GEOLOGICA CARPATHICA, 42, 3, BRATISLAVA, JUNE 1991, 181–191

METABASITES OF EDOUGH MTS. CRYSTALLINE COMPLEX (NE ALGERIA) AND ITS PERSPECTIVITY FOR TUNGSTEN

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(Received September 29, 1988; accepted in revised form December 13, 1990)

Abstract: The Edough crystalline complex is built up of different eruptive and metamorphic rocks, from which some metabasaltic rocks, pyroxenites, plagioclasites and pegmatites are very interesting from the point of view of tungsten mineralization. They are located in gneisses and mica schists of Precambrian to Paleozoic age. Tungsten mineralization is concentrated mostly in the pyroxenites and metabasaltic rocks, and therefore the origin and geochemistry of these rocks has been studied. All rocks under discussion were metamorphosed under amphibolite facies conditions and consequently they were recrystallized under greenschist facies conditions. Available analytical results from pyroxenites and metabasites show elevated contents of tungsten in the mentioned rock clans.

Key words: tungsten, pyroxenites, metabasites, Edough Mts., NE Algeria.

Introduction

In the Edough Mts., situated in the northeastern part of the Atlas (Maghrebide) belt in NE Algeria, there are occurrences of tungsten mineralization which were exploited in the past on the deposit Karézas near Annaba/Ex-Bône (Beauregard et al. 1958).

Since mineralizations with scheelite occur on the above mentioned locality in pyroxenites, we focused our geological as well as petrographical studies to all known occurrences of metaultramafic and metabasic rocks in the Edough Mts.

We found out that WO_3 contents in metaultramafites, metabasites and some other rock types are noteworthy and they provide indications for prospection for industrial mineralizations in the region. From our studies it also follows that principal types of metabasites belong to the group of tholeiitic rocks similar to recent eruptives in oceanic basins.

Geological setting of Edough Mts.

The Edough Mts. in the sense of Durand Delga and Fondboté (1980) forms a part of the eastern section of the Maghrebides. The last detailed study concerning the mountain range has been published by Hilly (1962). More recently, geotectonic evolution of the mountain range has been delt with by Vila (1970, 1980). The study of Ilavský and Snopková (1987) deals with the stratigraphy of metamorphic complexes and structural-tectonic analysis of the mountain range (Fig. 1). The last mentioned authors (l.c.) distinguished on the basis of micropaleontological study 4 independent formations, or groups, in the metamorphic complexes of Edough Mts.

1. *Séraidi, or Edough Group* (gneiss formation), the age of which is most probably Proterozoic to Cambrian. The protolith of this metamorphic formation was of sedimentary-volcanic character. The formation was several times metamorphosed, so that the rocks belong to the group of polymetamorphites.

2. *Belélieta Group* (denoted in the past as schist formation, or "série des alternances") is formed by various metamorphic equivalents of sedimentary and volcanic rocks. In this series there are known silicite (chert) intercalations containing palynomorphs of Ordovician to Devonian age (Ilavský and Snopková, 1987).

3. *Berrahal Group* ("schistes satinés" formation) is as to its rock content of the protolith similar to the previously mentioned series. However, it differs from the previous formation by its having been affected by metamorphism of retrograde type.

4. *"Voile Noire" Group* (or amphibolite formation) is lying discordantly and disharmonically on the schist formation. The age of the Voile Noire Group is probably Middle Devonian to Lower Carboniferous. Rocks of this complex were metamorphosed in the amphibolite facies conditions and subsequently they were affected by retrograde metamorphism under greenschist facies conditions (Fig. 2).

The Edough Mts., as well as the Voile Noire Group, is characterized by nappe tectonic style. The mountain range as a whole was during Eocene, or the Savian phase of the Alpine orogeny, thrusted over the Lower Kabylia massif. This is indicated by the fact that Tertiary (Badenian) magmatic rocks in the area Cap de Fer-Ain Barbar-Chaiba and associated

