergent, divergent,

and strike-slip environments: Analytical and approximate solutions for a thin viscous sheet model. *J. Geophys. l Res.,* 90: 3551-3557.
JEŽEK J., SCHULMANN K. and THOMPSON, A.B. 2000. Development of strain parameters in front of an obliquely colliding indenter. EGS "Stephan Mueller" topical conference on Continental Collision and the Tectonosedimentary Evolution of Forelands: Mechanics of Coupling and far-field Deformation, Amsterdam 2000. *J. Czech Geol. Soc.*, 45: 236-237.

Whole-Rock Geochemistry and Nd Isotopic Composition of Metavolcanics from the Netvořice – Neveklov and Sedlčany – – Krásná Hora Islets: their Petrogenesis and Implications for Geodynamic Processes at the Teplá–Barrandian–Moldanubian boundary

Václav KACHLÍK[1], Vojtěch JANOUŠEK[2], Radek HEŘMÁNEK[1] and Petra VÍTKOVÁ[1]

[1] *Department of Geology and Palaeontology, Albertov 6, 128 43 Prague 2, Czech Republic*
[2] *Czech Geological Survey, Klárov 3, 118 21 Prague 1, Czech Republic*

The boundary between two contrasting terranes of the Bohemian Massif – Teplá–Barrandian and Moldanubian – is obscured by Variscan Central Bohemian Pluton. Its roof pendants (the so-called Islet zone) is represented by Late Proterozoic to Early Palaeozoic volcanosedimentary succession of the Teplá – Barrandian affinity and Middle Devonian orthogneisses (Kachlík 1992; Košler et al. 1993). The Netvořice–Neveklov (NN) and Sedlčany–Krásná Hora (SK) islets are built by Late Proterozoic flyshoid rocks of the Svrchnice Formation (Chlupáč 1989) and associated metavolcanics. These are unconformably overlain by varied Early Palaeozoic sequences (Kachlík 1992 and references therein). Except for weak Cadomian deformation and metamorphism of Late Proterozoic complexes, the rocks of the Islet zone underwent strong Variscan LP-HT overprint associated with granitoid intrusions (Kachlík 1992).

The metavolcanic rocks in the area under the study crop out in several stratigraphic levels. Late Proterozoic metavolcanics and metadiabase dykes crop out in both islets, the presence of Cambrian volcanism is limited only to the NN islet, Ordovician felsic volcanoclastics are known from the basal part of the Krašovice Formation of the SK islet.

Metadiabase dykes penetrating all stratigraphic units are obviously the youngest.

Late Proterozoic volcanism evolved in space and time from relatively primitive tholeiites, low-Ti tholeiitic basalts and basaltic andesites to calc-alkaline basalts, andesites and felsic acid metavolcanics. The tholeiites show low SiO_2 contents (49–51%), high $TiO_2 > 1\%$, alkalis $> 3\%$ and flat REE patterns. The low-Ti basalts have higher SiO_2 (51–53 %), lower TiO_2 (0.5–0.7%), alkalis $< 2\%$ and U-shaped REE patterns.

The boninites (Le Bas 2000) often form sills or dykes intruding basaltic metavolcanics and overlying metasediments of the Svrchnice Formation. However, in the Jílové Zone were also found boninitic pillow lavas. The metaboninites have relatively high SiO_2 (52–56%), CaO ($CaO/Al_2O_3 \sim 1$), mg# (60–80) and Cr (400–2000 ppm) together with low TiO_2 (0.3–0.5%), and alkalis ($< 2\%$); typical are U-shaped REE patterns. These rocks are equivalent of high Ca-(meta-) boninites (Crawford 1989). The Nd isotopic data for metaboninites and associated basalts indicate either an important mantle heterogeneity, different degrees of crustal contamination and/or variable mantle metasomatism (ε^{650}_{Nd} + 2.5 to + 6, T^{DM}_{Nd} 0.86 – 1.08 Ga). Intermediate and acid volcanics have also relatively primitive features ($\varepsilon^{650}_{Nd} = +5.0$ to +4.3, $T^{DM}_{Nd} = 0.90 – 0.95$ Ga) pointing to their unevolved, probably mantle-derived parental magma.

The characteristic incompatible element enrichment, HFSE depletion and negative Ce anomaly on MORB-normalized spiderdiagrams suggest that all the studied Proterozoic volcanics are comparable with island arc lavas (Waldhausrová 1984; Fediuk 1992a,b). Intimate spatial and temporal relationship between tholeiitic basalts and boninites may indicate a genetic link. The tholeiitic basalts were most probably derived from a mantle diapir beneath an immature arc that became, as a consequence, quite refractory. The subsequent LP partial melting of this (harzburgitic) residue enriched by migration of subduction-derived fluids or, more likely, by small OIB-type melt fractions, would have produced high-Mg siliceous boninitic magmas and low Ti-basalts. To achieve this, anomalous thermal conditions (subduction of active spreading centre or opening of a back-arc basin) were required. Evolution of Proterozoic island arc continued by extrusion of more evolved low-K calc--alkaline basaltoandesites and acid volcanics, reflecting increasing maturity of the arc.

The **Cambrian** metavolcanics are associated with shallow--water mature metasandstones with intercalations of metaconglomerates, passing upwards into metapelitic lithologies. In contrast to Proterozoic metavolcanics, the Cambrian intermediate to acid volcanic rocks (metarhyolite, metadacite, metatrachyte) prevail over the basic ones. If compared with Proterozoic acid volcanics, the Cambrian ones are more evolved, with higher SiO_2 (66–76%) and alkali contents (4–8%), as well as steeper REE patterns. On the other hand, U-shaped REE patterns and depletion in HFSE are typical of both age groups. Nd isotopic data (ε^{530}_{Nd}+1.5 to + 8.6, $T^{DM}_{Nd} = 0.51 – 1.04$ Ga) show some role for recycled Precambrian material besides more important juvenile, depleted-mantle derived component. The Cambrian volcanism probably represented a vaning stage of destructive margin setting and an onset of extension, which caused an origin of narrow intracontinental basins on the Proterozoic basement.

The youngest volcanic products are metadiabase **dykes**, sometimes preserving ophitic textures where relics of mostly amphibolized pyroxenes are locked among randomly dis-