Geol. Soc. Glasgow, 1890 (or 1891), described as that of the Carboniferous *Estheria tegulata*, Jones, at p. 84. In *E. tessellata*, an allied form (*ibid.*, p. 82, pl. v, figs. 2-4), a similar arrangement is also shown of a concentric being crossed by a radial system of structural lines.

The Figs. 3d-g, Pl. XI, GEOL. MAG., 1897, pp. 289-293, might be regarded of special interest as showing how much the interstitial bar-ornament may be sometimes developed into superficial radials; but the intermediate stages are wanting. In *Estheriella* the radials certainly have the appearance of having been due to pressure at nearly a right angle to the vertical height of the valve, giving the sharp radials in Figs. 11 and 13 of Pl. II, GEOL. MAG., 1891. What may perhaps be looked upon as obscure traces of *radials* (regarded at the time of description as probably the remains of pressure wrinkles) are visible in the figure of *Estheria Greyi*, GEOL. MAG., 1878, Pl. III, Fig. 1. Better and more numerous specimens are wanted for further detailed examination.

EXPLANATION OF PLATE II.

- FIG. 1.—Malayan specimen 'B.' *Estheriella radiata* (Salinas), var. *multilineata*, nov. A pair of valves, lying open, with the outer surface exposed. Magnified 3 diam.
 ,, 2.—Malayan specimen 'A.' The same species. A pair of valves, lying open and exposing the insides. Magnified 3 diam.
 ,, 3.—Malayan specimen '10.' The same species. Dextral valve. Magnified $\frac{3}{2}$ diam.
 ,, 4.—Malayan specimen '10.' The same species. Part of the surface of Fig. 3. Magnified 8 diam.

III. — NOTES ON SOME ROCKS FROM ARARAT.

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S.

DURING a journey through Russian Armenia in 1893 Mr. H. F. B. Lynch ascended Ararat and collected a number of small specimens from that mountain and other parts of the country. These, after his return, he placed in my hands, requesting me to examine them. At that time he intended to include my report in a book then in preparation, which was completed after a second journey (through the Turkish provinces) in 1898.¹ On this occasion he was accompanied by Mr. Felix Oswald, B.Sc., who studied the geology of the country and collected numerous specimens. Mr. Lynch accordingly decided to omit from his work all geological details, and leave these to be dealt with separately by Mr. Oswald. But some time must still elapse, owing to the pressure of official duties, before he will have completed the work, and as they did not, on the second journey, go near Ararat, I have decided, since the mountain has so much historic interest, to publish my notes, though a little has already appeared on this subject. Herr H. Abich, to whose unwearied labours we are so greatly

¹ "Armenia: Travels and Studies." 2 vols. Longmans, 1901. The ascent of Ararat is described in chs. xi-xiii (vol. i).

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Hedley, Proc. Acad.

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J. F. Waddington, Ltd.

Triassic *Estherella* from the Malay Peninsula.

indebted for information about the geology of Asia Minor, ascended Ararat on July 29, 1845,¹ and Dr. F. Becke² has described the microscopic structure of three specimens which he brought down. One is from the summit, another from a parasitic cone, Takjaltu, on the south-east slope, and a third from the same slope of Little Ararat. Mr. Lynch's collection, as will be seen, is a much larger one, so that it gives a more complete idea of the materials of the mountain.

The volcanic mass of Ararat, a natural monument to mark the place where three empires meet, rises at one end of the Aghri Dagh range from a rudely elliptical base measuring about 28 miles from N.W. to S.E. by 23 miles in the transverse direction. The mountain viewed from the north, where it is seen towering up to some 14,000 feet above the Araxes valley, shows a long ridge, its eastern end crowned by the fairly steep cone of Little Ararat (12,840 feet), from which it descends to about 9,000 feet, and then rises, at first gently, afterwards more sharply, to the snowy pyramid of Great Ararat (16,916 feet).³ On its northern side a chasm or glen runs up towards the summit into the heart of the mountain. This also was visited by Mr. Lynch, who informs us that in 1840 it was to some extent modified by an earthquake.

Great Ararat.

In his ascent of Ararat he encamped first at a height of about 7,500 feet in an upland valley on the northern side of the depression (about 8,800 feet) between Little and Great Ararat, and for the second night on the south-eastern side of the latter, at an elevation of 12,194 feet. A specimen marked Great Ararat Camp (A) is a dark-gray rock containing numerous whitish felspar crystals (up to about 0·1 inch in diameter) and some minute vesicles. Microscopic examination shows a base consisting of a light-brown glass crowded with minute prismatic microliths and speckled with opacite. In this ground-mass are scattered grains of hematite or magnetite and crystals of plagioclase felspar.⁴ The latter frequently contain numerous glass enclosures with vacuoles, which not seldom are crowded in an outer zone of the crystals. Pyroxene also occurs, and although the grains of it have a general resemblance, there is probably more than one species present. Some exhibit slight pleochroism and straight extinction, indicating a mineral akin to

¹ For early ascents of Ararat, see *Alpine Journal*, vol. viii, p. 213.

