

The veinstone being found more or less mixed up with the decomposed rock, appears to indicate that their ages may be identical.

4th. The quartz-trachytes and sandstone are recent, and most certainly Post-tertiary.

APPENDIX.

REPORT on some ROCK SPECIMENS collected by MR. GEORGE ATTWOOD.

By W. H. HUDLESTON, Esq., F.G.S., F.C.S., &c.

Six specimens were carefully examined. Five of these are igneous rocks, having all the appearance of lavas; and although considerable differences exist between some of them, yet four out of the five, and perhaps all five, must come within the category of augite-andesites. The hand-specimens show a dark compact base with numerous crystals of feldspars, *usually small*. Thus the general structure, viewed macroscopically, is micro-porphyritic. In most cases the feldspars are inclined to be vitreous; but in one instance, where the crystals are rather larger, they are of a dull white.

The character of the ground-mass in thin section is seen to range from a trachydolerite, where there is a considerable development of microcrystalline matter, consisting for the most part of acicular prisms of triclinic feldspar, to a rock in which the felsitic texture is in the ascendant and the tendency to doleritic texture is reduced to a minimum.

Generally speaking, the feldspars are fresh, and polarize with considerable brilliancy. They are mostly triclinic, though not without orthoclase (sanidine) in some cases. Without analysis it is impossible to state positively what the triclinic feldspars may be, though probably oligoclase is the most abundant. Judging from the analogy of similar rocks, andesine is also present; but the more basic varieties of feldspar are probably rare or absent.

There is a fair amount of very fresh augite, in crystals which are smaller than those of the feldspars and less numerous. Associated with these augite crystals, and sometimes independent of them, occurs a fair amount of magnetite or pyrite, which in some cases has undergone partial oxidation. The accessory minerals are by no means plentiful, though one may note a stray needle of apatite here and there. If any olivine exists, it must be in very small quantity; but some of the augite crystals are so rounded at the edges that they might perhaps be taken for grains of olivine.

The specific gravity ranges from about 2.55 to 2.80, being on the whole rather low for rocks with some augite and so much triclinic feldspar in addition to a fair proportion of iron minerals. This circumstance is an additional point in favour of the notion that in most cases the bulk of the feldspar is oligoclase. Furthermore the microscopic examination would lead one to believe that the specimens for the most part belong to a class of rocks intermediate between the dolerites and the acidic trachytes.

No. 1. "*In situ*, Paradise Valley." Specific gravity 2.76. Black

compact matrix, full of small crystals of glittering feldspars porphyritically distributed. This rock has undergone but little alteration.

In thin section the ground-mass appears black with a greenish grey tinge. It is opaque and granular, but relieved by a moderate display of small triclinic feldspars. On the whole, however, the felsitic texture prevails over the doleritic or microcrystalline.

The large feldspar crystals are numerous and clean at the edges, contrasting well with the ground-mass. They are probably all triclinic, and polarize with great brilliancy. Some are tolerably free from inclusions; others contain quantities of the base, which frequently occur in fantastic arrangements.

The augite crystals are not numerous, or large, but are well defined, and, like the feldspars, polarize very effectively. There are several specks and triangular pieces, which present the same optical properties and probably belong to the same species. The iron mineral is mostly magnetite, but is far from being plentiful.

No. 2. "*In situ*, La Palma, N.W. of Turrialba." Specific gravity 2.82. A somewhat scanty grey matrix full of crystals of a white feldspar larger than in the last specimen, less vitreous, and rather prone to kaolinize. The augite crystals, associated with some iron mineral, are quite obvious in the hand-specimen, which is less compact and more porphyritic than No. 1.

In thin sections the ground-mass is seen to be grey, opaque and woolly; so that in this case the felsitic texture predominates, to the almost entire exclusion of the doleritic or microcrystalline, notwithstanding the fact that this is the most dense of all the specimens.

