Scurdie Ness to Usan Harbour

[NO 734 567]–[NO 726 545]

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Introduction

The outcrops on the east coast of Angus, south of Montrose are the best exposures of the lower part of the Montrose Volcanic Formation, which comprises an older sequence of basaltic andesites (the 'Ferryden lavas') and younger basalts (the 'Usan lavas'). This formation is intercalated with clastic sedimentary rocks of the Arbuthnott Group, within the Lower Old Red Sandstone succession of the Strathmore Basin (Armstrong and Paterson, 1970). The thick sequence of lava flows is chiefly composed of olivine basalts and orthopyroxene-feldspar-phyric andesites with few intercalated conglomerates. Structures within the flows and their relationships to penecontemporaneous sedimentary rocks are well exhibited.

This excellent section was first described by Geikie (1897) and later in more detail by Jowett (1913) and Robson (1948). Pillows within the Usan lavas were described as the best examples Jowett had seen along this coast. Heddle (1901) recorded that calcite, chalcedony, agate and chloritic minerals occur within the amygdales. Some of the lavas within this section have been analysed as part of a petrochemical study of the British Lower Old Red Sandstone lavas (Thirlwall, 1979).

Description

The 'Ferryden lavas' are exposed at the north end of the section [NO 733 567] around Scurdie Ness ('scurdie' is the local term for the lavas), and farther south along the coast [NO 732 564] they are faulted against the younger 'Usan lavas' (Figure 9.21). The trace of a large open ENE-trending anticline, the Ochil–Sidlaw Anticline, transacts Scurdie Ness, so that the section southwards along the coast passes from the oldest exposed lavas of the Montrose Volcanic Formation, up through the younger flows. The dip on the southern limb of the anticline is about 10° to the SSE. The Montrose Volcanic Formation in this area is estimated to be about 200 m thick with the lava pile thinning out to the NE and SW

The Ferryden lavas around Scurdie Ness nearly all contain conspicuous feldspar phenocrysts. These lavas were termed enstatite-olivine basalts by Jowett (1913) and were classified as andesites by Robson (1948). Although the lavas are mainly dark-grey in colour, they locally weather greenish, purple or brownish-red. The flows rarely exceed 3 m in thickness and the base of each is irregular with a flinty, chilled zone. In places, the chilled lavas appear to have formed pillow shapes. The coarser-grained centre of the flow is capped by a purplish weathered slaggy, amygdaloidal top, which is commonly fissured. The amygdales and cavities at Scurdie Ness contain green chloritic infill and agates of various sizes. Veins of chalcedony and gypsum are also present. Lenses of hard, green or reddish-brown, fine-grained sandstone have infilled the fissures from an overlying bed. Subsequent lava flows have incorporated and disturbed the fine-grained, slightly calcareous sandstone not only baking it but causing it to buckle, break up and even produce amygdales within the sediment itself (Jowett, 1913). Just north of the fault that separates the Ferryden from the Usan lavas, an intercalated lens of coarser sandstone is almost entirely composed of volcanic detritus.

The Usan lavas are well exposed on the wave-cut platform and in small sea stacks, which extend from the fault southwards to Usan Harbour. They were described as olivine basalts by Jowett (1913) and as basalts by Robson (1948). These lavas are fine grained with reddish pseudomorphs after phenocrysts of olivine and they lack the conspicuous feldspar phenocrysts of the Ferryden lavas. Fresh 'Usan lava' is dark-grey but depending on the amount of weathering, ranges from shades of purple, brown and red into a lilac colour, particularly in the amygdaloidal tops. Fissures in the slaggy and brecciated tops are filled with sandstone, but locally the base of an overlying flow lies directly on sandstone-filled, fissured, compact lava, which suggests that any slaggy top or conglomerate originally intervening had been removed. Locally, there are intercalated lenses of reddish cross-bedded sandstone and conglomerate containing

pebbles of locally derived lava (Figure 9.22).

Jowett (1913) mapped two thicker intercalations of conglomerate and sandstone within the Usan lava sequence. The northernmost, about 500 m SE of Mains of Usan at [NO 732 554], is a clast-supported, coarsening-upwards conglomerate (Figure 9.22) containing well-rounded boulders of volcanic rock, 0.6–1 m across, with a lens of red sandstone up to 0.45 m thick at its base. The boulders, some of which are feldspar-phyric lavas (i.e. not only the local Usan lavas), are set in a matrix of coarse-grained volcaniclastic sandstone. Spheroidal pillows with a concentric arrangement of amygdales occur in the lower part of the lava flow overlying this sedimentary intercalation. The other thick conglomeratic intercalation lies about 700 m SSE of Mains of Usan at [NO 730 550], and rests on an irregular channelled surface in the lava below. All the boulders in this conglomerate are volcanic rocks with feldspar phenocrysts (? Ferryden type lavas). On the coast, east of Fishtown of Usan, The Spindle on the Rock [NO 725 547] is part of a NNW-trending, 2 m-wide dyke of porphyritic andesite (Jowett, 1913). On the rock-platform to the SE of this dyke, which constitutes the southernmost outcrops of the GCR site [NO 727 544], Jowett mapped some of the lava flows as enstatite basalts; these are characterized by large plagioclase phenocrysts and a lack of olivine.

