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ART. XXXVII.—*On the Geology of Southern Patagonia;* by J. B. HATCHER.

IT is the purpose of this paper to record such facts relating to the geology of southern Patagonia as were observed by the author during his explorations in that country from May 1st, 1896 to June 5th, 1897, while collecting vertebrate fossils for Princeton University; to offer a few suggestions as to the age and origin of the different sedimentary deposits and their stratigraphic relations to one another as displayed by sections in different parts of the region; and to make some remarks in regard to the agencies which have determined the present topographical features of the district visited.

Partly in order to assist others who may visit this country for the purpose of collecting fossils, but more especially for the purpose of facilitating the work of future investigators who may desire either to verify or disprove the correctness of my observations, I present here a sketch map of the Argentine territory of Santa Cruz (see p. 347), on which I have designated the most promising localities for vertebrate fossils observed by myself and my assistant, Mr. O. A. Peterson; and those places at which the stratigraphical sections accompanying this paper were made. It is believed that with the aid of this map it will be readily possible for anyone to identify all the more important localities mentioned in the text.

While my observations and conclusions are in many in-

stances quite different from, and in a few cases directly opposed to those of Dr. Florentino Ameghino and his brother Carlos Ameghino; yet it is believed that most of the conclusions reached are fully warranted by the facts observed; and that in the present paper there will be found an important supplement to our knowledge of this region, which has already been so much increased by the combined efforts of the brothers Ameghino.

Mesozoic Rocks.

Jurassic?—The oldest sedimentary deposits seen by the writer were a series of black, very hard, but much fractured slates, with Ammonites fairly abundant, but not sufficiently well-preserved to admit of identification. These beds, which I propose to call the *Mayer River beds*, in some places at least, rest directly on the eruptive rocks which here form the great mass of the Cordilleras; they are well represented on the right bank of the lower fork of Mayer River, just where it emerges from a deep gorge about three miles above its confluence with the main stream.* A greater development of these beds may be seen at the west end of Bald Mountain, an elevation in the middle of Mayer Basin; at this locality they have a decided eastwardly dip and an estimated thickness of 1500 feet. In their uppermost layers, they are sometimes of a red or yellow color and are less fractured and more cleavable than on Mayer River. No fossils were found on Bald Mountain.

The Mayer River beds are referred to the Jurassic, partly because of the Ammonites found in them, which appear to resemble Jurassic forms; but more especially on account of their lithological characters and because of the great thickness of the sedimentary rocks overlying them, which, by the presence of Dinosaurian remains in their uppermost strata, can hardly be more recent than Cretaceous.

Cretaceous.—Immediately, but unconformably, overlying the Mayer River beds, is a series of heavily bedded, light brown sandstones, becoming variegated above, exceedingly barren of fossils and with an estimated thickness of 1000 feet. In their lower layers they resemble in appearance the Dakota sandstones of our western States. They are well represented near the source of Mayer River, where they extend for several miles in an unbroken wall, forming the southern border of Mayer basin. With the exception of uncharacteristic plant impressions no fossils were found in these sandstones. They are referred to the Cretaceous upon stratigraphical evidences

* Many of the water courses and topographic features mentioned in this paper will not be found located on any of the current maps of Patagonia. For reference they have been located and given names on the accompanying map.

and are supposed to represent the variegated sandstones (*Areniscas abigarradas*) of Carlos Ameghino;* although both in this region, and on the upper Rio Chalia they appear to be unconformable with the overlying Dinosaur beds.

The Guaranitic beds.—Above the barren sandstones there is a series of variously colored sandstones and clays of immense thickness, not less than 2000 feet, and in which there occur in the greatest profusion the mineralized trunks of trees and, less frequently, Dinosaurian remains. Dr. Ameghino† has already called these beds the *Guaranitica beds* and referred them to the Upper Cretaceous upon the evidence afforded by the Dinosaurs found in them. The Guaranitic beds are well represented on the head of Lignite creek on the south side of Mayer basin, and on the upper Rio Chalia; in both of these localities they are much tilted and have a general dip to the southeast.

The Pyrotherium beds.—I mention here the Pyrotherium beds and place them in the Cretaceous entirely upon the authority of Ameghino. In my work on the Upper Rios Chalia and Chico I was unable anywhere to identify the Pyrotherium beds or to find evidences of the rich mammalian fauna found in them by Carlos Ameghino. According to Dr. Ameghino these beds immediately overlie the Dinosaur beds and pass insensibly into them.‡ No difficulty whatever was experienced in determining the Guaranitic beds and in finding Dinosaurian remains in them. I searched faithfully these Dinosaur beds from the base of the marine Tertiary above to the barren sandstones below for mammal remains, but *without the slightest success.* I never found in position in the Dinosaur beds a single mammal bone or tooth. I did find mammal remains in this region which seem to pertain to the genus Pyrotherium, but they belong to a horizon much more recent than the Guaranitic beds or even the Patagonian beds, and should not be placed lower in the geological scale than Miocene, for they are above the Supra-Patagonian beds of Ameghino. I present here in fig. 1 an incisor tooth, No. 15101 in our collection, which from its size and shape appears to agree pretty closely with the incisors of Pyrotherium. Only part of that portion projecting from the jaw is preserved and this is nine inches in length and nearly three inches in greatest diameter.

* See "Note on Geol. and Pal. of Argentina," Geol. Mag., Jan., 1897, p. 5, and Bol. Inst. Geografica Argentina, vol. xvii, 1896, pp. 87–108, and C. Ameghino, "Expl. Geol. en la Patagonia," Bol. Inst. Geografica Argentina, vol. xi, 1890, pp. 1–46.

† See F. Ameghino, "La Argentina al Traves de las Ultimas Epocas Geologicas; Imprenta de pabla E Coni e Hijos, Buenos Aires, 1897, p. 33.

‡ F. Ameghino, Note on Geol. and Pal. of Argentina, Geol. Mag., London. January, 1897, pp. 4–20.

It was found associated with the remains of other mammals, birds and small reptiles. From the stratigraphic position of the beds in which this tooth and the associated fossils were

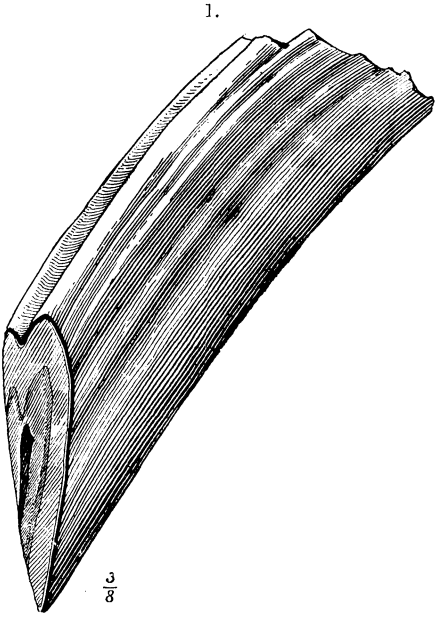

FIG. 1, right sup. incisor of Pyrotherium? three-eighths natural size.

found I did not suspect that they were in any way related to the Pyrotherium beds and spent very little time in them.

I seriously question the stratigraphic position of the Pyrotherium beds as determined by the brothers Ameghino, although it may seem presumptuous on my part, since I was unable to identify the beds at all, and the explorations, travels and opportunities for observations in this region of Señor Carlos Ameghino have been far more extensive than have my own. It is certainly remarkable that in these beds containing Dinosaurian remains, associated according to Ameghino with the remains of mammals, some of them, as for example Pyrotherium of *immense* size, only a little less than that of the elephant and consequently easily to be seen, I could have searched for weeks without ever finding a single mammalian bone, while every day I found Dinosaurian remains.