The large feldspars are not so clean-cut as in No. 1, and are more contaminated with included portions of the ground-mass, which, in one or two cases, are yet in the condition of glass towards the centre of the inclusions. Still the feldspars polarize with much brilliancy and, with one exception, are all markedly triclinic. Andesine may constitute a considerable portion of them. With great care it might be possible to obtain a sufficiency for an analysis.

The crystals of augite are fairly numerous, smaller as a rule than the feldspars, with a tendency to be grouped in bunches, in which case they are much intermingled with an iron mineral. Some very characteristic forms occur, such as it is impossible to mistake. Pale yellow to greenish yellow in ordinary light, all these augites polarize very effectively, in which case the numerous inclusions of the same mineral are very conspicuous. When the angles are rounded, such crystals become oval or almost circular in section. The iron mineral, presumably magnetite, in some cases evinces a tendency towards the formation of limonite at the edges; and this rust-coloured stain is communicated to some of the crystals of feldspar and augite. There are appearances also of pyrites in a limited portion of the polished surface from which the slice has been cut.

No. 3. "San Mateo Boulders." Not examined closely. Near to No. 1, but with a more felsitic ground-mass.

No. 4. "Black Rock, Lower San Rafael Level." Specific gravity 2.72. A very compact rock, brownish-black, lustreless, and but

slightly conchoidal in fracture. Largely charged with small crystals of pyrite, chiefly in cakes. Contains crystals of a somewhat vitreous felspar in moderate amount, together with some augite. Structure microporphyritic.

In thin sections the general mass appears of a brownish black colour, very opaque and granular, but relieved by numerous small prisms of triclinic felspars, more than in any of the other specimens. In this case the granular or felsitic texture and the microcrystalline or doleritic texture occur in almost equal amount. It would seem therefore to be a well-balanced trachydolerite.

This being less porphyritic than the two previous specimens, the large felspars are not so numerous, and are, on the whole, in worse condition. The inclusions of ground-mass in the crystalline matter are less well contrasted; and in some cases a certain amount of granulation has supervened. Still the crystals polarize fairly well, though the triclinic character is not so strongly marked, and there are appearances which would lead one to suspect interlamination or mixing of orthoclase. A crystal or two of sanidine may be noted.

The augites are mostly small, and not very numerous. Besides one or two characteristic forms, frequently much rounded at the angles, there is one large triangular piece with well-defined edges which evidently belongs to this variety of pyroxene. Pyrite and, perhaps, magnetite occur sporadically in small crystalline forms; and, besides this, the opacity of the base is much increased by numerous small dots of ferrite, which may include both the previously mentioned species.

No. 5. "Cartago Rock." Specific gravity 2.54? A trachytic rock; matrix close, and of a grey colour, rather prone to fracture, and studded with felspars, mostly glassy and brittle. The specimen examined was very full of air, owing to cracks and to the cavities resulting from the fractured crystals of felspar.

In thin section the ground-mass appears greyish; it is highly felsitic in texture, there being but little trace of microcrystalline matter. Hence this specimen scarcely comes within the group of trachydolerites, but approaches the acidic trachytes more than any of these lavas. The ground-mass occupies a large proportion of the slice.

Most of the felspars, even in this specimen, are triclinic, and are probably mainly oligoclase, but with some which I take to be sanidine. The inclusions are small and mostly granulated, like the base, but occasionally in a state of glass. As a whole they are in good condition, and polarize with great brilliancy. Many of the felspars break out on grinding, so that it has not been easy to select a slice sufficiently free from flaws.

The augites are fairly numerous; one long greenish crystal is more dichroic than the rest, and may be slightly altered. Several of the crystals, as usual, have their angles much rounded, presenting in one or two instances a pyriform shape. The majority are fresh, and polarize well. The iron mineral is mostly magnetite, often in well-defined octahedra, but in some cases having a tendency

to further oxidation at the edges. The smaller ferrites are not numerous.

