ON THE ORIGIN AND PETROLOGY (SPECIALLY OF THE SOUTH
SIDE) OF SALISBURY CRAGS, EDINBURGH.

By ANDREW TAYLOR, F.C.S., Assistant Secretary of the Botanical
Society of Edinburgh.

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(*Abstract.*)

The author was inclined to trace the origin of the Craggs to some movement connected with the warping of the adjacent Midlothian coal basin—possibly, too, the upheaval of the Pentlands. Lateral compression, or forces acting simultaneously in two directions, may have caused Crag-structure. The greenstone, or dolerite, may not have been ejected as a fluid lava, but as a loose ash-bed, and its compact structure may be due to subsequent consolidation.

Many of the features connected with the great earthquake wave of 1868, in the Sandwich Islands, as described by Mr. Brigham in the Memoirs of the Boston Society of Natural History, afford comparison for study of the natural history of Salisbury Craggs. A great band of mud issued out of no crater—but an earth chasm—and spread for miles in a few hours. It speedily showed chasms and cracks, while alkaline vapours were perceptible at certain parts of its course. In a short time after its formation, a native thrust in his hand into the mass, to find it perfectly cold. It is conceivable that the Craggs could thus have issued from one or two earth chasms. And particular attention was called to several spots down from the great quarry on the south side, as well as on to the convergent slope to the Hunter's Bog, in proof of this. Hutton, no doubt, gave his dictum that the aqueous strata of the Crag were similar to those now forming by modern causes. But, in order to draw a parallel betwixt the greenstone and modern lava, his adherents had to postulate its formation under great pressure, probably under ocean depths. Prof. Jamieson has elaborately shown (*Edin. Phil. Journ.*, Vol. i, 1819) that the strength of the Neptunian argument lay in the difficulty of proving the so-called aqueous strata to be identical with those now forming by modern causes. Boue quietly hinted that the sandstones, shales, and limestones of the hill were a special formation. Indeed, the large quartz crystals in the sandstone of the quarry of the Hunter's Bog, as well as the marked petrological appearances of the

sandstones of the neighbouring Grange district suggest this. On the other hand, the marked physical appearances at the junctions of the igneous and aqueous rocks have been the strongest points of the Huttonians. Recent microscopic examinations show no distinctive differences betwixt the two rocks; nor have they proved the dolerite identical with Vesuvian lava. According to Professor Hull, no British dolerite, except that from the Wolf Rock, is so.

Mr. Ivison Macadam, F.C.S., made the accompanying analyses, which tell their own story in this description. They relate first to an upright vent or thin mass of white rock to be found just below the southern termination of the great quarry. The ground immediately above the footpath is covered by great *débris* heaps, but the observer surmounting these will find the spot without difficulty; indeed the white streak in the rock marking the site of the vent is so prominent as to be seen from the neighbouring houses.

The analysis shows the red sandstone of many authors to be a dolomitic limestone. The pocket at the northern extremity of the great quarry, classical in all local descriptions because supposed to give ocular proof of the decolorising power of the surrounding liquid lava, may then be due in some sort to crystallisation. Near this the dolerite beds may gradually be seen passing from the coarse-grained into the hard sonorous variety; calcite and zeolites are seen by the naked eye to be predominant features of the rock. Indeed we are reminded of Daubrée's synthesis of such rocks from Roman bricks at Plombières. So, too, does the white vent. It is about five feet broad, and veins of calcite break and ramify, in a vertical line, through part of it, leaving slickenside markings on the walls. Daubrée has shown that calcite may be deposited at a temperature of 70°C. If Sir James Hull's hypothesis that it was formed under great pressure were correct, it should prevail as much in the dolomite as in the greenstone. The great quantity of iron prevalent is notable. Professor Geikie has shown that this peculiarity is seen also by the microscope. The greenstone has thus a composition and specific gravity different from Vesuvian lavas. According to Huttonian ideas the red colour of the dolomite was due to iron filtered into it by the heated superincumbent lava; but Jamieson's "slate clay" underneath it has much more iron, nearly as much as the greenstone itself. The presence of a small quantity of copper is notable; it has previously been observed in similar rocks on the Braids and at Currie. Jamieson has noted in the sandstones of the city, galena, iron pyrites, and blende;

