Petrology of a Monchiquite from the Welsh Borderlands

S. K. Haslett

Abstract: The petrology of a monchiquite from Llanllowell, Gwent, is described and compared with monchiquite occurring at Great House, Gwent. The monchiquite is amygdaloidal, and set in a mafic Fe-rich groundmass are prominent large plates of calcite which pseudomorph clino-pyroxene and former olivine phenocrysts. The two occurrences of monchiquite are found to be similar, suggesting a common origin at depth.

In 1911, Boulton described the occurrence of a monchiquite intrusion at Great House (ST 431971). Some years later, Pocock (1940) noted a second intrusion of monchiquite at Llanllowell (ST 403982) (see 3 & 4 of Fig. 1 for location). Both intrusions were poorly exposed and it was not until after the Second World War (during which time both intrusions were quarried for hardcore) that a detailed description was made (Eyles and Blundell, 1957). The Great House intrusion was found to be a volcanic vent, infilled with agglomerate which contained blocks of fossiliferous lower Carboniferous Limestone and was cut by a monchiquite dyke, trending roughly NW-SE. The Llanllowell intrusion was also thought to be a dyke, trending in a NW-SE direction. It was postulated by Eyles and Blundell (1957) that the Llanllowell dyke may be an extension to the Great House intrusion, but they were unable to find any outcrop of monchiquite in the intervening area.

Haslett (1990) carried out a magnetic survey of the Llanllowell intrusion to determine whether or not it was an extension to the intrusion at Great House. The results revealed that the Llanllowell intrusion was not superficially connected with the Great House intrusion, but that the two may be connected at depth. Furthermore, the dimensions of the Llanllowell intrusion were found to differ greatly from previous measurements. Instead of a smaller linear dyke, the Llanllowell intrusion was found to be sub-linear (elliptical), which suggests it may have been a volcanic feeder pipe. Cox (1954) suggested that the intrusion at Great House was a pipe intrusion, but this view was later dismissed by Eyles and Blundell (1957).

In the light of the new data it seems plausible to suggest that both the monchiquite intrusions of central Gwent were feeder pipes to post early Carboniferous volcanoes. However, in order to determine whether the two monchiquites originated from a common magma source, a petrological study was required. The petrology of the Great House monchiquite has already been described by Boulton (1911) and Knill (*in* Welch and Trotter, 1961, p.139), and it is the purpose of this article to describe petrologically monchiquite from the Llanllowell intrusion.

Geological Setting

The two intrusions are emplaced in Old Red Sandstone strata of Gedinnian and Siegenian age (Barclay and Green, 1981). The Llanllowell intrusion is seen to pierce both the Raglan Mudstone Formation and the *Psammosteus* Limestone, which is locally used to identify the base of the Dittonian. The Great House intrusion, however, occupies a higher stratigraphic position near the base of the Brownstone Group, which locally comprises sandstones and marls. It is known that the Great House intrusion does occupy a volcanic vent, and the fact that the monchiquite cuts agglomerate in the vent with a near vertical contact (Eyles and Blundell, 1957) suggests that there was more than one eruptive episode. The lack of agglomerate in the Llanllowell intrusion could be attributed to its lower stratigraphic position.

