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THE CRYSTAL CHEMISTRY OF SPODUMENE IN SOME GRANITIC APLITE–PEGMATITE BODIES OF NORTHERN PORTUGAL: A COMPARATIVE REVIEW: DISCUSSION

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Charoy *et al.* (1992) omitted to include, in their survey of spodumene occurrences in Portugal, reference to our work (Gomes & Nunes 1990) on the characterization of spodumene from the large field of aplite–pegmatite bodies at Serra de Arga, Minho, between Ponte de Lima and Caminha, in the northern part of Portugal (Figs. 1, 2). We consider this occurrence to be important, given the complex association there of spodumene and other lithium-bearing minerals, some of which had not been identified in

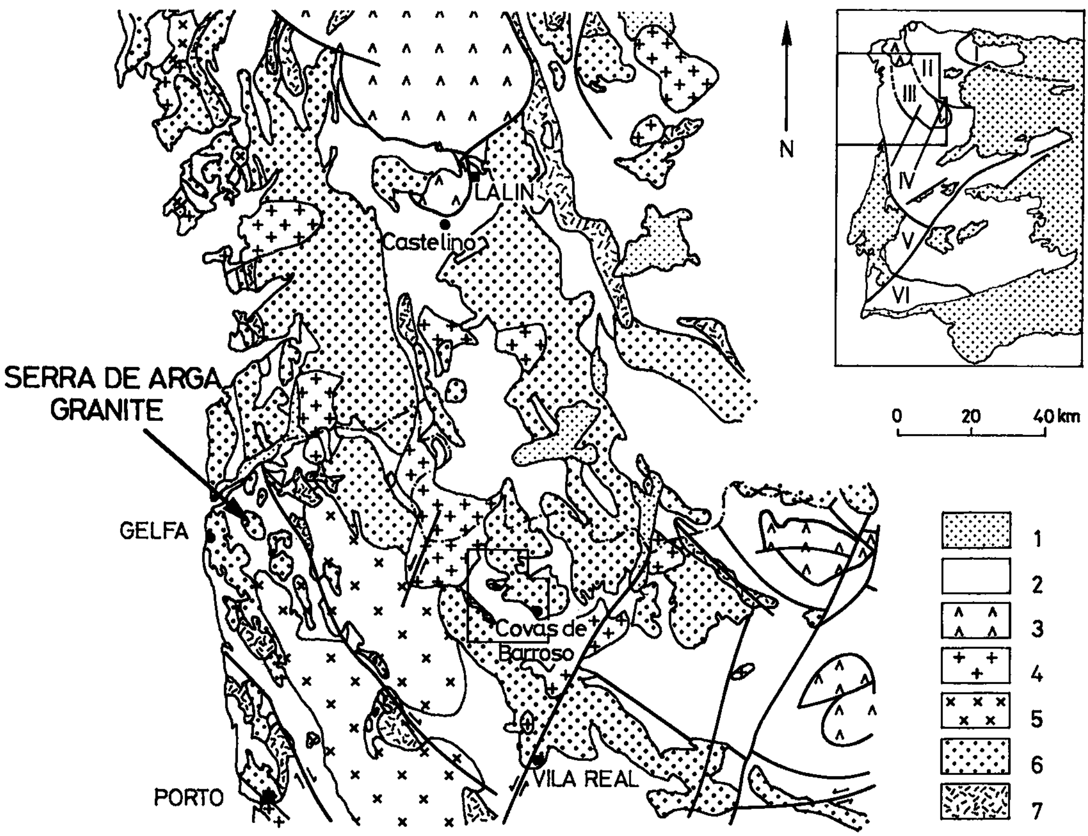

FIG. 1. Geological sketch-map of the northwest part of the Iberian Peninsula presented in Charoy *et al.* (1992), on which the location of the Serra de Arga granite is shown. 1) Mesozoic and Tertiary. 2) undifferentiated Paleozoic and Precambrian metamorphic rocks, 3) catazonal complexes from Galicia and Portugal, 4) to 7) Hercynian granites: 4) post-tectonic biotite granite, 5) late tectonic biotite granite, 6) syn- to late tectonic two-mica granite, 7) syntectonic biotite granite. Inset: major geotectonic units of the Iberian Peninsula: I) Cantabrian Zone, II) Asturian–Leonese Zone, III) Middle Galicia – Tra's-os-Montes Zone, IV) Central Iberian Zone, V) Ossa–Morena Zone, VI) South Portuguese Zone.