Considering the immense size and highly specialized character of many, in fact of most of the mammals described by Ameghino from the Pyrotherium beds, it does not seem possible that they could have lived in Cretaceous times and coex-

isted with the Dinosaurs of that period. From a study of the figures and descriptions published by Dr. Ameghino of the fossils found in the Pyrotherium beds, one is even led to believe that they may belong to a period more recent than that of the Santa Cruz beds. I present here in fig. 2, taken from one of Ameghino's latest publications, the superior dentition of *Morphippus imbricatus*, one of the smaller ungulates described by him as coming from the Cretaceous of Patagonia.

2.

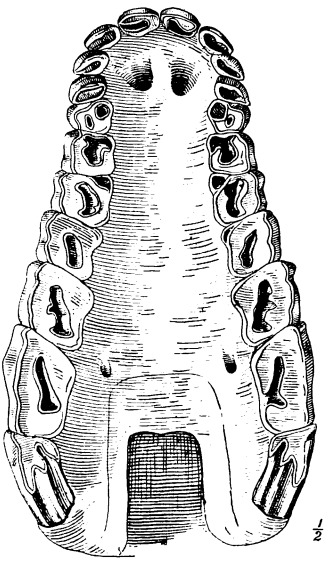

FIG. 2. Sup. dentition of *Morphippus imbricatus* Amegh., after Ameghino. One-half nat. size.

The entirely molariform condition of the premolars and the cupped incisors are especially noteworthy. In his "Notes on the Geology and Paleontology of Argentina" previously referred to, he says on page 8, in speaking of the Pyrotherium fauna, "The unarmored edentates are also numerous and of types resembling those of the Santa Cruz formation, but generally of much more considerable size. Nevertheless some forms show very primitive characters, having the molars provided with a well developed layer of enamel.

"With these edentates there are Carnivorous animals of a size approximating to that of the largest bears of the present day, but similar to those of the Santa Cruz formation." This is certainly a greater size than that attained by any of the Carnivorous animals of the Santa Cruz beds. Moreover many of

the ungulates described by Ameghino as from the Pyrotherium beds are larger than the allied forms in the Santa Cruz beds. Now as regards structure and specialization of parts we are as yet unable to judge in many cases just which forms are the more specialized. In not a few instances, in his descriptions of remains from the Pyrotherium beds, he shows that they are not distinguished either generically or specifically from allied forms in the Santa Cruz beds, sometimes that they are decidedly more specialized than the latter, and almost always that they are of a size and structure showing a close relation with the fauna of the Santa Cruz beds and not at all what we should expect from the Cretaceous. As instances of this I may cite that in his "Première Contribution à la Connaissance de la faune Mammalogique des Couches à Pyrotherium" on page 44, in closing his description of *Asmodeus Osborni* he remarks, "Cet animal est assurément un des plus gros mammifères qui ait foulé la surface de la terre." Again on page 50 in defining the genus *Ancylocœlus*, he compares it with *Homalodontotherium*, a closely allied genus from the Santa Cruz beds but which is distinguished from the latter partly by the dental formula, which he finds to be $I\frac{3}{3}C\frac{1}{1}P\frac{4}{4}M\frac{3}{3}$ in *Homalodontotherium*, while in Ancylocœlus from the Pyrotherium beds there is a reduction in the number of inferior premolars to three on either side, a marked advance over the Santa Cruz form. On page 56 he mentions edentates from these beds of the stature of Mylodon. Many other similar examples might be cited, but enough has been done to show that we are not dealing with a Cretaceous fauna. Thus, from his own figures and descriptions it would appear that in the matter of size at least, there is a *decided* advantage in favor of forms found in the Pyrotherium beds as compared with related forms from the Santa Cruz beds. In the history of the development of every mammalian phylum in the northern hemisphere, so far as I am aware, there is a decided and gradual increase in the size of the individual from the lower to the higher forms. According to Dr. Ameghino, exactly the opposite has taken place in South America. It would be interesting to know why it is that natural causes always working by the same methods have produced such opposite results in the two hemispheres, when as is everywhere shown, especially among the ungulates there are such marked cases of parallelism in structural development.

Whatever may be the relation of the Pyrotherium beds to the Santa Cruz beds, I feel sure that the mammalian fauna described by Florentino Ameghino as from the Pyrotherium beds does not occur associated with the Dinosaurian remains of the Guaranitic beds, unless such association is due to secondary deposition of the latter or a superficial mingling of

remains from two or more distinct horizons by recent erosion; which latter has been the cause of much confusion in other instances, as for example, the Loup Fork and Equus beds of our western plains.

Dr. Ameghino,* in giving his reasons for referring the Pyrotherium beds to the Cretaceous, says: "I rely on the fact that these beds with remains of Pyrotherium everywhere accompany the red sandstones with remains of Dinosaurs, so that it has not hitherto been possible to separate them in an absolute manner. These sandstones in certain places exhibit nothing but bones of Dinosaurs; in others they show only remains of mammals and small reptiles of types not yet determined, while at other points all these remains are shown mixed together, at least to *all appearance* (italics mine), always accompanied by a great quantity of silicified wood." Now according to Ameghino's own statements, in the localities where this Pyrotherium fauna has been found most abundantly, the nature of the country is just such as to bring about a mingling of remains really belonging to quite different horizons, and thus their association in the same horizon may be only *apparent*, as he himself has in reality suggested. In another publication† he says: "Malheureusement ce nouveau gisement se trouvait dans une région absolument inconnue et accidentèe d'une manière épouvantable; il s'égara au milieu de ce labyrinthe et ne put en sortir qu'à dure peine en abandonant une partie du matériel de voyage." I may also add that in the region of Mayer basin and the upper Rio Chalia, especially the former, there have been great disturbances, so that the Guaranitic beds and the superimposed Tertiary deposits are inclined at high angles. In such a region the exact stratigraphic relations of the different beds are not always easily determined, and in some cases grave errors have arisen through false determinations made by most capable men. As an example of this, it need only be remembered that Señor Carlos Ameghino spent five years in Patagonia, working mostly in the Santa Cruz beds, before discovering that they overlie the Patagonian beds,‡ all the while considering them as below the latter series (although Darwin had fifty years before suggested the true conditions),§ and this far out from the mountains and in a region singularly free from faults or dislocations of any kind, where the strata are approximately horizontal and succeed one another in regular order.

* Loc. cit.

† See Prémière Contribution à la Connaissance de la Faune Mammalogique des Couches à Pyrotherium. Florentino Ameghino, Bol. del Inst. Geo. Arg., tome xv, cahiers 11 et 12.

‡ See Énumération Synoptique des Espèces de Mammifères Fossiles des Formations Éocènes de Patagonie, par Florentino Ameghino. Buenos Aires 1894, pp. 1–8.

§ See Geol. Observ. on South America, p. 117.

It is true that Dr. Florentino Ameghino states that the variegated sandstones of the interior extend to the Atlantic coast, and are covered in concordant stratification by the same strata with *Pyrotherium;* but since he gives no localities and nowhere describes any remains of Pyrotherium or other mammals from those beds as having been found at San Julian or other localities on the coast, the correct identification of those beds as Pyrotherium may well be questioned.

I have dwelt at some length upon the question of the age of the Pyrotherium beds because of the importance of the problems involved. If the beds containing this remarkable mammalian fauna be really Cretaceous, not only may the value of vertebrate fossils as means of correlation be seriously questioned, but a very decided blow will also be struck at the validity of all correlations based on paleontological evidences, whether of vertebrates, invertebrates or plants.

Until this entire region has been carefully explored and the stratigraphic position of the Pyrotherium beds accurately determined, by men trained in stratigraphic work, the question of their exact position in relation to the Dinosaur beds and to the different Tertiary beds, as well, will remain unsettled in the minds of most vertebrate paleontologists.

Tertiary Deposits—Eocene.

