Spring Cove, North Somerset

[ST 310 625]

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Introduction

The Spring Cove GCR site, a coastal section north of Weston-super-Mare, has been selected as a representative of Arundian (Dinantian) extrusive igneous rocks from southern England. Submarine pillow lavas display an intimate association with adjacent carbonate rocks and the section provides excellent exposures of the Dinantian succession from the top of the Gully Oolite, through the Caswell Bay Mudstone, to the Birnbeck Limestone, for which Spring Cove is the type locality (Figure 7.20).

The presence of igneous rocks in the Weston-super-Mare district has long been known, though uncertainty as to their intrusive or extrusive nature was not resolved until the descriptions of Geikie and Strahan (1899). Numerous publications provided descriptions of the lavas (Boulton, 1904; Strahan and Cantrill, 1912; Reynolds, 1917; Speedyman in Savage, 1977), culminating in the detailed lithological and petrographical descriptions in the Geological Survey memoir for the district (Whittaker and Green, 1983).

Sibly (1905) showed that the volcanic rocks of the Weston-super-Mare district occur at two distinct stratigraphical positions, estimated to be about 145 m apart (Whittaker and Green, 1983). The lower, Middle Hope Volcanic Beds, described in the Middle Hope GCR site report, have subsequently been shown to be Courceyan in age, and the higher volcanic rocks, which include the Spring Cove Lava, are Arundian (George *et al.,* 1976). Whittaker and Green (1983) have demonstrated that the Spring Cove Lava is approximately contemporaneous with lavas and tuffs from the Bristol district at Goblin Combe, Broadfield Down, Cadbury Camp and Tickenham, and that the volcanic activity occurred over a relatively wide area and included several small vents.

Description

The Spring Cove GCR site comprises a lava about 15 m thick with an exposed length along-strike of about 140 m (Figure 7.20). It occurs within the Birnbeck Limestone, which contains corals and brachiopods indicative of an early Arundian age (Whittaker and Green, 1983). The lava has a gently undulating contact with the underlying limestone and the strata dip at about 25° to the south.

The critical stratigraphical section at Spring Cove (see below) is derived from a composite section logged by G.W. Green (Geological Survey 1:10 560 map ST 36 SW, 1967) and reproduced by Whittaker and Green (1983).

	Thickness (m)
Birnbeck Limestone	
Limestone, reddish-fawn, dolomitized but with relict cross-bedding and corals; tuffaceous debris in lower 1.5 m, increasing towards the base	9.7
Spring Cove Lava	

Olivine basalt, typically fine grained, chocolate-brown, massive and highly amygdaloidal with imperfect pillow structures and red oolitic limestone fragments in all stages of alteration and assimilation, which in places appear to occupy spaces between pillows (Figure 7.21). In the centre of the exposure, cindery lava is mixed with broken limestone fragments. Calcite veins are common throughout. The base is irregular and channelled up to 1.2 m into the underlying limestone	*c.* 15.0
Birnbeck Limestone	
Limestone, red and grey, very massive, dolomitized, but with relict cross-bedding, ooliths, corals and crinoid debris	up to 12.0

Boulton (1904) described a progressive variation in the lava. To the north-east a 27 m section was described as a relatively uniform 'pillowy' basalt, brecciated and amygdaloidal with large masses of limestone. The pillows are best developed at the base of the lava, where they have a diameter of 1 m or more. To the south-west of this an 18 m-long exposure was described by Boulton as tuff or agglomerate with masses of highly slaggy basalt, 1.5–1.8 m long, and lumps of limestone, often very fractured, up to 3.7 m in length. Speedyman (in Savage, 1977) described one 'agglomeratic tuff' cutting obliquely across the lava. In this body, the larger blocks of limestone and rounded pillows of basalt are commonly closely spaced and are elongate parallel to the margins. The matrix comprises densely packed angular fragments of basalt and has a planar fabric that is deformed around the blocks. The 'agglomeratic tuff' is overlain locally by basaltic pillow lavas with rare irregular 'agglo-meratic' zones. The remaining approximately 100 m of section was described as hard, massive, purplish-brown, slightly amygdaloidal olivine basalt with pseudomorphs after olivine (Boulton, 1904; Speedyman in Savage, 1977). Pillows and rare blocks of limestone up to 0.3 m across occur in this basalt.