small quantities of cobalt-ore were also found in a whin dyke in Albany Street. In walking along the footpath behind the Crags, immediately after crossing through the Hause, small patches of this dolomite may be observed in the greenstone; beautiful blebs of calcite here come up through it. Little veins of iron ore and greenstone may also be seen traversing the footpath, still further up taking a zigzag form, now longitudinal, now vertical, and finally terminating in the abrupt front of the Crags. So, too, do parts of the parent rock show the main vein and cross vein structure in hand specimens. This suggests a method of Crag building for this southern end, which is all greenstone, and which is twice as steep on this face as the further portion where the sandstone comes on. Maclaren has pointed out the great hummock of trap running up in the direction of the Cat's Nick. Similar hummocks, though much smaller in size, may also be noted to run up to the vents indicated in this paper. Immediately above the first great quarry portions of the rock were bared, under direction of Sir Henry James, for geological study. Attention is called to two phenomena—leaving glacialists to expatiate on ice scratches said to be disclosed. Fleming describes what he called flaws—"This surface is marked by numerous small parallel ridges, seldom reaching two inches in breadth, very shallow, scarcely exceeding half an inch in depth, occasionally preserving for a couple of yards their distinctive character, at other times slightly waved, but throughout exhibiting generally a continuous parallel linear arrangement." They are observable on the sandstone of the Bog Crag and on the red-stone of the footpath of the Radical Road, below where we are now supposed to stand; they are not ripple marks: And the analyses adduced may remove the objection to their being considered marks of the contraction of the rocks. On a space of open rock near to this a series of elliptical holes about an inch long and as much apart is disclosed for a space of seven feet or so. These may be called steam-pores.

Maclaren makes this south side of the Crags to have been formed with the rest of Arthur's Seat long after the other part of them. The author eschews chronology in this paper. Neither does he trace the southern termination of the greenstone bed beyond the Hause into Arthur's Seat. Perhaps the bed of siliceous limestone found just beyond Samson's Ribs may be the continuation of that which is lost in the cutting into which the Queen's Drive plunges.

Former controversialists on the age of Arthur's Seat have begun at the top, Hebrew-wise, reading the stone-book backwards. The author's only contribution to the controversy would be to begin with the foundations of their argument, briefly saying in Scotch law fashion, *quoad ultra*, denied! The author considers the petrological peculiarities of St. Leonards and Salisbury Crags are such as to take them out of the regular bedded sequence usually given them in diagrams illustrative of the age of Arthur's Seat. Dr. Hibbert, in writing of the extinct volcanoes of the Giffel, shows that, in the deposit of the basin of the Rieden, floods of water, carrying mud and ashes, were contemporary with the flow of trachytic and basalt dykes. He suggests that, during the eruptions, the superambient waters of the lake, heated and saturated with gases from the crater, would be imbued with a new power of effecting chemical change. The petrology of the Crags suggests similar analogies. If the great zone of boulders of the Hunter's Bog, and elsewhere, had been separated from the parent rock at the intersections of the bedding, during the ash and basalt flows going to form the Crags, heat sufficient to effect great change must have arisen. Daubrée has shown how dry clay triturated against itself, had its temperature raised in three-quarters of an hour from 18° C. to 40° C., and thus speculates how mechanical force may be transformed into heat, as on the Alps. The slickensides and flaws so abundant round Arthur's Seat acquire new significance in the light of this experiment.

The first of the samples analysed was taken from the vent itself; the second from the rock next to and surrounding the vent; whilst the third analysis shows the composition of the main or unaltered rock.

No. 1 Sample is soft and friable, and is readily pulverized to a light green powder. Specific gravity 2·619. It is evidently an altered greenstone. The powder yields effervescence on treating with an acid.

No. 2 Sample, or the rock surrounding the vent, is of a much darker colour than the rock of the vent. It is compact and hard, and shows veins and cavities filled with calcite crystals. It gives a grey powder when pulverized. Specific gravity of rock 2·707. The powder shows effervescence on the addition of acid.

