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Mineralogical and geochemical features of pegmatites from the Ursuya Massif (Western Pyrenees, France)

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ABSTRACT. — In the Ursuya massif, pegmatites appear associated to metamorphic rocks in the granulite and amphibolite facies. They occur mainly as lenticular segregations conforming to the host rocks, sometimes showing internal zonation. The main minerals are: quartz, K-feldspar, plagioclase, ± biotite, ± muscovite. Other minerals such as tourmaline, apatite, monazite, sillimanite, garnet, Fe-Ti oxides, andalusite and cordierite are less frequent. Trace element distribution in pegmatite rocks, muscovites and K-feldspars is within the range reported for barren-ceramic pegmatites. Mineralogical, geochemical and field data suggest that some pegmatites are cogenetic products from ultrametamorphic processes of partial melting. Other pegmatites may have evolved in a more or less autonomous way, being injected after the main metamorphic phase. There seems to be no strict correlation between the pegmatites and the different metamorphic facies present in the Ursuya massif.

Key words: Ursuya massif, pegmatite, gneisses, granulite facies, trace elements.

ASPECTS MINERALOGIQUES ET GEOCHIMIQUES DES PEGMATITES DU MASSIF DE L'URSUYA (PYRENEES OCCIDENTALES, FRANCE).

SOMMAIRE. — Dans le Massif de L'Ursuya il y a des pegmatites lieés aux roches métamorphiques en faciès des amphibolites et des granulites. Les pegmatites se manifestent surtout sous formes lenticulaires et poches généralement concordants avec la foliation régionale, parfois avec une zonation interne. La paragénèse principal englobe les minéraux suivants: quartz + feldspath-K + plagioclase ± biotite ± muscovite. Autres phases comme tourmaline, apatite, monazite, grenat, sillimanite, andalousite et cordiérite sont plus rares. La distribution des éléments en traces des roches pegmatitiques, muscovites et feldspaths-K est compatible avec les téneurs caractéristiques des pegmatites céramiques de niveaux profonds. Les données géologiques, minéralogiques et géochimiques suggérent que certaines pegmatites seraient produits cogénétiques des processus ultramétamorphiques de fusion partiel. Il existe d'autres pegmatites qui auraient évolué d'une manière plus ou moins autonome, avec une mise en place postérieur á la phase métamorphique principal. Il ne se remarque pas une stricte corrélation entre les pegmatites et les différentes faciès métamorphiques du Massif de L'Ursuya.

Mots clés: Massif de L'Ursuya, pegmatite, gneisses, faciès granulites, éléments traces.

Introduction

In the Ursuya massif, some pegmatite segregations appear associated to metamorphozed materials from the granulite to the amphibolite facies. These segregations show a wide range of relationships with the host-rocks, from a gradational association with leucosome stringers of migmatitic gneisses to an apparent lack of spatial and genetic relation with them. The metamorphic terranes in the granulite facies contain only barren, ceramic or allanite- and monazite-bearing pegmatites, which were derived during regional metamorphism (GINSBURG et al., 1979).

The present communication deals with some mineralogical and geochemical features of these pegmatite segregations, in order to know their character and genetic conditions.

