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U-Pb geochronology and geochemistry of rutiles from metaconglomerate in the Sakar-Strandzha zone, SE Bulgaria

U-Pb геохронология и геохимия на рутили от метаконгломерат в Сакар-Странджанската зона, ЮИ България

Tzvetomila Vladinova[1], Milena Georgieva[2], Irena Peytcheva[1]
Цветомила Владинова[1], Милена Георгиева[2], Ирена Пейчева[1]

[1] Geological Institute, Bulgarian Academy of Sciences, Acad.G. Bonchev str., 1113 Sofia Bulgaria;
E-mails: tz.vladinova@gmail.com; peytcheva@erdw.ethz.ch
[2] Sofia University “St. Kliment Ohridski”, 15 Tsar Osvoboditel Blvd., 1504 Sofia, Bulgaria; E-mail: milena@gea.uni-sofia.bg

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The Sakar-Strandzha zone (Ivanov, 2017) is a Mesozoic orogenic belt composed of Variscan basement, Triassic–Jurassic metasedimentary cover and Upper Cretaceous volcano-sedimentary sequences. The metasedimentary succession (impure marbles, calcite-biotite schists, metabreccia-conglomerate, garnet-staurolite micascishts) affected by amphibolite facies metamorphism (Tzankova, Pristavova, 2007) belongs to the Topolovgrad group (Sakar Type Triassic) (Chatalov, 1990). A variety of metasedimentary rocks and P-T conditions provide suitable environment for metamorphic rutile appearance. In this study we use rutiles from metabreccia-conglomerate part of the Paleocastro Formation (Srem village area, N42°01'43.30, E26°29'37.60) as geochronometer and provenance tracer.

Methodology

In studied sample we observed abundance of rutile crystals (100–200 μm) which were separated by the standard techniques. The images of backscattered electron (BSE) identify inclusions, areas of replacement and ilmenite exsolution needles. The trace element composition and U/Pb isotopic ratios (for rutile grains U>5 ppm) ware measured by LA-ICP-MS at the Geological Institute of BAS using external reference materials NIST610 and rutile R10 (Luvizotto et al., 2009).

Petrographic observations and results

The prominent minerals in metabreccia-conglomerate are plagioclase, quartz, biotite, chlorite, white mica and epidote with common accessory minerals of rutile, zircon, monazite, apatite and magnetite. The coarsed-grained clasts of plagioclase and quartz are affected by intense sericitization. Biotite occurs as big porphyroblasts filled with inclusions of quartz, sub-euhedral prismatic rutile, rarely acicular rutile (sagenite type) (Fig. 1a) and small rutile twinning. The chlorite replacing biotite is accompanied by rutile, magnetite and hematite aggregation (Fig. 1b). Single acicular rutile inclusions in chlorite are rarely observed (Fig. 1b). The finer-grained matrix represents alternation of triple junction quartz zone and bands of fine white mica with elongate quartz and rounded rutile grains. The petrographic observations propose detrital origin of rounded rutile and some sub-euhedral prismatic inclusions in biotite. The rutile formed concomitantly with breakdown of biotite to chlorite suggests metamorphic origin (Fig. b).

The separated rutile crystals are brownish with morphology dominated by sub-euhedral prismatic or xenomorphic with rarely rutile twinning (Fig. 1c). The rutile grains have completely homogeneous internal structure and numerous inclusions (quartz, albite, titanite, apatite, and zircon). Thin il-

