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MINERALOGY OF CHROMITITE, BULQIZA ULTRAMAFIC MASSIF, ALBANIAN OPHIOLITIC COMPLEX

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Abstract

Ultramafic massif of Bulqiza belongs to Eastern Jurassic Albanian ophiolite belt of IAT-BSV- type. This massif is the most important chromite-bearing ore. The mantle ultramafics have extremely refractory nature. This is due to the high partial fusion of upper mantle which is depleted in CaO and $Al_2 O_3$ *. The chromitite is situated to different parts of ultramafic pile, from bottom Cpx-harzburgites up to massive dunites and cumulate ultramafic but the mainly chromite potential belongs to mantle harzburgite –dunite level and to transition dunites partly. The chromite is chiefly of Cr-rich metallurgical type. The atomic ratios of chromite , Fo of olivine and some physical properties of them vary according to the chromitite setting and reflects the evolution of Ol-Sp equilibrium process depended of the chromite concentration, from baren dunitic lenses towards dunite envelops of the ore bodies and the interstitial and inclusions of olivine within chromite grains. Two particular chromite deposits are the Bulqiza- Batra tabular folded ore body and Shkalla, pencil –like ore body.*

***Key words**: Chromitite mineralogy, ultramafic, massif Bulqiza Albania.*

1. Introduction

Widespread ophiolitic rocks in Albania occur along two ophiolitic belts, the Western and the Eastern ones characterized by individual petrological, geochemical and metallogenic features .The Western belt comprises ophiolitic rocks of Jurassic age and MOR-type affinity and includes high – Ti basaltic rocks. On the contrary, the ophiolitic rocks of Eastern belt show IAT type geochemical character and comprise of low-Ti basalts. This belt suggested that it is formed over a subduction zone (SSZ) (Alliu et al., 1994; Shallo et al., 1995; Kodra et al., 1995). This ophiolitic belt is composed by some massifs, with them, the Bulqiza massif is most important for its high chromite- bearing. Many chromite occurences and some big and very big deposits are situated in this massif related chiefly to harzburgite –dunitic mantle part and partly with super MOHO- dunites. The ore body are folded tabular, podiform, banded – layered and pencil – like even. The principal rock constituent are mantle harzurgites and super MOHO –dunites, whereas the Pl-dunites, lherzolites, wehrlites, pyroxenites and gabbroic rocks, are less abbundant. The Bulqiza massif, similarly to other Eastern ophiolitic complexes such the Vurinous and Troodos. (Çina et al., 1986; Econoumu et al., 1986; Panayiotou et al., 1986), has been affected by intensive partial melting of the upper mantle as it is implying by depletion in CaO and Al_2O_3 and enrichment in MgO and Cr_2O_3 of the mantle rocks. The chromite is of Cr-rich, metallurgical type, with a few exceptions, for some occurances composed by Al- rich chromite – type .It is remarkable that olivine as dunite and chromitite – component is two much forsteritic type. The morphology and textures of ore body as well as the chemical composition and some physical properties of chromite are subordinated related to their geological setting, from Cpx- harzburgite of deeper part to upwords super MOHO-dunites and ultramafite – mafite sequences. All the same ,the composition of olivine is variable related to chromite concentration, as reflection of equilibrium process between ol- sp. The aim of this review is to make known the mineralogy of chromitite of one of the most distinguished chromitite-bearing ultramafic massif of Bulqiza, and wider for the Eastern ophiolitic complexes in general.

1.1 Analyses' methods and conditions.

The analyses of chromite and olivine are brought out by electronic microprobe CAMEBAX under the conditions accelerating voltage 15 kV and a current of 10 nA, time of caption 10 sec. The correction programme ZAF by Honoc and Tong (1978). The analyses have been conducted in MGA-BRGM, France by Ch. Gilles and D. Ohnenstetter. The parameter of the elementary cell of chromite have been extracted from the Ro-analyse with 4x time camera of Guinier and Wolff, anticathode Cu- Ka1, 36 kV, 20 mA with the assistance of F. Pillard at MGA-Mineralogy Geochemistry Analyses, France.

