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ALBANIAN OPHIOLITES. I - MAGMATIC AND METAMORPHIC PROCESSES ASSOCIATED WITH THE INITIATION OF A SUBDUCTION

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ABSTRACT

The Albanian ophiolite complexes, of Jurassic age, cover about 4,000 km^2. They crop out as a NNW-SSE trending belt in the Mirdita tectonic zone. This belt shows a remarkable petrological diversity. Low- and very low-Ti magmatisms, particularly abundant to the East, seems to follow a high-Ti magmatism mainly located to the West. This diversity has been interpreted as a result of the original setting of these magmatic bodies: a mid-ocean ridge setting for the high-Ti magmatism, and a supra-subduction zone setting for the low- and very low-Ti magmatisms. Nevertheless, no break appears neither in magma compositions nor in space and time: the data support the hypothesis that Albanian ophiolites formed in a setting where both high-Ti, low-Ti and very low-Ti magmatims coexisted either spatially or temporally.

The studies of the ophiolitic metamorphic sole can provide important information concerning this setting: a metamorphic sole, less than 0.5 km thick, occurs on both the eastern and western sides of the ophiolite belt. It mainly consists of amphibolites, gneisses and micaschists which grade rapidely downward into relatively unmetamorphosed rocks, and originates from high-Ti plutonic and volcanic rocks and from siliciclastic sediments. P-T conditions range from 800 to 850°C and 0.9-1.2 GPa in the granulite facies rocks, and from 300 to 400°C and 0.2-0.3 GPa in the greenschist facies rocks. According to $^{40}Ar/^{39}Ar$ geochronological data, magmatic samples from the ophiolites give ages indistinguisable from the age of the sole at the same latitude.

An initiation of a subduction at or near a ridge can account for most of the previous observations. The high temperature-high pressure metamorphism observed in the infra-ophiolitic sole can be related to the subduction of a young, and still hot oceanic lithosphere at depth of at least 30 km. Dehydration ot this subducting lithosphere and release of H_2O into a hot, refractory overlying mantle wedge can induce low- to very low-Ti magmatisms above the slab. High-Ti basalts would attest for the persistence of a residual spreading ridge magmatism. Therefore, the Albanian ophiolites probably bear witness to the metamorphic and magmatic processes related to an infant subduction zone. They suggest that high-Ti magmatisms showing a MORB affinity can be closely linked to low- to very low-Ti island-arc type magmatisms during the pre-arc stage, and they consequently present a significant opportunity for the investigation of supra-subduction zone ophiolites and fore-arc areas.

INTRODUCTION

According to the plate tectonic theory, the fate of the oceanic lithosphere is to sink into the mantle along subduction zones. Ophiolites represent interesting exceptions, since they are interpreted as fragments of oceanic lithosphere emplaced (obducted) onto continental margins. This peculiar fate of the oceanic lithosphere that constitutes ophiolites needs specific explanations, and could be related to special settings for their formation. On the other hand, ophiolites often include rocks different from samples dragded or drilled from ocean floors today formed at ocean ridge axis: petrological data suggest in many cases that these special settings could be related to subduction processes (Miyashiro, 1973; Pearce et al., 1984).

Albanian ophiolites show a conspicuous petrographical diversity associated to good exposure conditions, and therefore consitute a remarkable field for a case study concerning the formation of an obducted oceanic lithosphere.

The Albanian ophiolite complexes, of Jurassic age, cover about 4,000 km^2 (ISPGJ-IGJN, 1983). They crop out as a NNW-SSE trending belt in the Mirdita tectonic zone (Fig. 1). Complete sequences, including ultramafic tectonites, cumulates, dyke complexes, effusive rocks and radiolarian cherts are well exposed in the northern complexes. On the other hand, the southern complexes are incomplete and only consist of the lower part of the sequence (tectonites and lower cumulates). A metamorphic sole occur along both the eastern and western sides of the ophiolitic belt, between serpentinized peridotites and a sedimentary substratum (Turku, 1987; Carosi et al., 1996; Dimo, 1997; Vergély et al., 1998).

For a long time, Albanian authors have shown that petrologic and metallogenic data support the distinction of two types of ophiolites (Shallo et al., 1987). In the western (W) type, harzburgites and lherzolites are overlain by dunite and pl-lherzolites, troctolites and gabbros, while acid plutonic rocks are scarce. The volcanic component consists of Ti-rich tholeiitic basalts. The eastern (E) type consists of, from bottom to top, harzburgites and dunites enclosing huge chromite deposits, wehrlites, pyroxenites, gabbro-norites, isotropic gabbros, plagiogranites, well-exposed sheeted dyke complexes and volcanic formations. Hypabyssal and volcanic rocks consist of low-Ti basalts, andesites, dacites, rhyolites and boninites.

Different interpretations were proposed in order to explain such diversity.