Interpretation

These lavas are inferred to be some of the earliest of the Montrose Volcanic Centre, which lay to the NE, now under the North Sea (Geikie, 1897). The volcanic succession, exposed in the core of the Ochil–Sidlaw Anticline, must be at about its thickest in the Scurdie Ness to Usan Harbour area although its base is not seen. The lack of pyroclastic rocks within this sequence suggests that the eruptions from the Montrose Centre were essentially quiescent.

The Ferryden lavas are chiefly basaltic andesites, containing phenocrysts of labradorite and enstatite; olivine is restricted to the ground-mass together with augite and andesine (Jowett, 1913; Robson, 1948). Some of the enstatite is intergrown with augite (?exsolution) but more commonly each phenocryst of enstatite has a border of granular augite. The Usan lavas were described by Jowett as olivine basalts with altered phenocrysts of olivine set in a fine-grained matrix of augite and feldspar. However, Robson (1948) recorded microphenocrysts of andesine and some groundmass feldspar of higher alkali content. A distinct flow-structure is indicated by alignment of feldspar laths and elongation of amygdales. The enstatite basalts without olivine (Jowett, 1913), in the upper part of the Usan lavas, were classed as andesites by Robson (1948) and attributed to fractionation of the more basic magmas.

Some lavas from this site have been analysed by Thirlwall (1979) as part of his Terryden Member', which comprises all the lavas from Ferryden to Lunan Bay (i.e. both the Ferryden and Usan lavas). He divided the lavas into geochemical ranges using $A1_2O_3$ contents and Zr/Nb ratios. The alumina ranges from 15.8 to 16.1% for the Ferryden lavas as described above, and from 16.9 to 17.3% for the Usan lavas. He concluded from a study of the trace elements that the variation is unlikely to be the result of fractional crystallization.

The Scurdie Ness to Usan Harbour section shows in excellent three-dimensional detail the relationships between the lava flows of both the Ferryden and Usan lavas and the intercalated sedimentary rocks. The intermittent outpourings of fairly fluid gaseous lavas were punctuated by relatively short episodes of local erosion and deposition of fine sediment that accumulated in shallow waters. A slow but steady rate of subsidence is inferred within the Strathmore Basin, for although the lavas were hardly eroded before the deposition of the sediment, there was a considerable amount of penecontemporaneous oxidation (reddening) of the tops of lava flows. The fact that thicker, coarser conglomeratic beds are intercalated with the younger lavas might be due to increasing time intervals between flows as volcanic activity waned, or to changes in local topography as the lava pile built up. The local development of pillows at the bases of flows, as recorded by Jowett (1913), suggests that in places the lavas flowed into shallow water. On the contrary, Robson (1948) stated that pillow-structure is not known from these lavas, which he suggested precluded any suggestion that they formed in deep water. However, Robson agreed that the evidence from the fracturing and infilling of the lavas by sediment implied deposition in shallow water.

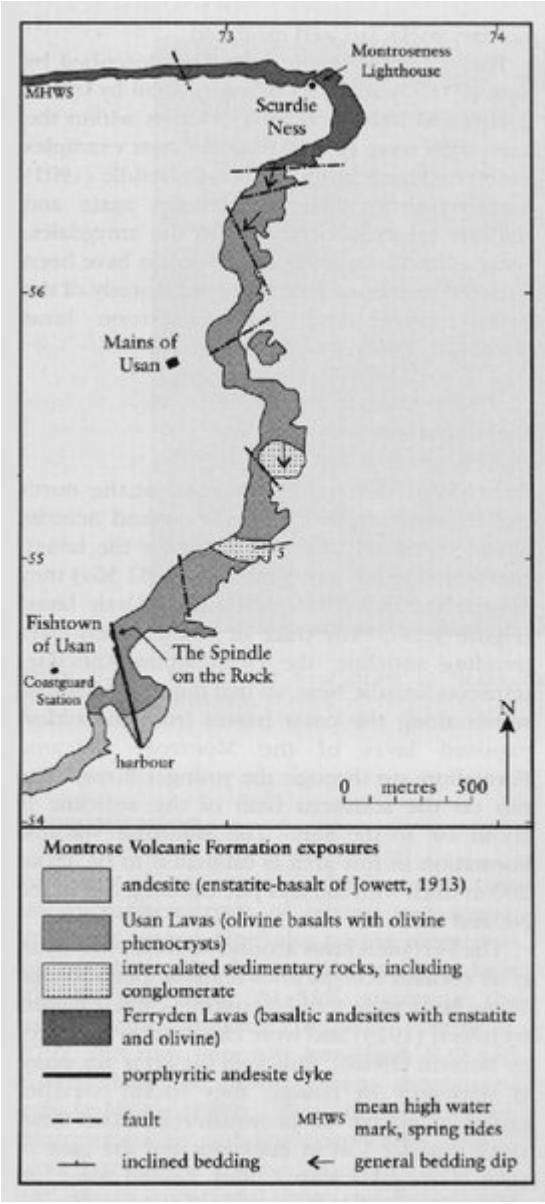
Interaction of the molten lavas with wet sediment can be studied in this section; as the wet sediment was ripped up and incorporated into the lava, it appears that the water was vaporized before the sediment was baked so that amygdales eventually developed in the sedimentary rock as well as in the lava. A study of the section could prove examples of