2. Geology and chromitite-bearing of the massif.

The Bulqiza ultramafic massif is situated at Eastern ophiolitic belt. It covers a surface of 350 km^2, with a thickness about 5 – 6 km. It is surrounded by different sediments, from Triassic, Triassic – Jurassic limestones, and partly is covered by Cretaceous limestones and Neogenic molassic sediments. This massif consists mainly of mantle harzburgites, Eastern and central part, by super – MOHO dunites ,South – Western and Western parts and by ultramafic – mafic intrusive rocks at Western side (Fig.1). This massif is remarkable for its high chromite- bearing mineralization. About 100 occurances and 15 deposits occur. Among them, some are big and very big as Bulqiza – Batra, Shkalla, Thekna, Ternova, Lugu Gjat, and Krasta deposits. The most important chromite mineralization is situated at central part of massif related to harzburgite – dunites, and partly at South - South – Western part related to super - MOHO dunites. Only from Bulqiza – Batra deposits are extracted about 20 mega ton high grande chromite ore. The ore bodies have tabular concordant and semi concordant folded shapes, podiform and banded-layered , even pencil –like morphology. The exceptional is Bulqiza deposit represented by tabular folded ore bodies, 5000m in strike and 0,5 up to 5-10 m thick. The ore body came out at the height of 1570 m over the sea level and goes down to 300 m under the sea level. The other particular deposit is Shkalla, pencil – like ore bodies . These have oval - shaped surface section from 5 to 25 m^2 and go up to 1500m downwards. The chromite is Cr-rich metallurgical high grande type. It is situated at different part of ultramafic pile, from that related to deep mantle cpx – harzburgites, towards upper harzburgite – dunite and dunite – harzburgite parts, up to super –MOHO dunites, even to ultramafite – mafite and troctolite sequences. The most chromite –bearing potential is situated at 300 up 1200 m interval below super-MOHO dunites and only low – grande chromite ores are related at middle – deep dunitic sequence (Fig.2). The chromite ore grade concerning its geological setting decreases from mantle harzburgite – dunitic level of high to highest grande from 37% to 45% Cr_2O_3 even 53% Cr_2O3 for pencil –like ore body, upwards for dunite – harzburgite part (middle grade, from 30% to 35% Cr_2O_3) and particularly for super – MOHO dunites (lower grade, from 18% to 25% Cr_2O_3).

2.1 Petrography

The most common mineral components of chromitites are chromite and olivine, as well as serpentine. In small quantities occur also the other silicate minerals clinopyroxen, orthopyroxen, amfi-