1) W-type and E-type ophiolites correspond to slow versus fast oceanic ridges (Tashko, 1996), or to amagmatic versus magmatic episodes, respectively (Boudier et al, 1997; Nicolas et al., 1999). These interpretations are interesting because they explain important structural differences between the two types of ophiolites. Although, in our opinion, they do not take into account their petrologic diversity.

2) The diversity of Albanian ophiolites is the result of their different original setting (Shallo et al., 1987) : the W-type formed in a mid-ocean ridge (MOR), and the E-type

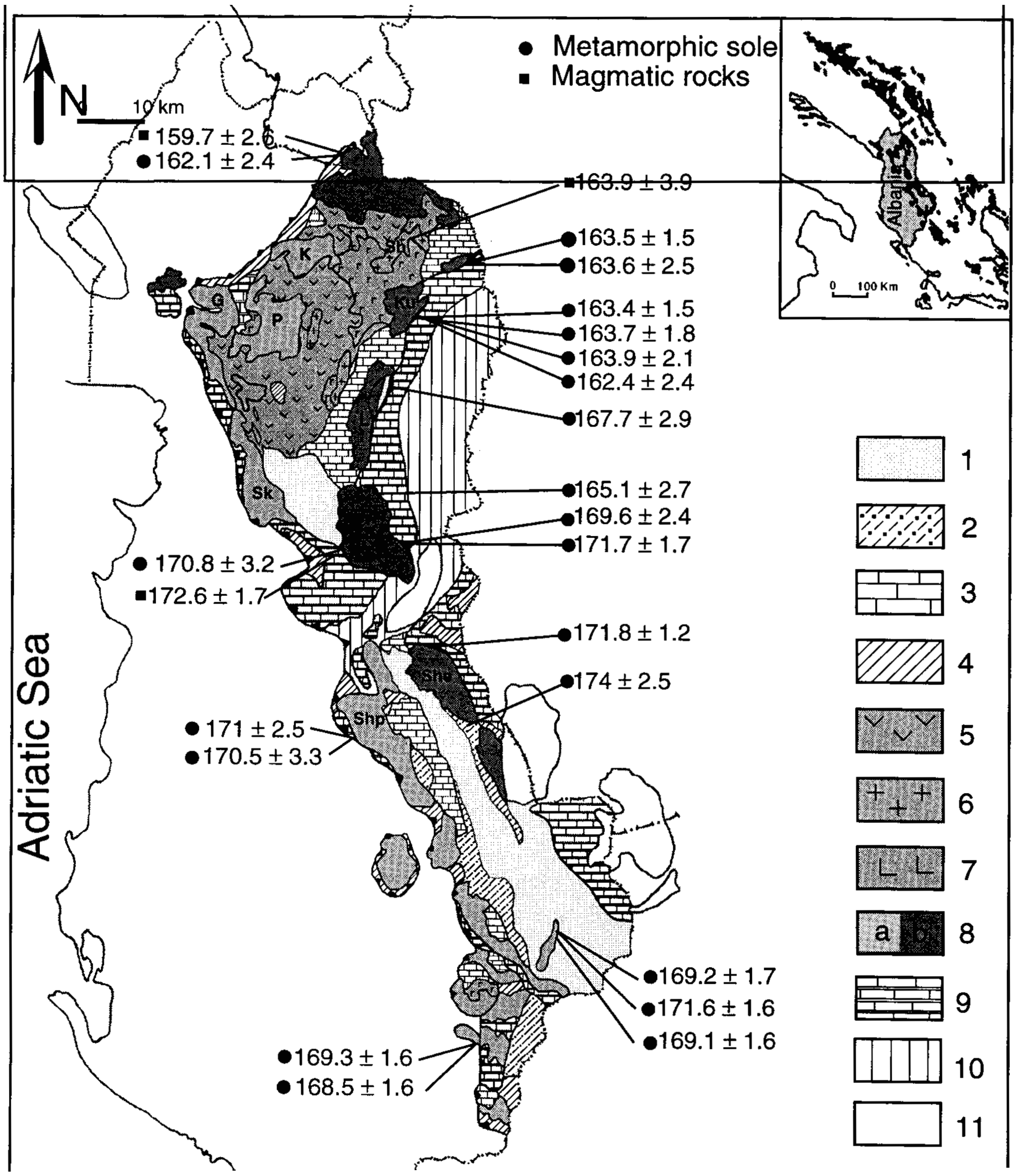

Fig. 1 - Simplified geological map of the Mirdita zone (ISPGJ-IGJN, 1983) and location of ^{40}Ar/^{39}Ar age determinations.
1- Neogene; 2- Palaeogene; 3- Cretaceous limestones; 4- flysch and/or ophiolitic melange of the late Jurassic - late Cretaceous; 5- volcanic and hypabyssal rocks; 6- plagiogranites; 7- gabbroid complex; 8- ultramafic rocks: a- western type; b- eastern type; 9- Triassic-Jurassic carbonate substratum; 10- Korabi zone; 11- external zones. B- Bulqiza; G- Gomsiqe; L- Lura; T- Tropoja; K- Krrab; Ku- Kukës; P- Puka; Shp- Shpat; She- Shebenik; Sk- Skënderberg.