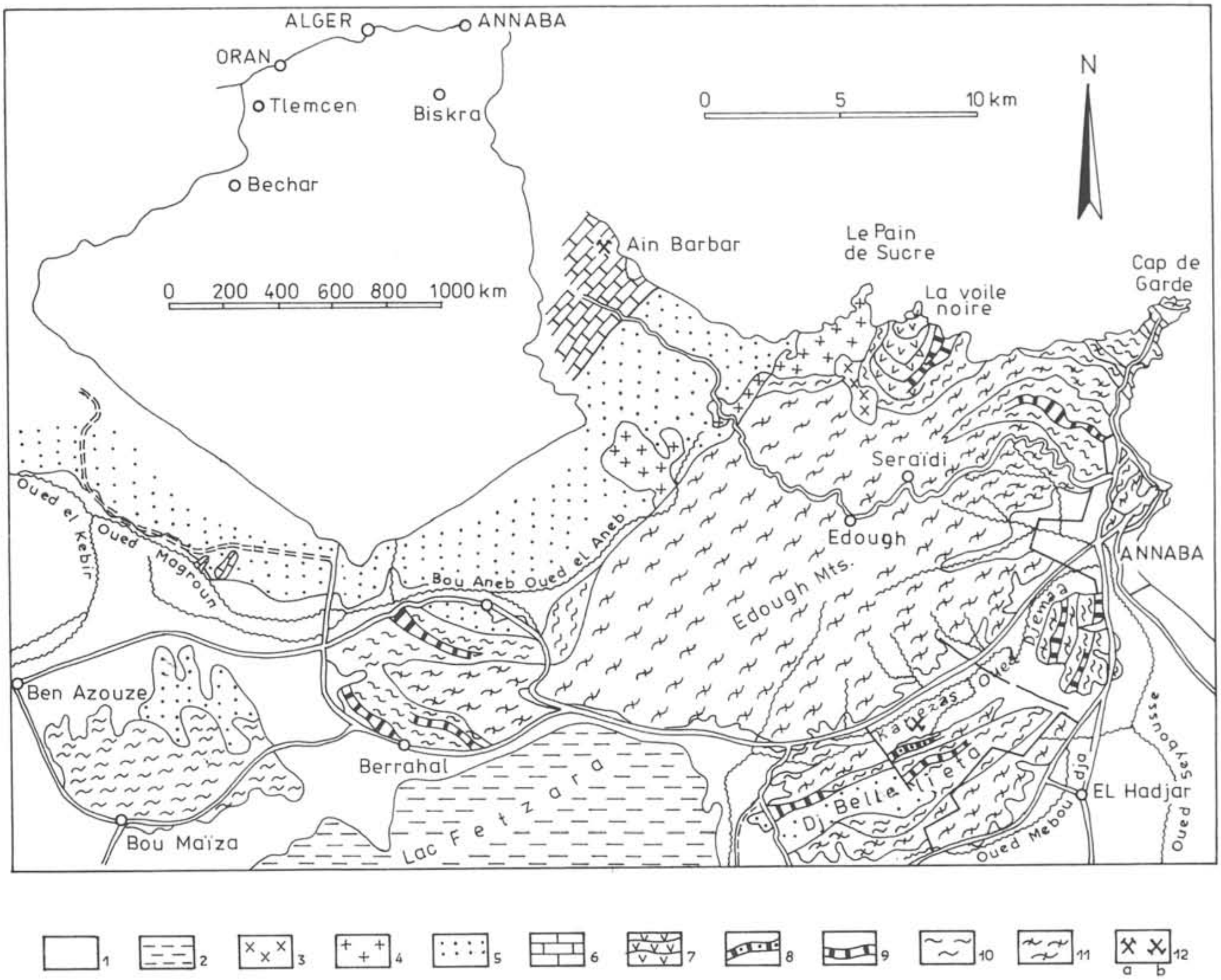

Fig. 1. Schematic geological map of Edough Mts., Wilaya Annaba, NE Algeria. After Hilly (1962), revised by Ilavský.
1 – Quaternary (soils, debris, river alluvia and marine beach sands); 2 – lacustrine Quaternary (Fetrzara); 3 – Miocene (rhyolites, porphyrites); 4 – Miocene (microgranites and porphyrites); 5 – Paleogene (sandstones and shales of the flysch); 6 – Cretaceous (sandstones and shales); 7 – Lower Paleozoic (amphibolites, their tuffs and tuffites); 8 – Lower Paleozoic (pyroxenites); 9 – Lower Paleozoic (marbles, crystalline limestones and dolomites); 10 – Lower Paleozoic (schists); 11 – augen- and banded gneisses – Lower Paleozoic; 12 – mines a) operating, b) not operating.

sediments are already post-orogenic in the sense of dynamic models of orogenic zones (Stille 1924, 1953; Durand Delga and Fondboté 1980; Vila 1980).

The Belélieta Group (i.e. schist formation) is formed by rhythmically alternating beds of biotite-muscovite schists and augen- to banded gneisses. While the schists belong to the category of para-ectinites, in which we cannot observe any substantial participation of feldspar material, the augen- and banded gneisses have the character of stratoid embreschites, with observable migration of neosome (mobilisate).

Both principal lithofacial types are conformly folded, in longitudal as well as transversal direction (Figs. 2, 3). From the direction of belts in the geological map (Fig. 2) we can see that bedding planes of the rock sequence are inclined alternatively to the north or to the south, from which anticlinal and synclinal structures of E–W direction can be deduced, with slight inclination of the rocks to the north or to the south.

Metamorphism and folding of the schist formation took place before the ampibolite formation of the Voile Noire Group formed (or was thrusted), since the two formations have totally different tectonic styles (Fig. 3).

Geological and structural-tectonic conditions of the Voile Noire Group

The Voile Noire Group (or amphibolite formation) represents, according to Ilavský and Snopková (1987), an independent structural and lithofacial unit with characteristic rock content. It differs from older units of the Edough Mts. crystalline complexes and was probably thrusted on them (Figs. 4, 5, 6).

Hilly (1962) described in the past the predominant rocks of this units as "feldspar amphibolites", which are lying on

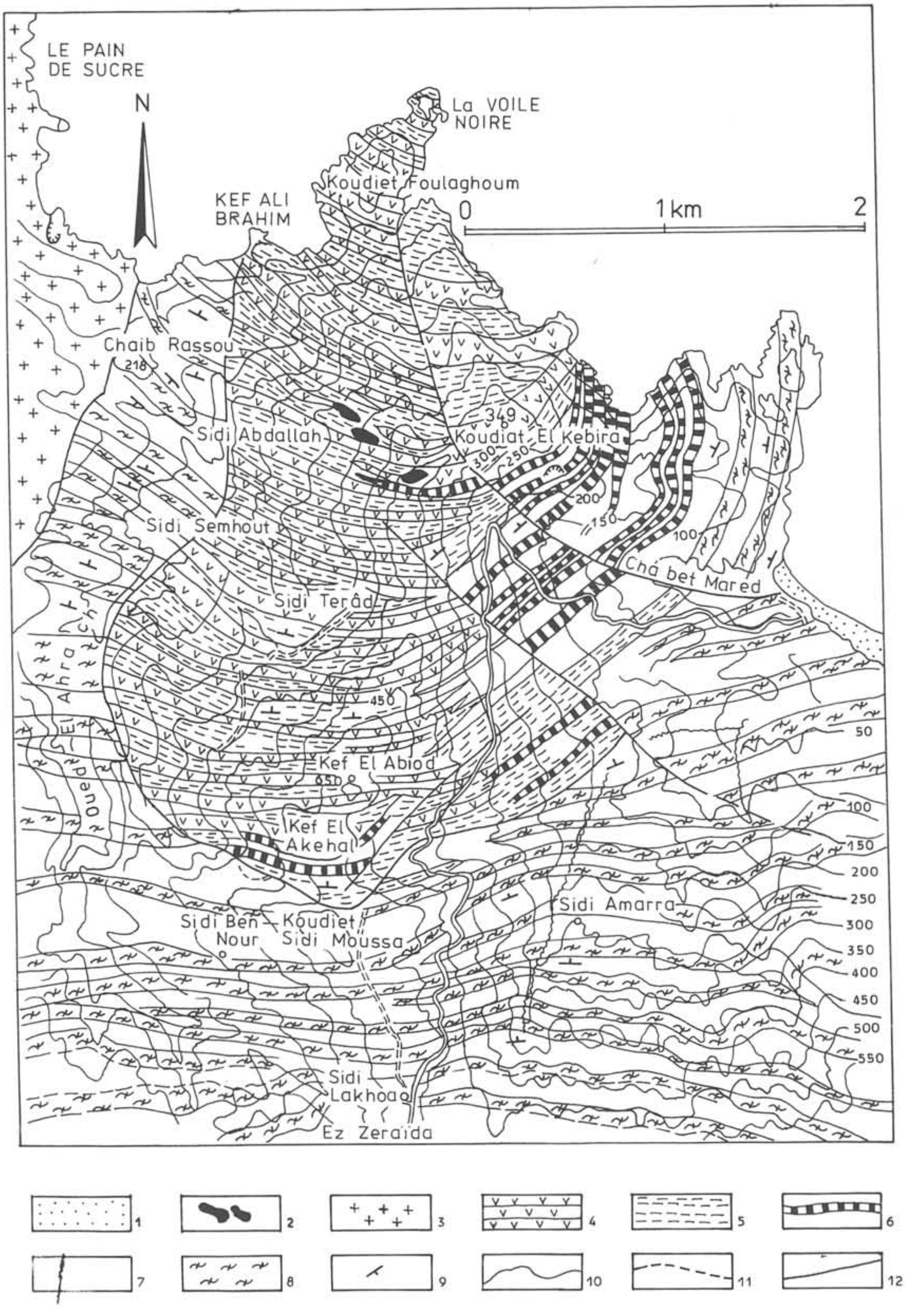

Fig. 2. Geological map of the amphibolite formation (Voile Noire Group in the region Ez Zeraida-Voile Noire, northern part of the Edough Mts., at asphalted road to Seraidi Beach.
1 – Quaternary (beach sands); 2 – rhyolites to porhyrites – Miocene; 3 – microgranites – Miocene; 4 – amphibolites; 5 – basic tuffs and tuffites; 6 – marbles: metamorphosed limestones and dolomites; 7 – schists; 8 – augen- and banded gneisses; 4–8 – Lower Paleozoic; 9 – strike and dip of beds; 10 – faults; 11 – sharp boundaries of rock complexes and rocks; 12 – boundaries between rocks with facial transitions.

