ARMAGH

AUGHNAGURGAN, nr. Keady, ~~[illegible]~~ Armagh, Ireland.

N-F (1959) 29 Lead mine in List of Mines for 1916 ("suspended")

CLAY, nr. Keady, Armagh, Ireland.

N-F(1959), 28: Lead mine.

COLLEGE MINES, nr. Keady, Armagh, Ireland.

N-F (1959) 28 2 ml W by S of Keady. Lode 9 ft wide. Shafts to up to 35 fm. Lead mines. Abandoned 1864

CREGGAN, Armagh, Ireland.

N-F(1959), 29. Lead mine ca ½ ml NE of Creggan. Had tall chimney. Had "argentiferous galena in a magma of barytes with quartz & mundic".

DERRYNOOSE MINES, nr. Keady, Armagh, Ireland.

N-F(1959), 28: Ca $1\frac{1}{2}$ ml SW of COLLEGE MINES (q.v.)
galena; blende; pyrite. Deep levels barren
Abandoned <1845

KEADY, Armagh, Ireland.

See also AUGHNAGURGAN; CLAY; COLLEGE MINES; DERRYNOOSE MINES; TULLYNAWOOD;

BM: Galena.

SLIEVE GULLION Armagh, Ireland

TBJones *et al* MM (1969) 37 489-496.

Alkali-felspar, mentioned.

TULLYDONNEL, Armagh, Ireland.

N-F (1959), 31 (Map, p 28). Copper mine, abandoned 1853. Lode 2ft wide - matrix quartz & "carbonate of lime". Chalcopyrite seen on dump.

TULLYNAWOOD, nr Keady, Armagh, Ireland.

N-F(1959), 28. Lead mine. Rich one said to have been struck in a shaft at 60 ft.

Min Mag (1992) 56, 75-83.

Table 1. Representative analyses of garnets from schists (samples 080, 081 and 082), aplites (123 and 124) and garnetiferous spodumene pegmatites (129, 130, 349 and 091). Oxides in wt%, formulae normalised 24 oxygens. Endmember abbreviations: alm = almandine, sp = spessartine, py = pyrope, and = andradite, gr = grossular.

Sample	080	081	082	123	124	129	130	349	091
SiO_2	36.18	36.33	36.43	35.30	34.94	35.53	35.49	35.81	35.60
TiO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al_2O_3	20.54	20.73	20.84	20.14	20.18	20.26	20.43	20.50	20.50
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe_2O_3	nd	nd	nd	nd	nd	nd	nd	nd	nd
FeO	35.62	33.92	34.05	17.39	17.41	11.45	11.09	11.76	12.25
MnO	4.70	5.64	5.59	26.60	25.90	32.19	32.67	31.34	31.24
MgO	2.06	1.96	2.22	0.00	0.00	0.00	0.00	0.27	0.20
CaO	0.73	0.91	1.05	0.37	0.35	0.41	0.25	0.38	0.21
Total	**99.83**	**99.49**	**100.18**	**99.80**	**99.78**	**99.84**	**99.93**	**100.06**	**100.00**
	Number of ions on the basis of 24(O)								
Si IV	5.94	5.96	5.93	5.90	5.89	5.92	5.90	5.93	5.91
Al IV	0.06	0.04	0.07	0.10	0.11	0.08	0.10	0.07	0.09
Al VI	3.91	3.96	3.93	3.86	3.90	3.89	3.91	3.92	3.92
Ti VI	-	-	-	-	-	-	-	-	-
Cr	-	-	-	-	-	-	-	-	-
Fe^{+3}	-	-	-	-	-	-	-	-	-
Fe^{+2}	4.89	4.65	4.64	2.43	2.45	1.59	1.54	1.63	1.70
Mn^{+2}	0.65	0.78	0.77	3.76	3.70	4.54	4.60	4.39	4.39
Mg	0.50	0.48	0.54	-	-	-	-	0.07	0.05
Ca	0.13	0.16	0.18	0.07	0.06	0.07	0.04	0.07	0.04
No anal	7	6	5	5	3	15	3	6	5
Alm%	79.20	76.59	75.64	38.82	39.49	25.68	24.92	26.45	27.52
Sp%	10.58	12.90	12.58	60.13	59.51	73.14	74.36	71.40	71.08
Py%	8.15	7.88	8.80	-	-	-	-	1.07	0.80
And+Gr%	2.07	2.63	2.99	1.05	1.00	1.18	0.72	1.08	0.60

constrain the petrogenesis and P–T–X evolution of the Aclare Li deposit as described by Whitworth and Rankin (1989), Whitworth *et al.* (1989), and McArdle and Kennan (1987).

