Water Crag, Cumbria

[SD 153 973]

Introduction

At Water Crag, west of Devoke Water, the Eskdale Granite, the largest exposed portion of the granitic Lake District Batholith, is in contact with rocks of the Ordovician Skiddaw Group and Borrowdale Volcanic Group. Adjacent to the contact the granite has been altered to a quartz-topaz greisen, and locally a remarkable quartz-andalusite rock is present adjacent to mudstones of the Skiddaw Group. Local concentrations of disseminated arsenic, bismuth and molybdenum minerals occur within the greisen.

The Eskdale Granite has been the subject of studies by Dwerryhouse (1909), Simpson (1934), Trotter *et al*. (1937), Firman (1978b), Rundle (1979, 1981), Ansari (1983), O'Brien *et al.* (1985), Firman and Lee (1986), and Young *et al.* (1988). Although the occurrence of greisens was noted by Dwerryhouse (1909), Simpson (1934), and Ansari (1983), their widespread occurrence was first described by Young (1985a). The unusual quartz-andalusite rock was first noted by Ansari (1983) and was described in greater detail by Young *et al.* (1988). The presence of metalliferous mineralization within the greisen was reported by Young (1985b).

Description

Water Crag provides one of the most extensive and spectacular examples of a greisen associated with the margin of the Eskdale Granite.

On the northern and north-western flanks of the hill, the Eskdale Granite, here with a chilled facies of mainly aphyric microgranite, dips southwards beneath a cover of hornfelsed basaltic andesites and volcanic sediments belonging to the Birker Fell Formation of the Borrowdale Volcanic Group (Figure 2.4). The contact may be traced around the western and southern flanks of the hill, although here a narrow belt of strongly hornfelsed and steeply inclined and cleaved slates, referred by Trotter *et al.* (1937) to the Skiddaw Group, intervenes between the granite and volcanic rocks. The slates are well exposed at several places on the hill, although their junction with the volcanic rocks is nowhere exposed, and their relationship with these rocks is unclear.

Near the summit of the hill a remarkable quartz-andalusite rock forms a prominent rib up to 1 m wide and 4 m long which separates coarse-grained granite and its greisenized equivalent from the hornfelsed slates (Figure 2.5). The junction of this andalusite-quartz rock with the adjacent rocks is not exposed. This rock was first recognized by Ansari (1983), although the presence of andalusite within the nearby greisen was first noted by Simpson (1934). Young (1985a), and Young *et al.* (1988) provided detailed descriptions of this rock. In hand specimen it is seen to comprise coarse-grained colourless quartz In which occur numerous patches, up to 8 mm across, of rose-pink andalusite. Lenticular pockets, up to 0.2 m across and 0.5 m long, of much purer compact pink to creamish-white andalusite are also present. A crude radial development of andalusite crystals may be seen locally in these lenses. A little white mica occurs along minor shears. Thin-sections of this rock reveal that much of the andalusite is fresh and unaltered, although locally some alteration to fine-grained sericite may be seen. Young *et al* (1988) figured thin-sections of this andalusite-quartz rock.

On the southern slopes of Water Crag large ice-smoothed surfaces of the granite exhibit patchy alteration to a coarse-grained greisen in roughly vertical ribs up to 2 m wide. Young (1985a) and Young *et al.* (1988) have given detailed descriptions of this rock. These ribs tend to parallel the granite contact, although several ribs up to 1 m wide run almost at right-angles to it. The greisen appears to have developed adjacent to, and in association with, a major set of joints. Greisenization may be seen up to 30 m from the granite contact. Much of the greisen at Water Crag consists of a coarse-grained quartz-topaz rock, mainly of a grain-size comparable with the parent granite. In hand specimen the quartz varies from colourless to smoky grey. Topaz is conspicuous as white or pale-cream rather saccharoidal patches and isolated anhedral crystals up to 8 mm across which commonly display a characteristic basal cleavage. A few scattered grains of pink andalusite occur locally and these appear to become more numerous as the contact with the hornfelsed slate is approached. Rarely, a little deep-purple fluorite is seen coating joint-surfaces. The junction with the unaltered granite is transitional over a few centimetres. In places, quartz-mica greisen is present in this transition zone. Young *et al.* (1988) figured a thin-section of the quartz-topaz greisen.

Locally a few streaks and pockets, up to 1 cm across, within the quartz-topaz greisen contain a fine-grained mixture of metallic minerals including arsenopyrite, bismuthinite, native bismuth and molybdenite. The latter mineral occurs as rare isolated flakes up to 0.5 mm across, scattered through the quartz-topaz greisen. Traces of the supergene minerals scorodite and ferrimolybdite have been identified and very small specimens have been obtained which show affinities with the rare bismuth supergene minerals zavaritskite (BiOF) and rooseveltite ($BiAsO_4$) (Young, 1985a,b).

Interpretation

The quartz-topaz greisen at Water Crag is one of a number of greisens identified at the margins of the Eskdale Granite (Young, 1985a; Young *et al.,* 1988). These are typically either quartz-topaz or quartz-mica rocks. Whereas at Water Crag most of the greisen is a quartz-topaz rock, small areas of quartz-mica greisen are also present.

