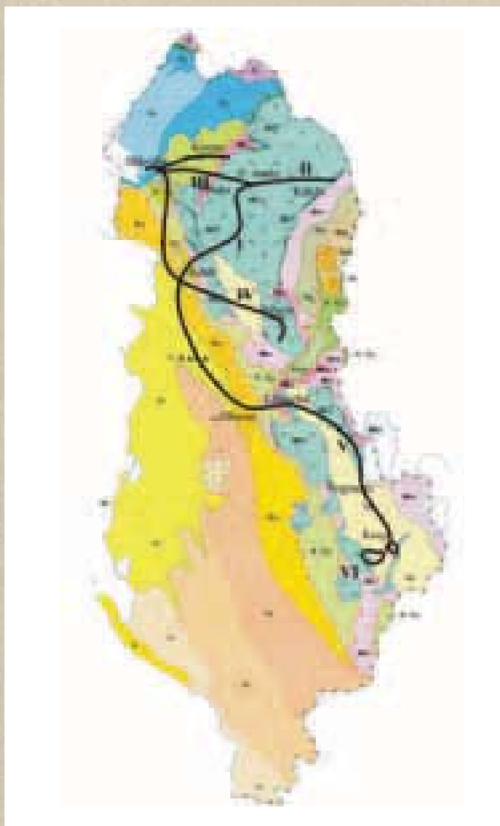
Field Trip Guide Book - P71

Volume n° 6 - from P55 to PW06

32nd INTERNATIONAL GEOLOGICAL CONGRESS

GEOLOGICAL SETTING OF ALBANIAN OPHIOLITIC BELT (ALBANIA)



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Florence - Italy
August 20-28, 2004

Post-Congress **P71**

The scientific content of this guide is under the total responsibility of the Authors

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GEOLOGICAL SETTING OF ALBANIAN OPHIOLITIC BELT (ALBANIA)

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Front Cover:
Geological map of Albania and field trip itineraries

Leader: S. Meco
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Introduction

Albania is part of the Alpine – Mediterranean mountain belt and can be subdivided into a number of predominantly NNW - SSE striking geotectonic units. The presence or absence of Cretaceous transgression as well as the presence or absence of magmatic rocks is the principal feature dividing the inner and outer units. The inner units are characterized by the Lower Cretaceous discordance and the presence of abundant magmatic rocks whereas in the outer units an almost continuous sedimentation from Triassic to Paleogene is detected. The geotectonic units of Albanides are from east to west: the Korabi, the Mirdita and the Krasta – Cukali zone, the Albanian Alps (restricted to the northernmost part of Albania), the Kruja, the Ionian, the Sazani zone and, finally, the Albano – Thessalian or Adriatic trough.

The Mirdita zone is comparable to the Subpelagonian (Pindos) zone in Greece and is the most important unit considered here. The ophiolites in this zone are connected in the north with the Dinaric ophiolites across the Shkoder-Peje line and are followed by the Pindos ophiolites in the south. They occupy an area of 4300 Km2, where 1/3 are ultramafic and 2/3 mafic rocks, while the acid ones have a poor distribution. The Albanian ophiolites can be subdivided into two belts (mainly in Northern Albania), which are different in their internal stratigraphy, petrography and geochemistry (Shallo 1992, 1994, Beccaluva et al. 1994a, b, Bortolotti et al. 1996, Robertson and Shallo 2000). Apart from their lithology (see below) both belts exhibit a different thickness as indicated by geophysical measurements (Frasheri et al. 1996). The eastern belt (eastern ophiolites) show a six to ten (up to fourteen) kilometer-thick column while the western belt (western ophiolites) comprises only a two to three kilometer-thick sequence.
The eastern ophiolites are characterized by thick harzburgitic tectonites, followed by dunitic and pyroxenitic cumulates, as well as gabbros and plagiogranites. A well-developed sheeted dyke complex exists beneath the volcanic sequence that consists of basaltic pillow lavas, andesites and rhyodacites. The ophiolitic sequence ends with a relatively thin chert up to a maximum of 15 metres, which, in turn, is overlain by Jurassic and Lower Cretaceous turbidites. The western ophiolites comprise harzburgitic and lherzolitic tectonites as well as plagioclase-bearing lherzolitic and dunitic cumulates. Relatively thin troctolites and gabbros are directly overlain by basaltic pillow lavas. A sheeted dyke complex is generally missing.
The geochemistry reflects the differences between the two ophiolite types. Basalts of the western ophiolites show mainly a MOR (Mid ocean ridge) character. By contrast the basalts of the eastern ophiolites are comparable with those formed above a supra-subduction zone (SSZ) environment or in an island arc (Bortolotti et al. 1996). Both ophiolites originated during Middle to Late Jurassic time as outlined below. Their mutual tectonic relation is still unclear, but there is no clear cut tectonic boundary between the two belts. Both ophiolites exhibit metamorphic soles consisting of amphibolites, micaschists and greenschists at their base (Turku 1987, Carosi et al. 1996, Bébien et al. 2000, Dimo et al. 1999, Dimo–Lahitte et al. 2001). 40Ar/39Ar age determinations indicate the formation of the metamorphic soles and thus the possible first emplacement of the ophiolites at 161-173 Ma i.e. Middle to Late Jurassic times (Bajocian to Callovian). Palaeontological evidence, using radiolarian, also suggests a Middle to Late Jurassic age (Bajocian to Callovian) for the formation of the ophiolites (Marcucci et al. 1994, Kodra et al. 1995, Marcucci and Prela 1996). A more comprehensive discussion of the stratigraphic problems regarding the palaeontological and the geochronological evidence is found in Robertson and Shallo (2000).
The analyses of stratigraphic, structural, petrological and geochemical data lead to the determination of two well-distinguished ophiolitic belts with MORB and SSZ but also various evidence that demonstrates a lateral transition between the two types. The study of ophiolites in the southern Mirdita zone also testifies to their longitudinal evolution (Hoek et al. 2002).
Different models are adopted to reconstruct the tectonic event succession in the Mirdita Oceanic basin but finally the situation in the Lau basin seems to be a very attractive model, which can explain the compositional variation of lavas from MOR to SSZ type.

DAY 1

Leaders : Prof. Dr. Lirim Hoxha, Institute of Geological Research, Prof. As. Dr. Agim Sinojmeri Faculty of Geology and Mining

On this day there will be a short review of volcanic sequences of the Mirdita zone from the western contact to the center of Mirdita.

GEOLOGY AND METALLOGENY OUTLINE

The study area located in the central northern part of Albania consists mainly of ophiolites and sedimentary rocks affected by thrust and reverse and normal faults (fig.1).

From the western through the eastern parts the following sequences are present: the Maastrichtian-Eocene flysch, the Middle-Upper Triassic platform in the limestone. In biomicritic marls over populated by planktonic forms Chondrites up to 7 centimeters long are also found, considered to be Late Cretaceous in age.

The Middle-Upper Triassic platform carbonate are located at the western and eastern peripheral parts of the ophiolites studied, on the western side. These rocks, although disrupted, outcrop from the highest

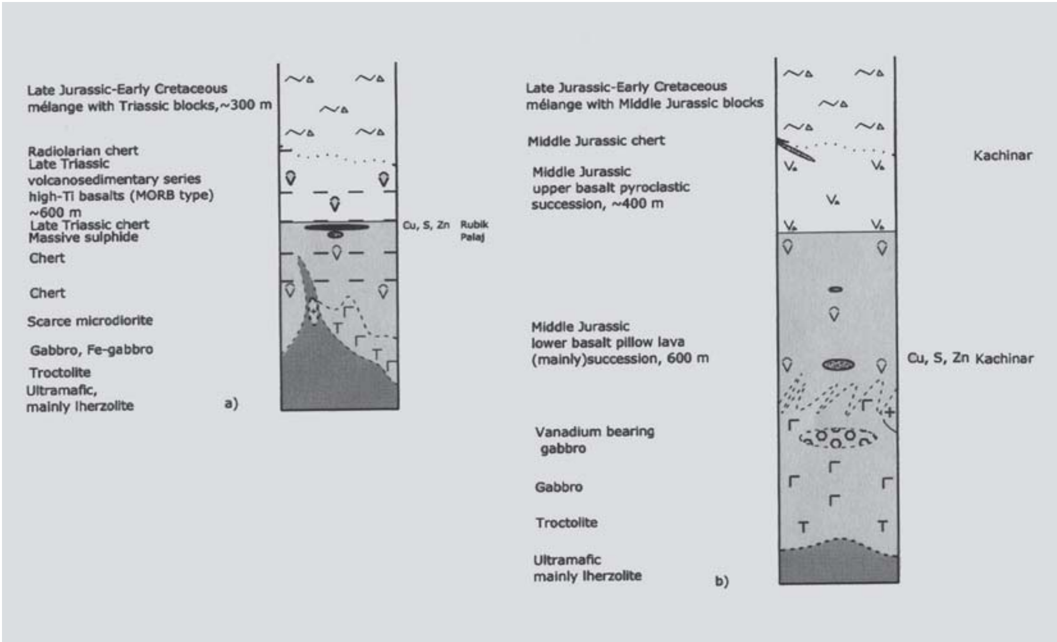

Figure 1 - Magmatic sequences of western type ophiolites

carbonate, the western type Lower Cretaceous mélange and flysch, the western type Triassic-Jurassic ophiolites, the eastern type Lower Cretaceous mélange, the eastern type Jurassic ophiolites, the Barremian-Aptian platform as well as the Neogene molasses and Quaternary deposits.

The Maastrichtian-Eocene flysch of Krasta zone (analogous of the Budva zone in the Dinarides and the Pindos zone in the Hellenides) - Crops out at the western part of the Upper Jurassic-Lower Cretaceous flysch-like deposits. Its uppermost parts belong to the Eocene stage (ISPGJ-IGJN 1983). In the study area, it consists mainly of intercalation of argillite, sandstone and marl and more rarely limestone and conglomerate. Globigerina tricolunides, Globorotalia angulata, Globigerina spp. and Globorotalia spp. belonging to the Middle Paleocene have been found peak of the area (Vela, 1170 m above sea level) down to about 100 m above sea level (Fandi River), with an apparent width of tens and hundreds of meters to 2 km and much more (outside study area). They are considered as “carbonate periphery” of ophiolites (Shallo 1985) or “continental margin of the Adria (=Apulia) plate” (Bortolotti et al.1996) or in a more precise way they are the lateral equivalent of the Pelagonian marginal units of Greece (Baumgartner 1985; De Bono et al. in press). They consist of micritic marls and stromatolitic limestone’s with Involutina sp. and Ostracoda of Late Triassic (Norian-Rhaetian)-Early Liassic age.

The western type mélange

The heterogeneous colored mélange (mélange) - The uppermost part of the western and eastern volcanic ophiolite is overlain by a remarkable deposition, a "block -in-matrix-type" mélange set in an argillite matrix, considered to be Late Jurassic-Early Cretaceous in age, throughout the study area (ISPGJ-IGJN 1982; Shallo et al.1985; Shallo 1994).

In the Rubiku area, the apparent uppermost part, argillaceous-siliceous shales and chert succession (deep sea sediments) of the volcano sedimentary series as well as Upper Triassic platform carbonate followed by a few to 10 meters argillaceous-siliceous depositions (e.g.Vela area), are overlain by mélange, consisting of sandstone, basic volcanic, volcanic hosted massive sulphide ores (e.g. Vela area), metamorphic ultramafics (ophicalcite), Triassic limestone blocks and clasts, ranging from about 100 meters to tens-of meters and meter scale. Based on the finding of Calpionellidae it is considered to be Late Jurassic-Early Cretaceous age (ISPGJ-IGJN 1982; Shallo 1994) or as Early Cretaceous (Hoxha 1990). From the age of youngest Upper Jurassic blocks comprising the mélange its age can be considered as Lower Cretaceous. Its thickness is about 350 meters.

In the Kachinar-Gziky area, the top part of Upper Bajocian-Lower Callovian manganiferous argillitic-siliceous series with chert (deep sea sediments) at the base, as well as both volcanic successions, are overlain by the mélange consisting of turbidites, Jurassic volcanics, Triassic limestone, chert, metamorphic ultramafics (high grade serpentinized harzburgite mixed with kaolinite-clay, chromium grains, magnetite, hematite and chlorite, so-called ophicalcite), from about a hundred meters to tens of meters and meters in thickness. The mélange might represent a shallow water, Lower Cretaceous post obduction deposits.

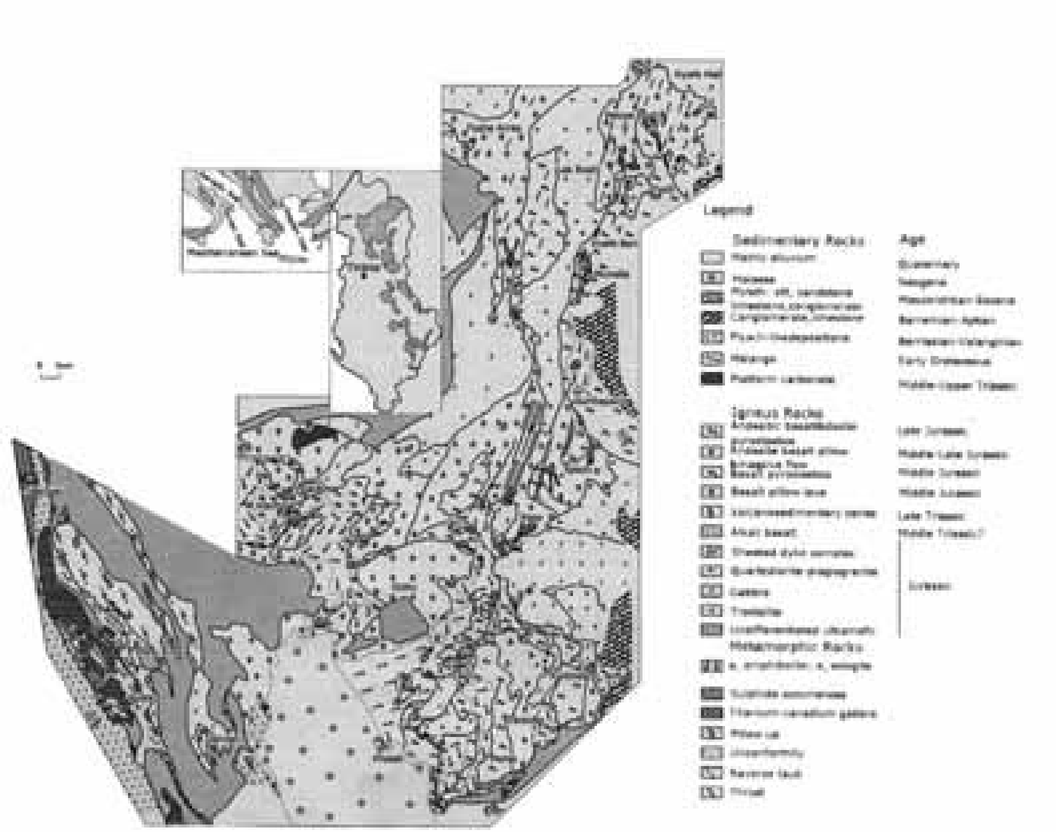

Figure 2 - Geologic map of the study region

Radiolarian assemblages found in the cherts at the base indicate Late Bathonian-Early Callovian ages (Marcucci et al.1994; Prela 2000). The drill proved thickness of the mélange at Kachinar area is about 350 meters.

Western type flysch

Upper Jurassic-Lower Cretaceous (Tithonian-Berriasian) flysch-like depositions - Crop out inside and outside the ophiolites, at the western part of the mélange-limestone association.

In the Derven area, relying on findings of the Crassicollaria biozone at the base of a 200- to 300-meter thick succession of flysch-like deposits transgressively overlying the ophiolites, the succession was dated as Tithonian-Berriasian (Gjata et al. 1989).

At the western part of the ophiolite-mélange-limestone association, flysch-like depositions are represented by a highly folded northwest trending formation, composed by marl, limestone, and sandstone intercalations. Calpionellidae and Calpionellopsis oblonga belonging to Late Berriasian-Early Valanginian age were found whereas at the Traschan area (Fig.2) Saccocoma, Cadosina sp., Globochaete alpina and Calpionella alpina dated the Tithonia-Berriasian (Hoxha 1990). These deposits represent a syn to post-obduction deposition and seem to be equivalent with the Lower Cretaceous Bosnian and Beotian (Greece) flysch belts.

Western type Triassic-Jurassic ophiolites

Western belt ophiolite - Consists of high-Ti tholeiites within volcano-sedimentary series in the western peripheral parts and the volcanic sequence in the western part (Fig.1, 2), mainly with lherzolite mantle suite and minor harzburgite and dunite tectonite and ultramafic and mafic cumulates (Shallo et al.1985; Beccaluva et al.1994).

Westernmost part ophiolites of Rubik-Vela area - The apparent lithological-stratigraphical sections comprise volcano-sedimentary series toped by hematite radiolarian chert and underlain by intrusive rocks. It must be emphasized that ultramafic rocks underlie volcano-sedimentary rocks (e.g. Vela area, fig.1) and give "wedges" both in volcano-sedimentary rocks (e.g.Rubik-Vela area) and volcanics of the Derveni area (ISPGJ-IGJN 1982; Hoxha, 1990).

The volcano-sedimentary series (Fig.2) comprises high-Ti tholeiitic pillow lavas of MORB affinity (Shallo et al. 1985; Beccaluva et al. 1994), with scarce intercalation of argillic-silicic-sericite/sericite-silicic-carbonate shales and slates, and infrequently, hematite radiolarian chert, varying in thickness from 2 meters up to 5 meters thick. The series is about 600 m thick, northwest trending with a dip of pillows and sedimentary intercalation 500 to 800 to the NE, and 800 to 850 to the SW at Rubiku sulphide deposit area.

The radiolarian assemblages (Capnodoce anapetas De Wever, Capnuchosphaera tricornis De Wever, C. deweveri Kozur et Mostler, C. triassica, C.sp., Sarla cf. hadrecaena (Der Wever), Spongostulus carnicus Kozur et Mostler, Triassocampe sp., Canoptum sp., Xiphoteca? Sp., Corum perfectum Blome group*) of the chert specimens, taken at intercalation with massive sulphide ores, indicate a Middle-Late Carnian, possibly including Early Norian (Hoxha 1995).

The presence of Triassic radiolarian assemblages in the volcano-sedimentary series and radiolarian cherts of Rubiku have been previously emphasized by Kelliçi (1990) and Marcucci et al. (1994).

At Rubiku deposit and its vicinity, basaltic pillow lavas are overlain by agglomerate and argillic-silicous shales topped by yellow-reddish hematite manganiferous radiolarian chert.

Volcano-sedimentary series, is underlain by gabbro, troctolite, ferro-gabbro, very scarce minor microdiorite (Rubik) as well as ultramafic injections and "wedges", ranging in thickness from a few meters up to 100 m (Derven sulphide deposit).

Altered ultramafic rocks, serpentinites as well as greenschist-amphibolite facies represent metamorphic rocks.

It must be emphasized that, all western type ultramafics, are significantly serpentinised and in many cases changed to serpentinites.

Greenschist-amphibolite facies is widespread in the western ophiolite belt; it is located along the volcano-sedimentary-ultramafic contact with thickness from a few meters up to 120 meters, with amphibolites from 2 to 4 meters (fig. 1). The metamorphic sole is supposed to have been formed due to a westward overall regional compression and intraoceanic subduction (Hoxha 1995). 39Ar/40Ar radiometric dating of metamorphic sole specimens taken in the northwestern part (not far form the study area) carried out in the Montpellier University laboratory indicate a Bajocian-Bathonian age (Dimo 1997).

In the southern continuation of the greenschist-amphibolite facies, in lherzolite breccias, in the vicinity of Derveni eclogite of griquatite type sulphide deposits are found (Gjata 1990).

At Rubiku deposit, volcanic hosted massive pyrite-chalcopyrite ores are in close association with yellow-reddish radiolarian chert.

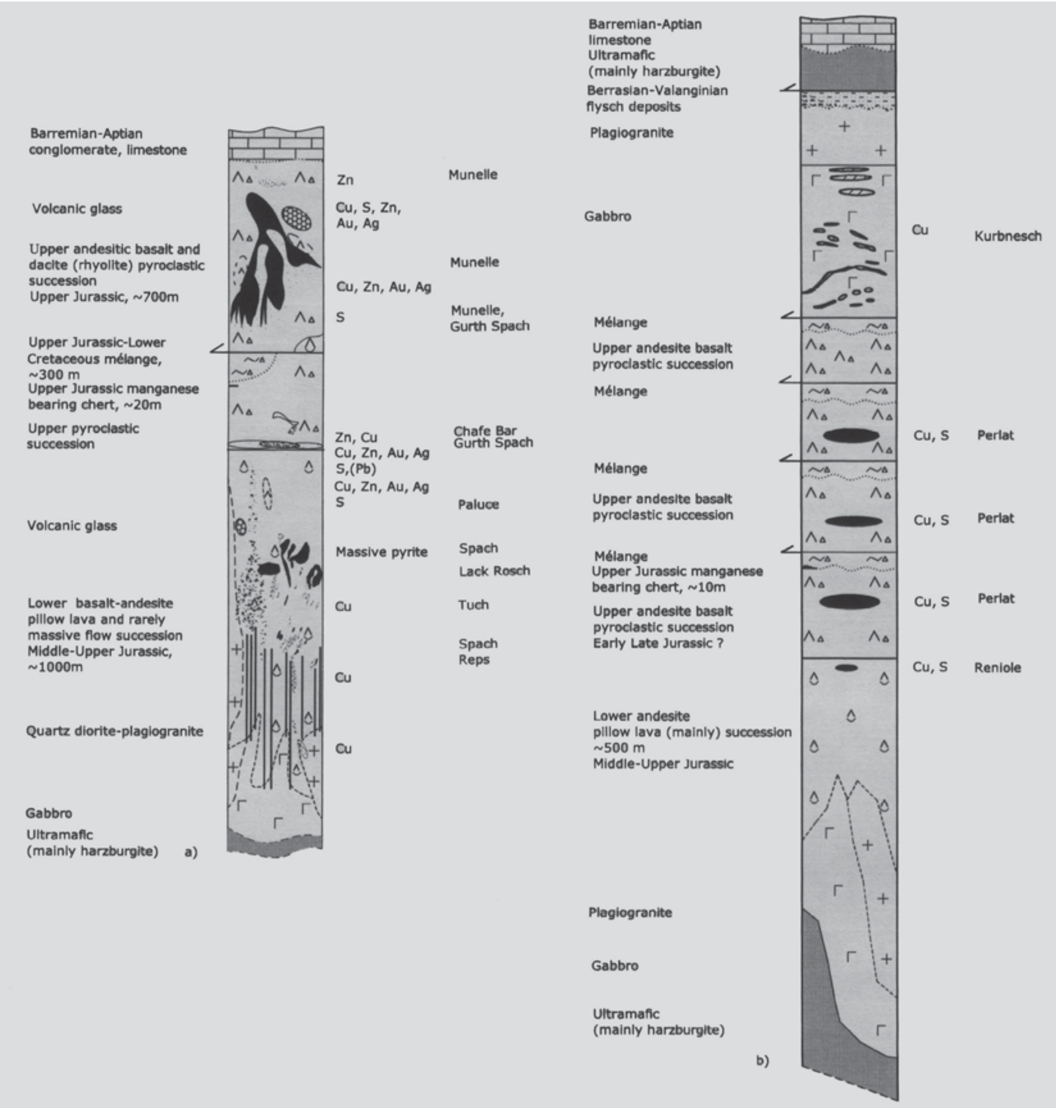

Figure 3 - Volcanic sequences of eastern type ophiolite

Western part ophiolite of Gziky-Kachinar area - The lithological-stratigraphical section consists of volcanic sequence overlain by Middle Jurassic hematite shales and is underlain by gabbro, scarce plagiogranite and ultramafic rocks (Fig. 1, 2).