Geological setting

The Leinster Granite is the largest granitic batholith in the British Isles and covers an area >1500 km^2. It is a poorly mineralised granite–granodiorite intrusion comprising five separate plutons, usually termed units (Brindley, 1973), intruded *en echelon* into complexly deformed Lower Palaeozoic metasedimentary and metavolcanic rocks (Brindley, 1973; Brück, 1974; Brück *et al.*, 1979). The Northern Unit was dated at 405 ± 2 Ma by the U–Pb method (O'Connor *et al.*, 1989). Geochemical and isotopic data of Brück and O'Connor (1977) and Davies (1983) have been interpreted as representing fractional crystallisation of a calc–alkaline parent magma. However, Sweetman (1988) considered that partial melting of a Lower Palaeozoic, immature, sedimentary source produced a parental granitic melt which crystallised without further differentiation to form the northern end of the Blackstairs Unit. At the southern end of this Unit, the remaining melt partially crystallised to form a sequence of intrusions with slightly differing SiO_2 contents. A similar petrogenesis was envisaged for the whole of the Leinster Granite (Sweetman, 1988). Five bedrock occurrences of lithium pegmatites are spatially and temporally associated with the Granite and minor tonalite–granodiorite sheets (Steiger and von Knorring, 1974; Scoon, 1978; Luecke, 1981; Whitworth, 1989).

Host rocks comprise complexly deformed Ordovician–Silurian quartz arenites, greywackes, turbidites and volcanics (Brück *et al.*, 1979) which represent the transition from trough to shelf sedimentation followed by repeated turbidite incursions into the trough (McArdle, 1981). A single penetrative fabric is commonplace in the Lower Palaeozoic rocks of SE Ireland but is cut by later, non-penetrative fabrics (McArdle and Kennedy, 1985). Structural patterns now seen in the rocks reflect polyphase deformation determined during the initial D1 and D2 phases. Shearing characterised the D2 phase, as manifested by the activation of the East Carlow Deformation Zone (ECDZ), a major shear zone on the south-eastern

