

Ion microprobe U-Pb zircon ages of pre-Alpine rocks in the Balkan, Sredna Gora, and Rhodope terranes of Bulgaria: Constraints on Neoproterozoic and Variscan tectonic evolution

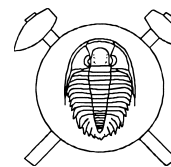
C. W. CARRIGAN¹ – S. B. MUKASA² – I. HAYDOUTOV³ – K. KOLCHEVA⁴

¹ University of Michigan, cwarrig@umich.edu

² University of Michigan, mukasa@umich.edu

³ Geological Institute, Bulgarian Academy of Sciences, ihaydu@geology.bas.bg

⁴ Sofia University, Bulgaria



The geological evolution of the Balkan terranes is poorly known primarily due to a lack of robust age constraints. Their involvement in Variscan tectonic activity is likely, but so far unresolved. New U-Pb zircon ages of igneous and meta-igneous rocks determined by ion microprobe methods provide important constraints on the Pre-Alpine evolution of three tectonic terranes in Bulgaria – the Balkan, Sredna Gora, and Rhodope.

The Balkan Terrane in northwestern Bulgaria contains a Cambrian volcanic-sedimentary sequence that is intruded by calc-alkaline sills and plutons. These rocks intrude and overlie a nearly complete Precambrian ophiolite sequence with MORB affinities. The volcano-sedimentary sequence and the intrusive rocks have been interpreted as an island arc terrane that developed outboard of Gondwana. We have attempted to date three intrusive rocks of the island arc sequence – the Pilatovitz Gabbro, the Stakevtci Granite, and the Klisura granite (thought to be correlative to the Stakevtci). Zircons from the Pilatovitz Gabbro yield an age of 493.0 ± 6.6 Ma, and verify the Cambrian-Early Ordovician age of the island arc. Zircons from all samples of the granitic rocks are similar, showing numerous inherited cores mantled by magmatic rims. The analyses of magmatic rims for all samples range from Cambrian to Permian, and represent extensive but variable Pb loss. A small cluster of older analyses gives an age of 527 ± 18 Ma, which may represent the true age. The inherited cores also show abundant Pb loss, but a few range from ~ 550 – 700 Ma and one analysis is ~ 1.7 Ga. The inheritance ages are similar to Pan African ages and provide further evidence of a Gondwanan heritage for this terrane. The older core (~ 1.7 Ga) suggests that either the sources of the granitic magmas contain a component of that age, or that the granites were contaminated by detrital material from the sedimentary sequence that they intrude. Regardless, the presence of detrital material indicates proximity of the developing island arc to a continental source. The ages of detrital grains in the sedimentary rocks are totally unknown; our planned future studies will further delineate the likely presence and nature of this detrital component and attempt to correlate inherited and detrital ages to a source terrane. New data for the San Nikola granite, part of the Variscan granitoid suite that intrudes the Balkan Terrane, gives an age of 313.8 ± 3.5 Ma.

The Sredna Gora terrane contains high-grade metamorphic rocks of unknown age and affinity that are intruded by granites of variable composition and overlain by Permian-Triassic clastic sedimentary rocks. The metamorphic basement rocks are predominantly psammitic to pelitic paragneisses metamorphosed in the upper amphibolite facies. The granitic rocks have been subdivided into three pulses based upon mineralogy and intrusive relationships. Rocks in the oldest group are metaluminous biotite-hornblende bearing rocks with megacrystic potassium feldspar. The two younger groups are strongly peraluminous two-mica granites. Previous age constraints on the granitic intrusive rocks by Rb-Sr isochron techniques verified the three pulses were of broadly Variscan age, but indicated a wide age span (>100 million years) for these intrusives. The new U-Pb zircon ages indicate that most of these granites probably formed within a much shorter time span. The Smilovene granite of the oldest group yields an age of 307.7 ± 4.5 Ma (Rb-Sr age 342 ± 27 Ma), while the Strelcha pluton of the third and youngest group yields an age of 285.5 ± 5.2 Ma (Rb-Sr age 238 ± 37 Ma). Inherited cores are not present in zircons from the Smilovene granite or the similar San Nikola granite to the north in the Balkan Terrane. Zircons from the Strelcha pluton are dominated by xenocrystic grains, about half of which are mantled by brighter magmatic zones. The inherited grains range in age from the magmatic age at ~ 285 Ma to ~ 450 Ma (one discordant point has a $^{207}\text{Pb}^*/^{206}\text{Pb}^*$ age of ~ 560 Ma). The ages obtained for the granites indicate that diverse styles of granitic magmatism were generated in the same area in a roughly short time span (~ 25 myr). Very little else is currently known about their depth of origin, level of emplacement, the nature of their sources, or the tectonic setting in which they were generated.

