MINERAL GEOCHEMISTRY AND PETROGENESIS OF GRANITIC PEGMATITES IN THE FREGENEDA-ALMENDRA AREA (SPAIN AND PORTUGAL)

ROMEU VIEIRA[1§], ENCARNACIÓN RODA-ROBLES[2#], ALFONSO PESQUERA[2] & ALEXANDRE LIMA[3]

[1]Centro de Geologia da Universidade do Porto, Portugal; [§]romeu.vieira@fc.up.pt
[2]Dpto. Mineralogía y Petrología, Universidad del País Vasco/EHU, España; [#]encar.roda@ehu.es
[3]Dpto. Geologia, Ambiente e Ordenamento do Território, FCUP, Porto, Portugal

Seventh Hutton Symposium on Granites and Related Rocks
Avila, Spain, July 4-9 2011

GEOLOGICALL SETTING & PEGMATITES DESCRIPTION

➢ The **Fregeneda-Almendra** pegmatitic field (FA) is located in the **Central-Iberian Zone**, in the western part of a narrow **metamorphic belt**, with an E-W trend (Figure 1).

➢ Bordered by the syn-tectonic Variscan **Mêda-Penedono-Lumbrales leucogranite complex (MPL)** to the south, and by the late-tectonic **Saucelle granite** to the NE (Figure 1);

➢ These granites and most of the pegmatites intruded the pre-Ordovician metasediments of the **Schist-Metagreywacke Complex (SMC)** (Figure 1).

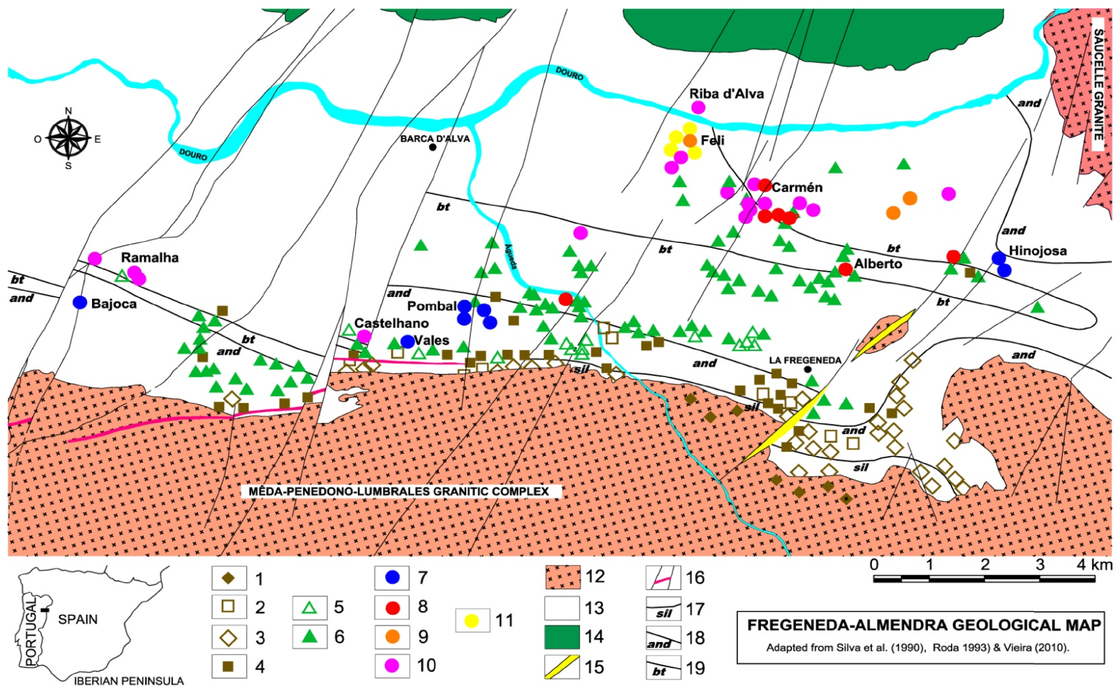

FIGURE 1. Distribution of the pegmatite types in the Fregeneda-Almendra area.
Legend: Group i) 1– simple interior; 2 – quartz + andalusite conformable dykes; 3 – simple dykes and apophyses; 4 – simple conformable; Group ii) 5– K-feldspar discordant dykes; 6 – simple discordant; Group iii) 7 – petalite-bearing discordant; 8 – spodumene-bearing discordant; 9 – Li-mica + spodumene discordant; 10 – Li-mica-bearing discordant; 11 – Sn-bearing discordant; 12 – syntectonic Variscan granites; 13 – Pre-Ordovician schist-metagreywacke complex; 14 – Ordovician formations; 15 – quartz segregations fractures; 16 – porphyry granitic/riolitic and faults; 17 – sillimanite isograd; 18 – andalusite isograd; 19 – biotite isograd.