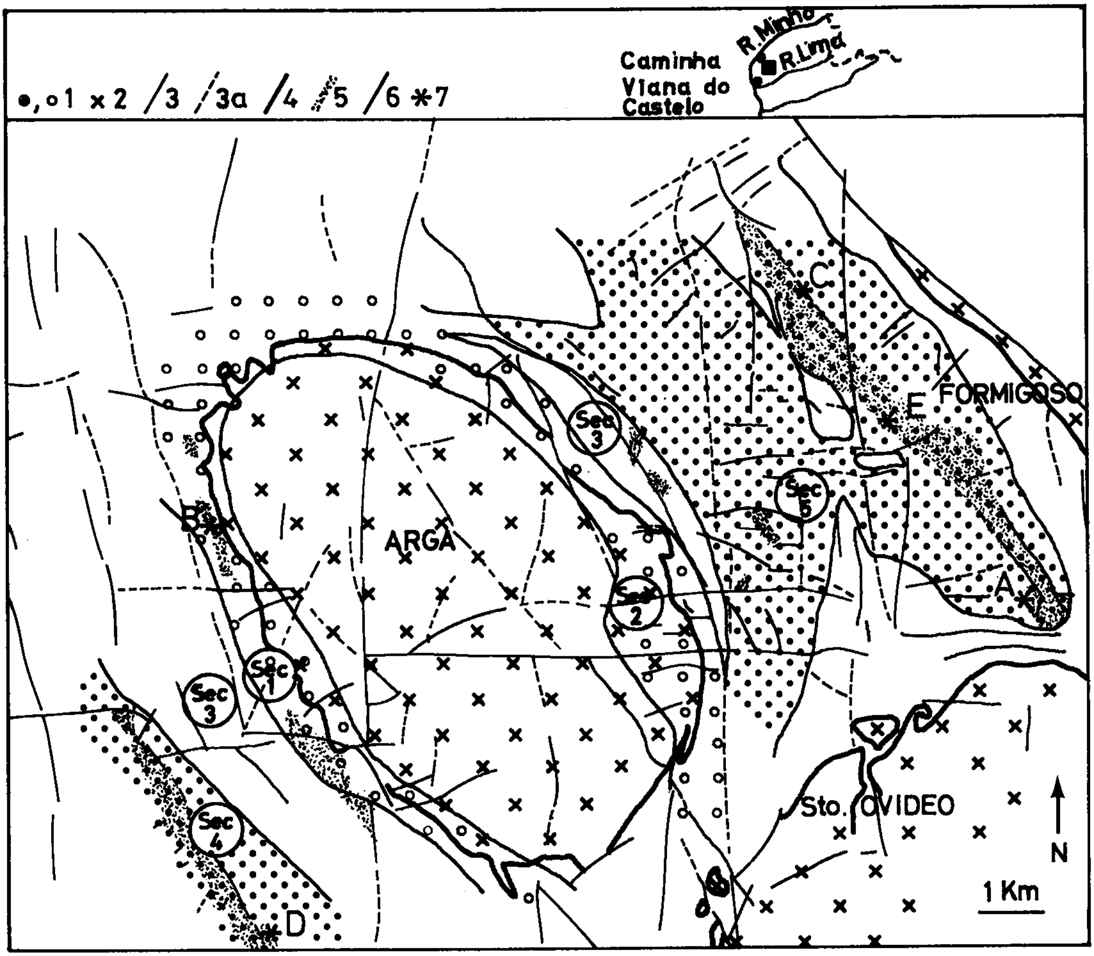

FIG. 2. Spatial distribution of the Arga field of granitic pegmatites, and position of the main occurrences of Li. Symbols: 1 Sectors with a dense network of aplite and pegmatite bodies [SEC 1: proximal, western sector; SEC 2: proximal, eastern sector; SEC 3: adjacent antiforms; sills in the apical position of the antiforms; SEC 4: distal, western sector; SEC 5: distal, eastern sector], 2 Granite, 3 Faults (3a, unproven), 4 Contacts, 5 Areas characterized by a higher percentage of Li minerals in the sills, 6 Limits of sectors, 7 "Type localities" of mineral paragenesis: A: Formigoso (petalite + spodumene + amblygonite ± zinnwaldite ± lepidolite), B: Pedras Frias (spodumene + amblygonite ± zinnwaldite), C: Picoto do Carvalho (spodumene + amblygonite ± eucryptite ± zinnwaldite ± lepidolite), D: Verdes – Folgadoiro (spodumene + amblygonite + zinnwaldite + lepidolite), and E: Balouca (elbaite–liddicoatite + zinnwaldite + amblygonite + lithiophilite–triphylite ± lazulite–scorzalite. Note that all parageneses contain, in addition, cassiterite and columbite–tantalite.

Portugal before our investigation. In particular, we provided details of the complex associations of Li minerals developed in the swarm of sills associated with the evolution of the diapiric Serra de Arga granite. We referred to the presence of zinnwaldite (Neiva 1954) and lepidolite (Neiva 1944). In addition, we reported the first documented occurrence of petalite (Table 1), eucryptite and elbaite–liddicoatite in Portuguese granitic pegmatites.

Concerning the Gelfa occurrence, which Charoy *et al.