B14 Tintagel Head–Bossiney Haven

[SX 047 892]–[SX 066 895]

Highlights

This is the type locality for the Tintagel Volcanic Formation, a late sequence of alkali basalt, basinal volcanics of early Carboniferous age. It is also important because the metamorphic grade is higher than elsewhere in this region.

Introduction

This scenic coastal section of north Cornwall extends from The Island at Tintagel Head via the headlands of Barras Nose and Willapark to the deep, narrow inlet of Bossiney Haven. It is historically famous for the folklore of King Arthur that is attached to ancient Tintagel Castle and its prehistoric earthworks.

The site includes examples of the early Carboniferous Tintagel Volcanic Formation that occur within the Tredorn Nappe ((Figure 4.35); Selwood and Thomas, 1986a) and whose volcanic equivalents can be traced southwards to Trebarwith Strand and inland to Lewannick, north-east of Bodmin Moor (Selwood, 1961, 1971; Stewart, 1981). Exposures typical of the Tintagel Volcanic Formation just inland and along the north Cornish coast show a series of variably foliated metabasic lavas and volcaniclastics (Dearman *et al.,* 1970; Freshney *et al.,* 1972) whose original nature is often difficult to determine (Figure 4.36). The local Tredorn Nappe stratigraphy (Stewart, 1981) comprises a Dinantian sequence with the Tintagel Volcanic Formation sandwiched between a lower Barras Nose Formation and an upper Trambley Cove Formation, all of which are overlain by Upper Devonian slates transported into place on the Willapark Thrust. The main part of the Tintagel Volcanic Formation forms a north–south band running inland from Tintagel to Treknow and cropping out on the coast at Trebarwith Strand (Figure 4.37). This forms a single structural unit, whereas due to further thrusting and normal faulting, it is repeated on the coast around Tintagel Head to form a separate overriding slice (Freshney *et al.,* 1972).

Recent work on the Tintagel Volcanic Formation and associated metasediments has been concerned with the grade of metamorphism and their geochemical composition and petrogenesis. Early work described the occurrence and preponderance of low-grade phyllosilicates in both pelites and volcanics, as well as chloritoid-bearing phyllites and Mn-garnet-bearing slates (Tilley, 1925; Phillips, 1928). Freshney *et al.* (1972) recognized the low-grade and polyphase nature of the metamorphism and, in particular, considered late biotite porphyroblasts within the Tintagel Volcanic Formation to be the effect of superimposed contact metamorphism. Mn-rich garnets have been found in the low-grade Delabole Slates, in graphitic slates associated with the Tintagel Volcanic Formation and in zoned phosphatic nodules within the Transition Group of the local area (Phillips, 1928; Primmer, 1982; Andrews and Power, 1984). Illite crystallinity studies and pelite mineral paragenesis indicate that the Trebarwith Strand to Boscastle area is characterized by the greenschist facies relative to the lower-grade regional metamorphism ('anchizone') to the north and south (Brazier *et al.,* 1979; Primmer, 1983a, 1983b).

Description

Within the coastal site are located two tectonic slices containing various metavolcanic rocks of the Tintagel Volcanic Formation – the area around The Island, Tintagel Head and Barras Nose form a thin, upper, thrust-bounded slice capped with late Devonian slates, whereas Smith's Cliff and Gullastem to Bossiney Haven are part of the main, but lower, thrust segment of the meta-volcanics exposed inland and at Trebarwith Strand (Figure 4.37).

The Island at Tintagel Head shows a thin horizon of the Tintagel Volcanic Formation sandwiched between dark, late Devonian slates, with the metavolcanics dipping gently to the north-west and forming the base of the headland to seaward (Figure 4.38). The low-lying neck of land joining The Island to the mainland is a low-angle fault zone which

continues north-eastwards across Barras Nose headland. The metavolcanics within this area are heavily sheared vesicular lavas and various cleaved volcaniclastics (tuffs and possibly agglomerates). On the west side of Barras Nose the volcanics are boudinaged with resistant vesicular lava phacoids set in a foliated, calcareous greenschist matrix; they have a gradational contact with the underlying Barras Nose Formation slates. A NNW lineation is common here and lava fragments are also aligned in the same direction (Freshney and McKeown, *in* Dearman *et al.,* 1970). Magnetite octahedra may be found concentrated into lenses and thin bands within highly carbonated pale grey-green meta-volcanics, showing the extreme degradation of the original volcanics.