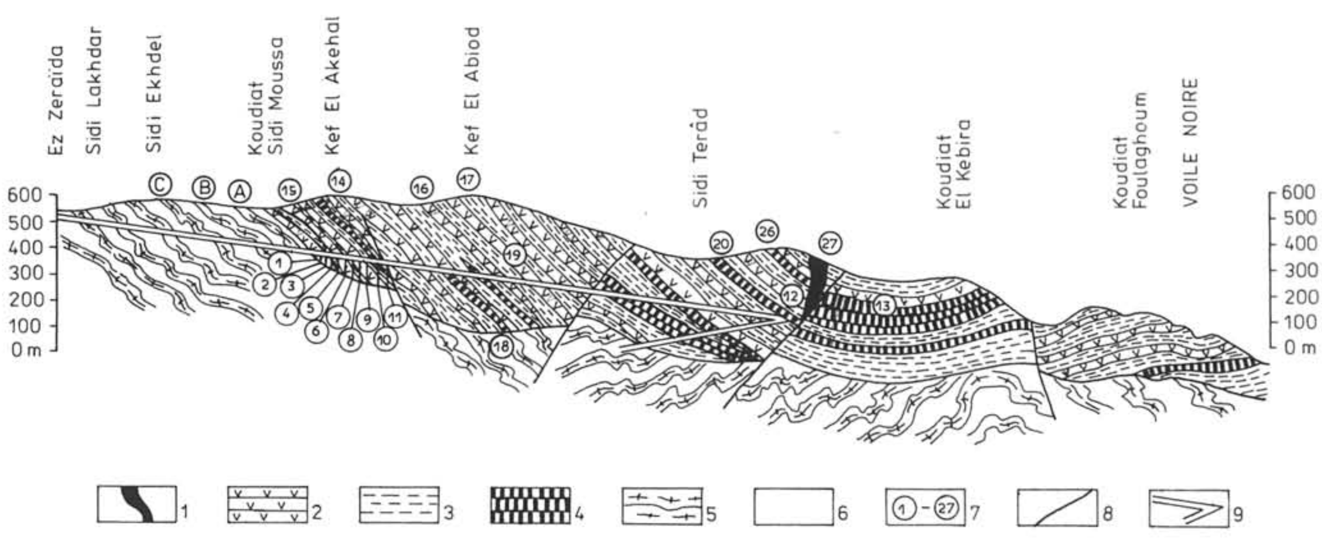

Fig. 3. Geological-structural section across the Voile Noire Group (amphibolite formation) from the south (Ez Zeraida) to the north (Koudiat Foutaghoum).
1 – rhyolite vein bodies (Tertiary); 2 – diabases and dolerites; 3 – diabase tuffs and tuffites; 4 – limestone and dolomite beds in diabase formation; 2–4 – Voile Noire Group (amphibolite formation); 5 – augen- and banded schists to gneisses; 6 – fine-grained two-mica schists to gneisses; 5–6 – Belélieta Group (schist formation); 7 – numbers of samples selected for analyses and petrographic investigations; 8 – faults; 9 – asphalted road from Annaba to Seraidi Beach.

a schist basement. The amphibolites are, according to this author, markedly banded and in a vertical section they alternate multiple times with epidosite beds.

The amphibolites are built up of hastingsite (Hilly still used the name "hudsonite"), plagioclases and quartz. Plagioclases have the anorthite molecule content of andesine to labradorite.

In minor amounts there are epidote minerals, garnet and sphene. Hilly (1962) described in the amphibolite formation also several pyroxenite layers forming conform beds with a thicknes of several *cm* to *dm* (Fig. 7). Characteristic is also the presence of amphibole garnetites and "gneiss granulites" occurring alternatively with garnetites or pyroxenites (l.c.). The mentioned author reported also löllingite and scheelite mineralizations in pyroxenite and amphibole garnetite beds, but he did not characterize these minerals in greater detail.

Pyroxenites, amphibolites, epidosites and garnetites formed according to Hilly (l.c.) as a result of metamorphism of carbonates or marls (Figs. 8, 9). The source of metamorphic effects was granite intrusion of Miocene age from which feldspar material penetrated into the described sedimentary complex lit-par-lit and changed the rocks into augen- to banded gneisses.

The amphibolite formation, or in our denomination the Voile Noire Group, is lying discordantly on the gneiss, or schist group, which is documented also by the geological map (Fig. 2) and section (Fig. 3) made from the south (Ez Zeraida) to the north (Voile Noire). As we can see, the amphibolite formation is lying on various members of older formations. It is evidenced not only by the discordancy, but probably also by a stratigraphical hiatus between the amphibolite formation and its basement. In the south, on the area between Sidi Moussa-Kef El Akehal to Kef El Abiod, the basement of the amphibolite formation consists of amphibolites with beds of metatuffs and metatuffites of basic volcanics (Fig. 3) metamorphosed to greenschist facies (diaphtorized chlorite-sericite schists). On this area, thin layers of metacarbonates (limestones and dolomites), epidosites and garnetites occur in the amphibolite formation. On the other hand, the basement of the formation on the territory Voile Noire-Koudiat El Kebira is formed by schists (originally pelites – Fig. 10) containing beds of crystalline limestones as well as dolomites. Amphibolite bodies (= metaeruptives) are the uppermost sequence and they contain metatuff and metatuffite beds (Koudiat El Kebira, Koudiat Khalagoun). Epidosite intercalations are in this part of the formation minor in quantity, or even rare.

Taking into account the lithological-petrographical differences of the two above mentioned principal developments of the amphibolite formation we can say that volcanogenic development is prevalent on the south, while on the north the prevalent facies are carbonate ones.

Lateral facial changes from south to the north are thus reflected also in the increase of the number of carbonate beds towards the north, acquiring in this direction also greater thicknesses (Fig. 5). While in the south (Kef Akehal-Kef El Abiod) carbonate layers are several centimeters to tens of centimeters thick, in the north (Sidid Terâd) carbonate beds acquire thicknesses of several meters to tens of meters and their number at the same time increases. Carbonate bodies are in the north (Koudiat El Kebira) as much as hundred meters thick.

The amphibolite formation is folded into shallow folds the axes of which have E–W direction and the inclination of fold limbs is slight, 10–30° to the both sides. The folds are several kilometers long.

In the area of Koudiat El Kebira there is synclinal fold closure which was – as we can deduce from the lithological development – also the deepest part of the sedimentary basin with pelitomorphic and carbonate development. At the same time the pelitomorphic development seems to be the oldest, i.e. the lowermost part of the amphibolite formation.