The Patagonian beds.—Extending along the Atlantic coast in an almost unbroken succession from New Bay on the north to near the mouth of the Coy River on the south, there is a series of light-colored, well stratified sandstones and clays, usually quite soft but sometimes, especially in the sandstone layers, enclosing very hard, lenticular concretions. These beds are known as the Patagonian beds, and the typical locality for them may be considered as the Atlantic coast anywhere from Port Desire to the mouth of the Santa Cruz River. They attain to a thickness of several hundred feet, are of marine origin and are everywhere characterized by marine invertebrates in great abundance. In the region south of Port Desire they dip very gradually to the southeastward, so that their uppermost strata disappear beneath the waters of the Atlantic about midway between the Santa Cruz and Coy Rivers.

In regard to the age of the Patagonian beds there has been great difference of opinion, but most persons acquainted with them and with the invertebrate fauna found in them agree in referring them to the Eocene. Dr. Ameghino, in discussing this question, says:* "The fact is that the Patagonian formation begins with the Upper Cretaceous, but acquires its great-

* See Notes on Geol. and Pal. of Arg, p. 12.

est development during the Eocene. The fossiliferous deposits of Quiriquina were at first regarded as Tertiary, and were only assigned to the Cretaceous after there had been discovered in them remains of *Plesiosaurus* (*Cimoliosaurus*) *chilensis*, of *Ammonites*, and some other Secondary genera.

"The late Cretaceous formation of the coast of Chili exhibits absolutely the same aspect and the same lithological characters as the Patagonian formation. The facies of the fauna is equally the same, since the Cretaceous fauna of Quiriquina only differs from the fauna of the Patagonian formation by the presence of eight genera (*Ammonites*, *Hamites*, *Baculites*, *Pugnellus*, *Cinulia*, *Pholadomya*, *Monopleura*, *Trigonia*), which are not met with in this latter; while 85 per cent, more or less, of the genera of the Cretaceous formation are also found in the Eocene Patagonian formation. Moreover according to Philippi, the best authority on the subject, 20 per cent of the species of shells of the Cretaceous formation of Algarroba are likewise species of the Patagonian formation, and it will be recognized that in Patagonia the marine Cretaceous and Eocene formations pass from one to the other in a gradual and insensible manner."

Granting that the facts as stated above are correct, and Dr. W. Moericke* has shown that considerable doubt exists as to the above association of species at the localities mentioned, they do not justify Dr. Ameghino's conclusion that the Lower Patagonian beds belong to the Upper Cretaceous; for in regard to the eight genera mentioned above as found only in the Cretaceous of the west coast and not in the Patagonian beds, it should be remembered that of these, six are characteristic of the Mesozoic, and are unknown in any deposit later than Cretaceous, while the two remaining, *Pholadomya and Trigonia*, are found indiscriminately from the Lias to recent times. The per cent of genera or even of species common to the two deposits is of less importance than the character of the genera and species peculiar to each. Now six of the eight genera found in the Cretaceous deposits of the west coast and absent in the Patagonian beds are typical Mesozoic genera, while most of those genera found only in the Patagonian beds are unknown from the Cretaceous, and the greater number of genera common to both have been found in different localities throughout the world in both Secondary and Tertiary deposits, and are therefore unimportant in determining the age of either series of beds. If the Lower Patagonian beds really belong to the Cretaceous, since they are of distinctly marine origin, we should find in them some trace of that unusually prolific Cephalopod fauna (*Ammonites*, *Hamites*, *Scaphites*, *Baculites*,

* Neues. Jahrb., etc., Beil. Bd. x, 1896, p. 594.

etc.,) the remains of which are everywhere so abundant in all the known marine Cretaceous deposits of the world, but which are singularly wanting in the Patagonian beds. Since there has not been reported up to the present time a single species characteristic of the Cretaceous period from the *typical* Patagonian beds on the east coast of Patagonia, and since the entire facies of the fauna is Tertiary, there is no good reason, from a paleontological standpoint, for referring any part of this formation to the Cretaceous.

The arguments advanced by Dr. Ameghino for assigning the Lower Patagonian beds to the Upper Cretaceous on account of certain remains of Mosasaurs, Plesiosaurs and fish of Cretaceous types found in the vicinity of Lake Viedma, are of little value, since those beds have never been properly identified as the Patagonian beds.

The stratigraphical evidences in favor of referring the whole of the Patagonian beds to the Tertiary appear to be quite conclusive, assuming that the Guaranitic beds are Upper Cretaceous. That there was a considerable lapse of time between the close of the deposition of the one, and the beginning of that of the other, series of deposits is evidenced by the altered nature of the materials, which show not only that they were derived largely from different sources, but that they were deposited in the one instance in fresh water and in the other in salt water over identically the same geographical districts. Again the appearance of the Guaranitic beds, on the coast at San Julian, where there are no disturbances in the Patagonian beds, can best be accounted for by assuming that they represent a prominence in those beds, due to erosion, which took place after the close of the deposition of the Guaranitic beds and prior to the deposition of the Patagonian beds. Moreover in vast areas, throughout the interior, the Guaranitic beds are immediately overlaid by formations much more recent than Patagonian, thus showing a decided unconformity by overlap between the two series. No interstratification of the two series has ever been observed, which would have been the natural result had they been deposited simultaneously and had marine and fresh-water conditions prevailed at the same time in adjacent regions.

Most of the confusion which has arisen regarding the age of the Patagonian beds, has doubtless been due very largely to the carelessness of collectors. For many years every fossil-bearing horizon discovered anywhere in southern South America and containing a large oyster, was referred without question to the Patagonian beds, and collections were made indiscriminately at many different localities and from many different horizons from the Upper Cretaceous to the Pliocene, all referred to the Patagonian beds and placed in the hands of specialists for

study, often with no other remark than that they were from the Patagonian beds. In this manner, for years, the fauna of the Patagonian beds has been made to include everything from the Upper Cretaceous deposits of the west coast to the Supra-Patagonian beds, the beds in Entre Rios on the Parana and, very likely, some forms from the Cape Fairweather beds of Pliocene age. It is therefore not surprising, in view of this unwarranted association of fossils, that the opinions of conchologists should have varied so much in regard to the age of these beds.

What is especially needed, is a complete series of the invertebrates from the typical localities at the mouth of the Santa Cruz and Desire rivers and the intervening coast, for study and comparison with forms from horizons in both Europe and North America, the age of which has been accurately determined from stratigraphical evidences. With this end in view we made a small collection from near the mouth of the Santa Cruz River, which has been placed in the hands of Dr. A. E. Ortmann, who considers them as not older than Eocene and has thus far identified the following genera and species: *Ostrea hatcheri* (Ort.); *Cucullæa alta* (Sow.); *Pecten* sp.?; *Perna* sp.?; *Arca* sp.?; *Limopsis insolita* (Sow.); *Limopsis aff. araucana* (Phil.); *Cardita patagonica* (Sow.); *C. inaequalis* (Phil.); *Venus meridionalis* (Sow.); *V. volkmanni* (Phil.); *Glycimeris* sp.?; *Dentalium majus* (Sow.)?; *Trochus laevis* (Sow.); *Turritella ambulacrum* (Sow.); *Turritella affinis* (Hup.); *Crepidula gregaria* (Sow.); *Natica obtecta* (Phil.); *Struthiolaria ornata* (Sow.); *Ficula carolina* (d'Orb.); *Voluta* sp.?; *Fusus darwinianus* (Phil.); *Cancer patagonicus* (Phil.).

Incomplete as this collection doubtless is, yet it may be regarded as typical of the beds in question. It is hoped that we may soon be able to make more extensive collections from these beds, but from the evidence already at hand there seems no good reason for referring any part of the Patagonian beds to a more remote age than Eocene.

Miocene.