Farther along the coast at the cliffs of Gullastem, about 100 m of typical metavolcanic greenschists are seen, 'interbedded' with harder, sometimes boundinaged and contorted, crystal tuffs and lavas or possibly thin intrusive horizons. The typical assemblage consists of albite, chlorite, epidote, carbonate and sometimes actinolite. The greenschists may enclose lenses of vesicular lava which could represent sheared pillow lavas with the cores now forming the resistant lenses and the rims, the foliated matrix. On the rocky beach below the cliffs, are many blocks of massive and variably sheared gabbro traversed by greenschist zones. Although these blocks have been derived from an unknown locality, a sheet-like intrusive mass forms the crags near the cliff-top path at Smith's Cliff. This is often referred to as an epidiorite, but it resembles other Cornish metadolerites and metagabbros with low-grade secondary minerals replacing ophitically related primary pyroxene and plagioclase. To the south of Willapark (through Rocky Valley) to Bossiney Haven, the Tintagel Volcanic Formation is largely composed of volcaniclastics with various crystal–lithic tuffs and basalt-bearing agglomerates.

The highly foliated greenschist assemblages of the Tintagel Volcanic Formation also indicate greenschist facies (biotite zone) developed under high $P0_2$ equilibrium conditions (Robinson and Read, 1981; Primmer, 1982). The Tintagel Volcanic Formation exhibits two periods of mineral growth — syntectonic with the development of the dominant albite–epidote–chlorite assemblage which forms the main foliation, and post-tectonic with the static, random overgrowth of biotite and albite porphyroblasts. In this context, Robinson and Read (1981) considered the late biotite overgrowths to be regional in origin, rather than due to contact metamorphism as suggested by Freshney *et al.* (1972). Although the greenschists and less-foliated members of the Tintagel Volcanic Formation have long been recognized as a metavolcanic suite, geochemical data indicate that they were originally a single, differentiated, comagmatic association of alkali-basalt composition with intraplate chemical characteristics, not dissimilar to their Devonian analogues in the same general area (Robinson and Sexton, 1987; Rice-Birchall and Floyd, 1988).

Interpretation

Although situated within a highly tectonized zone of north Cornwall, the Tintagel Volcanic Formation is representative of the continuing volcanic pulses associated with the deepening of basins, this time during the early Carboniferous. Chemically, these rocks are not dissimilar (in terms of incompatible-element ratios and abundances) to their late Devonian analogues (Rice-Birchall and Floyd, 1988) and form part of the same alkaline north Cornwall–Devon magmatic province (this chapter, 'Lithology and chemical variation' section).

The volcanic products appear to be more varied at this level than in the late Devonian, with the apparent extensive development of volcaniclastics. This could indicate a more explosive mode of volcanism, near shallow submarine vents, relative to the 'quiet' effusion of deep submarine lava flows. However, many of the metavolcanics have been extensively foliated (to greenschists) and it is not always possible in the field to determine if the enclosed resistant lava phacoids were originally part of a pillow-lava sequence or the larger fragments within a series of volcaniclastics of variable grain size. There is good evidence to show that the enclosed lenses are mainly quenched and holocrystalline plagioclase-phyric basalt and that the bulk chemical composition of the greenschists is that of an alkali basalt (Rice-Birchall and Floyd, 1988). Relatively homogeneous agglomerates are mentioned by Freshney *et al.* (1972) within the Tintagel Volcanic Formation, although these have also suffered shearing, and could in some cases represent low-strain zones originally composed of pillow lavas or pillow breccias.

