TIMING AND MAGMA EVOLUTION OF UPPER CRETACEOUS ROCKS IN MEDET CU-PORPHYRY DEPOSIT: ISOTOPE-GEOCHRONOLOGICAL AND GEOCHEMICAL CONSTRAINTS

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Introduction

The Europe’s world-class copper-porphyry and Au-epithermal deposits are hosted by an elongated belt of intensive Late Cretaceous magmatic activity, known as the “Carpathian-Balkan Segment” of the “Tethyan Eurasian Metallogenic Belt” (Jankovic, 1976 and 1977), the “Banatitic Magmatic and Metallogenic Belt” (e.g. Berza et al., 1998, Ciobanu et al., 2002) or the Apuseni-Banat-Timok-Srednogorie belt (ABTSB) (Popov et al. 2000, 2003). A great number of important ore-deposits (mainly Cu-Au-Mo) are associated with this belt. Abundant new data on the geodynamic control of various ore deposits, the geochronology and geochemistry of the Late Cretaceous magmatism and the special features of the related Cu-Au deposits in ABTSB have been added during the activity of the GEODE (GEodynamic and Ore Deposit Evolution) project funded by the European Science Foundation. These allow new insights on the regional setting and genesis of the ore deposits of the belt.

Aims and methods

In the present study we focus on the geochronological and isotope-geochemical characteristics of Cretaceous magmatic rocks in the region of Medet deposit (Fig.1) – Bulgaria’s first known porphyry copper type deposit (Ushev, 1962). It is situated in the central part of the Srednogorie zone, Bulgaria (Fig. 1). Special attention is devoted to the basement rocks – metamorphites and Variscan igneous rocks. The region of the deposit provide good opportunity for studying the link between magmatism and ore formation, as well as the role of both the crustal protoliths and the subcontinental mantle lithosphere as magma sources.

For this purpose we used the following methods:

- ID-TIMS techniques for the precise U-Pb single zircon dating and Rb-Sr and Sm-Nd whole rock isotope tracing of the magmatic rocks and the basement;
- MC-ICP-MS for the analyses of the Hf isotopes;
- LA-ICP-MS for the main and trace element geochemistry.

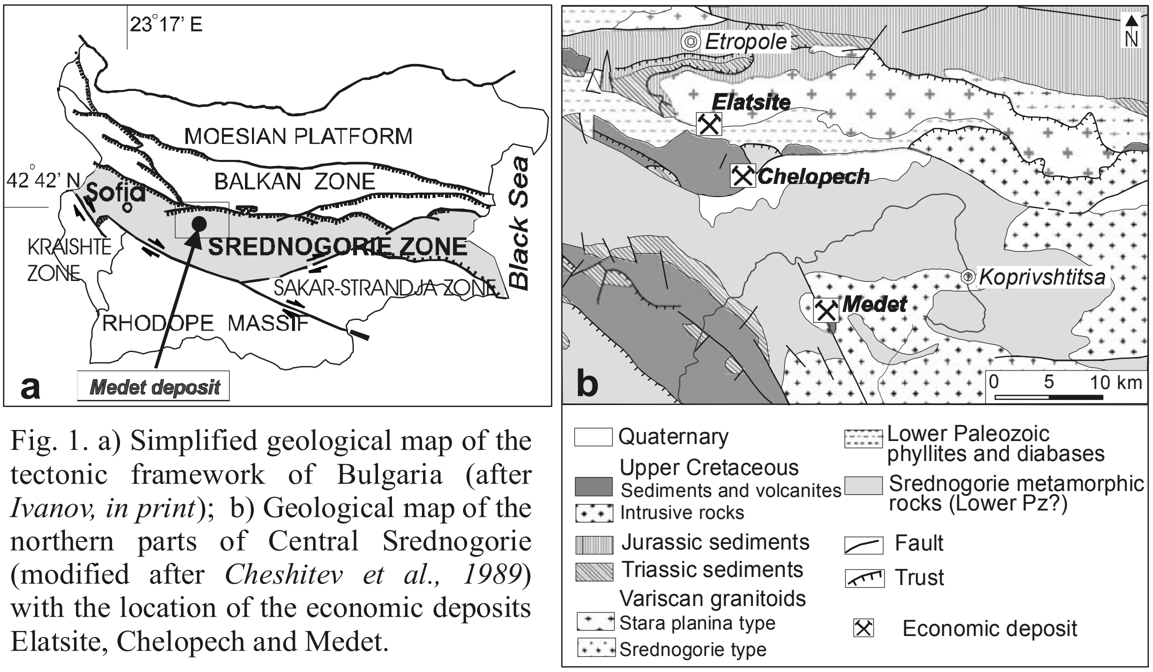

Fig. 1. a) Simplified geological map of the tectonic framework of Bulgaria (after *Ivanov, in print*); b) Geological map of the northern parts of Central Srednogorie (modified after *Cheshitev et al., 1989*) with the location of the economic deposits Elatsite, Chelopech and Medet.