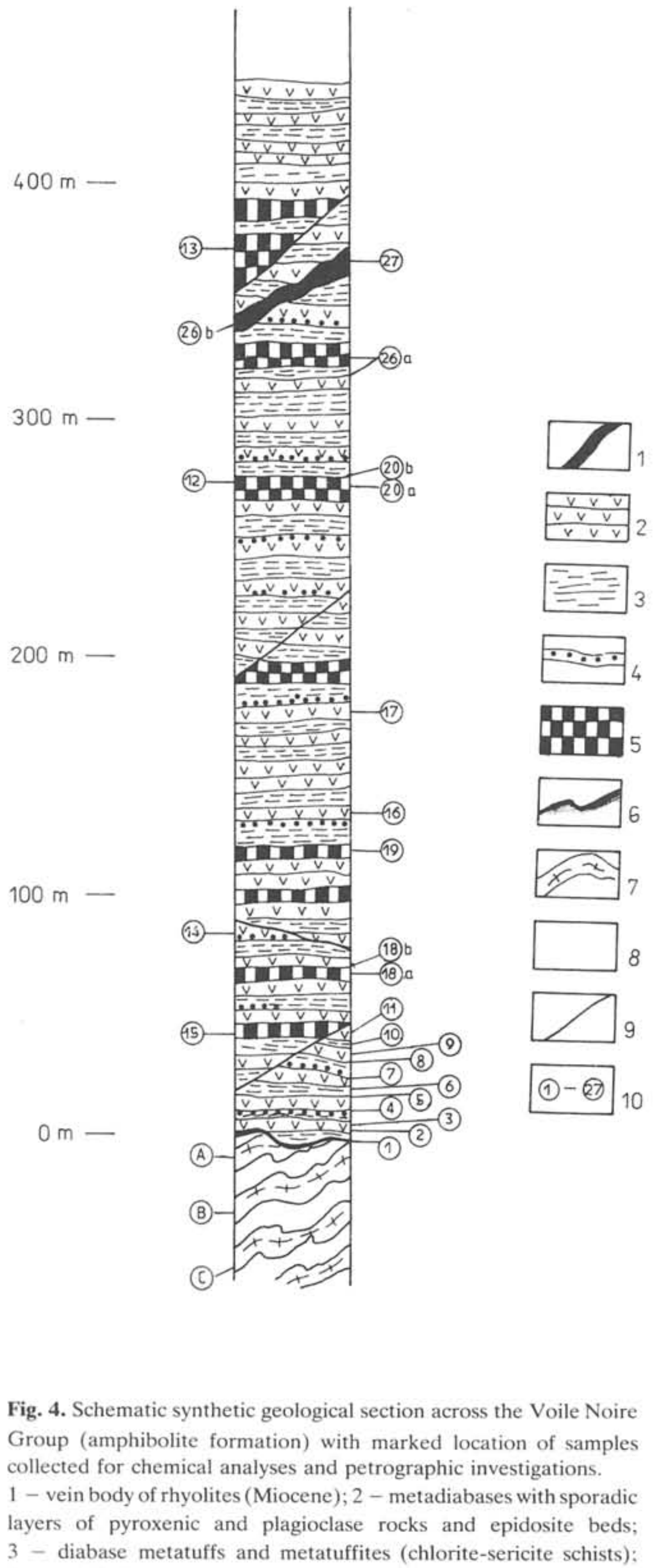

Fig. 4. Schematic synthetic geological section across the Voile Noire Group (amphibolite formation) with marked location of samples collected for chemical analyses and petrographic investigations.
1 – vein body of rhyolites (Miocene); 2 – metadiabases with sporadic layers of pyroxenic and plagioclase rocks and epidosite beds; 3 – diabase metatuffs and metatuffites (chlorite-sericite schists); 4 – epidosite layers in metadiabases; 5 – beds of crystalline limestones or dolomites in the Voile Noire Group; 6 – discordancy (thrust) plane between schist formation at the basement and the overlying Voile Noire Group (diabase formation); 7 – augen-gneiss beds with transitions into banded gneisses; 8 – beds of fine-grained, two-mica banded schists; 7–8 – Belélieta Group (schist formation) of Devonian age; 9 – faults; 10 – samples collected for geochemical and petrographic studies.

Geochemistry of amphibolites of the Voile Noire Group

One of the fundamental aims of geochemical studies of metamorphic complexes of various ages and metamorphism types is the determination of the character of protolith in such sequences. To solve this problem, several discriminating, predominantly geochemical criteria were suggested in the last decade, allowing to distinguish rocks of ortho- and para-origin, as well as to characterize the studied complexes within the above mentioned principal proveniences.

Genetical considerations concerning the Voile Noire amphibolite complex can be in this stage of studies based on available major oxide contents and sets of selected trace elements (Tabs. 1–8).

From the numerous graphical representations of discriminating relationships of major and trace elements we shall further deal with the following.

In the already classical discrimination diagram MgO: CaO:FeO_t (Walker et al. 1960) with distinguished fields for metabasites of ortho- (I) and para-origin (II) the projections of the analysed rocks do not have unambiguous position (Fig. 11). The majority falls into the area where the above mentioned fields are overlapping. The second part of the projection points is situated in the field of sedimentogenic rocks, or in its immediate vicinity.

In the diagram with axes of Niggli's "c" and "mg" values (Leake 1964; Fig. 12) the absolute majority of the analysed rocks projects into the area of basic members of the Karoo dolerite differentiation trend. Van de Kamp (1968) used as discriminating values for the solution of the discussed problems also the "al-alk" and "c" values of Niggli's system (Fig. 13). Analyses of the Voile Noire amphibolite formation are in this diagram as well projected into the field of magmatic rocks.

Magmatic origin of the protolith of amphibolites from the studied unit is indicated unambiguously also by trace element contents. Thus, e.g. projection points of the analysed amphibolites of the Voile Noire Group in the diagram with coordinates Zr:Ni are situated in the field designated by Janda et al. (1965) to orthoamphibolites (Fig. 14).

From the above mentioned relationships of selected elements, which are by the majority of present authors considered to be immobile or mobile only in a restricted range, it follows that the protolith of amphibolites of the Voile Noire Group corresponded to eruptive rocks of basaltic composition. It is quite logical that this statement does not exclude from our considerations equivalent pyroclastic material in the case that its deposits did not contain substantial or predominant admixture of sedimentogenic material of any type.

Next one in the hierarchy of problems is the attempt to classify the studied rock set with some of principal geotectonic types of volcanism. Projection points in the diagram FeO_t vs FeO_t/MgO (Fig. 15), even though only in the most basic approximation, follow the trend of oceanic volcanics and they approach the field of tholeiitic suite. The ratio Zr:Ni (Shervais, 1982) as well as other ones allow to consider the analysed metabasites to be the products of alteration of OFB/MORB, or similar types. Even though the projection field of the discussed rocks is slightly shifted in relation to the distinguished fields of the Ti/1000:Zr diagram (Pearce and Cann 1978), their geochemical similarity to oceanic floor basalts is evident.

