Golden Hill Quarry, Monmouthshire

[ST 4308 9709]

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Introduction

An understanding of the mineralogy and chemistry of the Earth's lower crust and upper mantle is provided mainly by the study of xenoliths brought to the surface by magmas. The nature of the lithosphere in southern Britain is poorly understood, owing to the dearth of mantle and lower-crustal xenolith occurrences, in contrast to the area to the north of the Iapetus Suture (see chapters 2, 4 and 5). The supposed volcanic diatreme pipe at Golden Hill Quarry, in the county of Monmouthshire, along with a nearby associated dyke at Glen Court [ST 4036 9824], is of national importance as it represents one of only two occurrences of mantle-derived xenoliths in southern Britain, the other being at Calton Hill, Derbyshire (see GCR site report).

The first account of the Golden Hill Quarry diatreme pipe was by Boulton (1911), who provided a petrographic account of the igneous rocks, and described the presence of a dyke or plug, containing augite and biotite megacrysts and probable ultramafic nodules, all contained in a monchiquitic groundmass. This study was based on the rather poor exposures available at that time. Subsequent quarrying in the late 1940s and early 1950s provided much better exposures, particularly of the contacts, precipitating the report by Cox (1954).

A more complete description of these more extensive exposures was provided by Eyles and Blundell (1957) who reported that in fact the majority of the igneous material at the quarry is agglomeratic, and that this was the site of a volcanic vent, cut by a monchiquite dyke. Eyles and Blundell also provided critical evidence for the age of the volcanic activity. Welch and Trotter (1961) gave a further account of the petrography of the monchiquite, while Upton *et al.* (1983) referred to the presence at Golden Hill Quarry of carbonated and/or hydrated biotite-rich ultramafic xenoliths (probably biotite pyroxenites), biotite megacrysts and tectonized quartz-plagioclase xenoliths. Finally, Haslett (1992) compared the petrography of the Golden Hill Quarry monchiquite with a similar rock exposed at Glen Court, 3 km to the WNW

On the basis of stratigraphical evidence, combined with the age of blocks contained in the diatreme pipe at Golden Hill Quarry, the magmatism is thought to be Early Carboniferous in age (Eyles and Blundell, 1957). There is scattered evidence for Carboniferous igneous activity across a wide area in southern Britain, and the Golden Hill Quarry GCR site provides important regional information concerning the character and extent of this episode in south Wales.

Description

The Golden Hill Quarry GCR site is located to the north-east of Great House Farm (Figure 7.22), some 7 km south-east of Usk. The quarry, now disused, is some 100 m in diameter and up to 15 m deep. It contains an agglomeratic facies and a NW-orientated dyke, cutting through sandstones (Brownstones) of Devonian age (Figure 7.23). Aeromagnetic data suggest that the overall form of the intrusion is pipe-like, with a total surface area of no more than 900 m^2. The host rock is a monchiquite.

The most complete description of the Golden Hill Quarry agglomerates and the monchiquite intrusion, however, lies in the unpublished work of D.T. Moffat, which is included in part in the account below.

The dyke is exposed only at the southern margin of the quarry (*c.* 10% of the outcrop area). It consists of a melanocratic, dark-grey, fine-grained, xenolithic, amygdaloidal monchiquite. In thin section this rock is seen to possess a groundmass comprising laths of plagioclase and pyroxene, rare biotite and minor ?analcime and magnetite, along with euhedral microphenocrysts of olivine and clinopyroxene (now replaced by chlorite-like phases, carbonate or serpentine) all set in abundant, partially devitrified glass. Included xenoliths, which make up 5–15% of the rock, comprise sedimentary

wall-rock, tectonized quartz-plagioclase rocks, and ultramafic lithologies, in addition to mafic megacrysts (Figure 7.24), typically in the range 0.4–4 cm. All are of similar character to those present in the agglomeratic facies (see below).

