B16 Greystone Quarry

[SX 364 807]

Highlights

Early Carboniferous, high-level dolerites were here intruded into unconsolidated, fossiliferous sediments penecontemporaneously with early deformation. The presence of a series of thrust units, including exposure of the tectonically important Greystone thrust, is also regionally important.

Introduction

The site includes the working quarry cut into the valley side and situated on the west bank of the River Tamar.

Recent structural interpretations of central south-west England, between Bodmin Moor and Dartmoor, have demonstrated the importance of 'thin-skinned' thrust–nappe tectonics involving late Devonian and early Carboniferous rocks (Isaac *et al.,* 1982). Within the quarry site a number of thrust surfaces have been identified (Turner, 1982), of which the tectonically highest and youngest is the regionally significant Greystone Thrust. This thrust carries late Devonian green slates over an early Carboniferous allochthonous sequence of basinal cherts and argillites within the Greystone Nappe (Isaac *et al.,* 1982). The early Carboniferous succession is also characterized by thick doleritic intrusions and spatially associated basic lavas. Faunal dating of the enclosing sediments (Stewart, 1981) indicates a period of volcanism that lasted from latest Tournaisian to mid-Viséan times (Chandler and Isaac, 1982).

Description

The quarry site is largely composed of a number of doleritic intrusions and early Carboniferous basinal argillites and cherts. At the highest level (varying from about 50 m to 100 m OD) is the undulating Greystone Thrust surface, on top of which the late Devonian green slates are exposed around the western side of the quarry. A geological map and cross-sections of the quarry (Turner, 1982) are shown in (Figure 4.40), and these illustrate a number of sub-Greystone thrusts (T2–T5) with highly undulating surfaces within dolerites and along chert horizons. The generally competent nature of the dolerites produced thrust ramping, both parallel and perpendicular to the direction of movement (Turner, 1982).

Although some of the massive dolerites appear to have an intrusive sill-like relationship with the sediments, the development of pillowy tops implies intrusion at a high-level into wet sediments. Also, detailed examination of contact relationships and enclosed sedimentary xenoliths shows that the intrusives cut deformed, early compaction and burial fabrics in the sediments. This implies that although the sediments were wet and only partly consolidated, the volcanics were intruded contemporaneously with the start of gravity-induced deformation (Isaac *et al.,* 1982; Chandler and Isaac, 1982).

The dominant intrusives are mildly altered, subophitic-textured metadolerites with variable secondary assemblages of chlorite, white mica, albite and carbonate. The larger sills, however, have suffered most alteration in the marginal zone in contact with the sediments and can be extensively carbonated. Material derived from cores in the volcanics show greater variability with vesicular (infilled with chlorite and calcite) and plagioclase-phyric (now albitized or replaced by carbonate or rarely epidote) flows and minor intrusives with flow banding. The ubiquitous and typically low-grade assemblages and apparent lack of actinolite is possibly indicative of the pumpellyite facies of regional metamorphism (pumpellyite was tentatively identified by Chandler and Isaac (1982) from the Launceston area to the north); this is supported by the clay mineralogy (illite–chlorite) of the local sediments (Grainger and Witte, 1981).

Interpretation

The environmental importance of the intrusions (as seen in the site) lies in their association with the lavas, both of which are said to have stable-element compositions akin to ocean-floor basalts (Chandler and Isaac, 1982). The particular chemical signature for the volcanics and the facies relations of the associated sediments have been interpreted as representing the development of a small, rifted basin, that is, one floored by basaltic ocean crust and with restricted pelagic sedimentation, but generated near to a neritic carbonate platform (Chandler and Isaac, 1982). This model was considered to be speculative by Selwood and Thomas (1986b), both in terms of facies interpretation and the significance of the volcanics which they consider were developed at the basin- slope margin. Limited chemical data on dolerites collected from the Greystone Quarry showed them to have a alkali-basalt lineage (rather than MOR-like tholeiites) and to be representative of an intraplate tectonic environment, in common with other intrusives in north Cornwall and Devon (Floyd, 1983).

The significance of this site lies in the close relationship between structural features (for example, the recognition of the Greystone Thrust), and emplacement of doleritic intrusives. Intimate contact features with the sediments not only illustrate the high-level emplacement of these volcanics into wet sediments, but that they were intruded during the commencement of deformation. Also, faunal dating of the sediments in the area has tied down the phase of magmatism to a 19-million-year period during the early Carboniferous; bracketing of magmatic events to such narrow limits is not readily achieved for other Variscan volcanic centres.