The volcanic sequence consists of an Upper basalt pyroclastic succession averaging 400 meters and Lower basalt pillows (mainly) and massive succession, about 600 meters thick.

The radiolarian assemblages of the chert specimens taken at the uppermost part of Gziky and West Kachinar deposit volcanics, indicate Late Bathonian-Early Callovian age (Marcucci et al.1994; Prela 2000).

Volcanic hosted massive and stockwork sulphide, mainly pyrite-chalcopyrite and lesser sphalerite, affected by hydrothermal alteration, are found in the lowermost part of the pillow succession (Kachinar) and in the uppermost part, of the pyroclastic succession (Western Kachinar).

The enormous resources of vanadium-bearing titaniferous gabbros of the Kachinar area located

at their uppermost part, at the base of volcanics, averaging TiO_2 7%; Fe_2O_3 17% and V_2O_5 about 0.2%, should be noted.
The eastern type mélange
In the Kyafe Mali-Reps area the mélange consists of the same rocks as at the Kachinar-Gziky area as well as huge limestone, sub-alkali volcanics (trachyandesite, trachybasalt, not components of ophiolites), occasionally mixed up, and serpentine blocks, along a 1.7-kilometer long zone. It should be noted that olistoliths of limestone, from tens-of-meters to meter scale are found all along the front of Kurbnesch-Reps thrust (fig.1).
In the Reps area limestones are rich in fauna: Ptychites sp., Sturia ex.gr., Sansonorini Mays, Gymnites ex.gr.incultus (Beyrich) belonging to the Anisian stage. In biomicritic marl and phosphatic olistoliths blocks 1 to 3 m in size are found: Pelagic Bivalves, Nodosaridae, Frondicularia sp., Ostracoda, Ophthalmidiinae, Ophthalmidium sp., Ophthalmidium cf Carinatum of pelagic or pelagic and neritic facies, ranging in age from Ladinian to Late Triassic. The thickness of mélange based on drillings is about 250 m.
In the northernmost part of the study area near the Munella deposit, within the mélange there is also a block of granite 2x3 meters in size.

The eastern type Jurassic ophiolites
The Eastern belt ophiolite - This belt is characterized by low-Ti tholeiites of basalt-andesite and andesite-dacite (rhyolite) series underlain by sheeted dyke complex injections, and quartzdiorite-plagiogranite and gabbro plutonics (ISPGJ-IGJN 1982; Shallo et al. 1985; Beccaluva et al.1994) extending from Kyafe Mali in the north to Perlati in the south, offering the best prospects regarding copper-pyrite-zinc and precious metals mineralization. The presence of boninites (Shallo, 1990) indicate the rhyodacite formations in this area as the products of an extreme differentiation stage of the boninitic melt.
The volcanic formations of the eastern ophiolitic belt are characterised by the presence of boninites (Shallo, 1990). Among the products of the boninitic melt, the rhyodacite formations are the extreme stage of its differentiation.
Northern Kyafe Mali-Spach area - It is comprised of two volcanic successions, the lower and the upper one (fig. 3).
The Middle-Upper Jurassic lower andesite-basalt pillow lava succession - It consists mainly of pillows (spilite) and occasional massive flows with interlayered tuffites and agglomerates, about 1000 m thick. The pillows have ellipsoidal or spherical structures, generally from 0.3 m to 2 m. They have a glassy rim and quenched glass filling the interstitial cavities. The inside shows an amygdaloidal texture, with elongated vesicles, ranging in size from a few millimeters to 20 millimeters, filled with secondary minerals such as carbonate, quartz, zeolite and rarely pyrite and chalcopyrite.
Several sulphide deposits are located in this volcanic sequence (ex. : Tuch, Spatch, Laku Roshi) (fig. 3).
Dykes, extending over more than 30 km, from Reps to Kyaf Mali, are several centimeters to 2-3 meters thick, consist of dolerite, microdiorite, andesite, dacite or rhyodacite and rare boninite dykes (Shallo 1994; Beccaluva et al. 1994).
The Upper Jurassic upper andesitic basalt and dacite pyroclastic succession, 0.5 to 0.7 km thick, consists mainly of pyroclastic rocks basalto-andesitic pillow-lavas and massive flows, rhyodacitic domes and subordinated interlayered volcanic glasses. This succession is followed by a 1 m to 10 m thick manganese-bearing hematite radiolarian chert. The upper sequence had the best development in the Kimza-Munella area (fig. 4).

Massive rhyodacitic formations, 350÷400 m thick, with subordinated basaltic flows and one hyaloclastic level, are developed in the bottom of the upper unit in the Munella region (fig. 5). The chemical analysis of the rhyodacitic formations show high Si contents (SiO_2 ~ 78 %) and low Al and K contents (Al_2O_3 ~ 10.5 % ; K_2O ~ 0.25 %), excepting two pyritised samples with about 2.5 % K_2O. The FeO/MgO ratio varies from 2 to 6 according to the FeO variations (5 to 9 %) and minor changes in MgO (1.5 to 2 %). They are also Ti-poor (TiO_2 : 0.30 to 0.35 %).
The black vesicular basalts with andesitic intercalations, up to 300 m thick, constitute the top of the upper unit in the Munella region. Fine albite crystals associated with chlorite (pennine), magnetite and recrystallized glass constitute the black mass of rocks, while the vesicles, more than 5 mm in diameter, are filled by opal, epidote, albite, chlorite and sulfides. Bulk analyses indicate very low Ti-content (TiO_2 = 0.7 %) and low FeO/MgO ratio. This type of basalt (VLT) delineates the upper part of volcanic sequence in the island arcs (upper lavas of Troodos or Oman), testing the impoverishment of the source with incompatible elements at the end of magnatic

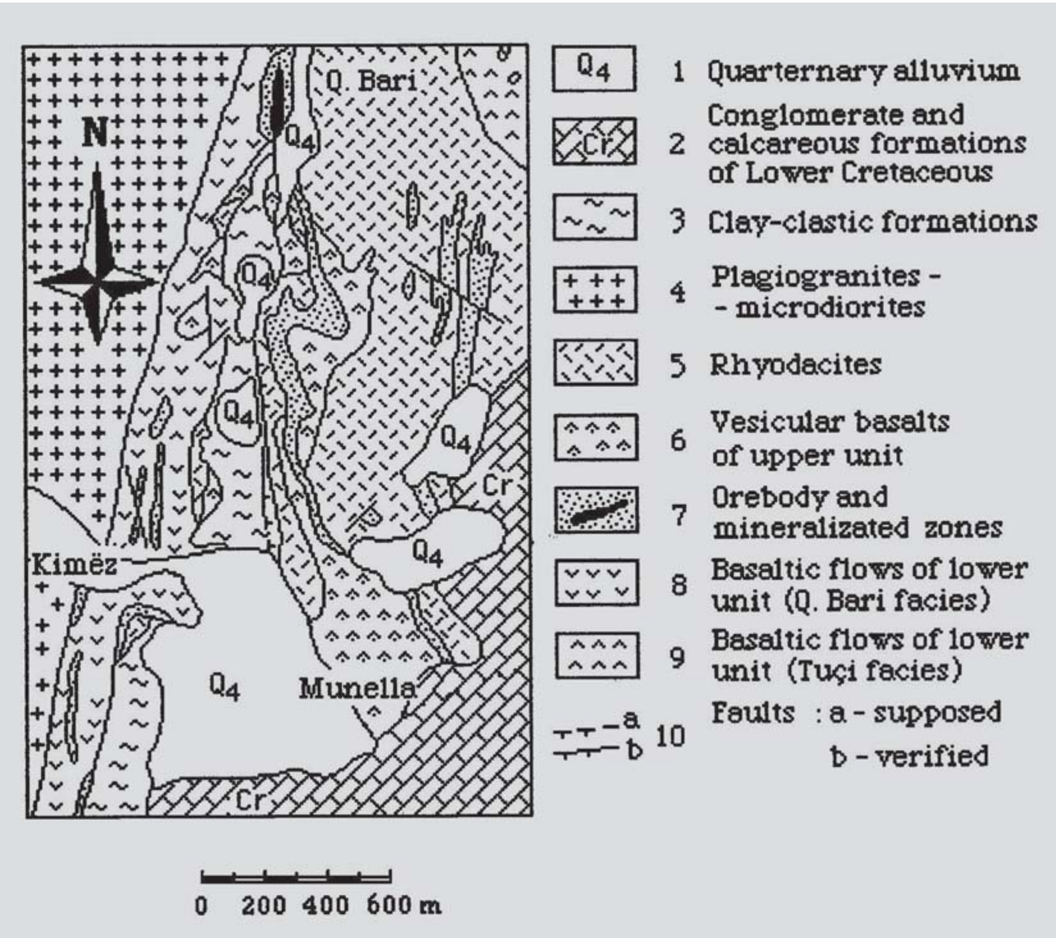

Figure 4 - Geologic map of Munella region

evolution (Ohnenstetter and Sider, 1988).

The monomineral zeolitic rocks, mainly composed of stilbite, develop east of the sulfide deposit, and divide the basalts and rhyodacites discontinuously. They are richer in Ca and Al, poorer in Si ($SiO2$ ~ 68 %) than rhyodacites, presenting a chemical composition compatible with altered andesites. Another feature of zeolitic rocks is the absence of the Eu-negative anomaly, differing from the other Munella volcanic formations (Sinojmeri 1990, 1994). (Fig. 5)

At the top of rhyodacites the sulphide hidrothermal submarine mineralization of Munella is developed (fig. 5). The mineralized bodies reveal a lateral and vertical zonality delineated by increasing Zn and Pb content to the rim and to the highest levels.

The radiolarian cherts, covering the massive stratiform orebody, indicate the suspension of volcanic activities where the basaltic and andesito-basaltic nature of overlayred lava probably indicate the beginning of a new volcanic cycle. Lower Cretaceous terrigenous and carbonate deposits cover the top of this volcanic sequence.

The radiolarian assemblages taken in the chert at the uppermost part of Kyafe Bari volcanics indicate Late Callovian to Early Oxfordian age (Marcucci et al. 1994; Prela 2000).

In a cross section from the western through the eastern parts of the study area, overthrusting of the western and the eastern type ophiolites onto Upper Triassic limestone overlain by Lower Cretaceous mélange is quite clear, they in turn, are underthrusted by Lower Cretaceous flysch-like deposits (Fig.4).

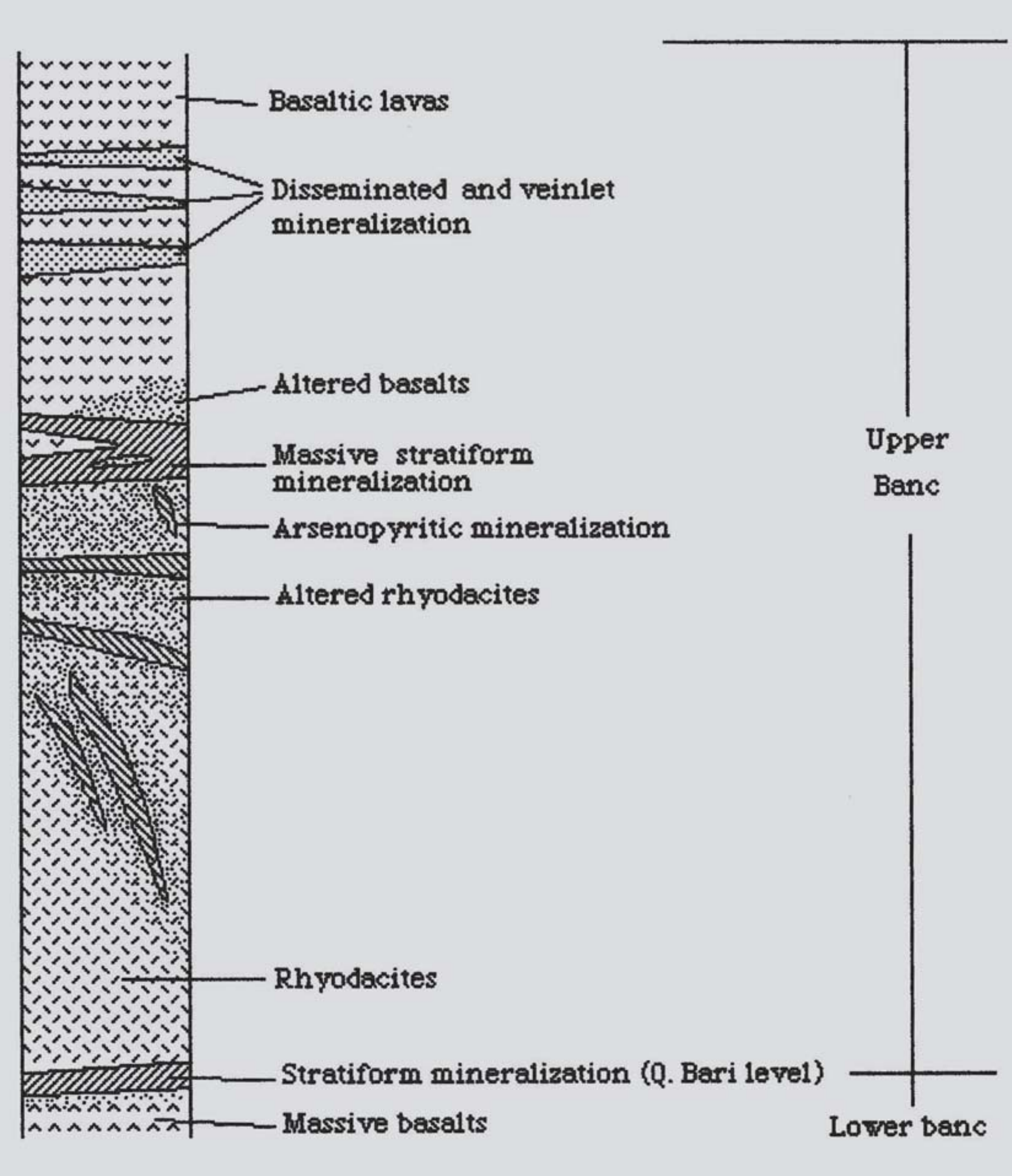

Figure 5 - Location of different ore types of Munella in the volcanic sequence

Excursion Stops:

During this excursion we will cross the volcanic formations of Eastern and Central Mirdita.

Stop 1:

Locality: Rubik

Topic: The contact of ophiolites with Triassic-Jurassic carbonates.

The volcano-sedimentary series comprises high-Ti tholeiitic pillow lavas of MORB affinity, with scarce intercalation of argillic-silicic-sericite/sericite-silicic-carbonate shales and slates, and infrequently, hematite radiolarian chert. Between basalt and chert lie lenses of massive sulphide (pyrite, chalcopyrite).

Stop 2:

Locality: Road from Rubiku to Fushe Arrez
Topic: The contact of ophiolites with Triassic-Jurassic carbonates.

The volcanic sequence consists of an Upper basalt pyroclastic succession and Lower basalt pillows (mainly) and massive succession.

Basaltic pillow lava is very well exposed along the road.

Stop 3:

Locality: Kyafe Mali
Topic: Lower part of eastern type Ophiolites

The volcanic sequence consists mainly of pillows and occasional massive flows. The pillows have ellipsoidal or spherical structures, generally from 0.3 m to 2 m. They have glassy rims and quenched glass filling interstitial cavities. The inside shows an amygdaloidal texture, with elongated vesicles, ranging in size from a few millimeters to 20 millimeters, filled with secondary minerals such as carbonate, quartz, zeolite and rarely pyrite and chalcopyrite.

A parallel dyke system is well distinguished from the road.

Stop 4:

Locality: Kimza
Topic: Lower part of eastern type Ophiolites.

Outcrops of quartz-diorite/plagiogranite, sheeted dykes and volcanic rocks from the lower andesito-basaltic series. A system of subvertical diabasic and dioritic dykes 2-3m thick with a dominant NNE strike is developed over the plagiogranites. These dykes represent the lower boundary of the sheeted – dyke complex. Chemical analyses from these dykes reveal tholeiitic composition and indicate a boninite affinity.

Stop 5:

Munella.

Outcrops of the volcanic rocks of the upper part of the basalt-dacite lava sequence that forms the top of the eastern ophiolite. Radiolarian chert covers this volcanic series and is itself overlayed by Lower Cretaceous terrigenous and carbonate deposits. The overlying Lower Cretaceous limestones are only mildly deformed. Volcanic rocks are represented by fine grained to glassy, aphyric and rarely phyric andesitic-basaltic pillowed and massive lavas, breccias and hyaloclastics, phyric dacite, rhyodacite and rhyolite extrusives and pyroclastics, as well as andesite-basaltic, andesitic, boninitic and rhyodactic glasses. These rocks have a vesicular texture. Massive zeolitic rocks of andesitic composition outcrops at the contact of rhyodacites with basalts of the top of the section. The chemical composition of the volcanic rocks shows the presence of arc tholeiites and boninites, similar to the volcanic rocks formed in the supra-subduction zone setting (Shallo 1992). In this area the biggest volcanogenic sulfide deposit in Albania is located, represented by submarine hydrothermal type mineralization, mostly pyrite-chalcopyrite at the center and more polymetalic in the lateral and upper parts. In these deposits interesting Au contents are detected.

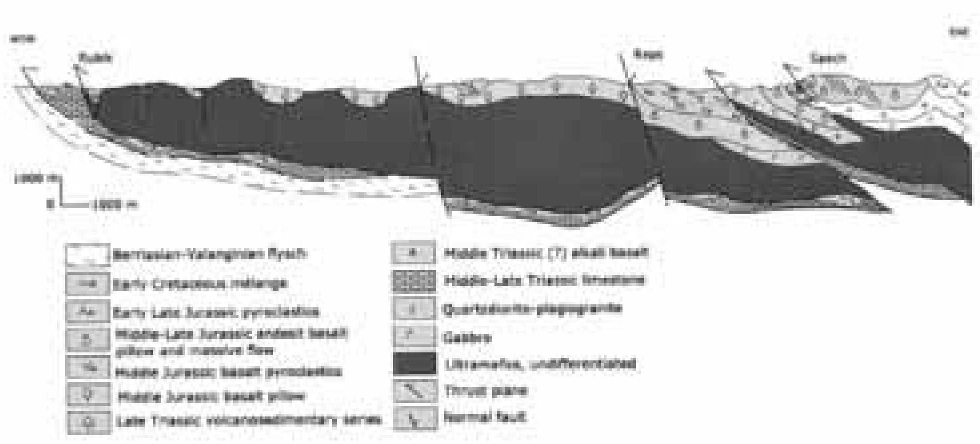

Figure 6 - Cross section from the eastern parts of the study area

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Stop 6:

Lak Roshi.

Basalt-andesitic sequence of lower unit with subordinate intercalations of rhyolite. Rhyolite dykes and plagiogranite intrusions intersect the volcanic rocks. The volcanic glasses found in this area are of andesite and dacite composition and are exceptionally fresh.

A hydrothermal submarine sulphide mineralization is located within hyaloandesite basalt (fig. 7). Interesting Au and Se contents are found in these deposits.

DAY 2

ITINERARY DAY 2 : The Eastern Ophiolites
Guides: A. Meshi, I. Hoxha, I. Milushi
Itinerary : Fushe Arres–Kukes
The Kukes Ophiolite massif

The Kukes ophiolitic massif is located in the NE part of the eastern ophiolitic belt of Mirdita.

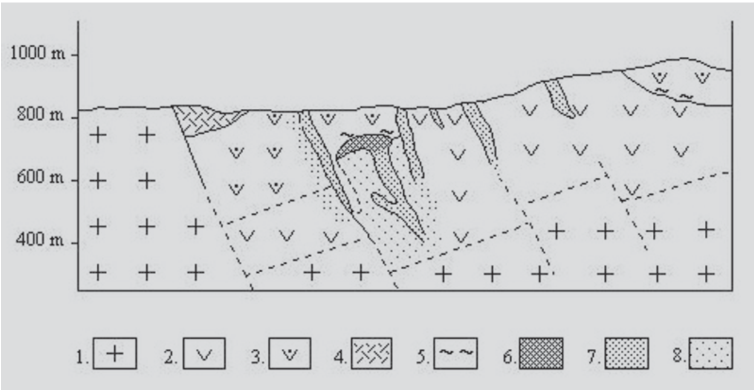

Figure 7 - Cross section of Laku Roshi sulphide deposits. 1. Plagjeogranite 2. Basalt 3. Andesito-basalts 4. Rhyolites 5. Radiolarian chert 6. Massif mineralizated body 7. Disseminated mineralization 8. Altered surrounding rocks

It represents the most complete lithological continuity of this belt. This fact makes the Kukes massif of particular interest as regards to reconstruction of the tectonic events that generated this Tethysian oceanic lithosphere trough during the Middle Jurassic.

The division into the western (lherzolitic) and eastern (harzburgitic) belts, where the Kukes ophiolitic massif is located, has been assumed based on the petrological variations (Ndojaj, 1963; Dede et al., 1966; Tashko, 1976; Shallo et al., 1985; Cina et al., 1987). This distinction has been ascribed by Shallo et al. (1995) as two distinct geodynamic sites: the western ophiolite being derived from an oceanic lithosphere and the eastern one from a suprasubduction environment. Kodra et al. (1995) and Tashko (1996) favour a progressive development of oceanic crust in which the western lherzolitic ophiolite represents an early stage and the eastern harzburgitic ophiolite, a more mature stage of oceanic spreading. The model of Hoxha (1995), based on structural and kinematical studies, indicates that the Kukes ultramafic massif might represent the eastern flank of a paleoridge striking NNW-SSE. All the groups regard the ophiolite as being derived from the opening of a local oceanic rift and discard an allochthonous origin as proposed by Robertson (1996) and Robertson and Shallo (2000). Finally, Nicolas et al., (1999) ascribes the contrast between the eastern and western massifs to successive episodes of magmatic and amagmatic spreading in a slow spreading environment. In this context, the Kukes ophiolite is the most typical representative of the eastern belt, exposing all the features of a spreading magmatic episode.

Emplaced during the Middle - Late Jurassic on the continental margin of the Korab-Pelagonian craton, the Mirdita ophiolite nape has been involved in the southwestwards thrusting of Dinaric-Albanic-Helenic units during the Eocene Alpine tectonics. However, it has not been affected nor only mildly deformed by Alpine events, as marked by sub-horizontal Cretaceous deposits that cover the Kukes ophiolite massif. (Fig.9)

The dike complex of steep dip (Nicolas et al., 1999) also indicates that the ophiolite has not been significantly tilted. The planar sub-horizontal structures of low-T peridotites confirm that this ophiolite has not been affected by the orogenic deformation. This is of major importance because it proves that in contrast with zones bordering it, the Kukes internal corridor has eluded major Eocene Alpine deformation. The 10km thickness (Bushati 1996) of the Kukes ophiolite massif could explain the near absence of the Alpine deformation in this corridor.