The agglomerate comprises fragments of the monchiquitic dyke (70–80%) along with sedimentary wall-rock, tectonized quartz-plagioclase rocks, ultramafic xenoliths (10–25%) and mafic megacrysts (3–15%), contained in a clay- and carbonate-rich ochreous matrix with scattered quartz crystals. The clasts are rounded, oblate ellipsoid to spherical in shape, and range in size from 0.5 cm to 15 cm. Within the pipe, Moffat (unpublished manuscript) noted a number of petrographically distinct subunits, although each is massive, unstratified and lacking obvious sorting.

The monchiquitic fragments (up to 5 cm across) are virtually identical to the monchiquite of the dyke (see above). The wall-rock fragments comprise chiefly sub-angular to rounded, red to green, fine- to medium-grained sandstones, red-brown mudstones and micaceous sandstones, reaching a maximum size of 150 cm. In addition, however, Eyles and Blundell (1957) reported the presence of various lithologies of Visean and Tournaisian age.

The quartz-plagioclase xenoliths are small (0.5–2 cm) in size and rare (less than 1% of all xenoliths). They comprise medium-grained plagioclase porphyroclasts contained within a granular mosaic of strained quartz crystals. They are broadly tonalitic in composition.

Ultramafic xenoliths are typically rounded and are in the size range 0.5–15 cm. Investigation of the primary mineralogy of these nodules is extremely difficult due to the intense nature of alteration, with almost all the mafic phases being replaced by carbonate, serpentine and chlorite-like minerals. Originally, they appear to have been peridotites (lherzolites and harzburgites), with 62–85% olivine, 10–25% orthopyroxene, 2–12% clinopyroxene, and less than 3% chrome-spinel and minor glass (D.T. Moffat, unpublished manuscript). Original clinopyroxenes (chrome-rich diopsides) are the most common mineral to show at least partial preservation. Texturally, the majority of the ultramafic xenoliths are coarse grained (grain size in the range 0.4–1.0 cm) and show little evidence of deformation. Some xenoliths, however, show evidence of deformation, recrystallization and annealing.

Mafic megacrysts in the agglomerate, as in the dyke, comprise clinopyroxene and biotite. Clinopyroxene megacrysts typically have diameters of 1–5 cm and are subhedral to anhedral. Most are pale- to emerald-green chrome-rich diopsides, although a small proportion are black in colour and of augitic composition, the latter typically possessing lamellar intergrowths of ilmenite. Biotite megacrysts are euhedral to subhedral, dark-brown single crystals ranging between 0.5 cm and 5 cm in size. They are phlogopitic in composition.

The age of magmatic activity at Golden Hill Quarry is constrained in three ways. First, the agglomerate and dyke cut through strata of early Devonian age. Secondly, Ramsbottom (in Eyles and Blundell, 1957) identified various fossils of Carboniferous age in carbonate blocks from the agglomerate. In particular, he recorded Visean age fossils in a block of crinoidal limestone, with no post Visean age fossils being identified, suggesting that magma-tism may have occurred during Visean times. However, a K-Ar date of 336 ± 7 Ma (*c.* 342 Ma using new constants) (Fitch *et al.,* 1969) and an Ar-Ar plateau age of 347 ± 3.2 Ma (M. Timmerman, pers. comm., 2002), both on biotite megacrysts, suggest a Tournaisian or very early Visean age.

Interpretation

The earliest account by Boulton (1911) interpreted the Golden Hill Quarry igneous rocks as forming either a wide, irregular dyke or a plug, although it is clear that interpretation was hampered by poor exposure. Better exposures, resulting from more extensive quarrying, allowed Cox (1954) to propose that the intrusion has a plug-like form, and to compare it to the kimberlite pipes of the Kimberley area of South Africa. Eyles and Blundell (1957) argued that it does indeed have a pipe-like form, but is in fact a volcanic vent, comparing it with the volcanic vents exposed on the Ayrshire coast of Scotland, rather than the Kimberley-type pipes.