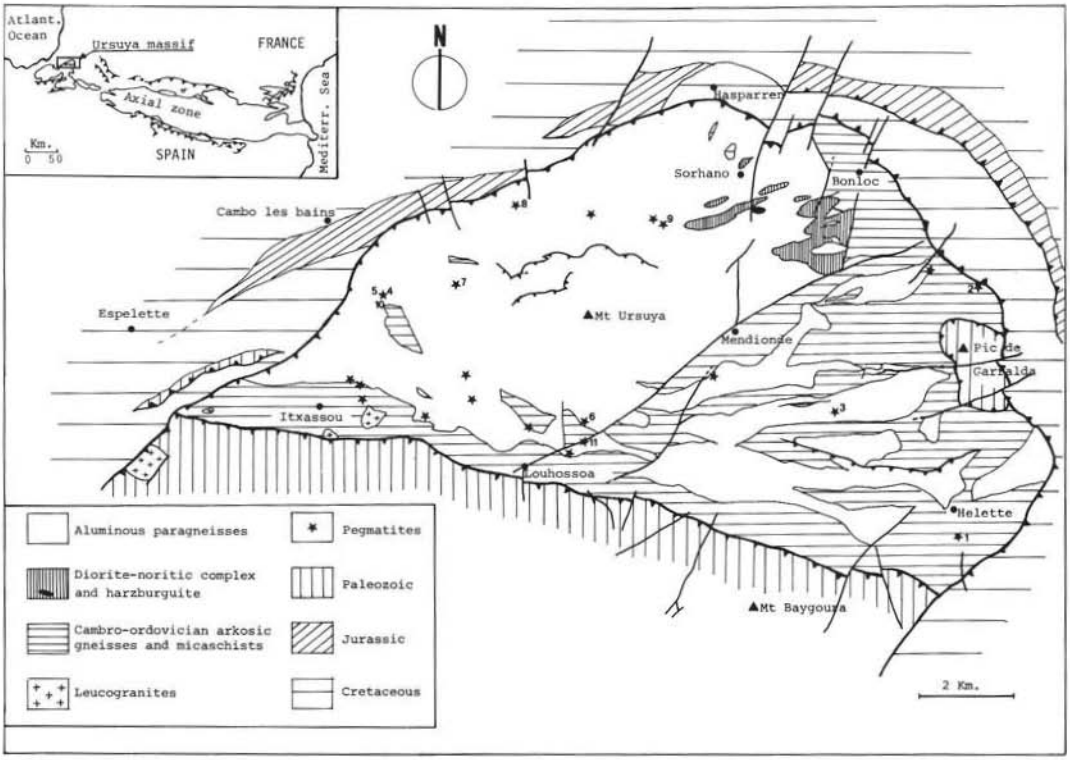

Fig. 1. — Generalized geological map of Usuya massif adapted from 1:50000 map of lholdy (BOISSONNAS J., 1974), showing sampling locations mentioned in text.

Geological setting

The Ursuya massif forms part of the Basque Pyrenees and is located approximately 25 km east of the Atlantic coast (Fig. 1). Geologically, it is bordered by the Paleozoic Aldudes-Quinto Real massif to the south, and the Cinco Villas massif to the west. Together with those of Mendibeltza and Igounze, they constitute the Basque Paleozoic.

The Ursuya massif is in contact with Mesozoic materials and Ordovician schists and quartzites in the north and south respectively. Basically, it comprises two large lithological assemblages: 1) a Precambrian gneissic complex, where aluminous rocks (paragneisses, micaschists, kinzigites, leptinites) of the granulite facies occur; 2) a heterogeneous complex lying above, composed of Cambro-Ordovician arkosic gneisses, amphibolites, micashists with sillimanite and marbles (Fig. 1). The rocks of the first complex seem to have undergone P-T conditions of 6 ± 0.5 kb and 775 ± 50°C (VIELZEUF D., 1984). The pegmatite bodies are associated both to the Precambrian gneissic complex and to the Cambro-Ordovician complex, although they also appear at the contact of both assemblages (Fig. 1). The presence of small (< 500 m) leucogranitic bodies SW of the massif should also be noted (Fig. 1).

Analytical methods

Modal data for fine to coarse grained pegmatite rocks were collected by optical point-count, considering an analytical error of < 2.45% according to CHAYES F. (1956).