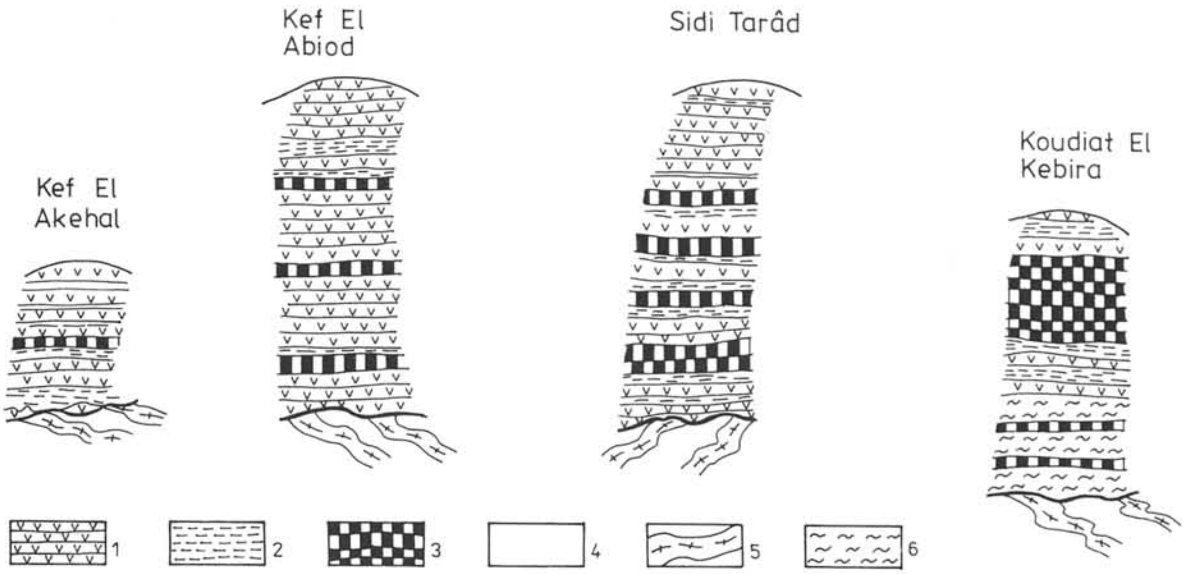

Fig. 5. Schematic geological sections across the Voile Noire Group from the south (Kef El Akehal) to the north (Koudiat El Kebira) with facial transitions of lateral type in limestone and dolomite beds.
1 – metadiabases with pyroxenite and plagioclasite intercalations; 2 – diabase metatuffs and metatuffites (chlorite-sericite schists); 3 – limestone and dolomite beds; 4 – banded fine-grained gneisses; 5 – coarse-grained augen-gneisses; 6 – two-mica schists; 4–6 – Belélieta Group (schist formation).

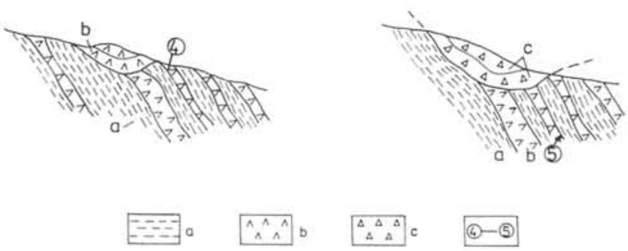

Fig. 6. Volcanoclastic structures of discordant type in bedded amphibolites of the voile Noire Group. Asphalted road to the Seraide Beach.
a – fine stratified metatuffs of basic volcanics; b – stratified amphibolites; c – metatuffs till volcanic metabreccias; 4–5 – rock samples for petrographic as well as for geochemical study.

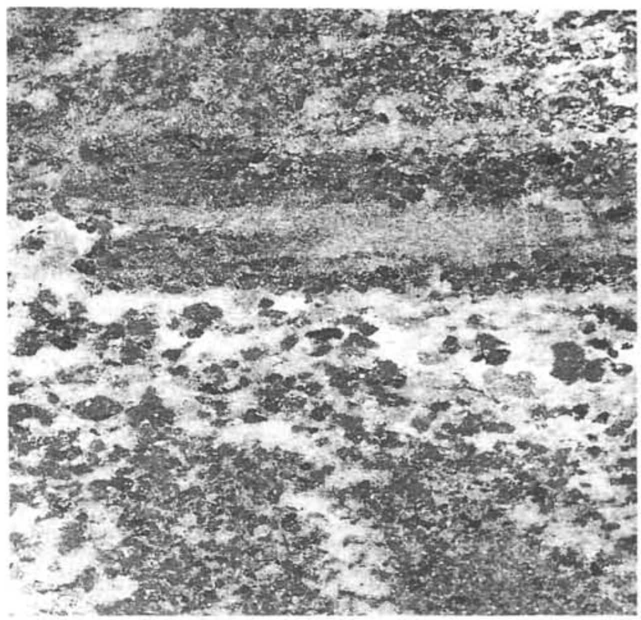

Fig. 7. Fine-grained amphibolites with thin quartz and feldspar layers of mobilization character (gran size – 1 *mm*). The rock have been affected by collection recrystallization of amphibole. Voile Noire Group (Edough. Mts.). Magnif. 2.5 ×, II polars.

As a conclusion of the geochemical-genetical study it can be stated that in spite of considerable variations in the contents of some determined elements, especially trace elements, the contents of discriminating (immobile) elements allow to classify the protolith of the Voile Noire Group amphibolites as tholeiitic types of basic volcanics, of recent oceanic-basin OFB or MORB types.

Selected metallic elements in rocks of Edough Mts.

In the following part we present an overview of the contents of selected 15 (predominantly metallic) elements. Analytical results explain theoretical as well as practical aspects of their distribution in rocks as well as the principles of their distribution in each rock type. The numbers of analyses in individual rock types are mostly low, and thus they can serve only for orientation (Tabs. 2–8, values are in *ppm*). These results were on one hand a part of petrogenetic studies in general, on the other hand they were used for the study of distribution of the elements in vertical profiles in individual rock types. Last but not least, they can serve as a basis for future prospection for W, Cu, Ag and Au in the whole region.

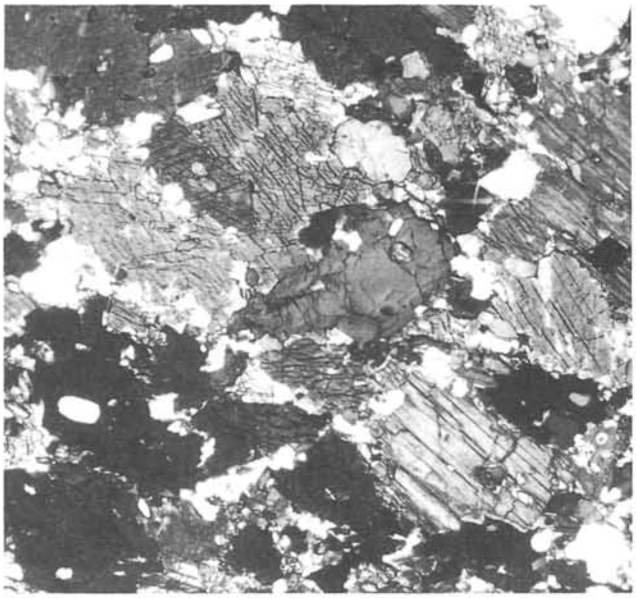

Fig. 8. Granonematoblastic fabric of erlane composed of calcite, amphibole. Voile Noire Group (Edough Mts.). Magnif. 30 ×, X polars.

