Dalnabo and Easter Balmoral Quarries

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Introduction

The geology of Upper Deeside and Glen Gairn is dominated by large bodies of intrusive igneous rocks ranging in composition from diorite to granite. Best known of these is certainly the Lochnagar Granite (Oldershaw, 1974), but more recent mapping in the district (Smith et al., 2002) has identified and named separate intrusions such as the Abergeldie Complex and the Glen Gairn and Coilacreich granites. These bodies were emplaced between 426 and 416 ma and form part of the extensive suite of late Caledonian granitoids of NE Scotland, generally referred to as the Newer Granites. The present erosion level appears to be close to the original roof zone of several intrusions so roof pendants of metasedimentary and subordinate metaigneous Dalradian rocks occur widely and because they appear to be relatively undisturbed by the intrusions it is possible with the help of pointers from the Dalradian to the south-west to establish a broad lithostratigraphy. The main effect of these intrusions is to overprint the regional metamorphic textures and minerals to produce contact effects. This is most evident in pelites and impure meta-limestones.

The small disused limestone quarry above Dalnabo Farm in Glen Gairn has long been recognised as a source of fine specimens of calc-silicate minerals, particularly vesuvianite. A number of such mineral specimens are lodged in the Heddle Collection at the Royal Museum Scotland in Edinburgh, but photographs of the typical mineral assemblages can be found on the web site of the Hudson Institute of Mineralogy at New York State University. These testify to the global significance of the site. The earliest known account of the site and its minerals can be found in Heddle (1882) and it is evident that the eminent Victorian mineralogist visited the site some time before this. Significantly, this is the first recorded occurrence of vesuvianite in the United Kingdom, and the paper also contains a chemical analysis of the mineral for ten oxides including water. The quarry is also briefly mentioned in Heddle's magnum opus The Mineralogy of Scotland, published posthumously in 1901. The Geological Survey Memoir for Sheet 75 (Scotland) (Hinxman, 1896) recognised it as a "well-known locality for rare and beautiful mineral specimens, first made known by Professor Heddle". The Survey's description, however, does not use the name Dalnabo, but makes reference to Rinloan, one of the cottages near Dalnabo Farm. The former quarry is now extensively overgrown by self-sown saplings, fallen tree branches, moss and other scrub vegetation. However, the significance of the site, other than for the beauty of its mineral specimens, is that it provides one of the few examples of skarn-type mineralisation in Scotland. As such a description of the Dalnabo site was included in the Geological Guide to the Aberdeen area (Crane, 1987).

By contrast the former limestone quarry at Easter Balmoral is largely unknown. It is not recorded on the1:10,560 map compiled in the late 19th century during the primary geological survey, neither is it described in the Geological Survey Memoir for Sheet 65 (Scotland) (Barrow and Cunningham Craig, 1912), so it is possible that the quarry had not been opened at that stage. The reason why Easter Balmoral is included in the site is that, although the evidence of skarns is considerably more limited, it contains excellent examples of minerals, particularly vesuvianite derived from contact metamorphism of impure metalimestones.

Description

Dalnabo Quarry is located on the south-west side of Glen Gairn, 8 km north-west of Ballater, near the northern tip of a long spur from Geallaig Hill. It is reached by a gently inclined track leading from the A939. It was formerly worked for limestone, but Heddle in his 1882 paper, notes with sadness its passing as an active quarry since it provided such fine specimens of the calc-silicate minerals. At some later stage the quarry was reopened as a source of roadstone. Easter Balmoral Quarry is located on the northern slope of Tom Buailteach close to the summit, 9.5 km west-south-west of Ballater and 7.5 km south-south-west of Dalnabo. The Dalnabo Quarry consists of a single face on the south side cut into the hillside which, although heavily vegetated, along with the loose blocks at its base, provides good evidence of the rock and mineral types present. By contrast the quarry workings at Easter Balmoral are in two parts, an extensive, lower working that lies in a mature coniferous forestry plantation and a smaller upper face set within grass pasture south of the boundary wall and fence. The lower, or main, working has been partly backfilled with rubbish and the faces are partly obscured by forest litter and other vegetation.