Minor and trace element analyses for pegmatites and Precambrian gneisic rocks were carried out on homogenized whole-rock powder by wavelengh-dispersive X-ray spectrometry. Li and Be were analysed by

TABLE 1

Typical modes for pegmatites from Ursuya massif. Samples 1 and 2 correspond to pegmatites associated to Cambro-Ordovician materials (Fig. 1)

Samples	1	2	3	4	5	6	7	8	9	10
Quartz	37,7	33,2	29,8	36,3	27,7	25,0	64,9	39,2	28,6	32,6
K-Feldspar	4,6	21,1	38,5	39,6	39,1	50,1	11,3	31,6	27,0	31,2
Plagioclase	46,4	39,9	25,5	20,8	26,2	20,2	0,6	23,8	21,7	1,1
Biotite	—	—	5,8	2,1	1,4	3,2	10,0	—	3,9	4,7
Muscovite	4,8	2,4	—	—	3,8	—	0,4	0,4	2,7	9,8
Tourmaline	3,7	0,2	—	—	—	—	—	—	—	—
Garnet	1,9	2,6	—	—	—	—	3,6	—	—	—
Sillimanite	—	—	—	—	—	—	6,2	—	1,6	—
Andalusite	—	—	—	—	—	—	—	—	—	10,9
Cordierite	—	—	—	—	—	—	—	—	11,7	—
Accesories	0,2(1)	0,1(1)	—	0,1(1)	0,8(2)	0,9(2)	2,7(3)	3,4(4)	0,4(2)	1,6(5)
Monazite	—	—	—	—	—	—	—	1,1	—	—
Late muscovite	0,7	0,5	0,4	1,1	1,0	0,6	0,3	0,5	2,4	8,1
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

(1) Sillimanite+Opaque (2) Zircon+Apatite+Sill.+Op. (3) Op.+Zr.+Ap. (4) Zr.+Op.+Sill. (5) Op.

atomic absortion spectroscopy. Feldspars and muscovites were separated from several pegmatite segregations and analysed in the same way.

Morphology and mineralogy

The pegmatite bodies occur as lenticular segregations conforming to the fabric of the host-rocks (N90°-110°E), from centimetric to decametric thickness, and also as irregular masses of variable size, (generally < 100 m) which discordantly cut the host-rocks. Some pegmatite segregations show a relevant deformation with boudinage structures. They present a heterogranular medium-to-coarse grain granitic texture, where graphic local intergrowths are observed. Some of these pegmatites show internal zoning with a coarse-grained core consisting of tourmaline + quartz ± K-feldspar, and medium-grained rims with graphic texture consisting of K-feldspar + quartz ± plagioclase.

The mineral assemblage in the pegmatites is quartz + K-feldspar + plagioclase ± biotite ± muscovite ± tourmaline ± sillimanite ± andalusite ± cordierite ± garnet ± monazite ± apatite ± zircon ± Fe-Ti oxides. Quartz, K-feldspar and plagioclase are the main minerals, with a variable modal proportion (Table 1). All these minerals, except tourmaline, andalusite and monazite, appear in the associated metamorphic rocks.

Quartz generally appears as fine to coarse xenomorphic crystals, with wavy extinction. Occasionally, bipyramidal forms are observed, more or less corroded by K-feldspar.

K-feldspar is xenomorphic, of medium to coarse grain. It usually forms granophyric intergrowhts with quartz. It displays perthitic texture (film, vein and patch perthites) and often a partial or complete cross-hatched texture. The crystals sometimes show deformation bands, wavy extinction, subgrains, and microfractures as a result of deformation. The structural state is variable from orthoclase to maximun microcline. According to the equations of KROLL H., RIBBE P.H. (1983), ($t_1o + t_1m$) and (t_1o-t_1m) vary between 0.82-0.98 and 0.35-1.00 respectively, for triclinic samples. The Or bulk percentage from some samples homogenized at 1050°C and determined by X-ray diffraction methods (WRIGHT T.L., 1968), ranges between 79%-91% Or. The Or contents of the K-rich phase calculated from the cell volume (KROLL H., RIBBE P.H., 1983) varies between 89%-100% Or.