² H. Abich: "Geologische Forschungen in den kaukasischen Ländern," iii, 102. A general description of the chief varieties is given by Dr. Parrot, who made the first ascent in 1829 ("Journey to Ararat," p. 198, N.D.).

³ This is the height given by Mr. Lynch; other authorities make it 17,100 feet. The snow-line in Summer is about 13,500 feet.

⁴ I prefer to leave this indefinite name in all these rock-specimens. Many of the crystals are not fitted for measurement by reason of enclosures, etc. Others give indefinite results, but in most of the specimens I have identified labradorite, and more than one species is present, the microliths agreeing better with oligoclase. I have thought it needless to note the variations in size. The largest (in B, b, 1) is about ·08 inch long, but they commonly range from about ·06 inch downwards, the pyroxenes running a little smaller.

amblystegite, while in others the extinction angle varies, being once or twice large enough for augite.

"Below the summit of Great Ararat (B)." Twenty-eight rock fragments, some of them very small, were collected just below the summit¹ of Great Ararat, at about 16,700 feet. They vary much in colour and aspect, but probably include only three or four varieties.

One group (B, a) appears to be represented in its freshest condition by a dark-grey rock resembling that already described, and the microscope shows no great difference. The glassy base is a little more ferrite-stained and has fewer distinct transparent microliths; the plagioclase feldspars have fewer and smaller glass enclosures; the pyroxenes are similar, one or two being certainly augite.

A second group (B, b, 2) is represented in its freshest state by a slightly darker, more porous, more porphyritic rock. A slice of it shows a larger amount of glass than the others, this being of a rich brown colour with granules of opacite and a fair number of transparent microliths. In it we find grains of iron-oxide (hematite in part); plagioclase feldspars, generally idiomorphic, occasionally with rather abundant glass enclosures in the larger specimens (probably from partial melting), and a light-brownish pyroxene, some crystals of it certainly augite, perhaps one or two amblystegite.

Three specimens (B, b, 1) of a blackish glassy material studded with small crystals of white feldspar. The specific gravity of one specimen is 2.483.² A slice cut from one of the specimens shows a glass which exhibits a fluxional structure and is present in larger amount than in any of the other rocks. It is generally brown, but with almost colourless streaks, is studded with microliths, both minute belonites and small prisms apparently of feldspar, and is slightly spotted with granules of iron-oxide. In this base are crystals, sharp-edged, broken, or rounded, of plagioclase feldspar, magnetite, or hematite, hornblende and amblystegite. Glass enclosures in the feldspar are small in size and variable in amount, in several cases developed mostly in the exterior zone. The rock is a pitchstone (andesite).

A number of light-coloured fragments (B, 6) varying from yellowish-grey to almost white, the differences probably being due to the amount of decomposition. A specimen sliced shows the rock to be less well preserved than the others, but its differences are only varietal. It also contains amblystegite.

The description of Herr Abich's specimen, said to come from the summit of Great Ararat (on which no rock was exposed when Mr. Lynch reached it), agrees so closely with that given above under B, b, 1, that I have little doubt the rocks are substantially identical. His specimen contains a rhombic pyroxene which Dr. Becke names bronzite, but which I think would now be regarded

¹ The highest rock visible at the time of Mr. Lynch's visit.

² Determined by Walker's balance.

as amblystegite, and a green non-pleochroic augite instead of the fairly pleochroic (brownish-green) hornblende.

The specimen from the Takjaltu, a parasitic cone on the south-east slope of Ararat, must have come from the main pyramid not very far from Mr. Lynch's line of ascent. It is "a pale grey compact porphyritic rock, with plagioclasic felspar and a little sanidine, glass enclosures being frequent, sometimes forming a kind of network. A pale green, almost colourless augite is rather rare, with remnants of a strongly pleochroic hornblende (a pale yellow, *b* red - brown, *c* brown - red) and a pale green, almost colourless bronzite more abundant than either."¹

A specimen from the south-east side of Little Ararat is a porous bronzite-augite andesite, in which Dr. Becke recognises oligoclase or andesine, rich in glass inclusions, magnetite, a green augite, and 'bronzite' in long thin prisms up to .06 inch.

Chasm of Arguri (Great Ararat).