The Supra-Patagonian Beds.—After the deposition of the Patagonian beds this region was for a considerable period elevated above the level of the sea and subjected to erosion, and doubtless much of the material composing the Patagonian beds was then completely removed over large areas, especially in what is now the interior region. This period of erosion was of sufficient duration to accomplish great changes in the marine fauna of the regions; for in the succeeding strata, which are also of marine origin, there is almost a completely new list in the species represented, while several new genera have been

introduced, and the entire aspect of the fauna changed from Eocene to Miocene, according to Dr. Ortmann, who has also studied our collections of invertebrates from these beds and has identified the following forms: *Cidaris* sp.?; *Scutella* sp.?; *Bryozoa; Terebratula patagonica* (Sow.); *Ostrea phillippii* (Ort.); *O. hatcheri* (Ort.); *Pectunculus* sp.?; *Glycimeris* sp.?; *Fissurella; Solarium; Trochita costellata* (Phil.); *Turritella affinis* (Hup.); *Crepidula gregaria* (Sow.?); *Scalaria rugolosa* (Sow.); *Struthiolaria chilensis; Natica solida* (Sow.); *Balanus varians* (Sow.); *Chthamalus antiquus* (Phil.).

The Supra-Patagonian beds are composed of alternating layers of sandstones and clays, usually of a yellow or light brown color with a rich invertebrate fauna. Ameghino states that they have a thickness of 30 meters, but in the interior, along the base of the Cordilleras, they certainly attain to a much greater thickness, and I should not hesitate to allot to them a thickness of fully 150 meters at Shell Gap, where Lignite Creek emerges from Mayer basin. In this region, as also on the upper Rio Chalia, they rest unconformably upon the Guaranitic beds and dip to the eastward at an angle of about 15° as shown in fig. 3.

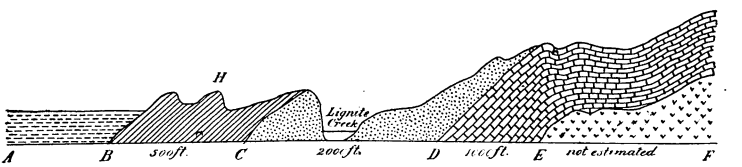

FIG. 3. Section of sedimentary deposits as displayed on south side of Lignite Creek and southern border of Mayer basin, from a point one mile east of Shell Gap to the western border of the basin. A–B. Fresh-water, Santa Cruz beds; B–C. Marine Supra-Patagonian beds; C–D. Fresh-water? Guaranitic beds; D–E Barren sandstones: E–F. Marine Mayer River beds and igneous rocks. Distance from A to F about 15 miles. Relative inclination of strata to base-line. A–F. exaggerated for effect, thus increasing thickness of deposits relatively to length of section displayed.

The Santa Cruz beds.—I cannot agree with Dr. Ameghino in considering the Santa Cruz beds as belonging to the same series with the Supra-Patagonian beds. My reasons for separating them are because the Santa Cruz beds are of fresh or brackish water origin, as shown by the diatoms which they contain;* and also I am brought to this conclusion by the fact that all along the foot hills of the Cordilleras the Supra-Patagonian beds were observed, inclined at high angles, while in the same region the Santa Cruz beds are approximately horizontal and show almost no evidences of disturbance. At Shell Gap, on Lignite Creek, this creek has cut a narrow gorge through the sandstones and clays of the Supra-Pata-

* See Geol. Obs. on S. A., by Darwin, p. 117.

gonian beds, which are here inclined at an angle of not less than 15°, while not more than one-half mile below, on the right bank of the same stream, may be seen an outcrop of sandstones of the Santa Cruz beds, which appear nearly horizontal. In fact, so far as I was able to determine, the inclination of the Santa Cruz beds is nowhere appreciable, except at certain points along the water courses, where it is possible to take in at one view stretches of several miles of the strata, and then there is apparent only a very gentle dip to the southeast.

I nowhere found mammals in the marine beds, nor did I anywhere find the two series interstratified. I observed the contact between the two series at many different localities and did occasionally find bones below the base of the Santa Cruz beds, but they were such as had fallen down from above. On one or two occasions I found bones in strata which were absolutely lower than other strata in the same vicinity where marine invertebrates were abundant, and I at first believed that there had been an interstratification of the two series, but upon careful examination, I found that the layer with the invertebrates did not continue on so as to actually overlie that with the bones, and I was brought to the conclusion that the Santa Cruz beds had here been deposited upon the eroded surface of the Supra-Patagonian beds. An example of this may be seen in a small cañon on the south side of the Rio Chico about two miles below Sierra Oveja. In going up the valley of Chico River it is impossible to be mistaken as to the old crater (*Sierra Oveja*), since it rises directly from the bank of the stream and compels one, if traveling with a vehicle, either to cross the river or go around to the west of the mountain, neither of which routes is particularly good. About two miles below this crater there enters the river valley from the west a narrow, deep cañon. Ascending this cañon some 200 yards, there appears on the south side of it a projecting sandstone ledge, about two feet thick, with an abundance of oyster shells. Proceeding a little farther, the cañon is seen to open out into a small, deeply eroded, "bad land" basin. Continuous all the while on your left is the oyster-bearing, sandstone ledge, which, at a distance of about one-half mile from the mouth of the cañon, becomes covered by talus: this condition continues for perhaps 100 yards, when the section is again clear, and in the lowermost layers there are mammal remains, while the sandstone layer with its oysters is nowhere to be found. It is true that the bottom of the cañon has been all the time rising, but the elevation did not appear sufficient to bring the shell-bearing layer below its surface; I therefore concluded that the sandstone layer with oysters had been eroded away before the deposition of the mammalian beds.

From the high angle of inclination of the Supra-Patagonian beds all along the eastern base of the mountains, it is evident that at the close of that period there were great orographic movements throughout southern South America. Not only were the Cordilleras greatly elevated, but also the region to the eastward, far beyond the present limits of the Atlantic coast, was brought above sea level. The eastern border of this great land mass was perhaps not far to the eastward of the Falkland Islands, and may be approximately represented by an imaginary line connecting these islands with certain outlying bodies of Primary Rock at Port Desire, and other places farther north, and perhaps extending also in a southeasterly direction as far as South Georgia Island. The great development of the Santa Cruz beds along the coast, especially between the Coy and Gallegos Rivers, as well as the very shallow nature of the water between that coast and the Falkland Islands, are both important evidences of a much greater eastward extension of the land during the Santa Cruz period than at present.

Consequent upon the elevation which took place at the close of the Supra-Patagonian period, there was between the borders of the old land-mass, now represented on the east by the Porphyries of Port Desire, and by the Falkland Islands; and on the west by the Cordilleras, a depression, in which were laid down the fresh-water, lacustrine deposits, now known as the Santa Cruz beds, and containing one of the richest and most varied vertebrate faunas known. That the Santa Cruz beds are of fresh-water origin rather than marine is shown by the diatoms. It is also clear from the nature and composition of the strata, that they were not deposited in a great, continuous lake, but rather in a low, flat, marshy country with smaller lakes and connecting water courses. As evidences of this I would cite the numerous examples of cross-bedding, and the fact that the beds of sandstones, clays and conglomerates continually replace one another, both of which facts are well shown in fig. 6 at G and J, and in figures 10 and 11.

The Santa Cruz beds may be separated, according to the vertebrate remains found in them, into an upper and lower horizon. The strata of the lower Santa Cruz beds, as compared with those of the upper, are of a lighter color, more continuous and are composed of finer materials, containing few or no conglomerates. They are best displayed in the bluffs of the Santa Cruz, and of the upper Chalia and Chico Rivers, where they are characterized by the great numbers of herbivorous marsupials and gigantic birds found in them. The upper Santa Cruz beds are best exhibited in the bluffs of the sea and the Gallegos River from Coy Inlet to Guer Aike,

where they are characterized by the scarcity of herbivorous marsupials and bird remains and the abundance of the remains of carnivorous marsupials, edentates, ungulates, rodents, etc.