Petrographical details for the lava and adjacent sedimentary rocks were provided by Whittaker and Green (1983). The basalt contains olivine and possibly augite phenocrysts, up to 3 mm in length, showing slightly corroded euhedral outlines, though totally pseudomorphed by calcite and a clay mineral. The ground-mass comprises microlitic feldpars, forming laths rarely longer than 0.8 mm, which are highly altered and show a swirling flow alignment. The groundmass is deeply stained by ferric oxide. Morgan and Reynolds (1904) and Reynolds (1917) described a 'variolitic', or spherulitic glassy basalt, but Whittaker and Green (1983) described this as a finely mottled pale-red and dark-reddish-brown scoriaceous rock and were unable to identify any evidence of spherules (varioles). They did, however, describe ovoid vesicles filled with iron-stained calcite and vermicular clay aggregates.

Interpretation

The section is notable for the presence of reddened oolitic limestone for 12 m below the lava, which is not observed in this part of the succession elsewhere in the district. The limestone contains iron-stained, sub-angular to rounded pumice fragments, which are generally devitrified and replaced by a clay mineral or carbonate. Some pumice fragments and other clastic fragments display oolitic coatings. An unusual feature of the limestone is the presence of authigenic orthoclase, which has developed in micrite pellets and ooliths in the tuffaceous limestones. Ashy particles have also been noted up to 2.4 m above the lava (Morgan and Reynolds, 1904). These have been described by Whittaker and Green (1983) as comprising sub-rounded argillized fragments of fine-grained basalt in a matrix of sparry calcite.

Reynolds (1917) published two chemical analyses for the 'variolitic' basalts at Spring Cove, noting low Na_2O (0.72 and 1.10%) and very high K_2O (5.01 and 4.93%) contents. The internal structure of lenticular sheets of lava, tuff and agglomerate, sloping to the south, as described by Boulton (1904), was used by him to suggest the presence of a vent to the north.

The complex relationships between pillow lavas, tuffs and agglomerates suggest that the section shows more than one lava. The pillow structures, for which this site is of importance, are indicative of subaqueous eruption, and hence Reynolds (1917) interpreted the lavas as spilites, but he did note the low sodium and very high potassium contents,

which are atypical of spilites. In a review of Carboniferous basalts in the Bristol district, Dearnley (1960) observed that the more highly vesicular and altered the rock, the higher the total alkali content and the lower the Na:K ratio. He concluded that the petrographical and geochemical characteristics are indicative of late-stage autometasomatism by alkali-rich residual fluids rather than as a result of interaction of magma with seawater to produce spilites, as proposed by Reynolds, and this interpretation was accepted by Whittaker and Green (1983).

The irregular shape of limestone fragments present within the lava in various stages of alteration and assimilation (Figure 7.21) and the slightly undulating and cross-cutting relationship of the lava with underlying limestones, led Boulton (1904) and Whittaker and Green (1983) to suggest that the lava was extruded onto sediments that were not fully consolidated. The 'tuffs and agglomerates' were interpreted by Speedyman (in Savage, 1977) as an autobreccia, possibly formed as a result of a submarine slide of pillow lavas with included clasts of limestone. These deposits were subsequently over-ridden by further pillow lavas.

