D2 Webberton Cross Quarry

[SX 875 871]

Highlights

This quarry provides one of the best exposures of a basalt of the post-Variscan volcanics; the basal lava/soft-sediment contact is also well exposed.

Introduction

The site covers the disused, elongate northern quarry of the pair located in School Wood, about 300 m south-west of Webberton Cross, near Dunchideock.

The late Carboniferous–early Permian post-orogenic volcanics of the Exeter Volcanic 'Series' comprise both basalts and a mixed bag of potassic lavas that includes lamprophyres (Tidmarsh, 1932; Knill, 1969, 1982). The site is representative of the basaltic group which was considered by Ussher (1902) to occur at the base of the Permian and to be the earliest expression of post-orogenic volcanism in the area. A K/Ar whole-rock date for the basalt from Webberton Quarry gave an age of 291 Ma (recalculated from 281 Ma quoted by Miller and Mohr, 1964), that is, late Stephanian relative to the Carboniferous–Permian boundary at 286 Ma.

The petrography of the basalt and others in the Exeter area has been described by Knill (1969). Chemical data on this basalt and other members of the suite have illustrated the highly incompatible-element-enriched nature of these rocks (Cosgrove, 1972; Thorpe *et al.,* 1986; Leat *et al.,* 1987; Thorpe, 1987). As a group, the basalts form a single, cogenetie, mildly alkaline series related by minor mafic and plagioclase fractionation (Floyd, 1983; Leat *et al.,* 1987). They (including the Webberton Cross basalt) are also characterized by small, variable Nb and Ta negative anomalies on chondrite-normalized multi-element diagrams, that are often a feature of subduction-related magmas. This chemical signature was interpreted as implying that the basalts might have come from a mantle source modified by subduction-related processes (Leat *et al.,* 1987), although similar features can be produced by crustal contamination by local sediments, as suggested by Grimmer and Floyd (1986).

Description

Although the quarry walls are somewhat overgrown and mainly composed of basalt, towards the existing quarry floor can be seen the highly vesicular base of a flow resting on an intimate admixture of lava and baked sediment (Figure 6.6). The sandy sediment originally represented the surface over which the lava flowed and which became incorporated into the base of the flow. Lithological change towards the base of the lava flow is gradational, with an increase in the size, proportion and irregularity of the vesicles in the slightly flow-banded lava, together with the incoming of hematitic sandstone and siltstone fragments in greater and greater abundance. Neither the lava nor the sediments are sharp-angled blocks in this zone; they exhibit very irregular, penetrating junctions and intimately mixed relationships. This feature suggests that the lava flowed over and penetrated wet, partly consolidated sediments that were baked, and which, in turn, rapidly chilled the hot lava. Further evidence for the reaction between lava and sediment is probably provided by the neptunean dykes mentioned by Knill (1969). Although sediments overlie the basalts (eastern half of the quarry), it seems more likely that the sediment fill of these structures was extruded up from the base, rather than infilling erosional gullies in the lava flow from the top.

Most of the quarry face (15–20 m high) is apparently composed of a single lava flow, as neither interflow breccias nor reddened horizons are visible. The lava is an olivine–plagioclase-phyric alkali basalt with a matrix of granular plagioclase, calcic augite, abundant Ti–Fe oxides and minor alkali feldspar. It is often highly altered with abundant secondary serpentine, hematite, carbonate, zeolites, analcite and clays. Olivine is always replaced by serpentine and Fe-oxides.

The plagioclase phenocrysts are zoned labradorites with more sodic rims; they exhibit an unusual lacy texture of vermicular Fe-oxide inclusions (Knill, 1969). The lava is variably vesicular (Figure 6.7), although away from the basal contact, the vesicles are generally small and round. They are often mulled with zeolites or white clay. The secondary assemblages are typical of very low-grade, hydrothermal oxidative alteration, which is often characteristic of ancient subaerial flows.

