CHAPTER III.

THE KING'S PARK AND ARTHUR'S SEAT.

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Even to the non-geological observer it is fairly obvious that Arthur's Seat is a hill of volcanic origin, but few are aware that it contains rocks belonging to at least three volcanoes. Two of these had their craters at the point which is now the Lion's Head or the summit of the hill ; the neck of the filled-up crater of the third one is situated on the slope behind Salisbury Craigs.

It will be convenient for the purpose of description to consider the King's Park as divisible into three parts, viz., Salisbury Craigs, the Whinny Hill, and Arthur's Seat. (See Plate 4, Fig. 1.)

Salisbury Craigs is a very beautiful example of an intrusive sheet. The rock of which it consists is teschenite or analcite-dolerite, consisting of augite, olivine, plagioclase feldspar and analcite. It is by no means fresh, the olivine in particular being usually replaced by serpentine. Intrusive sheets of teschenite are quite common in the Firth of Forth district, and well-known examples occur at Gullane and at Mons Hill, near Dalmeny. We cannot say with absolute certainty at what time these sheets were intruded, but the balance of probability is in favour of their belonging to the underground manifestations of the volcanic activity that gave rise to the chain of Lower Carboniferous volcanoes that are so prominent in the Lothians and Fife.

It seems clear, however, that Salisbury Craigs is not intimately connected with any of the Arthur's Seat volcanoes ; that is to say, it did not proceed from either of the three necks that occur in the King's Park. Very likely it was forced along the bedding planes of the sandstones and shales from some point to the west of its present cliff. This view is supported by the fact that the sheet or "sill" obviously thins down and dies out as we trace it in an eastward direction along the Radical Road towards the agglomerate of Arthur's Seat.

By the earth-movements that have folded the Carboniferous rocks of this district the Salisbury Craigs sheet has been tilted till it dips to the east at an angle of 25 degrees. As it is much harder than the sandstones above and below, it shows very clearly the phenomena of "dip slope and escarpment." The steep grassy slope beneath the cliff covers the edges of the sandstones that underlie the sheet. On the back of the sheet some patches of sandstone remain ; they may be seen in old quarries on the west side of the Hunter's Bog, and belong to the Ballagan Beds, which are the lowest Carboniferous rocks in the Lothians. At its north end, in fact, the Salisbury Craigs sill must be very

nearly at the horizon where the Upper Old Sandstone passes into the Carboniferous. It does not exactly follow the bedding planes, but the centre occupies a somewhat lower position than the edges of the sheet.

The sedimentary rocks above and below the teschenite sill are very well exposed in the fine sections along the Radical Road. At the junction with the sill they are intensely baked, especially those that overlie the igneous rock. The mudstones are converted into hard, flinty porcellanites, and the sandstones have their calcareous cement recrystallised with the formation of small granules of green pyroxene. Large irregular blocks of sandstone have been caught up in the igneous rock and thoroughly baked and hardened. In some places the teschenite gives off veins that penetrate the sandstone, and these are fine-grained dark rocks that must have been at one time partly glassy. Both at its base and at its top the sill cuts across the bedding planes of the sediments quite distinctly every here and there, though, as a whole, it accords fairly well with them in dip and in strike. (Pl. 1.B.) We may mention also that, especially towards its south end, there is evidence that the sill is composite, that is to say it consists of more than one injection, and its earlier parts are cut into and veined by the later intrusions.

Near the highest point of the west face of the sill there are two dykes that ascend vertically through the cliff. The section is one of the best in the Edinburgh district to show the typical method of occurrence of dykes, as they can be seen running up the cliff which here is nearly a hundred feet high.

The Hunter's Bog is the valley between Salisbury Craigs and Arthur's Seat. On one side it is defined by the dip slope of the sill, which is covered here and there by layers of sandstone and shale. The base of the valley has been eroded out of the sediments of the Lower Carboniferous, and the eastern side is bounded by the escarpments of the Long Row lava and the precipitous face of Arthur's Seat neck.