formed in a supra-subduction zone (SSZ) (Fig. 2). An East-dipping subduction may separate western, MOR-type ophiolites from eastern, SSZ-type ophiolites (Beccaluva et al., 1994b; Shallo, 1994). Alternatively, the growth of infant-arc lithosphere (E-type ophiolites) within older, MOR-type lithosphere (W-type ophiolites) may be a consequence of the initiation of intra-oceanic-subduction (Jones et al., 1991; Gjata et al., 1992; Manika, 1994).

The latter models imply noticeable age differences between the two ophiolite types (at least of several millions years). In fact, this is confirmed neither by petrological data, nor by paleontological data on radiolarian cherts found at the top of the ophiolites or by geochronological data from the metamorphic soles. Therefore, we propose in this paper that both W- and E-type Albanian ophiolites are related to a subduction process.

We shall justify this suggestion by considering successively the magmatic rocks and the metamorphic soles. The results of a numerical model developed with the intention of investigating the consequences of subduction initiation at a mid-ocean ridge (Insergueix-Filippi et al., this volume) will complete our approach.

DIVERSITY OF MAGMA COMPOSITIONS

TiO_2 contents and magma types

TiO_2 contents are very usefull to illustrate the magma diversity in ophiolites (Bébien, 1972; Beccaluva et al., 1979; Serri, 1981). The report of effusive and hypabyssal rock compositions on a TiO_2 versus FeO*/MgO diagram

(Miyashiro, 1973; Bébien, 1980; Bébien et al., 1980) leads us to the distinction of three magma types in Albanian ophiolites (Fig. 3).

High-Ti magmatism. Effusive rocks in this group are mainly basalts and ferrobasalts. A pronounced rise in TiO_2 from 0.75% to 3.5% correlates with an increase in FeO*/MgO from 0.5 in Mg-rich basalts to 3.1 in ferrobasalts (Fig. 3a). This evolution is also expressed by a decrease in Cr and Ni and an increase in the less mobile incompatible elements during alteration processes such as V, Y, and Zr. On the other hand, SiO^2 contents do not show any significant variation and hardly exceed 50% (Fig. 3b). The related plutonic sections are thin and discontinuous. They consist of troctolites, olivine-gabbros, gabbros, gabbronorites and ferrogabbronorites. Textures indicate an early crystallization of spinel, olivine and plagioclase, followed by clinopyroxene, then by orthopyroxene and titanomagnetite. Pyroxene is Ti-rich, and plagioclase shows an important variation in An-content which correlates with the decrease in FeO/MgO in olivine and pyroxene. Basaltic and gabbroic rocks are in contact with relatively undepleted harzburgitic to lherzolitic tectonites: Al_2O_3 is abundant in spinel and pyroxenes, and clinopyroxene presents noticeable amounts of TiO_2 and Na_2O.

Low- and very low-Ti magmatisms. The very low-Ti group includes a wide range of effusive rocks. Abundant andesites are associated with basalts, boninites and dacites. Al_2O_3 and CaO contents in the less altered boninitic samples suggest that they belong to the type 3 low-Ca boninites and to the high-Ca boninites (Crawford et al., 1989). Very low-Ti basalts only differ from these boninites because of their lower SiO_2 contents. MgO contents can reach 15% in the more Mg-rich basaltic and boninitic samples, which are also remarkably rich in Cr (more than 700 ppm) and Ni. The Si-enrichment in andesites is accompanied by a decrease of FeO, MgO, Cr and Ni contents, and the FeO*/MgO ratio only shows a noticeable increase in dacites. All the rocks in this group are very poor in Y, Zr, and rare earth elements. Basic, intermediate and acidic rocks with similar composition are present in well exposed sheeted dyke complexes.