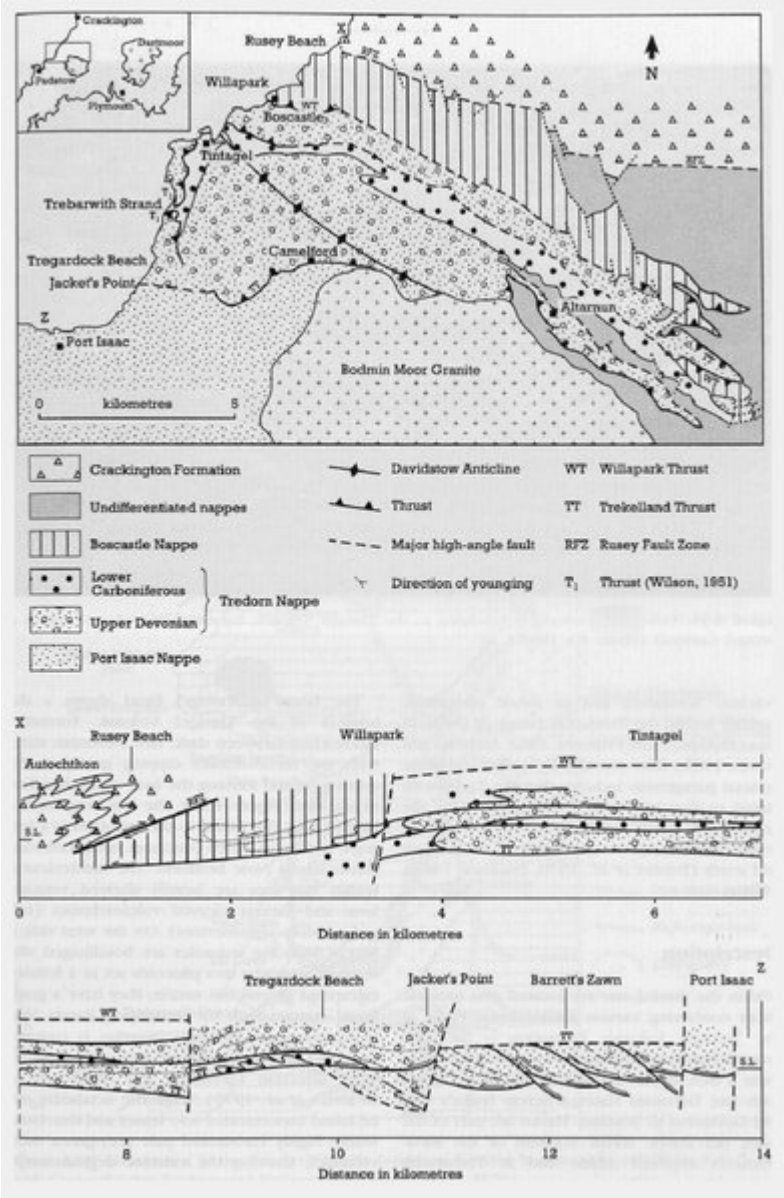
The other feature of this site is the nature and grade of metamorphism exhibited by the meta-volcanic greenschists. The textures and mineral assemblages support evidence derived from work done on the associated sediments of the region

and demonstrate that the Tintagel–Boscastle area is representative of biotite-zone greenschist facies of regional metamorphism. This is significant in a regional context, as the areas to the north and south are lower grade 'anchizone' which typifies much of north Cornwall. This is approximately equivalent to the pumpellyite facies exhibited by metadolerite intrusives near Padstow (Floyd and Rowbotham, 1982). Two phases of metamorphic mineral growth are recognized in the green-schists, although the late, static growth of biotite is now considered to be regional in origin (it is in equilibrium with earlier phases), rather than due to the effects of superimposed contact metamorphism by the Variscan granites.

