Lea Larks

[NX 563 690]

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Introduction

This GCR site is located in the centre of the Fleet pluton; the rocks exposed are representative of the evolved central facies, which is very uncommon among the Scottish late Caledonian granites in being a peraluminous garnet-bearing two-mica granite. Such highly evolved garnet-bearing granites are rather unusual worldwide. The general significance of the Fleet pluton is discussed in the Clatteringshaws Dam GCR site. It represents the final event of Caledonian pluton-ism in mainland Scotland and is significant in providing important constraints on the end-stages of the Caledonian Orogeny and the closure of the Iapetus Ocean.

Zonation in the Fleet pluton takes the form of a small central facies of fine-grained granites within the main coarse-grained biotite granite and biotite-muscovite granite facies, as shown on (Figure 8.31). There is a sharp contact between the inner and outer facies, and xenoliths of coarse-grained granite are found within the fine-grained, demonstrating that the central pulse is the last major intrusive event (Parslow, 1968). This central facies is the most evolved of the pluton and is particularly distinctive in compositional terms.

Small, apparently magmatic, garnets are present in the granites of this facies in the vicinity of this site. These are spessartines, similar to those described by Macleod (1992) in aplites from the marginal zones. Such garnets are usually associated with highly evolved granitic melts of appropriate bulk composition, probably as the result of extensive fractional crystallization (Speer and Becker, 1992).

The Lea Larks GCR site was selected as representative of the most evolved facies of the Fleet pluton. It is well exposed and accessible via forestry tracks. The rocks of this facies are rare, and have almost nothing in common petrogenetically with the other late Caledonian granites of Scotland.

Description

The white-weathering exposures at Lea Larks are of muscovite granite, an extreme variant of the 'fine-grained biotite-muscovite granite' facies of Parslow (1968), although technically the rock here is medium grained. It is a leucocratic granite, comprising quartz, alkali feldspar and plagioclase, with plates of muscovite up to 5 mm. Scarce garnet occurs as small, anhedral crystals (about 0.5 mm), which are not obvious in hand specimen. The rock is almost devoid of biotite save for some rare flakes that have been largely chloritized. There is little evidence of strain in these rocks and the textural features are essentially igneous apart from some late alteration of feldspars. The fabric is more isotropic than in the foliated granites of the main coarse-grained outer facies of the pluton.

Interpretation

Granites at Lea Larks are highly evolved, even in the broad context of the late Caledonian granites. They have about 76% SiO_2 and a normative composition of more than 95% quartz + orthoclase + albite, approaching the 2 kbar ternary minimum. About 2.5% normative corundum indicates a strongly peraluminous composition, which is reflected by the presence of muscovite. Most trace elements are strongly depleted relative to other late Caledonian granite plutons, and to the outer facies of this pluton. The sole exception is Rb, which reaches levels of over 500 ppm in some samples. Initial $^{87}Sr/^{86}Sr$ ratios of 0.7076–0.7109 are significantly higher than in the outer facies, but the oxygen isotopes are indistinguishable (Halliday *et al.,* 1980). Overall, the geochemical features suggest that the highly evolved composition was probably achieved by fractional crystalliz4tion, particularly through the removal of feldspars and accessory minerals.

The bulk composition of the Fleet pluton is peraluminous, and granites at the Lea Larks site are strongly so. Strongly peraluminous compositions suggest a pelitic source rock (Miller, 1985; White and Chappell, 1988) and the combined major oxide and isotopic composition of this facies are consistent with this interpretation (Halliday *et al*.,1980). However, such highly evolved compositions have also been attributed to fractional crystallization (Clarke, 1992); and Halliday *et al.* (1981), reviewing the origins of peraluminous compositions in granitic magmas, suggested that this may have involved subalumi-nous amphiboles. However, there is no evidence that amphibole ever crystallized from any of the magmas of the Fleet pluton and thus this mechanism can be discounted. It seems that the magma from which these muscovite granites formed was originally peraluminous, with S-type characteristics, and that it evolved through the fractional crystallization of feldspars.

Almandine garnets occur in earlier Caledonian granitic rocks of the Lake District (Firman, 1978b; see Chapter 4) and Connemara, Ireland (Bradshaw *et al.,* 1969). However, spessartine occurs only in highly evolved granitic rocks; in the British Caledonides it has been recorded only from aplites and pegmatites, from the outer marginal facies of the Cairngorm pluton (Harrison, 1988) and from Lea Larks. The presence of garnet, albeit in rather small abundance, is important as an indication of extensive fractional crystallization of peraluminous granite magmas (Speer and Becker, 1992). Garnets in granites have also been interpreted as refractory relics from the melting of a pelitic protolith (Green, 1976). However, the composition of the spessartine garnets at Lea Larks and the evolved compositions of the whole rock are more consistent with a magmatic origin. In an analogous pluton, Speer and Becker (1992) show such garnets to be late magmatic, crystallizing at about 650°C.

