7. On Quaternary deposits and changes of level in Patagonia and Tierra del Fuego.

By

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During the Swedish Expedition to Patagonia and Tierra del Fuego in 1907—1909 under the direction of Dr. C. SKOTTSBERG, I had opportunity to pay attention also to some facts bearing on the history of this region in Quaternary time. But as I was mostly engaged in studying the stratigraphy and palæontology of the older formations, I am only able to give some few and scattered notes on the questions to be dealt with in this paper. They may, however, be of some assistance to future explorers. — Mr. P. D. QUENSEL made before my arrival in Patagonia an interesting trip to the eastern border-zone of the Cordillera between Ultima Esperanza and Lago Argentino. During three months spent in this region, he studied also the past as well as the recent glaciation. After we had joined in Punta Arenas, in February 1908, to continue the geological work in co-operation, QUENSEL followed up his investigations of the glacial features in other parts of Patagonia and Tierra del Fuego. The main results of his studies appear in a paper published in the present volume of this Bulletin.[1] For the present I will confine myself to two different and yet closely connected subjects: a description of some glacial sedimentary deposits and a discussion of the Quaternary changes of level.

Quaternary deposits and submergence of Tierra del Fuego.

Ever since the occurrence of a wide-spread glaciation in the southern part of South America was first stated, it has been generally regarded as contemporaneous with that of the northern hemisphere. Without attaching too much importance to opinions of a different nature, it is evident, however, that the simultaneousness should not be taken for granted *a*

[1] P. D. QUENSEL.

priori. In any case, there appears to be some interest attached to fossiliferous deposits, occurring in connection with glacial beds. Unfortunately the knowledge of such deposits is, however, very scanty and more of a nature to stimulate to further investigation.

Of very great interest is a bed of gray clay discovered by Professor O. NORDENSKJÖLD[1] north of Rio Cullen on the Atlantic coast of Tierra del Fuego. It rests on plant-bearing Tertiary layers and is covered by boulder-clay. A specimen of the clay was examined by Prof. P. T. CLEVE and found to contain needles of Spongia and Diatomaceæ, mostly marine. The fossils are of a decidedly Quaternary character. Unfortunately, there is no record of the height of this deposit above the present sea level.

During the Swedish South Polar Expedition in 1901—1903, Prof. J. G. ANDERSSON discovered an interesting Quaternary deposit on Gable Island, in the eastern part of the Beagle Channel. In a paper in this Bulletin[2] he has described the structure of the island, but unfortunately his collections were lost with the »Antarctic». In March 1909 I found opportunity to pay a short visit to this interesting locality.

Almost the whole of Gable Island is built up by Quaternary deposits, the underlying solid rock only projecting, according to J. G. ANDERSSON, in a small outcrop on the NE. Side. The lower part of these deposits consists — at least along the W. side — of a series of alternating beds of sand and gravel, varying in thickness and with an undulating upper surface. These lower series, considered by ANDERSSON as being of fluvio-glacial origin, is covered by a typical boulder-clay, containing comparatively few and small boulders in a rather coarse matrix. The thickness of the whole deposit varies considerably. On the west side the lower stratified series generally varies between *10—30* m. in thickness. The highest point of the island reaches — according to the Argentine chart — a height of *92 m.*

Near the SW. point of the island ANDERSSON made the interesting discovery of organic remains in the boulder-clay. The fossils consisted of worn and fragmentary shells of mussels and barnacles. As mentioned above, the collection was afterwards lost, and ANDERSSON was not able to decide whether the shells were of Tertiary or older Quaternary age. In any case it is evident, that the fragments have been carried away by the ice from some unknown marine deposit.

When visiting the island I soon found in the boulder-clay some fragments of shells, apparently corresponding to those collected by ANDERSSON. But in another place, probably south of his locality, I discovered also in the stratified beds underlaying the boulder-clay some better preserved

[1] O. NORDENSKJÖLD. Über die posttertiären Ablagerungen der Magellansländer. Wissenschaftliche Ergebnisse der Schwedischen Expedition nach den Magellansländern 1895—1897. (I:1.) Stockholm 1899. P. 36.