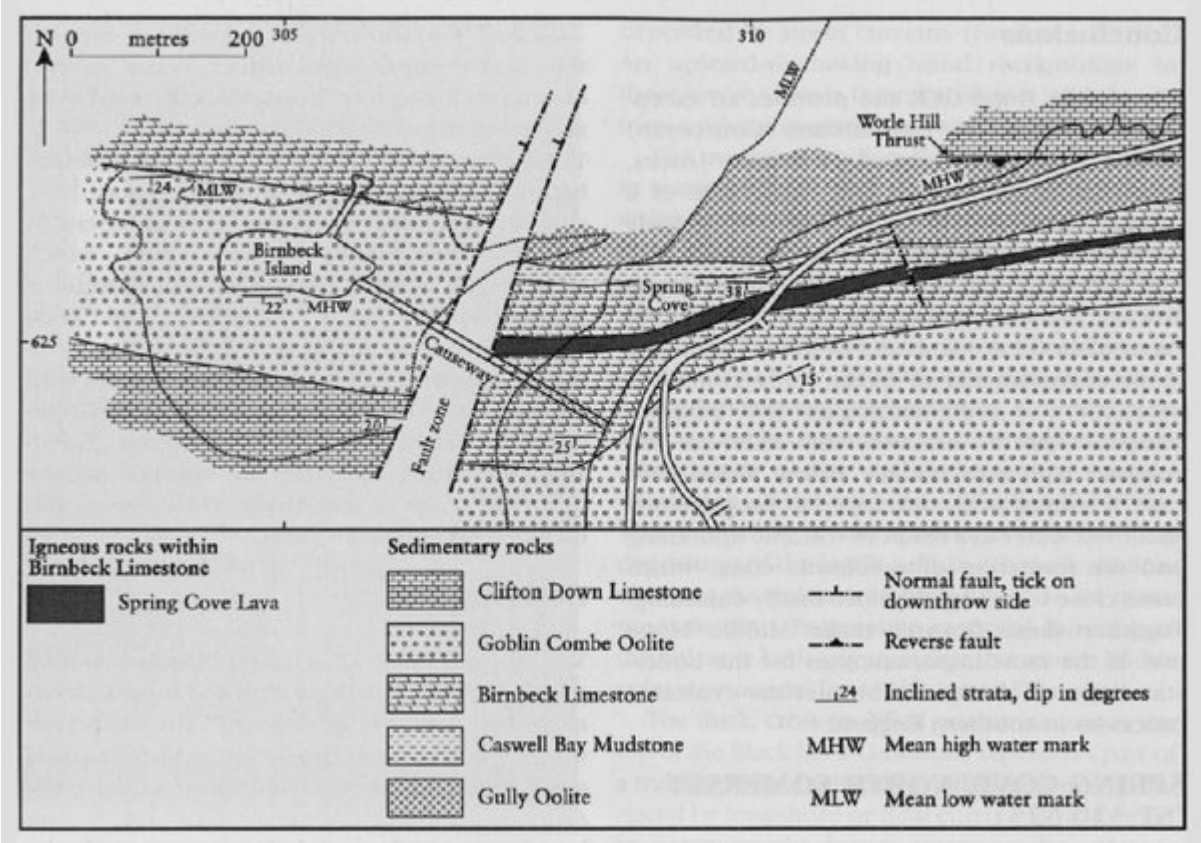
Red-stained limestones present above the lava contain highly altered basalt fragments, which are interpreted as the erosion products of the underlying lava. The limestones immediately beneath the lava ¯contain pumaceous material, which is interpreted not as primary ash-fall material but as the product of reworking and re-sedimentation. Oolitic coatings to some pumice fragments suggest that the pumice had undergone some marine transport and the growth of authigenic orthoclase before the final development of the oolitic coating suggests that high concentrations of potassium were present in the environment of limestone deposition (Whittaker and Green, 1983). The red iron staining of the limestone is generally considered to be due to the weathering of the tuffaceous material present (Geikie and Strahan, 1899; Whittaker and Green, 1983), though Morgan and Reynolds (1904), Boulton (1904) and Reynolds (1917) had disputed this interpretation. Both the iron and the potassium were probably derived from fragments of lava and volcanic glass as a product of leaching following re-sedimentation in an enclosed basin where concentrations of the leached material could occur (Whittaker and Green, 1983).