➢ Most of the veins from the FA pegmatitic field correspond to the **less evolved** ones, grouped in two main groups: **(i) barren pegmatites** (types 1, 2, 3 and 4); and **(ii) intermediate discordant pegmatites** (Figure 1; Table 1);

➢ A **third group** of pegmatites (Figure 1; Table 1) represents ~10% of the aplite-pegmatite veins from the Fregeneda-Almendra. They are mainly rich in **Li-minerals** (types 7, 8, 9 and 10) and/or **cassiterite** (type 11);

➢ The main Li-bearing mineral assemblages are **petalite** (type 7), **spodumene** (type 8), ***lepidolite*** + **spodumene** (type 9), and ***lepidolite*** (type 10) (Table 1).

TABLE 1. Main characteristics of the types of pegmatites recognized in the Fregeneda-Almendra area.

Type	Mineralogy		Morphology and structure	Remarks	Enrichment
	Main	Other			
(1)	Qtz, Kfs	Ms, Ab, Tur, Bt	Dyke-like; thickness < 50 cm	Scarce; within the MPL granite	K, Al, Si, (B, P)
(2)	Qtz, And	Ms, Tur, Kfs	Conformable dyke-like; thickness < 50 cm	Scarce; boudinage structures	Al, Si, (B, K)
(3)	Qtz, Kfs, Ms	Ab, Tur, Bt, Fe-Mn Pho	Irregular and bulbous masses; ellipsoidal or lenticular forms	More common to east; graphic texture	K, Al, Si, (B, P)
(4)	Qtz, Kfs, Ms, Ab	And, Tur, Grt, Bt	Conformable dyke-like locally with internal zonation; thick. < 1 m	Abundant; graphic texture	Al, Na, B
(5)	Kfs, Qtz	Ms, Py	Discordant dyke-like; thickness > 1m	Scarce; main component is pink Kfs	K
(6)	Qtz, Kfs, Ab, Ms	± Fe-Mn Pho, ± Mbs, ± Tur, Cst, CT	Discordant dyke-like; thickness < 10 cm to 2 m	Most abundant; internal zoning can be present	K, Na, Al, Si, (P, Li)
(7)	Qtz, Pet, Ab, Kfs	Ms, Cst, CT, ± Mbs, Fe-Mn Pho ± Ecr	Discordant dyke-like without internal zonation; thickness 5-30 m	Bajoca, Pombal and Hinojosa del Duero	Li, Sn, P
(8)	Qtz, Spd, Ab, Kfs	Ms, Mbs, Pet, Fe-Mn Pho	Discordant dyke-like without internal zonation; thickness 4-15 m	Alberto and Valdecoso	Li, P (Sn)
(9)	Qtz, Ab, Kfs, Li-mica, Ms, Spd	Mbs, Cst, CT, Ap, ± Ecr, Fe-Mn Pho	Discordant dyke-like; internal zoning common; thick. < 15 m	Feli	Li, Sn, P, F, (Rb, Cs)
(10)	Qtz, Ab, Li-mica, Kfs	Ms, Cst, CT, Mbs	Discordant dyke-like; internal zoning common; thick. < 3 m	Cármen, Riba d'Alva and Ramalha	Li, Sn, P, F, (Rb, Cs)
(11)	Qtz, Cst, Ab	Ab, Ms, Kfs, CT, Ap	Discordant dyke-like; locally with internal zoning; thick. < 50 cm	Only in the eastern part, Feli	Sn, K

Note: Qtz – quartz; Kfs – K-feldspar; Ms – muscovite; Ab – albite; Tur – Tourmaline; And – Andalusite; Chl – chlorite; Bt – biotite; Grt – garnet; Py – pyrite; Pho – phosphates; Mbs – montebrasite; Pet – petalite; Spd – spodumene; Cst – cassiterite; CT – Nb-Ta oxides; Ap – apatite; Ecr – eucryptite. MPL – Meda-Penedono-Lumbrales granitic complex.

GEOCHRONOLOGICAL DATA & PETROGENETIC MODELLING

➢ **Micas** from the muscovite-*lepidolite* series were separated from the different pegmatite types, as well as from the MPL granitic complex and from another granite detected by drills in the north of the area;

➢ These mica samples have been used to date their hosting rocks by the step-heating **$^{40}Ar/^{39}Ar$ method** (Table 2.).

TABLE 2. $^{40}Ar^*/^{39}Ar$ isotopic data from the Fregeneda–Almendra pegmatite field. (M – MPL granite; F – Feli non-outcroping granite; Ms – muscovite; Ms-Li – lithium-muscovite).