An inverse metamorphic sole is observed alongside

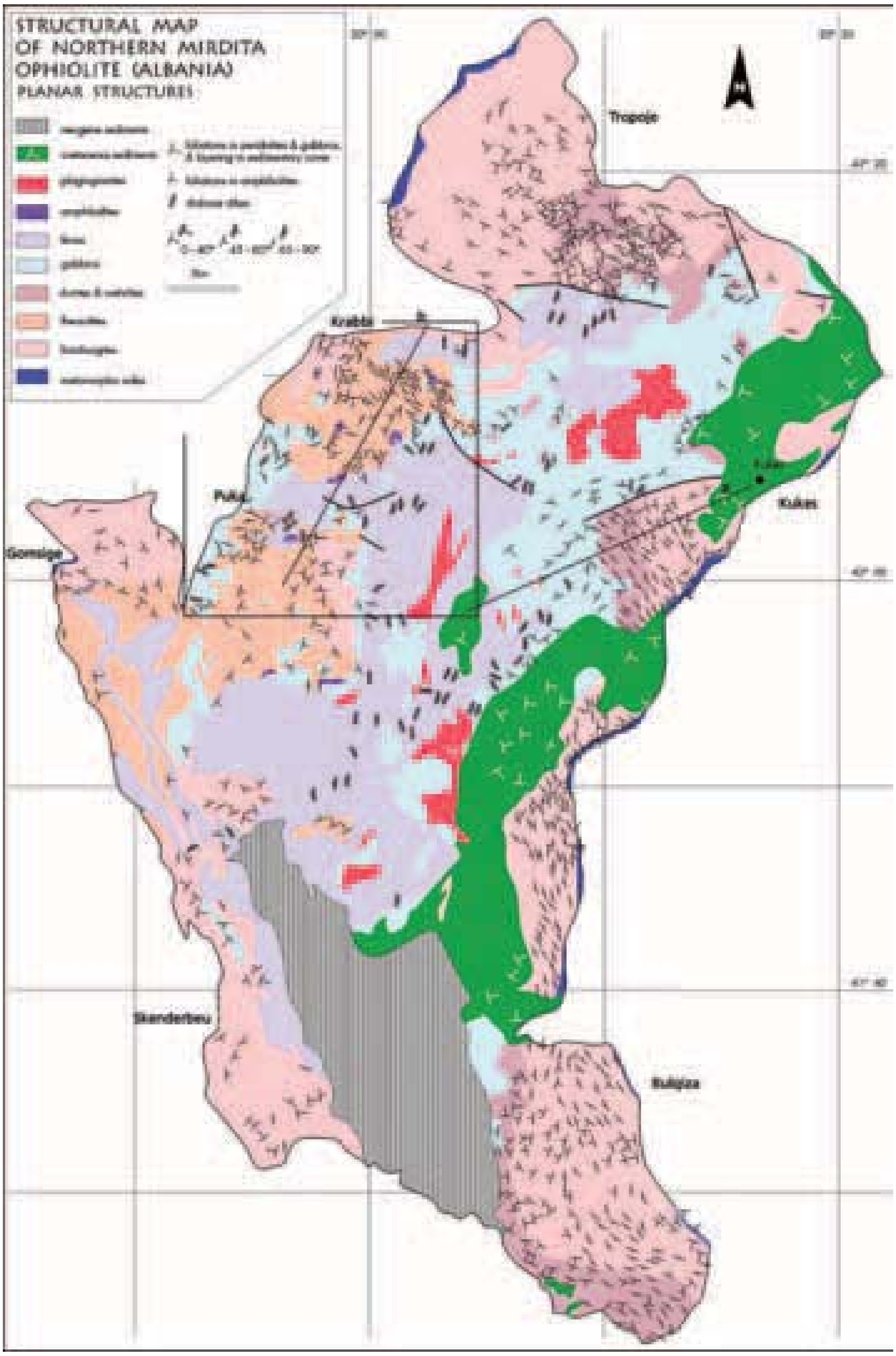

Figure 8 - Geological and structural map of the northern Mirdita ophiolite showing planar structures. After Nicolas et al., 1999.

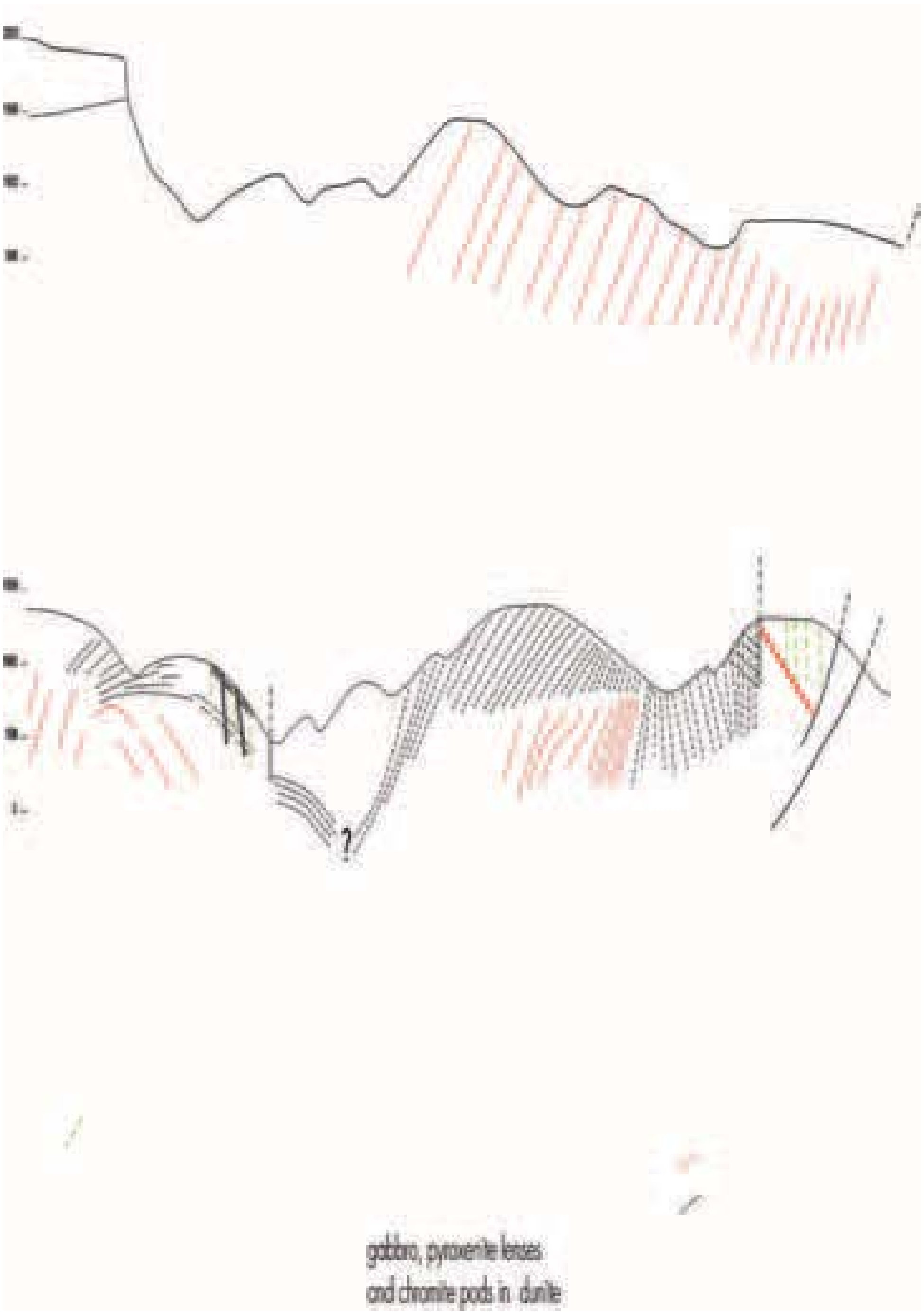

Figure 9 - Cross section (location in Fig.8) illustrating the differences between (a) the central Mirdita depression and the eastern Kukes massif with a typical ophiolite oceanic lithosphere, and (b) the western Puka and Krrabi massifs whose thin crust and tectonized uppermost mantle evoke a setting with mantle denudation. Notice the Upper Jurassic-Lower Cretaceous subhorizontal and transgressive limestones. After Nicolas et al. 1999).

the SE border. This metamorphic sole is connected to the ophiolite of the Kukes massif and moreover it is in the contact of the low temperature peridotites. Ar40/Ar39 age determinations for the amphibolites from the high grade metamorphic sole date 163 Ma (Vergely et al., 1998). U/Pb radiogenic dates of 166±22Ma in the apatites from plagiogranites intruding lowermost basaltic lavas (Ivanaj, 1993) provide a minimum age of the oceanic crust. The radiolaritic dating (Prela et al., 2000) suggests the age of Late Bayosian–Early Callovian for the fauna associated to lower basaltic lavas and the age of Middle Callovian–Late Oxfordian for the fauna associated with dacitic flows.

The near coincidence of the ophiolite and detachment ages, and the occurrence of high grade metamorphism in the garnet amphibolite facies soles suggest that the lithosphere involved in the intraoceanic detachment was young and hot. The placement of the ophiolite is postdated by the deposits of Upper Jurassic and Lower Cretaceous limestones.

Stop 7:

The dike complex

The differentiated keratophyre dikes are abundant in this field. Their composition is from andesite – dacite up to rhyolite (Shallo and Gjata 1995) and they are Si-saturated low-tholeiites with IAT and boninitic affinity.

Figure 10 - The keratophyre veins of the sheeted dikes complex

Based on structural relations in this outcrop, at least two dike generations have been defined: one is earlier, striking at 55NW50; the other one is later, striking at 20W70 and intersecting the first one. The dike/dike contacts are often tectonized, alongside which the hydrothermal veins, mostly epidote, are developed.

In other places, the entire complex of doleritic dikes is developed, but it is ill-organized and discontinuous. Being an early generation it is intensively hydrotheramalized and altered, making the outline of the dike/dike contact almost impossible. The roots of the doleritic dikes complex in the upper part of the isotrope gabbros are extremely broken but the deformation always remains at a low temperature, corresponding to the green schist facies. A doleritic dike compilation for the entire ophiolite results in an average orientation of 10E80 (Nicolas et al., 1999).

Stop 8:

Gabbro section

The gabbros are concordant in the top of the ultramafic unit west of the massif, but, to the north the contact is faulted and vertical (Fig.11) and indicates a right strip-slip motion. Locally, near the tectonic zone a dunite-gabbro contact is observed, which is not connected to late tectonics. (Fig.11)

This specific contact has come out because of the absence of serpentinite alongside it. Also, on the dunite side websterite is observed while on the other side – a recrystallized but not well-foliated dolerite. The gabbro facies itself is very heterogeneous (gabbro with fine grain amphibole, gabbro with well-oriented amphibole and intruded by gabbros with amphibole). All the rocks are strongly fractured and reinjected, giving the gabbro facies a breccial look. This, together with a low temperature lithospheric deformation in the peridotites (Hoxha and Buollier, 1995) observed near this fault, could therefore be described as an early dextral ductile shear zone.

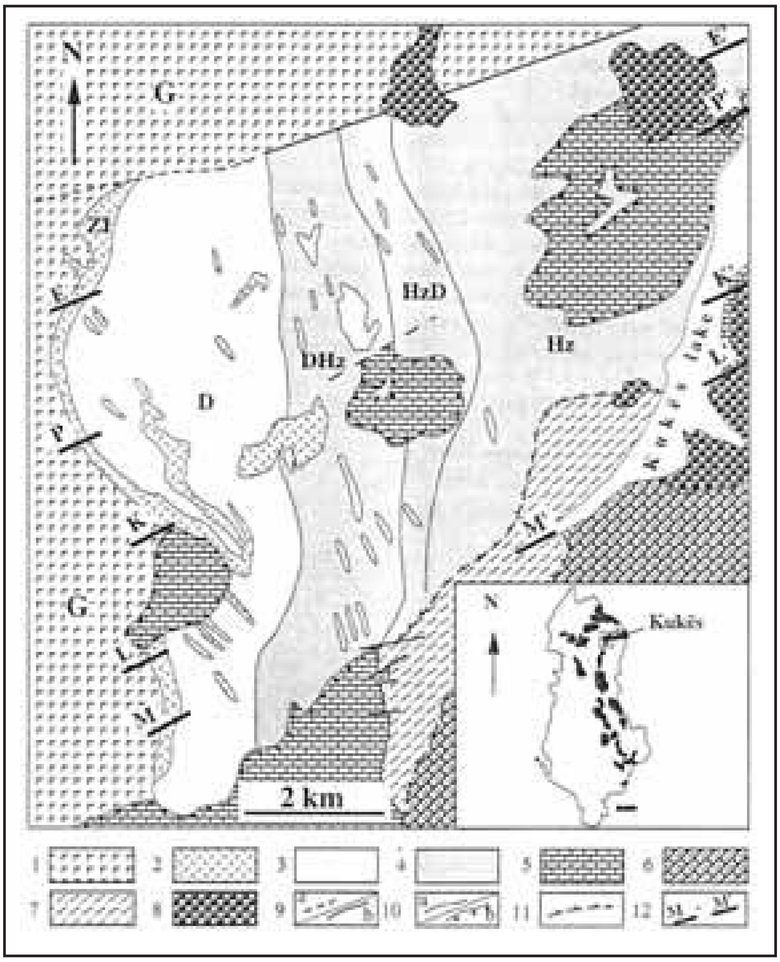

Figure 11 - Schematic geological map of the Kukes ultramafik massif. 1. gabbro-norite(G); 2.intermediate zone(Zi); 3.dunites(D); 4.harzburgites(Hz); 5.Lower cretaceous limestones; 6.Upper Triassic-Lower Jurassic limestones; 7. volcano-sedimentary mélange and metamorphic sole. After Hoxha and Boullier, 1995)

The gabbros at the base are layered and become more isotropic towards the top. The layering is characterized by richer layers of clinopyroxene in a comparison ratio to plagioclase. In layered gabbros the magmatic foliation is weak, while the lineation is fairly good. A very strong lineation of mineral aggregates in a layered troctolite facies (Fig.12) presents dynamic features at Moho level.

In the outcrop of this stop area, in gabbros of SL type the 2 cm-thick pyroxenite/gabbro (140E35) beddings are displaced by right decimetric shears, subsiding to the NE block. Perhaps these shears are of magmatic origin because they touch only a layer, being so very local. They correspond to a boudinage of pyroxenite bedding. Gradually, layered gabbros pass to foliated and laminated gabbros of direction (S=120SW60 and L=265W30). Further up, the laminated character becomes less marked, accompanied by the appearance of two pyroxenes (gabbronorites) The isotrope gabbros occupy the top of the gabbro section and are represented by fine grain gabbros (microgabbro lenses), fairly heterogeneous in terms of the local presence of foliated facies in them. Hydrothermal activity is intensively developed and the pegmatoid gabbros, probably of recrystallization origin, are more present in these levels. Plenty of wehrlite, lherzolite, pyroxenite, and harzburgite intrusions are characteristic in all the gabbro sections.

In the gabbro section all the rocks seem to be very altered, mainly due to hydrothermal activity. The regional geological model includes a magmatic chamber affected by intensive hydrothermal activity up to the Moho boundary, probably deeper, suggesting that the total thickness of the gabbro - dike complex - extrusive rocks is reduced.

Stop 9:

The mantle section

The Kukes massif exposes a mantle section with a maximum thickness of 4 km (Gjata et al., 1995). It indicates a lithological zoning (Hoxha and Boullier, 1995), which from down-up or from east towards west (Fig.11) is represented by: the harzburgite zone (Hz), the dunite-harzburgite zone (HzD), the massive

Figure 12 - Strong lineation in the troctolite-wehrlite intercalation.The excellent layering of gabbros with wehrlites (Fig.13) continue upward.

dunite zone (D), the intermediate zone (Zi).
In the harzburgite zone (Hz) the average composition of the harzburgite is 80% olivine (forsterite, 17% ortopiroxene (enstatite), 3% clinopyroxene (diopside) and 2% spinel. In the harzburgite zone, some dunitic lenses of modest to small dimensions are presented.
Depending on the relative amount of dunite and harzburgite, the harzburgite-dunite zone may be divided into two sub-zones: (1) a lower harzburgite-dunite sub-zone, where dunite lenses within the harzburgites are observed (2) an upper dunite-harzburgite (DHz) sub-zone, in which the abundance of dunite lenses increases upwards. Both sub-zones have the same mineral paragenesis (olivine, ortopyroxene, clinopyroxene and spinel). The chromite-rich deposits in this zone (Fig.15-a) are of great economic interest.

The dunites (D) are well developed in the Kukes massif. They contain some chromite lenses which are almost unexploited. These dunites contain several percentages of interstitial clinopyroxene and remnant orthopyroxene. Locally, a secondary amphibole is developed along orthopyroxene cleavage. The chromitic beddings are locally folded (Fig.16) or displaced along the normal shear zone
In the northern part of the massif, near the fault contact with gabbros, exceptionally fresh dunite outcrops are observed. Also, numerous concordant and subconcordant dikes (Fig.17) or sills of clinopyroxene with olivine, werhlite, lherzolite and websterite are present in this zone. They grow upward in amount and dimensions, near the intermediate zone.

The intermediate ultramafic–mafic zone (Zi) is well exposed in the contact between massive dunites and layered gabbros. It is characterized by intercalations of clinopyroxene with olivine, werhlite, websterite with olivine, lherzolite, peridotites with plagioclase, troctolite, gabbropyroxenite with olivine and gabbro with olivine. Numerous vertical dikes of pyroxenite and gabbro intersect the section. The gabbro dikes are observed only in the zone just under the Moho. They present an irregular statistical orientation orthogonal with spinel lineation (Hoxha and Boullier, 1995).
The Kukes massif peridotites are predominantly of high temperature characterized by equant, high-T porphyroclastic and/or tabular textures with elongated olivine (1 to 3 mm) and internally large substructures. The foliation is very regular and oriented NW-SE with an average dip of 450

Figure 13 - The layering of gabbros with wehrlites
Locally, gabbros with hidden graded bedding are developed (Fig. 14)

Figure 14 - Gabbros with graded bedding structures.

to the west and a mineral lineation of SW-NE orientation. The shear direction which is deduced from the observed obliquity between shape and the lattice fabric of olivine, displays shear direction with the top moving towards the east in the deeper mantle and a shear direction towards the west in the shallow section (Fig.18)

The reversal of shear direction corresponds to the boundary of massif dunite with DHz sub-zone. In the

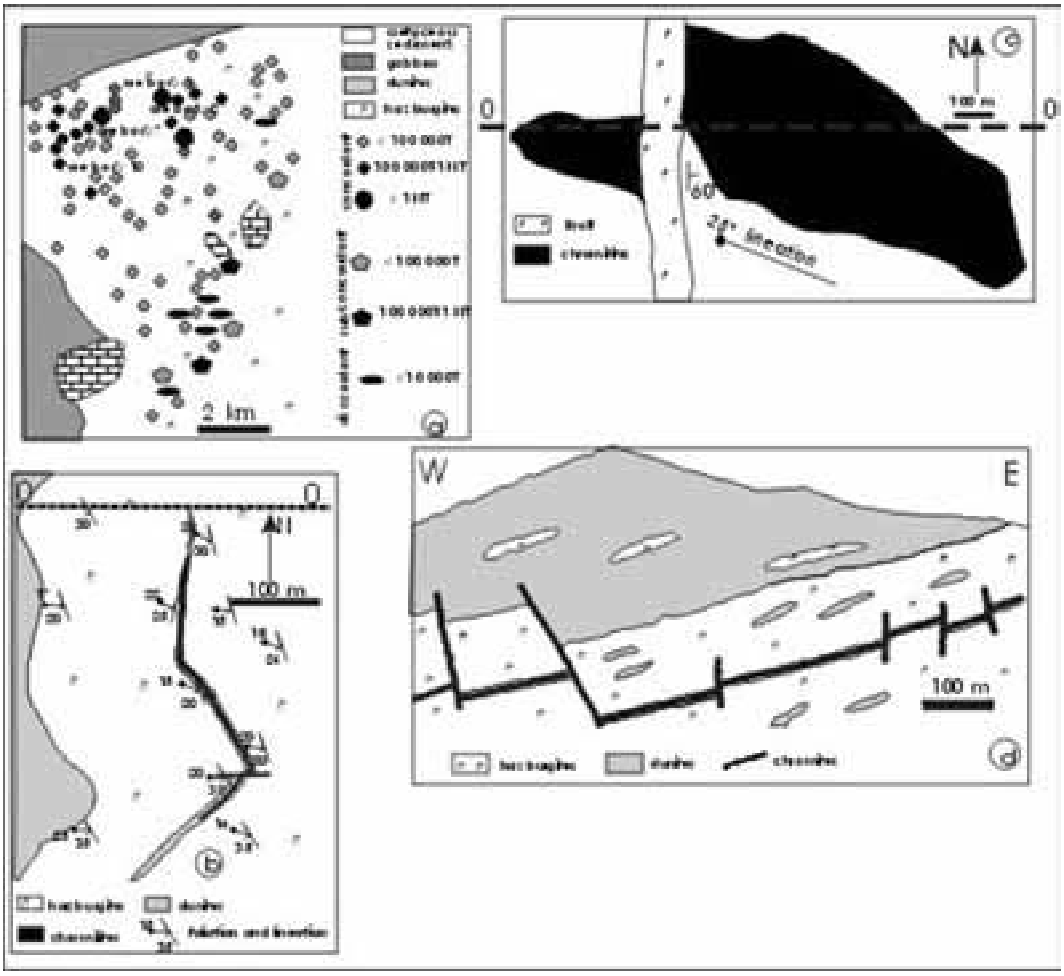

Figure 15 - Distribution of chromitite ore bodies and structural types of chromites in the Kukes massif b. geological map of the ore bodies Nb 1, ore deposit Kalimash 2, Kukes. c. cross-section 0-0 in the ore bodies 1. d. horizontal projection of the ore bodies 1. After Meshi, in press

Figure 16 - Isoclinal folds of decimetric range in banding chromite.