There has been much doubt in regard to the age of the Santa Cruz beds. Darwin* was the first to determine that they were distinct from the Patagonian beds and to suggest their true stratigraphic position in regard to the latter. Dr. Florentino Ameghino† and his brother Carlos Ameghino, during the first five years of their labors on the mammalian fauna of the Santa Cruz beds, supposed them to underlie the Patagonian beds which most conchologists agree in referring to the Eocene. They therefore considered the Santa Cruz beds as Lower Eocene and the Patagonian beds Upper Eocene. Finally on his sixth journey into this region Carlos Ameghino was able to determine the exact stratigraphic relations of these deposits, and their relative position in the Tertiary scale was exactly reversed.

So far as any observations bearing upon the stratigraphic relations of the Santa Cruz beds are concerned, there is absolutely nothing against referring to them any age from Lower Miocene to Lower Pliocene. That they are not older than Middle Miocene is pretty clearly shown, since they have been seen to rest unconformably upon the Supra-Patagonian beds, in regard to the invertebrate fauna of which Dr. Ortmann writes as follows: "The most interesting form of the Supra-Patagonian beds is the *Scutella*. According to Zittel (*Handbuch der Palaeontologie*, vol. i, p. 522), all the species of *Scutella* are found in the Oligocene and Miocene; so that this fact tends to confirm Moericke's opinion (N. Jahrb. Min., etc., Beil. Bd. x, pp. 593 and 596) of the Miocene age of the Patagonian beds, at least of a part of the so-called Patagonian beds. If this is true, the Santa Cruz beds overlying the Scutella beds cannot be Eocene."

In any attempt to correlate the Santa Cruz beds with other Tertiary strata of either Europe or North America, nothing will be found of more value than the remarkable vertebrate fauna which they contain. There is absolutely no ground, from a stratigraphical standpoint, for presuming that the mammalia of this region were any more advanced in early Tertiary times than were the mammalia of the northern hemisphere; hence, notwithstanding the fact, that the Santa Cruz fauna is so dissimilar to any known in either Europe or North America, if among the ungulates, rodents and other orders common to

* See Geol. Obs. on S. A., Darwin, p. 117.

† See Énumeration Synoptique des Espèces de Mamifères Fossiles des Formations Éocènes de Patagonie, par Florentino Ameghino, pp. 4–5 (Buenos Aires), 1894.

both, forms are found, no matter how dissimilar they may be, yet showing approximately the same degree of development along those lines of progression common to both, it is only fair to consider beds containing such forms as of approximately the same geological age, and such correlation of the deposits of Patagonia will, it is believed, receive the sanction of most paleontologists and geologists, until good reasons are produced to show that it is at fault. It was largely for the purpose of securing material with which to make such comparisons that our expedition to Patagonia was undertaken. Several tons of most excellent fossils were procured from various horizons in the Santa Cruz beds, among which are the skulls and greater portions of the skeletons of nearly every genus reported from these beds. This material is being rapidly freed from the matrix and prepared for study, and in a short time it will be possible to compare these forms, point for point, with the skeletons of animals found in our own Tertiary deposits, the age of which has been determined beyond reasonable doubt, both from paleontological and stratigraphical evidences. While the final results of such comparisons are yet to be attained, enough has already been done to demonstrate the comparatively modern aspect of the fauna of the Upper Santa Cruz beds. For the benefit of those interested and who may not have had an opportunity of studying for themselves the figures and descriptions already published by Dr. Ameghino, I present here in figs. 4, 4*a*, 5, the metatarsals and superior dentition of one of the Proterotheridæ, drawn from part of No. 15107 in our collection. Note the complex structure of the molars and pre-molars, the molariform condition of the latter, the long diastema, the absence of incisors, etc., in the dentition, while in the metatarsals there is the very great tendency to monodactylism, as shown by the rudimentary character of metatarsals II and IV, and the extremely well-developed metapodial keel on metatarsal III. These or other characters, equally indicative of a high degree of specialization, are met with in nearly every group of animals in these beds. In consideration of the stratigraphic position of the Santa Cruz beds and the degree of specialization exhibited by the mammalian remains found in them, it is difficult to see how they can pertain to a period more remote than Miocene.

Pliocene.

The Cape Fairweather beds.—In this Journal for September last, the author described and gave a section of certain marine deposits found near Cape Fairweather, overlying the Santa Cruz beds, and named them the *Cape Fairweather beds.* At

that time I had not seen Dr. Ameghino's article entitled "Notes on the Geology and Paleontology of Argentina,"* in which he gives the first notice of marine deposits, found in this region, overlying the Santa Cruz beds. My observations regarding the relations of these marine beds to the Shingle formation (*Tehuelche formation of Ameghino*) do not agree with those of Señor Carlos Ameghino. Dr. Ameghino, on page 17 of the paper just cited, after quoting at some length from a letter from Carlos Ameghino, concludes: "According to this the bowlders were deposited at the bottom of the sea,

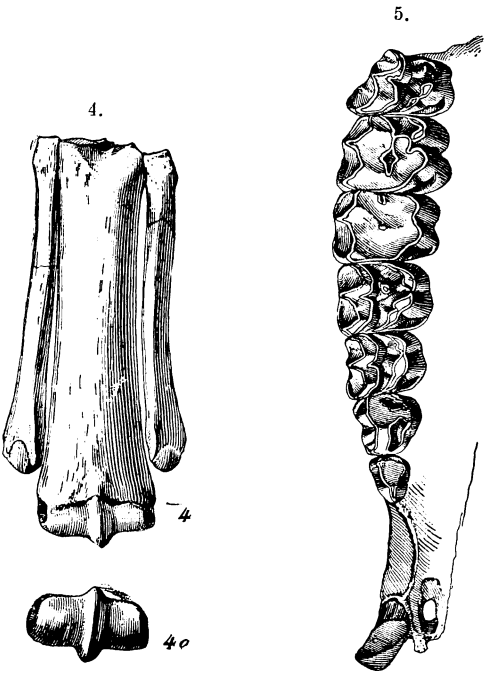

FIG 4. Front view of metatarsals of *Diadiaphorus majusculus?* Amegh. from No. 15107 Princ. col., fig. 4a; view of distal end of metatarsal III, showing great development of metapodial keel.

FIG. 5. Crown view of sup. dentition of *Diadiaphorus majusculus?* Amegh. from No. 15107, Princ. col.

and over them there extended at other periods a vast formation of marine shells, of which there only remains diminished traces at certain definite spots." This is exactly the opposite of what I observed near Cape Fairweather on the coast, where there is a splendid continuous section from the Shingle formation through the Cape Fairweather beds and some 300 feet of

* See Geol. Mag., January, 1897, pp. 4–20.

the Santa Cruz beds, and where it is absolutely impossible to mistake the relative position of the series of deposits. As shown in the section given in my original description of these beds, and reproduced here in fig. 6, the beds with marine invertebrates underlie the Shingle formation.

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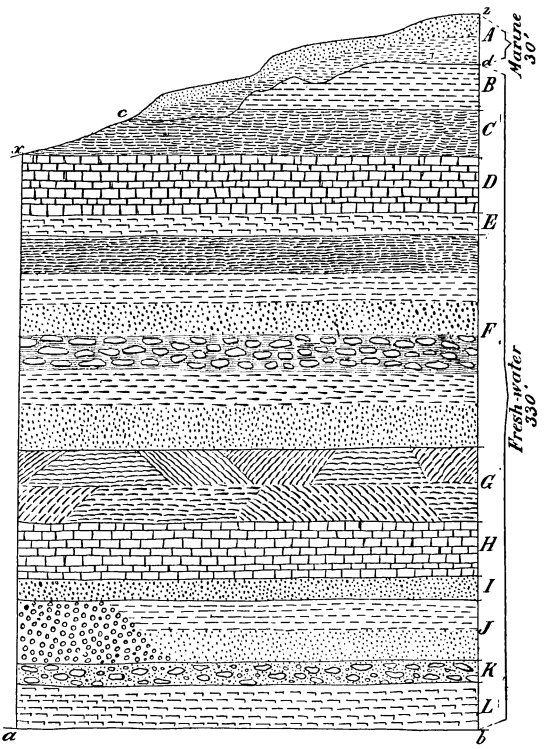

FIG. 6. Section near Cape Fairweather showing relations between Cape Fairweather and Santa Cruz beds. *b–d.* Santa Cruz beds. *d–z.* Marine beds, consisting below of Cape Fairweather beds and above of the bowlder formation. *c–d.* Contact between Cape Fairweather and Santa Cruz beds.

