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Obducted serpentinites in the Rhodope Massif and their stratigraphic, paleotectonic and metamorphic significance

Обдуцираните серпентинити в Родопския Масив и тяхното стратиграфско, палеотектонско и метаморфно значение

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Introduction

The origin and emplacement mechanism of serpentinites, one of the main components of ophiolitic associations in the continental crust, has been the subject of a variety of evolving hypotheses and concepts for more than a century. The discussions intensified after adoption of the plate tectonic paradigm. Serpentinites are widespread in some parts of the Rhodope Massif. Various opinions regarding their genesis include that they represent: autoserpentinised ultrabasic igneous rocks, protrusions, exhumed subduction mantle wedges, thrust bodies, sutures, mélanges, etc. The serpentinites in the Rhodope Massif are a classic example of the obduction of ocean crust fragments on continental margins. Their significance as stratigraphic, paleotectonic and metamorphic markers demands reassessment. A concise description of the main distinctive features of serpentinites relevant to their primary position and subsequent evolution, is presented, with a view to stimulate new discussions within the Bulgarian scientific community.

Geological setting

The ophiolites in the Rhodope Massif are part of a Precambrian metamorphic complex which is divided into two groups: the lower one – Prarhodopean Supergroup (PRS), consists of a typical ancient continental gneiss to granite-gneiss series. It has been repeatedly subjected to thermal and substance influence and has acquired an average granodiorite geochemical signature. The upper – Rhodopeanan Supergroup (RS), composed of Variegated and Marble formations, represent transgressive delayed volcanogenic-sedimentary materials, metamorphosed into amphibolites, mica-schists, marbles and quartzites. The Rhodopean ophiolite association (ROA) of serpentinites, amphibolites and gabbro takes up space in the low levels of the Variegated formation (Fig. 1a). Rare amphibolite dykes and bodies crosscut the gneisses of PRS. All rocks are metamorphosed to amphibolite facies. The stratigraphic sequence, despite tectonic folding and faulting, is relatively well preserved. Where the primary relationships are recognizable, they show that the metamorphic complex has a unitary stratigraphic structure (Kozhoukharova, 2008).

Main characteristic of serpentinites

The interpretation of the primary genesis and implantation of the serpentinites into continental crust is justified by the following distinctive features:

a) the permanence of the ophiolite association as a component, with the amphibolites and schists, in the Variegated formation;

b) they form elongate bodies ranging in size from meters to 10–12 km in length, concordant to host layers, distributed mainly in SE and SW Rhodope. Discordant serpentinite wedges crossing metamorphic layers are not observed anywhere;

c) serpentinites constantly occupy the same level at the base of Variegated formation, directly on the gneisses sole, covered or as inclusions in amphibolites and schists;

d) their high degree of serpentinization – 85–95% serpentine: lizardite with chrysotile in inner parts and antigorite on the periphery of the bodies. Such high hydratization is only possible in the