Conclusions

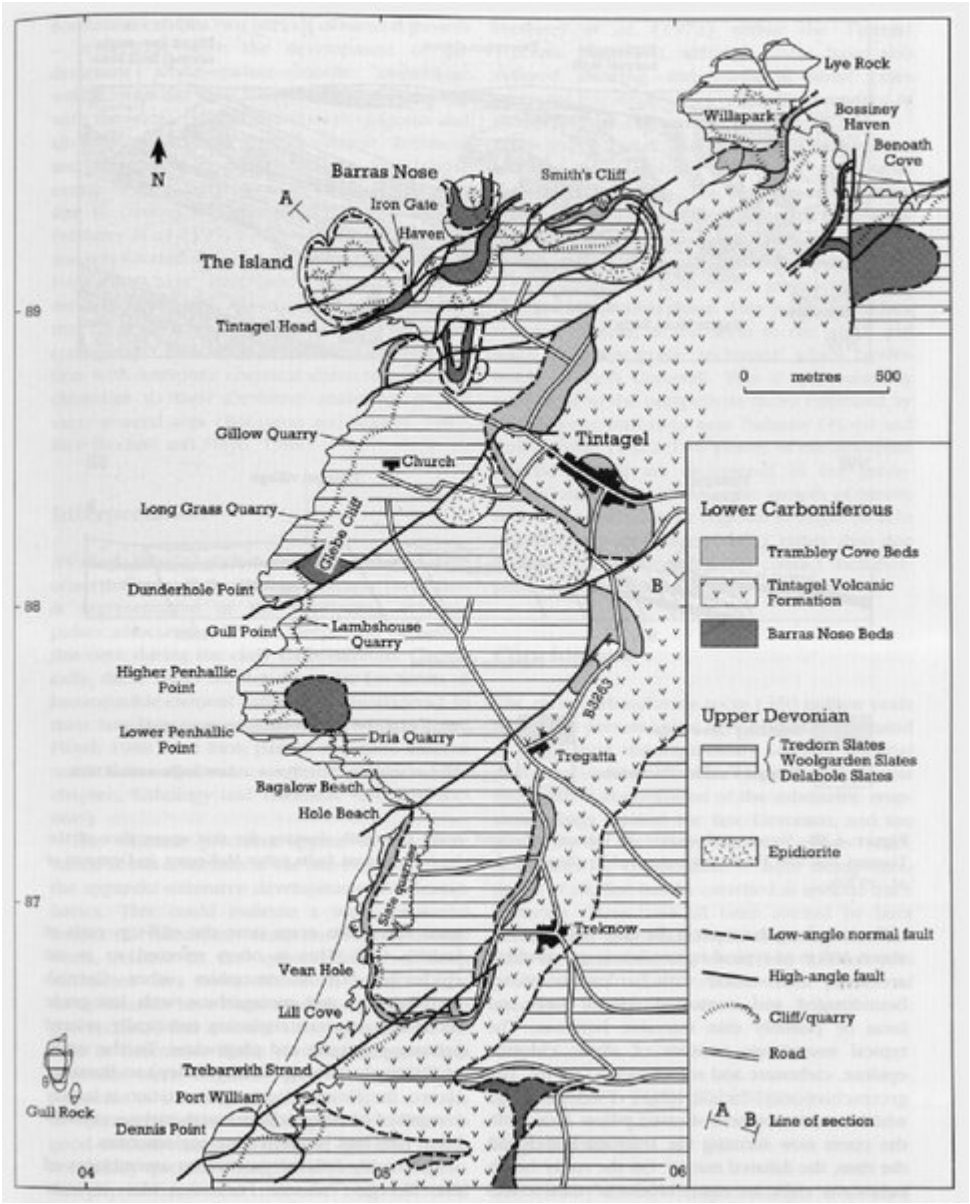
The early Carboniferous rocks (350 million years before the present) seen here originally consisted of basalt lavas and fragmentary volcanic material deposited under water. The volcanic episode was essentially a continuation of the submarine eruptions which typified the late Devonian, and the products of the two volcanic events share similarities of composition – both being composed of alkaline basalts enriched in specific trace elements. They have all been altered by later deformation and metamorphism during the Vari-scan mountain-building event and foliated into green schists which exhibit two phases of secondary mineral growth.

