and molars agree with those already described in the Catalogue of the Fayûm Vertebrates (p. 87).

The total length of the mandible here figured is 13·8 cm., its depth beneath the condyle about 6·5 cm. The lengths of the teeth in millimetres are: canine, 4 app.; pm. 1, 7; pm. 2, 8; pm. 3, 8; pm. 4, 9; m. 1, 10; m. 2, 13; m. 3, 18. The total length of the tooth series (c. to m. 3) is 7·5 cm.; the length of the molar series is 4 cm.

In the other specimen the depth of the ramus beneath m. 3 is 4·3 cm., and the distance from the hinder end of m. 3 to the posterior border of the mandible is about 5·5 cm.

Several more or less imperfect curved front upper incisors of Hyracoids were collected. They were of varying size and are triangular in section, the two anterior faces only being covered with enamel.

The remains of Carnivora are very rare, and few were obtained, the most important being a fragment of the left maxilla, with two teeth (pm. 4 and m. 1). The molar is almost exactly intermediate in form between the corresponding teeth in *Pterodon* and *Hyænodon*, having a less prominent inner tubercle and longer posterior blade than in the former, but in these characters more resembling the latter. It seems, therefore, that this maxilla belonged to *Apterodon macrognathus*, a species founded on a mandible, the dentition of which is likewise in some respects intermediate between that found in the genera above referred to; it also agrees in size with the specimen now under consideration.

An enormous canine, probably that of *Pterodon africanus*, some cervical vertebræ, and a tibia were also obtained.

One rather notable find was the ulna of a large wading bird, apparently nearly allied to *Ardea*. Compared with the same bone of *Ardea goliath*, this ulna is somewhat smaller and notably stouter in proportion to its length, but in the form of its extremities and of the various muscle impressions it is closely similar. Bird bones are extremely rare in these beds, at least in sufficiently good condition to collect.

*No notable reptilian remains were found.*

It will be seen that very much more remains to be done in the Fayûm, many of the animals described being only very incompletely known, from mere fragments; in several important instances, e.g. *Geniohyus*, the skull remains quite unknown.

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## II.—Notes on the Rocks of the "Beagle" Collection.

### I.

By Alfred Harker, M.A., F.R.S.

THE voyage of the "Beagle" in 1831–6 was not only the starting-point of Charles Darwin's scientific career, but also, and more particularly, it laid the foundation for the whole of his geological work, as embodied in the well-known series of volumes.[1] The

[1] "Journal and Remarks," 1839; 2nd edition, entitled "Journal of Researches . . . during the Voyage of H.M.S. 'Beagle' . . . ," 1845. "The Structure and Distribution of Coral Reefs," 1842. "Geological Observations on the Volcanic Islands . . . ," 1844. "Geological Observations on South America . . . ," 1846.

collections which he gathered during that prolonged voyage of exploration have therefore no small interest of a historical and sentimental kind. It is believed that they possess also a certain intrinsic value; inasmuch as an examination of these original specimens, with the advantages conferred by modern petrographical methods, may sometimes help towards a better understanding of the recorded observations. Owing to his choice of plain language in preference to the now antiquated terminology of his time, Darwin is seldom obscure to a modern reader; but his characterization of the igneous rocks which he observed is necessarily crude and vague. Not a few passages may be considerably elucidated by merely indicating the nature of the rocks which are designated by such old-fashioned comprehensive names as 'porphyry,' 'greenstone,' and 'basalt.' In general, no more than this will be attempted, at least for those islands and districts which have been studied by other geologists with the aid of modern appliances.

The greater part of the "Beagle" collection is now housed in the Sedgwick Museum at Cambridge. It includes some 2,000 rock-specimens, a certain number being lost or missing, and most of the fossils having passed long ago into other hands. Procured often under difficult conditions, carried in many cases long distances overland, and stowed in a confined space on shipboard, the specimens are for the most part not of the size and shape favoured by museum collectors; but they are sufficient to illustrate the rock-masses which they represent, and to provide thin slices for microscopical examination. The original annotated catalogue, occupying four closely written note-books, is a monument of patient labour. Under each number is a condensed description of the rock, as seen by the eye and the lens, besides the necessary records of locality and occurrence. On the opposite page are additional notes, also made during the voyage, giving the results of examination with the blow-pipe, goniometer, magnet, and acid-bottle. Less commonly there are entries made at some later time, sometimes noting an opinion of Henslow or Miller, to whom particular questions had been referred. A copy of this manuscript list is placed with the collection, and it will be referred to as the "Catalogue."