Plagioclase usually appears twinned (Ab, Pericline, Ab-Ala and Ab-Carlsbad twins). It is subautomorphic-xenomorphic with fine to coarse grain. Its composition is < An_{26}. The crystals may display normal or patchy zoning as well as myrmekitic intergrowths close to K-feldspar. The plagioclase is completely albitized in some pegmatites.

Biotite is a fine to medium sized prismatic mineral. It sometimes appears partially altered to chlorite and other times replaced by muscovite.

Muscovite is relatively abundant. Two main types may be distinguished: 1) book muscovite associated to quartz + k-feldspar, and 2) late muscovite produced by plagioclase decomposition. The crystals sometimes show clear effects of deformation (distorted crystals, wavy extinction, kinking).

Black tourmaline is a fine or coarse sized accessory mineral, frequent in some pegmatites. It shows an optical zonation: yellowish-brown inner zones and bluish-green outer zones.

Sillimanite is prismatic and appears significatively in some pegmatites (Table 1). Its proportion increases towards the host rocks. *Andalusite* is authomorphic-subauthomorphic, prismatic, and appears occasionally in some pegmatites. *Cordierite* also occurs occasionally (Table 1).

Garnet is subautomorphic-xenomorphic, of fine to medium size. It is partially altered to chlorite, which is typical of primitive pegmatites. (CERNY P., HAWTHORNE F.C., 1982).

Monazite, apatite, zircon and opaques minerals represent accessory phases in these rocks.

Geochemistry

Results of trace element analyses carried out on pegmatite rocks associated to the two metamorphic complex are expressed in Fig. 2. Most elements present an average value lower than 50 ppm: Zr, Nb, Sn, V, La, Zn, Pb, W, Cu, Ni and Co. The higher average concentrations for both types of pegmatites correspond to Li (110-150 ppm), Sr (60-260 ppm), Rb (150-210 ppm) and Ba (35-1050 ppm). On the other hand, certain differences between the pegmatites associated to the Precambrian gneisses and the pegmatites associated to the Cambro-Ordovician materials may be observed: the average content in Sr, Rb, Ba, Zr, V, La and Pb is higher in the first one but the average content in Cu, Co, Sn, Nb, Zn and W is lower. The variation of trace element contents in the

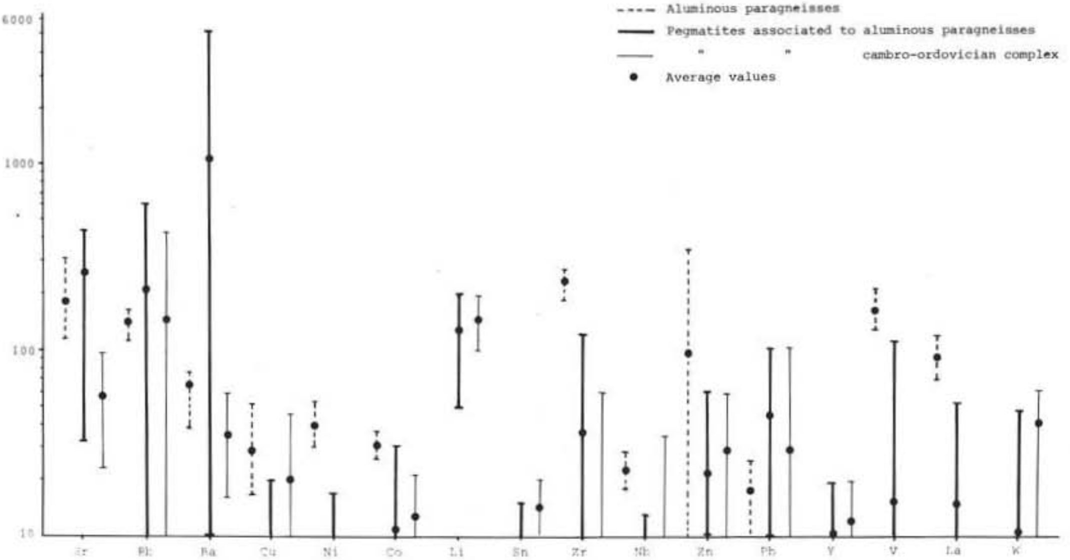

Fig. 2. — Variation in content of some trace elements in pegmatites and gneisses from Ursuya massif.