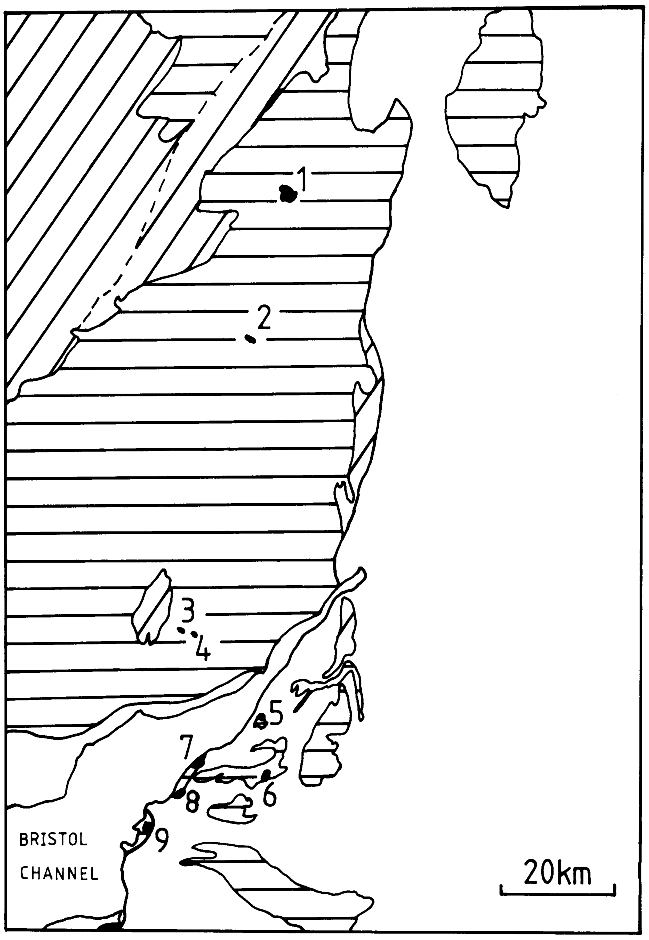

Fig. 1. Generalised geology and locations of the basic and ultrabasic igneous occurrences in the Welsh Borderlands and Bristol area. 1. Brockhill, 2. Bartestree, 3. Llanllowell, 4. Great House, 5. Tickenham, 6. Goblin Coombe, 7. Woodspring, 8. Spring Cove, 9. Uphill.
Key to shading: diagonal lines = Lower Palaeozoic; horizontal lines = Upper Palaeozoic; areas left blank (other than the Bristol Channel) = Mesozoic; solid shading = igneous occurrence.

Petrology

The representative sample upon which this study is based was collected from the middle of the Llanllowell intrusion, approximately half-way along transect 3 of Haslett (1990).

Hand specimen. The outer crust of the specimen has weathered to a rusty-yellow colour and is not calcareous. However, the fresh interior is dark blue-green in colour and reacts with dilute hydrochloric acid. The dark aphanitic groundmass supports numerous light coloured phenocrysts and irregular amygdales, both up to 3mm in diameter. In the outer weathered zone the amygdales have been lost, leaving empty cavities. Veins can be seen infilled with a pale green mineral, probably chlorite. Some reddish-brown patches of hematite also occur.

