EVOLUTION OF THE SOUTH ALBANIAN OPHIOLITES: MOR VS. SSZ OPHIOLITES

V. HOECK[1], F. KOLLER[2], T. MEISEL[3], K. ONUZI[4] and E. KNERINGER[2]

[1]Institute of Geology and Palaeontology, Unversity of Salzburg, Hellbrunnerstr. 34, 5020 Salzburg, Austria
[2]Institute of Petrology, University of Vienna, Geozentrum, Althanstr. 14, 1090 Vienna, Austria
(friedrich.koller@univie.ac.at)
[3]Institute of General and Analytical Chemistry, University of Leoben, 8700 Leoben, Austria
[4]Institute of Geological Research, Blloku Vasil Shanto, Tirana, Albania

Abstract: The Albanian ophiolites are part of a large ophiolitic belt ranging from Croatia to Greece. In south Albania three subunits called Voskopoja s. str., Morava and Rehove were recently investigated. In contrast to north Albania with a clear subdivision into a eastern belt with MOR character and in a western belt formed above a supra-subduction zone (SSZ). In the investigated south Albanian ophiolites the basalts show a transitions between a MOR and a SSZ environment.

Key words: Jurassic ophiolites, MORB, SSZ, Albania, Dinaride-Hellenides

Introduction and Geology:

The Albanian Ophiolites are part of a large ophiolitic belt ranging from Croatia across Northern Bosnia, Montenegro and Albania to Greece. A more westernly ophiolite unit is accompanied by an eastern unit bordering the Serbo-Macedonian massif and ranging from Central Serbia across the Vardar zone to Northern Greece. The western unit in turn, can be divided - at least in Northern Albania - into two belts with distinct geology, petrology and geochemistry. The twofold division is not so clear anymore in the South-Albanian ophiolites. While the Northern Albanian ophiolites formed by an eastern MOR and western SSZ belt are comparatively well studied (Beccaluva et al. 1994, Bortolotti et al. 1996, Robertson and Shallo 2000, Nicolas et al. 1999), only little is published on the Southern Albanian ophiolites (e. g. Hoeck and Koller, 1999, Hoeck et al. 2002).

Within the western belt of the southern Albanian ophiolites the Voskopoja ophiolite consists of three subunits called Voskopoja s. str., Morava and Rehove. They comprise predominantly lherzolites with only minor occurrences of harzburgites and dunites in the mantle section. The upper mantle section is overlain by a complex of ultramafic and mafic cumulates including wehrlites, troctolites and olivine gabbros. Gabbronorites are restricted to Morava. Isotropic cpx-gabbros, extrusives and sediments were found only in Rehove and Voskopoja s. str. The volcanic section is dominated by basaltic breccias including megablocks with sheeted dikes and pillow lavas. Singular dikes occur. The basaltic breccias grade into sandstones which in turn are interlayered with argillites and cherts.

Geochemistry of the mantle section:

The mantle sections is formed mainly by lherzolites, minor harzburgites and rare dunites. Chemically the lherzolites contain 33-40 wt% MgO, 2.0-3.2 wt% Al_2O_3 and 1.5-3 wt% CaO. X_{Mg} ranges from 0.89-0.91. Generally, the Ni content ranges from 1700 to 2200 ppm, in Rehove it goes up to 2600 ppm, the Cr content ranges from 2200-2700 ppm, in few lherzolites it reaches up to 4000 ppm. The harzburgites are even more serpentinized compared with the lherzolites. Therefore the MgO content varies from 32 to 43 wt%. The Al_2O_3 content ranges from 0.4-1.8 wt% and the CaO from 0-2.1 wt%. The Ni concentration is higher then in the lherzolites ranging from 2100-2500 ppm and Cr varies from 2000-2700 ppm. The dunites only found in Voskopoja are totally serpentinized with very low Al_2O_3 and CaO.

Layered ultramafics and gabbros:

The layered ultramafics and gabbros include wehrlites, troctolites, melagabbros olivingabbros and gabbronorites. The wehrlites contain 35-42 wt% SiO_2, the gabbros go up to 51 wt%. The MgO varies from 7-25 wt% in the gabbros and from 27-38 wt% in the wehrlites. Al_2O_3 is lowest with 2-3 wt% in the ultramafic cumulates from Morava and Voskopoja, it ranges from 4 to 9 wt% in Rehove. The gabbros cover a wide field from 11 –27 wt%. Accordingly, the CaO is distributed in a similar way varying from 1-6 wt% in the wehrlites and from 9-15 wt% in the gabbros. TiO_2 varies from 0.1-0.4 wt% without any significant distribution between gabbros and ultramafic cumulates. There is a clear positive correlation of Ni and Cr with 1400-2400 ppm Ni and 1800- 3500 ppm Cr in the ultramafics. In the gabbros Ni varies from 150-1100 ppm and Cr from 100-1400 ppm.