Figure 17 - Clinopyroxenite dike tectonically transposed and folded in the intermediate zone between the dunites and the gabbros

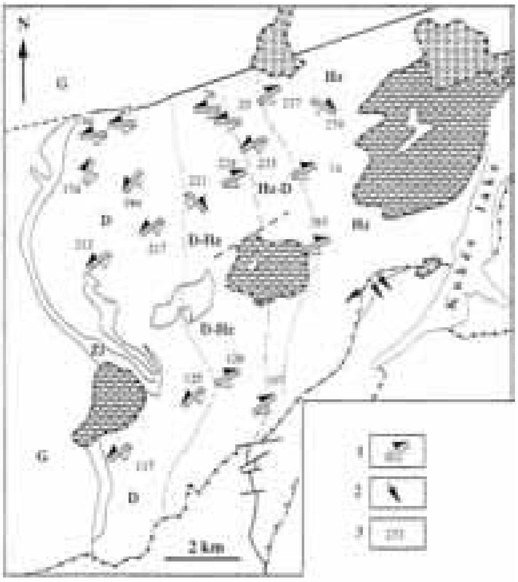

Figure 18 - Map of shear sense in the Kukes ultramafic massif. 1.black arrow shows the sense of movement of the upper block relative to the lower one in the peridotites. 2. sense of movement of the upper block relative to the lower one in metamorphic sole. 3. number of samples studied for lattice – preferred orientation. After Hoxha and Boullier,1995.

northern part of the massif, near fault contact with the gabbros, the deformation of the low-Tin peridotite is recorded. In the samples with porphyroclastic textures the neoblasts tend to form an equigranular matrix surrounding the porphyroclasts.

Stop 10:

The underlaid-ophiolitic formations

The Triassic-Jurassic limestones (Fig.11) that occupy the SE part of the Kukes ultramafic massif are composed of grey neritic limestones, locally containing stamotolite fragments and megalodontes. The thickness of the limestones is on the order of 1 km and the degree of recrystallization increases upward in the formation (Hoxha, 1993).

The volcano-sedimentary mélange is characterized by the predominance of sedimentary rocks, i.e siliceous, siliceous-argillaceous, siliceous-argillaceous-graphitic schists, radiolarites and sandstones intercalated with basaltic lavas of MORB affinity (Shallo and Gjata, 1995). This complex can be compared to the "diabase-chert" formation in the Dinarides (Ciric, 1984). A copper ore deposit (Gjegjan) is localized within such a volcano-sedimentary mélange. The sulphide mineralization represents massive stratiform pyrite-chalcopyrite ore bodies with an irregular magnetite layer located in the radiolarite/basalt contact. As secondary mineralizations chalcosine, coveline, bornite, native copper, etc. can be mentioned. The mineral reserves of Gjegjani ore deposit (already mined) were over 5 million tons with 3% Cu. A lot of ground geophysical exploration methods such as Self Potential (initial

Figure 19 - Amphibolites folded in the metamorphic soles of the Kukes massif .

discovery method in 1959) IP/Resistivity, IP/ Resistivity "Real Section", magnetics, EM, gravity, borehole logging, etc, has been used over this ore deposit and around it for over three decades.

The metamorphic sole of the Kukes massif is observed locally between the ultramafic and volcano-sedimentary mélange with which it appears in continuity (Hoxha and Boullier 1995). It is constituted by two types of rocks: (1) finely layered amphibolites and folded (Fig.19) showing a metamorphic foliation, a stretching lineation and a granolepidoblastic texture; (2) Micaceous quartzites and micaschists with garnet which probably developed during a low grade regional metamorphism (Turku, 1987). (Fig.19)

ITINERARY KUKES - NIMCE

Leaders: Alaudin Kodra, Selam Meco, Bardhyl Muceku

From Kukes to Rexhepaj – 3 km paved road, while from Rexhepaj to Nimce, about 10 km dirt road.

Itinerary description – The itinerary Kukes – Nimce passes through young molassic formations and terrigeneous/carbonaceous formations of Paleozoic age. These formations belong to the western part of the microcontinent Korab – Pelagonian. The Mesozoic formations of this region are interpreted by many scholars (Kodra, Gjata 1982, Shallo 1984, Meço et al. 2000) as parts of the eastern continental border of the Mirdita oceanic basin, extended during the Triassic – Jurassic periods.

From Kukesi town towards Rexhepaj village the itinerary passes through Pliocene – Pleistocene (N2- Q-p) molasses with a thin cover of Holocenic deposits.

The molasses consist of not well-consolidated conglomerates. The pebbles and boulders are formed from Triassic – Jurassic ophiolitic massifs, from Mesozoic carbonaceous formations, from Verrucano series as well as from quartzites, ignimbrites, etc of Lower Paleozoic. The sandstone and gravel matrix consists of the same content as the pebbles and boulders. The conglomerates are intercalated with sandstones, siltstones and clays in the bottom part. The total thickness reaches up to 300m.

The Pliocene – Pleistocene molasses are laid over the ophiolitic basement or over the continental formation of the ophiolite's periphery.

Stop 11:

Geological cros-section Kukes-Rexhepaj-Vanas and Nimąe (Fig.20)

In the southern continuation, near the villages of Bicaj, Domen, Resk, etc., over the platform limestones, red nodular limestone with manganese nodules of condensed thickness (1 – 6m) lie. The age of nodular limestone is Lower – Middle Jurassic, as determined based on the presence of microfacies with Involutina liassica, embryonic ammonites, plenty of Pelagic bivalves, Protoglobigerina, etc (Kodra 1981).

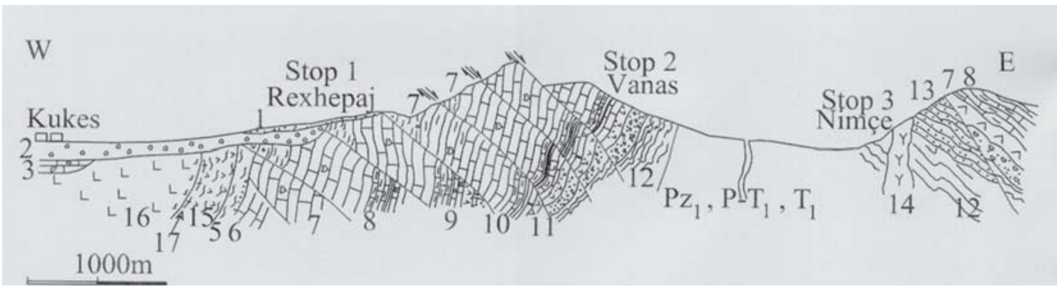

Figure 20 – Cross section Kukes Nimce (legend see fig. 21)

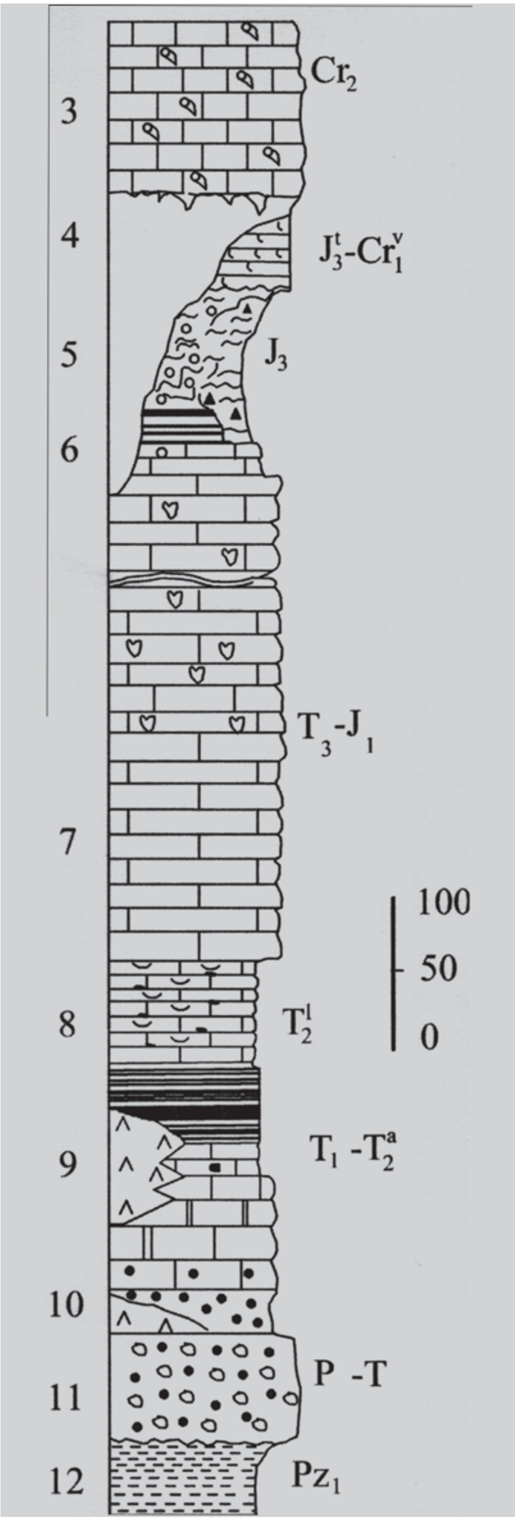

Figure 21 - Generalized column of Gjallica Unit - 1.Breccia (Q), 2.conglomerates (N2-Qp), 3.rudist limestone, (Cr), 4.Firza flysch (J3t-Cr1v), 5.Block in matrix "type mélange",6.Radiolarites and nodular limestone (J), 7.shallow water-limestone (T3-J1), 8.charty limestone (T2l), 9.Dolomites, nodular limestone and radiolarites (T2a), 10.Sandstone limestone, sandstones and rift-related volcanics (T1), 11.Conglomerates – Verrucano (P-T1), 12.Shales etc.(Pz1), 13.arcose sandstones (Pz), 14.Monzonite-sienites (Pz), 15.Triassic ophiolites (βT2-J1) , 16.Jurassic ophiolites (_J2), 17.metamorphic sole (_sJ2)

The limestone are covered by radiolaritic silica (5 – 15m) of Middle – Upper Jurassic (Kellici et al., 1994, Kodra et al., 1994, 1995), Marcucci et al., 1995). Upper Jurassic breccia and tufobreccia are laid over the radiolaritic silica (Fig. 21).

The geological interpretations (Kodra, 1986) supported by geophysical data, (Avxhiu, Bushati and Alikaj 1984), suggest that below Pliocene molasses there is a tectonic placement of Triassic – Liassic ophiolites (basalt - radiolarite) over the "block in matrix" mélange and of Jurassic ophiolites (mainly mantle sequences) over the Triassic – Liassic basalt – radiolarite. In the basement of this sequence the metamorphic sole is located, the age of which corresponds to Middle Jurassic (J2) (174-162 M.a.) (Dimo 1997, Kodra et al 1994, Cadet at al 1994).

Stop 12:

(Vanas)

In the itinerary from Rexhepaj to Vanat the Upper Triassic – Lower Jurassic platform limestones continue. The dip is near-vertical. The great thickness of over 3km is due to repetition of the section for tectonic reasons. The listric paleofaults occurring during the extensional regime in Late Triassic – Early Liassic that closed the oceanic basin of Mirdita, were transformed to inverse faults, markedly increasing the thickness of the platformic limestones. Plenty of megalodontes are encountered there (Pinari et al 1970) like Megalodus sp., M.triqueter, M.damesi, etc. Also, the corals Montlivaultia norica, Phyllocaenia decustata, Coccophyllum sturi, etc, are found.

The Upper Triassic section offers foraminiferic microfacies rich in Involutina gr.sinousa, I.gaschei, I.communis, Trochamina alpina, T.jaunensis, Ophtalmidium fusiforme, O.chalinychiangense, Glomospira friedli, Turrispirilina hantkeni, etc. In the bottom part of the platformic limestones the microfacies with Clypeina bessici of Karnian is encountered. The transition to the Lower Jurassic is

Table 1

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	H_{2O}^+	H_2O^-	Hk	Totali
269	70.66	0.37	14.08	0.72	0.12	1.62	0.84	4.11	3.09	1.55		0.15	99.99
1656	74.95	0.14	11.48	-	0.02	0.92	0.28	4.77	2.90	-	0.12	0.46	100.94

accepted as indicated through the abundant presence of the Thaumatoporella parvovesiculifera algae. Stop 2 includes an interval of about 500m:
- platy biomicritic limestones with siliceous rocks containing green tuff seams. The ammonite Aploceras avianum, dating to the Ladinian (Kodra 1976) is encountered in the platy limestone. In the upper part of these limestones, directly under the platformic

- reddish conglomerate Verrucano (150m). The conglomerate age is accepted as Lower Permo-Triassic,
- black Silurian schists .

Stop 3 (Nimce):
In the itinerary from Vanat to Nimce these terrigenous formations are encountered:
- quartzite, sandstone, phyllitic schist, porphyritoide

Table 2

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	H_{2O}^+	H_2O^-	Hk	Totali
269	70.66	0.37	14.08	0.72	0.12	1.62	0.84	4.11	3.09	1.55		0.15	99.99
1656	74.95	0.14	11.48	-	0.02	0.92	0.28	4.77	2.90	-	0.12	0.46	100.94

limestone are found conodonts (Budurovignathus mungoensis, B.diebeli), which serve as proof of the Ladinian top.
The tuff seams are of acid-alkaline content (Tab.10 at Shehu et al 1990)- radiolaritic silica (15m)
- red nodular limestone of Upper Anisian with Meandrospira dinarica (Han Bulog) (4m),
- yellowish-rose dolomitic limestone with lentils of red nodular limestone. Their Spathian age is proved through Neospathodus homeri,
- calcarenitic limestone, oolitic limestone with Meandrospira pusilla, arkose sandstones etc (also Spathian),
- basalts, basaltic porphyry and sometimes basalts with titanaugite and olivine. In analog levels on strike, in addition to basalts in limited amounts, sub-volcanic porphyry-quartz rocks are encountered,
The chemical composition of the Lower Triassic volcanic rocks is calcium – alkaline with increased content of Ti and Al in basic kinds (Shehu et al 1990).

and limestone lentils with Scyphocrinites (Upper Silurian – Lower Devonian),
- Verrucano conglomerates and sandstones (Permian – Lower Triassic),
- terrigenous and carbonaceous formations (Spathian) (Meço et al 2000)

In stop 3 (Nimce) a small massif of montzonite-sienite is outcropped with dimensions 2 x 0.4 km. The absolute age of the massif is given in the boundary between Carboniferous and Permian (Nasi et al., 1972, Shallo 1977, Kodra 1986, Meço et al., 2000). This small intrusion is localized amongst Silurian sericite-siliceous-graphitic schists in the bottom part and arkose sandstones in the upper part. Further up the Spathian and Anisian basalts and limestones continue, proved by conodonts (Neospathodus triangularis, N.homeri, Chiosella timorensis, etc) (Meço 1988) and microfacies (Kodra 1986).
The Nimce montzonite-sienite massif is characterized by taxite of structural-textural heterogeneity and by various mineralogical mica ratios. The leucocratic

Table 3

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O^-	H_2O^+	P_2O_5	HK	Total
564	56.06	0.64	16.85	3.56	4.89	0.11	3.20	3.01	3.60	5.81	0.46	1.12	0.40	0.70	100.41
564[a]	54.67	0.87	7.52	3.18	4.45	0.10	2.13	2.38	2.85	7.10	0.58	1.96	0.50	1.26	99.58
565	51.10	1.28	15.40	13.56	2.23	0.10	2.23	2.38	1.05	6.10	0.38	1.36	0.55	1.86	99.58
134	51.79	1.02	15.40	4.00	4.47	0.14	4.73	6.03	3.14	5.70	0.37	2.99	-	0.59	100.37
1074	53.49	0.76	12.20	3.00	4.06	0.15	3.22	3.58	3.33	7.15	0.74	1.36	-	2.39	99.43
1872	57.94	1.25	21.32	2.55	0.14	0.125	0.46	2.00	5.40	5.10	0.22	-	0.03	1.80	99.34

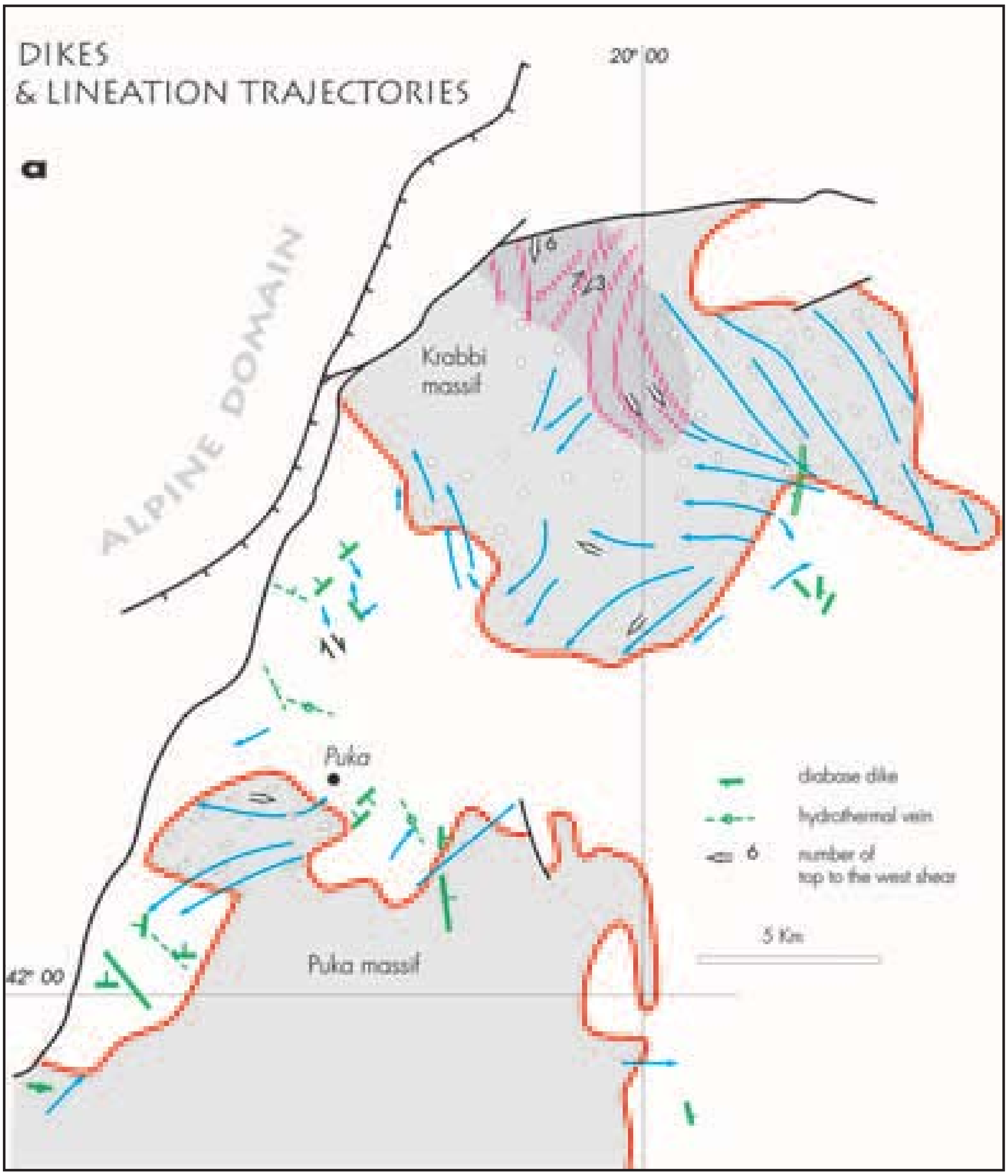

Figure 23 - Detailed map of the crustal saddle between the Krrabi massif and the northern part of Puka massif: dikes and lineation trajectories.

kinds (sienite) are noticed in the upper part, near the contact with arkose sandstones, while the melanocratic and plagioclasic kinds (montzonite) are predominant in the massif. The main minerals of montzonite are:

- plagioclase of zonal structure. It is of andesine-labrador kind,
- microcline in small grains shape, often it is found albitized,
- foil-shaped biotite. Often it contains poikilitic intercalation of small apatite prisms,
- amphibole and seldom monocline pyroxene,

The accessory minerals are: apatite (1-2%), seldom sphene, etc.

The montzonite-sienite rocks are quite altered:

sericitized, amphibolized, chloritized, etc.
In many cases a process of metasomatization of sienites arkose sandstones is identified.
The montzonite-sienite rocks are interrupted by camptonite, microgranosienite and thin albitic veins. The chemical analyses (Tab. 3) indicate that they are rocks of normal to saturated series with Al and have an alkaline bias (Shallo 1977).
564 – biotitic sienite, 564a – biotitic sienite, 565-montzonite, 134 – camptonite,
1074 – montzonite, 1872 – sienite.
The isotopic analysis with K-Ar of montzonite-sienite rocks indicates an age of 294 ±16 M.y (Meco et al., 2000). During the later tectogenesis the massif underwent two enormous deformations.

Figure 22 - Gabbro dikes in the plagioclase peridotite

Through the Zircon fission – track method the montzonite rocks of Shishtaveci date as 126 ± 6.5M.a. The apatite - fission track method indicates the age of 11.2 ± 0.3 M.a. for the Nimce montzonite rocks.

Itinerary

DAY 3

The western ophiolites
Field leaders: Avni Meshi, Ibrahim Milushi, Ismail Hoxha
Itinerary: Fushe Arres – Shkoder
The Krrabi–Puka–Gomsiqe massifs
As noted above (see description of Itinerary Day 2) peridotite massifs in the Mirdita ophiolite have been divided by some authors into eastern harzburgite and western lhezolite massifs because the lherzolites with plagioclase are locally well developed in the western massifs, whereas the eastern massifs are uniformly composed of harzburgite. But, detailed structural mapping of western massifs (Fig.8) reveal that peridotites with plagioclase are effected by a large flow in low – T, boundary of lithosphere conditions, including the hartzburgite with high – T textures in their center. It is clearly observed in the field that in the mylonite facies of plagioclase peridotite, the clinopyroxene and plagioclase have been introduced by tectonic dispersion of gabbro dikes (Fig.22) and melt impregnation patches (Nicolas et al. 1999).
Outside these intensely deformed areas the peridotite is a clinopyroxene - bearing harzburgite. The melt impregnation and the low – T deformation are associated with/and affect mainly the upper levels of the massifs, close to the contact with crustal oceanic units (Fig.23, 24)
In conclusion, the deep peridotite of western massifs are harzburgite with clinopyroxene similar to the eastern ones. The difference is in the upper levels, close to the Moho, where the porphyroclastic and mylonitic facies of low – T are conspicuous. This facies is developed in peridotite with plagioclase and amphibole in the western massifs contrasting with massive dunite and peridotite of the intermediate zone of the eastern massif which are of high – T porphyroclastic and granoblastic facies.
The crustal rocks above the western peridotite massifs are markedly different (Fig.9) compared with the crustal rocks above the eastern massifs. Gabbros ranging from troctolites, leucogabbros, ferogabbros have limited extension and are strongly plastically deformed and become isoclinally folded flaser gabbro near the Moho. The sheeted dike complex seems to be variously developed and the rapid transition from isotropic gabbros to pillow lavas (Fig.9b, 23, 24) suggest that this complex is locally reduced. The upper part of the crustal section is composed of diabase dikes, sills and extrusive rocks. The total absence of gabbro and sometimes of the sheeted dyke complex or both of them and the direct contacts of peridotite with extrusive rocks suggests that the western massifs of Mirdita corridor represent an atypical "ophiolite".

Stop 13:

Special Moho surface
A very special Moho surface represented of schist serpentinite and extrusive rock contact can be observed here. At this level the olivine– antigorite schists are intensively deformed and are cut off by undeformed diabase dikes. This is evidence that low temperature deformation had been yielded oceanic ridge before injection of these diabases. They range in orientation from N-S with an eastward moderate dip. Abundant epidote veins alternate these diabases.