Geological setting and sampling

The region of Medet deposit is build up by high-grade metamorphic rocks (gneisses and rarely amphibolites), intruded by Variscan (Zagorchev and Moorbath, 1987; Carrigan et al., 2003) granodiorites and granites (Smilovene and Koprivshtitsa plutons, Fig. 1b). Dabovski et al. (1972) consider the gabbro south of Medet deposit as part of the Carboniferous magmatic complex; their opinion was later supported by K/Ar amphibole and biotite age of 255 and 256 Ma (Chipchakova and Lilov, 1976). The basement is intruded by the rocks of Medet pluton (Ushev et al., 1962; Chipchakova, 2002) - a small stock-like body (~3 km^2), which is believed to represent the apical parts of a larger and deeper intrusive body as the magnetic anomalies suggest. The pluton is emplaced at the intersection of the NNW-oriented Panagyurishte deep-seated fault zone with faults developed along the contact between the Paleozoic granitoids and metamorphic basement rocks (Popov and Bayraktarov, 1978; Popov and Popov, 2000).

The Medet pluton is built up by the following main phases (Chipchakova, 2002; Strashimirov et al., 2002: (i) quartz-monzodiorites (equigranular and rarely porphyritic); (ii) granodiorites (as well as transitions between quartz-diorite and granodiorite). Aplitic granosyenites and aplite-pegmatites cross cut all these rocks.

The samples for this study are selected from:

- Upper Cretaceous igneous rocks: the Q-gabbrodiorite (AvQ111), correlated earlier with the Variscan Q-gabbro, the Q-monzodiorite porphyry (AvQ038), granodiorite porphyry (AvQ-112) and one aplitic vein (AvQ040);
- metamorphic basement – gneiss AvQ010;
- Variscan plutons: Smilovene granodiorite (AvQ109), Koprivshtitsa granite (AvQ110), and Medet Q-gabbro (AvQ014).

Whole-rock geochemistry

Published data about the major and trace element geochemistry (Daieva and Chipchakova, 1997; Kamenov et al., 2003) argue for island-arc character of the Upper Cretaceous magmatites in the region of Medet. Our new data are in agreement with them: the REE patterns of the newly sampled Cretaceous rocks are characterised by enrichment in the LREE and flat or slightly depleted HREE. Eu-anomaly is absent or week. The multi-element patterns are characterised by depletion in Ta-Nb, enrichment in LILE and by low values of HFSE, which is typical for subduction-related magmatic sequences.

These data are compared with the geochemical characteristics of the host rocks, in order to estimate the influence of the latter as a possible source for the Upper Cretaceous magma. Noteworthy is the similarity of the trace and rear-earth element distribution in the Variscan and Cretaceous magmatic rocks; in the basement rocks trace and rear-earth elements differ in patterns and content and give evidence for different origin (crustal, mixed and mantle) of the protoliths.

Geochronology and isotope geochemistry

Published K-Ar ages are 90-88 Ma for the quartz-monzodiorite (Lilov and Chipchakova, 1999) and 88-87 Ma – for the K-silicate alteration (Chipchakova, 2002). Recent Ar-Ar age of amphibole from a granodiorite sample is 85.70 Ma (Handler et al., 2004). Lips et al. (2004) reported an intrusion age of 90.4 ± 0.9 for "igneous biotite" from Medet, whereas three white mica (sericite) samples revealed a plateau age of 79.0 ± 0.8 Ma to 79.5 ± 0.7 Ma, informative for an overprinting alteration process (low-temperature?) in the deposit.

Our preliminary U-Pb zircon analyses give evidence for an Early Palaeozoic age of the gneiss protoliths near Koprivshtitsa (sample AvQ010, Peytcheva and von Quadt, 2004).

For the Variscan basement very close age reveal the zircons of the Medet gabbro (AvQ014, 305.55 ± 0.50 Ma) and the Smilovene granite (AvQ109, 305.3 ± 1.3 Ma), as well as the monazites of the Koprivshtitsa granite (AvQ110, 304.8 ± 0.8 Ma). Furthermore the gabbro shows mixed crust-mantle characteristics, according to the $eHf_{(300)}$ zircon value of +0.14 and whole-rock initial strontium ratio of 0.7043. These data fit very well with the I-type affinity of the Smilovene and Koprivhtitsa granites.