Three are labelled as "typical stones." Two of these (C) are yellowish-brown fragments, obviously rotten lava. The third (D) is a compact darkish-grey rock, speckled with lightish-grey. A slice of this exhibits only varietal differences from some of those already described; the base is nearly that of the specimen A. There are crystals of felspar and of pyroxene as before, though the former are not quite so large as usual.

Of the other rocks (E) from Arguri, three appear to be consolidated andesitic ash or fine breccia; three are lavas in a very decomposed condition; one is a slightly porous reddish rock, with small crystals of glassy felspar, probably allied to some of the varieties already described; and another is a similar rock of a more glassy aspect and deeper red colour, both the felspars and the glass intervals being slightly larger. A slice from the last shows the actual glass to be fairly clear, but it is studded with very minute, slightly brown microliths, and contains a large number of rodlets of iron-oxide. It exhibits a fluxional structure. The porphyritic minerals call for no special remark except that the rock is rather deficient in pyroxenic constituents.

Little Ararat.

Two rocks² (F), one evidently a grey andesite similar to those already described, the other pinker in tint, probably much the same kind but rather decomposed; it may be this rock which gives the peak its dominant violet hue. Microscopic examination shows the former to be a pyroxene-andesite with only insignificant varietal differences from the grey rocks already described. Pyroxene is not very abundant, but among it is augite, perhaps also amblystegite.

A third specimen (G) is a rock of generally similar structure, but of more brick-red colour. (It is stated to give a pinker tinge to some parts of the peak.) This exhibits some slight differences under

¹ A condensed translation of the original description.

² Said to be typical of the dominant rock of the peak.

the microscope. Its base is a sienna-brown glass, containing numerous felspar microliths, with some grains of hematite, perhaps also of pyroxene. In this are plagioclase felspars, much as usual, and some pyroxene crystals, most of which appear to be augite.

Other Rocks from Little Ararat.

Three specimens (H). One is a slightly porous, dark rock, with small crystals of lighter-coloured felspar; another a similar rock, but a little more porous, and the felspar slightly less conspicuous; both these weather an Indian-red colour, and the latter is slightly streaked with that tint. A third rock is a piece of vesicular scoria of a purplish-brown colour, weathering red. The microscope shows the base of the first specimen to be a rather light-brown glass (containing numerous acicular microliths and grains of opacite) in which are scattered many felspar crystals of various sizes, up to about 0.11 inch, the larger not unfrequently broken and sometimes full of glass enclosures. There is also some augite, distinct amblystegite, and iron-oxide. The larger minerals are pretty clearly of a distinctly earlier date than the final consolidation of the rock. The second specimen shows only varietal differences from the other one; the glass is rather browner, the felspar crystals do not run quite so large, and augite distinctly predominates over amblystegite. The arrangement of the glass enclosures in some of the felspars suggests that they have been produced by a local melting down rather than by inclusions of magma. The ground of the red streaks under the microscope is a richer red, more like that of G. These two rocks most resemble B, b, 2.

General Remarks.

So far as we can infer from these specimens, the rocks of Ararat, considering its size, exhibit surprisingly slight differences. They are augite-andesites, varying slightly in the nature of the glassy base, the size of the felspars, the occasional presence of a hornblende, and the amount of amblystegite, which mineral, however, probably is rarely quite absent. The larger felspars are sometimes corroded or broken, and not unfrequently an outer zone may be distinguished, by either containing more enclosures, or being more free from them, or extinguishing at a slightly different angle. The enclosures apparently are of five types—(a) small separate microliths or mineral granules, in some cases possibly a pyroxene, (b) very minute belonites, associated in clouds, (c) minute dust, (d) brownish glass, (e) cavities. Where one or more is conspicuous this is noticed above, and I am disposed to regard the glass enclosures as more often results of partial and local melting in a crystal owing to irregularities of chemical composition than to enclosures of the original magma.

Aghri Dagh.

This name is applied to the range of which Ararat forms the eastern bastion, and sometimes even to that mountain. It is nearly 100 miles in extent, its peaks rising in one case to more than

11,000 feet above sea-level, and its passes 7,000 to 8,500 feet.¹ It was crossed by a pass south of Kars (slightly to the west), from some part of which these specimens must have come (see vol. i, ch. xx). The rocks are said to be granite, diabase, etc.