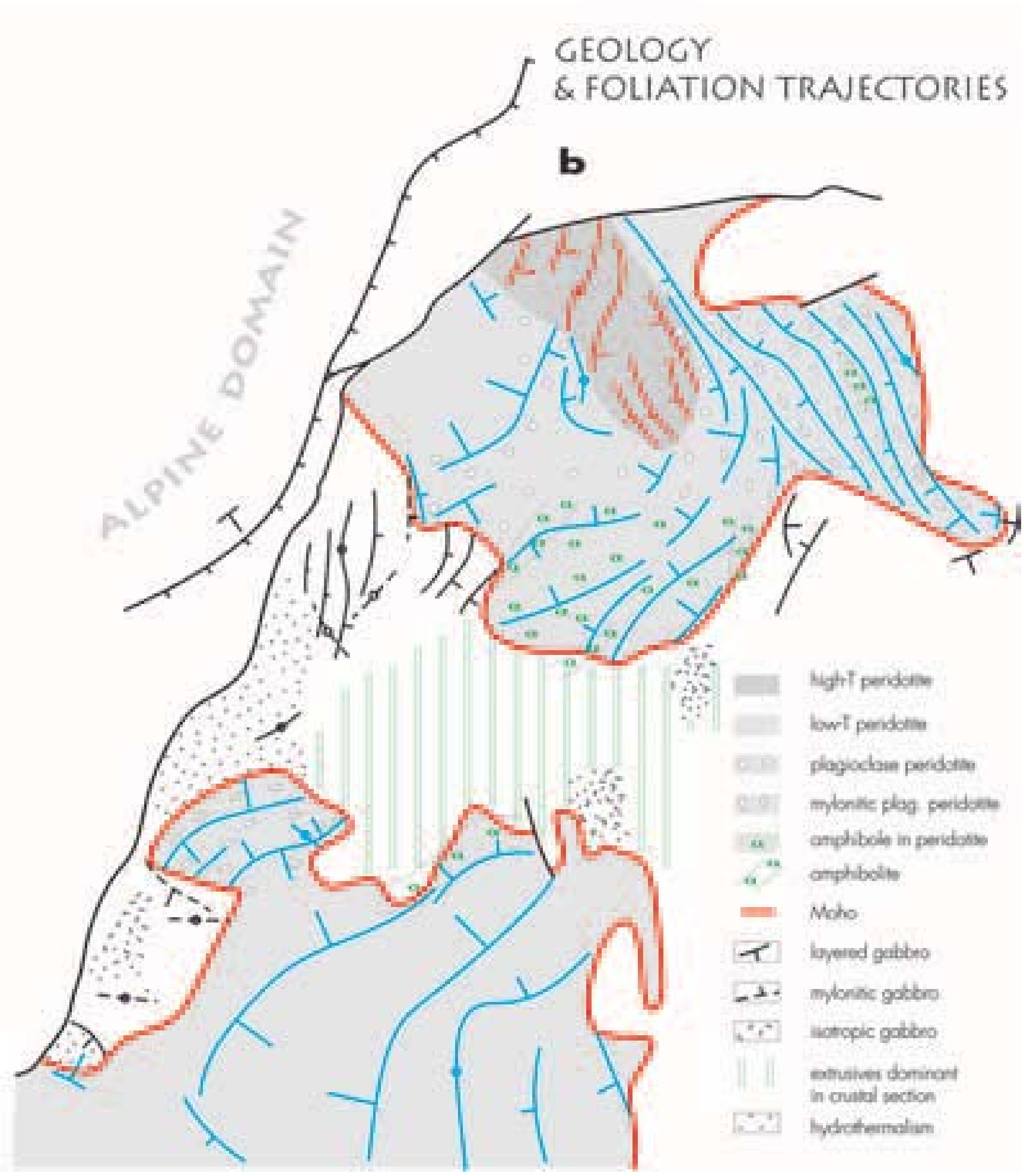

Figure 24 - Detailed map of the crustal saddle between the Krrabi massif and the northern part of Puka massif: geology and foliation.

A submylonitic amphibolite facies is developed in the extrusive rocks at the contact with peridotite. A similar facies is developed on the other side of the saddle in the southern contact of the Krrabi massif peridotite with extrusive crust rocks . This facies does not seem to have the same origin as the amphibolite found in the metamorphic sole of Mirdita ophiolite. Internal structures in this amphibolite (foliation and lineation) in both Puka–Krrabi saddle sides have the same behavior as internal structures in mylonite facies of amphibole – bearing peridotite. At the same time inside the latter, abundant amphibolite lenses with dimensions up to some hundred meters are also evidenced.

Figure 25 - Isoclinal fold in the plagioclase peridotites with axis of fold parallel to the lineation

Figure 26 - Open fold noticed by plagioclasite bedding

A generation of undeformed diabase dikes cuts the amphibolite/peridotite contact. In contrast, nowhere in the metamorphic sole is a similar phenomenon observed. This is one more testimony that the mantle/crust contact is early, developed in amhpibolite facies conditions and in the presence of water during oceanic accretion process (Nicolas et al., 1999). The detailed map of the area separating the Krrabi and Puka massifs (Fig. 23) illustrates how the crustal section is reduced at the expense of the gabbros in the western massifs. The saddle between the Krrabi and Puka massifs is mainly occupied by diabase dikes, sills and extrusive rocks. The attenuation of the crust is accompanied and accentuated by an intense deformation below and above the Moho. Melt- impregnated peridotites were plastically deformed under low – T conditions. Below the Krrabi – Puka saddle the amphibole – bearing peridotites with a submylonitic to mylonitic texture have developed. Here, Moho is tectonized with peridotite– gabbro mylonites and/or antigoritic schist in the contact with metamorphic or hydrothermally altered crustal formation (Fig.24). The contacts, which have variable orientations, reflect intense deformations in conditions related to oceanic accretion. The situation is illustrated in figure 9b in which the Moho surface seems to have preserved its original attitude, showing that in this "ophiolite", the tectonized Moho surfaces were not initially horizontal. The dome-shaped morphology of the western peridotite massifs appears to be controlled by a tectonized envelope which could correspond to the Moho level (Nicolas et al., 1999).

Stop 14:

Plagioclasic peridotites

The peridotites with plagioclase are part of the upper level of the Puka massif that contacts with crustal units. Their thickness is in the order of 1km. Further down, the high-T harzburgites with Cpx are exposed. Here, the plagioclase peridotites are extremely deformed. This facies is submillonitic up to millonitic. The isoclinal folds (Fig.25) are encompassed in an open fold

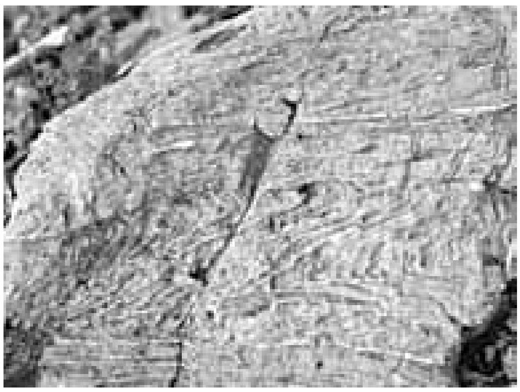

Figure 27 - The shear zones in the millonitic facies of the plagioclase peridotites. Near these shear zones, a rotation of the first stage foliation is observed

Figure 28 - Flaser gabbros in the plagioclase peridotites

deformation (Fig.26) of the axis 100W30.

A very fine foliation is noticed in the axial plane. Out of this axial plane the foliation of the first stage presents fairly heterogeneous behaviour. This foliation makes up the axial plane of the first isoclinal folds. Beautiful plagioclase layers in this millonitic peridotite facies also expose open folds of the second stage of the deformation. Millimetric shear zones (Fig.27) are very characteristic in this zone.

They pinpoint the plagioclase injections. In proximity to this shear zone an irregularity in the first stage foliation is observed.

In peridotites with plagioclase, flaser gabbro lenses (Fig.28) of several meters to tenths of meters are very common.

They are tectonically transposed in the structure of surrounding peridotites. A series of intense gabbro veins which are intruded in ductile – brittle shear zones are also found, causing bent and displacement of the millonitic foliation in peridotites.

All over the western massifs, the plagioclasic peridotites contact with crustal units through gabbro rocks. Near this contact the gabbros are well-layered. In layered gabbros with olivine graded bedding is noticed. This gives evidence of the presence of magmatic cameras, perhaps episodic, in this atypical "ophiolite". However these gabbros are very heterogeneous. The isotrope gabbro-diorites with amphibole and pyroxenite-pegmatite gabbros, of recrystallization origin, make the internal structure of the gabbro section very complex. Peridotite enclaves in these gabbros are fairly prominent. Numerous diabase veins, isotropic gabbro veins, recrystallized and foliated diabases, hydrothermal veins of quartz and maybe of prenitit, or green amphibole veins are typically exposed to these gabbros. The isotrope gabbros of variable texture rich in amphibole are placed straight upward. They are intersected by dolerites of cold laterals. In fact, in these gabbros, the diabases make up roughly 50% of the unit.

The verlitic intrusions are very common in gabbros themselves and in their contact with underlying peridotites. They are mostly troctolite verlites (the presence of olivine and orthoclase) and are very broken in low temperatures. The plageogranitic intrusions are present in the gabbro section of the western massifs. The chemical composition and the REE pattern of quartz diorite/plageogranites indicate a clear affinity SSZ (Shallo and Gjata, 1995).

Stop 15:

High-T Harzburgites

During the continuation of the itinerary towards stop 3.3, the tectonic contact between the Puka and Gomsiqe massifs is observed. In the contact, on the Gomsiqe massif side, there exists a schist band with blocks of NNE orientation and dip E at 50º. A series of scales of the volcano-sedimentary mélange are placed over this contact. This scale unit in concert with the Puka massif has overthrusted over the Gomsiqe massif. In the stop area, there are mantle harzburgites with Cpx outcrop. They are deformed at high temperature and the deformation structures are well developed. The characteristic of mantle deformation structures at high temperatures in western massifs is the subvertical lineation structure.

A tectonized volcano-sedimentary mélange is underlain to this massif. The tectonic character of this mélange is indicated by the presence of an amphibolite scale of the metamorphic sole. Here, the absence of basal peridotites with Low-T deformation in continuity to garnet amphibolites of high grade clearly indicates the tectonic nature of this contact. All the peridotite-mélange unit overthrusts over the Krasta-Cukali zone.

Stop 16:

Ultrabasics over the external zones

In this stop the most advanced slices of ultrabasics over the external zones of Albanides are exposed. The ultrabasic rocks are located over a volcano-sedimentary mélange and the unit overthrusts over the flysch deposits of the Krasta – Cukali zone. Similarly to the Puke – Gomsiqe contact, a band of block schists is noticed in this contact, as well. The fracture plans of orientation NW at dip 30º retain a lineation of roughly E-W direction, recording an ophiolite movement sense towards the west. This compressional tectonic event belongs to the Alpine deformation during the Eocene-Oligocene age (Kilias et al., 2001). During this event the overthrust of the Albanian Alps formation over the Krasta – Cukali zone towards SSW occurred. This overthrust is very well exposed on the SW side of Shkodra city.

DAY 4

The Skenderbeg and Bulqiza mafic – ultramafic ophiolitic complexes and related chromitic ore deposits and PGE mineralizaton.

Field leaders: Prof. Dr. Ilir Alliu, Prof.Dr. Bashkim Lleshi

Itinerary: Tirana – Miloti – Shkopeti – Burreli – Bulqiza – Krasta.

Introduction

This itinerary provides an overview of two ultramafic-mafic massifs, representing the two ophiolitic belts of Albania, their mantle and cumulate sequences and related chromitic ore deposits and PGE –mineralization.

The itinerary runs through the deep and narrow valley of the river Mati, along the national paved road Tirana – Miloti - Shkopeti – Burreli – Bulqiza – Krasta, 150 km long. This excursion will take approximately 10 hours.

Field references will be: the Geological Map of Albania, scale 1:200 000, and the Geological Map of Bulqiza ultramafic massif, scale 1:50 000.

Outline of the Skenderbeg and Bulqiza ultramafic massifs

The Skenderbeg ultramafic massif

The Skenderbeg ultramafic massif belongs to the Western Ophiolite Belt of Albania. Based on the petrographic, geochemical and metallogenic features, the ultramafic sequence of the Western Belt is denominated “ the lherzolitic ultramafic sequence”. This sequence consists largely of lherzolites with low clinopyroxene and small dunite lenses and thin dunite strips. Upwards, the plagioclase lherzolites with plagioclase dunites and less pyroxenite, predominate. This part of the section is intersected by thin veins of gabbropegmatites and pyroxenites.The top of the ultramafic section consists of plagioclase ultramafics with gabbroic lenses and dykes.

Lherzolites with clinopyroxene consists of 60%-80% olivine (Fo 88-90), 15%-25% orthopyroxene (En 86-90), less than 10% clinopyroxene (diopside En 48-51, Fs 3-6 and Wo 41-48) and chromespinel 1-3%.

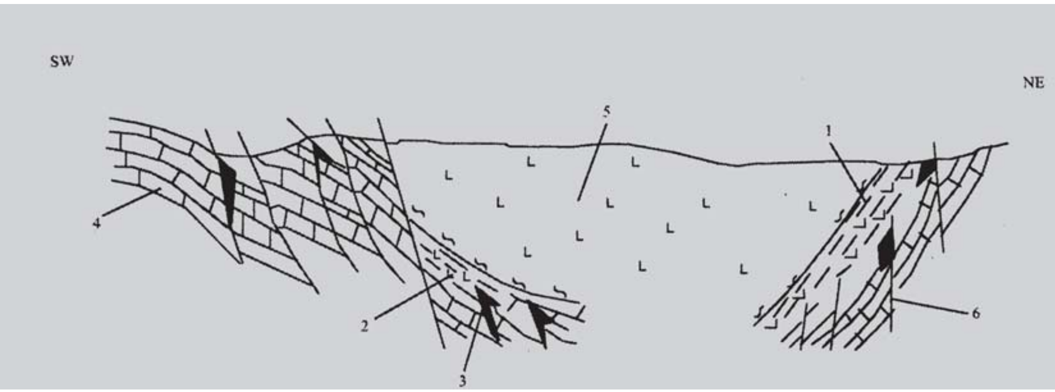

Figure 29 - Geological cross section through the Bulqiza ultramafic massif (After Kodra et al.,1982). 1. amphibolites; 2.diabase-radiolarites; 3. serpentinites; 4. limestones; 5. ultramafics; 6. fault.

They have clear banded texture and subparallel - parallel foliation. Their porphyroclastic to millonitic structures suggest the levels of high-P and low-T of the lithospheric plastic flow in sectors of the contact with the platformic periphery or in narrow zones inside the massif itself. The coarse grained structure suggests plastic asthenospheric flow for most of the lherzolitic section.

Dunites are scarce and they occur as banded and irregular intercalations and they compose less than 5% - 10% of the upper part of the lherzolitic section. Dunites consist nearly totally of olivine (Fo 88-90) and isolated grains of orthopyroxene (En 86-90) and chromespinel.

Upwards, the plagioclase lherzolites, sometimes intercalated with dunites or plagioclase dunites, predominate. They show clear rhythmic banding, foliation and lineation. In these lherzolites, the elongated interstitial plagioclase conditions are very clear near vertical lineation in conformity with the foliation and lineation of harzburgite- lherzolites of the lower levels. The plagioclase lherzolites consist of 60%- 80% olivine, 5%-10% orthopyroxene. 10%-15% clinopyroxene. 5%-10% plagioclase and 1%-2% accessory chromite.

Chromite mineralization

Chromite mineralization in Skenderbeg ultramafic massif is scarce. Small podiform chromite orebodies of limited size occur within the middle-upper parts of the harzburgites with clinopyroxene (lherzolites) and scarce dunite lenses. The known chromite mineralization consists of 5 ore showings, represented by small lentiform orebodies within the lherzolite harzburgites. The ore grade varies 25% - 32% Cr_2O_3. Nevertheless the low chromite-bearing potential of the ultramafic sequence of the Skenderbeg ultramafic massif, the petrologic features of this sequence such as the high-Mg values and the low differences in minor elements in comparison with the ultramafic sequence of the eastern ophiolites, allow us to consider it as an intermediate sequence between the eastern (SSZ) and the typical lherzolitic ones of the ophiolites of the lherzolitic type or of the first type (Ohnenstetter et al., 1991).

Titanomagnetite mineralization

This mineralization occurs at the lowest levels of gabbroic rocks, consisting of ferrogabbros near the Ulza area. This mineralization is in conformity with the rhythmic banding of gabbros. The mineralization consists mainly of ilmenite and titanomagnetite. The presence of this mineralization agrees with the petrologic and geochemical features of the western ophiolites and represents a typical metallogenic feature of these ophiolites.

Suphide mineralization

The sulphide mineralization consists of pyrrhotite related to the plagioclase lherzolites and of pyrite-chalcopyrite related to the basalts. Sulphide disseminations occur within the talchized ultramafic rocks, as well.

Talc mineralization

The main manifestation of talc mineralization consists of a well developed 1500m x 500m talc zone within the hydrothermally altered ultramafic rocks.

The Bulqiza ultramafic massif (BUM)

The Bulqiza ultramafic-mafic massif is one of the most representative massifs of the Albania ophiolites. It belongs to the Eastern ophiolitic belt and is characterized by a very high chromite-bearing potential. Its outcrop occupies for some 352 km2. The geophysical data (gravimetry) suggest a thickness of some 6 km (Bushati,1988).

The outskirts of the massif consist of sedimentary rocks. In the north, northeast and southwest, the Bulqiza ophiolites contact tectonically the Upper Triassic – Lower Jurassic limestones, belonging to neritic and to a lesser degree to pelagic facies, and the Late Jurassic volcano-sedimentary formation (sectors Martaneshi, Peshku, Perroi i Helmit, etc.). In the southeast and south, the massif is structurally flanked by the Upper Jurassic – Lower Cretaceous marly-sandy flysch (sectors Kacnia – Lepuraku, Lena, Plani i Bardhe) and by the ophiolitic melange of ultramafic and extrusive composition (sectors Ballenja, Manazdreni).

Other younger formations belong to Lower Cretaceous, consisting of terrigenous-carbonaceous composition (sectors Cerruja and Lajthiza) and the youngest ones are the molasses of Burreli depression, dated Neogene, that in unconformity overlie the western margin of the massif, from Plani i Bardhe to Vinjolli.

To the east, harzburgites are in contact with the amphibolite sole. Geochronology of K-Ar in amphibolites (Kodra et al.,1994) and Rb-Sr (phlogopite) (Tashko et al.,1990) suggest an age of 164 -+ 5 Ma and 158 -+4 Ma, respectively.

The structure of the chromite orebodies, the analysis of the primary structural elements of lineation and foliation and the spatial relationships between the rock lithologies of the ultramafic sequence of the massif show a folded inner structure. To the south, the foliation strike is 1000-1200, the dip varies 400 to 700 NE and the mineral lineations are, on the average, horizontal. In the central and northern parts, foliation strike is 1200 – 1550, on the average, the dip is mainly 600 to 800 SW and the mineral lineations show a preferential northwest plunge (Dobi et al.,1983; Premti, 1985; Qorlaze et al., 1989; Meshi, 1996).
Several asymmetric – isoclinal folds overturned eastwards are recognized mainly in the mantle rocks. Generally, they have a submeridional – meridional direction sometimes complicated by horizontal and vertical faults and/or folds.
At the southern part of the massif, consisting largely of cumulates, generally southwestern monoclinal dipping of ultramafic cumulates is typical.
Generally, it is accepted that BMU, in regional plane, represents a monocline with submeridional – southeastern direction complicated by folding of smaller magnitudes.
The crustal section (cumulate sequence or "transition zone") has a thickness of 300m – 600m. (Dobi et al., 1981); Premti, 1985; Cina et al., 1986; Alliu, 1991).
SiO_2, MgO, Fe_2O_3 and FeO are the major components that determine the rock chemistry of the massif. Their values vary within a wide range. SiO_2 varies from 31.38% to 51.58%; MgO 32.21% - 51.41%; Fe_2O_3 0% - 10.03% and FeO 0% - 9.80%.
The serpentinization is the main secondary process that has effected the rocks of BUM. Going from the western sector towards the eastern one, the transition serpentinites – serpentinized rocks of different grades – fresh rocks are observed. The same trend is also observed towards the depth of the massif. Being an allochemical process, it has changed the view of the primary chemistry of the massif.

Chromite mineralization

BUM is the most important chromite-bearing ultramafic massif in Albania. More than 20 million tons of rich chromite ore have been exploited so far, and the remaining unexploited ore reserves (the present explored ore reserves "in situ") are of the same amount. There are numerous known chromite ore deposits and ore showings in BMU. Among them, Bulqiza and Batra are the two main deposits that for their size, morphology and structure are unique for the entire Alpine Ophiolite Belt. The mineralization lies at different levels of the mantle and cumulate sequences. The most important ones belong to the uppermost part of tectonites. The chromite mineralization found related to the mantle sequence belongs to three main lithological levels: 1) harzburgites without or with scarce dunites; 2) harzburgites with dunite intercalations and 3) dunites with harzburgite intercalations. The second level has the highest chromite-bearing potential.
The chromite mineralization in the cumulate sequence belongs to three lithologic levels: 1) cumulate harzburgites; 2) dunites; 3) uppermost dunites. Morphologic features of the mantle chromite ore deposits are as follows:
-Tabular concordant folded orebodies (Bulqiza-Batra area);
-Tabular concordant and subconcordant orebodies (Lugu i Gjate, Qafe Bualli, Liqeni i Dervishit, Fushe Lope, Manazdre, Ternova);
-Pipe-like concordant and subconcordant orebodies (Shkalla, Lucana, Lugu i Qershise);
- Podiform orebodies orebodies (Thekna area).
Cumulate chromites have platy-concordant and lentiform-concordant orebodies.

PGE mineralization

Studies of the last few years (Cina, 1989; Ohnenstetter et al., 1991, Lleshi, 1989, 1991), suggest that, despite the Alpine nature of the Albanian ophiolites, PGE mineralization does occur.
Three types of PGE mineralization are distinguished in BUM on the basis of their stratigraphic position, conditions of formation and mineral assemblages:
1) Ru, Os and Ir related to mantle chromites like minute euhedral inclusions; Ru, partially Os- and Ir-sulphide (laurite) and alloys (Ru-Os-Ir; Os-Ir) are the main minerals.
2) Platinium mineralization related to chromites of the dunite-harzburgite levels with laurite and Ru-Os-Ir alloys, braggite, sperrylite and Ir-sulphoarsenures and BMS.
3) Palladium mineralization related to cumulate dunites, consisting of BMS (pentlandite) with isomorphic Pd.