I provisionally correlated the Cape Fairweather beds with certain deposits discovered by Darwin at San Sebastian Bay on the east coast of Tierra del Fuego. Until the fauna of the latter beds is known, it will be impossible to verify the accuracy of this correlation. The aspect of the very meagre fauna found in them by Darwin, as well as the very considerable increase in thickness to which they attain at San Sebastian, are both important evidences in favor of this correlation; for as mentioned in my previous paper, all the Tertiary deposits of

this region increase in thickness as we proceed southward along the coast, and appear first toward the north capping the summits of the higher table lands, then farther south they are brought to the water's level by a slight southeasterly dip, and finally, still farther south, they entirely disappear beneath the sea.

In discussing the age of these marine beds Dr. Ameghino refers them to the Miocene because they contain oysters "of large size and of a species similar to that characterizing the Santa Cruz formation." Prof. Henry A. Pilsbry, who has studied our first collections from these beds and already published in the Proc. of the Phil. Acad. of Sci. a list, with descriptions of new species, refers these beds to the Pliocene. He has furnished me the following list of species: *Trophon laciniatus* Martyn, *T. inornatus* Pilsbry, *Calyptræa mammillaris* Brod. (?), *Turritella innotabilis* Pilsbry, *Cardium* sp. indet., *Pecten actinodes* Sowb., *Ostrea ferarresi* Orb.,* *O.* n. sp., *Pinna* sp. indet., *Magellania venosa* Sol. Of these he remarks "*Trophon laciniatus*, *Magellania venosa* and the *Calyptræa* are living species. The Cardium and Pinna may also be living. The others are extinct, but the Turitella is closely allied to a living Chilian form." We have since sent Dr. Pilsbry additional material which will enable him to nearly double the list of species, and which, he says, only confirms the Pliocene age of the beds.

The Tehuelche or Shingle Formation.—The presence of the Cape Fairweather beds with an abundant marine fauna, above the Santa Cruz beds, is positive proof of the submergence of this region. That this submergence took place long after the close of the Santa Cruz period can, I think, be well demonstrated, for, as shown in fig. 6, the Cape Fairweather beds are seen to rest upon the eroded surface of the Santa Cruz beds. This unconformity by erosion cannot be considered as due to a secondary deposition of the materials of the Cape Fairweather beds on the surface of the slope of the cañon where the section was made, for the two strata of bowlders and sandstones are here quite distinct, and show no mingling of materials, such as would have resulted from secondary deposition. Moreover the same unconformity is observable a little farther north in a section exposed for a long distance and where an absolutely level plain prevails above, as shown in fig. 7.

From these facts and others to be mentioned later, I conclude that after the deposition of the Santa Cruz beds and prior to the deposition of the Cape Fairweather beds this region was for a considerable period above sea level and subjected to erosion; during this period of erosion all the more

* In regard to the identification of the large oysters of Patagonia see paper by Dr. A. E. Ortmann in this number of this Journal, p. 355.

important water courses and many of the minor ones, which now exist, were outlined. After this, there was a subsidence sufficient to cause a submergence of this region beneath the sea, which prevailed in Pliocene times for a period ample for the deposition of the Cape Fairweather beds. Toward the close of the Pliocene there began a gradual elevation of this

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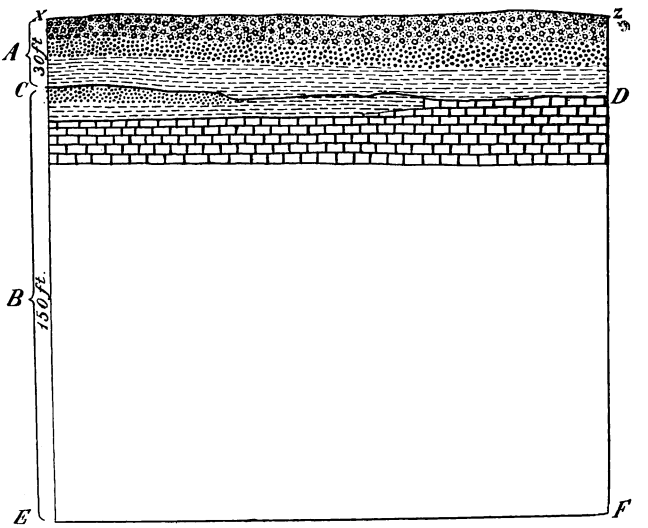
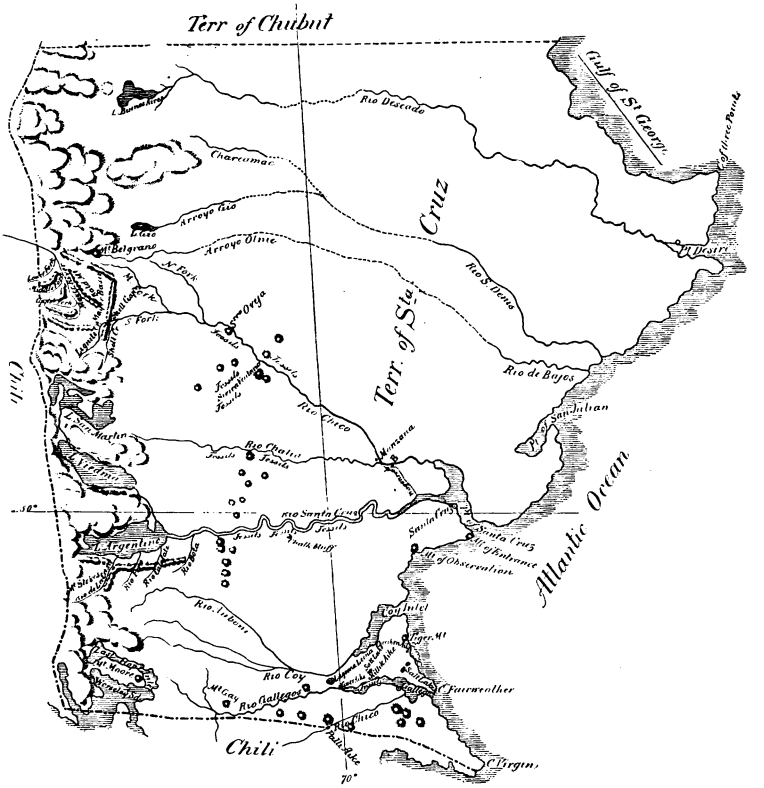


FIG. 7. Section showing unconformity by erosion between Cape Fairweather and Santa Cruz beds, made from top of land slide just north of section shown in fig. 6. *B.* Upper 150 feet of S. C. beds; *A.* Marine C. F. beds, composed below of sandstones with marine invertebrates and above of bowlder formation.

area, during which the great bowlder formation was deposited by the combined action of ice and water, and which resulted in bringing this region permanently above sea level. There can be little doubt that the origin of the numerous small salt lakes which now occur all over this region, and which occupy depressions in the surface of the plains, frequently several hundred feet in depth, dates from this period, and that they are due to confined bodies of salt water left in these depressions by the receding sea. Such depressions were, at some period during the elevation of this area, bays, formed usually near the source of small drainage channels tributary to the more important water courses, which existed in the former period of erosion. Across the mouths of these shallow bays there were thrown, by the tides, bars composed of sand and shingle which, as the elevation continued, confined considerable bodies of sea-water. If in such a body of water the loss by evaporation exceeded the gain by tributaries, there would be a gradual decrease in the

volume of water, until an equilibrium was reached, which would result in a small body of concentrated salt water, often with a deposit of salt at the bottom, due to precipitation from an oversaturated solution. This is exactly what is found to be the case in hundreds of places in this region. In all of these salt lakes the bluffs are always much lower on one side than on any of the other sides, and it is quite apparent that the present drainage system corresponds very closely with that of the former period of erosion.