Isotropic gabbros:

Most isotropic gabbros were analysed from Rehove. They display a narrow range of compositions with SiO_2 ranging from 48-51wt% and MgO from 7-11 wt%. CaO is high from 9-14 wt%, Al_2O_3 from 15-20 wt%. TiO_2 ranges from 0.3 to 1.8 wt%. Ni and Cr vary from 100-400 ppm and 100-1250 ppm respectively. Y and Zr are positively correlated with values as high as typical MORB compositions. The REE patterns are 10-20 times enriched with a depletion of the LREE. A weak positive Eu anomaly can be observed.

Geochemistry of the volcanics:

The basalts are predominantly cpx–plag basalts, partly aphyric, partly with plag phenocrysts. Some of them contain chromites and possible form relics after olivine. Rather high MgO values from 7-13 wt% indicate their relative primitive nature. Most of the basalts have between 200-450 ppm Cr and 50-300 ppm Ni, a typical convex upward REE pattern with an overall enrichment of 12-25 times chondrite. They are generally slightly LREE depleted.

Geochemically they can be divided into four groups (Hoeck at al., 2002):

a low Ni group,

a high Ni group,

a high Ti-Zr group,

a low Ti-Zr group.

The high Ni content in basalts of group (2) is interpreted as having originated from olivine and spinel xenocrysts. Apart from the high Ni content both groups, (1) and (2), are comparable with the volcanics of low to high Ti intermediate ophiolites. Beside the olivine and spinel accumulation in basalts of group (2), all basalts of both groups (1) and (2) derive from a rather similar mantle source with MOR character. Group (3) basalts are more evolved and can be correlated with the volcanics of the high Ti ophiolites in the western ophiolite belt in northern Albania. The basalts of the group (4) with a Zr/Y ratio <2 are typical SSZ basalts, common in volcanics in the eastern ophiolite belt in north Albania. In contrast to the eastern SSZ belt in north Albania, where volcanites range from basalts to andesites and rhyodacites the investigated ophiolites of south Albania contain only basalts.

Conclusions:

Our investigations from the Voskopoja ophiolite in the southwest of Albania support the view of Bebien et al. (1998, 2000). The investigated basalts are predominantly comparable to the basalts of the low to high Ti intermediate ophiolites of Bortolotti et al. (1996). This includes the low Ni group as well as the high Ni group. However, the amount of high Ti basalts broadly comparable to the equivalent group in northern Albania is much smaller in the south. In addition, we could identify a small but significant number of basalts, typically representing supra-subduction zone magmas. We believe that our random sampling in respect to lithology represents roughly the actual quantitative distribution of the different rock types. The appearance of the supra-subduction zone magmas, combined with the deminuation of the Ti rich lavas from north to south indicates some continuous variation along the western belt. This is corroborated by the complex structure of the Pindos ophiolite comprising a high number of supra-subduction zone (SSZ) volcanics, obviously on top of a MOR type basaltic sequence (Jones and Robertson 1991, Jones et al. 1991).

The results by Bebien et al. 1998, 2000, on the Shebenik Massif indicate some similarities, for example the occurrence of similar ultramafic-mafic cumulates, such as plagioclase wehrlites, troctolites and olivine gabbros, across the western and the eastern belt. The investigations in Voskopoja and surroundings argue for a variation along the strike of the western belt with an increasing SSZ influence towards the south. All these findings confirm the view that there is a more close petrological and geochemical connection between the still overall contrasting belts.

Bebien et al. 1998, postulate a two stage evolutionary model of the Shebenik ophiolite from the eastern belt including (1) the formation of an ultramafic – mafic cumulate sequence derived from Ti-rich magmas and (2) the formation of very low Ti to boninitic lavas. The two stages correspond quite well with the formation of the Voskopoja s. str.– Morava – Rehove ophiolite in the western belt. The main difference is that in the Shebenik massif cumulates rest on a mainly harzburgitic tectonite, in the west on a predomiantley lherzolitic mantle.

