

2. Extracts from Letters to the General Secretary, on the Analogy of the Structure of some Volcanic Rocks with that of Glaciers. By C. Darwin, Esq., F.R.S. Specimens were exhibited. With Observations on the same subject, made by Professor Forbes.

"I take the liberty of addressing you, knowing how much you are interested on the subject of your discovery of the veined structure of glacier ice. I have a specimen (from Mr Stokes's collection) of Mexican obsidian, which, judging from your description, must resemble, to a considerable degree, the zoned ice. It is zoned with quite straight parallel lines, like an agate; and these zones, as far as I can see under the microscope, appear entirely due to the greater or lesser number of excessively minute, flattened air cavities. I cannot avoid suspecting that in this case, and in many others, in which lava of the trachytic series (generally of very imperfect fluidity) are laminated, that the structure is due to the stretching of the mass or stream during its movement, as in the ice-streams of glaciers. \* \* \*

"If the subject of the lamination of volcanic rocks should interest you, I would venture to ask you to refer to p. 65-72 of my small volume of 'Geological Observations on Volcanic Islands.'\* I there

\* The laminated, volcanic rocks of Ascension, consist, as described by Mr Darwin, of excessively thin, quite parallel layers of minute crystals of quartz (determined by Professor Miller) and diopside; of atoms of an oxide of iron, and of an amorphous, black angitic mineral; and, lastly, of a more or less pure feldspathic stone, with perfect crystals of feldspar placed lengthways. The following is a portion of the passage referred to:—"Several causes appear capable of producing zones of different tension in masses semiliquified by heat. In a fragment of devitrified glass I have observed layers of spherulites, which appeared, from the manner in which they were abruptly bent, to have been produced by the simple contraction of the mass in the vessel, in which it cooled. In certain dykes on Mount *Ætna*, described by M. Elis de Beaumont, as bordered by alternating bands of scoriaceous and compact rock, one is led to suppose that the stretching movement of the surrounding strata, which originally produced the fissures, continued, whilst the injected rock remained fluid. Guided, however, by Professor Forbes's clear description of the zoned structure of glacier ice, far the most probable explanation of the laminated structure of these feldspathic rocks appears to be, that they have been stretched, whilst slowly flowing onwards in a pasty condition, in precisely the same manner, as Professor Forbes believes, that the ice of moving glaciers is stretched and fissured. In both cases, the zones may be compared to those in the finest agates; in both, they extend in the direction in which the mass has flowed, and those exposed on the surface are generally vertical. In the ice, the porous laminæ are rendered

throw out the idea, that the structure in question may perhaps be explained by your views on the zoned structure of glacier ice, the layers of less tension being, in the case of the Ascension obsidian-rocks, rendered apparent, chiefly by the crystalline and concretionary action superinduced in them, instead of, as in zoned ice, by the congelation of water.

“How singular it at first appears, that your discoveries in the structure of glacier ice should explain the structure, as I fully believe they will, of many volcanic masses. I, for one, have for years been quite confounded whenever I thought of the lamination of rocks which have flowed in a liquified state. Will your views throw any light on the primary laminated rocks? The laminae certainly seem very generally parallel to the lines of disturbance and movement. Believe me, &c.

C. DARWIN.”

To Professor FORBES.

Professor Forbes confirmed the previous remarks by others, made by himself on the specimens transmitted to him by Mr Darwin, and on specimens from Lipari and Iceland in the collection of the Royal Society, as well as by direct observations made by himself on the lava streams of *Ætna*.

distinct by the subsequent congelation of infiltrated water; in the stony feldspathic lavas by subsequent crystalline and concretionary action. The fragment of glassy obsidian in Mr Stokes's collection, which is zoned with minute air-cells, must strikingly resemble, judging from Professor Forbes's description, a fragment of the zoned ice; and if the rates of cooling and the nature of the mass had been favourable to its crystallization, or to concretionary action, we should here have had the finest parallel zones of different composition and texture. In glaciers, the lines of porous ice and of minute crevices seem to be due to an incipient stretching, caused by the central parts of the frozen stream moving faster than the sides and bottom, which are retarded by friction. Hence, in glaciers of certain form, and towards the lower end of most glaciers, the zones become horizontal. May we venture to suppose that, in the feldspathic lavas with horizontal laminae, we see an analogous case? All geologists who have examined trachytic regions have come to the conclusion, that the lavas of this series have possessed an exceedingly imperfect fluidity; and as it is evident that only matter thus characterized would be subject to become fissured, and to be formed into zones of different tensions, in the manner here supposed, we probably see the reason why augitic lavas, which appear, generally, to have possessed a higher degree of fluidity, are not, like the feldspathic lavas, divided into laminae of different composition and texture. Moreover, in the augitic series, there never appears to be any tendency to that kind of concretionary action, which, we have seen, plays an important part in the lamination of rocks of the trachytic series, or, at least, in rendering that structure apparent.”