Thermal processes in Triassic SEDEX ore deposit Vareš and adjacent pile of pillow lavas, Central Bosnia and Herzegovina

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The abstract deals with the two prominent representatives of Triassic advanced rifting magmatism, SEDEX ore deposit Vareš and its principal driving mechanism for fluid convection, a huge pile of pillow lavas. Their position, at the head of the obducted ophiolite front, accomplishes a general pattern which can be followed from the Zagorje-Mid-Transdanubian megaunit, Dinarides, Albanides and Hellenides. The products of Triassic advanced rifting magmatism, are situated within the basement of the growing carbonate platform in Mesozoic time, invaded by bulldozing, obducting slab of the oceanic crust, during collision and closure of the Neotethyan ocean in Jurassic-Lower Cretaceous time. Their present position is in the mélange, chaotic mixture of complex lithology, developed during ophiolite emplacement, or as para-autochtonous, at the base of or even within the carbonate platform itself. The both objects are situated at the head of the obducted ophiolite Krivaja-Konjuh massif.

The Vareš Fe-Pb-Zn-Ba SEDEX deposit is located 40 km northern from Sarajevo, Bosnia and Herzegovina. Mineralization is derived from hydrothermal sea floor exhalations within a Triassic rift depression of the Tethys.

The Vareš basalt quarry, situated in the vicinity of the deposit, exposes Middle Triassic pillow lavas, peperites and hyaloclastite breccias formed by extrusions of basaltic lava into unconsolidated seawater sediments. Interactions of basaltic lava with the seawater produced mostly chloritic alteration of basalt and precipitation of hydrothermal calcite in feeding channels of lava lobes and hyaloclastite breccia matrix. Calcite is associated with siderite, chlorite, zeolites and minor epidote.

Primary fluid inclusions (FIs) hosted by hydrothermal calcite reflect conditions of fluid/rock interaction. The coexistence of liquid-rich and vapour-rich FIs points to precipitation from boiling fluid and allows the estimation of trapping conditions. Assuming recent seawater salinity, homogenization temperatures in an interval between 275 and 290°C correspond to the formation depth between 650 and 900 m. Secondary two-phase (L+V) aqueous FIs display salinity close to the salinity of recent seawater (3.5-5.7 wt.% NaCl equ.) and their homogenization temperatures (TH) are in the range of 60–110°C.

The Vareš Fe-Pb-Zn-Ba SEDEX deposit comprises stratiform siderite–hematite–chert beds formed by exhalation of hydrotherms onto the bottom of rifting basin. The mineralization displays a distinct vertical zoning, reflecting a gradual change of redox conditions in the depositional environment. The sequence starts with bituminous, thinly bedded shales with pyrite and base metal sulfides, overlain by barite and siderite, deposited under reducing conditions. Overlying clastics and oolithic limestone are succeeded by hematite shale, hematite ± chert beds, deposited in oxidizing environment. The principal minerals are siderite, manganese-rich hematite, barite, pyrite, marcasite, chalcopyrite, galena, sphalerite, tetrahedrite and Pb-sulphosalts.

Microthermometric investigations on siderite and barite samples distinguished several FI types including: 1) Two-phase (L+V) NaCl-$CaCl_2$-H_2O FIs (2-6 wt.% NaCl equ.; TH ≈+110°C), 2) H_2O-CO_2-NaCl FIs (~4.5 wt.% NaCl equ.; TH ≈+100°C), 3) Aqueous FIs with liquid hydrocarbons, 4) Pure hydrocarbon FIs, and 5) Mono-phase aqueous FIs.

The FIs data indicate that modified seawater represents the major constituent of the mineralizing fluids and that magmatic activity in the region had served as principal driving mechanism for fluid convection. The presence of hydrocarbons reflects interaction of mineralizing fluids with organic rich sediments.

The total surface of the exposed pillow lava on both banks of the Stavnja rivulet exceeds several square km. The pillow lava pile is made of m-dm sized pillows rounded, semirounde, squeezed, contorted, green, red and gray in colour.

The foundation of the pile are lobs, partly disintegrated, turning into hyaloclastite breccias and pink peperites, within the inter-pillow space. The carbonate part of peperite contains Triassic index conodont fauna Paragondollela excelsa, Paragondollela foliata foliate, Paragondollela foliate inclinata, Nurella sp., CAI 6½, what appropriates to the Langobardian. The basalt was extruded into soft, unconsolidated sediments, of the Triassic rifting basin, and there are still no evidences of the oceanic crust which developed afterwards in Jurassic time.

Passive seismic experiment at the contact of the Dinarides and Pannonian Basin (ALPASS-DIPS) – deployment and characteristic receiver functions

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A group of active source seismic surveys have been performed in central Europe (CELEBRATION 2000, SUDETES 2003 and ALP 2002), covering wide area between Baltic and Adriatic sea. The main aim of these surveys was to determine more precisely the structure of the Earth's crust and upper mantle. Due to great problems related to shot-points, active seismic surveys have been more and more replaced by passive seismic experiments. The ALPASS-DIPS (Alpine Lithosphere and Upper Mantel PASsive Seismic Monitoring-DInarides-Pannonian Segment) is a continuation of the active ALP 2002 project, which covers a wide area of NW Dinarides, transition zone towards the Pannonian basin, and SW part of the Pannonian basin. Most of the temporary seismic stations, which are denominated Cro_01 to Cro_12, were deployed along the profile Alp07 permitting comparison and amendment of the active and passive seismic methods. Profile Alp07 stretches from Istra to the Drava river at Hungarian–Croatian border in a WSW–ENE direction. It is oriented approximately perpendicular to the Dinarides and the main faults in the Adriatic region. It stretches from the edge of the Adriatic microplate through the northern part of the Dinarides. The profile also crosses a wide ophiolite zone, which is divided into the narrow Dinaridic ophiolite zone and much wider Sava-Vardar zone, and terminates at eastern part of the Tisia block in the Pannonian basin.

Seismic modelling, both inverse and forward, was performed on the data gathered along Alp07 profile. The velocity model shows that the Moho depth is the greatest in the area of the Dinarides, reaching about 40 km and is shallowest (20–30 km) in the Pannonian basin. On the basis of seismic modelling, as well as gravity modelling, three types of crust were defined along the profile: the Dinaridic and the Pannonian crusts that are separated by a wide Transition zone. The Dinaridic crust is two-layered, while the Pannonian crust can be seen as a unique layer characterized by low seismic velocities and densities.

The data recorded within passive seismic project ALPASS-DIPS were processed using P-receiver function method, based on converted P-to-S phase. Analysis of receiver functions shows three types of seismograms: Dinaridic, Transitional and Pannonian. Pannonian type can be represented with data analysed at station CBP4M which belongs to the Pannonian crust. Transitional type can be seen at station Cro_07 because it is located in a Transition zone, while Dinaridic type can be observed at station Cro_03, and belongs to Dinaridic crust. Three major litospheric discontinuities can be defined at the Dinaridic type and the Transitional type, while the Pannonian type reveals only two discontinuities. To validate these results, receiver function modelling was performed. The main velocity contrast under the station Cro_03 is at the 42 km depth, which can be interpreted as Mohorovičić discontinuity. The upper crust is characterised by rather low velocities, but good agreement of the calculated and observed receiver functions could be obtained only with high-velocity layer at a depth between 3 and 5 km. The existence of high-velocity layer in the upper crust at the south-