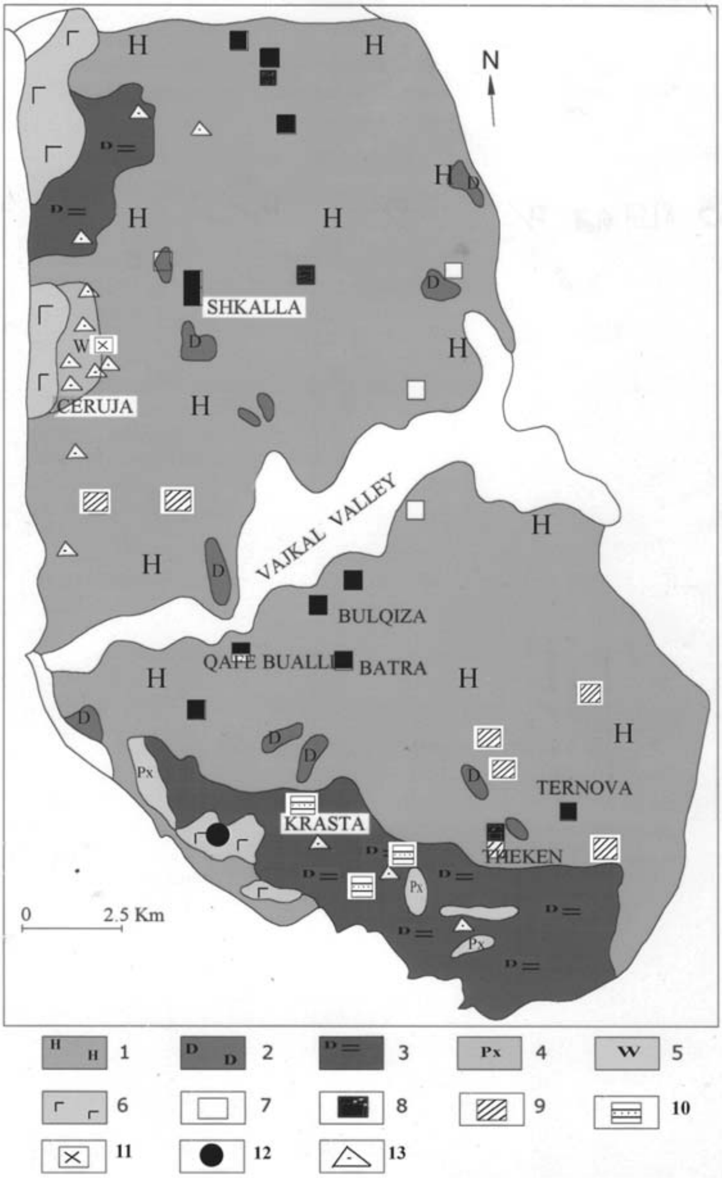

Fig. 1: Geological map of Bulqiza ultramafic massif and related mineralization.

1: Mantle harzburgites; 2: Mantle dunites , 3: Super - MOHO dunites, 4: Pyroxenites, 5:Wehrlites, pl - lherzolites ,pyroxenites; gabbros; 6: Gabbro- troctolites.

Chromite mineralization related to:

7: Deep mantle, cpx – harzburgites, Al – rich chromite type. 8: Middle mantle, harzburgite – dunite level, Cr-rich chromite type; 9: Upper mantle, dunite – hazburgite level, Cr- rich chromite type; 10: Super – MOHO dunitic transition zone, Cr- rich chromite type; 11: Ultramafite –mafite, cumulate sequences and intrusive rocks, Al –rich type chromite; 12: Troctolite sequence, Al- rich chromite; 13: Ni and Ni – Cu sulphide mineralization associated by PGM.

	LITHOLOGY	CHROMITE TYPES, GRADE ORE	Cr# (mol. 100xCr / (Cr+Al)	Mg#(mol 100xMg/ (Mg+Fe)	Elemen-tary cell a_0 Å
CUMUL. SEQUEN.	TROCTOLITE	Al- RICH REFRACTARY TYPE	42.7	79.8	8.198
	WEHRLITE	Al- RICH REFRACTARY TYPE MED - GRADE ORE	52.9	68.3	8.239
SUPER- MOHO TRANZITION ZONE	MASSIVE DUNITES	Cr-RICH METALLURGIRCAL TYPE , LOW- GRADE ORE	81.6 – 83.5	70 -78.5	8.309- 8.326
MANTLE TECTONITES	DUNITE-HARZBURGITE	Cr-RICH METALLURGIRCAL TYPE , LOW-MED.–GRADE ORE	80.9 -82.7	64.3 – 70.5	8.306
	HARZBURGITE DUNITE	Cr-RICH METALLURGIRCAL TYPE , HIGH- GRADE ORE	77.3 –81.9	68.8– 75	8.285- 8.303
	Cpx - HARZBURGITE	Al- RICH REFRACTARY TYPE MED - GRADE ORE	59.5	78.7	8.250

Fig. 2: Geological setting, types, grade ores and some significant chemical ratios of chromitites. Eastern ophoLite belt, ulramafite massif of bulqiza, Albania.

boles, Cr- diopside, Cr –garnet, Cr –chlorite, BMS and PGM. The minute grains of these minerals are included within host chromite grains and as interstitial forming between them also. It is interesting to point out the presence of uvarovite and kemmererite related to massive chromitite of vein – like ore body. The sulphide and arsenide of BME as pentlandite, millerite heazlewoodite, nickeline, maucherite, pyrrhotite, cubanite as well as of PGE mainly Ru, Os , Ir alloys and their sulphides, are related to super –MOHO dunites and upper mantle chromitite. The textural features of chromitites of tabular, podiform and vein – like ore bodies are varied, massive, dense dissemination and nodular. For banded – layered ore bodies disseminated and banded texture are characteristic. Some textural features of them testify on magmatic plastic deformation processes, and posmagmatic budinage (Figs 3: a, b, c and d). The chromite grains display euhedral and subhedral shape with 1 to 2mm up to 5mm dimensions (Figs 4: a, b and c). For the disseminated chromitite related to dunites, euhedral shape and less 1 mm size are more characteristic. The chromite grains contain many different inclusions, opx, cpx, ol, BMS and PMG (Figs 4: d and e). The partly metamorphosed chromite grains and transformed into Fe – chromite up to magnetite and its veinlets are observed. (Fig 4: f).