The Rhodope terrane of southern Bulgaria and northern Greece has long been a subject of controversy. It was initially regarded as an ancient (Archean) metamorphic terrane, but recent work has shown a significant metamorphic overprint in the Eocene (~ 40 Ma). However, numerous unmetamorphosed sedimentary rocks deposited on top of the metamorphic rocks are latest Cretaceous to Paleogene in age, indicating that much of the Rhodope metamorphic rocks must be older than Eocene. The age of this older metamorphism remains enigmatic, but is

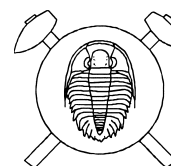
likely either Cretaceous (~100–120 Ma) or Variscan (~300 Ma). Protolith ages are almost totally unknown in the Rhodope Terrane, as most dating techniques that have been applied utilized systems known to be easily reset during metamorphism (i.e., Rb-Sr, $^{40}\text{Ar}/^{39}\text{Ar}$). The Bubiño gabbro, a component of the Variegated Fms., yields an age of 572 ± 5 Ma, and initial geochemical and petrological studies suggest this rock has boninite-like chemistry and was formed in a subduction zone setting. Data for another gabbroic unit from the north central Rhodope are not definitive, but clearly indicate an age >500 Ma. Zircons from both of these rocks also con-

tain homogeneous exterior zones that are interpreted as metamorphic, and yield Variscan ages ~300–350 Ma. These are the first Neoproterozoic protolith and Variscan metamorphic ages so far reported for the Rhodope Terrane. A granite from the Bela Reka antiform also yields a Variscan age of 301 ± 4 Ma, and contains a few inherited cores with ages of ~660 and ~2500 Ma. Although recently interpreted as a product of Cretaceous subduction, the lack of well-established metamorphic and protolith ages urges caution in making tectonic reconstructions. Our preliminary data indicate a significant Pre-Alpine tectonic history in the Rhodope Terrane.

Metamorphosed Hercynian granites in the Alpine structures of the Central Rhodopes, Bulgaria: Position and geochemistry

Z. CHERNEVA – M. GEORGIEVA

Geological Institute, Bulgarian Academy of Sciences, milena@geology.bas.bg



Modern views on the Rhodopes massif evolution distinguish two successive compressional and extensional stages completed in the Alpine time. Both stages resulted from the collision between Eurasian and African plates in early Cretaceous time. During the compressional stage, the rocks have been subjected to regional metamorphism and a system of large-scale south verging thrusts emerged. The extensional stage began with tectonic erosion of the anomalous thickened crust and continued with the formation of detachment fault system. The latter has been connected with a development of granitic and migmatitic domes and imposed graben depressions filled with sediments of Palaeogene age. The Late Cretaceous-Tertiary extensional system in the Central Rhodopes area consists of two plates: an upper plate (Asenitsa unit) that has been affected by amphibolite facies metamorphism ($550\text{ °C} / 13$ kbar); and a lower plate (Arda unit) that has been affected by migmatization ($620\text{--}680\text{ °C} / 4\text{--}8$ kbar). The Arda unit migmatites was exhumed during the Oligocene (35–34 Ma) and formed the core of the Central Rhodopian Dome.

The core of the Central Rhodopian Dome consists of migmatitic orthogneisses. U-Pb dating shows the Eocene age of migmatization 37–38 Ma (monazite and zircon from anatectic melts) and Hercynian age 308–310 Ma (zircon from gneiss and anatectic melts) of migmatite precursor. Geochemical data and zircon with magmatic oscillatory zoning indicate that the precursor was a granitoid rock of calc-alkaline affinity, which was emplaced ca. in a frame, represented at present by garnet-kyanite schists, marbles and metaeclogites.

Alpine migmatization ranged from subsolidus mobilization to low-temperature water-saturated melting in biotite stability field. Migmatite geochemistry corroborates a conclusion of low mobility of HFS elements and pres-

ervation of protolithic zircon during melting thus allowing an interpretation of orthogneisses protolith origin. In situ leucosome LREE and Zr concentrations coincide with those calculated for low temperature felsic peraluminous melts. The low total REE concentrations and distribution patterns without Eu-anomaly are dominant. LIL elements (Rb, Ba, Sr) occurring as trace constituents in major phases show larger variations compared to mesosome. Average Rb/Sr and Ba/Rb values of K-feldspar mineral separates show systematic changes in the sequence: in situ leucosome – mesosome – evolved melt (respectively Rb/Sr 0.49–0.65–0.93 and Ba/Rb 10.1 – 8.2–5.5) marking fractionation of crystallizing phases during incomplete melt extraction.

Protolith lithologies include hornblende-biotite granodiorite, biotite, and two-mica granites, and aplitic veins. Major and trace element signatures show magmatic differentiation trends, which are consistent with hornblende and plagioclase fractionation. REE data support such an interpretation. Granodiorite and biotite granite have similar total REE content (200–300 ppm), distribution patterns and negative Eu-anomaly (0.5–0.6). Aplitic granites (total REE <100 ppm) differ in higher HREE fractionation and pronounced negative Eu-anomaly (0.1–0.4). A/CNK ratio values in the suit range from 0.9 to 1.2. The oxygen isotopic composition of isolated samples $\delta^{18}\text{O}$ 6.2–8.3 and calculated initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.705–0.707) corroborate an assumption of predominant I-type granitoid protolith. Trace element discrimination plots based on Zr, Ta, Nb, and Hf distribution show close similarities with volcanic-arc granites and late or post-collision calc-alkaline intrusions, which may be derived from a mantle source but underwent extensive crustal contamination.