Conclusions

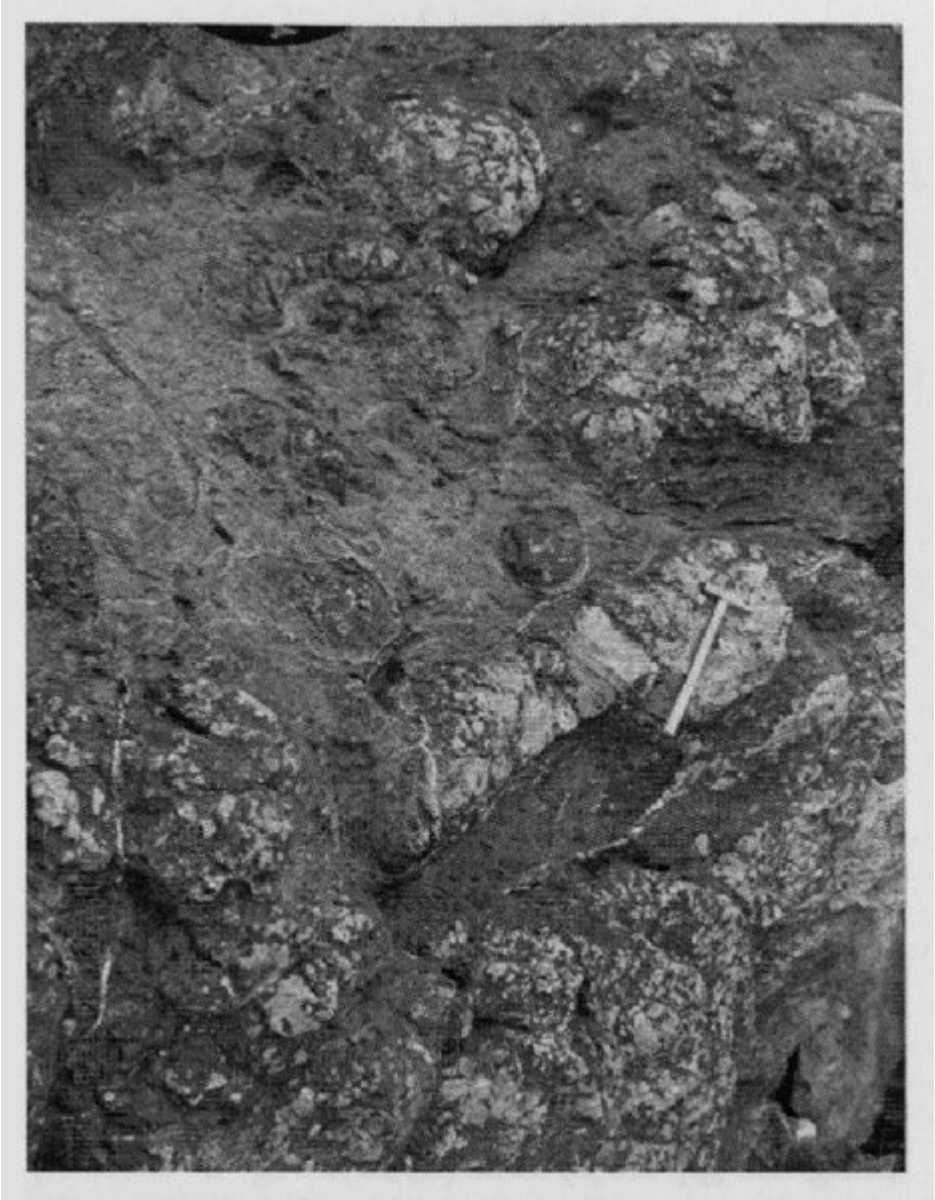
The Spring Cove GCR site represents Lower Carboniferous (Visean) volcanic rocks of southwest England, in a well-exposed and easily accessible section. It demonstrates fine examples of pillow lavas and brecciated lavas, formed when magma is erupted under water, in this case probably on the seabed.

The complex lava flow was extruded during a period of dominantly marine carbonate deposition. The lava was preceded by limestone containing reworked fragments of earlier pumice. The weathering of this volcanic material during and soon after deposition produced a distinctive red colouration to the limestone. This carbonate deposit was not fully consolidated when it became buried by the lava. As a result the lava has an undulating base and contains an abundance of irregularly shaped limestone blocks. The subsequent return to carbonate deposition is marked by the presence of further limestones above the lava. These limestones are also reddened due to the presence of fragments of basalt eroded from the underlying lava flow.

References



(Figure 7.20) Map of the Spring Cove GCR Site. After Whittaker and Green (1983).



(Figure 7.21) Basaltic pillow lava at the Spring Cove GCR site with clasts of altered limestone and numerous calcite veins [ST 309 625]. The hammer shaft is about 35 cm long. (Photo: British Geological Survey, No. A11792, reproduced with the permission of the Director, British Geological Survey, © NERC.)