3.1 Chemical composition of chromite in the various chromitite types

The Cr# in spinel can be regarded as a sensitive chemical parameter for the degree of depletion as long as it lies above 15 (Dick and Bullen 1984).The main chromites of Bulqiza massif show high-Cr character (Cr# vary from 77 to 83.5). The most frequent Mg# ratios is from 64.3 to 78. Only a few of them are of Al-rich type, with Cr# from 53 to 59. The associated olivine is of the high

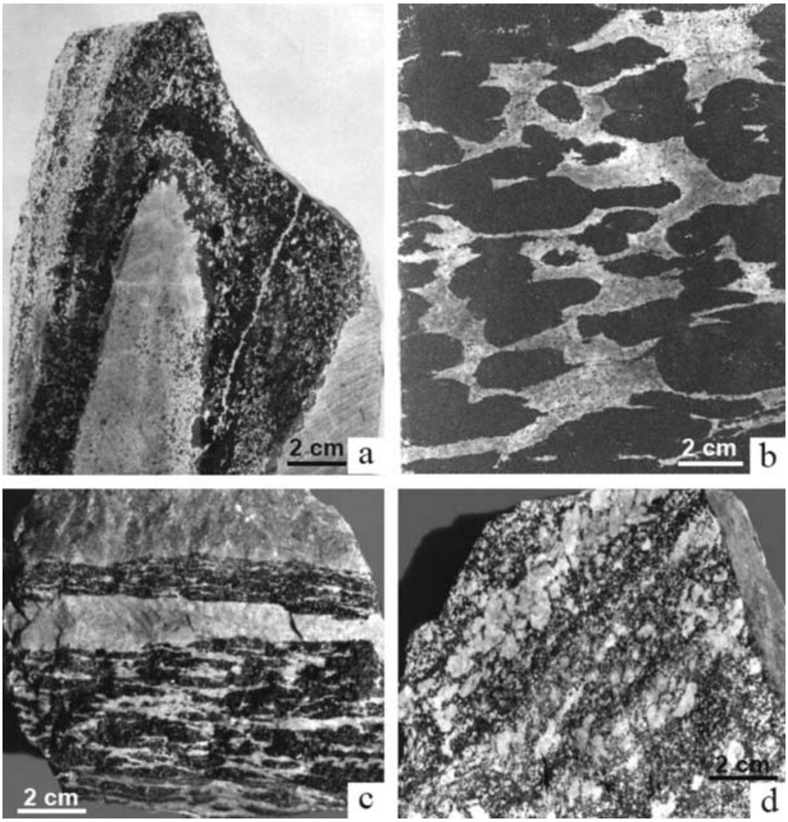

Fig. 3: a: The plastic sindeformed chromitite. The foliation plan of isoclin fold is parallel to axial plan of folding; b: Nodular chromitite, intensively deformed. The nodules are extended and crushed by strong attraction; Fig. c: The buddined chromitite transformed into banded – like shope. The pull-a- part lineation is expressed clearly; d: The chromitite intensively deformed ,transformed into lensoide – brekccious up to antinodular – shape.

forsteritic type, Fo from 90 to 96. In accordance with chromite composition the physical properties are not so variable. So, among them, the elementary cell parameter a_0, in average is from 8.285 Å to 8.326 Å, regardless some exceptions for the chromites related to deep Cpx-harzburgites and for these relate to ultramafic cumulates (a_0=8.25 and 8.239Å) (Fig 2.). Nevertheless, a clear tendency is evident regarding the correlation between chemical composition and its geological setting, from bottem Cpx –harzburgites to top super –MOHO dunites and ultramafic – mafic part. So, the Cr# ratios and some physical properties encrease, wereas the Mg# decrease from bottem upwards to top ultramafic pile. By the contrast, the chromite related to ultramafic– mafic sequence have lower Cr# and $a_{0\ ,}$ and high Mg# especially this related to troctolites (Fig. 2). The chemical composition of chromite for some particular deposits are reported in Table 1. Those compositions are different from less depleted Western ophiolitic belt of Al- rich nature mainly (Fig. 5). The chromite of Bulqiza massif is similar with Vourinos massif in Greece. The chromite of its Xerolivado and Skoumtsa deposits has Cr# from 0.80 to 0.83 and Mg# from 0.65 to 0.68. (Economou et al., 1986). But the similarity to chromite from Troodos (Kokkinoratsos, Kannures and Hadjipavlou) is less evident, because its chemical indicators are lower, Cr# from 0.72 to 0.76 and Mg# from 0.61 to 0.63. (Panayiotou et al., 1986; Dick and Bullen, 1984; Dietrich et al., 1987; Migiros et al., 1988; Konstatopoulou et al.,