Greisens are widely accepted as being the products of high-temperature hydrothermal-pneumatolytic metasomatic alteration of granite, developed during the final stages of cooling (Scherba, 1970). The field evidence for the Eskdale greisens, including that at Water Crag, is entirely consistent with such an origin. Moreover, although a magmatic origin has been proposed for certain quartz-topaz rocks found in association with granites (e.g. Collins and Coon, 1914; Scrivenor, 1914; Eadington and Nashar, 1978), the evidence at Water Crag and elsewhere in Eskdale points to a hydrothermal/metasomatic origin for the quartz-topaz rocks. Young *et al.* (1988) suggested that the widespread occurrence of greisens at the margins of the Eskdale Granite results from a concentration of volatile components ponded back by the relatively impervious hornfelsed country rocks near the roof of the intrusion. Ansari (1983) noted that compared to the parent granite, the greisens typically are enriched in SiO_2 and depleted in Al_2O_3, total iron, CaO, Na_2O and K_2O. There is evidence for local enrichment in Sn (Ansari, 1983), W and B (O'Brien *et al.,* 1985). Young *et al.* (1988) commented that the depletion in Li noted locally by O'Brien *et al.* (1985) is unusual, as in the greisens of South-west England and many other parts of the world enrichment in Li is more usual.

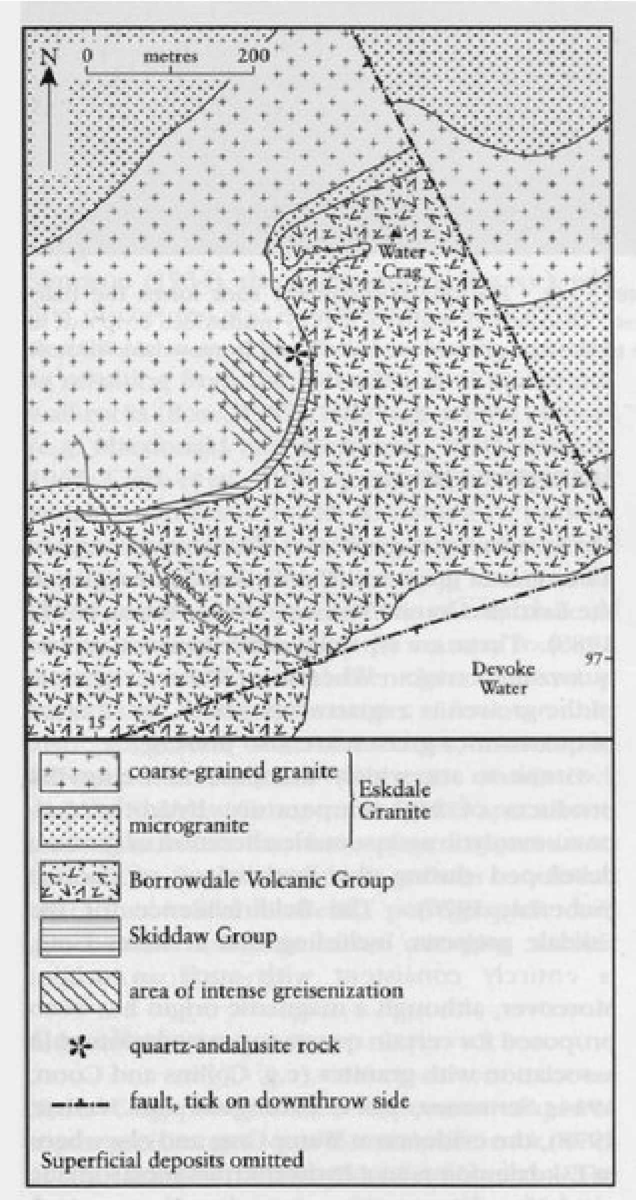
Young (1985a,b) proposed that the small amount of metalliferous mineralization within the greisen at Water Crag developed during the final consolidation of the granite, and commented on a possible genetic link with the copper and tungsten mineralization at Buckbarrow Beck (see GCR site report, this chapter).

Although the presence of andalusite within the greisen at Water Crag was first mentioned by Simpson (1934), the quartz-andalusite rock was first discovered and described by Ansari (1983). Andalusite in igneous rocks is usually regarded as resulting from the assimilation of aluminous wall-rocks (Rose, 1957), although several authors (e.g. Macdonald and Merriman, 1938; Haslam, 1965; Clark *et al.,* 1976) suggested mechanisms which could result in the formation of primary magmatic andalusite. In their discussion of the origins of andalusite at Water Crag, Young *et al.* (1988) pointed to the absence of any trace of visible contamination from the country rock and cite the overall major-element geochemistry in support of a magmatic origin. However, they also suggested that the close association between the restricted occurrence of this rock and the Skiddaw Group rocks invites speculation that assimilation may have played a part in its formation. On balance these authors concluded that the available field, petrographic and geochemical evidence does not give a clear indication of its origin.

Conclusions

Water Crag provides clear exposures of quartz-topaz greisen and quartz-andalusite rock, both at the margins of the Eskdale Granite. The greisen is interpreted as the product of high-temperature metasomatism of the granite during its final stages of cooling. Associated minor metalliferous mineralization may also be a product of this process. The unique quartz-andalusite rock may be a highly unusual modification of the granite, although whether the andalusite is the result of assimilation of adjacent slate or a primary magmatic product remains unclear.

[References](#)



(Figure 2.4) Geological sketch map of Water Crag.

(Figure 2.5) Outcrop of quartz-andalusite rock at Water Crag. The quartz-andalusite rock forms the pale-coloured outcrop immediately to the left of the map case. Hornfelsed Skiddaw Group mudstones crop out to the right of the map case. The rather rounded outcrops in the background are hornfelsed Borrowdale Volcanic Group rocks. (Photo: B. Young.)