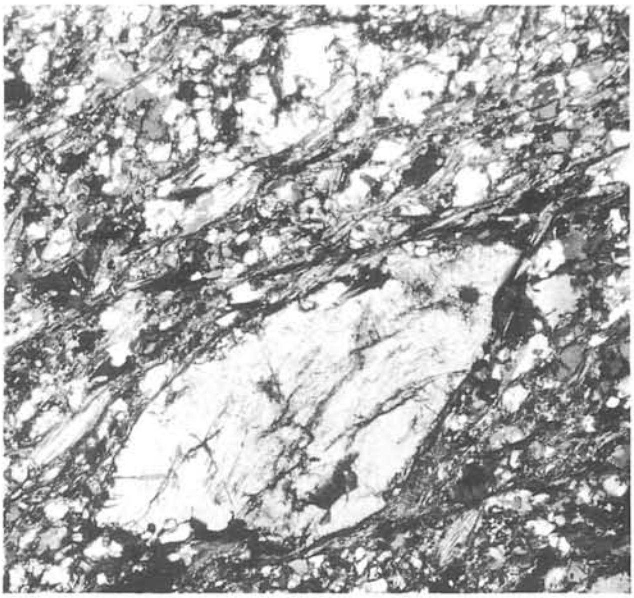

Fig. 10. Blastomylonite of fine-augen biotite gneiss. Belélieta Group in the basement of the Voile Noire Group (Edough Mts.). Sample Al. B. Magnif. 30 ×, X polars.

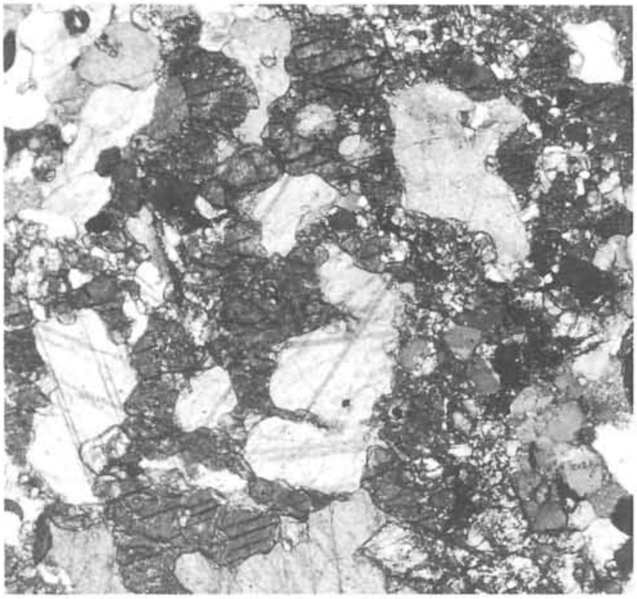

Fig. 9. Diablastic texture of erlane composed of calcite, amphibole, clinopyroxene, sphene and plagioclasses. Voile Noire Group (Edough Mts.).

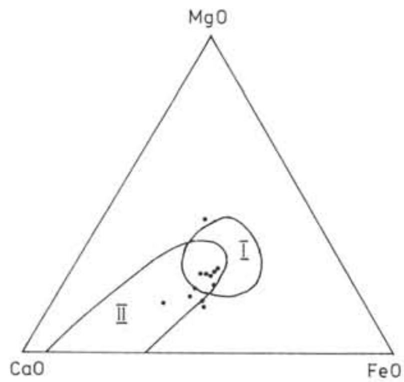

Fig. 11. Discrimination diagram MgO:CaO:FeO (Walker 1960).

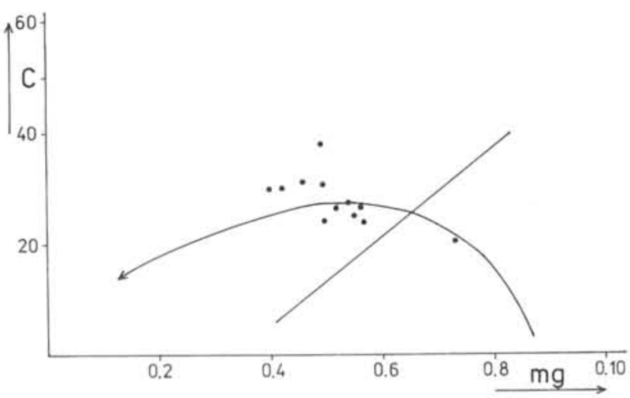

Fig. 12. Diagram with axes representing Niggli's "c" and "mg" values (Leake 1964).

From the presented outline of the geological setting of the mountain range and of the metamorphic history of the rock complexes it is evident that highest tungsten contents are in pyroxenites (max. 1.70 per cent) and amphibolites (0.1163 per cent). Other rock types have tungsten contents of about 2–3 *ppm*, or up to 10 *ppm*, which is the accepted background value for these rock types.

Table 1. Analyses of rocks (Paleozoic) — Edough Mts.