D.T. Moffat (unpublished manuscript) has provided the most recent interpretation, arguing that a transition from monchiquite through to agglomerate can be observed and that therefore the two facies are coeval. He took this gradation to reflect the transition from a liquid–solid dyke system to a gas–solid diatreme system. In the gas–solid system,

ultramafic mantle and lower-crustal xenoliths were transported rapidly to the near surface where they were mixed with blocks from the highest crustal levels. A circulatory flow was established, witnessed by some of the incorporated blocks being preserved at up to 1000 m below their original stratigraphical position. In this circulatory system, the ultra-mafic xenoliths were altered by carbonitization and hydrothermal fluids.

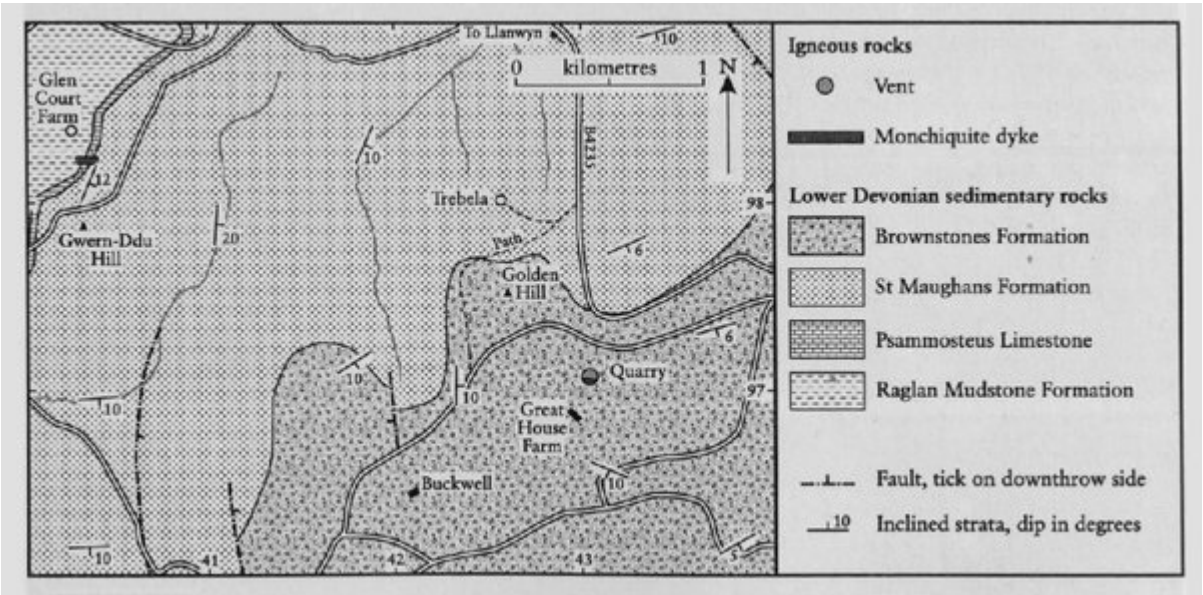
The ultramafic xenoliths appear to represent samples derived from the upper mantle (spinel-bearing lherzolites and harzburgites), while the tectonized quartz-plagioclase lithologies are possibly from lower-crustal levels.

On the basis of stratigraphical evidence, the age of included blocks, and K-Ar and Ar-Ar dates on biotite separates, the magmatic activity appears to be Early Carboniferous, most likely Tournaisian or earliest Visean, in age. Boulton (1911) correlated the Golden Hill Quarry monchiquite with the basic intrusion cutting Devonian strata at Bartestree, near Hereford (Reynolds, 1908). Farther to the south, Carboniferous age lavas and tuffs are exposed at a number of localities to the west of Bristol (see Whittaker and Green, 1983), as at the Spring Cove and Middle Hope GCR sites. Evidence for Carboniferous volcanism in Wales is scant, however. The Mathry quartz-dolerite dyke (Cave *et al.,* 1989), of probable Carboniferous age, can be traced for some 40 km across south-west Wales and interestingly is approximately in-line with the Golden Hill Quarry and Glen Court occurrences. A thin dyke was also exposed in a temporary road cut at Castleton, north-east of Cardiff, cutting strata of Devonian age and presumed to be of Carboniferous age (Lawrence *et al.,* 1981), while R.A. Waters (in Institute of Geological Sciences, 1978) reported the presence of thin tuffaceous siltstones and a bentonite in the Cwrt-yr-Ala borehole a short distance to the west of Cardiff. What makes correlation difficult, however, is that none of these sites contain lamprophyric rocks of the type seen at Golden Hill Quarry and Glen Court.