Sketch map of Argentine territory of Santa Cruz.

That the salt in these lakes has been derived from confined bodies of sea water and has not been leached from the surrounding bluffs, is clearly shown by the numerous springs of sweet water in many places, alongside of the salt lakes. All the streams and springs of this region have good fresh water. We never saw a single spring the waters of which were saline, and the surface of the ground is everywhere remarkably free from incrustations by any alkaline or other salts.

I have already stated that the deposition and distribution of the great bowlder formation was accomplished by the combined action of water and ice. The facts which have led to this conclusion are the great quantity of material left as rounded hillocks, composed of heterogeneous masses of angular rocks, often of great size, polished bowlders and much fine-grained, silted material, occurring as moraines all along the base of the mountains and sometimes extending for some distance out on the plains. Another fact also observed and bearing directly upon this question is the distribution throughout this formation of immense bowlders, which could not possibly have been transported to their present position by any other agency than that of ice. The number of these large, massive bowlders rapidly decreases to the eastward after reaching a point about thirty miles east of the Cordilleras, but they are found, though rarely, even as far east as the present coast. As an instance of this I may mention that one of these bowlders, weighing several thousand pounds, may be seen on the bluffs of the south side of the Rio Chico about ten miles below the mouth of Rio Chalia. It lies on the north side of and only a few yards from the road which leads from the port of Santa Cruz to the settlements on the lower Rio Chico. Its position is approximately shown on the map at the point marked +B. From the present position of this rock, weighing not less than 6000 pounds, to the mountains, is a distance of 200 miles, and it does not seem possible that this immense bowlder could have been transported that distance by any other agency than that of ice. I therefore conclude that, along with the elevation there were in the Cordilleras great accumulations of snow and ice, which produced glaciers extending out beyond the foot hills of the mountains even as far as the, at that time, eastern border of the sea. The glaciers no doubt transported most of the material now constituting the great bowlder formation from the Cordilleras to the sea, where it was afterwards distributed over the region to the eastward by the combined action of water and ice, either in the form of icebergs or floating shore and river ice. This would account for the enormously greater development of the bowlder formation near the Cordilleras than distant from them; for the gradually decreasing size of the rocks of which it is formed as we proceed eastward from the mountains, both of which facts have been observed and commented upon by Darwin; and also for the occasional occurrence in the formation of large bowlders in places far removed from the mountains, and which were doubtless carried by icebergs direct from the glaciers to their present positions.

Later Sedimentary Deposits.

In the region visited there are other sedimentary deposits, usually of very limited extent and evidently of quite recent origin. My observations do not warrant any very definite opinions regarding the origin or exact age of any of these deposits. Among them I may mention some of loess (?) in the

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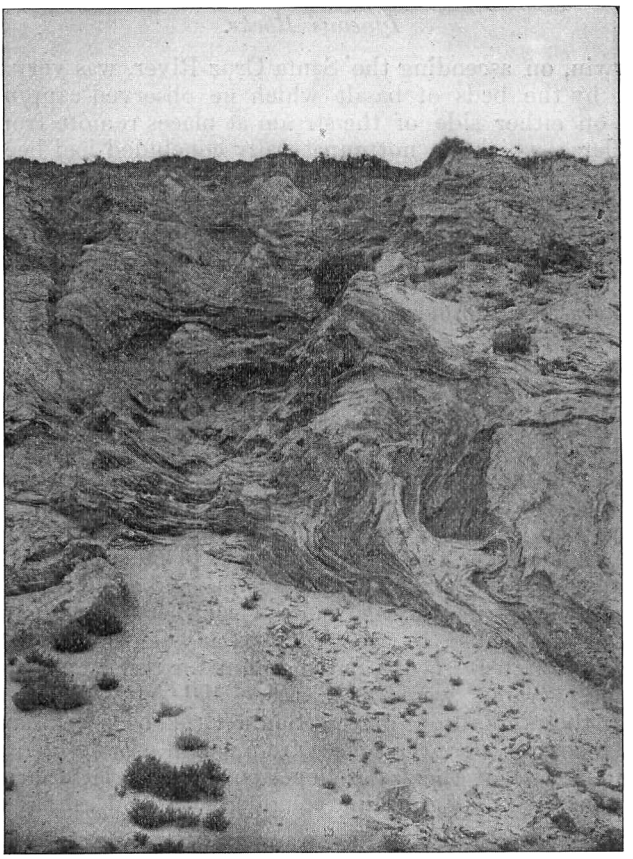

FIG. 8. Example of wind erosion on south fork of Rio Chico, Patagonia, from a photograph by the author.

high bluffs north of the Gallegos River, just west of Killik Aike. They rest unconformably upon the Santa Cruz beds, are about 40 feet thick and are composed of very fine sand

showing stratification toward the bottom, where we found the lignitized stems of small plants and parts of the skeletons of two rodents.

Important deposits of loess (?) were observed on the south fork of the Rio Chico, which may be really aqueous deposits belonging to the bowlder formation. They are best exposed in the bluffs of the stream, where they show beautiful examples of wind erosion, a section of which is shown here in fig. 8.

Igneous Rocks.

Darwin, on ascending the Santa Cruz River, was very much struck by the beds of basalt which he observed capping the bluffs on either side of the stream at places remote from the Cordilleras, which he not unnaturally concluded had been the source of all the basalts of this region. He considered these basalts as examples of long distance lava flows over a bed only very slightly inclined. Had Darwin gone overland into the interior, instead of up the Santa Cruz River, he could not have failed to discover that the source of these lava beds was not the Cordilleras, but numerous small craters, found often in the immediate vicinity. There is a group of these craters only a few miles inland, near the mouth of the Gallegos River; they are most numerous over an area about forty miles in breadth, extending across the country from north to south, and distant about 80 to 120 miles from the mountains. It is sometimes possible to travel more than 100 miles between this chain of craters and the Cordilleras without passing over a single lava bed, especially in the district south of the Santa Cruz River.

Notwithstanding that these craters exist in such great numbers all over the plains of Patagonia and penetrate right through the strata of the Santa Cruz beds, yet there was nowhere observable, in their vicinity, any faulting or disturbance of the latter I can only account for this on the theory, that these craters were in existence and active prior to and during the deposition of the Santa Cruz beds. I have no doubt that they were the source from which was derived much of the material of the latter deposits, since the latter are very largely composed of volcanic conglomerates and ash, as stated by Darwin.

It is also evident that many of these craters continued active long after the deposition of the Santa Cruz beds, for many of the lava flows may still be seen, in places, descending from the plains down over the slopes into the valleys of the water courses, showing that the latter had been eroded prior to the flow of streams exhibiting such conformation.

Many of the craters show, especially in their lower parts, a

well defined columnar structure ; while toward the top they are usually composed of great masses of vesicular slags and cinders with bright colors, jet black, steel blue, crimson and yellow predominating. One of these is shown in fig. 9. The columnar structure may be seen on the left near the base, while toward the summit only cinders and slags prevail. The two small "windows" on the left have suggested the name *Sierra Ventana.* It is on the right bank of the Rio Chico about 75 miles above the mouth of the Rio Chalia and rises to a height of perhaps 1200 feet.

