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XV. *The Geological Age of the Mountains of Santa Marta.*
By Professor HERMANN KARSTEN, M.D.*

THE Geological constitution of the mountain-mass of Sta. Marta has until recently remained quite unknown. It was only in consequence of my Report of 1852 upon "The neighbourhood of Maracaybo and the North coast of New Granada" (Karsten's *Archiv*, 1853), in which the geological age of these mountains was touched upon, and after the publication of the nearly simultaneous investigation of this region by Acosta (*Bull. Soc. Géol. Fr. sér. 2*, vol. ix. p. 396, June 1852), that these questions have been dealt with more in detail, both in my subsequent geological writings and in those of my successors.

Acosta, like myself, describes the Geological constitution of the Sierra Nevada de Sta. Marta as Plutonic, consisting of Granite, Gneiss, Syenite, Diorite, Eurite, &c., and of Porphyries traversed by veins of malachite. Neptunian strata, from which the age of the mountain-mass might be inferred, are not cited by Acosta; but he concludes, from the complete isolation of the massif, and from its East and West direction, that it existed long before the upheaval of the Cordillera, which runs North and South.

In my discourse upon "The Geological Constitution of New Granada" (*Amtlicher Bericht der Versammlung der Naturforscher*, 1856, Vienna 1857) I also describe the Sierra Nevada de Sta. Marta in more detail as a distinct mountain-system which abuts with its south-eastern declivity upon the chain of Ocaña striking northward from Bogota, and by subsequent upheavals there was united therewith by means of a narrow and low connecting range (p. 81). This mountain-mass of Sta. Marta consists of alternating beds of crystalline rocks:—Granite, Gneiss, Protogine, Syenite, Hornblende-, Chlorite- and Quartz-schists,—which have a general strike from S.W. to N.E. In the periphery of this formation there are readily weathering Diorites, Porphyries, Syenites, Granites, &c. Towards the east and south-east beds of the Cretaceous formation bound these rocks, a continuation of those which compose the mountains of Ocaña (Perija). The lowest of these Neptunian beds is a red sandy laminated marl in which *Ammonites santafecinus*, D'Orb., occurs, and which alternates upwards with dark, bituminous limestones and siliceous schists containing *Ammonites* and *Inocerami*. These are covered by light-blue limestone-beds, in which *Eozgyra*

* Communicated by the Author.

Boussingaultii is plentiful. Upon the neighbouring south-east foot of the Plutonic rocks of the Sierra Nevada are deposited correspondingly stratified but unfossiliferous calcareous and aluminous rocks, in part crystalline and schistose.

In the valleys of this Cretaceous formation Tertiary strata are deposited up to at the outside 200 metres. These appear to be entirely wanting on the northern slope, where, however, according to the statements of the natives, limestone containing Belemnites occurs.

In opposition to Acosta, Hettner (Petermann's *Geographische Mittheil.* 1885, p. 92) concludes from the direction of the centre of the mountains from S.S.W. to N.N.E., that the mass is a continuation of the Central Cordillera, which is likewise furnished with a nucleus of Plutonic rock, and to which this line of strike under 8° N. lat. leads eastwards from the river Nechi; an opinion which is in harmony with the development of these Colombian mountain-chains as deduced by me from the nature of the Neptunian strata, although the contemporaneity of the two existing mountain-systems is not thereby proved.

In my Viennese address on New Granada (*Amtlicher Bericht*, 1856), as well as in a more recent memoir on the Geology of the three northern Republics of South America*, in which I have brought together all that was observed by me in those countries, or that has been published by other travellers, I concluded that the mountains of Guiana are the central point of the different mountain-systems of Colombia, by which the direction of these mountain-chains was prescribed, having been elevated as the northern (Venezuela) and western (New Granada and Ecuador) borders of a great semicircular fissure which was formed in the solid crust of the earth around this primitive centre of upheaval, which, although it was not then recognizable in its whole extent by prominent mountain-masses, nevertheless traced out the direction of contemporaneous and subsequent eruptions.