Interpretation

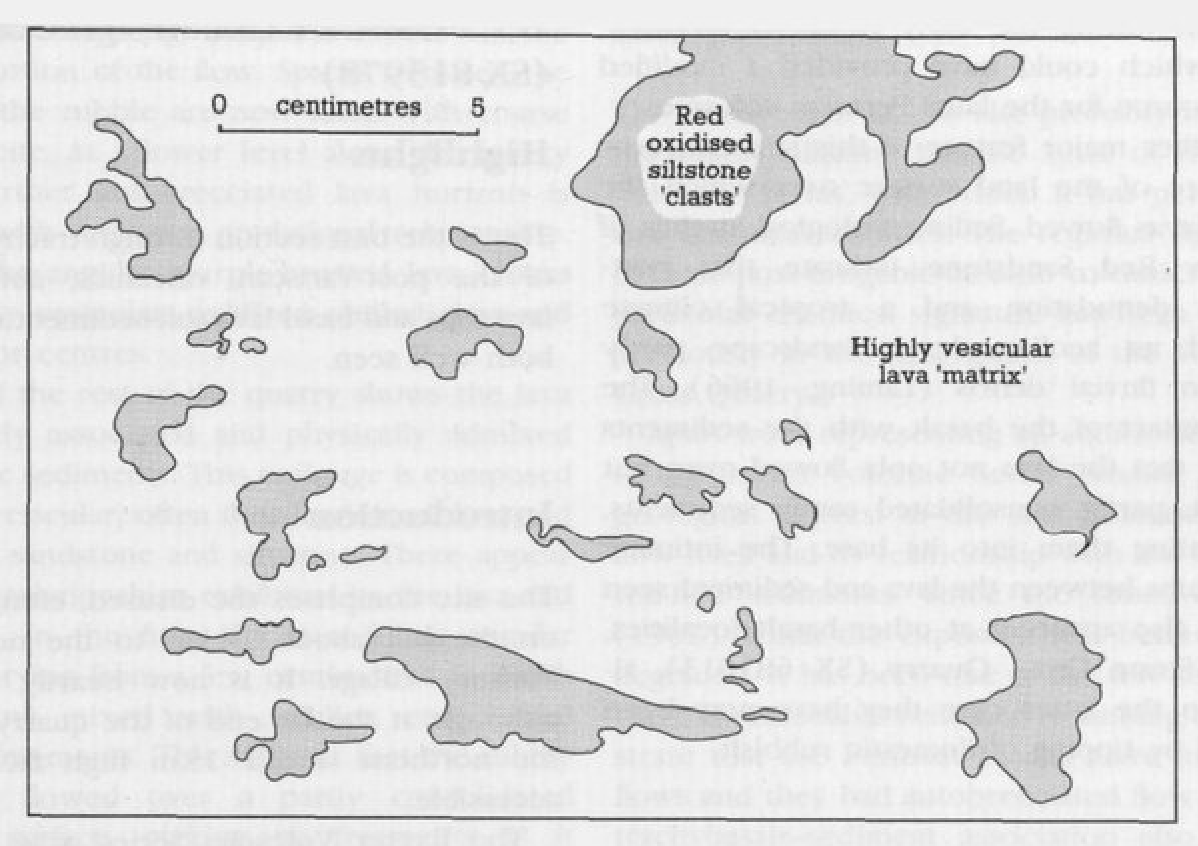
The mildly alkaline lava of this site is representative of the basaltic suite of post-orogenic, graben-related volcanics that form part of the Exeter Volcanic 'Series' of Stephanian–Permian age. According to Whittaker (1975), they are confined to the Crediton Trough and environs, which is interpreted as a small graben. In the global context of Permian rift-related magmas, they are insignificant and very small-volume extrusives (Grimmer and Floyd, 1986). However, in southwest England they are temporally associated with a potassic suite of rocks (dominated by lamprophyres) and are seen to share some of their chemical characteristics. In particular, all the Exeter Volcanic 'Series' rocks are incompatible-element-rich and have chemical features generally considered to be indicative of magmas generated in subduction zones (Grimmer and Floyd, 1986; Thorpe *et al.,* 1986; Leat *et al.,* 1987), although the chemical signature is less marked in the basalts. Previously, Cosgrove (1972) had considered that the whole suite belonged to the highly alkaline shoshonite series and that they were generated at a continental-plate margin. On the basis of their chemistry, Leat *et al.* (1987) concluded that the basalts were derived from an asthenospheric mantle source possibly modified by processes related to subduction, e.g. LIL-element enrichment, although Grimmer and Floyd (1986) stressed that a similar chemical feature could be generated by sediment contamination. Trace-element geochemistry cannot give a definitive answer in this respect, although geological inference concerning the tectonic environment suggests that there may well have been a subduction zone somewhere to the south during the early Devonian (Leeder, 1982), which could have provided a modified mantle source for the later Permian volcanics.

The other major feature of this site concerns the nature of the land surface over which the basaltic lavas flowed. Sedimentological studies of the New Red Sandstone indicate that post-orogenic denudation and a tropical climate produced an aeolian desert landscape partly buried in fluvial debris (Laming, 1966). The lower contact of the basalt with the sediments indicates that the lava not only flowed over, but into, wet, partly consolidated sandy sediments, incorporating them into its base. The intimate relationships between the lava and sediment seen here are also apparent at other basalt localities, such as Stone Cross Quarry [SS 681 013], although in the latter case they have now been obscured by tipping of domestic rubbish.