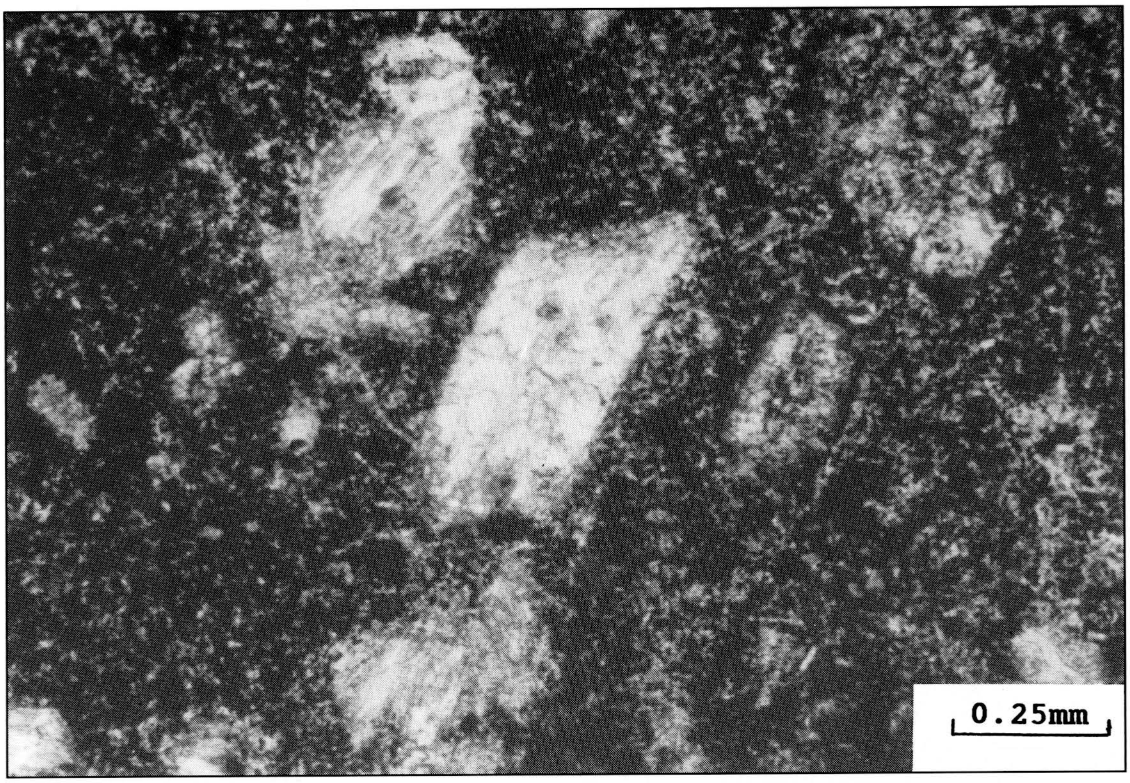

Fig. 2. Carbonate pseudomorphing clino-pyroxene.

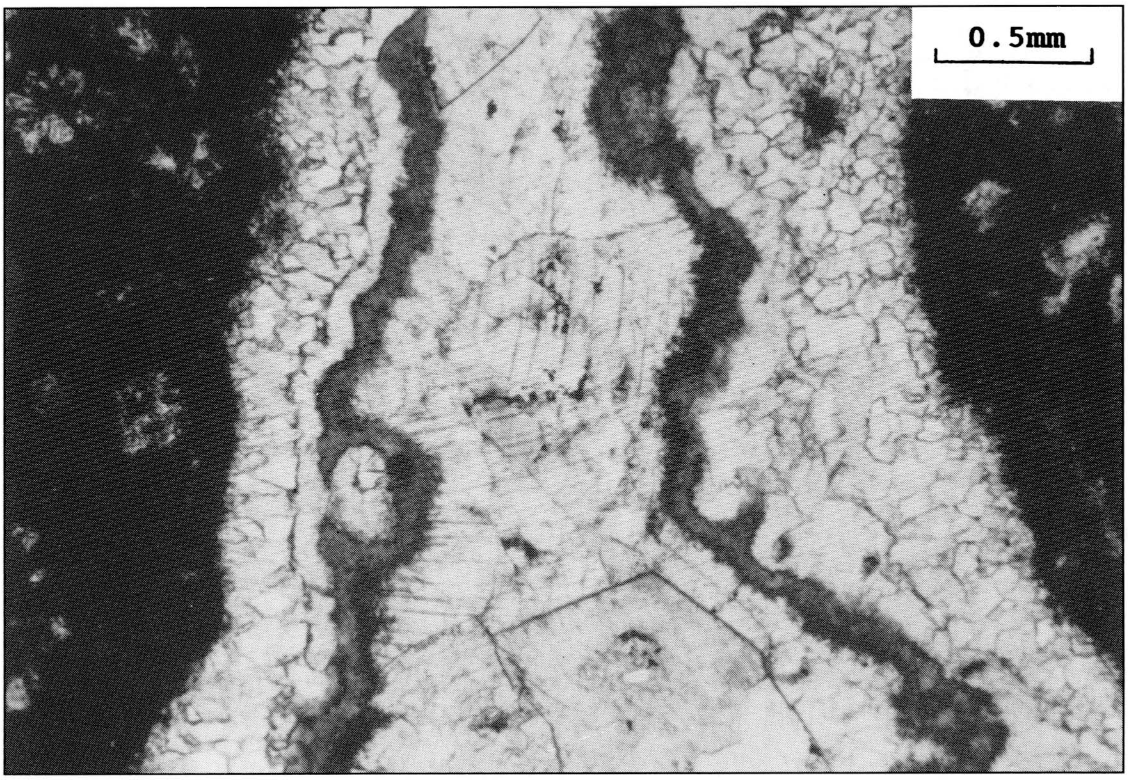

Fig. 3. Calcite and chlorite vein zonation.