### Santiago, Cape Verd Isles.

Although we shall in general omit petrographical details, some exception may be made in the case of rocks which have an interest of their own, and have not become generally known from published descriptions. Such are the lavas of the Cape Verd Isles, which present a considerable range of variety and include some remarkable types. The valuable work of Doelter[1] does not pretend to completeness; and these islands have been so seldom visited by geologists that specimens collected seventy years ago may still furnish interesting material for study.

Both on the outward and on the homeward voyage the "Beagle"

[1] C. Doelter: "Die Vulcane der Capverden und ihre Producte," Graz, 1882. A few rocks collected by Doelter have been described by Fr. Eigel: Tscherm. Min. Petr. Mitth. (2), vol. xi (1889), pp. 91–104. There are also some earlier notes by A. Stelzner: Berg. u. Hütt. Zeit., vol. xxiv, p. 47.

touched at Porto Praya, on the south coast of Santiago,[1] the largest of the Cape Verd group. Darwin utilised his time in exploring the geology of the port and the neighbouring parts of the island, and collected about 150 specimens. We shall refer to the more interesting of these in the order in which they are mentioned in the first chapter of "Volcanic Islands." Of some of them thin slices have been made, and the number of the slides, in the Sedgwick Museum cabinet, will be given in brackets.

The lowest rocks on the coast near Porto Praya and on Quail Island, underlying the white Tertiary limestone, are highly basic, non-felspathic lavas. The fresher specimens show a very dark and compact ground-mass, with crystals of yellow olivine and black augite, which are usually very abundant. Three examples which have been sliced illustrate three different types, and probably represent fairly the whole group. The first [4704] is a *limburgite*. Olivine is the dominant mineral, in perfectly fresh well-shaped crystals. Augite is also abundant, in good crystals with some tendency to stellate grouping. It is very pale in the slice, and often shows fine lamellar twinning. There are also a few little octahedra of magnetite, sometimes enclosed in the olivine. These minerals constitute the greater part of the rock, but there is in addition an abundant glassy base of deep brown colour, enclosing very numerous little rectangular gratings of magnetite.

The second type [4705] shows the same minerals, except that the olivine is largely replaced by serpentine and carbonates. The augite is strongly zoned. The ground-mass consists of a second generation of augite and magnetite, with slender needles of apatite and a clear isotropic base, which is quite colourless. This is evidently an example of the second variety of limburgite distinguished by Doelter (op. cit., pp. 134–137) as having a colourless instead of a brown glass. The true nature of the colourless base is, however, doubtful, and we shall recur to the subject below.

The third type [4706] differs from the foregoing in that olivine is scarcely represented. The phenocrysts are of a pale yellowish-brown augite, zoned and often twinned, with magnetite. The ground-mass consists, as in the last specimen, of abundant little idiomorphic augites, magnetite, many needles of apatite, and a colourless isotropic base, which is here in rather larger amount. This rock evidently belongs to the 'pyroxenites' of Doelter, which Rosenbusch more conveniently terms 'augitites,' the former name being preoccupied by a very different group of rocks. As in the limburgites, Doelter (op. cit., pp. 137–143) distinguishes two kinds, one having a brown glassy base and the other a colourless base, assumed to be also glassy.

The dykes mentioned by Darwin (p. 3) as intersecting these lavas seem to be of related types, but the only one sliced [4713] shows some differences. Augite preponderates over olivine among the porphyritic crystals. The ground-mass, in addition to augite and magnetite, contains little slender crystals of felspar, some with twinning. It is noteworthy that most of these crystals give low

[1] The common English spelling is here adopted. Darwin writes the name 'St. Jago,' and Doelter uses the Portuguese form 'S. Thiago.'

extinction-angles. There is an interstitial base of brown glass. Notwithstanding the presence of some felspar, the affinities of this rock are decidedly with the limburgites rather than the basalts.

The calcareous deposit calls for no remark. The white balls, mostly from one to two inches in diameter, built up by 'Nulliporæ,' are interesting as the analogue, on a giant scale, of a certain type of oolite. The alteration in the upper part of the calcareous deposit, where it is overlain by the younger lavas ("Volcanic Islands," pp. 5, 6), is probably due to solution and recrystallization at least as much as to metamorphism. Darwin's explanation of the curious intermingling of carbonate of lime and lava here, and again at Red Hill (pp. 10–14), will scarcely be accepted at the present day. He believed "that the lime has been erupted, mingled with the molten lava." His specimens seem to show merely a breccia of pieces of dark lava in a calcareous matrix, and again calcite and aragonite crystallized in the vesicles and interstices of a scoriaceous lava. This is also the opinion which Doelter formed on the spot.