There is an anomaly in connexion with this specimen which, unless due to faulty observation, one cannot well explain. A rock with a fair amount of triclinic felspar, presumably oligoclase, and some augite might be expected to have a higher specific gravity than 2.54. Even the lightest sanidine-oligoclase-trachytes are stated by Von Cotta to have a specific gravity of 2.6. It is just possible that the specimen contains cavities not accessible to water under ordinary pressure.

No. 6. "Los Castros rock, Aguacate Mountains." Specific gravity 2.78. An extremely close-grained rock of a dark-green colour and subconchoidal fracture, with only a moderate quantity of felspar crystals porphyritically distributed. Pyrites in small crystals, not scarce.

In thin sections the ground-mass appears of a greenish-grey colour, and is woolly and thoroughly dusted with small round ferrites, opaque, and little relieved by microcrystalline matter. Hence the texture is felsitic rather than doleritic.

The felspars are probably all triclinic. Though perfect in outline, they are so much suffused and granulated as to suggest the idea of partial decomposition; consequently their optical properties are feeble, and they stand out less distinctly from the base.

The augites polarize with great brilliancy, and are very characteristic. The iron minerals, probably both magnetite and pyrite, seem much mixed up with the augite crystals.

The augites constitute the principal feature in this rock, whose ground-mass is obviously more tinged with green in the vicinity of these groups of crystals than elsewhere. If the idea of greenstone were not so much associated with hornblende, of which I cannot in this specimen find a trace, one might almost call such a rock a "greenstone-andesite." In some respects it reminds me forcibly of certain "felsi-dolerites" occurring in the English lake-district.

No. 7. "Volcanic nodule, Turrialba." The specific gravity of this specimen is low. It is a light-grey fragmental rock, tolerably close in texture, and in the hand-specimen shows a somewhat gritty matrix with black specks. Tolerably opaque in thin sections, but slightly seamed with translucent cracks. The few crystalline fragments are much decomposed, and muddled with a brownish ferrite; specks of augite may be noticed.

The rock is doubtless pyroclastic; and if we may judge from the lavas previously described, it is a felspathic tuff largely made up of soda felspars.

No. 8. "Near Rio Barranca." Not examined closely. More coarsely fragmental than the last. Largely made up of soda felspars much kaolinized.

EXPLANATION OF PLATE XII.

Geological Map and Section from Punta Arenas, on the Bay of Nicoya, to the Volcanoes Irazu and Turrialba, Costa Rica.

DISCUSSION.