Type	Mica	Plateau age (Ma)	J-value	MSWD	% ^{39}Ar released	Isochron (Ma)	$(^{40}Ar/^{36}Ar)i$
M	Ms	311,2 ± 3,7	0,01547 ± 0,4%	0,08	84,40%	311,2 ± 1,7	344,4 ± 43,0
F	Ms	305,0 ± 3,3	0,01547 ± 0,4%	0,52	90,97%	306,3 ± 1,5	264,7 ± 10,6
1	Ms	303,7 ± 4,2	0,01517 ± 0,4%	0,42	90,08%	307,2 ± 6,1	383,4 ± 58,3
2	Ms	302,2 ± 3,6	0,01517 ± 0,4%	0,22	78,30%	302,8 ± 1,9	320,2 ± 56,4
3	Ms	300,0 ± 3,5	0,01517 ± 0,4%	0,40	74,62%	301,1 ± 2,6	308,3 ± 82,0
4	Ms	304,8 ± 4,7	0,01517 ± 0,4%	0,09	50,36%	305,4 ± 2,3	299,5 ± 18,8
6	Ms	303,8 ± 4,4	0,01517 ± 0,4%	0,06	67,06%	304,9 ± 1,8	305,2 ± 14,4
7	Ms	296,4 ± 3,5	0,01517 ± 0,4%	0,33	70,55%	297,0 ± 1,7	308,4 ± 31,6
8	Ms	303,6 ± 4,8	0,01517 ± 0,4%	0,08	81,13%	302,6 ± 2,6	353,6 ± 29,7
9	Ms-Li	295,3 ± 3,9	0,01517 ± 0,4%	0,39	88,99%	292,6 ± 2,4	449,1 ± 20,4
10	Ms-Li	295,1 ± 4,2	0,01517 ± 0,4%	0,34	100,00%	295,0 ± 2,9	307,1 ± 58,9
11	Ms	300,0 ± 3,1	0,01517 ± 0,4%	0,21	95,26%	301,3 ± 1,8	235,5 ± 26,6

➢ Values of **Li, Rb e Ba** from granites and SMC metasediments from the FA region (Table 3.) the **partial melting** of the SMC materials and subsequent **fractional crystallization** of the generated melts was modelled., using **Rayleigh equation** for fractional crystallization and **batch-melting equation** for partial melting (Figure 2.).

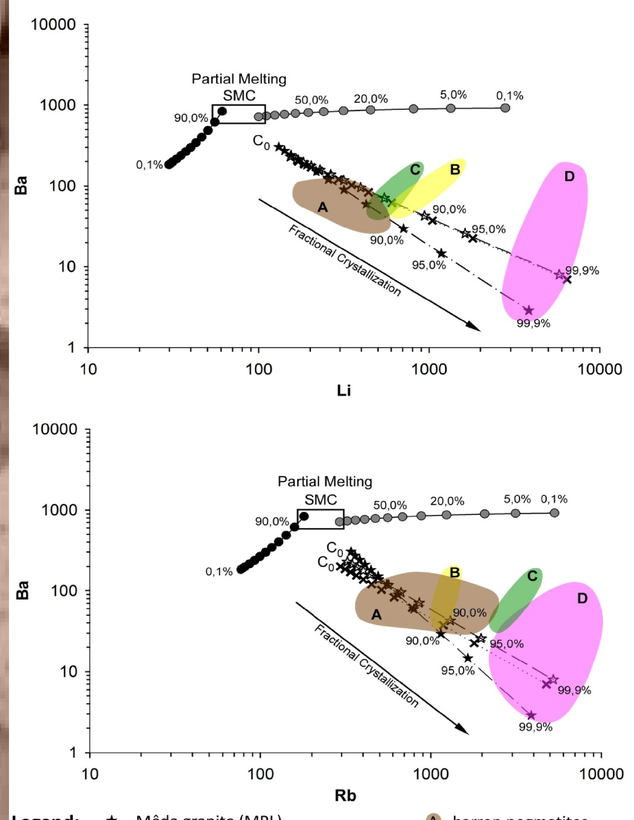

TABLE 3. Trace-element data and mineral mode from granites and metasediments from the Fregeneda –Almendra region.

	M[1]	SC[1]	VC[2]	SMC[3] with Bt	SMC[3] without Bt
			ppm		
Li	131	153	170	61	100
Rb	340	324	295	180	292
Ba	303	229	200	835	713
			vol. %		
Qtz	46	46	46	25	40
Kfs	22	18	20	13	12
Ab	18	22	20	-	20
Bt	4	2	2	55	-
Ms	10	12	12	8	-
Sil	-	-	-	-	14
Grt	-	-	-	-	1

[(1)]Gaspar (1997); [(2)] Bea (1976); [(3)] Roda et al. (1999).
M – Mêda granite (MPL); SC –Saucelle granite; VC –Villar de Ciervos granite ; SMC – Schist-Metagreywacke Complex

FIGURE 2. Modelling trends for **Li vs. Ba** and **Rb vs. Ba** for the fractional crystallization of the granitic melts (dashed lines between granites) subsequent to the partial-melting of the SMC (filled lines between SMC). A, B, C and D is for the whole-rock pegmatite types compositions from the Fregeneda-Almendra pegmatite field (Table 3.).