[2] J. G. ANDERSSON. Geological fragments from Tierra del Fuego. Bull. Geol. Inst. Upsala (VIII) 1906. P. 169—183.

marine shells. Most common were barnacles, mostly entire, and mussels, the latter very broken and fragmentary. Besides there were represented some few species of small gastropoda, to a great part perfectly entire. The fossils were found in the uppermost part of the stratified series, which attains in this place only a thickness of about *10* m. above sea-level. They were confined to certain well defined strata of a coarse sand, in which they occurred in great abundance. According to the current-bedding of the deposit, the fossiliferous strata cannot be followed for a greater distance, but thin out and disappear between barren layers.

The fossils were presented to the State Museum of Natural History in Stockholm. Through the courtesy of Prof. G. HOLM they were handed over for examination to Mr. R. HÄGG, who has kindly placed at my disposal the following report on the fauna, which I quote *in extenso*.

»The collection from Gable Island, handed over to me for determination, contains the following species:

1. *Saxatieria dubia* STREBEL. — 4 specimens. Present distribution: West Patagonia, Tierra del Fuego and the Falkland Islands, in a depth of 7—275 m.
2. *Euthria rosea* HOMB. et JACQ. — 2 specimens. West Patagonia, Tierra del Fuego and the Falkland Islands, 5,5—275 m.
3. *Euthria cerealis* ROCHEBR. et MAB. — 1 specimen. West Patagonia, Tierra del Fuego and the Falkland Islands, from the low-tide shore to 22 m.
4. *Euthria meridionalis* E. A. SMITH. — 2 specimens. West Patagonia, Tierra del Fuego, 11—45 m.
5. *Euthria Martensi* STREBEL. — 1 specimen. West Patagonia, Tierra del Fuego, 9—37 m.
6. *Antistreptus magellanicus* DALL. — 2 specimens. Found living outside the coast of Northern Argentina, in lat. s. 37°50′, in a depth of 100 m. (Swedish South Polar Expedition 1901—1903), near the eastern entrance to the Magellan Straits and in the Magellan Straits.
7. *Trophon laciniatus* MARTYN — 2 specimens. Chile, West Patagonia, Tierra del Fuego, the Falkland Islands and South Georgia, 11—160 m.
8. *Trophon dispar* MABILLE et ROCHEBR. — 1 specimen. Tierra del Fuego, 25 m.
9. *Cerithium pullum* PHIL. — 2 specimens. West Patagonia, Tierra del Fuego and the Falkland Islands, from the low-tide region to 275 m.
10. *Pecten patagonicus* KING. — 12 fragments. Tierra del Fuego, Southern Patagonia, and the Falkland Islands, 16—22 m.
11. *Venus Dombeyi* LAM. — 1 fragment. Peru, Chile and the Straits of Magellan (found there only once and very rare).
12. Undeterminable mussel — 7 fragments.
13. *Balanus* sp. — 7 complete specimens.

The fauna is to be considered as a homogeneous shallow-water fauna and consists mostly of species living now in the immediate vicinity of the locality. Most of the species are very common now. The occurrence of *Antistreptus* and *Venus* possibly indicates a warmer climate than at present. That the climate has in any case not been much colder than now, is seen from the fact that none of the species occurs in the proper Antarctic region. Only *Trophon laciniatus* reaches colder regions than Tierra del Fuego and the Falkland Islands. Of this species a young specimen has been found once at South Georgia, but this island should evidently be considered as lying outside the proper range of distribution of the species, which is Tierra del Fuego and the Falkland Islands.

That the fauna could have existed in the vicinity of a glacier must be regarded as excluded on account of the temperate character of the species and the predominance of the gastropoda as compared with the mussels. Also the vicinity of the mouth of a river is improbable. The fauna appears to have been living under favourable conditions. It is, of course, completely excluded that it could be of a Tertiary or Præglacial age. It looks like being of a very recent character, but it may also be interglacial. The specimens are in general well preserved. It is especially remarkable that all the Balanidæ are perfectly complete, a condition of preservation not common even in the undisturbed late Quaternary deposits of western Sweden. Nothing thus indicates that the shells have been transported or occur now in secondary position. A detailed account of the fauna will be published before long.»