Table 1. Chromite deposits: Deep mantle: 1.Takimi Pare, Harzburgit-dunite:2-3 Bulqiza, 4-Batra, 5 Shkalla, 6-Qafe Buall Dunite-harzburgite: 7- Lugu Gjate; 8-Thekna Super MOHO dunite:9-Krasta; Ultramafic -mafic cumulates: 10-Crruja;Troctolite :11- Stavec ; Pensil -like chromite - Cr-diopsite :12-Maja Hudres. Cr#= 100x Cr/(Cr+Al) atom.ratio Mg# = 100x Mg/(Mg+Fe^{2}+) atom ratio.

Table 1: Chemical composition of chromite ,Bulqiza ultramafite massif, Albania												
	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	0.09	0.07	0.07	0.03	0.06	0.16	0.01	0.09	0	0.06	0.2	0.11
TiO_2	0	0	0.07	0.1	0.07	0.18	0.08	0.16	0.06	0.26	0.16	0.05
Al_2O_3	21.3	9.89	10.38	11.49	8.8	8.6	9.51	8.73	8.98	22.8	31.73	15.22
Cr_2O_3	46.72	59.78	58.5	58.32	59.3	61.4	59.99	59.4	59.56	42.57	35.32	53.12
FeO	8.07	11.13	7.5	9.45	7.51	13.39	10.51	14.55	7.63	12.67	8.07	10.46
Fe_2O_3	5.18	3.84	5.71	4.21	6.43	1.14	3.66	4.7	6.45	4.15	5.05	4.63
MnO	0.31	0.39	0.37	0.27	0.32	0.19	0.34	0.27	0.43	0.17	0.34	0.36
MgO	17.42	14.27	16.72	15.71	16.5	14.11	14.58	11.5	16.51	15.58	18.63	15.22
NiO	0.1	0	0.09	0.11	0.36	0.09	0.05	0.08	0	0.17	0.12	0.05
CaO	0	0	0	0.01	0	0.01	0	0.01	0	0.01	0.01	0
V_2O_3	0.17	0.12	0.15	0.18	0	0.2	0.03	0.09	0.03	0.1	0.35	0.12
CoO	0.02	0.05	0.07	0.04	0	0.02	0	0.03	0	0.02	0.1	0
Total	31.27	29.8	30.61	29.98	31.12	29.15	29.17	31.23	31.05	32.87	32.67	30.84
Si	0.021	0.017	0.018	0.006	0.015	0.036	0.003	0.02	0	0.016	0.045	0.014
Ti	0	0	0.013	0.018	0.012	0.035	0.015	0.032	0.011	0.048	0.028	0.009
Al	6.069	3.01	3.1	3.43	2.66	2.655	2.914	2.717	2.705	6.595	8.563	4.522
Cr	8.931	12.2	11.721	11.68	12.021	12.714	12.328	12.027	12.027	8.261	6.356	10.586
Fe^{2+}	1.632	2.402	1.59	2.003	1.61	2.931	2.285	3.213	1.631	2.6	1.546	2.205
Fe^{3+}	0.943	0.746	1.089	0.802	1.241	0.245	0.715	0.934	1.239	0.768	0.87	4.63
Mn	0.063	0.084	0.079	0.059	0.07	0.042	0.075	0.06	0.093	0.035	0.066	0.077
Mg	6.276	5.429	6.313	5.931	6.306	5.44	5.64	4.491	6.284	5.675	6.358	5.678
Ni	0.02	0	0.017	0.021	0.073	0.02	0.01	0.017	0	0.034	0.022	0.05
Ca				0.003						0.003	0	
V	0.032	0.026	0.031	0.036	0	0.035	0.005	0.016	0.007	0.035	0.065	0.031
Co	0.003	0.01	0.023	0.008	0	0	0	0	0	0	0.019	0
Total	8.969	8.697	9.142	8.863	9.3	8.713	8.73	8.731	9.254	9.15	8.946	12.671
C#	0.595	0.802	0.791	0.773	0.819	0.827	0.809	0.82	0.816	0.529	0.427	0.701
Mg#	0.787	0.688	0.791	0.742	0.79	0.643	0.705	0.578	0.785	0.683	0.798	0.708