The lavas which overlie the calcareous rocks of the coast district (pp. 9, 10) are, judging by the specimens, poorer in conspicuous phenocrysts than the lower lavas. Usually some small olivines are the only element visible to the naked eye. The compact ground-mass has not the uniformly dark colour of the lower lavas, but is often mottled or streaked with lighter and darker shades of grey. A thin slice of one example [4703] shows small crystals of the usual olivine, pale augite, and magnetite, the olivine being largely replaced by pseudomorphs of a deep red-brown colour. In addition, there are small crystals of felspar with twin lamellation and low extinction-angles. There is finally an abundant isotropic base, quite colourless, enclosing very numerous slender needles of apatite. This colourless base is partly segregated into little patches and streaks relatively free from the crystallized constituents (except apatite), and in these places it shows unmistakably the cubic cleavage characteristic of analcime. The rock may therefore be styled an *analcime-basalt*, allied to monchiquite, the presence of some felspar being the only character distinguishing it from typical monchiquites.

In speaking of the lower lavas, the nature of the colourless isotropic base in the second and third types was left in doubt, its strictly interstitial occurrence making its identification a matter of difficulty. In the rock now considered, although isolation and chemical analysis are desirable to give confirmatory evidence, there can be no reasonable hesitation in recognizing the colourless substance as analcime; nor is there any reason to question its status as a primary constituent of the lava. How far a like interpretation may be applicable to 'limburgites' and 'augitites' with colourless base in the Cape Verd Isles and elsewhere, it would be rash to venture an opinion. If the colourless base in the rocks described above can be regarded as analcime, then [4705] may be named a *monchiquite*, and [4706] a monchiquite without olivine, or, according to the distinction made by J. F. Williams, a *fourchite*.

The lavas of Signal Post Hill[1] ("Volcanic Islands," p. 15) are

[1] 'Flagstaff Hill' in Catalogue; 'Mte. Facho' according to Doelter.

again of monchiquitic affinities. One fresh example has been sliced [4711]. It is a dark-grey rock of compact texture, enclosing abundant olivine, which is partly red from incipient change. Different stages of the process of alteration are shown by other specimens, the final product being the "dark jasper-red earthy mineral," with "indistinct cleavage," described by Darwin in a footnote. It is one of the variable and imperfectly-known alteration products of ferriferous olivine to which iddingsite and several allied substances belong. The slice shows the olivine here to be only slightly altered. As usual in these rocks, its crystals are sharply formed, as are those of the less plentiful augite. The latter mineral is very pale brown, with the zonary banding well marked between crossed nicols and sometimes assuming the hour-glass arrangement. There are also grains of black iron-ore and a few small flakes of biotite. The ground-mass is composed of numerous little crystals of augite and magnetite, with interstitial clear analcime and the usual apatite needles. The rock may be named a *monchiquite*. Another sliced specimen from the neighbourhood of the same hill [4712] is closely similar to the preceding, but the colourless interstitial matter shows some difference. For the most part it is isotropic, and may probably be set down as analcime, though the cleavage is not so evident as in the other slice. There are, however, patches, not distinguishable from the rest in natural light, which are birefringent, and are probably nepheline. It may be recalled that this mineral is found occasionally in the original monchiquites of Brazil.

The "inland hills of more ancient volcanic rocks" have not furnished many specimens to Darwin's collection, and none of these have been sliced. Fresh examples from the "upper strata" are dark compact rocks enclosing abundant little grains of olivine, and they may be allied generally to the limburgites and monchiquites, though in one case a few slender crystals of felspar are just discernible. The specimens from the "basal strata" are not fresh enough to be diagnosed, and are of close texture without visible crystals. They have a yellowish-white colour, with ferruginous staining, and it is possible that they are, as Darwin supposed, of trachytic nature, though Doelter found no true trachytes in the Cape Verd Isles.

