Notes on the Microscopical Structure of some Eruptive Rocks from Armenia and the Caucasus.

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In 1881-1882 Dr. A. Brotherus and his brother, A. H. Brotherus, made a botanical tour in Armenia and the Caucasus; the younger gentleman collected a few specimens of rocks met with during their journey, which, on his return, he kindly left to be examined by me.

This material consisted of later eruptive rocks; it was scanty, but as it was obtained in places from which we have no earlier information of a similar character, I have not thought it uncalled for to make in the following lines a slight contribution to our knowledge of the geognosy of the regions in question.

The microscopical analysis of rocks from the Caucasus made by Tschermak, Lagorio, and Möhl[1] relate in part to the identical rocks that I shall describe, but the localities are different.

The augite-andesites collected by Favre and described by Tschermak[2] are specimens from Kasbek and its vicinity; those again collected by Abich and described by Lagorio[3] are from Kasbek, Ararat, and Kobi. The material at my disposal, consisting of *liparite*, *augite-andesite* and *obsidian*, was mostly found along the general caravan road between Alexandropol in the Caucasus and Charput in Turkish Armenia.

To begin with *liparite*.

Liparite from Kars.—To the naked eye this rock exhibits the following appearance. In a reddish brown cryptocrystalline ground-mass we find porphyritically embedded minute sanidine crystals measuring 1·5-2 mm. in length and 0·5 mm. in breadth. On older fractures the otherwise clear sanidine has by decomposition assumed a yellowish tint. Under the microscope the ground-mass is found to consist throughout of a light-brown microfelsitic substance, in which sanidine, quartz, and a few glass particles are embedded. The sanidine crystals are of vitreous lustre, often

[1] Möhl, *Kaukasische Gesteine, Naturwiss. Ges. Isis.* Dresden, 1878.

[2] *Tschermak, Felsarten aus dem Kaukasus, Min. Mitth.* 1872, 2 Heft. p. 107; and *Min. Mitth.* 1875, p Heft. p. 131.

[3] *Lagorio A. Die Andesite des Kaukasus, Dorpat* 1880.

coloured yellow-brown by decomposition-products of iron which occur in the numerous fine cracks by which they are traversed. They constitute exclusively simple crystals, extinguishing parallel with the traces PM and lM. Frequently the sanidine crystals are broken and cut off, and the ground-mass is pressed in between the fragments. The sanidine does not contain any interpositions. (Fig. 1.)

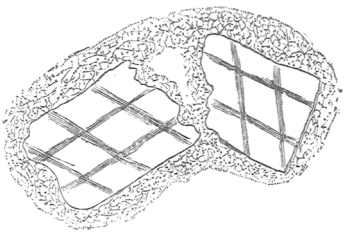

Fig. 1.

The quartz grains embedded in the ground-mass are distinguished by their unusual translucency and by the particularly sharp-defined outlines of their edges. They do not contain interpositions any more than the sanidine.

The glass particles lying scattered in the ground-mass have a dirty-grayish, and are sometimes tarnished of a brown or greenish colour by the action of iron oxide.

As accessory component parts there are apatite and magnetite, the last-mentioned decomposing into red oxide of iron.

Liparite from Charput.—Macroscopically this variety of liparite differs considerably from the preceding one. To the naked eye there appear in the grayish-green microcrystalline or dense ground-mass, porphyritically embedded sanidine crystals, as well as crystals of quartz. These last-mentioned are here, as in the preceding rock, clear and well developed, with exceedingly sharp outlines against the ground-mass.

Under the microscope the ground-mass of the liparite exhibits a well marked microfluxion structure. The sanidine crystals and the quartz individuals are lying in the ground-mass as if immersed in it. Under high microscopic powers the ground-mass presents the aspect of a covering or coat of both lenticular and somewhat lengthened glass particles pressed exceedingly close to one another, between and on which are attached numberless minute globulite-like grains of a greenish colour. Not unfrequently the glass base is developed into spherulitic structures. (Fig. 2.)

The quartz individuals lying in the ground-mass contain included small portions of the glass base of the same, but are otherwise destitute

of any interpositions. This last-mentioned is also the case with the sani-

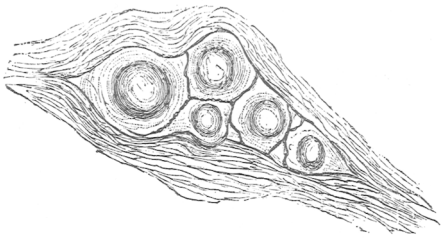

Fig. 2.

dine, which is traversed by numerous cracks and is, to all appearance, doomed to destruction by way of incipient decomposition.

Augite-andesite from Kars.—The macroscopical aspect of this rock is that of a microcrystalline red-brown cavernous mass, in which to the naked eye are to be discerned minute porphyritically embedded augite crystals. Some of the cavities are filled up with secondary brown-iron ore, calcite and chalcedony. Under the microscope the ground-mass of this rock is found to consist partly of an exceedingly fine-grained crystalline aggregate of minute plagioclase columns and augite, and partly of glass base, to which is added a vast multitude of dark particles. The larger of the plagioclase individuals emerging out of this ground-mass constitute lath-shaped parts, lengthened in the direction of the brachy-diagonal axis, and usually polysynthetically twinned, according to the albite law. Frequently they are besides of a concentric-zonal structure. Several sections of these larger plagioclase individuals were examined as to their optical character, the results thereof being the values of the extinction-angles in the below-mentioned zones.