In Voskopoja SSZ type basalts are closely associated with the MORBs. In addition, younger boninites intrude as dikes the western ophioliotes in the north and the layered and massive gabbros in the Shebenik Massif (Bortolotti et al. 1996, Bebien et al. 1998). At least some dikes crosscutting the ultramafics, layered gabbros and the isotropic gabbros in Voskopja s. str. and Rehove were assigned to group (4), the lowTi-Zr basalts. Thus, they are younger than the cumulates and the isotropic gabbros. These findings indicate a close spatial and probably also temporal relationship between the MOR and SSZ basalts

One model for the close relationship of MOR and SSZ basalts on the Shebenik ultramafic and mafic cumulate rocks combined with the occurrence of boninites has been put forward recently by Bebien et al. (2000) and Insergueix-Filippi et al. (2000). It is based on the assumption of a beginning intraoceanic subduction zone disturbing an astenospheric mantle plume beneath a mid ocean ridge. Such a situation could generate a possibly rare configuration of a close spatial and temporal relationship between an astenospheric mantle still producing MOR type melts and a subduction zone influenced mantle section with a high imput of water generating low Ti and very low Ti (boninitic) magmas.

An alternative model could be the Lau basin. Here a spreading zone is segmented into separate spreading centers and strikes obliquely to the subduction zone of the Tonga Graben (Pearce et al. 1995). As the subduction zone approaches the spreading zone it influences increasingly the magmas of the spreading zone by the imput of water and other mobile elements such as K, Ba, or Rb. In that way magmas were generated, which are similar to MORBs away from the subduction zone and suprasubduction type lavas, were the spreading zone and the subduction zone interferes.

References

Bebien, J., Shallo, M., Manika, K. and Gega, D., 1998. The Shebenik Massif (Albania): a link between MOR and SSZ-type ophioplites?. – Ofioliti, 23, 7-15.

Bebien, J., Dimo-Lahitte, A., Vergeli, P., Insergueix-Filippi, D. and Dupeyrat, L., 2000. Albanian ophiolites. I.- Magmatic and metamorphic pocesses associated with the initiation of a subduction. – Ofioliti 25(1), 39-45.

Beccaluva, L., Coltorti, M., Deda, T., Gjata, K., Hoxha, L., Kodra, A., Pirdeni, A., Premti, I., Saccani, E., Selimi, R., Shallo, M., Siena, F., Tashko, A., Tershana, A., Turku, I. and Vranai, A., 1994. A cross section through western and eastern ophiolitic belts of Albania (Working Group meeting of IGCP Project no. 256 - Field trip A). - Ofioliti, 19 (1), 3-26.

Bortolotti, V., Kodra, A., Marroni, M., Mustafa, F., Pandolfi, L., Principi, G. and Saccani, E., 1996. Geology and petrology of ophiolitic sequences in the Mirdita region (northern Albania). - Ofioliti, 21 (1), 3-20.

Hoeck, V. and Koller, F., 1999. The Albanian ophiolites and the Dinaride – Hellenide framework. – EUG 10, Strasbourg, J. Conf. Abstr. 4, 406.

Hoeck, V., Koller, F., Meisel, T., Onuzi, K. and Kneringer, E., 2002: The South Albanian Ophiolites: MOR vs. SSZ Ophiolites. - Submitted to Lithos.

Insergueix-Filippi, D., Dupeyrat, L, Dimo-Lahitte, A., Vegrely, P., and Bebien, J., 2000. Albanian ophiolites. II.- Model of subduczion zone infancy at a Mid Ocean Ridge. – Ofioliti 25(1), 47-53.

Jones, G. and Robertson, A.H.F., 1991. Tectono-stratigraphy and evolution of the Mesozoic Pindos ophiolite and related units, northwestern Greece. – J. Geol. Soc. 148, 267- 288.

Jones, G., Robertson, A.H.F. and Cann, J.R., 1991. Genesis and Emplacement of the Supra-Subduction Zone Pindos Ophiolite, Northwestern Greece. - In: Peters, Tj. et al. (eds.): Ophiolite Genesis and Evolution of the Oceanic Lithosphere, Ministry of Petroleum and Minerals, Sultanate of Oman, 1991, 771-799.

Nicolas, A. and Boudier, F., Meshi, A., 1999. Slow spreading accretion and mantle denudation in the Mirdita ophioplite (Albania). – J. Geophys. Res., 104, 15 155-15 167.

Pearce, J. A., Ernewein, M., Bloomer, S.H., Parson, L.M., Murton. B.J. and Johnson. L.E., 1995. Geochemistry of Lau Basin volcanic rocks: influence of ridge segmentation and arc proximity. In: Smellie, J.L. (ed.), 1995: Volcanism Associated with Extension Consuming Plate Margins. – Geol.Soc.Spec.Publ., 81,53-75.

Robertson, A.H.F. and Shallo, M., 2000. Mesozoic – Tertiary tectonic evolution of Albania in its regional Eastern Mediterranean context. – Tectonophysics, 316, 197 – 254.