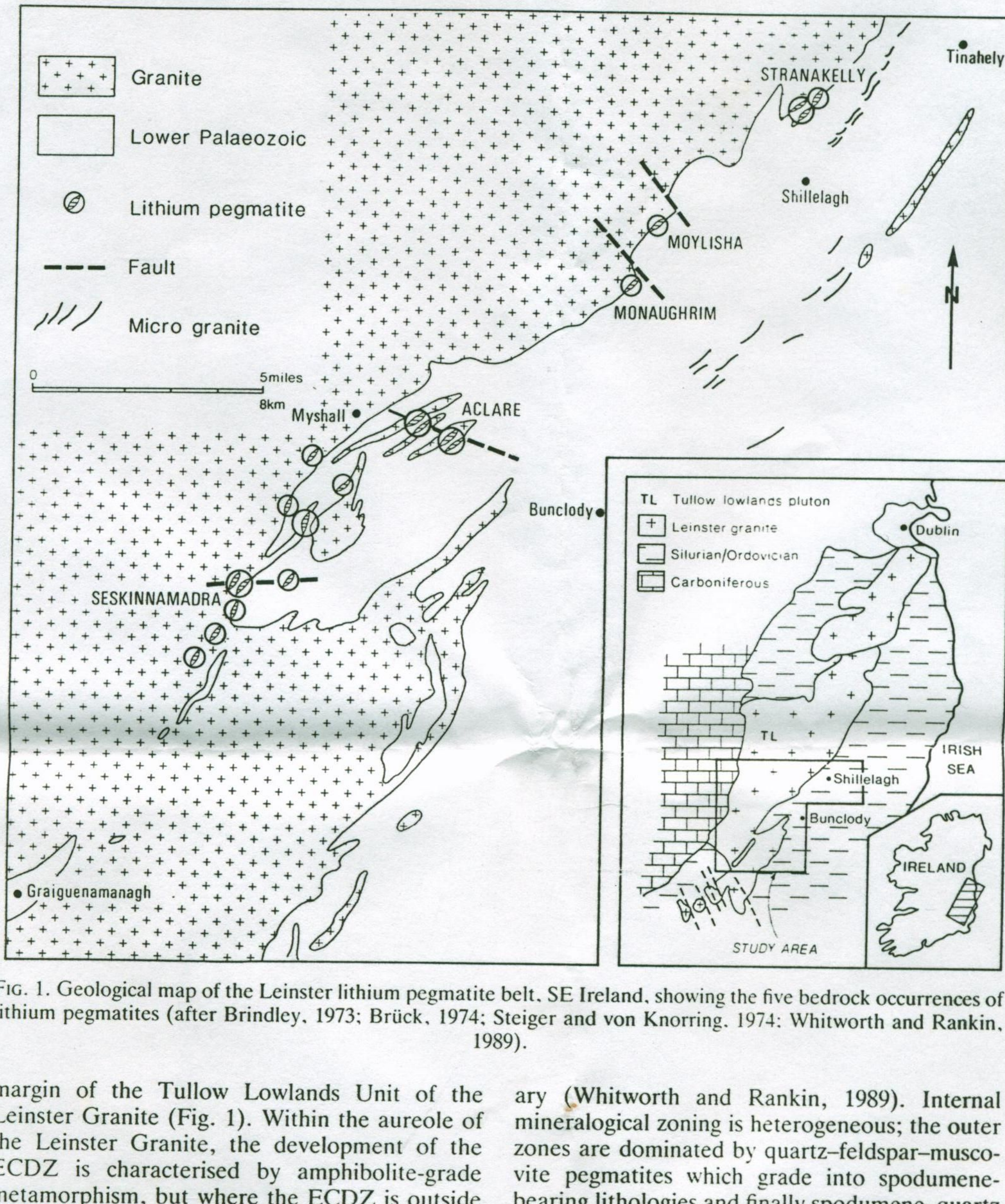

FIG. 1. Geological map of the Leinster lithium pegmatite belt, SE Ireland, showing the five bedrock occurrences of lithium pegmatites (after Brindley, 1973; Brück, 1974; Steiger and von Knorring, 1974; Whitworth and Rankin, 1989).

margin of the Tullow Lowlands Unit of the Leinster Granite (Fig. 1). Within the aureole of the Leinster Granite, the development of the ECDZ is characterised by amphibolite-grade metamorphism, but where the ECDZ is outside the aureole a greenschist-facies regional metamorphism prevailed (McArdle, 1981; McArdle and Kennan, 1987).

Li-bearing pegmatites have been discovered at thirteen localities in SE Ireland (Kennan *et al.*, 1986), of which five are proven bedrock occurrences, namely, Aclare, Seskinnamadra, Stranakelly, Monaughrim and Moylisha (Fig. 1). The largest pegmatite dyke which occurs at Aclare, is *c*. 20 m thick, internally zoned, cut by faults and is partially discordant to the schist–granite boundary (Whitworth and Rankin, 1989). Internal mineralogical zoning is heterogeneous; the outer zones are dominated by quartz–feldspar–muscovite pegmatites which grade into spodumene-bearing lithologies and finally spodumene–quartz pegmatite, quartz–feldspar pegmatite or quartz pods in the core (Fig. 2 of Whitworth and Rankin, 1989). Dykes at the remaining four prospects are composite in nature and all the pegmatites from the belt appear to be unaffected by the East Carlow Deformation Zone (Whitworth, 1989; cf. Steiger and von Knorring, 1974, and Gallagher, 1987). Gallagher (1987) reported a Rb–Sr cooling age of 360 ± 7 Ma for pegmatite from Aclare. The Leinster pegmatites are the only significantly mineralised pegmatite bodies yet found in