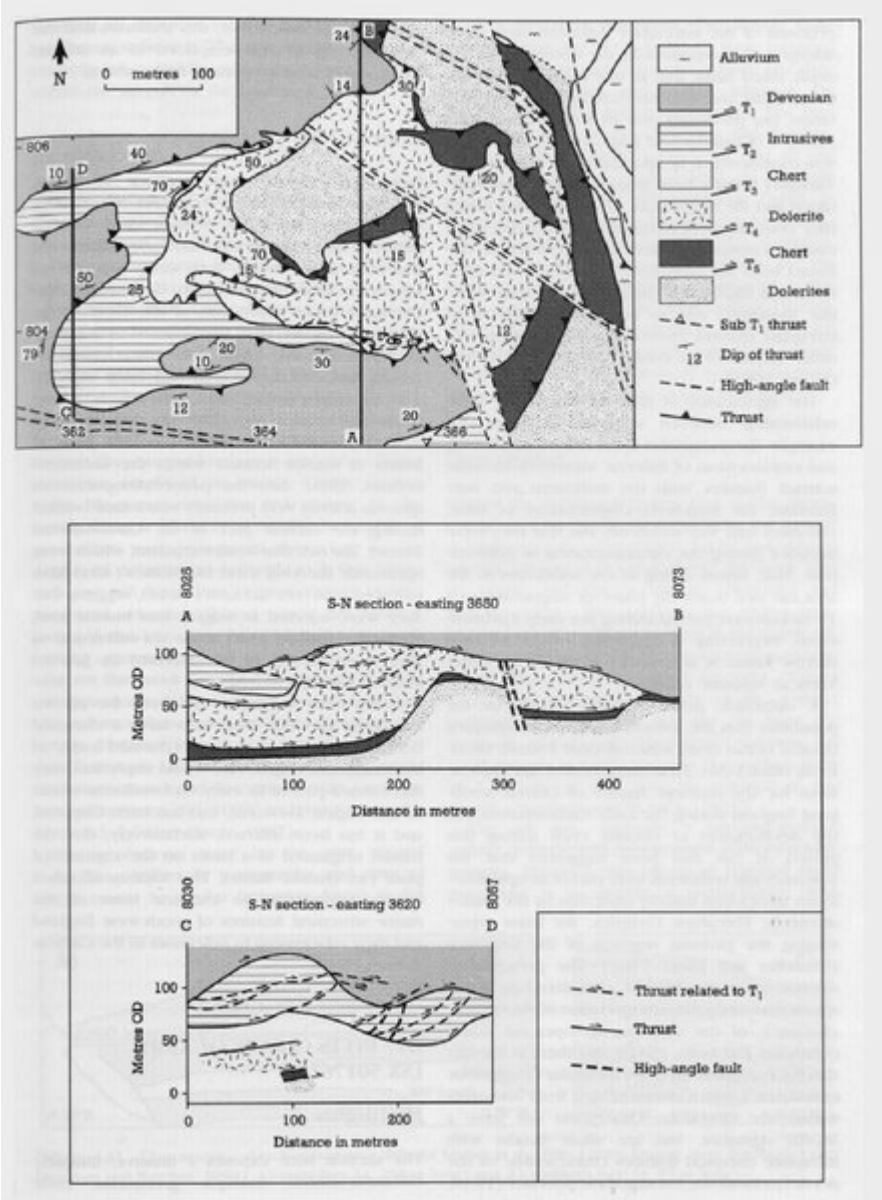
A debatable point, however, concerns the possibility that the intrusives and lavas represent basaltic ocean crust which floored a small, short-lived, rifted basin. This interpretation has implications for the tectonic regime of central southwest England during the early Carboniferous and the development of oceanic crust during this period. It has also been suggested that the volcanics and sediments were part of an ophiolite–flysch association initially underlain by the mafic–ultramafic Polyphant Complex, the latter representing the plutonic segment of the sequence (Chandler and Isaac, 1982). The presence of oceanic crust can only be considered as highly speculative since this interpretation of the variable chemistry of the volcanics is open to doubt (Chandler and Isaac, 1982); also there is the fact that the Polyphant rocks are dissimilar to ophiolitic cumulates. Limited chemical data from intrusives within the Greystone Quarry do not have a MORB signature, but are alkali basalts with intraplate chemical features characteristic of the north Cornwall–Devon magmatic province (Floyd, 1984). In tectonic terms, this indicates that the magmatic rocks were emplaced in an ensialic basin, rather than an oceanic-basin setting.

Conclusions

Here are exposed short sections of major, low-angle, fault-bounded structures which have brought together a pile of rock slices of very different age. Such thrusts may have transported the rock slices which they carry for tens of kilometres from the south. At Greystone, older Devonian rocks above one of the thrusts (the Greystone Thrust) have been carried over younger, Carboniferous rocks. The latter contained basalts and dolerites which had been injected into the clayey marine sediments, which in time lithified to become rock. They are dated as being around 350 million years old, on the basis of fossils of marine animals which the sediments contain. These date the penecontemporaneous igneous activity very precisely into a time bracket during the earliest part of the Carboniferous Period. The fact that some intrusions, which were apparently flat-lying sheet-like bodies (sills) have pillowed tops (see Gurnard's Head), suggests that they were injected as magma into marine sediments that still retained some sea-water, just as they were starting to be deformed by gravity-induced (slump) movements.

It has been suggested that both the sill-like intrusions and the lavas here have a chemical composition similar to basalts formed today at the mid-ocean ridges. This would imply that they had formed part of an early Carboniferous ocean in this region. However, this has been disputed, and it has been inferred, alternatively, that the basalts originated in a basin on the continental plate (an ensialic basin). This locality affords a unique opportunity to examine some of the major structural features of south-west England and their relationship to volcanism in the Carboniferous Period.

References



(Figure 4.40) Map and cross-sections of Greystone Quarry, showing the development of undulating thrust surfaces cutting dolerite and the transportation of Upper Devonian sediments over Lower Carboniferous volcanics by the major Greystone Thrust (after Turner, 1982).