1990; Georgiou et al., 1990; Gartzos et al., 1990). As is reported by Panayiotou et al. (1986), the variabitity of chromite composition is also evident concerning their geological setting in main dunites, harzburgite – dunite contact, transition zone and deep harzburgites.

In the Cr# vs. Mg# diagram (Fig. 5) the chromites of Bulqiza massif are compared to the chromites from the other Eastern ophiolitic complexes such as Vourinos and Troodos campareble to the spinels in Tertiary boninites from Western Pacific and Cape Vogel (Papua) and fild for spinels in island are arc-thoeliites (IAT) (Dietrich et al., 1987).

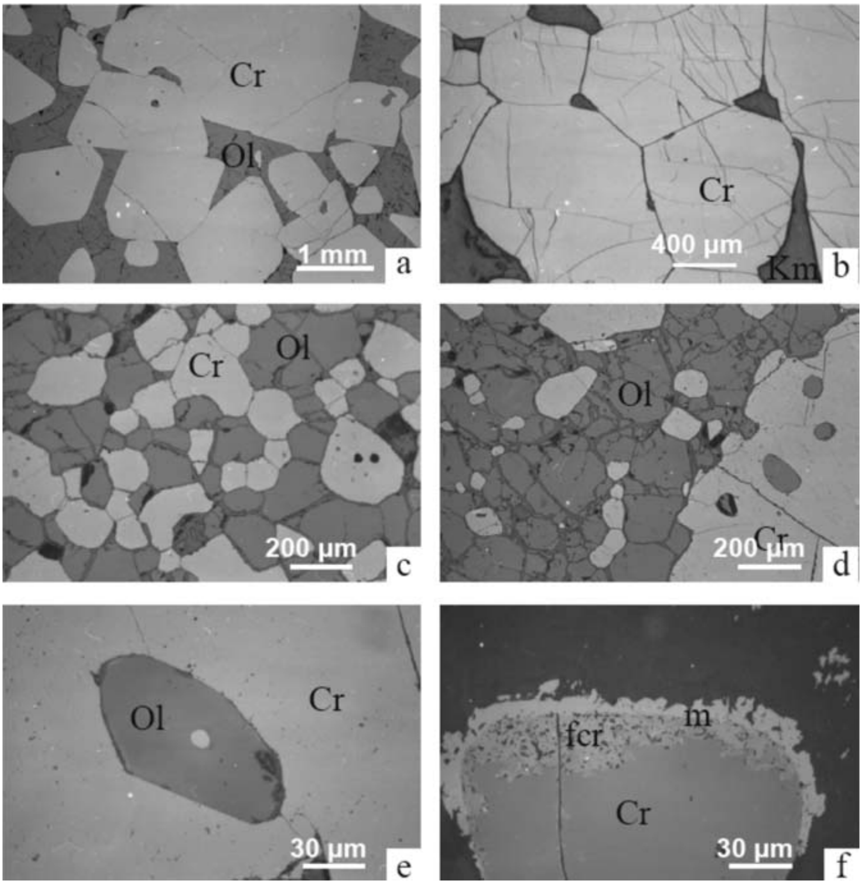

Fig. 4-a: Perfect euhedral chromite crystals (Cr) within olivine (Ol) groundmass; b: Massive chromitite built up by compressed euhedral crystals (Cr). Interstites filled by kemmererite; c: Different euhedral and anhedral chromite grains (Cr) towards olivine ones(Ol); d: The different relation between chromite and olivine: its inclusions (Ol) within chromite (Cr) grains and the contrary; e: The lense shaped olivine inclusions (Ol) within chromite (Cr) grains and the contrary, minute spheric chromite inclusion within bigger olivine inclusion f: The partly metamorphosed chromite grain (Cr) in to Fe – chromite (fCr) and surrounded by magnetite rim (m).