The Q-gabbrodiorite (AvQ111) from the deeper parts of Medet deposit represents the oldest Upper Cretaceous rock variety: concordant zircons reveal a mean $^{206}Pb/^{238}U$ age of 90.36 ± 0.48 Ma (Fig. 2). Old inherited zircon grains and cores from the same sample define a discordia line with an upper intercept age of 456.5 ± 5.5 Ma (Fig. 2). The εHf (460) value of the same zircons of +8.04 to +9.88 suggest mantle source of the old assimilated protoliths. It is noteworthy that the εHf (90) values for the old and young zircons are scattering in a narrow range between –0.81 and +2.12, whereas no correlation between inheritance and the negative values was found.

The ore-related Q-monzodiorite of Medet deposit (Chipchakova, 2002) shows an intrusion age of 89.63 ± 0.33 Ma. The eHf (90 Ma) values of the concordant zircons change between +1.24 and +4.42 indicating additional input of mantle magma. One grain with lead inheritance marks the assimilation of Lower Palaeozoic basement rocks with crustal characteristics ($\varepsilon Hf_{(90Ma)}$ of –3.78).

Conclusions

- Precise U-Pb zircon geochronological data argue for an age of about 90 Ma for the main Upper Cretaceous magmatism in Medet deposit.
- Based on Sr-Nd-whole rock and Hf-zircon isotope data at least two magma sources for the Cretaceous rocks in the Medet deposit should be constrained: the subcontinental enriched mantle and the pre-Variscan basement, the latter revealing mantle as well as crustal characteristics.
- The subcontinental lithosphere was enriched in subduction-slab derived elements (Rb, Th, K, Na, P), slightly enriched in ^{87}Sr and slightly depleted in ^{143}Nd, whereas the e-Hf isotope characteristics remain almost the same with time.
- Some geochemical characteristics (e.g. REE distribution) of the Upper Cretaceous igneous rocks could be inherited from the basement rocks, as some of the latter reveal similar geochemical features.

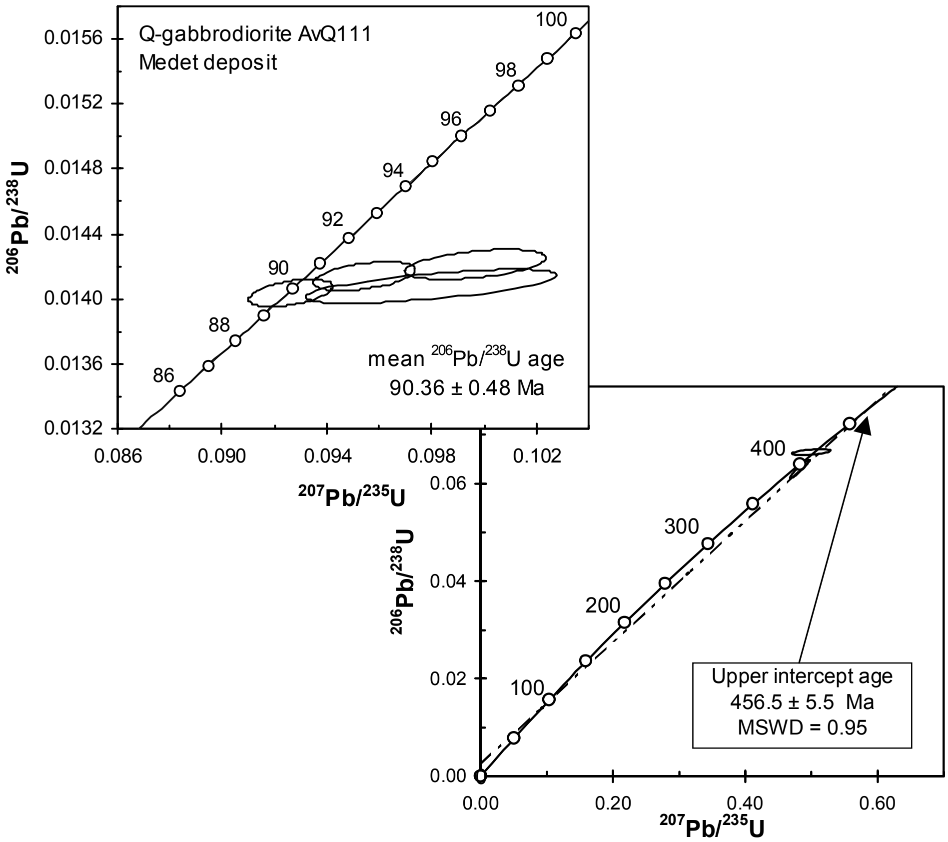

Fig. 2. U-Pb concordia diagrams for zircons of the Q-gabbrodiorite AvQ111, Medet deposit.

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