Since it has been possible to determine specifically a considerable number of the shells, this deposit is interesting from several points of view. The first question to be considered is, whether the fossils occur now in primary position. Though the collection includes only the better preserved specimens found after some searching in the locality, it is evident from the great number of determinable species that the somewhat fragmentary nature of the shells is not in itself sufficient reason for assuming a secondary position. The only fact which is open to some suspicion in this respect is the nature of the deposits. As has been remarked by ANDERSSON, the series suggests, mainly in regard of the current-bedding displayed in many parts, a strikingly fluvio-glacial origin. It is, of course, not impossible that the glacial streams may have carried the shells from some older deposit, over which the ice advanced, but it must be regarded, I think, as highly improbable that such large accumulations of shells could have been formed in this way. The perfect state of preservation of the barnacles and some of the gastropoda seems also to speak against such an adventurous mode of transport.

If the fossils occur, then, as seems for the present more probable, in primary position, the stratified series would have been deposited, at least partly, in the sea. It would be natural to assume, for reasons related above, that the layers were formed outside the ice-border from material

swept into the sea by the glacial streams. But the fauna, as known from HÄGG'S careful examination, can hardly have been living in the immediate vicinity of the ice. The current-bedding and the repeated alternating of layers of sand and gravel most decidedly suggest a deposition by running water. Also, the possibility that the series may have been formed as the delta of a river seems however — according to HÄGG — not to be in agreement with the nature of the fauna. Current-bedding of a deposit formed in shallow water may, in cases, result from the strong tidal currents of this region, but especially in regard to the thickness of the beds, this does not afford a sufficient explanation. I am forced, then, to leave for the present the question of the formation of the series open.

Whichever may have been the mode of formation of the series, it is of great interest that all the fossils have been found to belong to living species, and, with two exceptions occurring to-day in the immediate vicinity of the locality. HÄGG concludes accordingly, from the corresponding conditions in Northern Europe, that the fauna cannot be of præglacial age. As the exact age of the South American glaciation is not settled beyond dispute, it is however possible, though by no means probable, that a similar nature of the fauna may not necessarily involve a corresponding relation to the epoch of glaciation. Attention should be called in this connection to Prof. NORDENSKJÖLD'S important discovery of a fossiliferous clay, underlying boulder clay, at Rio Cullen on the Atlantic coast (see above, p. 94). Though this locality is not far from the probable outer limit of the maximum glaciation, all the 25 species of Diatomaceæ determined by Prof. CLEVE are still living, with exception of two forms which were not known before.

As I nowhere found the basement of the stratified series, it is uncertain whether it rests on a lower bed of boulder-clay or not. The stratigraphic conditions, therefore, give no direct evidence as to the question of the præ- or interglacial age of the series. But from other reasons there is little doubt that this cannot well be prior to the great glaciation, which extended in this region eastwards to the Staten Island. The thick Quaternary deposits of the Gable Island now almost bar the Beagle Channel, and it seems difficult to conceive how the ice could have failed to destroy such a projecting and yet feeble obstacle, when advancing in the direction of the narrow valley. We may then consider the series as being of late glacial or perhaps interglacial age. There is not yet any evidence as to how far the ice receded during the formation of the fossiliferous layers. As mentioned above, the fauna has a decidedly temperate character and HÄGG considers it as excluded that it could have lived close to the iceborder. The occurrence of *Antistreptus* and *Venus* indicates — according to HÄGG — that the climate has been warmer than now. At any rate, it is remarkable that not a single Antarctic species has been met with, and that the fauna decidedly indicates a climate not colder than the present. These facts seem to favour the idea that the fossiliferous deposit

represents an interglacial epoch. But, considering how little is known about the climate during the recession of the ice, it is not advisable to form any definite opinion as to the amount of the oscillation. The subsequent advance of the ice was, however, not great. The stratified deposits were only slightly eroded and covered by a bed of boulder-clay.