Several specimens are described in the Catalogue as "various crystalline rocks forming more central part of island," and are stated to come from north-west of Porto Praya, without closer specification. They evidently belong to the same group of lavas as those found in the coast district, and may be from some of the same flows. One example sliced [4707] is a *limburgite* like the one described above from Quail Island [4704], except that the brown glass is here more abundant than in the former case, and encloses only a few minute crystals of magnetite instead of the abundant skeleton growths. Another specimen [4708] is not very different. The porphyritic elements are the same as before, except that the olivine is now replaced by carbonates. In the ground-mass, besides the little crystals of augite, there are others of felspar, giving moderate extinction-angles, and the interstitial base is the usual deep brown glass of the limburgites.

A specimen from the precipice surrounding the village of S. Domingo ("Volcanic Islands," footnote on p. 20) shows the usual abundant crystals of olivine set in a dark compact ground-mass, but a thin slice [4714] brings out certain differences. The olivine crystals are transformed, marginally or sometimes totally, into a deep red-brown mineral, having a high birefringence comparable with that of the olivine but with oblique extinction. There are also a few small flakes of biotite in the rock. The general ground-mass shows abundant minute crystals of augite, with some of magnetite, in a colourless base, enclosing very abundant needles of apatite. The base is in part isotropic, doubtless analcime, but largely of a birefringent mineral, which seems to be felspar rather than nepheline. Much of it has the appearance of sanidine. In places, however, the interstitial material has segregated out into relatively large clear patches, and these consist partly of analcime, partly of a lamellated plagioclase with low extinction-angles.

It appears from the foregoing notes that the prevalent types of lavas in the southern part of this island are of highly basic or ultrabasic composition, and belong principally to the limburgite-monchiquite group, though including some aberrant varieties. There remain to be noticed the phonolites, which may perhaps be regarded as the leucocratic complements of the preceding. Darwin remarks that, among the trachytic-looking rocks which make the lower parts of the flat-topped hills inland from Porto Praya he found in three places "smooth conical hills of phonolite, abounding with fine crystals of glassy felspar, and with needles of hornblende" ("Volcanic Islands," pp. 19, 20). In the Catalogue two of the specimens are described as from 'paps' peeping up among the "various crystalline rocks" (limburgites, as we have seen) north-west of Porto Praya, and the third from "pap-like hills composed of vitreous felspar" north-east of Porto Praya. Darwin's account seems to imply, though not very clearly, that their relations are intrusive, but Doelter terms these little hills 'Kuppen.' The specimens show fresh crystals of sanidine, up to ½ inch in length, in a compact ground-mass of lighter or darker shades of grey, with the characteristic lustre imparted by abundant nepheline. While belonging to the *phonolite* family, they exhibit considerable variety of characters. The three specimens sliced illustrate as many different types, and they differ also from one described by Doelter[1] from the same neighbourhood.

In the first type of phonolite [4710] the porphyritic elements are sanidine and ægirine, with some crystals apparently of altered nepheline and a few octahedra of magnetite. The ægirine is green, with fairly marked pleochroism, and much of it occurs as aggregates of little crystals making pseudomorphs after larger crystals. The ground-mass, constituting the greater part of the rock, is composed of very abundant little crystals of nepheline with sanidine.

In the second type [4709] the porphyritic elements are more abundant, and include a greater variety of minerals. In addition to the large sanidines there are well-shaped crystals of nepheline, fairly

[1] Op. cit., pp. 88–91, with chemical analyses. The word 'nephelinarmen' at the beginning of the description should be 'nephelinreichen.'

numerous little dodecahedra of sodalite, turbid in the interior, abundant green pyroxene and deep brown melanite, and some rather irregularly-shaped crystals of pale sphene. The pyroxene is an ægirine-augite with strong pleochroism in bluer and yellower shades of green. The extinction-angle in vertical sections scarcely exceeds a value of about 30°. In one clinopinacoidal section the main part of the crystal gives 32°, while a border of rather deeper colour gives 27°. The ground-mass of the rock, with well-pronounced flow-structure, is composed of sanidine, nepheline, and a pyroxene, apparently ægirine, while slender needles of apatite are seen in places.