No.	Rock	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	TiO_2	P_2O_5	CaO	MgO	K_2O	Na_2O	loss of dessic.	loss of calcin.	Sum
Al. 1	Amphibolite (V. N.)	46.30	16.24	4.51	6.54	0.19	1.73	0.30	10.95	6.81	0.29	3.16	0.30	0.62	98.34
Al. 2	Amphibolite (V. N.)	43.42	17.50	5.44	6.22	0.19	1.56	0.26	13.09	6.17	0.32	2.84	0.34	1.01	98.36
Al. 3	Amphibolite (V. N.)	46.14	16.86	5.48	5.03	0.17	1.46	0.27	11.19	7.18	0.44	3.16	0.14	0.93	98.45
Al. 4	Epidosite (V. N.)	49.11	17.15	3.98	5.20	0.15	1.41	0.30	8.37	4.98	0.28	3.24	0.30	1.28	97.03
Al. 5	Amphibolite (V. N.)	43.69	16.55	6.67	5.53	0.19	1.38	0.22	12.06	7.79	0.33	2.39	0.38	1.53	98.71
Al. 6	Amphibolite (V. N.)	45.25	16.25	8.69	3.40	0.18	1.65	0.31	14.46	4.36	0.25	2.24	0.20	0.92	98.16
Al. 7a	Amphibolite (V. N.)	44.09	17.23	8.32	3.09	0.17	1.49	0.30	11.75	4.43	0.44	3.10	0.39	1.42	96.22
Al. 7b	Albitite (V. N.)	71.90	15.41	1.48	0.00	0.03	0.00	0.08	3.57	0.31	0.25	5.30	0.38	0.50	99.21
Al. 8	Epidosite (V. N.)	45.05	16.71	9.32	2.09	0.17	1.38	0.03	17.10	2.61	0.12	1.54	0.47	1.08	97.48
Al. 9	Amphibolite (V. N.)	45.12	18.25	6.63	5.23	0.22	1.72	0.28	11.94	4.23	0.42	3.23	0.30	0.32	97.67
Al. 10	Amphibolite (V. N.)	47.22	26.32	5.05	5.82	0.18	1.36	0.31	10.02	7.23	0.24	3.32	0.16	0.92	98.15
Al. 11	Amphibolite (V. N.) (silicified)	93.74	1.55	1.01	0.64	0.03	0.15	0.08	1.23	0.61	0.04	0.25	0.10	0.00	99.43
Al. 12	Limestone (V. N.)	0.00	0.50	0.97	0.00	0.01	0.00	0.09	50.48	5.99	0.00	0.10	0.16	41.69	99.99
Al. 13	Dolomite (V. N.)	0.00	0.87	0.37	0.00	0.03	0.00	0.00	31.70	21.65	0.00	0.15	0.20	45.03	100.00
Al. 14	Epidosite (V. N.)	45.02	17.55	6.84	3.45	0.15	1.28	0.30	12.53	4.67	0.37	3.93	0.27	0.00	96.36
Al. 15	Limestone (V. N.) silicified	65.26	16.93	1.38	1.45	0.05	0.30	0.18	6.17	1.93	0.15	4.89	0.22	0.62	99.53
Al. 16	Albitite (V. N.)	43.27	21.18	7.04	1.50	0.18	1.21	0.27	17.59	3.71	0.13	1.93	0.35	1.80	99.96
Al. 17	Albitite (V. N.) (epidot.)	44.48	16.50	8.47	3.25	0.14	1.43	0.27	16.46	4.74	0.15	2.12	0.49	1.76	100.26
Al. 18a	Limestone (V. N.) silicif.	18.78	6.58	1.77	0.64	0.08	0.23	0.16	39.90	1.74	1.86	0.25	0.16	27.39	99.54
Al. 18b	Limestone (V. N.)	4.93	1.73	1.25	0.00	0.08	0.06	0.10	50.86	0.98	0.34	0.11	0.16	39.70	100.30
Al. 19	Amphibolite (V. N.)	47.08	13.85	4.96	4.47	0.21	0.63	0.09	9.74	14.36	0.20	2.18	0.30	0.49	98.56
Al. 20a	Limestone (silic.)	41.75	19.29	8.18	1.23	0.29	1.06	0.44	19.57	3.44	0.16	0.95	0.30	1.70	98.86
Al. 20b	Amphibolite (V. N.)	48.10	18.38	4.96	4.30	0.21	1.23	0.20	9.90	6.93	0.40	4.16	0.22	0.64	99.63
Al. 21	Albitite (Kar.)	56.59	22.11	1.32	0.00	0.01	0.14	0.29	2.11	0.92	2.35	7.19	0.63	2.53	96.19
Al. 22	Pyroxenite (Kar.)	47.57	14.76	6.55	4.52	0.04	0.18	0.34	3.18	2.48	2.21	3.07	0.82	4.88	90.60
Al. 23	Pyroxenite (Kar.)	33.31	18.42	9.37	4.59	0.29	0.21	0.14	22.34	0.89	0.09	0.63	0.52	2.59	93.39
Al. 24	Pyroxenite with Plg.	30.43	3.84	16.33	9.99	0.30	0.00	0.12	23.69	0.87	0.07	0.25	1.03	7.88	94.80
Al. 26a	Amphibolite (Kar.)	61.10	15.22	1.22	3.10	0.06	0.41	0.16	3.43	2.70	3.92	2.94	0.22	0.94	95.42
Al. 26b	Dacite (V. N.)	49.49	14.98	5.66	6.33	0.18	1.63	0.35	10.62	7.38	0.31	2.85	0.20	0.90	97.88
Al. 27	Dacite — vein	62.15	13.93	1.59	2.58	0.10	0.40	0.26	3.52	2.82	4.91	1.64	0.33	3.86	98.09
Al. A	Gneiss with Hbl. (V. N.)	64.36	14.97	2.69	3.09	0.09	0.60	0.24	1.86	1.86	2.39	1.80	0.28	0.85	94.78
Al. B	Gneiss with Hbl. (V. N.)	66.37	15.11	2.95	2.64	0.10	0.32	0.22	2.56	2.69	3.17	3.01	0.30	0.79	100.23
Al. C	Gneiss (V. N.)	60.44	15.68	3.68	2.94	0.10	0.85	0.26	3.31	2.98	4.37	3.73	0.46	1.85	100.65
Al. I	Chert (Annaba)	76.01	15.93	0.37	2.30	0.03	0.08	0.19	1.07	0.40	0.32	0.53	0.20	0.48	97.91
Al. IV	Silicic rock (Annaba)	96.15	2.09	0.19	0.72	0.06	0.00	0.11	0.50	0.12	0.15	0.16	0.00	0.00	100.10
Al. V.	Erlan (Annaba)	49.65	16.03	3.90	7.19	0.15	0.78	0.19	14.01	2.79	0.73	0.97	0.56	2.18	99.14
Al. VI	Obsidian	97.10	0.26	0.29	0.65	0.01	0.00	0.06	0.50	0.13	0.03	0.13	0.24	2.64	100.04

Legend: V. N. — superficial samples of Voile Noire Group (see Figs. 3, 4); Kar. K. — samples of Karézas mine near Annaba town; Al. A, B, C — superficial samples in gneis series (or Belélieta) (see Figs. 3, 4); Al. I—IV — superficial samples in the gneis series (Belélieta) (see Ilavský and Snopková, 1987); Al. VI. — samples of Saharian Paleogene from Négrine town (Bir El Ater); Al. 26b and Al. 27 — samples of dacitic rocks of Miocene age (see Figs. 3, 4).

Table 2. Selected trace elements of pyroxenites in Edough Mts. (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 22	Pyroxenite	2	23	16	26	63	37	71	390	14	25	52	48	25 800	40	24
Al. 24	Pyroxenite	3	54	3	12	35	1 820	40	13	3	25	13	9	16 300	84	48
Al. 23	Pyroxenite	3	49	3	14	38	790	81	18	23	30	83	108	9 360	101	35
Average content		3	42	7	17	45	882	64	140	13	27	49	53	17 153	75	36

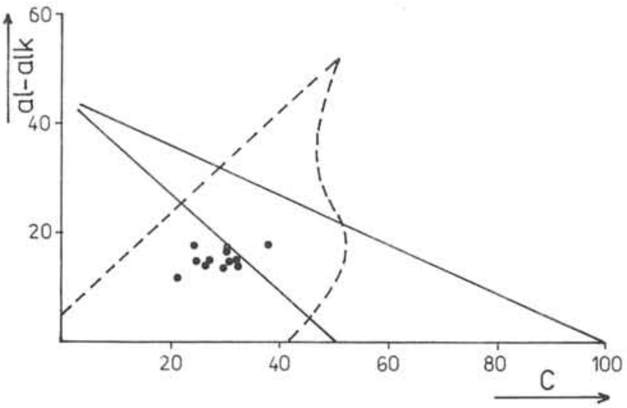

Fig. 13. Discriminating values "al-alk" and "c" according to Niggli (Van de Kamp 1968).