References

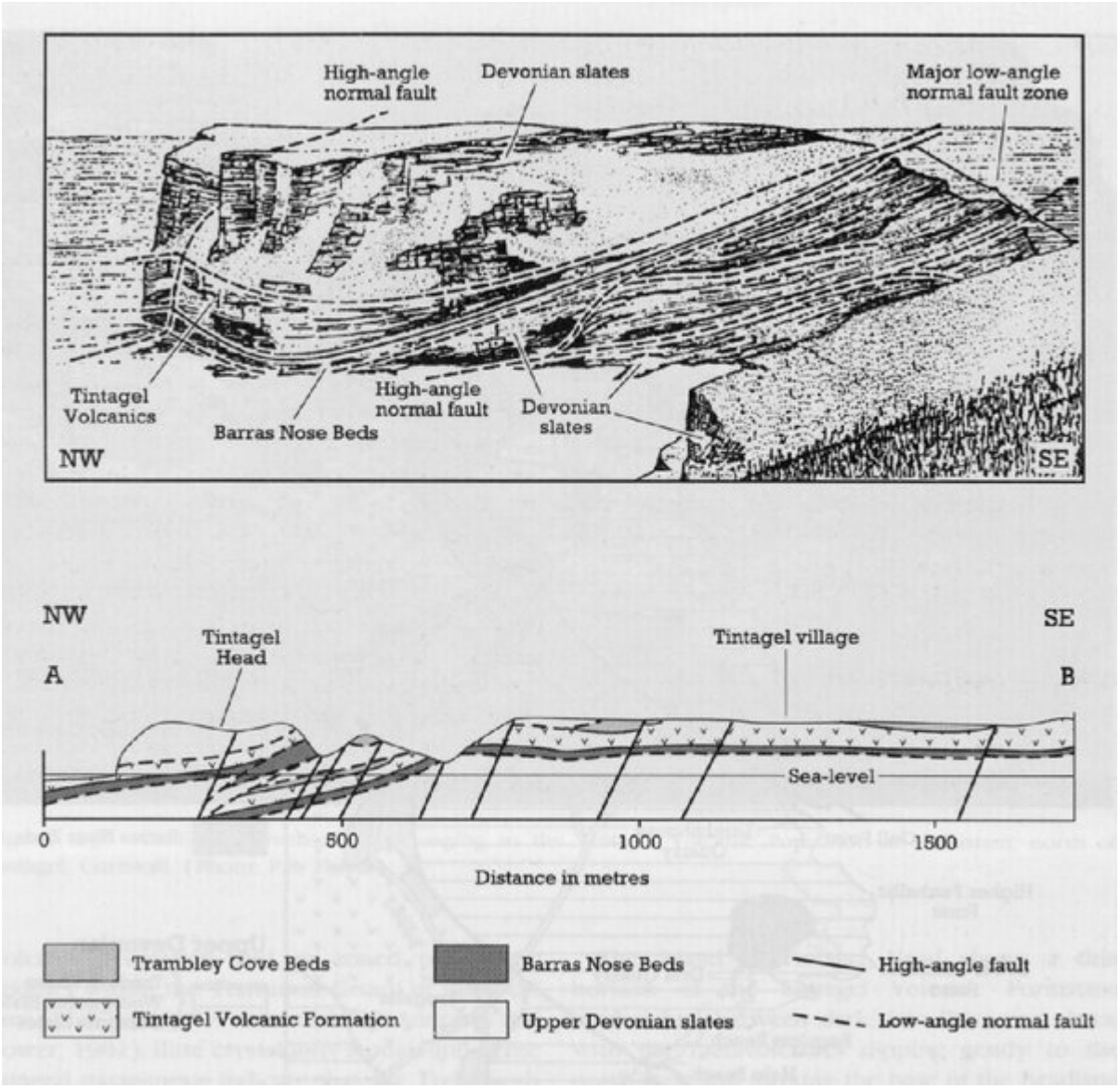


(Figure 4.35) (Opposite) Map and section of north Cornwall, showing the distribution and relationship of the major nappes (after Selwood and Thomas, 1986a). The Tintagel Volcanic Formation occurs in the Tredorn Nappe.

(Figure 4.36) Contorted greenschists belonging to the Tintagel Volcanic Formation at Gullastem, north of Tintagel, Cornwall. (Photo: P.A. Floyd.)



(Figure 4.37) Distribution of the Tintagel Volcanic Formation between Bossiney Bay and Trebarwith Strand, north Cornwall (after Freshney and McKeown, in Dearman et al., 1970).



(Figure 4.38) Sketch and section of Tintagel headland, north Cornwall, showing the thin upper slice of the Tintagel Volcanic Formation truncated by thrusts and cut by later normal faults (after McKeown. in Dearman et al., 1970).