TABLE 2

Variation range in concentrations of some trace elements for muscovites and K-feldspars separated from pegmatites

	Mu	K-Fd		Mu	K-Fd
Li	200-500	<20	W	20-100	<20
Rb	300-2000	200-600	Cu	<30	<20
Cs	20-150	<20	Ni	<20	<20
Ba	20-1500	800-1600	Mn	120-800	<20
K/Rb	60-300	180-550	Zn	70-200	n.d.
Ti	100-3500	105-130	Sc	<20	n.d.
V	10-100	b.d.	Ga	70-200	n.d.
Sn	<30*	<20	Cr	20-50	
Nb	200-250	<20	Zr	20-120	n.d.
Pb	<20	50-150	Ce	20-200	n.d.

Mu=Muscovite K-Fd=K-Feldspar
(*) One sample presents a value of 500 ppm.
b.d. Below the detection limit.
n.d. Not determined.

Precambrian gneisses is within the range obtained for associated pegmatites. However, the average concentrations of LIL elements (K, Rb, Ba, etc.) and compatible elements (Ni, Co, etc.) in pegmatites are higher and lower respectively in relation to the surrounding gneisses. Other elements such as Ta, Be, Ce, Ge and Sc are below the detection limit.

On the other hand, the concentrations of Li, Rb and Cs in muscovites and K-feldspars from pegmatites (Table 2) are within the zone defined by GORDIYENKO V.V. (1971) for barren-ceramic pegmatites. Moreover, the distribution of trace elements in muscovite samples is within the variation range reported for barren-ceramic pegmatites (CERNY P., BURT D.M., 1984) (Table 2). Other elements not represented in table 2, such as Y, Sr, Be, Ta and Co, are below the detection limit.

Discussion

Field observations and mineralogical and geochemical data suggest that the pegmatite bodies from the Ursuya massif correspond to the ceramic pegmatite type according to the classification by RUDENKO et al. (1975) or to type IV according to GINSBURG et al. (1979). However, the metamorphic environment of maximal depths (granulite facies), which characterizes this type of pegmatites, contrasts with the pressures estimated (6 ± 0.5 kb) for the deepest facies in the Ursuya massif (VIELZEUF D., 1984). This may be explained by the low-pressure character of the Hercynian metamorphism in this crustal region, where thermal gradients were relatively high (KORNPROBST et al., 1980). In any case, there are several facts suggesting that some pegmatite segregations are cogenetic products from the same ultrametamorphic process of partial melting: 1) common grading of the segregations into the leucosome layers of the migmatite rocks; 2) its conformity to the fabric of the surrounding rocks; 3) occurrence of metamorphic index minerals (sillimanite, biotite, etc.) in the host rocks and pegmatites; and 4) enrichment in LIL elements and depletion in compatible elements (Ni, Co, etc.) in the pegmatites, in relation to the surrounding gneisses.

On the other hand, the instability of biotite and the occurrence of muscovite in several pegmatites, as well as the occasional appearance of andalusite, suggest that some of these pegmatites evolved in a more or less autonomous way. In this case the controlling role of metamorphism was restricted to providing environment parameters (CENRY P., 1982), characterized by remarkable decompression as a result of a possible intracrustal displacement (VIELZEUF D., 1984). This implies a certain physico-chemical disequilibrium between the pegmatite injection and the surrounding metamorphic rocks. Consequently, the injection and crystallization of some pegmatites occurred after the main metamorphic phase. Finally, there does not seem to be a correlation between the pegmatite bodies and the different metamorphic facies present in the Ursuya massif.

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