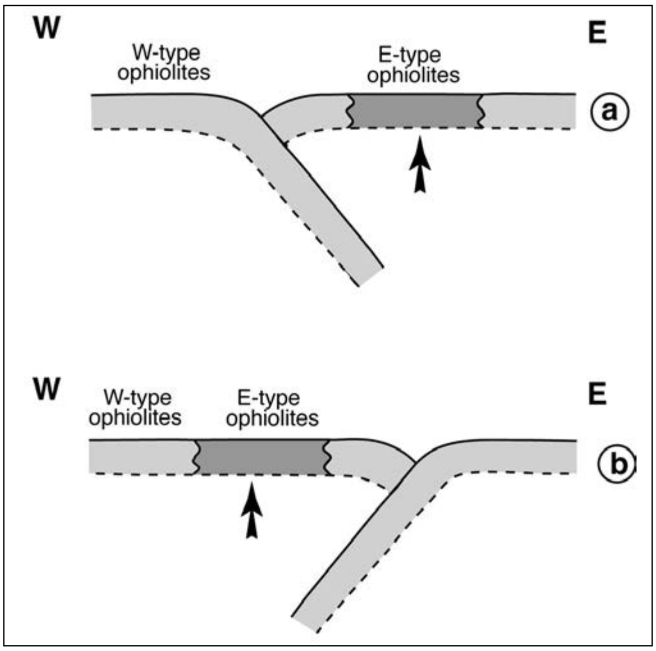

Fig. 2 - Tectonic models proposed to explain the diversity of the Albanian ophiolites:
a) an east-dipping subduction separates western, MOR-type ophiolites, from eastern, SSZ-type ophiolites (Beccaluva et al., 1994b; Shallo, 1994);
b) the formation of eastern, SSZ-type ophiolites within older, MOR-type ophiolites is a consequence of the initiation of a west-dipping subduction (Jones et al., 1991; Gjata et al., 1992; Manika, 1994).

Numerous effusive and hypabyssal basaltic and andesitic rocks plot between the fields of the high-Ti and very low-Ti magmatisms, on the TiO_2 versus FeO*/MgO diagram (Fig. 3a) and therefore belong to a third, low-Ti magmatism. The

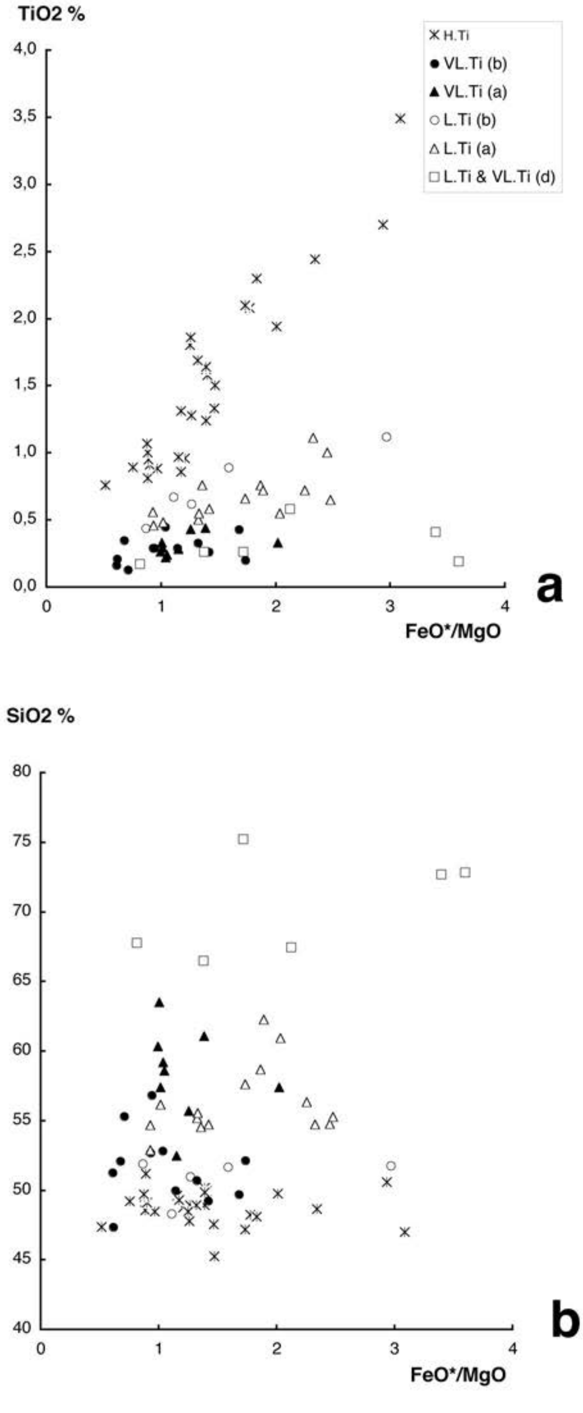

Fig. 3 - TiO^2 (a) and SiO^2 (b) versus FeO*/MgO for ophiolitic Albanian effusive and hypabyssal rocks (data from Beccaluva et al., 1994 a and b; Bortolotti et al., 1996; Manika, 1994; Shallo et al., 1987). H.Ti: high-Ti basalts; VL.Ti (b): very low-Ti basalts; VL.Ti (a): very low-Ti andesites; L.Ti (b): low-Ti basalts; L.Ti (a): low-Ti andesites; L.Ti and VL.Ti (d): low- and very low-Ti dacites.

transitional characteristics of this magmatism (between the high-Ti and very low-Ti groups) is also illustrated by the SiO_2 - FeO*/MgO diagram (Fig. 3b), and is attested by trace element contents. In fact, the dividing lines between the three groups are more or less arbitrary. Although most of the basalts considered by Bortolotti et al. (1996) as intermediate between the high-Ti and the low-Ti groups show low FeO*/MgO ratios combined with low TiO^2 contents and therefore probably correspond to primitive high-Ti magmas, some samples which are characterized at the same time by relatively high values, close to 1.2, of the FeO*/MgO ratio, by TiO_2 contents lower than 1% and by Ti/V ratios slightly below 20 (Shervais, 1982) could indeed express an evolution toward the low-Ti group. On the other hand, many basaltic and andesitic samples plot very close to the dividing line between the low-Ti and the very low-Ti groups on the TiO_2 versus FeO*/MgO diagram (Fig. 3a).