On the east side of the Hunter's Bog there is a small broken cliff known as the Dasses. It consists of porphyritic basalt and is obviously an intrusive sill as the sandstones that rest on it are much baked. This intrusion can be found also on the other side of Arthur's Seat, where it forms the Giral Craig. It is probably the same as the Heriot Mount sill that lies at the foot of Salisbury Craigs, as there is a considerable fault at the hollow below the Craigs which would throw down the Dasses sill and repeat its outcrop in that position. (Plate 3, Fig. 1.)

The Whinny Hill is the northern part of Arthur's Seat. It lies between St. Margaret's Loch and Dunsapie Loch. To one who looks at it from Holyrood it is perfectly clear that this hill is built up of flow upon flow of lava, as the little cliffs or escarpments can be followed by the eye along the face of the hill, each showing

by its dark brown colour and columnar jointing the nature of the rock of which it consists. In structure it is essentially similar to the Calton Hill, which, in fact, is a piece of the Whinny Hill that has been separated off by a great fault.

The lowest lava of the Whinny Hill series makes a long cliff along the east side of the Hunter's Bog, known as the Long Row. It rests upon the Lower Carboniferous sediments and it indicates the first manifestation of volcanic activity in the Edinburgh district after the long period of quiescence which had elapsed since the lava of Blackford Hill flowed out in Lower Old Red Sandstone time. This lava has a very slaggy and vesicular top, while the central part shows beautiful columnar jointing. (Plate 3, Fig. 1.)

This outflow is followed by a great series of volcanic rocks with very little sediment, which means that for a considerable time the showers of ashes and eruptions of lava were so frequent that there was little opportunity for the accumulation of sand and mud on the sea-bottom. The sea was quite shallow, and plants grew on the surface of the ash; their rootlets may still be seen passing down from the bedding planes. Above the Long Row there is a beautiful green valley known as the "Dry Dam." It is excavated in a set of ash-beds mixed with sediment which rest upon the Long Row lava. These softer rocks, like the sandstones of the Hunter's Bog, have been eaten back and form a valley overlooked and floored by the harder volcanic masses.

Across the mouth of the Dry Dam there runs a fault which dislocates all the outcrops. It cuts off a part of the Long Row to form the Haggis Knowe, a rounded knoll that lies at the south end of St. Margaret's Loch. This fault also throws down the lavas that occur at St. Anthony's Chapel, to the south of which it can be seen cutting through the face of the escarpment. At the chapel there are at least two beds of sandstone containing remains of plants and fishes that show clearly that the volcanic activity is to be assigned to the Carboniferous rather than to the Upper Old Red Sandstone period.

The upper part of the Whinny Hill consists of lava flows of which at least nineteen have been traced. Each of them forms a little escarpment, followed by a grass-grown dip slope. They dip to the east, and the highest lie beyond the limits of the King's Park. The lower lavas are dark olivine basalts; they are followed by basalts with large porphyritic crystals of labradorite feldspar (Markle type). Then come two or three flows of mugearite, which may be seen beyond Dunsapie and on the east side of the Queen's Drive. The last lava of all is again an olivine basalt. The succession is, on the whole, similar to that of the Calton Hill. (See Plate 3.)

There is little tuff between the lavas, and they probably followed one another at no great interval. It seems likely also that the volcano rose as an island above the surface of the

Carboniferous sea, though the Long Row and the next lava above it certainly flowed over the sea-bottom. The whole area was slowly subsiding. One or two intrusive masses occur among the lavas, from which they may be distinguished by their less persistent outcrops and the absence of the slaggy top and base, which are marked characteristics of the lavas. The top lava indicates the final cessation of vulcanicity in the Edinburgh district, which supervened just before the deposition of the Abbeyhill shales.