fluidization by intrusive magmas as described from rocks of similar type and age from Ayrshire (Kokelaar, 1982)(see the Port Schuchan to Dunure Castle, Culzean Harbour and Turnberry Lighthouse to Port Murray GCR site reports).

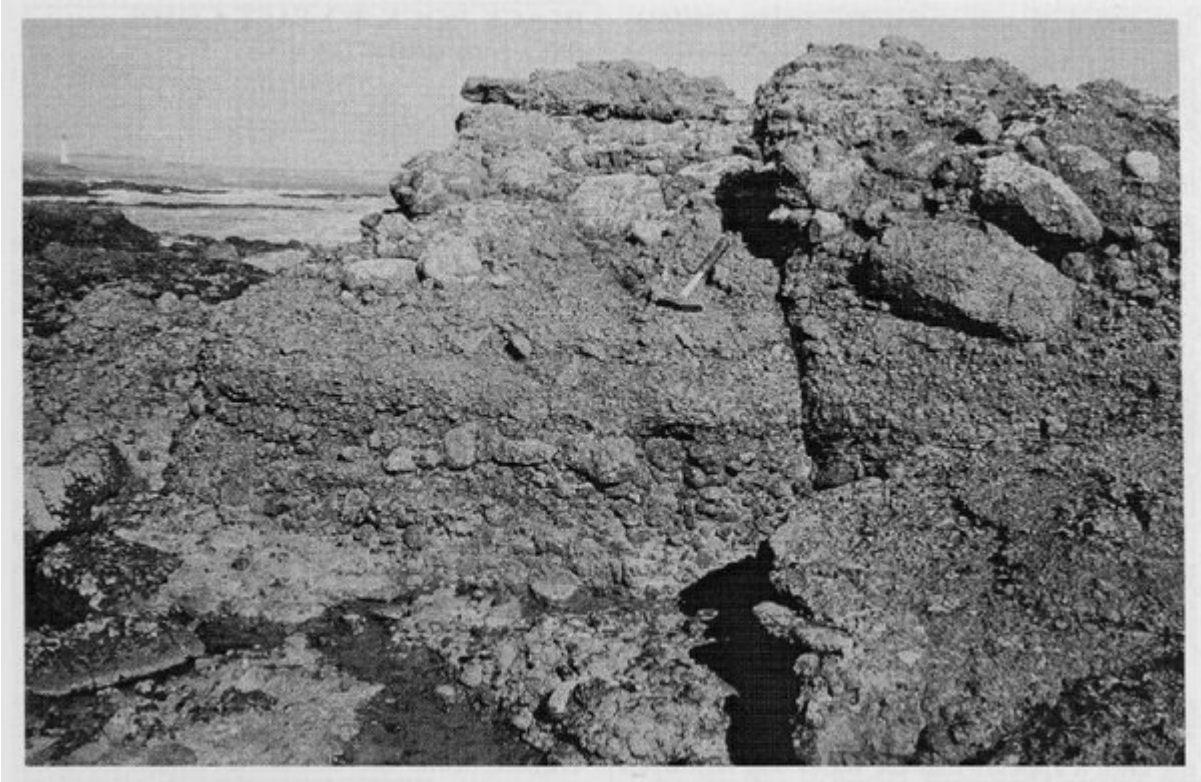
Conclusions

The Scurdie Ness to Usan Harbour coastal section is of national importance, both as a representative of the lower part of the Lower Old Red Sandstone, Montrose Volcanic Formation and for its value in reconstructing the environment and evolution of the Montrose Volcanic Centre. The olivine basalt to basaltic andesite lava sequences are excellently exposed along this coast. The main distinction between the Ferryden and Usan lavas is that the former are enstatite-feldspar-phyric with only groundmass olivine, whereas the latter are mainly fine-grained olivine-phyric basalts. Detailed contact relationships with the sedimentary intercalations are of special interest in this section together with possible examples of lava–wet sediment interaction.

References



(Figure 9.21) Map of coastal exposures of Montrose Volcanic Formation between Scurdie Ness and Usan Harbour, adapted from Jowett (1913).



(Figure 9.22) Bedded pebble and boulder conglomerate composed of lava clasts in coarsening up intercalation between lavas. Usan lavas, 500 m SE of Mains of Usan at [NO 732 554]. (Photo: R.A. Smith.)