No. 3 Sample.—The rock mass has a specific gravity of 2·806. The powder effervesces slightly when treated with acid.

No. 4 Sample is from a bed of limestone lying under the green-

stone. It is of a reddish iron colour, and is somewhat crystalline. When acted upon by acids it effervesces much, and yields a solution with a slight yellow tinge. The specific gravity is 2·637.

No. 5 Sample was obtained from a bed of sandstone underlying the limestone. It is greenish-white in colour, and is close-grained. When treated with acids it shows effervescence. Specific gravity 2·421.

No. 6 Sample is from the same stratum as *No. 5*, only it was taken further from the limestone and nearer the bottom of the bed. It has a slight green tinge of colour, and shows rust marks at parts. When acted on by acids it gives very slight effervescence. Specific gravity 2·536.

The average results of several analyses of these three minerals yielded the following figures calculated to percentages.

	<i>No. 1.</i>	<i>No. 2.</i>	<i>No. 3.</i>
<i>A. Soluble in</i>	<i>Rock forming Plug</i>	<i>Rock lying next</i>	<i>Rock mass pierced</i>
<i>Acids.</i>	<i>of South Vent.</i>	<i>to South Vent</i>	<i>by South Vent,</i>
		<i>and altered.</i>	<i>but unaltered.</i>
Ferric Oxide (Fe_2O_3)	12·68	13·96	20·94
Aluminic Oxide (Al_2O_3)	2·18	3·36	6·38
Calcic Oxide (CaO)	11·37	18·65	1·86
Magnesian Oxide (MgO)	0·74	0·75	0·73
Cupric Oxide (CuO)	0·42	0·43	0·33
Carbonic Anhydride (CO_2)	9·34	15·08	2·86
Soluble Silica	0·06	0·07	0·06
Potassic Oxide (K_2O)	2·18	1·35	0·21
Sodic Oxide (Na_2O)			
Loss			
Total Solution in Acids	38·97	53·65	33·37
<i>B. After fusion of the insoluble portion, and treatment for the second time with acids.</i>			
Ferric Oxide (Fe_2O_3)	10·05	4·13	8·54
Aluminic Oxide (Al_2O_3)	8·42	5·32	4·66
Calcic Oxide (CaO)	3·85	0·43	3·44
Magnesian Oxide (MgO)	0·33	0·03	2·86
Potassic and Sodic Oxides } and loss	0·32	0·01	0·69
Soluble after fusion	22·97	9·92	20·19
Insoluble Silica	35·74	34·97	45·38
Moisture	2·32	1·46	1·06
	100·00	100·00	100·00

	No. 4.	No. 5.	No. 6.
	<i>Limestone below greenstone and cut through by South Vent.</i>	<i>Sandstone below and next to the limestone.</i>	<i>Sandstone below limestone and lower down in stratum than No. 5.</i>
A. Soluble in Acids.			
Ferric Oxide (Fe_2O_3)	2.28	0.77	0.68
Aluminic Oxide (Al_2O_3)	0.38	1.46	1.53
Calcic Oxide (CaO)	18.95	9.18	1.14
Magnesian Oxide (MgO)	11.77	0.19	0.16
Carbonic Anhydride (CO_2) ...	35.79	5.78	1.20
Soluble Silica	0.03	0.05	0.04
Potassic and Sodid Oxides } and loss }	0.51	0.34	0.41
	—69.71	—17.77	—5.16

B. After fusion of the insoluble
portion and treatment for
the second time with acids.

Ferric Oxide (Fe_2O_3)	—	10.98	2.44
Aluminic Oxide (Al_2O_3)	—	0.03	0.12
Calcic Oxide (CaO)	—	0.22	1.13
Magnesian Oxide (MgO)	—	trace	0.84
Potassic and Sodid Oxides } and loss }	—	trace	0.59
Soluble after fusion	—	11.23	5.12
Insoluble Silica	28.93	69.83	88.68
Moisture	1.36	1.17	1.04
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>