Bedrock geology in the Dalnabo area comprises late Precambrian Dalradian metasedimentary and metabasic igneous rocks, and late-Silurian (Caledonian) granite. The Dalradian rocks comprise remnants of the roof zone of the Glen Gairn Granite Complex, and there is no direct stratigraphical correlation with Dalradian units in the surrounding area. However, on the evidence of the succession to the south the country rocks here are thought form part of the Blair Atholl Subgroup, referred to in the local stratigraphy as the Dalnabo Member. The upper part of the quarry face consists of metalimestone, part of an east-west striking lenticular body, which dips gently (up to 40O) to the north. The metalimestone unit occurs within a mixed sequence of semipelitic and psammitic rocks which can be seen in outcrops on the hillside above and to the south of the quarry. The lower eastern flank of the quarry exposes massive amphibolite, which probably originated as basaltic or doleritic intrusions. However, it is not possible to say whether they belong to the earlier or later suites of metabasic intrusions identified in the lower part of Glen Gairn (Smith et al., 2002). The granite piercing the roof zone to the west and south of the quarry is referred to as the Glen Gairn Granite whereas that to the east belongs to the Coilacreich Granite, a highly evolved, lithium enriched body within the Glen Gairn Granite Complex. This is one of the youngest of the Caledonian granites in the Ballater area, with a probable age of c.405 Ma.

The Easter Balmoral Quarry lies close to the southern extremity of a lens-shaped pod of the Rimarsin Limestone Formation which, in the local Dalradian lithostratigraphy forms the uppermost unit of the Blair Atholl Subgroup (Smith et al., 2002). The limestone is overlain to the east rocks of the Craig Leacach Quartzite Formation, which in the local absence of the Boulder Bed forms the lowermost unit of the Islay Subgroup. A small exposure of this quartzite can be seen around 90m south of the quarry, but rocks in the intervening ground comprise dark grey cordierite and sillimanite-bearing semipelites which become more pelitic downwards. That said, in the neighbourhood of the quarry the limestone is largely separated from the quartzite by medium grained diorite of the Abergeldie Diorite Complex (Smith et al., 2002). The diorite is cut by veins of coarse tonalite and granite. To the south-east of the quarry the diorite is separated from the limestone by a lensoid boss of coarse granite typical of the earliest phase of the Lochnagar Granite. To the west of the quarry the Dalradian succession below the limestone is cut out by diorite.

The metalimestones in both quarries are quite similar being thin bedded to finely laminated and ranging in colour from white to pale and mid grey. At Easter Balmoral the metalimestone unit as seen within the quarry is some 30 m thick, but the true thickness may be in excess of this as neither the overlying or underlying units are seen within the GCR site. Within the quarry the meta-limestone beds dip at 20-30O to the east. The succession here consists mainly of thin layers of pale to mid-grey meta-limestone between 20 and 50 mm thick, although locally may be more massive with layers up to 0.5 m thick. The meta-limestone also contains thin (less than 20 mm) ribs or more continuous layers of calc-silicate rock (impure limestone) and is cross-cut by veins of calcite. On the upper face, which provides a cross-strike section of 12.5 m true thickness, the meta-limestone is overlain by 1+m of more massive pale green calc-silicate rock with prominent vesuvianite porphyroblasts. There are several small faces in the lower part of the quarry revealing a sequence of meta-limestone with interbedded calc-silicate rock up to 200 mm thick and rare layers of rusty weathering fine grained chert-like rock. On occasion the metalimestones are cut by veinlets carrying calc-silicate minerals suggesting limited skarn development. This part of the quarry also includes a 20 mm thick unit of fine grained hornblende schist.

A meta-limestone specimen taken from the upper face contained 50-60% of carbonate grains which averaged 0.5 mm across and seldom exceeded 1.0 mm. The principal impurities are anhedral to granular diopside, largely sericitised plagioclase, hematite and opaque minerals. Scapolite (up to 2.5 mm across), rare tremolite, vesuvianite and sphene are also present.

At Dalnabo the calc-silicate bearing assemblages are found in metalimestone rocks. Although present as bands and lenses throughout the outcrop, there is a marked concentration close to the contact with the underlying amphibolite unit. Here, differential ductile deformation between the distinctive rock units is represented by large boudin-like voids with wavelengths of 2-3 m in the amphibolites. Cusps of banded metalimestone and calc-silicate minerals project into the boudin necks of the more competent amphibolite. On the western side of the quarry a discrete vertical zone, up to a metre wide, is exposed. This is largely made up of anastomosing veins and infilled fractures of calc-silicate minerals (mostly vesuvianite-rich) cutting across the metalimestones. Many of the veins are enclosed by pale-coloured reaction rims of wollastonite. Ribs and patches of calc-silicate minerals occur elsewhere within the metalimestones. Thin white veins, probably largely of feldspar with occasional calc-silicate minerals are also seen cutting through the amphibolites blocks at the foot of the quarry face.

