Traeth Penbryn

[SN 2875 5210]–[SN 2909 5232]

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Highlights

The site contains the best-known examples of veins and hydraulic fracture breccias produced by brittle deformation, caused by high fluid pressures before, or during, the earliest stages of regional Caledonian tectonism.

Introduction

This site, a sea-cliff section, comprises folded and cleaved Upper Ordovician sedimentary rocks of the Tresaith Formation (Craig, 1985). These are cut by a series of veins and hydraulic fracture breccias which have been described, discussed and illustrated by Craig (1985) and Fitches *et al.* (1986). These structures are considered to belong to a family of early brittle structures, other members of which are represented at the Allt Wen, Cormorant Rock, and Llangollen sites.

Description

Craig (1985) and Fitches *et al.* (1986) have shown that the brittle structures affecting the rocks here preceded the folds and cleavage; they attributed them to dewatering processes before, or during, the onset of regional deformation.

The country rocks of the Tresaith Formation (Ashgill Series) are thinly bedded, fine sandstones, siltstones, and mudstones. The structure of the section is mostly uncomplicated bedding (065/20°SE) and cleavage (075/35°SE) maintaining nearly uniform orientations except for local interruptions by small folds, to which cleavage is axial planar.

The veins fall into two main categories:

1. hydraulic vein breccias, and
2. simple and *en échelon* veins:

1. Hydraulic vein breccias

The largest vein breccia (Fitches *et al.,* 1986, Figure 4B) is more than 10 m in length, 0.20 m in thickness, and is oriented about 030/70°SE. The vein minerals are predominantly quartz, with a little carbonate and traces of pyrite. The breccia fragments are angular pieces of local country rock, many of which are totally suspended in the vein minerals, whereas others remain partly attached to the vein walls and have been only slightly rotated and detached from the country rock. Craig (1985) and Fitches *et al.* (1986) showed that vein breccias were formed after the country rocks had undergone extensive diagenesis, but before the development of the regional cleavage.

2. Simple and *en échelon* veins

Veins composed chiefly of quartz, with minor carbonate and pyrite, are common in this section, typically about 0.05 m thick, steeply dipping and aligned mostly NNE, but varying widely in orientation. Most veins occur singly, but locally, notably near the large vein breccia, several veins are disposed *en échelon* in tension gash arrays.

Some of these veins cut the vein breccia. In places, they are deformed by small open to tight folds, with wavelengths of a few centimetres or tens of centimetres, to which the cleavage has an axial-planar or fanning relationship.

Interpretation

Microfabric evidence, obtained from breccia clasts in the vein breccias shows that the growth of phyllosilicates in the bedding compaction fabric (Craig *et al.,* 1982) preceded the formation of a pressure solution fabric, which is itself misaligned due to variable amounts of rotation of the host fragments. This evidence indicates that breccia formation followed diagenesis. That brecciation preceded the cleavage is shown in two ways. Firstly, the breccia is cut by later veins which were themselves folded and cleaved by the regional deformation. Secondly, under the microscope, an earlier grain alignment fabric in the breccia fragments is crenulated on planes which are parallel with the cleavage in the country rocks.

The simple and *en échelon* veins also preceded the development of cleavage because they are deformed by folds to which the cleavage is axial planar. Craig (1985), by measuring the lengths of veins around folds, calculated that the former have been shortened in the cleavage by about 30%.

The brecciation and deposition of the minerals hosting the fragments are attributed, by Craig (1985) and Fitches *et al.* (1986), to hydraulic fracture processes similar to those advocated by Phillips (1972) to explain the post-tectonic veins of Mid-Wales.

Craig (1985) and Fitches *et al.* (1986) considered that the vein breccias and other veins were caused by high fluid pressures which developed during burial, but after lithification, of the (Upper Ordovician) sediment pile. The vein breccias were interpreted as a manifestation of extension of the sediment sheet caused by gliding down a slope under gravity, and the *en échelon* veins were taken to represent the flank of a sheet subjected to strike-slip displacements. The various veins belong to a family of early structures, of which other members, mostly the structures of the toes and central parts of glide sheets, are represented elsewhere.

Conclusions

The Traeth Penbryn site contains various types of veins (vein breccias, simple and *en échelon* northeasterly striking veins), which have been shown to have preceded the folds and cleavage produced during the main phase of the Caledonian Orogeny. These veins are regarded as indicators of pre-tectonic or early tectonic deformation processes which are very rarely represented in Lower Palaeozoic strata. The vein breccias (veins containing angular rock fragments set in a matrix of the mineral quartz) are perhaps unique in the Welsh Basin context. They are thought to have been produced by the action of fluids under high pressure acting on fractures brought about by stretching, and perhaps sliding on a large scale, of the Ordovician sediment pile. Subsequently the whole area was affected by the Caledonian earth movements during Silurian to Devonian times; the simple veins (which are later than the vein breccias because they cut them) were cleaved and folded. The site provides the best exposures in Wales of veins and other structures which can be proved to pre-date the Caledonian mountain-building episode.

References