Stop 17:

Shkopeti

The tectonic subvertical contact between the limestones of Upper Trias – Lower Jurassic and the Skenderbeg ultramafic massif of the Western

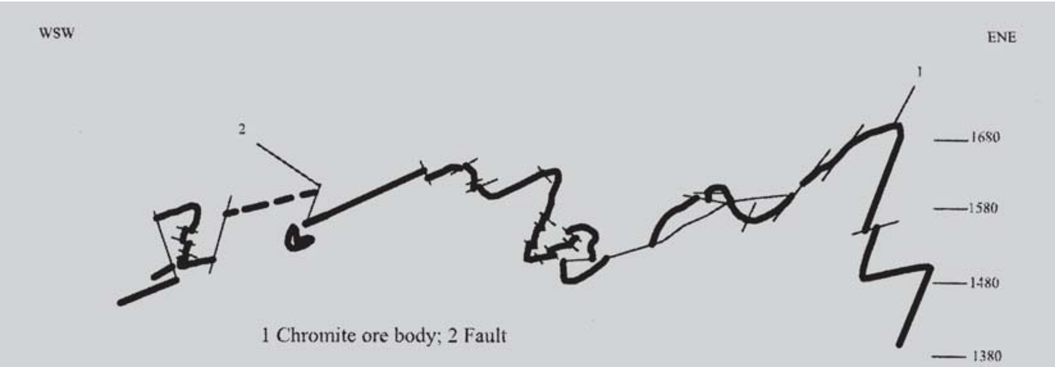

Figure 30 - Cross section through the southern part of Bulqiza chromite ore deposit (Karaj et al.,2001). 1. chromite orebody; 2. fault.

Ophiolite Belt of Albania, can be observed in this stop. Here, the ophiolites are represented by a layered ultramafic-mafic sequence consisting of dunites, plagioclase dunites, plagioclase wehrlites, melagabbros and troctolites. Dunites may contain up to 10% chromitite and rarely sulfides. At the Shkopeti area, EGP (Pt 0.2 ppm, Pd 0.053 ppm), Au 0.0173 ppm and Ni 0.3-0.4% geochemical aureolas are found (Gjata, 1980).

The socalled "volcano-sedimentary formation" or the "ophiolitic melange", lies on the top of the carbonatic sequence. It contains volcanic rocks, radiolarites and sandstones set in an argillitic matrix. To the west, folded subvertical structures in the limestone, affected by intensive block faulting, can be observed.

The outcrop of titanomagnetite mineralization in gabbros (showing "Tuneli i Madh") can be observed, as well. Gabbros also present good features for decorative stones.

Stop 18:

Ulza

The itinerary continues through the ultramafic section of the Skenderbeg massif. Two showings of sulphide mineralization (pyrite-chalcopyrite) related to diabases and a titanomagnetite showing in gabbros, occur.

Molassic deposits filling the graben structure of Burreli depression of Eocene age transgressively overlie the eastern flank of the Skenderbeg massif. They are represented by conglomerate – microconglomerates, sandstone-siltstones with ophiolitic clasts and rarely by clasts of limestones of Upper Triassic and Cretaceous.

From Ulza to Germani, the itinerary runs along the present road, on the molasses of the Burreli depression. At Germani, the eastern margin of the Skenderbeg ultramafic massif is overlain by the molasses of the Burreli depression. The molasses are full of Neogene macrofauna.

At this stop, the outcrop of the ultramafic section consists of altered rocks changed into talc. The talc zone extends for 1500m and is 300m – 500m wide. It also contains sparse disseminations of sulphide mineralization. Close to this zone, the showing of pyrrhotite "Perroi i Germanit" within the plagioclase lherzolites, crops out, as well.

Next to this stop, the Ferrochrome Smelting Plant of Burreli lies.

Stop 19:

Plani i Bardhe

After 20 km through the molasses of the Burreli depression, the itinerary enters the western contact of the Bulqiza ultramafic massif. This stop marks just this contact.

At this stop, the geological landscape is as follows: Upper Triassic – Lower Jurassic neritic limestones are overlain by the "volcano-sedimentary formation" of Upper Jurassic, which consists of schists, basaltic pillow- lavas intercalated with radiolarites, basalts, etc. The Bulqiza ultramafic massif overlies tectonically the "volcano-sedimentary formation". At the base of the ultramafic rocks, amphibolites crop out, representing the uppermost metamorphosed part of the "volcano-sedimentary formation".

Northwest of Stop 3, mantle tectonites of the northern part of Bulqiza massif are well exposed. At the western and southern borders, the cumulate ultramafic/mafic sequence, transgressively covered by Neogene deposits, crops out.

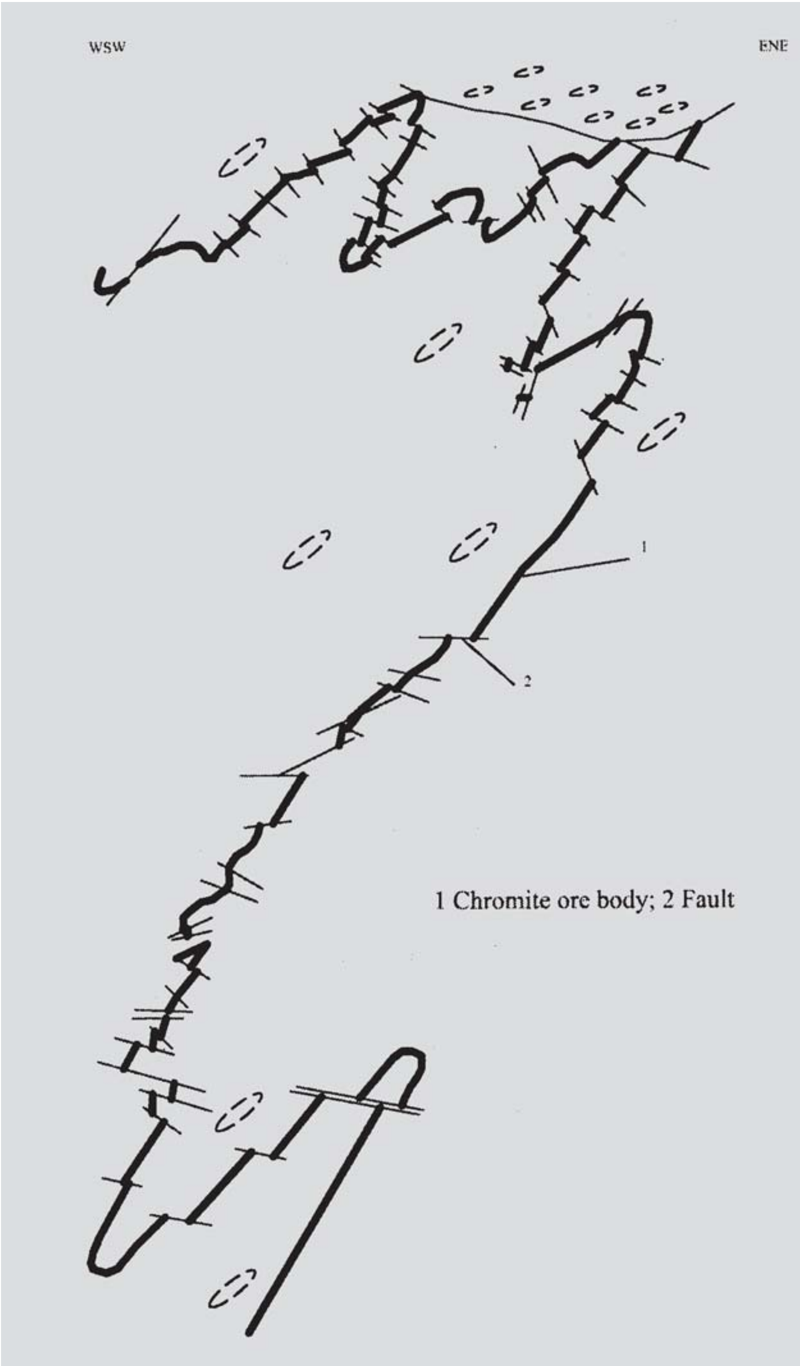

Figure 31 - Cross section through the northern part of Bulqiza chromite ore deposit (Karaj et al.,2001). 1. chromite orebody; 2. fault.

Stop 20:

Qafe Bualli

Serpentinized tectonic harzburgites with intercalations of dunite lenses can be observed at this stop. They show porphyroclastic texture and 3200-3400/400-600 southwestern foliation. Petrochemical data show the extremely high MgO content of these rocks, with MgO/(MgO + FeO) ratios ranging from 0.88 to 0.90 and very homogeneous composition.

Close to this stop, the hidden chromite deposit "Qafe Bualli" has been found. The reserves of this deposit explored so far, amount to some 2 million tons of chromite ore. This is the first hidden chromite deposit found so far in Albania.

Stop 21:

Bulqiza Chromite Deposit

At this stop, serpentinized harzburgites with dunite lenses, belonging to the middle part of the mantle section, can be observed. Harzburgite composition is about 78% olivine, 20% orthopyroxene and 1-2% Cr-spinel. Foliation is 3500/ 700 west-southwest.

The Bulqiza – Batra chromite deposit is the largest one found so far in Albania. It lies in the central part of Bulqiza ultramafic massif. The explored length of the orebody is about 5 km in strike, 500m – 1200m in dip and the

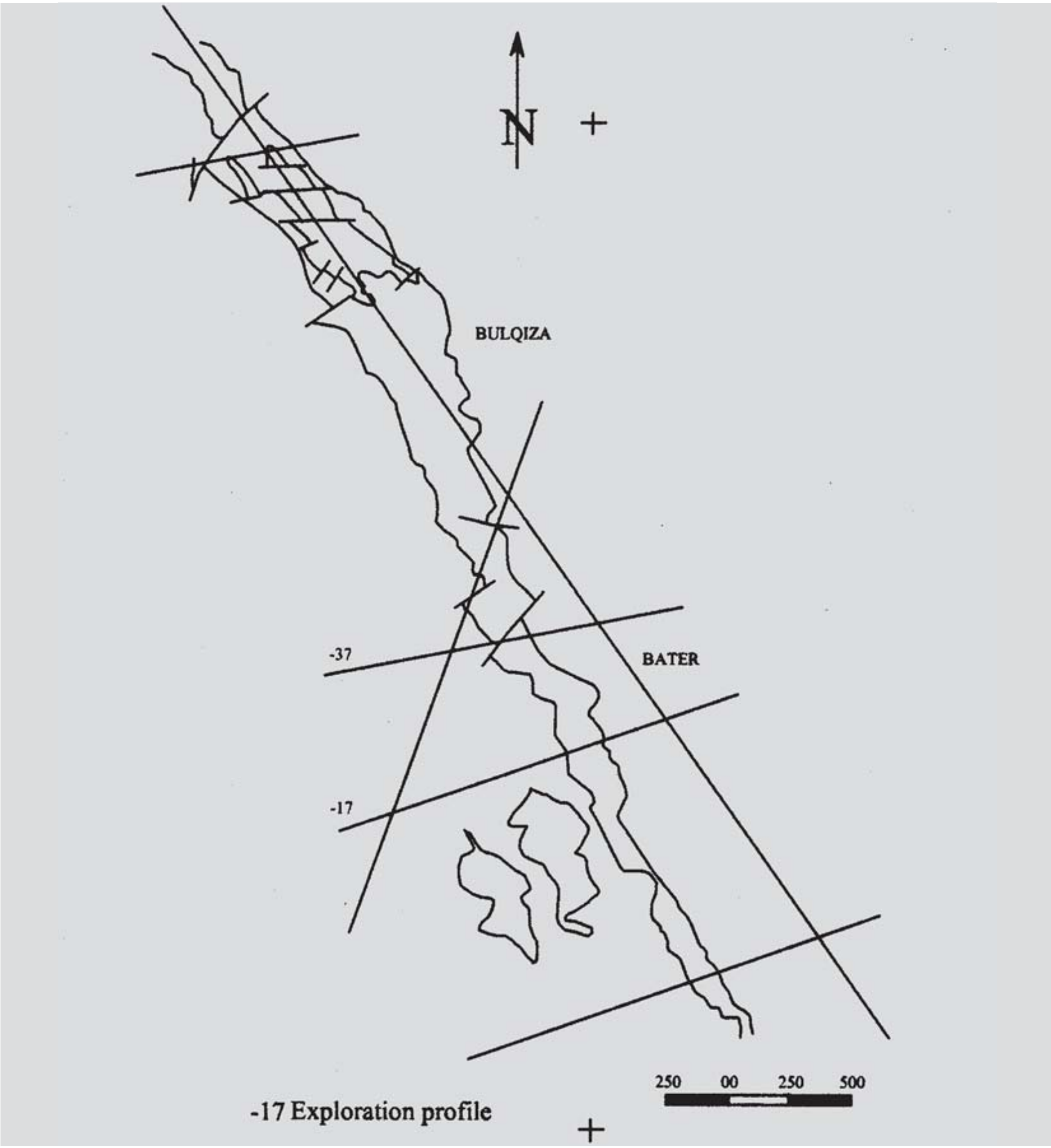

Figure 32 - Horizontal projection of Bulqiza- Batra chromite ore deposit (Karaj et al.,2001).

thickness of the orebody varies from 0.5m to 10m. It extends from the elevation +1600m above sea level to – 400m below sea level. This ore deposit represents an anticline structure with NE vergency. The strike is 3100-3300; the general dip is in SW with 200-300 and 700-800. The plunge shows NW orientation with 300 – 600 and SE with 120-150.

BUM represents a monocline structure, intensively folded along the strike and dip planes. The Bulqiza ore deposit, composed by several flanks of a single huge orebody, represents a part of this folded structure. The eastern flank orebodies are found in the north and gradually fade southwards, whereas the western flank orebodies are generally more developed southwards.

The initial outcrop of the Bulqiza ore deposit can be observed at this stop. The participants shall have the opportunity to see the Bulqiza mine, the oldest and biggest chromite mine in Albania.

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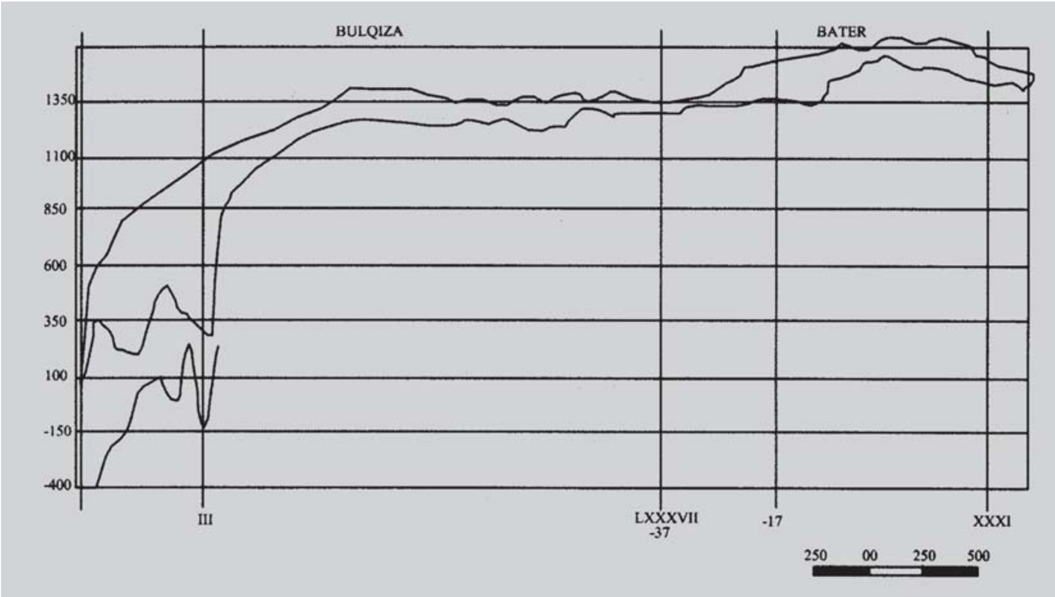

Figure 33 - Vertical projection of Bulqiza – Batra chromite ore deposit (Karaj et al.,2001)

Bulqiza mine, the oldest and the biggest chromite mine in Albania.

Stop 22:

Krasta

At this stop, the cumulate section of the southwestern part of the Bulqiza ultramafic massif is well exposed. The layered cumulate sequence, from the bottom to the top is as follows :

1-serpentinized dunites with up to 2% - 3% Cr-spinel; 2- dunites with 1% to 15% interstitial plagioclase, frequently replaced by hydrogrossular; 3- plagioclase –lherzolite (in which plagioclase is replaced by hydrogrossular) and wehrlite lenses; 4-pyroxenites (mainly websterites); 5- olivine mela-gabbros (with minor troctolites) and gabbronorites.

Krasta chromite deposit

Here, the most evolved part of the ultramafic section

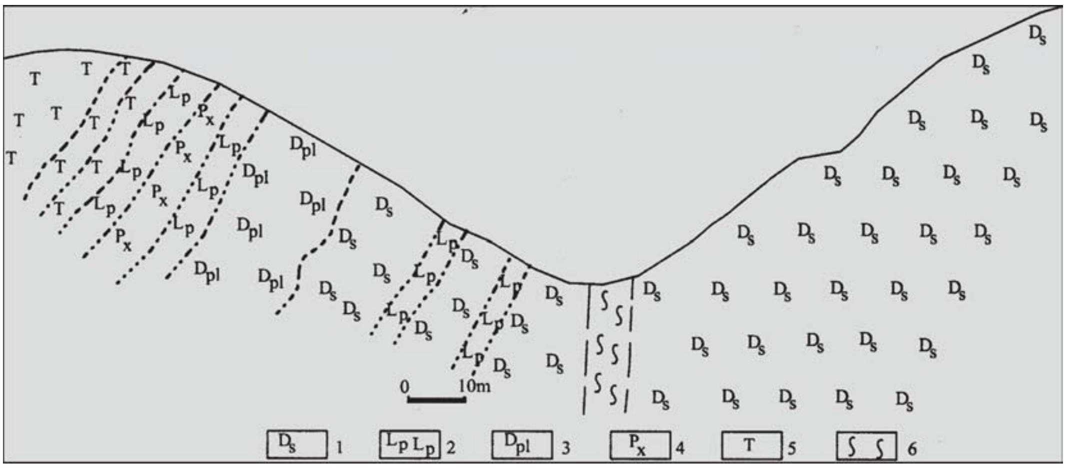

Figure 34 - Geological cross section through the cumulates of Krasta area (Dobi et al., 1981). 1.serpentinized dunites; 2.plagioclase lherzolites; 3.plagioclase dunites; 4.pyroxenites; 5.troctolite-olivinic gabbros; 6.fault.

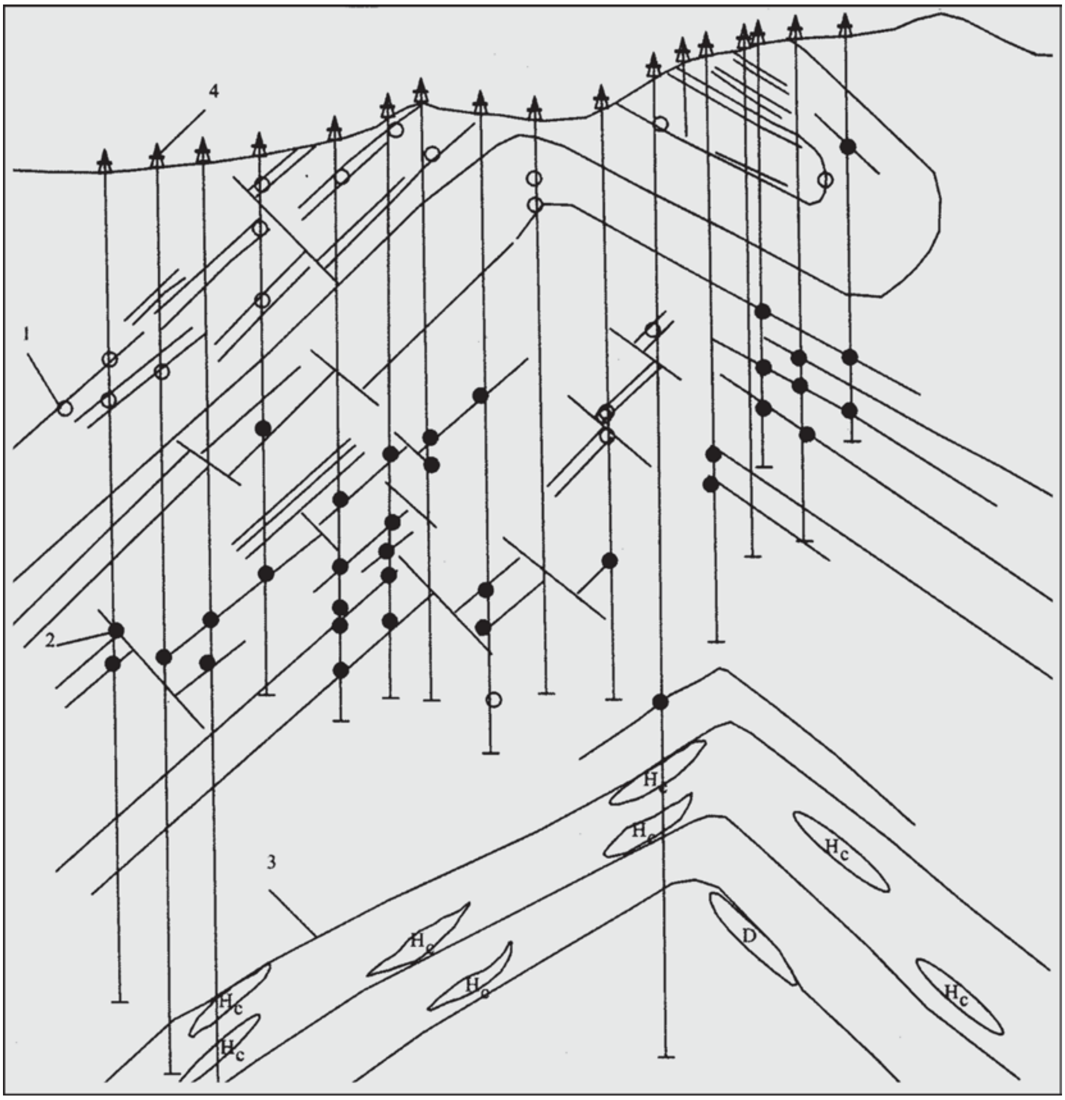

Figure 35 - Cross section through Krasta e Re ore deposit (Lleshi, 2001). 1.sulphide mineralization within dunites; 2. chromite mineralization within dunites; 3.boundary between the transitory dunites and the tectonite harzburgites; 4.exploration drillings.

of BUM occurs. Massive dunites of the Martaneshi area lie over the harzburgite-dunite mantel sequence. The position of the massive dunite sequence is strongly debated. A cumulate or mantle origin has been proposed, but the terms "dunite of transition zone" or "supra-Moho dunite" are the ones most used. Petrologic and petrochemical features show their intermediary character between mantle and cumulate dunite rocks (Karaj, 1992). The Krasta chromite deposit lies in the lower-middle part of the dunite section. It consists of several parallel chromite orebodies. The chromite orebodies within dunite are unconformable in respect to the mantle sequence (Stermasi et al., 1989).