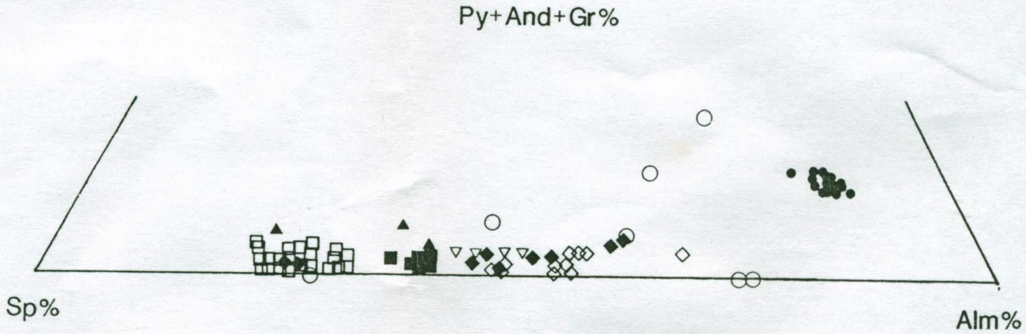

FIG. 2. Ternary plot of the mol.% of almandine (alm), spessartine (sp) and pyrope + andradite + grossular (py + and + gr) for garnets from Aclare and other granites. Aclare: garnetiferous spodumene pegmatite = open square, garnetiferous aplite = filled square, schist = filled circle. Others: Arabian granite (du Bray, 1988) = open circle, Cairngorm (Harrison, 1988) = open diamond, Galway granite and aplite (Leake, 1967) = filled triangle, Thai aplite (Manning, 1983) = filled diamond, Thai pegmatite (Manning, 1983) = inverted triangle.

Ireland (cf. Kennan *et al.*, 1986; Whitworth and Feely, 1989). Microgranite-hosted W–Sn mineralisation, in the form of scheelite with arsenopyrite and fluorite, is spatially associated with the Tullow Lowlands Unit (Gallagher, 1987, 1989) and minor vein-type Pb–Zn deposits also occur in the Northern and Lugnaquilla Units of the Granite (Williams and Kennan, 1983; Kennan *et al.*, 1986).

Garnet petrography and distribution

Garnet occurs in three lithologies at the Aclare pegmatite prospect, namely, garnetiferous spodumene pegmatite, garnetiferous aplite and garnet-bearing schist. The Aclare pegmatite was emplaced in schists which comprise fine- to medium-grained metasediments composed of quartz, muscovite, biotite, tourmaline, chlorite, staurolite, garnet and andalusite. Quartz occurs as idioblastic or angular grains up to 1 mm in diameter with patchy undulose extinction. Muscovite is ubiquitous and usually forms laths up to 3 mm long and 0.3 mm wide with inclusions, commonly of quartz. Biotite crystals are brown and some have hexagonal basal sections. Pyrite crystals up to 3 mm in size, usually in the form of poorly developed cubes, have undergone variable degrees of weathering to Fe-oxides. Poikiloblasts of staurolite with abundant quartz inclusions are common. Tourmaline occurs close (<5 m) to the pegmatite contact; it is typically acicular or lath-shaped, occasionally with rounded margins, brown and up to 5 mm in length. Hypersthene, cordierite and penninite were also noted in detailed studies of the host schists by McArdle (1981). Deep reddish-brown or black garnet porphyroblasts, 1 to 2 mm across, are subhedral to euhedral and commonly have poorly developed quartz pressure shadows. Garnet constitutes 0–6% of the Aclare schists and crystals commonly contain many quartz inclusions. Further details of the field relationships of the Aclare schists are given by McArdle and Kennan (1987).

Mineralised pegmatites (Scoon, 1978; Whitworth and Rankin, 1989) at Aclare are composed of quartz, spodumene, feldspar and muscovite with occasional garnet and accessory apatite and Ta–Nb oxides (Steiger and von Knorring, 1974; Scoon, 1978). Spodumene forms lath-shaped crystals up to 25 cm long, although it is commonly around 10 cm in size. When fresh it exhibits a pronounced cleavage, is white to light green and generally forms approximately 25% of the pegmatite. However, it is often altered to a fine-grained mass of muscovite ± albite. Quartz and albite crystals are also commonly around 10 cm in size, albite often exhibiting incipient sericitisation. Green muscovite phenocrysts up to 4 cm in diameter are subhedral to anhedral and have ragged margins. The pegmatite groundmass generally comprises a fine-grained intergrowth of quartz and feldspar. Garnets within mineralised pegmatites are sparse, but where present are red, subhedral to euhedral, measure up to 15 mm in diameter and contain abundant inclusions of quartz and feldspar. Fracturing of the garnets is ubiquitous, as is incipient alteration along the fractures. Reaction rims are absent. The garnetiferous pegmatites occur within the intermediate zone of the Aclare dyke (Whitworth, 1989; Whitworth and Rankin, 1989).

Garnetiferous aplites occur at the contact of the pegmatite body with the host schists. They comprise albite, quartz, muscovite and garnet and are dominated by lath-shaped albite crystals up to 1 mm in size. Quartz occurs as masses of anhedral crystals, each around 0.1 mm in diameter, or as discrete crystals mutually interlocked with fine-grained albite. Pale green muscovite crystals *c.* 0.5 mm in length are also common. Euhedral, red-brown garnets have diameters of 1–3 mm and make up 1–2% of the rock. Heavy fracturing is apparent in all garnets but reaction rims have not been observed.