A fairly coarse gneissoid rock (L, 2) is composed of quartz, pale pinkish buff felspar, and a green mineral. Under the microscope it is seen to consist of quartz, felspar (plagioclase apparently predominating), and a green chlorite. The rock, on examination with crossed nicols, seems to have been much modified by pressure, although now it is completely cemented. The larger grains of quartz have a fragmental aspect, and much of the mineral proves to be a mosaic of small grains, with a slightly streaky arrangement. The felspar has the same aspect, and some of the crystals are breaking up into a mosaic of small granular feldspars with a few flakes of white mica, the latter occurring elsewhere in the slide, though sparingly. The green mineral is apparently a chlorite, and there are also two small garnets and one or two zircons. From its general aspect I should consider the rock to be very old, as considerable mineral changes have occurred since it was acted upon by pressure.

Two specimens of a compact dull reddish-purple rock. It is found, under the microscope, to consist of long microlithic crystals of plagioclase felspar imbedded in a ferrite-stained base, and is not in a good state of preservation. Probably it comes near to the basalts, and formerly would have been called a melaphyre. The specific gravity is 2.709. A veined specimen appears, from the label, to be connected with this, though the rock itself is greener in colour, more like the next in order. The vein chiefly consists of calcite and epidote, with some iron staining.

A compact dull green rock (K), slightly veined with calcite, which forms jagged ridges, between Kagizman and Karakilisa, running like walls from north to south. Under the microscope it is found chiefly to consist of two minerals, the most abundant, green, probably a hornblende; the other, clear and colourless, most likely replacing a felspar. Iron-oxides and some small sphenes are present. The rock may be named a diabase, probably forming dykes.

Mr. Lynch brought back about a dozen specimens representing rocks which had attracted his notice during the rest of his journey, the majority being limestones from the neighbourhood of Lake Van. But as he returned to this district during his second journey, I have transferred my description of them to Mr. Oswald, with the exception of two specimens of a serpentine which my interest in that rock induces me to publish. One, with the label "On the road behind Akhtamar (Lake Van)," is a dark-green serpentine with some lighter streaks and with oblique slickensided surfaces, sometimes partially coated with cream-coloured or green steatite, giving to the specimen a rather lenticular form. Under the microscope the

¹ See Lynch, "Armenia," vol. i, p. 414 et seq., and vol. ii, p. 384.

serpentine indicates severe crushing (the flaky minerals often resembling antigorite), and contains a few much altered bastite crystals and powdered magnetite, more or less in streaks. It must originally have been a Saxonite, and in its present condition could be matched from several parts of the Alps. The other is labelled "Erzerum-Trebizond. Gorge beyond Pirnakapan. Kop Dagb."¹ It is a dark rock with an external steatitic film, generally greenish-white, but assuming a blue tinge where very thin. The specific gravity is 2.72. Microscopic examination shows it to consist of olivine partially changed into serpentine, bastite, in parts replaced by a mineral with slightly oblique extinction (? tremolite) or a minute fibrous one transverse to and obliterating the cleavages, magnetite in grains and occasionally in a powder (perhaps the latter sometimes hematite). The olivine is less altered than the bastite, for the former in most parts is only in the first stage of change, thin strings of serpentine occupying the cracks. Thus the rock is a partially serpentinized Saxonite not materially affected by pressure.

IV.—ON THE AGE OF THE GEBEL AHMAR SANDS AND SANDSTONE, THE PETRIFIED FOREST, AND THE ASSOCIATED LAVAS BETWEEN CAIRO AND SUEZ.

By T. BARRON, A.R.C.S., F.G.S.

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THE geological age of these beds has been the subject of much speculation by various geologists. In 1845 Orlebar² claimed to have found the Gebel Ahmar Sandstone at No. 3 Station on the Old Post Road to Suez, overlying Miocene beds containing *Scutella Zitteli*. O. Fraas³ in 1867 imagined he could trace a gradual passage between the Upper Moqattam and these beds, and concluded, therefore, that they were of marine origin and Lower Oligocene age, as they had undergone the same general earth-movements as the Eocene beds.

Dr. Schweinfurth,⁴ discussing the age and origin of these beds, says that there are two reasons for concluding that they are not marine: (1) they occur at different levels in various localities, and (2) they rest on a very uneven surface which does not differ much from the present-day relief. He, in fact, considers that the present-day relief of the surface had already been inaugurated before these beds were laid down. He also calls attention to the resemblance existing between the Pliocene sands in the Nile Valley and these beds, and finally groups them together in his map as (?) Pliocene.

¹ Lynch: "Armenia," vol. ii, p. 229.

² "Some observations on the Geology of the District between Cairo and Suez": Journ. Roy. Asiatic Soc., 1845.

³ "Aus dem Orient," 1867, pp. 157-8.

⁴ "Geol. Schichtengliederung d. Mokattam": Zeitschr. d. Deutsch. Geol. Gesells., 1883, p. 719 et seq.