The elevatory force which gave origin to this fissure in the periphery of the central mountain-mass already in existence appears to have acted from the east to the west and south, and indeed on the greatest scale in the north, gradually becoming weaker towards the south. On the contrary, the last considerable upheaval, that of the Tertiary epoch, followed the opposite direction; its greatest force was exerted in the south.

In the north the Plutonic mountain-chains which bound the

* *Géologie de l'ancienne Colombie Bolivarienne, Vénézuëla, Nouvelle Grenade et Ecuador.*—Berlin, Friedländer, 1886.

sea (Caracas, Sta. Marta) attained nearly their present elevation above the sea-level at their first upheaval, and were only a little further uplifted at the close of the Cretaceous* and Tertiary epochs, while the present Cordillera, extending southwards, remained still covered by the sea, and only attained its present form and elevation in this direction by means of the eruption of the trachytic masses and lavas, which occurred most powerfully in the south (Ecuador) and diminished gradually northwards (*Géologie*, p. 51).

The existing Sierra Nevada de Sta. Marta, like the mountains of Caracas, was already almost completely upheaved above the Cretaceous sea and still more completely above the sea of the succeeding Tertiary formation, as may be recognized from the conditions of stratification of the Neptunian deposits.

Whilst the Cordillera of New Granada and Ecuador, especially in its trachytic portions, is generally overlain nearly to the highest summits by strata of the Tertiary epoch, the two Plutonic mountain-masses of the north coast bear Tertiary deposits only up to small elevations (*Géologie*, pp. 12, 23, 52).

The two geographers, Simons and Sivers, the latest writers upon the Sierra Nevada, do not enlarge our knowledge of this geological question.

Simons (Proc. Roy. Geogr. Soc. 1879, 1881, and 1885), as the fruit of his investigations of the Sierra Nevada extending over several years, gives us an excellent geographical Map, the first and best of the original maps of this region founded upon personal surveys (Proc. R. G. S. 1881); as a completion of the admirable work of Codazzi, who, as is well known, perished under the deadly climate of the plains at the commencement of the survey of this province.

Upon the geological characters of the Sierra Nevada Simons says nothing. The traveller Sivers, who followed him (*Zeitschr. der Gesellsch. für Erdk.*, Berlin, 1888), adheres, as regards geology, to the results obtained by me (p. 57), saying upon the age of this mountain-massif, "It appears, therefore, that the Sierra Nevada de Sta. Marta is a very old piece of the earth's crust which had enjoyed a long continental period when the flooding of its margins by the Cretaceous sea commenced. After these deposits had lasted throughout the

* Steinmann's statement that the Jurassic formation also occurs in New Granada (*Neues Jahrb. der Min. &c.*, 1882) has proved to be erroneous. The Jurassic formation indicated by me, in consequence of Steinmann's publication, in my Map in the "*Géologie*, &c." is consequently to be altered to Cretaceous.

whole Cretaceous period, a folding of them took place in Tertiary times, by which the Sierra de Perija was produced, &c.”

The accompanying profile surveyed by me in the district of Papaijal on the river Rancheria (5) (Rio Hacha) and completed near Tomarazon in the west, and passing through the mountains Cerrejon (2) and Potrero de Venancio (3), gives an indication of the stratification of the rocks between the Sierra Nevada (4), and the Cordillera of Ocaña (Perija) which terminates here (1).—*a, a, a*, Red marly sandstone and laminated marl, alternating above with calcareous Cretaceous beds*; *b*, Tertiary strata; *c*, Porphyry with copper ores; *d*, Red quartz-porphyry; *e*, Plutonic rocks, such as also form the nucleus of the Sierra Nevada.

* In the uppermost, pale-blue limestone beds of the younger Cretaceous there are, in this district, near Chorrera, towards the summit of the hill, the so-called “Geological organs,”—perpendicular, cylindrical shafts, in parts 10–12 m. high and 4–5 m. in diameter, which I have fully described in the *Zeitschr. d. Geol. Gesellsch.* 1862, and in Westermann’s *Monatsheften*, 1863.