Both low-Ti and very low-Ti magmatisms participate to the genesis of huge plutonic complexes which mainly consist of dunites plus chromitites, pyroxenites and gabbronorites topped by relatively large plagiogranitic units. The textures of the plagioclase-websterites and gabbronorites indicate a late crystallization of an An-rich plagioclase, which fills up the space between ortho- and clinopyroxene. Least-squares mass balance calculations based on bulk rock and mineral compositions suggest that the evolution of most of these plutonic units and of the low-Ti volcanic group may be accounted for by fractional crystallization, in an initially open system, from low-Ti picritic parental magmas (Beccaluva et al., 1998). On the other hand, petrological and geochemichal data indicate that some large ultramafic, mafic and acidic units results from the intrusion and the differenciation of very low-Ti boninitic magmas (Bébien et al., 1997; Karadumi et al., 1998).

Thick sequences of harzburgitic and dunitic tectonites are related to these plutonic complexes. A particularly Cr-rich spinel (chromite) constitutes concentrations that have been intensely exploited, especially in the Bulqiza area. The very low abundance of clinopyroxene in these tectonites, and the low Al contents in pyroxenes testify a refractory formation.

Distributions, relationships, ages

The distribution of the high-Ti magmatism on the one hand, of the low and very low-Ti magmatisms on the other hand (Fig. 4) broadly corresponds to the previously proposed distribution of W-type and E-type ophiolites: high-Ti basalts are abundant to the West, whereas low- and very low-Ti magmatisms are mainly located to the East. However, low- to very low-Ti basaltic lavas and dykes have been recognized amongst rocks belonging to the high-Ti magmatism in the northwestern part of the Albanian ophiolite belt (Bortolotti et al., 1996). In particular, very low-Ti basaltic dykes are found in the dunites and troctolites which belong to the lowermost section of the high-Ti cumulitic sequence. The study of plutonic rocks in southern Albanian ophiolites seems to confirm this association of high-, low- and very low-Ti magmatisms (Beccaluva et al., 1994b; Manika, 1994; Onuzi et al., 1997; Bébien et al., 1998). The Shebenik complex in the southeastern part of the ophiolite belt, for example, appears to be heterogeneous: pyroxenitic units and boninite dykes result from the emplacement of Ti-poor, Si-rich boninitic liquids related to abundant harzburgitic tectonites; they intrude plagioclase-bearing wehrlites, troctolites and gabbros which are products of the crystallization of relatively Ti-rich tholeiitic liquids. It

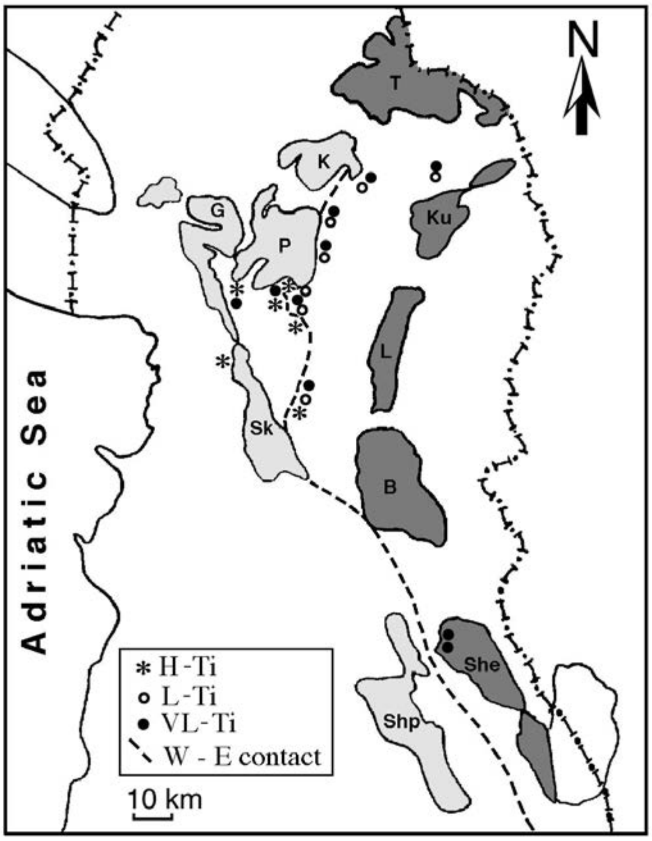

Fig. 4 - Location of the high-Ti, low-Ti and very low-Ti magmatisms in Albanian ophiolites. Inferred boundary between W-type and E-type ophiolites (W - E contact) according to Shallo (1994).