The most prominent of the calc-silicate minerals found in both quarries is vesuvianite. This occurs either as well-formed crystals up to 14 cm long or massive aggregates that are red-brown in colour (although occasionally green according to Heddle, 1901). This mineral was formerly also known as idocrase. The other main calc-silicate minerals recorded at Dalnabo are sahlite, an iron-enriched variety of diopside, and garnets ranging in composition from grossular to essonite; the latter was formerly known as cinnamon stone because of its brown colour. Heddle (1901) also recorded epidote, prehnite and greenovite (manganese-rich titanite). In places the aggregates of vesuvianite overgrow the pre-existing foliation within the metalimestone, and are often enclosed by white reaction haloes.

Interpretation

The Dalradian rocks of the two quarries were deposited during the late Precambrian in a shallow shelf environment on the edge of an early ocean, mostly as carbonate-rich sediments. The occasional intermixing with silica-rich detrital material gave rise to sporadic interbedded impure metalimestones. Sheet-like minor basaltic intrusions were emplaced some time after sedimentation before deformation occurred.

During the ensuing Ordovician Grampian Orogenic event these rocks were folded and metamorphosed under Buchan-type (high temperature-low pressure) conditions. In pure metalimestones this simply resulted in widespread recrystallisation of the carbonate grains. However, in impure metalimestones the carbonate may react with free silica in the detrital component to produce a range of calc-silicate minerals including diopside and grossular garnet. It was during this deformation that the voids in the amphibolites, which now host some of the calc-silicate mineral concentrations, were formed at Dalnabo. Subsequent emplacement of the large granite and diorite intrusion gave rise to widespread contact metamorphism in the Dalradian rocks which resulted in the regional metamorphic textures and mineral assemblages being partly overprinted.

It is stressed that some of the surviving calc-silicate minerals were created during the regional event so the presence in particular of diopside and grossular garnet, and even possibly vesuvianite cannot be simply taken as evidence of contact metamorphism, although the latter mineral has seldom been recorded away from areas containing the late Caledonian granitoids . The clues to the origin of these calc-silicate minerals lie in the textures with the regional ones having a distinct directional alignment of minerals, whereas the contact examples are characterised by a non directional alignment and often granular arrangement of minerals. The calc-silicate minerals in the veinlets cutting metalimestones seen at Dalnabo and to a much lesser extent at Easter Balmoral may have originated as skarns, when hot aqueous solutions emanating from the underlying intrusions brought in silicon, aluminium and iron, leading to widespread metasomatism within the roof zone to the intrusion. Reaction of the magmatic fluids with metalimestones within the host Blair Atholl Subgroup rocks led to the formation of the calcium-rich silicate mineral assemblages to form skarns, or more precisely exoskarns.

The difference between the abundance of skarns at Dalnabo and their shortage at Easter Balmoral may be down to the nature of the underlying intrusions, in that water- and gas-rich fluids separating out from the crystallising magma are a common feature during the late emplacements of granites, but not so evident with diorites which would be drier. This is likely to have been the case with the adjacent Coilacreich Granite which is known to have been enriched in lithium and fluorine and one of the most evolved granites in the district. More significantly, it also demonstrates ample evidence (e.g. greisens) of being affected by late-stage fluids.

Conclusions

The two quarries together provide readily accessible exposures of contact metamorphosed and metasomatised Dalradian pure and impure metalimestones. The quarry face at Dalnabo also provides compelling evidence that the bulk of the calc-silicate minerals formed as skarns, and is one of the few occurrences in Scotland to demonstrate such an origin, whereas the calc-silicate minerals at Easter Balmoral largely originated in impure limestone beds. The Dalnabo Quarry site remains an excellent source of well-formed and beautiful calc-silicate mineral specimens, most notably vesuvianite. It is also noted for some less common minerals including essonite and greenovite.

References

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