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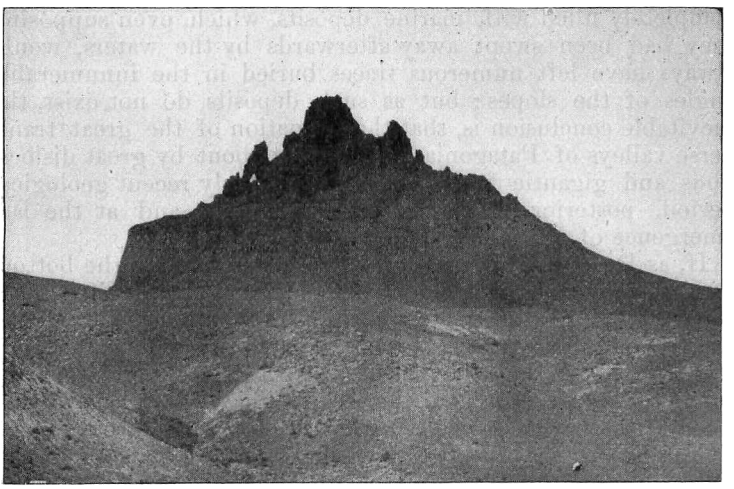

FIG. 9. Sierra Ventana, Rio Chico, Patagonia, from a photo. by the author.

The Transverse Valleys of Patagonia.

Dr. Florentino Ameghino, in his "Notes on the Geology and Paleontology of Argentina," after discussing at some length the bowlder formation, takes up the origin of the transverse valleys of Patagonia. Since it appears to me that Dr. Ameghino is entirely wrong here, not only in his conclusions but also in his statement of facts, I quote him fully on this question. He says, on page 18: "Having now dispelled the ignorance as to the origin of the bowlder formation, this leads us naturally to determine the age of the formation of the transverse valleys of Patagonia. It is evident that at the bottom of the ancient sea in which the bowlders were deposited, these were scattered by the waters in a uniform manner over all the submerged territory. The same may be said of the sheets of

basalt; these also must have extended in a comparatively uniform manner, without forming the steep cliffs which they exhibit to-day in the river valleys. Darwin, speaking of the scarps of the valley of the river Santa Cruz, said that the cliffs of basalt of the two opposite sides were recognizable immediately as at one time forming a continuous bed. The same may be said of the beds of bowlders which in many parts form the opposite cliffs of the Patagonian valleys; those beds were continuous across the valleys, but there are now no traces of them.

"It is evident that if the valleys had existed before the great marine submergence referred to, they would have been completely filled with marine deposits, which, even supposing they had been swept away afterwards by the waters, would always have left numerous traces buried in the innumerable angles of the slopes; but as such deposits do not exist, the inevitable conclusion is, that the formation of the great transverse valleys of Patagonia was brought about by great dislocations and gigantic faults at a comparatively recent geological period, posterior to the bowlder formation and at the last emergence of the land."

If, as Dr. Ameghino states, "it is evident that at the bottom of the ancient sea in which the bowlders were deposited these were scattered by the waters in a uniform manner over all the submerged territory," is it consequently evident, as he concludes, that "if the valleys had existed before the great marine submergence referred to, they would have been completely filled with marine deposits," when these valleys are all many times deeper than the entire thickness of the bowlder formation? It certainly is not evident that these valleys would have been completely filled with marine deposits; but it is quite evident, that over their slopes and in their bottoms there would have been deposited a layer of bowlders, at least equalling in thickness that of the bowlder beds of the table lands. It is further evident, that supposing they had been afterwards swept away by the waters, they would have left numerous deposits buried in the innumerable angles of the slopes; and this is just what is to be seen in the sides of the cañons and larger water courses at almost every section shown along the coast or elsewhere. In fig. 6 are shown not only the bowlder formation but also the underlying Cape Fairweather beds, both occupying angles in the slope. In figs. 10 and 11 the remnants of the bowlder formation are shown occupying angles in the slopes of the cañons along this coast. At the points where both the latter sections are shown, it is quite possible to determine the relative amount of erosion which has taken place prior to and since the deposition of the bowlder formation.

Now, again, if, as Dr. Ameghino states: "The inevitable conclusion is, that the formation of the great transverse valleys of Patagonia was brought about by great dislocations and

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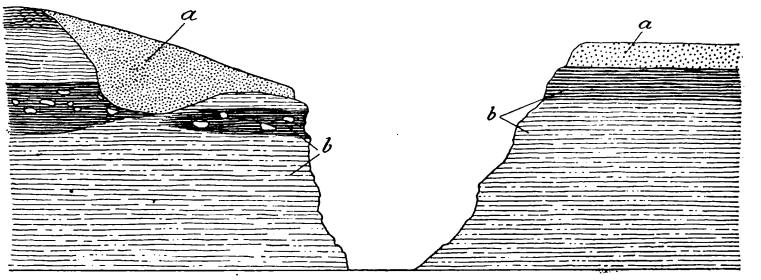

FIG. 10. Section as displayed in bluffs of coast at Corriken Aike about 18 miles south of Coy Inlet, showing the bowlder formation occupying angles in the slope of the cañon. *a*. Bowlder formation. *b*. Santa Cruz beds.

gigantic faults at a comparatively recent geological period, posterior to the bowlder formation and at the last emergence of the land"; how could these beds of basalt and bowlders now

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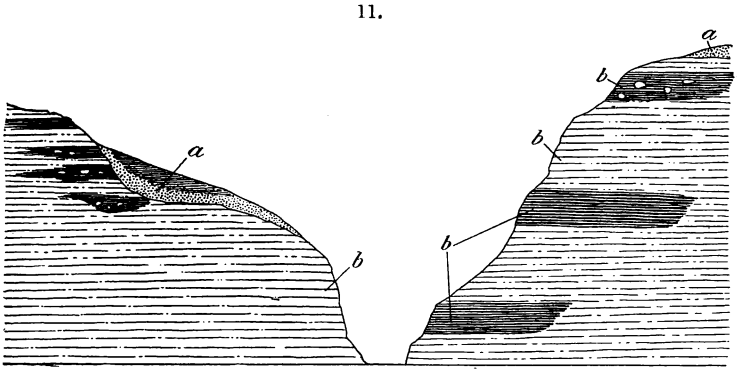

FIG. 11. Section as displayed in bluffs of sea coast at mouth of cañon about 10 miles south of Coy Inlet, showing bowlder formation occupying angles in slope of cañon. *b*. Represents S. C. beds; *a*. Bowlder formation covered by heterogeneous material of secondary deposition accumulated during the present period of erosion. The dark areas shown in both the above sections in the S. C. beds are composed of discontinuous strata of heavily bedded sandstones enclosing large concretions shown as white areas on the sketch.

form opposite cliffs of the valleys, as he has stated above? If there are such gigantic faults in this region, surely there should have been ere this some recorded observation concerning them. In so far as I know, no one has ever observed any dislocation

in these beds. My own impression was that the different strata on opposite sides of any given water course were remarkably similar and easily identified. Darwin also states, on page 119 of his "Geological Observations on South America," that the land in this region has been upraised without the strata having been in a single instance, as far as his observations went, unequally tilted or dislocated by a fault. I think it has now been pretty clearly shown that the transverse valleys of Patagonia are due to erosion, and that this erosion was partially accomplished before the deposition of the bowlder formation. The lava beds, which now form opposite cliffs of the same valley, had their origin either during the deposition of the Santa Cruz beds or *immediately* after, and before any considerable erosion had taken place; while those showing conformation with an eroded surface—and there are many such—were ejected long after the close of the Santa Cruz period.

As an aid to others intending to visit this country for the purpose of collecting fossils, the following suggestions as to localities may be of some service. I have already indicated on the map the most promising localities for fossils in the Santa Cruz beds. I should especially recommend the bluffs on the north side of the Gallegos River from Guer Aike to a point opposite Gallegos; and the beach, below the bluffs, laid bare at low tide, on the coast between Corriken Aike and Coy Inlet. In the interior there are very promising localities in the bluffs of the Santa Cruz, Chalia and Chico rivers, and over a large area between the last two streams lying directly south of Sierra Ventana.

Princeton University, Sept. 26, 1897.