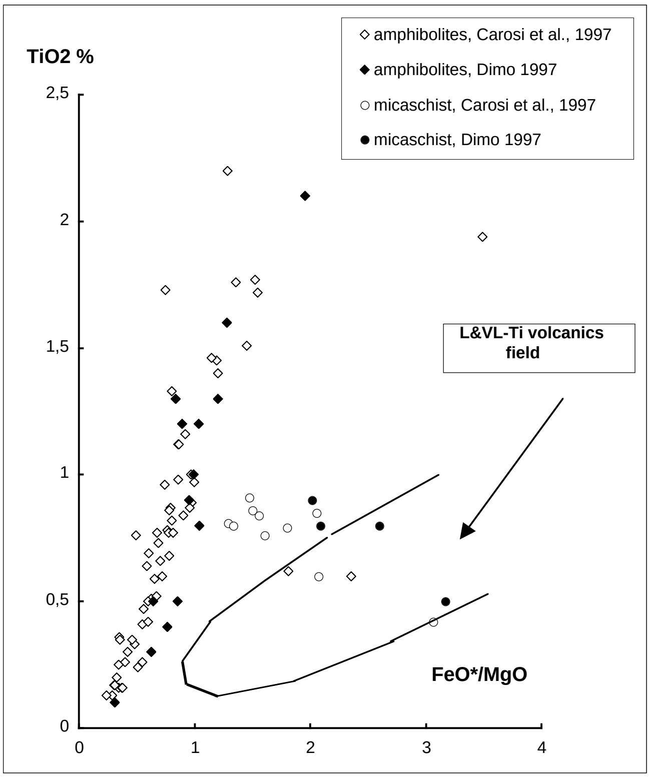

Fig. 5 - TiO^2 and SiO^2 versus FeO*/MgO for the metamorphic sole.

must be emphasized that in all these cases, the very low-Ti magmatism follows the high-Ti magmatism.

Both north-western and north-eastern ophiolites display a sedimentary cover consisting of radiolarian cherts which are roughly coeval in all the examined sections (Bortolotti et al., 1996). The stratigraphical base of the cherts sampled in the western part of the ophiolite belt ranges from late Bajocian/early Bathonian to late Bathonian-early Callovian, whereas the radiolarian assemblages found in the base of cherts from eastern ophiolites suggest an age ranging from late Bathonian to early Callovian.

$^{40}Ar/^{39}Ar$ geochronology (Fig. 1) confirms these data (Vergély et al., 1998). The Shemri plagiogranites in the north-eastern part of the Albanian ophiolite belt give an age of 163.8±1.8 Ma; petrological features observed in these plagiogranites are considered to be typical of acidic members of boninitic series (Bébien et al., 1997). A doleritic dyke in the Bulqiza massif gives an age of 172±1.7 Ma.

In Albanian ophiolites, low- and very low-Ti magmatisms, particularly abundant to the E, seem to follow a high-Ti magmatism mainly located to the W. Nevertheless, as far as we know, no break appears neither in magma compositions nor in space and time. Generally high-Ti magmatisms on the one hand, and low- to very low-Ti magmatisms in the other hand are related to different settings, which are mid-ocean ridges for the formers and island arcs for the latters. However, all the available data support the hypothesis that the Albanian ophiolites were formed in a setting where both high-Ti, low-Ti and very low-Ti magmatisms coexisted either spatially or temporally (Bortolotti et al., 1996). Consideration of the ophiolitic metamorphic soles will afford important informations concerning this setting.

OPHIOLITIC METAMORPHIC SOLES

Geological setting

The Albanian ophiolites are thrust onto a substratum made up of a Triassic to Middle Jurassic carbonate sequence, and a volcano-sedimentary formation that includes Triassic radiolarites. A metamorphic sole, less than 0.5 km thick, occurs along both the eastern and the western sides of the ophiolite belt, between the serpentinized peridotites and the substratum. It mainly consists of amphibolites, gneisses and micaschists, grading rapidly downward into relatively unmetamorphosed rocks.