A great part of the chromites of Bulqiza massif, such as those related to harzburgite- dunitic, dunite-harzburgitic and super MOHO dunites are characterized by high Cr# ratios similarly to those of Troodos, chromites from the main dunite and from southern Vourinos massif. All these chromites are analogues to boninites and IAT environment.

On the contrary, some of the chromites from Bulqiza related to deep Cpx- harzburgites and especially, these related to ultramafic cumulate have low up to very low Cr# ratios similarly to the others from the contact between the harzburgite and the transition zone of Troodos as well as those from Kissavos and Rodiani are characterized by low Cr# ratios.

Regarding to the Mg# ratios, the difference between these complexes is less evident. This parameter varies between narrow limits, 62 up to 78 in average.

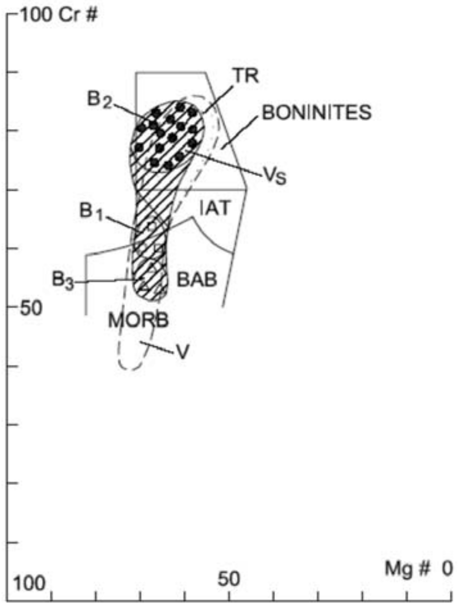

Fig. 5: Cr# versus Mg# for chromites of B-Bulqiza massif, Albania and of similarly, V- Vourinos and TR- Troodos with reference to boninitic lavas from Western Pacific, IAT and MORB environments (Data from Dick and Bullen, 1984; Economou et al., 1986; Panayiotou et al., 1986; Georgiou et al., 1990; Konstantopoulou et al., 1990; Gartzos et al., 1990. Chromite of Bulqiza massif related to: B_1- deep mantle Cpx- harzburgites; B_2- ultramafic cumulates; B_3- mantle harzburgite-dunitic, dunitic-harzburgitic and super MOHO dunitic parts; Vs- Southern Vourinos massif.

3.1.1 The composition of olivine and the equilibrium temperature.

The compositional change of olivine is also very interesting, from baren dunitic lenses towards the dunitic envelops of the ore bodies, interstitial and inclusions of olivine within chromitite, Fo varies in the range from 90 to 96.5 (Table 2). According to xMg and xFe variations in olivine and spinel, the temperatures, calculated on the Ol – Sp termometer (by Lehmann, 1981) vary widly, from 650 to 750 C^0 for the chromitite, up to 800^0C for accessoire chromites (Table 3).

The differences of Fm reflects the evolution of Ol – Sp equilibrium process depended from the grade of chromite concentration. So the chromitite Ol – Sp equilibrium has been more prolongated and was interopted in lower temperatures. On the contrary, for schiren and especially for accessorial chromites this equilibrium has been blocked early, in high temperatures. As suggested by Economou (1984) the systematic variation of olivine composition is propably a result of subsolidus reaction.

4. Conclusions

The Bulqiza ultramafite massif belongs to Eastern ophiolite belt of Albania. It is the most important chromite-bearing in Alpin Mediterranean belt.The rock composition of this massif mainly by mantle harzurgites and super –MOHO dunites , and by fosteritic olivine and enstatitic orthopyroxen, rock – forming minerals, is distinguished by high magnesian character. This is due to high partial melting of upper mantle and intensively mantle –crust interaction . In the consequence, a thick super-MOHO dunitic sequence is formed. The ultramafic – mafic intrusive rocks are present also. The consequence of hight partial melting, the upper part of ultramafic pile is high consumptioned and impoverished by CaO and Al_2O_3 and enriched by MgO and Cr_2O_3. The chromite mineralization is situated at all ultramafic pile, but the most important chromite potential belongs to harzburgite –dunitic and partly to super –MOHO dunitic part , about from 300m down super- MOHO level, to 1200m. The predominant chromitite is of Cr- rich chromite high – grande ore, metallurgical – type. Among

Table 2.