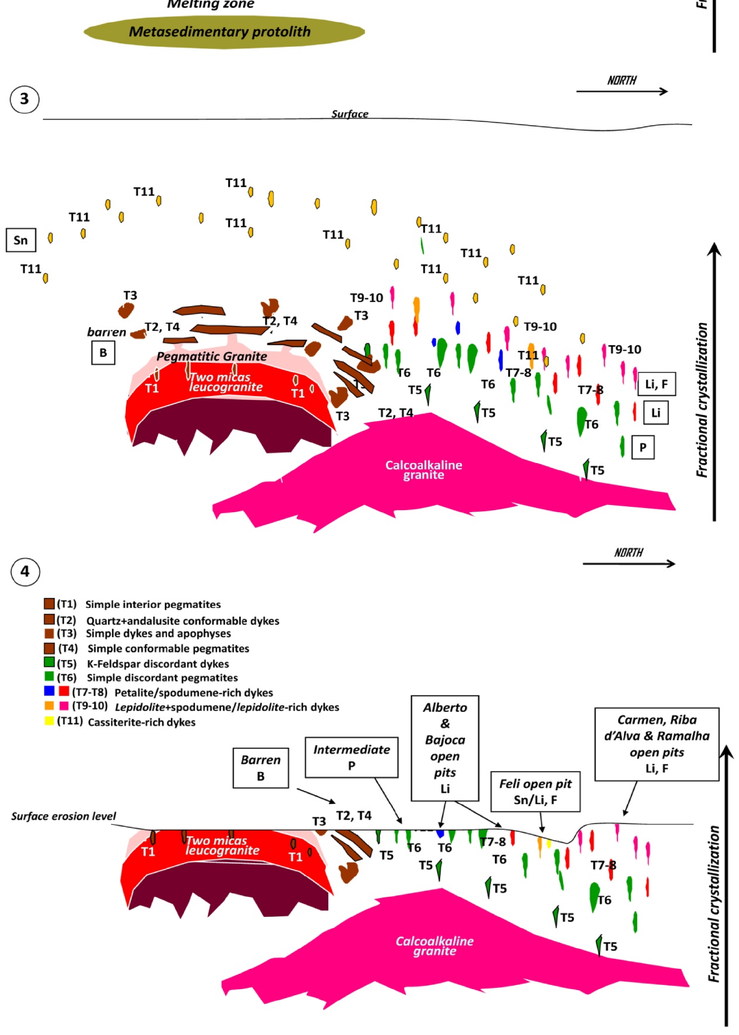

FIGURE 3. Fregeneda-Almendra model sequence for the metamorphic and magmatic events operating in the pegmatites formation.

➢ A **first event** of pegmatite formation would be related to the crystallization of the syn- to late-D_3 Variscan MPL granitic complex. **Lower rates of fractional crystallization**, from a melt with similar composition to the MPL, would originate the **T1** and **T3** pegmatites, whereas **higher degrees of fractional crystallization** would be related to the origin of the **Sn-rich dykes**. These bodies, with plateau ages ranging between 300,0±3,5 to 304,8±4,4 Myr, intruded S3 tectonic foliations (N100º-120°E) and are connected to the Variscan poly-harmonic folding and to the MPL emplacement.;

➢ **T2** and **T4** veins that outcrop in the proximities of the MPL (Alamo Complex) would be coetaneous or preceding this process;

➢ The **T6** and the **Li-rich pegmatites** represent highly differentiated melts. They infill late-tectonic Variscan structures (NNE-SSW and NE-SW), with plateau ages ranging from 295,1±4,2 to 296,4±3,5 Myr. Modeling demonstrate that these pegmatites would be related to **high rates (≥90%) of fractional crystallization** from melts with compositions analogous to the late- to post-D_3 Variscan granites (e.g., Saucelle or Villar de Ciervo granites). The difference of 10 Myr in the age between the late-D_3 Variscan granites and these pegmatites, exclude those granites as potential generators of the Li-rich pegmatites;

➢ Thus, the evolved pegmatites could be related to a late-Variscan (300 to 280 Myr) non-outcropping granite as a result of **high rates (≥ 90%) of fractional crystallization.**

Acknowledgements: This work has been supported by the research project CRUP E-30/07 & EHU08/02. Romeu Vieira is financed by Fundação para a Ciência e a Tecnologia (POCTI-FSE), within the compass of a PhD. Thesis, ref. SFRH/BD/16911/2004.