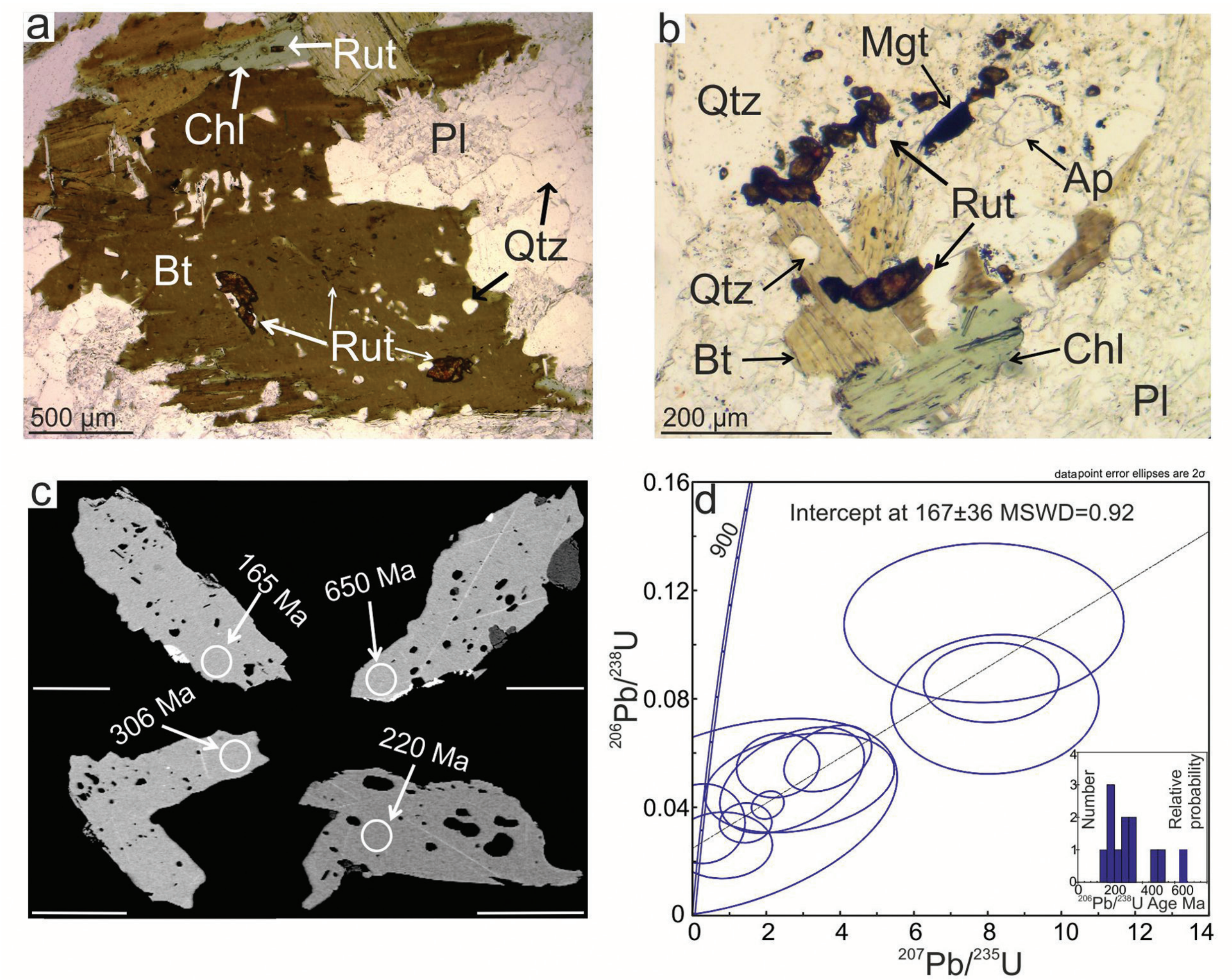

Fig. 1. *a–b*, Photomicrographs of metabreccia-conglomerate, transmitted-light: *a*, sagenite rutile and sub-euhedral rutile inclusion in biotite porphyroblast; *b*, chlorite replacing biotite accompanied by rutile, magnetite aggregation; *c*, BSE image of sub-euhedral prismatic, xenomorphic rutile grains and twinning (scale bar 100 µm); *d*, Concordia diagram with an inset of Probability density plot $^{206}Pb/^{238}U$ ages in the range of 165–650 Ma.

menite lamellae are rarely observed on BSE images (Fig. 1c).

The rutile ages yielded concordant to sub-concordant results with a spread of $^{206}Pb/^{238}U$ ages between 165 Ma and 650 Ma with major cluster around 180–250 Ma and secondary in range 260–360 Ma displayed on probability density plot (Fig. 1d). The LA-ICP-MS U-Pb in-situ analyses define a discordia line with a lower intercept age of 167±35 Ma (2σ error uncertainties; MSWD = 0.92) interpreted as the time of metamorphic rutile growth (Fig. 1d). The bigger error uncertainties of individual points are result of low U content (around 5 to max 15 ppm) but high common lead contribution.

The variation of trace element in the rutile population is: 148–337 ppm Ta; 1730–2583 ppm Nb (mean Nb/Ta=9.41); 3.93–635 ppm W; 4.80–940 ppm Hf; Fe>5591 probably due to presence of ilmenite lamellae. The Zr concentration of 66.10–203 ppm corresponds to temperature range of 525–669 °C calculated by Zr-in-rutile calibration (Zack et al., 2004a).

Conclusions

The production of rutile by a metamorphic reaction provides powerful tool for recognizing the metamorphic growth history. The advantage of rutile dating for tracking the metamorphic evolution is emphasized by comparison with U–Pb detrital zircon geochronology recorded only the Early Carboniferous–Early Permian source age (Vladinova et al., 2018) for the same sample. The results of U–Pb rutile geochronology show large age heterogeneity because of the volume lead diffusion within grains. However, rutile ages determine lower intercept at

Middle Jurassic time indicating the metamorphic rutile crystallization. The Jurassic metamorphic rutiles could be related with Alpine metamorphic overprint described for the region by Cattò et al. (2017) and Gerdjikov (2005). The Zr content and Nb/Ta ratios correspond to amphibolite facies of metamorphism known in the area.

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