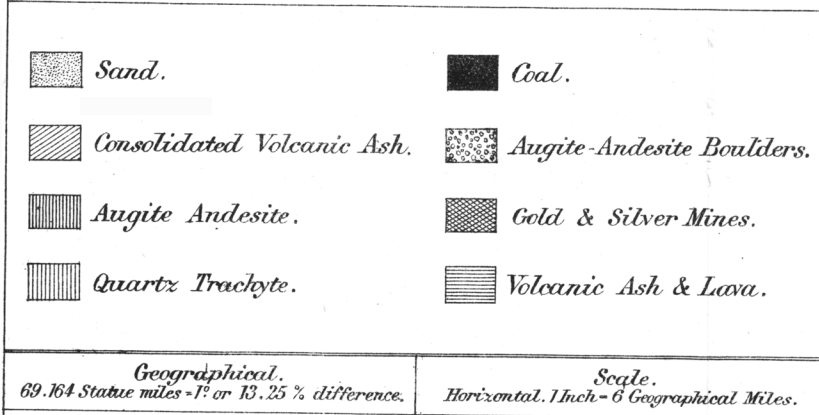
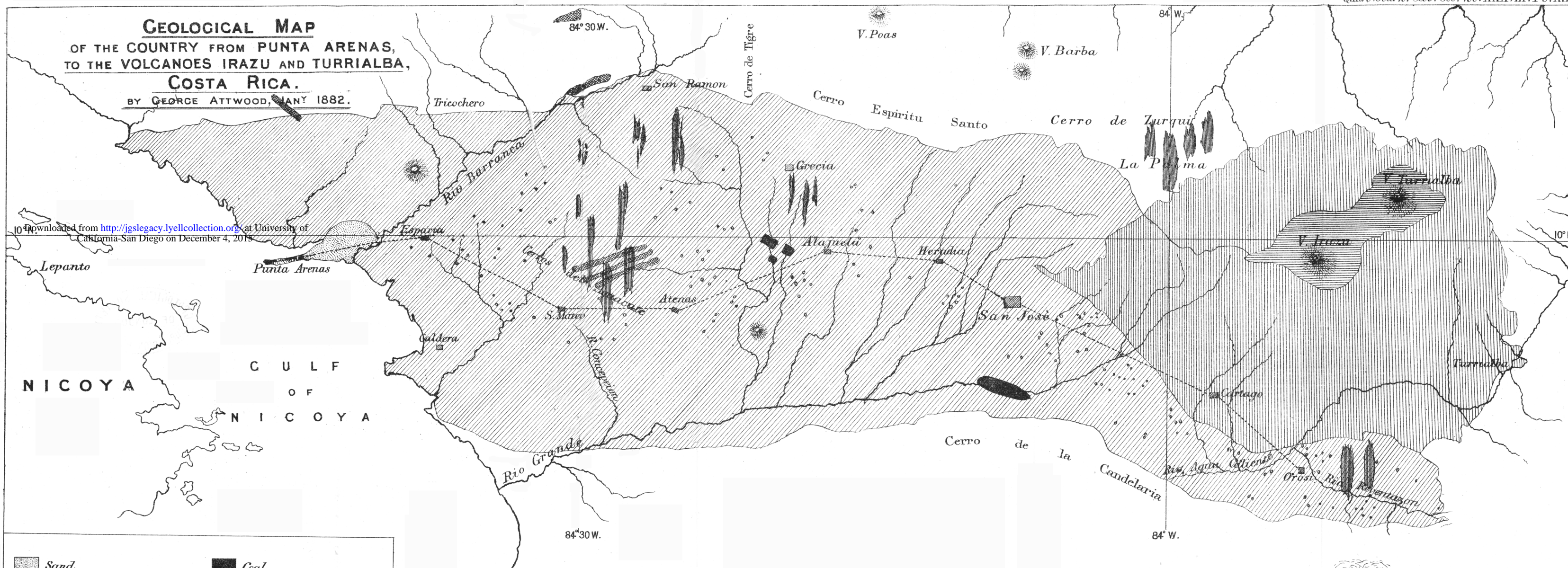
Mr. BAUERMAN expressed his sense of the value of a section made in a little-known country. It was an interesting question, looking at the comparatively modern date of the igneous rock described and the absence of schistose rock, whether the seas had previously communicated. As for the condition of the transformed masses of rock containing minerals, he was glad to find Mr. Attwood had observed it; for he had noticed the same thing in Spain and North America, and thought that it had been too often overlooked in the search for lodes.

Mr. WARINGTON SMYTH said he should like to ask Mr. Attwood on what grounds he stated that there were no more ancient rocks than those which he had seen. Had not vegetation possibly masked them, and might not there be granitic rocks to furnish the kaolin? Was the coal merely carbonized stems or a true lignite? Was the entire run of the veins metalliferous?

Mr. ATTWOOD said that he had not himself seen any other case of metalliferous rock like those which he had described. Very likely the oceans had once communicated. He saw no signs of granite in the country. As for the vein-matter in the lodes, he thought that the augite-andesite and the fissures in which these lodes occurred were of about the same age. The coal was only limited in area, but varied from partly carbonized matter to true lignite. The sandstones, like the coal, were only found in the ravines near the volcanoes, and were of small area.

GEOLOGICAL MAP OF THE COUNTRY FROM PUNTA ARENAS, TO THE VOLCANOES IRAZU AND TURRIALBA, COSTA RICA.

BY GEORGE ATTWOOD, M.A. 1882.



SECTION FROM THE BAY OF NICOYA, COSTA RICA, TO THE VOLCANOES IRAZU AND TURRIALBA.