The significance of the Fleet pluton in terms of its tectonic setting during end-Caledonian times has been discussed in the Clatteringshaws Dam GCR site. The Lea Larks site represents the most evolved facies of the zoned pluton.

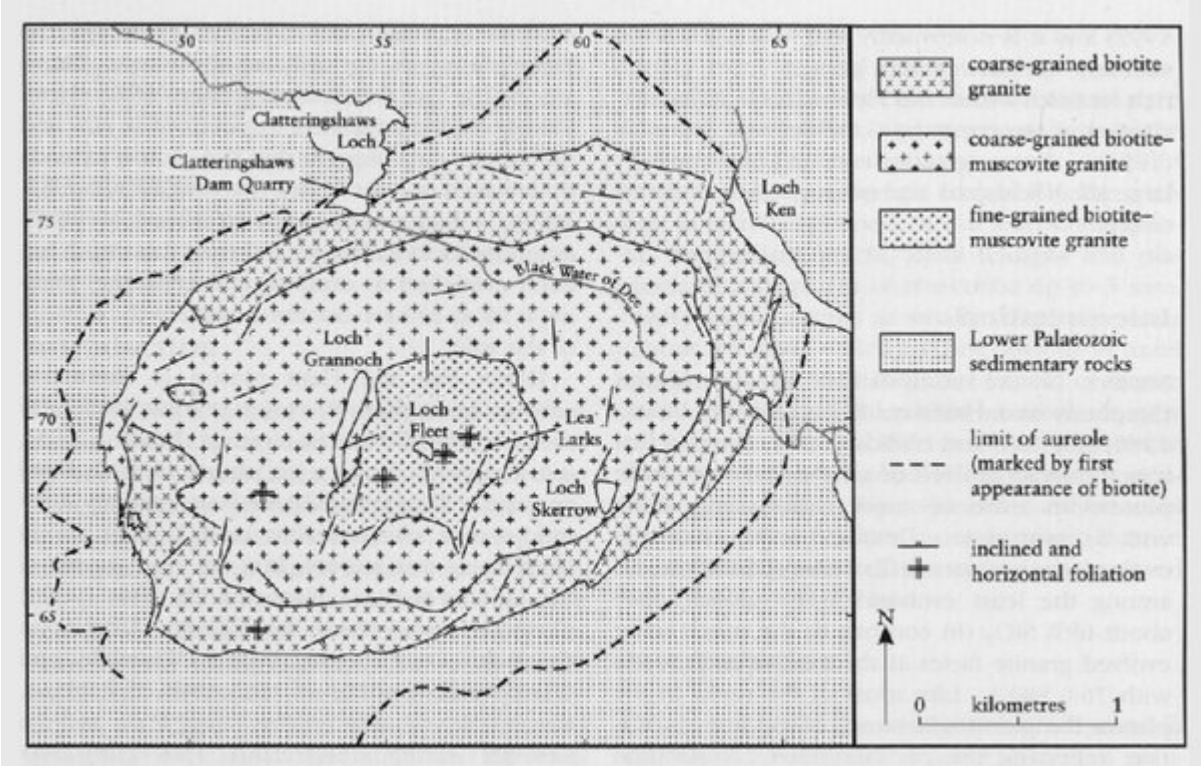
Conclusions

The Lea Larks GCR site represents one of the most highly evolved forms of granite found in the late Caledonian granitic suites of Scotland. The granite at Lea Larks contains garnet and the chemical composition of the rock suggests a long history of fractional crystallization, leading to the generation of a highly evolved melt through the separation of crystals from the magma. These processes are important for understanding the mechanisms by which certain elements (including economically important metals) become enriched in evolved magmas, and ultimately in fluids derived from them.

The compositions of these rocks also reveal that the source of the magmas had a major component of crustal sedimentary rocks not unlike those which presently host the pluton but also with similarities to those of the Lake District, suggesting that these may be present at depth beneath the present Fleet pluton.

Further study of these outcrops will improve understanding of how highly aluminous magmas evolve in their late stages and may also provide tectonomagmatic constraints on models for the closure of the Iapetus Ocean and subsequent collisional events.

References



(Figure 8.31) Map of the Fleet pluton, adapted from Parslow (1968), showing the locations of the Clatteringshaws Dam Quarry and Lea Larks GCR sites.