Sole protoliths

On the basis of petrochemical data, the amphibolites clearly originate from basaltic and gabbroic protoliths. SiO^2 contents are on the whole less than 50%. The amounts of Al_2O_3, FeO, MgO, CaO, TiO_2, or of trace elements such as Cr, Ni, Y, Zr, show large variations. In the TiO_2 versus FeO*/MgO diagram (Fig. 5), most of the amphibolites plot close to the straight line TiO_2 = FeO*/MgO. Some amphibolites plot in the same field than the high-Ti basalts found near the top of the ophiolitic sequence, and trace element contents broadly confirm this similarity. The other amphibolites, although characterized by low-Ti contents, clearly differ from low- to very low-Ti hypabyssal and volcanic formations by lower FeO*/MgO ratios. Such very low FeO*/MgO ratios are unlikely present in magmatic liquids originated from the mantle, but are present in cumulates. Accumulation of variable amounts of plagioclase and olivine, often associated with clinopyroxene, accounts for variations in aluminium, iron, magnesium and nickel contents, as well as for low incompatible element contents. These characteristics are typical of troctolites and olivine gabbros related to high-Ti basalts (Turku, 1987; Carosi et al., 1996; Dimo, 1997). Therefore, as far as we know, no indisputable evidence of the presence of low- to very low-Ti magmatisms occurs in the metamorphic soles: the amphibolites present along both the eastern and western sides of the ophiolite belt seem to include only members of high-Ti magmatisms.

Micaschists and gneisses are characterized by higher SiO^2 contents (57% < SiO^2 < 80%), and chemically range from clays to graywackes protoliths. Trace element contents well compare with those determined for the continental crust (Taylor and MacLennan, 1985). The protoliths of micaschists and gneisses are probably siliciclastic sediments with pelitic components (Carosi et al., 1996; Dimo, 1997).

Thermobarometry

The metamorphic sole shows a steep apparent inverted metamorphic gradient, with granulitic assemblages preserved close to the contact with the obducted peridotites, going downward into almandine-amphibolite sub-facies assemblages, amphibolite facies, then greenschist facies rocks (Fig. 6).

Granulitic assemblages are found near Gjonaj (SW of the Bulqiza complexe) and Derstila (W of the Shpati massif). They are characterized by the association of pyrope- almandine garnet, diopside ± enstatite, labradorite, quartz and accessory phases (rutile, apatite, magnetite). Corresponding P-T conditions are estimated at 800-850°C and 0.9-1.2 GPa (Dimo, 1997). Retrograde transformations to garnet-amphibole assemblages are marked by the development of kelyphitic textures around the garnet and the replacement of pyroxene by amphibole.

The evolution of the mineral assemblages downward through the sole is marked by a rapid disappearance first of

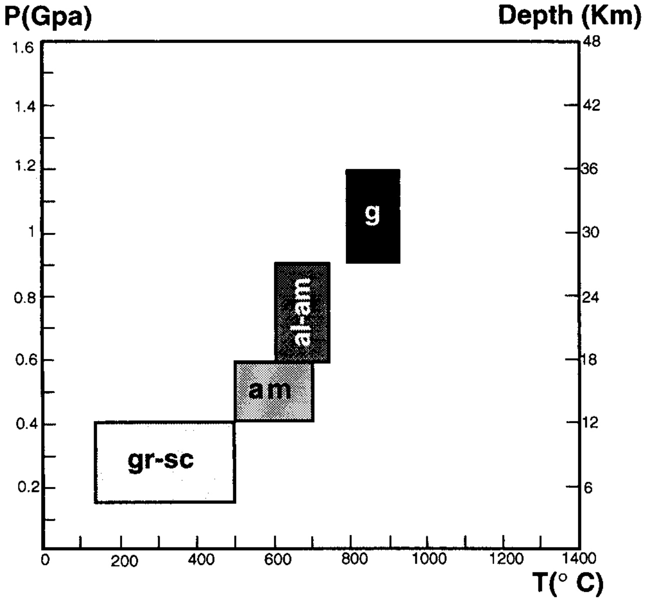

Fig. 6 - Pressure-temperature conditions of formation of the different metamorphic facies in the metamorphic sole (g: granulite facies; al-am: almandine amphibolite sub-facies; am: amphibolite facies; gr-sc: greenchist facies).

enstatite and then of diopside. Garnet evolves from almandine-pyrope to almandine and finally disappears. Anorthite content in plagioclase decrease from 60 % to 15-20 %. In the whole metamorphic sole, P-T conditions range from the values determined in the granulite facies rocks to 300-400°C and 0.2-0.3 GPa in the greenschist facies rocks.

Therefore, the metamorphic soles that are presently exposed along both sides of the Albanian ophiolite belt are clearly made up of rocks transformed in different places under different P-T conditions, corresponding to depth of about 30-35 km for the more metamorphosed ones. They have been afterwards exhumed and piled up during the thrusting of the ophiolitic nappe.

The study of garnet pyroxenite enclaves in a serpentinite breccia that crosscuts effusives near Derveni (NW of the Albanian ophiolite belt) confirms and complements these results (Gjata et al., 1992). According to geochemical data, these garnet pyroxenites probably originate from oceanic crust gabbroic protoliths, and thermobarometric considerations indicate that they show high temperature (ca 1200°C) and high pressure (ca 1.5 GPa) primary assemblages.