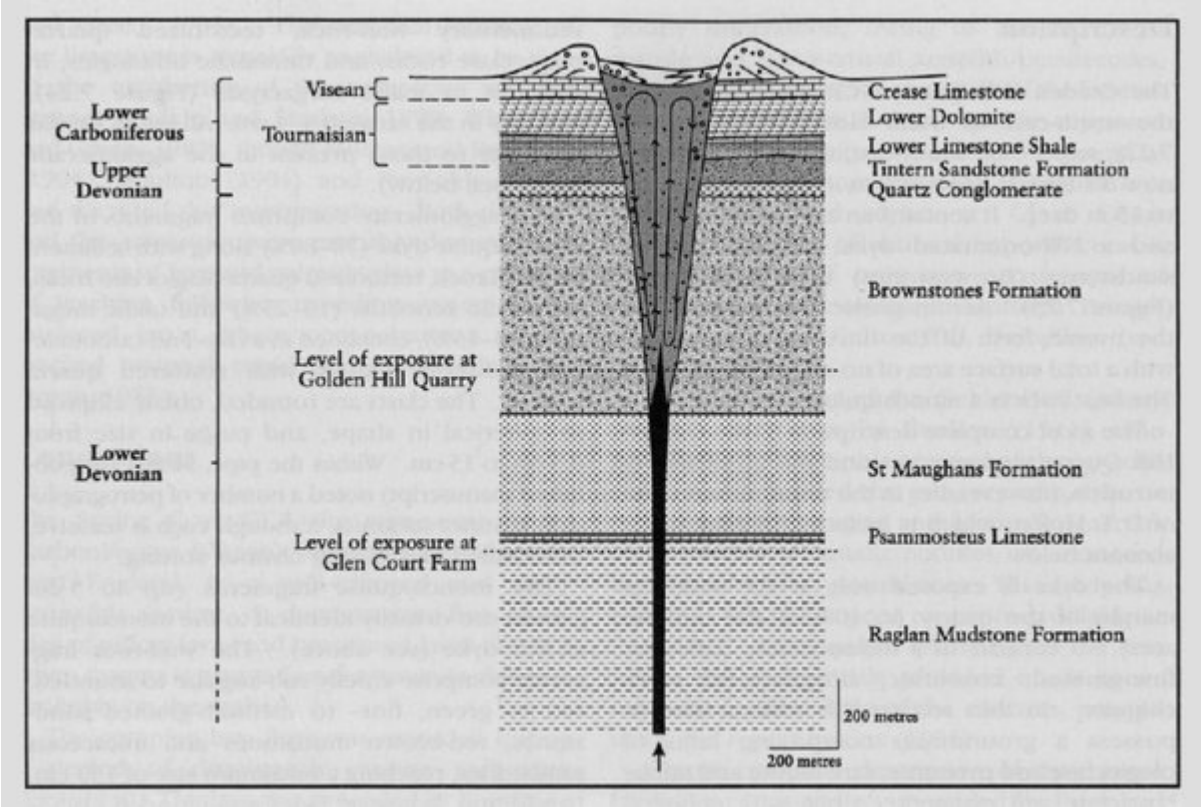
Conclusions

The Golden Hill Quarry GCR site exposes a volcanic pipe and an associated dyke-like intru sion of probable Early Carboniferous age. The intrusion is of an unusual rock-type termed 'monchiquite', and the pipe is infilled with a coarse deposit, which contains a variety of exotic blocks as well as large individual crystals of magmatic origin. The exotic blocks derived from the wall-rock, along with stratigraphical relationships between the pipe and surrounding country rocks, provide age constraints for the igneous activity. The site is most important, however, because of the presence of a variety of ultramafic rocks that originated in the Earth's mantle and quartz-plagioclase rocks that probably came from the lower part of the Earth's crust. These have been carried to higher crustal levels by rising magma and occur as blocks and fragments (xenoliths) in both the pipe and the intrusion. This is one of only two sites in southern Britain where mantle-derived xenoliths are known to occur, and hence is of national importance in providing an insight into the character of the mantle beneath this area.