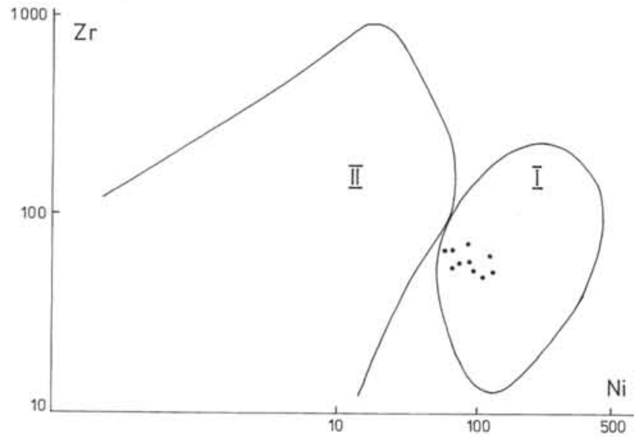

Fig. 14. The ratio Zr:Ni in basic rocks of the Voile Noire Group (Janda et al. 1965).

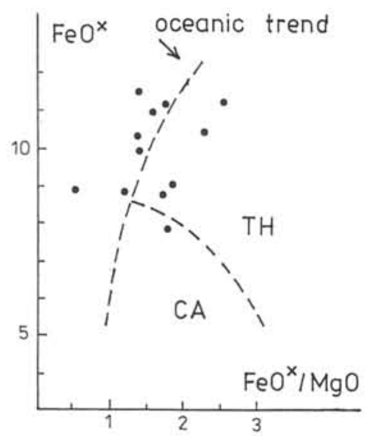

Fig. 15. The ratio FeO/FeO^x + MgO in basic rocks of the Voile Noire Group (Pearce 1975).

Conclusion

The rocks of the amphibolite (= Voile Noire) formation of Edough Mts. have polymetamorphic character. The first metamorphic event took place in PTX conditions of the amphibolite facies. The subsequent metamorphic recrystallization is characterized by PTX conditions of the greenschist facies, i.e. in relation to the first event it has retrogressive trend.

The complex of Precambrian/Paleozoic rocks of the amphibolite (Voile Noire) formation contains rocks of sedimentogenic (pyroxenites) as well as magmatogenic (metabasalts) origin. The latter correspond by their contents of genetically significant elements to metamorphic equivalents of tholeiites of OFB type.

Increased concentration of tungsten in pyroxenites or also in metabasalts, as well as in other rock types (Tabs. 2–8) indicate that these rocks are primary concentrators of this (as well as other) economically interesting element. Polymetamorphic development of the complex caused local redistribution of the originally "stratabound" type of scheelite mineralization.

Table 3. Selected trace elements in amphibolites; Voile Noire Group — Edough Mts. (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 26a	Amphibolite	0.7	29	200	11	159	30	12	8	120	35	153	251	7800	115	42
Al. 20b	Amphibolite	0.5	2	10	30	214	86	10	10	78	20	105	229	15	80	25
Al. 19	Amphibolite	0.8	22	7	45	1413	10	15	16	447	20	45	98	2	121	42
Al. 11	Amphibolite silic.	0.8	3	79	4	224	35	12	3	7	10	6	8	4	25	10
Al. 10	Amphibolite	0.6	7	39	32	447	35	16	4	118	15	100	295	2	82	54
Al. 9	Amphibolite	1	4	28	42	603	38	17	3	87	25	115	275	2	197	76
Al. 7a	Amphibolite	1	12	58	38	282	42	19	3	76	20	93	302	2	88	71
Al. 6	Amphibolite	1	9	36	34	195	31	20	4	71	25	87	316	3	78	71
Al. 5	Amphibolite	1	4	26	38	372	16	20	4	96	30	93	269	2	113	55
Al. 3	Amphibolite	1	4	45	40	363	28	21	3	102	35	214	302	2	104	50
Al. 2	Amphibolite	2	6	33	41	269	63	16	8	120	20	71	282	2	95	66
Al. 1	Amphibolite	1	8	66	36	174	48	23	4	83	25	118	288	2	280	59
Al. A	Amphibolite	1	145	224	7	79	10	13	29	33	40	79	69	9600	107	22
Al. B	Amphibolite	1	14	363	11	166	41	14	28	27	35	81	87	5	105	52
Al. C	Porphyrite	1	17	398	15	138	18	17	33	32	25	76	100	3	78	89
Average content		1	19	107	28	339	35	16	11	93	25	96	211	1163	111	52

Table 4. Selected trace elements of carbonaceous rocks — Edough Mts. (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 20a	Lemestone (silicified)	8	22	9	22	511	21	15	7	69	40	135	339	2	42	28
Al. 12	Limestone	8	3	3	—	15	8	—	1	—	5	62	—	2	26	—
Al. 18b	Limestone	8	3	83	3	29	10	4	11	3	55	316	204	2	42	11
Al. 18b	Limestone	4	3	182	10	52	18	4	8	20	55	1000	170	7	31	21
Al. 15	Limestone	1	3	3	8	120	31	5	3	20	20	214	71	2	78	13
Average content		6	7		9	145	18	6	6	22	35		145	3	44	15

Table 5. Selected trace elements of epidosites; Voile Noire Group — Edough Mts. (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 14	Epidosite	2	6	20	32	282	38	15	6	59	35	100	302	2	88	40
Al. 8	Epidosite	1	7	44	27	631	99	23	4	55	25	112	309	2	60	45
Al. 4	Epidosite	1	7	30	37	257	14	19	1	76	25	76	257	2	470	55
Al. 17	Albitite (epidot.)	1	9	21	35	501	51	19	10	132	25	63	282	2	78	45
Average content		1	7	29	33	418	51	19	5	81	28	88	288	2	174	46

Table 6. Selected trace elements of albitites and aplite in Edough Mts. (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 7b	Albitite	0.3	31	81	5	45	14	14	2	7	30	170	12	2	78	10
Al. 16	Albitite	92	5	11	23	562	17	27	3	66	35	178	302	20	50	32
Al. 21	Aplite	0.3	23	159	—	18	11	37	3	3	15	1 000	32	2	14	3
Average content			20		9		14	26	3		27			2		

Table 7. Selected trace elements of siliceous rocks (various in age) — Algeria (*ppm*).

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. VI	Chert	0.2	331	355	—	166	6	—	3	—	5	—	—	5	16	—
Al. V.	Silicite	2	51	200	20	151	29	25	22	48	40	331	182	2	125	83
Al. IV	Quartzite	1	41	3162	—	316	56	4	125	4	90	14	—	4	550	—
Al. I	Obsidian	0.2	1	30	14	112	19	25	10	28	5	20	129	9	35	170

Legend: Al. VI, Al. V, Al. IV — Paleozoic of Edough Mts.; Al. I — Paleogene of Sahara, Négrine-Bir El Ater towns.

Table 8. Selected trace elements of dacites (Miocene in age) — Edough Mts. (*ppm*)

No.	Rock	Ag	B	Ba	Co	Cr	Cu	Ga	Li	Ni	Pb	Sr	V	W	Zn	Zr
Al. 27	Dacite (vein)	1	22	219	9	63	15	16	55	23	50	87	44	2	129	26
Al. 26b	Dacite	1	9	11	36	1259	37	12	8	120	35	151	251	4	115	42

Translated by K. Janáková

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