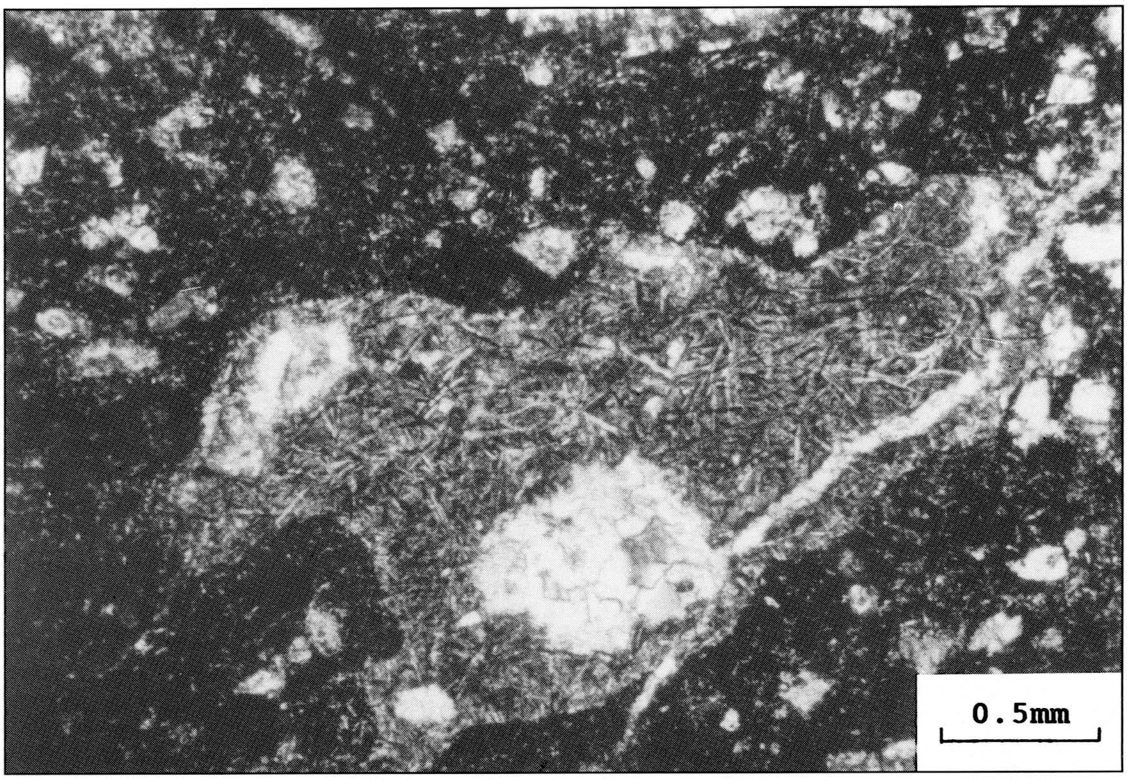

Fig. 4. An amygdale infilled with radiating natrolite.

Thin section. Many of the minerals present are of secondary origin. Carbonates are abundant in the groundmass, in veins, in amygdales, and as pseudomorphs. Notably, calcite is seen to pseudomorph sub-hedral clino-pyroxenes, which have a decayed, fractured appearance (Fig. 2), and anhedral olivines possessing characteristic cracking. Some of the larger veins display a zonation in which small anhedral calcite crystals line the edge of the veins, with larger sub-hedral calcite crystals occupying the central zone. These larger calcite crystals clearly show rhombohedral cleavage. The outer and inner calcite zones are then separated by a thin zone of pleochroic chlorite (Fig. 3). Small chlorite crystals are also associated with calcite pseudomorphs of clino-pyroxene, giving many pseudomorphs a green tinge. Calcite and chlorite are also found in amygdales. However, these two minerals play a secondary role, with radiating natrolite being the dominant amygdale mineral (Fig. 4). Also, very small analcime crystals are associated with the natrolite amygdales.