* (1992) described, we wish to contribute the following information, in light of our ongoing projects in the area. The spodumene-bearing bodies of aplite and pegmatite are not exclusively intragranitic, as claimed, but are mainly found beyond the pluton. In the coastal area north of Viana do Castelo, the bodies of aplite–pegmatite are enclosed in a well-exposed metasedimentary host-rock, in volumes exceeding those noted within the pluton. Spodumene may account for up to 20% of the volume of the bodies, and crystals may attain 30 cm in length. In addition to the tourmaline and garnet noted by Charoy *et al.*

TABLE 1. COMPOSITION AND UNIT-CELL DIMENSIONS OF SPODUMENE AND PETALITE FROM FORMIGOSO (A), PICOTO DO CARVALHO (C), AND VERDES - FOLGADOIRO (D)*

	SPODUMENE, D	PETALITE, A
SiO_2 wt.%	64.22	75.88
Al_2O_3	26.59	17.60
Fe_2O_3	0.09	0.03
MnO	0.04	0.01
MgO	0.02	0.01
CaO	0.07	<0.01
Na_2O	0.15	0.10
K_2O	0.03	<0.01
TiO_2	<0.01	<0.01
P_2O_5	0.23	0.09
Li_2O	6.71	4.62
LOI	1.32	1.62
total	99.47	99.90
Si	2.03	3.94
^{VI}Al		0.06
^{IV}Al	0.99	1.02
Li	0.86	0.97
Na	0.01	0.004
Fe		0.001

	SPODUMENE, C	SPODUMENE, D	PETALITE, A
a (Å)	9.463(1)	9.467(3)	11.746(7)
b (Å)	8.398(1)	8.390(2)	5.137(2)
c (Å)	5.221(1)	5.221(2)	7.624(2)
β (°)	110.193(15)	110.183(32)	112.940(30)
V ($Å^3$)	389.41(09)	389.20(16)	423.64(20)

* Sample locations can be found on Figure 2. Further details are provided in Gomes & Nunes (1990, Table 4).

(1992), cassiterite ± columbite–tantalite or zinnwaldite ± amblygonite ± topaz are found. We consider the Gelfa occurrence to be a part of a more extensive field of aplite and pegmatite bodies covering the entire coast north of Viana do Castelo.

The presence of a symplectitic intergrowth of spodumene with quartz in shear zones in the Serra do Barroso occurrence was noted by Charoy *et al.* (1992). Gomes & Nunes (1990) attributed the symplectitic intergrowth to the pseudomorphic (isochemical) replacement of petalite. We considered the almost complete transformations of petalite in shear zones to the east of Serra de Arga to be a possible result of a path of increasing pressure resulting from shearing in the P–T grid proposed by London (1984).