Garnet chemistry

Garnet chemistry is, in general, very complicated when viewed as a whole (see Černy and Hawthorne, 1982, for a brief review). Members of the pyralspite series (spessartine–almandine–pyrope) are the most common garnets in granitic rocks (Miller and Stoddard, 1981; du Bray, 1988). Almandine is common in simple pegmatites but spessartine is predominant in Li-rich varieties (Baldwin and von Knorring, 1983), although this does not exclude pyrope or almandine components in many of the garnets hosted by Li-rich pegmatites. Almandine is typically found in regionally metamorphosed argillaceous sediments, along with certain members of the ugrandite series. With increasing metamorphic grade, FeO and MgO substitute for CaO and MnO in the garnet lattice i.e. the mol.% of spessartine and almandine decrease and increase respectively.

Garnets analysed from the Aclare pegmatite body belong to the almandine–spessartine solid-solution series (Table 1). They all comprise at least 88 mol.% almandine + spessartine and in many samples these two end-members make up more than 98% of the garnet (Fig. 2); pyrope constitutes up to 8.88 mol.%. Chemical zoning is absent (cf. Baldwin and von Knorring, 1983). Systematic compositional differences between garnets hosted by the schists, pegmatites and aplites at Aclare have been noted (Fig. 2). Garnets hosted by schists are rich in almandine (up to 79.2 mol.%) with subordinate spessartine, pyrope and andradite. However, garnets from the spodumene pegmatite generally contain over 70 mol.% almandine together with minor andradite; pyrope is low or absent. Aplite-hosted garnets are similar to those in the pegmatites but contain more almandine at the expense of spessartine. Plots of the Aclare garnets in terms of end-members are compared with other granite pegmatite- and aplite-hosted garnets in Fig. 2.

It is apparent that the schist-hosted garnets from Aclare contain the most almandine. Garnets from spodumene pegmatite fall in the field for Li-rich pegmatites of Baldwin and von Knorring (1983), although there is some overlap with the Li-poor pegmatite field. Garnets in the aplite have lower spessartine contents than those of Li-poor pegmatites but higher than most of the aplite- and pegmatite-hosted garnets of Manning (1983). Garnets from the Li-poor Galway Granite, Ireland (Leake, 1967), and Li-poor aplite from Thailand (Manning, 1983), have similar spessartine contents to garnets in the garnetiferous aplites from Leinster. In general, garnets from the Leinster lithium pegmatites have higher spessartine contents than those from Galway or Thailand. Garnets in peraluminous granites from Cairngorm (Harrison, 1988) and the Arabian Shield (du Bray, 1988) contain lower amounts of spessartine than the Aclare pegmatite- and aplite-hosted garnets. These data show that the chemistry of the pegmatite-hosted garnets from Aclare are typical of those in Li pegmatites (cf. Baldwin and von Knorring, 1983). However, the compositions of the Leinster garnets are similar to those found in other pegmatites and aplites which are not necessarily rich in lithium (cf. Leake, 1967; Manning, 1983).

Discussion

The origin of garnets in granitic rocks and lithium pegmatites has long been problematical since many of these rocks were not intruded at the great depths commonly believed to have been responsible for garnet nucleation. Their presence in granitic rocks has allowed some authors to constrain the petrogenesis of the host rocks by relating host rock geochemistry, field and textural relationships to garnet chemistry e.g. Green and Ringwood (1968), Fitton (1972), du Bray (1988) and Stone (1988). Until recently, this has not been the case for Li-rich pegmatites (cf. Baldwin and von Knorring 1983). The Leinster garnet data are assessed firstly in terms of the partial melting of a Li-rich protolith model favoured by McArdle and Kennan (1987 and 1988) and then in the light of the 'magmatic' model of Whitworth and Rankin (1989) and Whitworth *et al.* (1989).

Partial melting model. Pichavant *et al.* (1988) showed that Peruvian macusanite, a natural analogue of Li pegmatite magmas (London *et al.* 1988), was formed by partial melting of crystal material such as altered rhyolitic lavas or argillaceous material. High Li, B and H_2O in this magma imparted great mobility despite its high SiO_2 content. This, together with little evidence for assimilation of other material during ascent, led Pichavant *et al.* (1988) to postulate a rapid rise through the crust. Kennan *et al.* (1986) and McArdle and Kennan (1987, 1988) have proposed