Improved U/Pb dating of CA-treated zircons from northern parts of Central Srednogorie for accurate geological interpretation

Усъвършенствано U/Pb датиране на химично абразирани циркони от северните части на Централното Средногорие за коректна геоложка интерпретация

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Introduction

Application of Chemical Abrasion (CA) technique (Mundil et al., 2004; Mattinson, 2005) to zircons removes radiation damaged parts and inclusions and leads to improved precision of U-Pb age dating (von Quadt et al., 2011; Schaltegger et al., 2014). With time it became a routine step of zircon treatment prior to chemical dissolution and Isotope Dilution-Thermal Ionization Mass Spectrometry (ID-TIMS). The combination of CA with the widely applied Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) improves the precision and accuracy of zircon dates, while removing the substantial parts with lead loss and reducing data scatter (von Quadt et al., 2014; Peytcheva et al., 2014). Here we apply CA-ID-TIMS and CA-LA-ICP-MS techniques on previously dated and new zircon samples from the region of Elatsite and Chelopech deposits in the northern parts of Central Srednogorie, Bulgaria with the aim to refining age data precision and improving geological interpretations.

Samples and analytical methods

Four samples of Upper Cretaceous volcanic and subvolcanic rocks from Elatsite and Chelopech deposits and their region were selected. Sample AvQ006 represents the late syn- to post-ore granodiorite porphyry with needle amphibole phenocrysts from Elatsite deposit. Samples CH114 and CH56 are from the Murgana pre-ore dome-like andesitic-trachydacitic bodies and from syn-ore andesite in Chelopech deposit, respectively. Details of their geological setting are given in von Quadt et al. (2002) and Stoykov et al. (2004). One additional granodiorite porphyry sample is sampled in the Etropole ore-occurrence (Etr14-1).

Zircon separates are analyzed by CA-LA-ICP-MS, and the age data are compared with the CA-ID-TIMS $^{206}Pb/^{238}U$ dates. ID-TIMS U-Pb analyses are performed at the Institute of Geochemistry and Petrology, ETH-Zurich, using low-blank chemical procedure, the ET 2535 spike (see www.earth-time.org) and Thermo Fischer TRITON Plus TIMS. The latter is equipped with a MasCom multiplier backed by a digital ion counting system. For data reduction the Redux program is applied (see www.earth-time.org). Detailed description of the chemical preparation and analytical procedure are given in von Quadt et al. (2011, 2014). LA-ICP-MS U-Th-Pb isotope zircon analyses are carried out using a New Wave Research (NWR) 193 nm excimer laser UP-193FX attached to a Perkin-Elmer ELAN DRC-e quadrupole Inductively Coupled Plasma-Mass Spectrometer (LA-ICP-MS) at the Geological Institute, Bulgarian Academy of Science in Sofia. An in-laboratory designed ablation cell with lowered position effects, “squid” smoothing device, energy density on sample ca. 8.5–8.8 J/cm^{-2} and repetition rate of 8 are used. Ablation craters are 35 µm. All experiments were performed using He as carrier gas. The analyses are carried out in blocks of 22, using GJ1 zircon standard for fractionation corrections (2 analyses at the beginning, 2 in the middle and 2 at the end of the block) and Plesovice SRM as a secondary standard. Preliminary background subtraction, setting /filtering of isotope signals, instrumental drift correction and data calculations are performed using the Glitter program (van Achterberg et al., 2001). A Th-disequilibrium correction is applied to all analyses. For each sample, all concordant zircons were used to calculate a concordia age, or a mean $^{238}U/^{206}Pb$ age. The plots were processed using ISOPLOT 3.0 (Ludwig, 2001) or ISOPLOT 4.15.

Results and discussion

The results of U-Pb zircon dating are summarized on Fig. 1. New Concordia age data of CA-treated zircons are compared to TIMS non-CA former age data. CA-LA-ICP-MS zircon age is slightly older for sample CH56, compared with published data, and slightly younger for samples CH114 and AvQ006. The error uncertainties (see 2 σ error bars on Fig. 1) are too big to distinguish between the magmatic events/pulses.

The CA-ID-TIMS zircon ages are generally about 0.35–0.72 Ma older than the published U-Pb zircon ages. One exception is the sample CH114, where the ages coincide within error is 92.2±0.3 (TIMS on air-abraded zircons) and 92.05±0.10 (CA-ID-TIMS). It should be mentioned that Murgana dome-like dacitic bodies are dated 91.95±0.28 Ma by Chambefort et al. (2007), which age is negligibly younger than the new CA-ID-TIMS date.

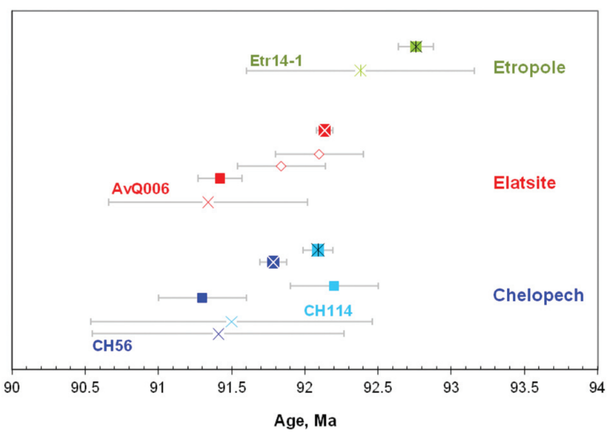

Fig. 1. U-Pb zircon age data for ore-related magmatic rocks in Chelopech, Elatsite and Etropole deposits/occurrence. Symbols: Crosses – CA-LA-ICP-MS analyses, and filled squares with crosses – CA-ID-TIMD data. Published data of von Quadt et al. (2002) and Stoykov et al. (2004) are also shown as filled squares for the same samples, and as diamonds for pre- to syn-ore porphyries in Elatsite. Error bars are 2 SD.

In Elatsite there is a substantial difference between the published age of 91.42±0.15 Ma for the late-syn to post-ore granodiorite porphyry (AvQ006) and the newly obtained age 92.14±0.06 Ma. We should assume also older ages for the whole magmatic activity in the deposit but this suggestion needs additional work with the application of the CA-ID-TIMS techniques. The latter will also help understanding the temporal succession of magmatic intrusions and extrusions, including the granodiorite porphyry from Etropole occurrence that is now distinct older than the dated subvolcanics in Elatsite (Fig. 1).

Important conclusion from the high-precision CA-ID-TIMS new dating of the magmatism in Chelopech is the very close age of the volcanics (sample CH114 and CH56) – 92.14±0.06 Ma and 91.784±0.092 Ma, respectively. It is in agreement with recently published data for short life of the ore-producing magmatic-hydrothermal systems (e.g. von Quadt et al., 2011), although magmatic activity may last longer and lead to heating and convection of fluids. Another important result is the temporal distinction of ore-bearing magmatism in Elatsite and Chelopech, as the new age data (with lower uncertainties) for AvQ006 and CH56 do not overlap in time (Fig. 1).

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