The centre and summit of Arthur's Seat, the Lion Hill, contain the remains of two distinct volcanic necks or craters, one of which rose through or alongside of the other (Pl. 4, Fig 1). One of these is known as the Lion's Head vent, and it forms the north-west and highest part of the hill; the other is the Lion's Haunch vent, and it is considerably the larger. The great cliff of red agglomerate which frowns over the south part of the Queen's Drive belongs to the Lion's Haunch vent. The junction between the two necks is seen in the gully on the west face of the hill which is known as the Guttet Haddie. There the agglomerate of the Lion's Haunch vent contains pieces of the Lion's Head basalt, which form a sort of scree due to the breaking up of the basalt under atmospheric erosion. This proves that the Lion's Head vent is the older of the two.

The margins of these two conjoint necks produce bluff natural features in a good many places. The wall which closes the upper end of the Dry Dam arises from the great columnar mass of tuff where it passes across the top of that valley. We can follow the edge of the crater across the outcrop of the Long Row basalt, and it forms also the lofty cliff which fronts the Hunter's Bog. From there it passes round by the Raven Rock, past Sampson's Ribs, and follows the line of the Duddingston Road almost to the end of the loch. Through the remainder of its circuit the wall of the old crater is not marked by any natural features, but traverses a smooth grassy slope. Dunsapie Hill, however, indicates the north-eastern margin of the volcanic vent.

In the Hunter's Bog and at Sampson's Ribs the vent is bounded by Lower Carboniferous and Upper Old Red Sandstone rocks, but on its north and west faces it is in contact with lavas and ashes of the Whinny Hill and Dry Dam groups. The junction with the Long Row basalt for example is clearly visible at the head of the Dry Dam, and the same lava is found on the south side of the neck in the Queen's Drive above Duddingston Loch. The ash of the neck, however, weathers at about the same rate as the ashes and lavas of the Whinny Hill, and no strong natural feature is produced by erosion at the junction of these two sets of rocks.

Although the main mass of the necks consists of agglomerate, PROC. GEOL. ASSOC., VOL. XXV, PART 1, 1914.]

there are both lava-form and intrusive basalts within its compass. These may be divided into a peripheral and a central group.

The peripheral intrusions comprise masses of crystalline igneous rocks that have risen along the side of the neck, perhaps between the ash in the crater and the crater's walls. Dunsapie and Sampson's Ribs are the best examples of these; they are both porphyritic olivine basalts.

The central intrusions occur well within the mass of agglomerate; the best example is the basalt which forms the Lion's Head. It rises as a column in the throat of the old volcano, and spreads out at the top into a mushroom-shaped mass, thus, perhaps, indicating the cup-shaped bottom of the crater-pit. Its intrusive character is shown by the numerous dykes which spread out from it through the agglomerate that rises above the Hunter's Bog.

The Lion's Haunch basalt is rather a cake-shaped mass than a column. It may have risen through an orifice near the south-eastern margin of the crater, and has spread out through the agglomerate of the second vent.

The peripheral lavas are very curious in many respects. One of them occurs in the *col* above the Dry Dam. In the splendid section afforded by the rock-cuttings on the Queen's Drive many small flows of basalt are seen in the coarse agglomerate, which here contains enormous ejected blocks. These basalt flows are often brecciated, perhaps by movement during cooling, and they are perhaps small intrusions that have arisen along cracks on the ash near the edge of the crater, or they may be small *coulées* of lava that have clung to the inner slopes of the old pit. In the Raven Rock they occur on a considerable scale, and are cut by tongues of intrusive basalt and by several small dykes.

The great red agglomerate of the Queen's Drive is one of the most impressive features of Arthur's Seat. Its tumultuous assemblage of blocks, some of them 12 to 15 ft. in diameter, is striking evidence of the violence of the eruptions that took place on this side. In this ash there are also many pieces of sandstone, shale and limestone, or cornstone. The materials have mostly a distinct bedding, which dips inwards from the boundary of the neck at high angles. Mixed with the ashes are layers of argillaceous sediment that must have gathered under the action of water during periods of comparative quiescence.