Geochronology

Several ^{40}Ar/^{39}Ar radiometric ages have recently been determined on amphiboles and micas from metamorphic rocks (Dimo, 1997; Vergély et al., 1998). The main results are as follows (Fig. 1). 1) At the same latitude, the eastern and western metamorphic soles give the same ages. 2) These ages range from 160 to 164 Ma in the northern complexes, 165 to 172 Ma in the median complexes, and 169 to 174 Ma in the southern ones. A Sm/Nd age of 166±2 Ma obtained from the garnet pyroxenites in the Derveni breccia (Gjata et al., 1992) agrees with these results. 3) At the same latitude, age determinations on rocks from the metamorphic sole and on a few magmatic samples from the ophiolite are indistinguishable. Moreover, in the northern part of the belt, this age is also probably the age of the radiolarian cherts that overlay the ophiolite (Bortolotti et al., 1996). Therefore, the sole metamorphism and at least the late stages of the ophiolitic magmatism are coeval.

The homogeneity of the different data obtained within the same sampling area probably result from fast cooling of metamorphic soles as the rocks were emplaced upon colder oceanic crustal formations.

DISCUSSION

To sum up, the Albanian ophiolites are characterized: 1) by the presence of low- to very low-Ti magmatisms, including boninites, in close association in space and time with high-Ti magmatisms; 2) by a high temperature-high pressure metamorphism observed in the infra-ophiolitic sole which originates from high-Ti plutonic and volcanic rocks and from siliciclastic sediments with pelitic components; 3) by the similitude of ages determined on magmatic samples from ophiolites and metamorphic samples from the infra-ophiolitic sole.

These data indicate that, *at the same time*: 1) high-Ti plutonic and volcanic rocks were transformed under different P-T conditions, corresponding to depth of about 30-35 km for the more metamorphosed ones (up to about 45 km for the garnet pyroxenites at Derveni according to Gjata et al., 1992); 2) partial melting processes occuring in the mantle gave rise to the formation of very low-, low- and high-Ti magmas.

An initiation of a subduction at or near a ridge, already proposed for Albanian ophiolites by Gjata et al. (1992) and by Manika (1994), can account for most of these facts. The high temperature-high pressure metamorphism observed in the infra-ophiolitic sole can be related to the subduction of a young, still hot oceanic lithosphere at depth of at least 30-35 km. Dehydration of this subducting lithosphere and release of H_2O into a hot, refractory overlying mantle wedge can induce low- to very low-Ti magmatisms including boninites above the slab. On the basis of experimental studies (Duncan and Green, 1987; Crawford et al., 1989; Umino and Kushiro, 1989) it is now widely accepted (Pearce et al., 1992; Danyushevsky et al., 1995) that boninite petrogenesis in the mantle requires high temperatures, relatively low pressures and presence of H^2O. Moreover, present-day boninites seem to be exclusively present in forearc regions (Monzier et al., 1993; Sigurdsson et al., 1993; Danyushevsky et al., 1995). High-Ti basalts provide evidences for the persistence of a residual spreading ridge magmatism as already proposed by Boudier et al. (1988) in a model of oceanic thrusting at an active ridge.

In order to test this hypothesis, a subduction zone infancy at a ridge axis has been numerically investigated in a 2D convective domain modelling the upper mantle where surface and subducting plates displacements are prescribed by time-dependent kinematic boundary conditions (Insergueix-Filippi et al., this issue). Experiments indicate that the initiation of a subduction at a ridge axis does not stop immediately the ascending asthenospheric flow, but leads to a deviation of its upper part in the same direction as the subducting lithosphere. Preservation of high temperatures in the mantle wedge favours the setting of short-lived boninitic magmatism at the earliest stages of subduction initiation, partly contemporaneous with a progressive extinction of MORB magmatism and initiation of arc magmatism. At the same time, temperatures in the subducting oceanic crust lead to the development of high temperature-high pressure metamorphic rocks.

CONCLUSIONS

In our study of Albanian ophiolites, we have taken into account at once the main petrological characteristics and the mutual relationships of the various formations that constitute the upper part of the ophiolite sequences, the nature of the protoliths and the conditions of metamorphism in the metamorphic sole and, for both the magmatic units and the metamorphic soles, the radiochronological data.

Our main result is that, in contrast to previously proposed hypotheses, it is virtually impossible to ascribe the various plutonic and volcanic formations present in the crustal sequences to different stages and tectonic settings. Consequently, a sharp distinction between ophiolites related to a mid-ocean ridge setting (W-type ophiolites) on the one hand, and to convergence processes (obduction and/or subduction, E-type ophiolites) on the other hand cannot be performed. Albanian ophiolites as a whole probably bear witness to the metamorphic and magmatic processes related to an infant subduction zone. They suggest that high-Ti magmatisms showing a MORB affinity can be closely linked with low- to very low-Ti island-arc type magmatisms during the pre-arc stage, and they consequently present a significant opportunity for the investigation of supra-subduction zone ophiolites and fore-arc areas.

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