Finally, in our opinion, a proper evaluation of the mineral potential of the pegmatite fields in the Hercynian province of northern Portugal cannot neglect the highly evolved residual melts associated with the Arga granite (Gomes & Nunes 1990, Gomes 1992). The modal proportion of petalite attains 15 vol. % in some bodies in the Formigoso area (Fig. 2). Some bodies of homogeneous aplite and pegmatite approach 8,000 ppm Li, and contain disseminated spodumene and petalite. Lepidolite-bearing pegmatites in the same field may exceed 12,000 ppm Li.

THE CRYSTAL CHEMISTRY OF SPODUMENE IN SOME GRANITIC APLITE–PEGMATITE BODIES OF NORTHERN PORTUGAL: A COMPARATIVE REVIEW: REPLY

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It is unfortunate that at the time our paper was submitted to this journal, early in 1991, we were unaware of the paper of Gomes and Nunes which, though attributed a date of 1990, actually appeared late in 1991. In our paper, we did include all relevant references available to us, including the paper of Torre de Assunção (1954) concerning the Gelfa area. We based our sampling in that area on that investigator's description of spodumene in aplitic veins that cross-cut strongly foliated two-mica granite, in order to obtain suitable samples for a comparison of the crystal chemistry of such spodumene with that from other occurrences and environments. It was not our intention to embark upon a detailed regional study, and we focused instead on the aplite–pegmatite bodies of the Barroso area, where one of us (FN) has been engaged in collaborative studies with DGGM (Geological Survey of Portugal) for several years.

We accept that symplectitic intergrowths of spodumene + quartz have been classically interpreted as a result of the breakdown of petalite. In our opinion, however, such a reaction is unlikely in the Barroso area. The sheaf-like aggregates of spodumene + quartz are evidently in equilibrium with the stable fragments of spodumene they enclose (Charoy *et al.* 1992, Fig. 4b), and cannot be produced by breakdown of early petalite. Such an assumption would constrain a very unlikely path of P–T evolution in the diagram of London (1984).

We are happy to note the interesting associations of Li-bearing minerals documented by Gomes & Nunes (1990). It seems obvious that the Hercynian Province of northwestern Portugal holds much potential for Li and Sn mineralization, the exploration of which will be incumbent on the staff of DGGM.

REFERENCES

CHAROY, B., LHOTE, F., DUSAUSOY, Y. & NORONHA, F. (1992): The crystal chemistry of spodumene in some granitic aplite–pegmatite bodies of northern Portugal: a comparative review. *Can. Mineral.* **30**, 639-651, 1189.

GOMES, C.L. (1992): Recursos Minerais do distrito de Viana do Castelo e dos Concelhos de Vila Verde, Amares e Terras de Bouro. *Apreciação qualitativa do estado actual e perspectivas de aproveitamento. Unpubl. Rep. for the INTERREG PROGRAM – CEE Operational Program for the Development of the Frontier Regions of Galicia – Spain and Minho – Portugal.*

______ & NUNES, J.E.L. (1990): As paragénes correspondentes à mineralização litinífera do campo aplito-pegmatítico de Arga–Minho (Norte de Portugal). *Memórias e Noticias, Publ. Mus. Lab. Mineral. Geol., Univ. Coimbra* **109**, 131-166.

LONDON, D. (1984): Experimental phase equilibria in the system $LiAlSiO_4 - SiO_2 - H_2O$: a petrogenetic grid for the lithium-rich pegmatites. *Am. Mineral.* **69**, 995-1004.

NEIVA, J.M.C. (1944): *Jazigos portugueses de cassiterite e de volframite.* Ph.D. thesis, Univ. Porto, Porto, Portugal.

______ (1954): Pegmatitos com cassiterite e tantalite–columbite de Cabração (Ponte de Lima – Serra de Arga). *Memórias e Notícias, Publ. Mus. Lab. Mineral. Geol., Univ. Coimbra* **36**.

TORRE DE ASSUNÇÃO, C. (1954): Notas de Mineralogia e Petrologia. III. Ocorrência de Espodumena em Gelfa (Âncora). *Bol. Mus. Lab. Mineral. Geol., Fac. Ciênc. Lisboa, 7ª Serie*, **22**, 29-32.

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