Table 2 Chemical analyses of olivine						
	1	2	3	4	5	6
SiO_2	40.98	41.53	41.02	40.65	41.08	41.2
FeO	7.85	7.24	4.06	5.08	2.99	2.78
CaO	0.04	0.05	0	0	0.01	0.04
Al_2O_3	0.04	0.02	0	0.01	0	0
MnO	0.33	0.02	0	0.04.	0.06	0.01
MgO	49.79	50.87	55.29	55.39	56.46	56.09
Cr_2O_3	0	0.06	0		0.03	0.18
NiO	0.5	0.33	0.67	0.4	0.62	0.67
Total	99.55	100.1	100.66	101.94	101.25	100.97
Si	1	1	0.972	0.97	0.97	0.974
Fe	0.16	0.15	0.081	0.1	0.059	0.055
Mn	0	0	0	0.01	0.01	0
Mg	1.81	1.83	1.963	1.95	1986	1.977
Cr					0.001	0.003
Ni	0.01	0.01	0.012	0.007	0.012	0.013
Total	2.98	2.99	3.025	3.028	3.029	3.023
Fo	91.1	92.3	95.18	94.7	96.5	96.7
Fa	8.9	7.7	4.82	5.3	3.5	3.3

1-In harzburgite; 2-In dunite; 3 and 4- interstitial in chromite; 5 and 6- inclusions within chromite.

Table 3.

	Table 3.	The equilibrum temperatures after olivine - spinel couple											
		Number of atoms in elementary cell of chromite and olivine											Temp C
	Al	Cr	Fe^{3+}	Fe^{2+}	Mg	FM	CAF	Si	Mg	Fe^{2+}	Fo	Fm	Lehm.
				CHROMITE						OLIVINE			
1	0.386	1.471	0.134	0.208	0.78	0.219	0.738	0.97	1.986	0.056	0.965	0.029	673
2	0.31	1.6	0.085	0.362	0.627	0.373	0.802	0.969	1.951	0.1	0.947	0.049	795
3	0.466	1.416	0.107	0.246	0.745	0.256	0.711	0.973	1.971	0.062	0.965	0.031	648
4	0.331	1.548	0.112	0.28	0.707	0.292	0.777	0.971	1.966	0.078	0.957	0.038	750
5	0.418	1.469	0.109	0.267	0.74	0.265	0.732	1.003	1.185	0.073		0.037	704
6	0.364	1.541	0.089	0.286	0.706	0.295	0.772	0.972	1.973	0.07		0.034	693
7	0.319	1.548	0.128	0.243	0.748	0.258	0.775	0.964	1.99	0.068	0.961	0.033	730
8	0.375	1.53	0.091	0.301	0.689	0.31	0.766	0.969	1.963	0.081	0.952	0.04	799
9	0.049	1.418	0.129	359	653	0.355	0.71	1.003	1.843	0.109		0.056	794
10	0.558	1.335	0.101	0.406	0.581	0.417	0.669	0.964	1.888	0.173	0.912	0.085	891
11	0.341	1.611	0.048	0.595	0.411	0.591	0.805	0.96	1.834	0.207		0.101	942

1 to 8;Chromitites; 9; Chromitic dunites; 10 and 11; Harzburgites. FM=Fe^{2}/ (Fe^{2+} Mg) atom., CAF = Cr/(Cr+Al+Fe^{3+}) atom.

them the other less important chromitite of Cr-rich metallurgical type also , but low – grande ores are related to super –MOHO dunites. The different restricted chromite ores, Al-rich, refractory type, are related to deep cpx –harzburgites and, in countrary at top of ultramafite – mafite sequences.The intensively partial melting of upper mantle is not fully sufficient argument to explain the high chromite concentration. As is suggested by Nicolas at al., (1991) the slow spreading, oxygen fugacity and the cool action of overlayered crust have played also their role for this concentration. The correlation between geological setting and the morphology, chromite –type, ore grande, chemical composition of chromite and textural features of chromitite, and ol – sp subsolidus reaction, are the arguments for the magmatic origin, complicated by later geodynamic processes.

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