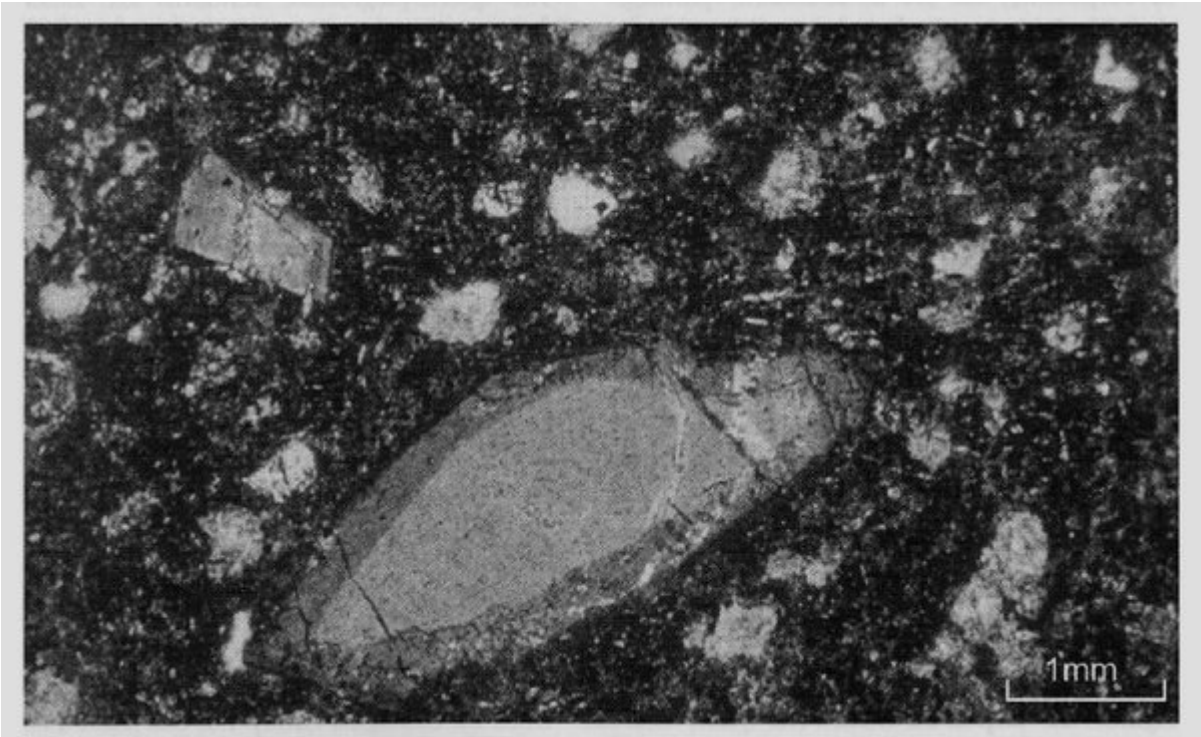
References



(Figure 7.22) Map of the Golden Hill Quarry GCR site. Based on Geological Survey 1:50 000 Sheet 250, Chepstow (1972).



(Figure 7.23) Schematic representation of the diatreme pipe, sub-diatreme monchiquite dyke and stratigraphical relationships at the Golden Hill Quarry GCR site. After D.T. Moffat (unpublished manuscript).



(Figure 7.24) Clinopyroxene megacryst in monchiquite from the Golden Hill Quarry. The crystal is 4 mm across. Crossed polars. (Photo: R.E. Bevins.)