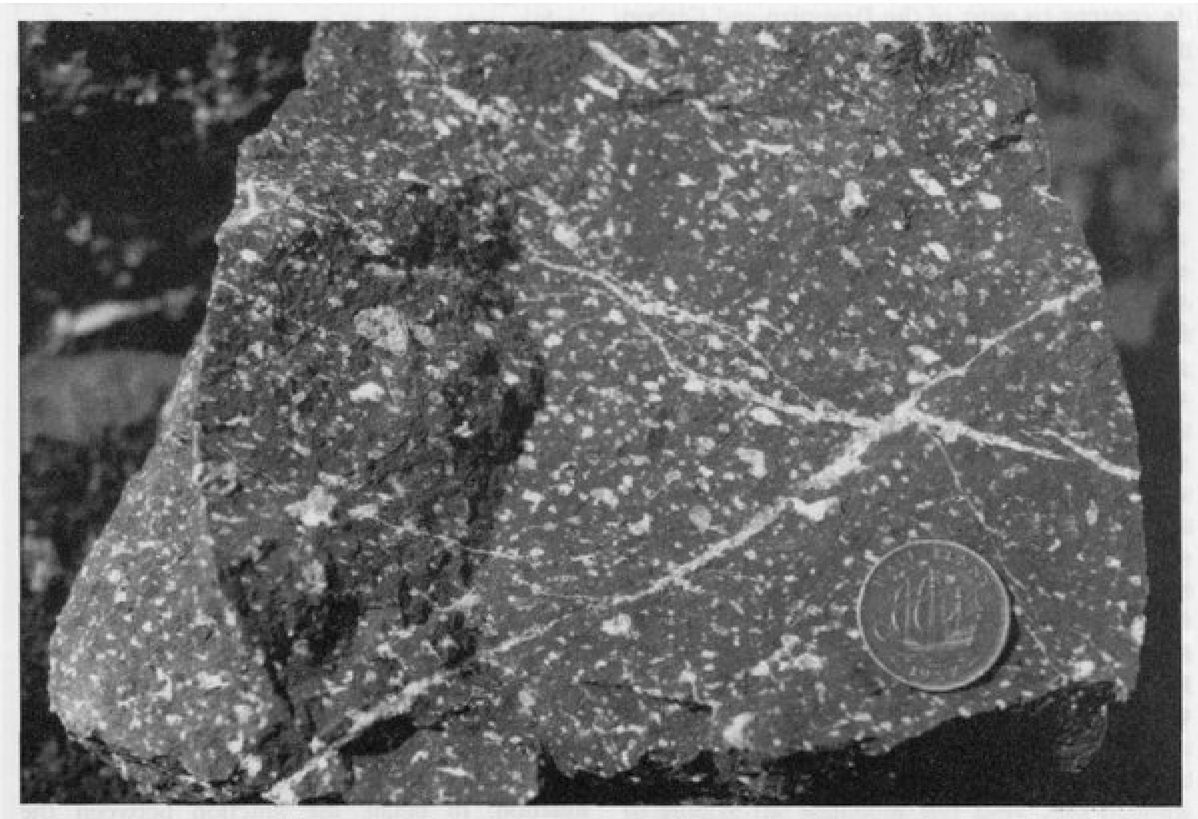
Conclusions

Basaltic lavas in this area erupted near the junction of the Carboniferous and Permian periods. In contrast to most of the Devonian and Carboniferous lavas described in this volume, this was not in a marine setting, but eruption occurred over an arid, rocky desert landscape under a tropical climate. At this site, however, the lavas traversed still-wet, riverine sands, fragments of which were incorporated into the base of the lava as it flowed across the irregularities of the land surface. Faint banding within the lavas indicates the direction of liquid flow. Such lavas are a feature of the Exeter–Crediton area which was probably a downfaulted trough at the time, with magma seeping up along marginal fractures. They are associated with another group of basic lavas with characteristic high potassium levels, which are known as lamprophyres. The particular chemistry of these two lava groups has been used as evidence of their initial formation from a mantle source associated at some time with a subduction zone such as found under modern oceanic island arcs. This site presents key evidence for the last phase of volcanicity that affected onshore southern Britain.

References



(Figure 6.6) Sketch of the lava—sediment relationship at the base of a late Stephanian basalt lava flow of the Exeter Volcanic 'Series', Webberton Cross Quarry, near Exeter.



(Figure 6.7) Highly amygdaloidal (vesicles infilled with white zeolites and/or clays) and oxidized subaerial basalt lava flow. Webberton Cross Quarry, Devon. (Photo: P.A. Floyd.)