The third type of phonolite [4715] differs from that last described in carrying hornblende. The sanidine, nepheline, sodalite, ægirine-augite, and melanite are present as before, and the ground-mass is of nepheline, sanidine, and ægirine, with fluxion-structure. The hornblende crystals are idiomorphic, usually twinned, and in colour from brownish-green to greenish-brown in the thin slice. They have been corroded by magmatic resorption, the product of this reaction being green ægirine-augite, which mineral also occurs separately in small idiomorphic crystals. It appears probable that the aggregates of ægirine crystals noted in the first type [4710] have likewise been formed at the expense of hornblende, the transformation in that case being complete. It may further be enquired how far the seemingly independent crystals of pyroxene in these rocks may be due to the breaking-up of such aggregates, which originated as resorption-pseudomorphs after hornblende.[1] If there be any truth in this suggestion, Doelter's distinction between augite-phonolites and hornblende-phonolites may perhaps mark no very essential difference. It is noteworthy that, in the phonolite from this neighbourhood which he studied, the two generations of pyroxene were found to differ greatly in composition, the one being an augite containing but little soda, and the other apparently an acmite or ægirine with a remarkable content of manganese.

The tephrites, basanites, felspar-basalts, and nepheline-basalts recorded by Doelter from various parts of the island of Santiago do not seem to be represented in the "Beagle" collection, so far as can be judged from megascopic characters; and the prevalent types in the district of Porto Praya are doubtless fairly illustrated by the specimens which we have selected for examination.

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## III.—The Relation of the Concretionary Nodules of the Yarra to the Calcareous Nodules known as 'Coal-Balls.'

By M. C. Stopes, Ph.D., D.Sc., Lecturer at Manchester University.

SPHEROIDAL concretions from the Yarra estuary which were found to contain plant-remains were described by Mr. Chapman recently in this journal.[2] The structures in themselves are of

[1] A like question has been raised by Washington with reference to the augite-grains in many hornblende-andesites: Journ. Geol., vol. iv (1896), pp. 273–278.

[2] F. Chapman, "On Concretionary Nodules with Plant-Remains found in the Old Bed of the Yarra at S. Melbourne; and their Resemblance to the Calcareous Nodules known as 'Coal-Balls'": Geol. Mag., December, 1906, p. 553.

considerable interest to geologists, and also to palæobotanists fro
fact that they contain "matted fragments of woody and foli
material." They were made the subject of some comparisons
the calcareous concretions from the Lancashire Coal-measures, a
a result certain general considerations were brought forward,
call for comment, and which are of sufficient importance to r
attention.

In the first place, the comparison which Mr. Chapman
between the Yarra concretions and the English 'coal-balls' is l
justified by the facts when they are carefully considered. By
who have a practical acquaintance with the English Coal-me
the 'coal-balls' or calcareous concretions which are found actua
the coal itself are at once recognised as being very different in
nature, formation, and occurrence from the clay ironstone o
nodules which are found widely distributed in the various beds
Carboniferous, and which also contain fragments of plants in
cases. Yet, though it is with the latter that the Yarra concr
more nearly approximate, it is to the former that Mr. Chapma
compared them. Nevertheless, he calls them 'clay nodules
describes the clayey nature of their outer layers, and states that
microscopic examination the matrix "was seen to consist of q
grains, fine calcareous and argillaceous particles, brown woody
and valves of the marine diatom *Actinocyclus*." Further, the r
from the nodule was shown, after treatment with H Cl, to con
"a fine angular quartz sand, the grains of which have a dia
varying generally between ·1 mm. and ·018 mm. Some tourn
and zircon crystals were also present." None of which things,
knowledge (except the woody tissue and the calcareous matte
in the least characteristic of the true 'coal-balls,' which are sing
free from such materials. Of the coal-balls I have examined
hundreds, both *in situ* and in the laboratory, and have also fo
the results of the many analyses which have been done for the
work I have been undertaking.

Mr. Chapman continues:—"From the occurrence of the nod
the sides of the old river channel, and seated in depressions, w
reasonably assume that they received their form in 'kettl
'potholes' in the clay bottom of the river bed." These facts,
are fundamentally opposed to those that hold for the Yorkshi
Lancashire 'coal-balls,' which occur neither in old river channe
in 'kettle' depressions, but are found in a normal seam replaci
coal in local patches, in which the stratification of the coal roun
is regular and undisturbed, and shows none of the 'swirling
suggested by Mr. Chapman for the cause of the rounded form o
concretions. When Mr. Chapman enters into the theory of
mode of formation he reveals that he is seriously hampered i
attempt by want of facts and an intimate knowledge of the
details of the case of the Lancashire and Yorkshire 'coal-balls.'

Though superficially the Yarra concretions and those of the E
coal-seams may appear to be similar structures, yet I thin
enough has been said to show that they are of fundamentally di
construction and mode of origin.