The mineralogy of the fine-grained groundmass is difficult to determine. Small opaque anhedral crystals of iron oxides are a main constituent. It is probably the abundance of this mineral that produces the rusty colour when weathered. Very fine-grained mafic minerals are present in the interstices, but are partially replaced by chlorite. Analcime and small biotite crystals are also present in the groundmass.

Discussion

A comparison between the Great House monchiquite and the Llanllowell monchiquite reveals many similarities. Both possess olivine and pyroxene phenocrysts, which in the Great House monchiquite are sometimes zoned. The presence of natrolite in amygdales and its association with chlorite and carbonate is common to both monchiquites. In the Great House monchiquite quartz is also found as an amygdale infill. Quartz was not seen in the Llanllowell monchiquite, and the presence of the mineral in the Great House monchiquite may be due to the incorporation of adjacent sandstone into the melt or from normal hydrothermal fluids, and is unlikely to be primary in origin, especially when considering the ultra-basic nature of the rock type.

The calcite composition of the Great House monchiquite varies according to its position in the intrusion. Monchiquite in close proximity to the country rock is high in calcite, whilst samples from the interior of the intrusion are depleted. The specimen from Llanllowell was collected from the centre of the intrusion and yet contains a high amount of calcite. The differences may be attributed to the smaller dimensions of the Llanllowell intrusion and to reaction with carbonate fluids emanating from the *Psammosteus* Limestone.

The groundmass of the Great House monchiquite was described as being composed of augite, carbonate, abundant iron-ore, chlorite and analcime, and therefore very similar to the Llanllowell monchiquite described above. However, plagioclase was noted from the groundmass of the Great House monchiquite, and its presence presents a problem of definition. If the plagioclase is primary in origin, then the rock-type should technically be termed camptonite; but if the plagioclase is secondary, then monchiquite is correct. Knill (*in* Welch and Trotter, 1961) described the feldspar as "subhedral acid plagioclase" suggesting poorly developed albite, and thus probably secondary in origin. However, there does appear to be some ambiguity concerning the presence of feldspar in defining monchiquite, and moreover, the plagioclase in the Great House monchiquite is extremely rare.

The main difference lies in the size of phenocrysts. Whereas the Llanllowell monchiquite possesses small crystals of pyroxene and olivine (less than 3mm), and very small biotite crystals (less than 0.25mm), the Great House monchiquite possesses very large phenocrysts of augite (up to 18cm long) and biotite (up to 5cm across). This size difference could be due either to the smaller size of the Llanllowell intrusion and therefore a greater cooling rate, or to a settling out of large phenocrysts.

Nevertheless, apart from minor differences which seem to be due to emplacement or post-emplacement processes, there is an over-riding similarity in the petrology of the two monchiquites, which suggests that they may be genetically related, possibly originating from a common magma source.

On a wider geographical scale, the relationships of other nearby Upper Palaeozoic basic and ultrabasic intrusions remain to be considered (see Francis, 1970 for a review and Fig. 1 for location). The dolerite intrusions of Bartestree and Brockhill (1 and 2 of Fig. 1) are both intruded into Devonian strata and are thought to be of late Carboniferous age. Interestingly, these composite intrusions contain an ultrabasic analcime-rich dolerite (teschenite) (Reynolds, 1908; Taylor, 1940). Also, to the south, numerous Viséan olivine-basalts which may be related are found in the Bristol district (5-9 of Fig. 1) (Reynolds, 1917; Kellaway and Welch, 1948).

Acknowledgements

I would like to thank Dr. George Rowbotham of the University of Keele, Staffordshire (where this study was undertaken), for his assistance and instruction in the use of the photo-microscope.

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Simon K. Haslett
School of Environmental Sciences
University of East Anglia
Norwich
NR4 7TJ