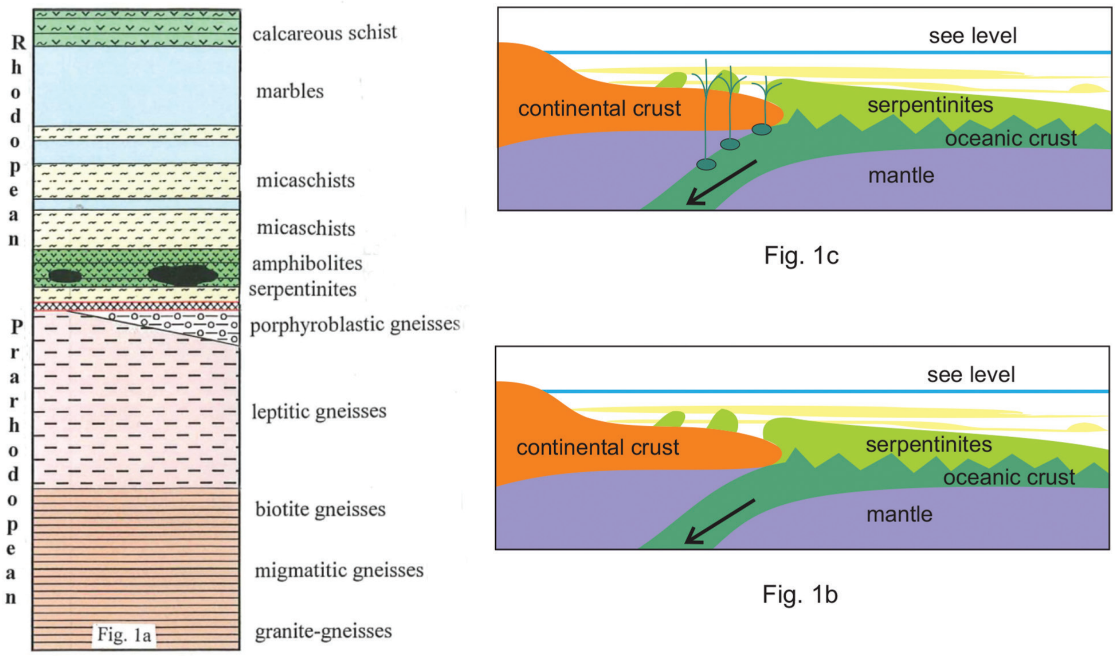

Fig. 1. *a*, stratigraphic column of the metamorphic complexes – Rhodope Massif; *b*, sketch of serpentinite obduction on the SSZ (supra-subduction zone); *c*, sketch of volcanic eruption on the same SSZ

ocean basins where, on the ultrabasic igneous rocks from the floor, an upper coat of serpentinite clay grows reaching a thickness of several kilometers (Deschamps et al., 2013).

e) the partial metamorphic alteration on the periphery of the large bodies and complete replacement of small lens-like bodies by talc-chlorite-actinolite schists. Incomplete replacement and preservation of lizardite-chyzotile indicate that the temperature of the regional metamorphism never exceeded 600 ^oC. Otherwise all serpentinites would become pyroxenites. The last ones being in the relatively dry continental crust, would never be serpentinized again;

f) some serpentinite bodies along tectonic zones in the crust suffered eclogitization *in situ*, represented by banded garnet-lherzolites (Kozoukharova, 1999a);

g) the serpentinites as well as amphibolites in some places are affected by metasomatism of pegmatite-aplite veins and granite fluids. As a result, peculiar metasomatic gabroids appear that should not be considered as elements of the ROA (Kozoukharova, 1999b).

The absolute age of the metamorphic basic rocks is determined by U-Pb dating on zircon as Neoproterozoic – 610 Ma in eclogites (Arkadakskiy et al., 2003), 572 Ma in meta-gabbro (Carrigan et al., 2003) and 566 Ma in meta-gabbro (von Quadt et al., 2010). These dates coincide with the time of ocean closure preceding the amalgamation of supercontinent Gondwana.

Conclusions

Juxtaposition of all the above features of the serpentinites, leads to the sole conclusion that they were implanted by an obduction mechanism into the continental crust, where all later metamorphic processes took place.

One possible scenario presents the sequence of events as follows: The Lower gneissic complex PRS may have been a part of a microcontinent after the breaking up of the Rodinia supercontinent. Formation of supra-subduction zone (SSZ) and obduction of serpentinite fragments start during closure of the ocean as contacts between continent and ultrabasic ocean plate developed. When the collision takes place, the upper soft and plastic layer of serpentinite clay brakes up due to shearing stress – effect of grater (Fig. 1b). The randomly shaped serpentinite fragments rise on the continent margins. Subsequently the serpentinites are partially dehydrated, lithified, and develop the “mesh” structure, typical of loss of water.

The remainder of the oceanic plate sinks below the continent where at a certain depth it melts and rising through channels covers the serpentinites as lavas and tuffs, together with pelitic-carbonate sediments. (Fig. 1c). The periphery of the serpentinite bodies, volcanics and sediments are metamorphosed to amphibolite facies talc-chlorite-actinolite schists, amphibolites, mica-schists and marbles. Eclogitization of serpentinites and other basic rocks occurs locally within tectonic zones – evidence of intrinsic crustal genesis of eclogitization in the Rhodope Massif.

A similar setting for the generation of an ophiolithic association as new lithosphere above a supra-subduction zone was also created during the Phanerozoic Eon. The closest examples are the ophiolites on the Albanido-Hellenide system zone of Western Balkans formed during the Tethys closure (Beccaluva et al., 2004)

The creation of the Rhodope ophiolitic association has taken place in a Neoproterozoic supra-subduction setting in two stages. During the first one, obduction of serpentinite fragments, scraped from the hydrated coat of the sliding ultrabasic plate, is established. In the second stage SSZ-type volcanism occurs including and covering serpentinite bodies. This determines the heterogeneous nature of the ophiolitic association`s formation. The ophiolites participate in the formation of primary continental crust and become an element of it. All subsequent changes on the ophiolites, including eclogitization, are crustal processes, provoked by pulses of magmato-tectonic energy.

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