On measuring the extinction-angles on sections in zone PM (0P : $\infty P \infty$) towards the twin-line of the lamellæ on each side of the said line, we obtained the following values :—

$$\frac{35°}{36°} : \frac{34°}{24°} : \frac{32°}{25°} : \frac{29°}{28°} : \frac{33°}{23°} : \frac{30°}{21°} : \frac{35°}{12°\cdot30}$$

When adding the values on each side of a twin-line thus obtained, we get the following figures:—

$$71° : 58° : 57° : 57° : 56° : 51° : 47°\cdot30.$$

Compared with the values arrived at by Michel-Levy[1] and Schuster[2] of

[1] Michel-Levy: *De l'Emploi de Microscope Polarisant, Ann. des Mines*, 1871.

[2] Schuster: *Optische Orientirung der Feldspathe, Tschermak's Min. Mitth.* Bd. III. 1880.

the angle between the extinction-directions in two plates contiguous to each other, these values seem to point to the existence of a plagioclase with a comparatively high percentage of lime.

In a plate intersected by a basal cleavage, the extinction on $\infty \breve{P} \infty$ is —32° towards the trace of $\infty \breve{P} \infty$ and $\infty P'$; a circumstance also holding good of Labradorite. Twin-streaked plates, according to the albite and pericline laws, are but very rarely met with.

The augite participates both in the construction of the ground-mass and in forming the porphyritic constituents. It has a pale green-yellow colour, which in the granules contained in the ground-mass assumes a darker tinge. The large porphyritic augite individuals are clear and translucent, having the shape of a short column, which in a cross-section manifests itself in a more or less uniformly hexagonal termination. The prismatic cleavage characteristic of the augite is frequently conspicuously marked.

Augite-andesite from Masgerth.—Macroscopically this rock exhibits a minutely granular brown-red mass, cavernously corroded on long exposed surfaces, in which augite crystals, 1 mm. in size and of bright green colour, are discernible to the naked eye.

When viewed under the microscope, the rock is found to be crystalline throughout. The finely granulated ground-mass is constituted by plagioclase and magnetite, decomposing into red oxide of iron. The porphyritic portions consist of plagioclase and augite. There is no trace of glass-base in the rock. Most of the plagioclase individuals, either merged in the ground-mass or porphyritically embedded in it, have the shape of a lath elongated in the direction of the brachydiagonal axis, and present an ordinary polysynthetic twin-formation, with a comparatively small angle between the extinction-directions on each side of a twin-seam. Several of them have, however, a more marked rectangular form, lack a polysynthetic twin-formation, and in their central core or nucleus as well as in their borders appear to be constituted by chemically different plagioclase substance. If the terminations of these probably basal sections are placed parallel with the principal sections of the crossed nicols, it will be found that the extinction-angle of the nucleus of the plagioclase individuals is a different one from that of their borders.

The following figures will demonstrate this :—

Border.	ext.	nucl.	ext.
,,	,,—8°	,,	,,—15°
,,	,,—6°	,,	,,—20°
,,	,,—7°	,,	,,—21°
,,	,,—7°	,,	,,—18°
,,	,,—8°	,,	,,—23°

This seems to suggest that the nucleus of these plagioclase individuals consists of some variation of plagioclase with a higher percentage of lime, possibly labradorite, whereas the surrounding matters are made up of a plagioclase with a lower percentage, and are perhaps andesine.

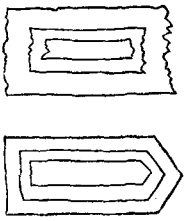

Fig. 3.

The plagioclase individuals contain included brown glass in great abundance, not unfrequently they are bent and broken into minute fragments.

The augite presents under the microscope the appearance of a wine-yellow colour, and shows scarcely any indication of pleochroism. On the other hand, the augite porphyritically embedded almost always occurs with well-defined terminations. Sometimes the augite is clear and free from any enclosed or attached particles. Sometimes, again, these accumulate in the augite in a vast profusion. Among these inter and juxtapositions, consisting partly of fluid cavities with air-bubbles and partly of magnetite (which evinces a great tendency to pass into red oxide of iron), the former are as a rule included in the central parts of the augite, whereas the latter partly in a narrow zone surround the borders or edges of the augite individuals, and partly group themselves in clusters about a larger or smaller portion of their sections. In the latter case, their profusion may sometimes assume such proportions as almost wholly to cover the augite, leaving it but in a few stray places or points to glimmer forth through the covering of the particles attached.

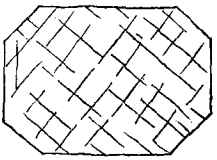

Fig. 4.

Obsidian from Kars.—This volcanic product appears in hand specimens black, is perfectly vitreous, and has a shelly fracture. Not the least indication of devitrification is microscopically to be detected.

In a prepared specimen there appears a variety of zone-like bands of almost exclusively pure glass substance; further, such a substance with enclosed minute colourless rod-like crystals ranged in the same direction, belonites; and finally the identical substance with hair-like black straight or geniculated inclusions, besides minute rounded black grains, trichites.

Fig. 5.

On a comparison of the Caucasian augite-andesites examined by Tschermak and Lagorio, it will appear that the rocks in question do not, like those from Elbrus and Kasben described by Tschermak, contain quartz, but belong to the group of quartz-free augite-andesites.

As has been done by Lagorio, they may further be divided into a pleocrystalline and a micro-crystalline group, the former of them being represented by the augite-andesite from Masgerth, and the latter by that from Kars.