BMS – mineralization with PGE

The most remarkable feature of the Martaneshi dunites is the presence of base-metal sulphides associated with PGE (Lleshi, 2000, 2001; Ohnenstetter et al.,1991; Amosse et al.,1992; Karaj and Ohnenstetter,

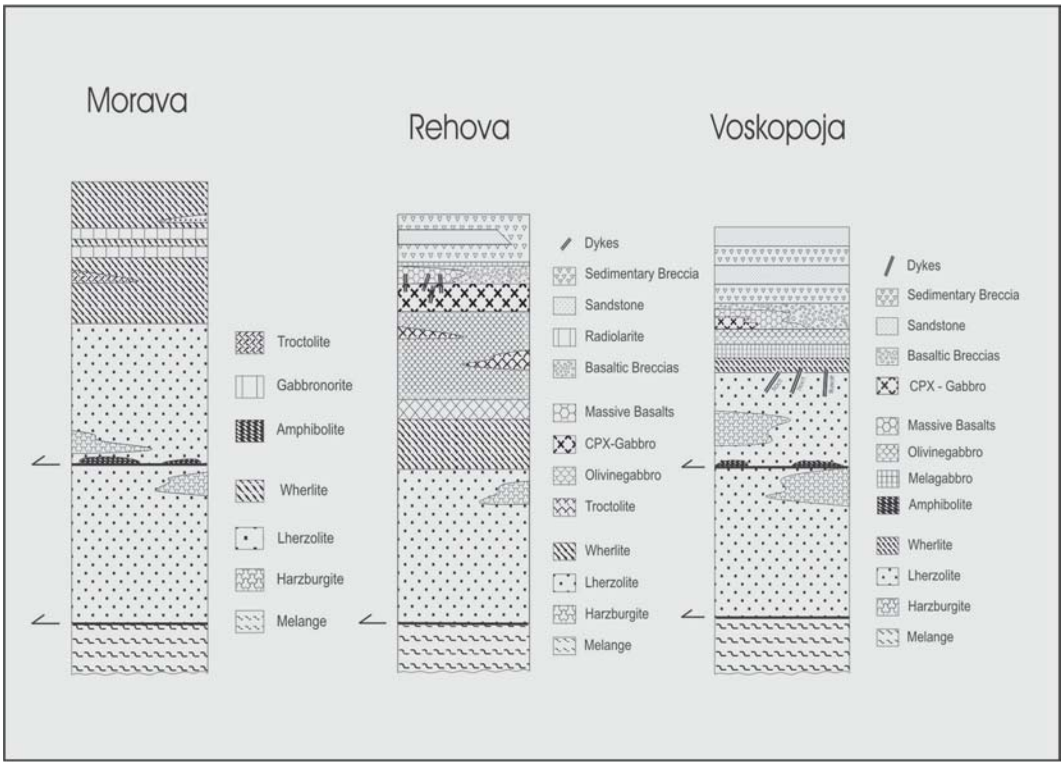

Figure 36 - Schematic profile sections through the ophiolites of Morava, Rehove and Voskopoja according to Hoeck et al., (2002).

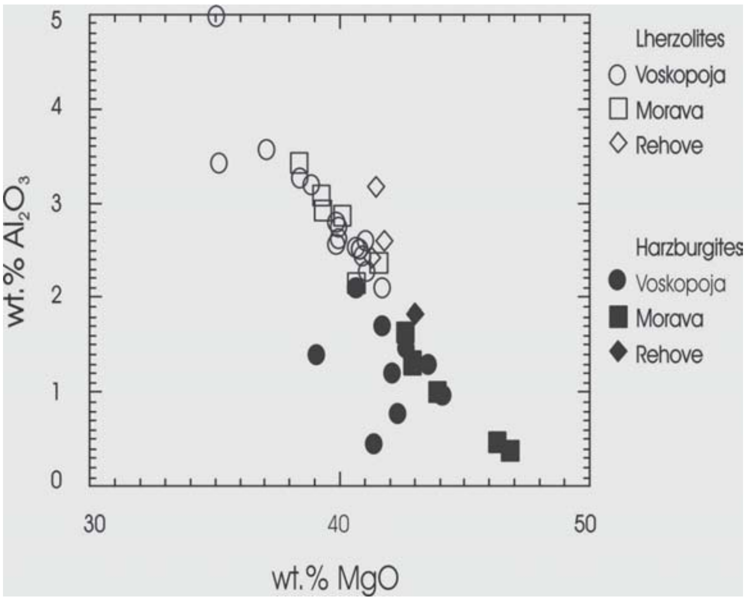

Figure 37 - MgO versus Al2O3 plot for the samples of the mantle section from the ophiolites of Morava, Rehove and Voskopja, (all data recalculated on a water free basis) according Hoeck et al. (2002).

1993;).

The sulphide-bearing dunites have a porphyroclastic to granoblastic texture, overprinted on a coarse grained relict texture, where olivine size can reach 5 mm.

The sulphide mineralization zones with PGE at Krasta e Re chromite deposit are 400m – 500m long, they extend up to 200m – 300m towards the dip and their thickness varies 1m-2m up to more than 5m-10. Their Ni-sulphide values vary 0.25% - 0.30%. There are some Ni-sulphide orebodies inside these mineralized zones such as the main orebody at the southern part of the ore deposit

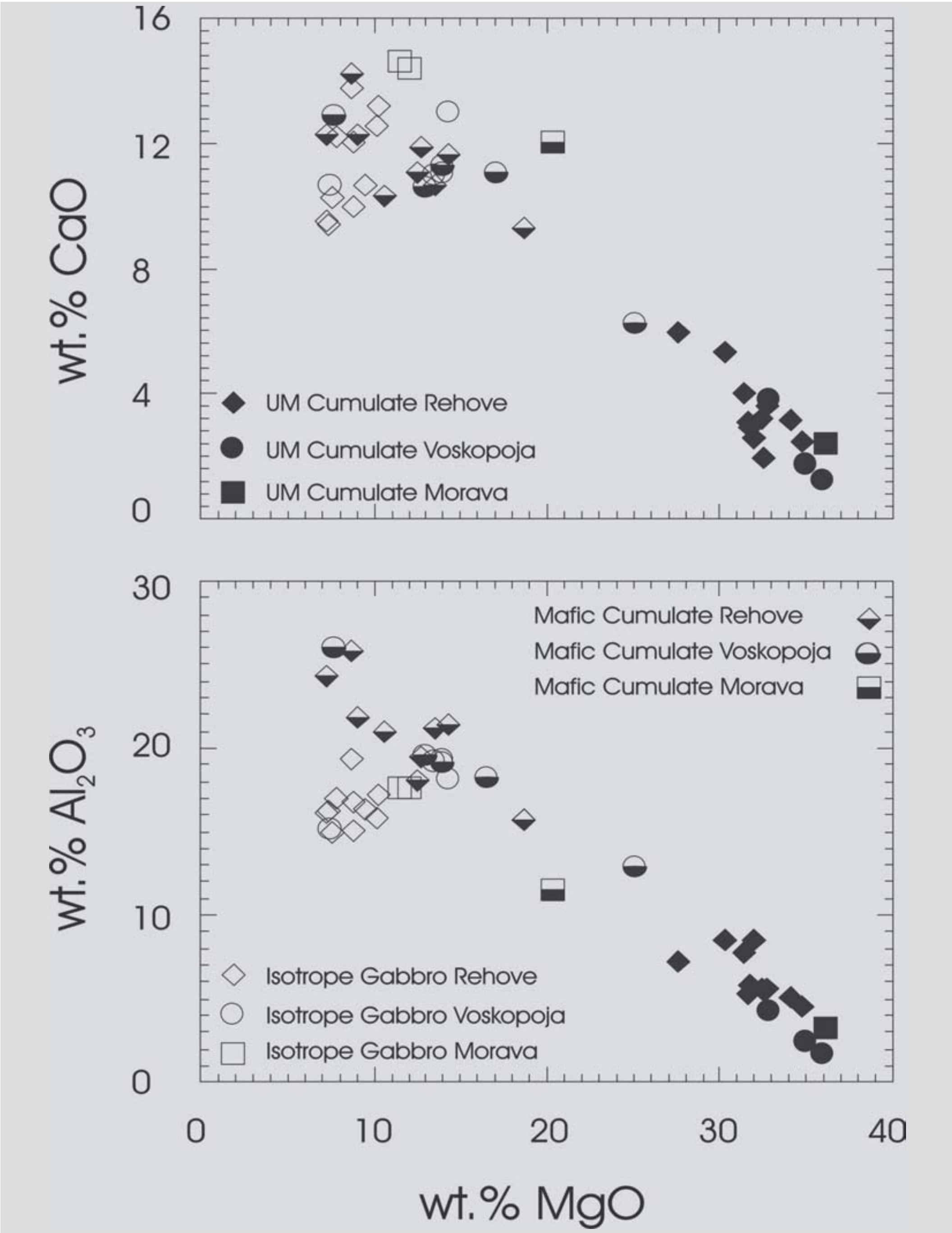

Figure 38 - MgO versus CaO and MgO versus Al2O3 plots for the ultramafic and mafic cumulates and for the isotrope gabbros of the plutonic section from the ophiolites of Morava, Rehove and Voskopja according Hoeck et al. (2002).

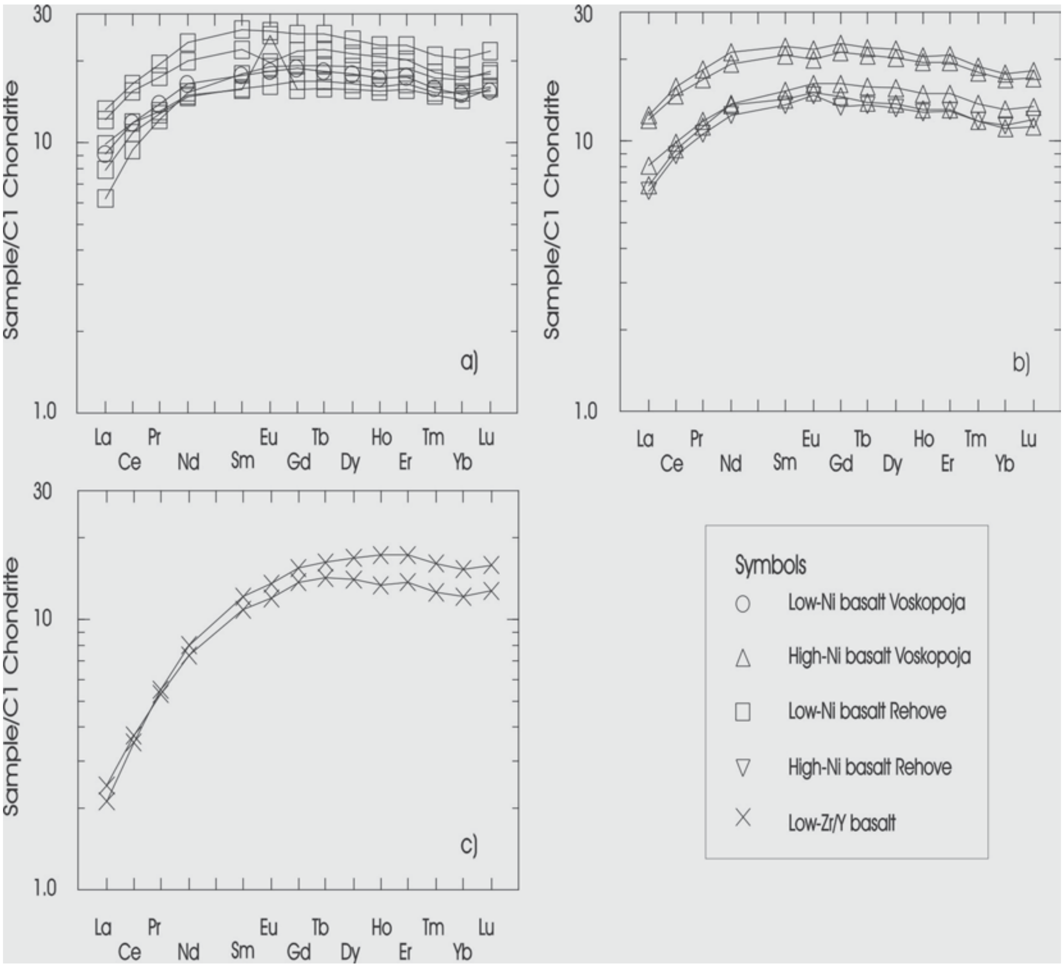

Figure 39 - REE element pattern normalized against C1 chondrite for the Low-Ni, high-Ni, and Low-Zr/Y basalts from Voskopoja and Rehove according Hoeck et al. (2002); normalizing values after Sun & McDonough (1989).

(Lleshi, 2000).

The main sulphide orebody found so far is 250m-300m long, 100m –150m deep and the thickness varies from some cm to 1m-2m and to less than 4-5m-10m (average 2 m). This orebody contains 0.5%-0.6% NiS, more than 2-3 ppm PGE, more than 0.5 – 1ppm Au, 0.1-0.6% Cu and 0.01-0.02% Co. The ore reserves of the main orebody with more than 0.5% NiS are estimated to be higher than 150,000 tons of Ni metal, 300 kg PGE and some 150 kg Au (Lleshi, 2001).

The ore deposits and showings with sulphide mineralization with PGE and Au compose the central strip between the two strips of chromite mineralization related to the Martaneshi dunites. This strip begins from Staveci to Krasta and Re deposit and extends towards the sulphide mineralization showings of Lugu i Thelle, Koxheraj, Guri i Mekes, Kodra e Nenes and Kaptina. The sulphide mineralization zones and orebodies with PGE are concordant with the chromite orebodies found in the uppermost part of dunites and this shows their magmatic origin. The most important PGEM are found in relation to sulphide mineralization orebodies, to the zones with sulphide dissemination and outside of them in the dunites of the uppermost part of the section, pyroxenites, as well as in the rich chromite orebodies belonging to this section (Lleshi, 2001).

Pentlandite is the main mineral partly transformed into millerite, awaruite, magnetite, copper and native iron.

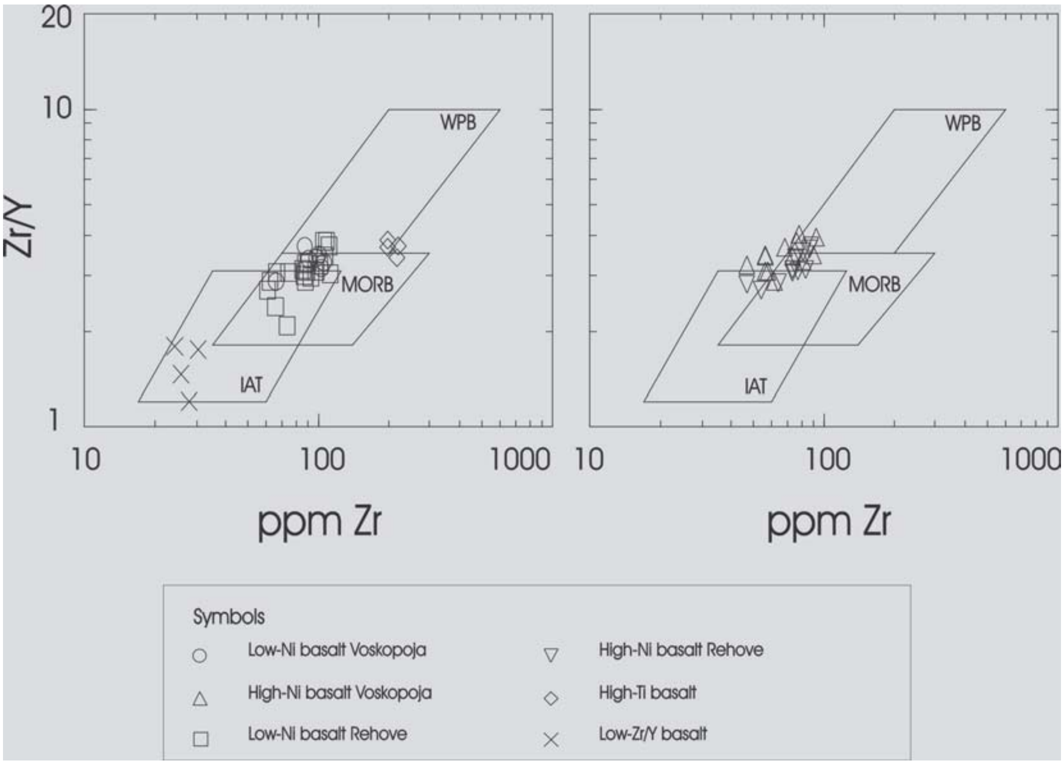

Figure 40 - Zr versus Zr/Y plot after Pearce & Norry (1979) for the basalt groups from the ophiolites of Voskopoja and Rehove according to Hoeck et al. (2002).

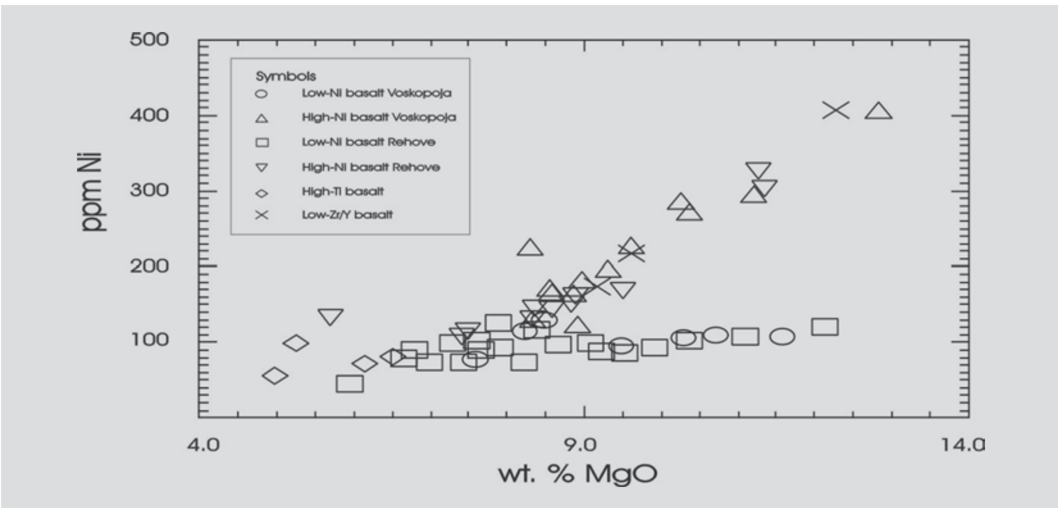

Figure 41 - MgO versus Ni plot for the basalt groups from the ophiolites of Voskopoja and Rehove according to Hoeck et al. (2002).

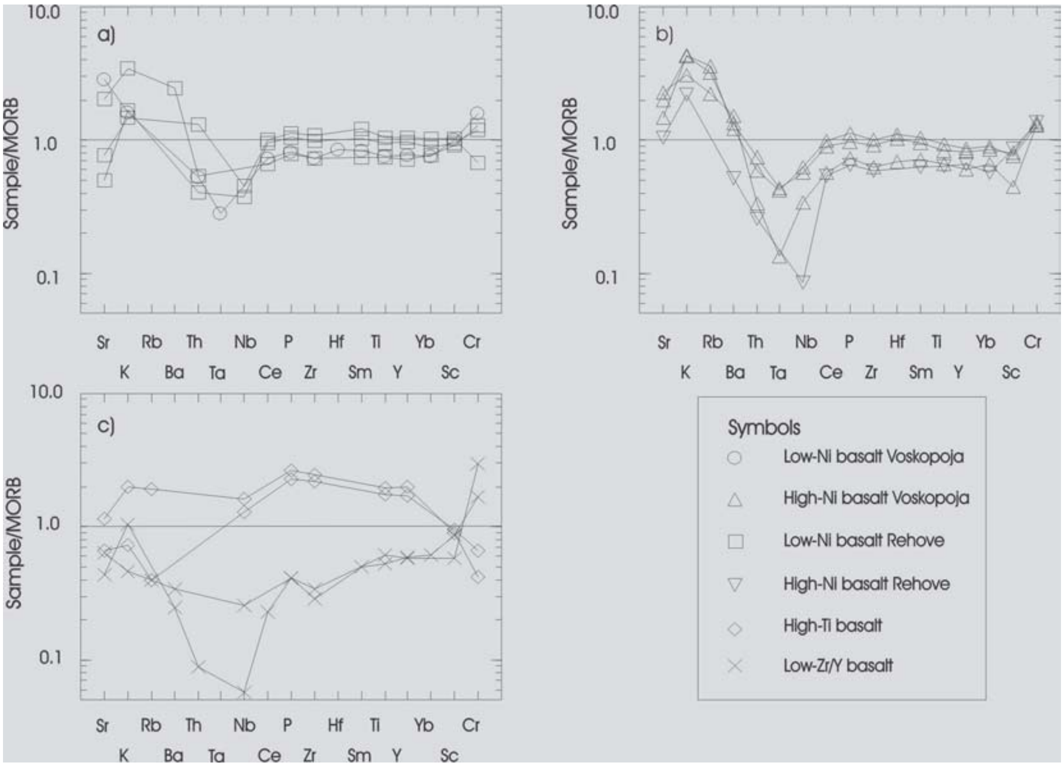

Figure 42 - Trace element concentrations for the basalts groups from the ophiolites of Voskopoja and Rehove according to Hoeck et al. (2002) normalized against MORB (Pearce, 1983).

PGE associated with Ni-sulphide mineralization varies from 143 ppb to 3451 ppb. Platinium and Palladium are the main Pt-group elements.

DAYS 5 - 6

The ophiolites in Southern Albania

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Similar to Northern Albania, the two belts can also be recognized in Southern Albania. The Western ophiolite belt comprises the Shpati, Vallamara, Devolli and Voskopoja Massif. The Eastern belt consists mainly of the large Shebenik Massif and relatively small ultramafic occurrences of serpentinite, close to the Greek border, the Massif of Bitinska. As the Voskopoja Massif is the best studied and the main target of the excursion in Southern Albania, it is described in more detail below.

The Voskopoja ophiolite can be divided into three subunits: the Voskopoja complex sensu strictu, SE and NW of the small town of Voskopoja, the Morava complex, mainly south of Korce and the southernmost complex of Rehove. The Voskopja and Morava complexes are separated by the north-south striking Neogene to Quaternary basin of Korce. A serpentinite mélange zone beneath the Morava and Voskopoja complexes separates both ophiolites from the Rehove complex. Since no better maps exist yet we refer here to the published Geological Map of Albania (ISPGJ-FGJN-IGJN 1983).

Three columnar sections including the complexes of Voskopoja, Rehove and Morava characterizing the lithological variation of the three ophiolites, are shown in Fig. 1. Two of these (Voskopoja and Morava) exhibit a thrust within the ultramafic mantle tectonites traced by a metamorphic sole. The lower thrust unit consists only of mantle tectonites, the upper thrust units show a continuous succession as

Figure 43 - E-rim of the Morava Massif where coal-bearing molasse sediments overlay the peridotites, Morave Massif. Area of an abundant coal mine, valley close to the village of Drenova.

does the Rehove complex. The three complexes are composed from bottom to top as follows (Fig. 36):
Above the tectonically underlaying mélange, all sections start with lherzolithe, interlayered by minor harzburgite and rare dunites. Two tectonic units were found in the Voskopoja and Morava complexes, separated by amphibolites and metasediments. In Voskopoja, the lherzolites contain completely rodingitized dykes of troctolites and rare basalts.

The ultramafic cumulates commonly comprise plagioclase wehrlite, melagabbros, mafic cumulates, olivine gabbros and troctolites. Only in Morava intrusions of gabbronorites and sills were found (Fig. 36). In the Rehove section ultramafic cumulates are overlain by cumulate olivine gabbros and troctolites. Isotropic gabbros are relatively frequent in Rehove, but rare in Voskopoja and missing in Morava. Individual basaltic dykes in the gabbros are widespread in Rehove, rare in Voskopoja and absent in Morava. Sheeted dykes may have been present originally, but they now occur only as megablocks in the breccias (see below). The ophiolite sequence in Morava ends with the plutonic sequence.

Massive basalts are observed in Rehove, as well as in Voskopoja, directly overlying the gabbros, but the most conspicuous and widespread rock type of the extrusive sequence are volcaniclastic sediments. They start from breccias and are often terminated by volcaniclastic sandstones (Fig.36). The thickness of the breccias is difficult to estimate due to discontinuous outcrops, it may reach up to several hundred metres. They contain mostly angular material. The size of the clasts is highly variable and ranging from centimetres to metres. Exceptionally, megablocks reach up to more than 100 metres in diametre and occasionally represent pillow lavas and sheeted dykes. In the upper parts of the volcaniclastic sediments conglomerates appear that contain sub-rounded to rounded clasts. In the lower parts of the stratigraphic succession the breccias are exclusively

Figure 44 - Layering of grabbroic to ultramafic composition, Morave Massif, valley close to the village of Korce.

clast-supported and partially devoid of matrix. However, the amount of matrix is small. Most of the breccias are monomict in that they contain only basaltic clasts, but the clasts themselves may vary in texture ranging from altered glass fragments to entirely crystalline basalt with ophitic textures. In the vicinity of the gabbros polymict breccias occur that contain clasts representing both, basalts and gabbros. In the higher parts of the sequence polymict breccias and conglomerates are generally more abundant. They are also clast-supported but contain a sandy, commonly red oxidized matrix as fill between the clasts that are sub-angular to sub-rounded and consist predominantly of basalt, but gabbro and radiolarite clasts are also common. The breccia/conglomerate sequences are conformably covered by a several metre-thick sandstone with variable grain size. The individual sandstone layers display a weakly upwards gradation and are up to 25cm thick. Within the sandstone complex intercalations of radiolarite layers up to 30cm thick occur. The sediments are in turn overlain by another, younger basaltic breccia.

The breccias could represent avalanche deposits of rockfalls, the conglomerates were probably deposited by debris flows and the sandstones by turbidity currents. The occurrence of radiolarites suggests a deep-water environment. The best outcrops of the volcaniclastic sediments are found in the Rehove section south of the village of Lubonje. The relation of the breccias to the more fine-grained sediments is similar to the Voskopoja section around the village of Shipcke and north of Mt. Oreni (N and S of Voskopoja, respectively).

Basaltic breccias in a comparable geological position are also found elsewhere in the western ophiolites, e.g. further to the north, where they are not so abundant (Beccaluva et al., 1994a, Bortolotti et al., 1996). Basaltic breccias reported by Robertson (1991) from Euboea (Greece) occur in the Pagodas mélange beneath the ophiolites. They are commonly interbedded with radiolarites. In southern Albania the relatively high amount of basalt breccias compared with the intact basalts above the isotropic gabbros

Figure 45 - Basalt dyke with chilled margin crosscutting an isotrope grabbro, Rehove Massif, ca 2 km south of the village of Lubonje.

Figure 46 - Monomicte basalt breccia, rather free of matrix and with components in the size up to 15 cm, Rehove Massif, ca 2 km south of Lubonje.

or layered gabbros gives evidence of a widespread decomposition and a subsequent redeposition of the fragmented basalts. This implies an irregular seafloor palaeo-topography. This could be the case in a transform fracture zone environment as shown e.g. by Barany and Karson (1989). They describe various basaltic breccias from the Clipperton fracture zone at the East Pacific Rise with a sequence from clast-supported to matrix-supported breccias. Basaltic breccias from the Arakapas fault belt at the Troodos Massif in Cyprus are also believed to have been formed partly by tectonic processes, partly by sedimentary processes in a transform fault zone (Simonian and Gass 1978; MacLeod and Murton 1993).

The results of our study can be summarized as follows:

The Voskopoja ophiolite consists predominately of lherzolites in the mantle section. The variation in the tectonites is shown in Fig.37, a MgO versus Al2O3 plot for the mantle section.

Above the mantle section the cumulate sequence is formed by wehrlites, troctolites and olivine-gabbros. Further gabbronorites are rare, isotropic clinopyroxene gabbros are overlain by massive basalt flows and mainly basaltic breccias. Isolated dykes occur. The basaltic breccias grade into sandstones, sometimes they are overlain by radiolarites. Thus, the whole ophiolite sequence fits well into the scheme of the western-type ophiolites (Shallo1992, 1994, Beccaluva et al. 1994a, b, Bortolotti et al. 1996, Robertson and Shallo 2000). The variation of the intrusive sections is documented in Fig.38. The cumulate section follows a trend evolution controlled by [olivine + orthopyroxene + clinopyroxene], for the isotropic gabbros the clinopyroxene is a more important phase.

Geochemically, the basalts show three groups (low, intermediate, high) in respect to their Ti and Zr contents (Fig. 39-42). The majority of basalts is assigned to the

intermediate group which in turn can be divided into a low-Ni group and a high-Ni group (Fig. 41). The high-Ni group primary contained formrelics of olivine and preserved Cr-spinel interpretated by Hoeck et al. (2002) as xenocrysts.
The low-Ti and Zr group also has a high Ni content and plot into the IAT-field (Fig. 40). The high-Ti and Zr group represent a rather evolved magma and is comparable to the high Ti ophiolites in the western ophiolites of northern Albania. The low-Ni and high-Ni groups (with intermediate to high Ti and Zr) represent more primitive melt and are comparable with the low to high intermediate Ti ophiolites (Bortolotti et al. 1996). The low-Ti and Zr basalt group has no equivalent in the western-type ophiolites in northern Albania.

Comparison of the ultramafic–mafic cumulates and the basaltic volcanics with those in the northern part of the western belt in Albania and the Pindos ophiolite indicates that there is a systematic variation in petrography and geochemistry from north to south in the western belt, with an increasingly distinct SSZ signature towards the south. Ultramafic and mafic cumulates as well as basalts from the Shebenik massif in the eastern belt are similar to those of Voskopoja, implying a genetic relationship.

The view held until now, assumes in general lherzolites as mantle tectonites in the Western belt and harzburgitic tectonites in the Eastern belt. By contrast, our recent investigations in Vallamara and Devolli Massifs revealed clearly that both massifs are dominated by an exceptionally fresh harzburgite in the interior of the massifs. The harzburgites consist of fresh olivines with kink bands, large opx crystals with cpx exolution lamellas, traces of cpx and Cr-spinell. The late serpentinization formed along fissures and cracks. The serpentinization is severe in the outer boundary zones and along faults, but exceptionally low within the interior parts of the massifs. These harzburgites are overlain in part by sometimes plagioclase-bearing peridotites and minor gabbros.

The Shpati Massif in turn, seems to be dominated by plagioclase peridotites including plagioclase-bearing ultramafic cumulates and gabbros. The cumulates are in part interlayered with gabbros, but can be in turn discordantly intruded by the latter. The gabbros comprise troctolites as well as cpx gabbros and are mostly highly altered. The provenance of basalts and basalt breccias in all three massifs seems to be questionable and not well understood. Apart from the basalts, which could be the volcanic section of the ophiolite bodies, other basalts may be associated with the mélange and tectonically underlie the ultramafic massifs. The few available geochemical analyses indicate mostly a MORB type composition of the basalts.

Excursion Stops:

During the excursion in Southern Albania, we will visit outcrops from the Shpati massif, the Morava Massif and Rehova Massif.

Stop 23:

Locality: Road from Elbasan to Librazhd, at the road bridge across the Skumbini river.
Topic: Layered peridotites intersected by rodingitized gabbros.

The peridotites include plagioclase-bearing dunites as well as plagioclase-bearing amphibole-peridotites. The ultermafics are interlayered with troctolites and melagabbros. The thickness of the individual layers range from dm to meters. The gabbros partially exhibit a flaser structure. The plagioclase in the gabbroic rock may be severely altered to prehnite, hydrogrossular or pumpellyite giving rise to a rodingite type alteration. The ultramafic layering as well as the gabbros dip steeply to the NNW to N, in some cases they dip to the NNE. This type of outcrop can be followed approximately 2 km to the west. They can be studied along the outcrops of the new road.

DAY 5

Stop 24. and 25:

Locality: Valleys east of Drenova and south of Korce.
Topic: The peridotites and layered complex of the Morava Massif.

The peridotites are overlain by coal-bearing Oligocene molasse-type sediments (Fig.43). The peridotite present a NNW-SSE striking banding. It dips towards NNE. Occasionally, tiny layers of plagioclase can be observed and followed over several meters. They follow the general banding. Several gabbro dykes, 20 to 30 cm thick, can be noticed. In the area south of Korce layering between mafic and ultramafic varietes are common (Fig.44).

DAY 6

Stop 26:

Locality: Rehove Massif, ca 2 km south of Lubonje.

Topic: Long cross section from layered grabbos to the gabbro-dyke complex and to the ophiolitic sediments.

Structurally, the deepest part is exposed towards the south. It consists of a gabbro sequence cut by basaltic dykes (Fig 45). Most of the gabbroic section is covered with vegetation and not well-exposed. Various blocks indicate that it consists of poikilitic wehrlites, troctolites with trondjhemitic dykes, as well as layered gabbros (Fig.38). Towards the north, the gabbro dyke complex grades into a monomictic breccia with angular basalt clasts ranging from cm to meter in size. This breccia is clast-supported, with only little mafic matrix (Fig.46). The component-supported breccia is in turn overlain by a polymictic breccia with a higher amount of matrix. These breccias are interbedded with volcanogenic sandstones with coarse-grained and fine-grained layers. They are turbiditic sandstones with upright grading and small channels. The sandstones in turn are overlain by component-supported breccia with almost no matrix and a sequence of radiolaritic shales, volcanogenic breccias and sandstones. Towards the hanging wall, the components become more rounded but are still poorly sorted.

References

Alliu I. et al., 1994. The Skanderbeg and Bulqiza mafic-ultramafic ophiolitic complexes and their relationships with chromititic ore deposits (Working Group Meeting of IGCP Project Nr.256 – Field Trip B). Ofioliti, 19 (1), 27-55.

Avxhiu,R., Bushati., Alikaj,P. (1984) – Buletini i Shkencve Gjeologjike, 2, 57-63,

Barany, I. and Karson, J.A., 1989. Basaltic breccias of the Clipperton fracture zone (east Pacific): Sedimentation and tectonics in a fast-slipping oceanic transform. – Geol. Soc. Am. Bull., 101, 204-220.

Bébien, 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., 1994a. 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.

Beccaluva, L., Coltorti, M., Premti, I., Saccani, E., Siena, F. and Zeda, O., 1994b. Mid-ocean ridge and suprasubduction affinities in the ophiolitic belts of Albania. - Ofioliti, 19 (1), 77-96.

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.

Bonneau M., Cadet J.P., Maluski,H., Ivanaj, A. (1995) – B.SH.GJ.,1,83-84,

Bushati S., Shpresa D., Duli F. and Xhomo A. (1996). Geotectonic ophiolite position inner Albanides according to the gravitu data. Rep. cent. Geophus. Geochemic. Explor, Tirana, Albania.

Cina A., Tashko A and Tershana A (1987). The Bulqiza and Gomsiqe ultrabasic massifs, ophiolites of Albanides: a geochemical comparison. Ophioliti, 12, 219-236.

Carosi, R. Cortesogno, L., Gaggero, L. and Marroni, M., 1996. Geological and petrological features of the metamorphic sole from the Mirdita nappe, northern Albania. - Ofioliti, 21 (1) 21-40.

Dimo, A., Vergely, P. and Monie, P., 1999. Genesis of metamorphic rocks in the Albanian ophiolites - EUG 10, Strasbourg, J. Conf. Abstr. 4, 406.

Dimo-Lahitte. A., Monie, P. and Vergely, P., 2001. Metamorphic soles from the Albanian Ophiolites: Petrology, 40Ar/39Ar geochronology, and geodynamic evolution. – Tectonics, 20, No.1, 78-96.

Frasheri, A., Nishani, P., Bushati, S., Hyseni, A., 1996. Relationship between tectonic zones of the Albanides, based on results of geophysical studies. In: Ziegler, P. A., Horwath, F. (Eds.), Peri-Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. Mem. Mus. Hist. Nat., Paris, 170, 485-511.

Gjata K., Shallo M and Meshi A. (1995). Overview of the Kukes – Kaptina ophiolite massif. In Albanian ophiolites and related mineralization. Editions BRGM, 153-166.

Hoeck, V., Koller, F., Meisel, T., Onuzi, K., Kneringe, E., (2002): The South Albanien Ophiolites: MOR vs. SSZ Ophiolites. - Lithos, 143-164.

Hoxha L. - The Jurassic-Cretaceous orogenic event and its effects in exploration of sulphide ores,

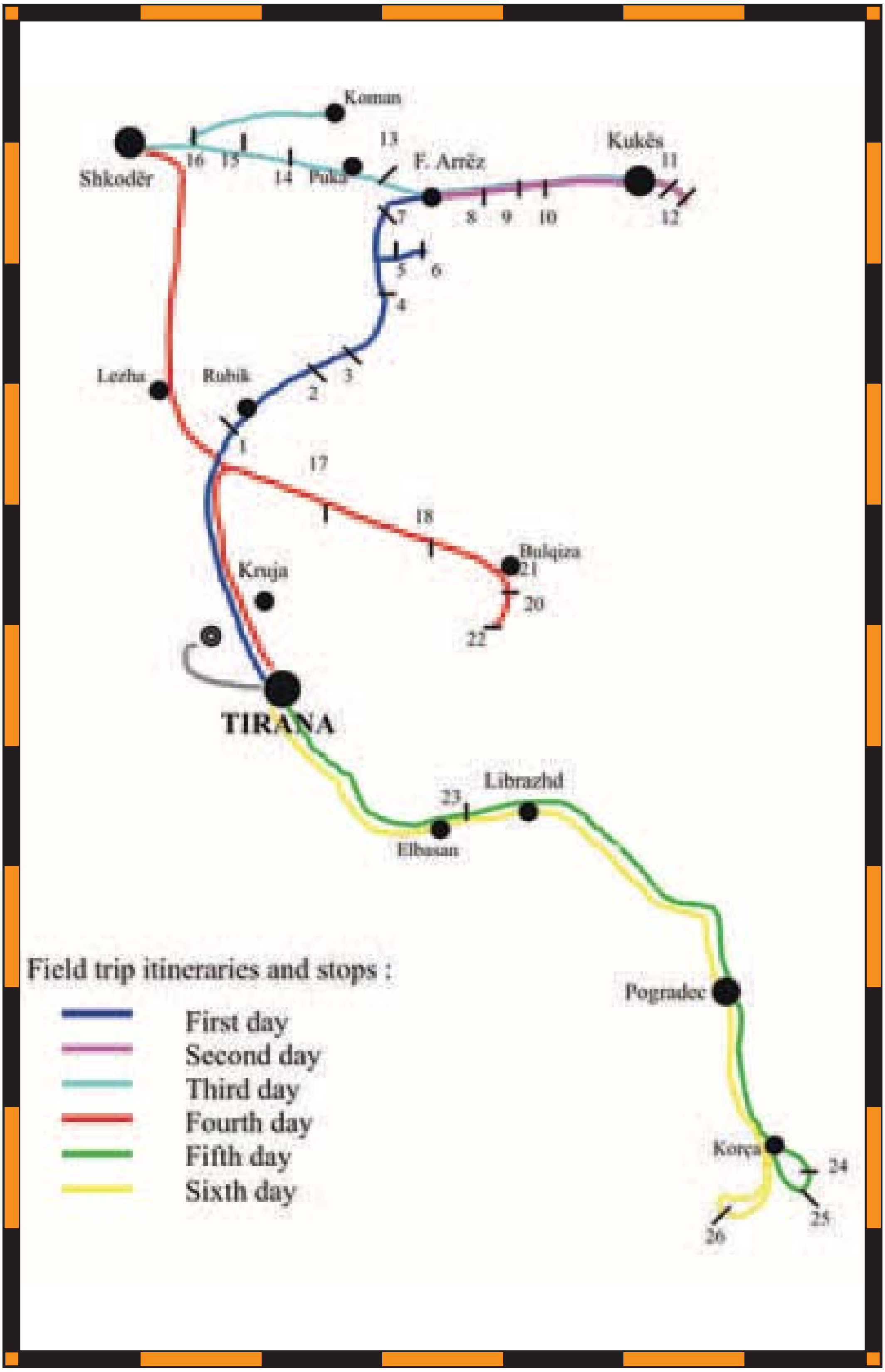
Albanian ophiolites, Albania. - Eclogae geol.Helv.94 (2001) 339-350
Hoxha M. and Boullier A.M. (1995). The peridotites of the Kukes ophiolite (Albanie): Structure and kinematics. Tectonophysics, 249, 217-231.
ISPGJ-FGJM-IGJN, 1983. Harta gjeologjike e Shqiperise. Scale 1:200 000, Tirana.
Karaj N., 1992. Repartition des platinoïdes, chromites et sulfures dans le massif de Bulqiza, Albanie. Incidence sur le processus metallogeniques dans les ophiolites. PhD. Universite d'Orleans, France.
Kelliçi,I.,de Wever,P., Kodra,A. (1994) – Revue de Micropal., 37,3, 209-222,
Kilias A., Tranos M., Mountrakis D., Shallo M., Marto A., Turku I. (2001). Geometry and kinematic of deformation in the Albanian orogenic belt during the Tertiary. Journal of Geodinamics, 31, 169-187.
Kodra, A. Gjata, K. and Bakali, F., 1995. The Mirdita oceanic basin from rifting to closure. - In: Workshop on Albanian ophiolites and related mineralization. IUGS/UNESCO Modeling Programme, Papers and Abstracts, Field guidebook, 10. - 17. October, 1995, 9-26.
Kodra,A., Gjata,K., Xhomo,A. (2000) – Buletini i Shkencve Gjeologjike,1, 5-26,
MacLeod, C.J. & Murton, B.J., 1993. Structure and tectonic evolution of the Southern Troodos Transform Fault Zone, Cyprus. – In: Prichard, H:M., Alabaster, T., Harris, N.B.W., Neary, C.R. (Eds.): Magmatic Processes and Plate tectonics. Geol. Soc. Spec. Publ. No. 76, 141-176.
N.B.W., Neary, C.R. (Eds.): Magmatic Processes and Plate tectonics. Geol. Soc. Spec. Publ. No. 76, 141-176
Marcucci, M., Kodra, A., Pirdeni, A. and Gjata, T. 1994. Radiolarian assemblage in the Triasic and Jurassic cherts of Albania. – Ofioliti, 19, 10-115,
Marcucci, M. and Prela, M. 1996. The Lumi i Zi (Puke) section of the Kalur cherts: radiolarian assemblages and comparison with other sections in northern Albania. – Ofioliti 21, 71-77.
Marcucci, M., Prela, M., Cortese, G.,Kodra, A. (1998) – Ofioliti, 23(2), 101-105.
Meço, S. (1988) – Buletini i Shkencve Gjeologjike, 2, 97-112.
Meço, S., Aliaj, Sh., Turku, I. (2000) – Geology of Albania, Gebrüder Borntraeger, 28, Stuttgart, 246pp
Ohnenstetter M. et al., 1991. Le potential platinifere des ophiolites: mineralisations en elements du groupe du platine (PGE) dans les massifs de Tropoja et Bulqiza, Albania. C.R. Acad. Sci. Paris 313, ser.II: 201-208.
Ohnenstetter, M. Sider, H. 1988. Contraintes Geochimiques apportees par le magmatisme sur le development du bassin marginal ensialique du Beaujolais au Devonien. – Bul. Soc. Geol. Fr., 3, 499-510
Pearce, J.A., 1983. Role of the sub-continental lithosphere in magma genesis at active continental margins. In: Hawkesworth, C.J., Norry, M.J. (Eds.): Continental Basalts and Mantle Xenoliths. Shiva publishing limited, 230-249.
Pearce, J.A., and Norry, M.J., 1979. Petrogenetic implications of Ti, Zr, Y and Nb variations in volcanic rocks. Contrib. Mineral. Petrol. 69, 33-47.
Prela M., Marcucci M. and Chiari M (2000). Jurassic radiolarian biostratigraphy of the sedimentary cover of ophiolites in the Mirdita area, Albania: new data. Ofioliti 25,55-62.
Robertson, A.H.F., 1991. Origin and emplacement of an inferred late Jurassic subduction-accretion complex, Euboea, eastern Greece. – Geol. Mag., 128, 27-41.
Robertson, A.H.F. and Shallo, M., 2000. Mesozoic – Tertiary tectonic evolution of Albania in its regional Eastern Mediterranean context. – Tectonophysics, 316, 197 – 254.
Shallo, M., 1992. Geological evolution of the Albanian ophiolites and their platform periphery. - Geol. Rdsch., 81, 681-694, Stuttgart.
Shallo M., Cina A., and Turku I (1995). Outline of the metallogeny of the Albanian MOR- and SSZ-type ophiolites. In Albanian ophiolites and related mineralization, editions BRGM, 27-47.
Shallo M. and Gjata K. (1995). Overview of the central Mirdita region. In Albanian ophiolites and related mineralization. Editions BRGM, 139-152.
Simonian, K.O. and Gass, I.G., 1978. Arakapas fault belt, Cyprus: A fossil transform fault. – Geol. Soc. Am. Bull., 89, 1220-1230.
Sinojmeri, A. 1990. Mineralogie et Parageneses du gisement volcanogene a Cu, Zn, Pb, Au de Munella. – PhD Thesis, Univ. Orleans France
Sinojmeri, A. 1994. Sea-Floor sulfide mineralizations of Munella Deposits, Central Mirdita, Albania. Bul. Of the Geol. Soc. Of Greece, vol. XXX/3, 265-274
Sun S.S. and McDonough, W.F., 1989. Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: Saunders, A.D. & Norry, M.J. (Eds.): Magmatism in the Oceanic basin: Geological Society Special Pub. 42, 313-345.
Tashko A. et al., 1990. Rreth geokronologjise absolute

te masiveve ultrabazike te Albanideve. Bul. Shk. Gjeol., 1: 39-46.
Tashko A. (1996). Diversites geochimiques, petrologique et structurales des ophiolites des Albanides. Bull. Soc. Geol. Fr., 167, 335-343.
Turku, I., 1987. Metamorphites from Kukes ultramafic massif (northeastern margin of the Mirdita ophiolitic zone, Albania. - Ofioliti, 12 (1), 137 – 150.
Vergely P., Dimo A. and Mone P (1998). Datation des semelles metamorphiques ophiolitiques d'Albanie par la methode 40 Ar/ 39Ar: Consequences sur le mecanisme d'obduction. C.R. acad. Sci., Paris, 326, 717-723.
Xhomo, A., Kodra, A., Gjata, K. (2002) – Buletini i Shkencve Gjeologjike, 1, 5-20,

Back Cover:
field trip itinerary

FIELD TRIP MAP

32nd INTERNATIONAL GEOLOGICAL CONGRESS



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