That the stratified series remains now *in situ* is evident. As the fossils occur probably in primary position, they consequently give some information as to the height of the sea-level at the time of their deposition. The fossils were found at a height of *8—10* m. above the present high-water mark, and as all species live in shallow water, the minimum of submergence would be somewhat greater than is indicated by this figure. The stratification of the deposits appears, however, quite conformable — apart from the subordinate current-bedding — and it would be natural to assume a uniform mode of formation for the whole series. The thickness of the stratified beds is in places at least *30* m., and that figure would accordingly represent the minimum of submergence. At present this is only a conjecture which may be confirmed by the discovery of fossils also in the higher parts of the series.

DARWIN[1] was the first to prove definitely the existence of a Quaternary submergence in the southern part of South America. His opinions, as relating to Patagonia and Tierra del Fuego, cannot, however, be maintained, because he regarded the boulder-clay formation as a submarine deposit — in accordance with LYELL's Drift-theory. The marine shells recorded by him from places of great height above the sea have, in most cases, certainly been brought there in recent times. This objection applies also to similar observations of AGASSIZ. Indisputable evidence of a Quaternary submergence has been afforded later by O. NORDENSKJÖLD (l. c. p. 56). At *Páramo* on the Atlantic Coast of Tierra del Fuego he collected, *10* m. above sea level, a specimen of clay which was found by CLEVE to contain needles of Spongia and the marine Diatomaceæ *Paralia sulcata* (EHB.) CLEVE and *Actinoptychus undulatus* EHB. This is the only reliable account, from Tierra del Fuego, of marine Quaternary fossils. Marine deposits reach, according to NORDENSKJÖLD, to a height of *20—30* m., but he makes no report of fossils from any other place. Traces of a still greater submergence he believed to exist in the shape of terraces and raised beaches. Of interest is a terrace on O'Brien Island in the western part of the Beagle Channel, cut out in solid rock at a height of *25—40* m. above sea-level. Other terraces are recorded from Porvenir (*30* m.) and the Patagonian Channels (*30—40* m.) The best developed terrace was found on the south side of Bahia Inútil,

[1] CHARLES DARWIN. On the Distribution of Erratic Boulders and on the Contemporaneous Unstratified Deposits of South America. Trans. Geol. Soc. London. Second series. Vol. 6. 1842. p. 415. See also: Geological Observations on South America. London 1846.

at *50—60* m., and this is considered by NORDENSKJÖLD to be the *minimum of postglacial submergence.* On higher levels no unquestionable traces of marine action were met with, but on the slopes of the Martial Mountains, near Ushuaia, boulders of foreign origin were found to a height of *100* m. These boulders may, however, originate from the moraines. At Disappointment Bay a somewhat doubtful terrace with erratic boulders is recorded *100* m. above sea-level.

J. G. ANDERSSON[1] has called attention to a series of marked beach-terraces on a much lower level at the Beagle Channel. Near Harberton their height is only *3,5* m. They seem to rise towards W., but no exact observations were obtained here. Near Ushuaia NORDENSKJÖLD has recorded a marked terrace on *10* m. From these facts ANDERSSON draws the conclusion that the upheaval of land has probably been unequal as in Scandinavia. He considers this terrace-line as the postglacial marine limit.

Before entering on my own observations in this point I will call attention to a fact which I think it will be good to bear in mind in a discussion of old shoremarks in Tierra del Fuego and the Patagonian Channels. It is clear from a glance at the map that the geographical features in these parts would favour, during the time of glaciation, the formation of ice-dammed lakes. Such lakes may have originated in different ways, as marginal lakes, or dammed up by glaciers coming down from another valley etc. In most cases it is impossible to trace by other facts the existence of such ice-dammed lakes, and their shore-lines will then be easily mistaken for proofs of submergence. Many of the terraces recorded from the Magellan Territory are probably of this origin. This same remark applies also to the terraces to be described here. As it is, however, in many cases, at present impossible to distinguish between the two kinds of terraces, they will be here all grouped together, but only when it is particularly remarked, should they be regarded as being of marine origin.

When visiting the Beagle Channel in March 1909, I observed in several places raised beach-terraces on a low level, apparently of marine origin. On the north side of Gable Island there is a very distinct terrace *6* m. above sea-level. Farther west, at the mouth of Rio Grande near Ushuaia, I measured an accumulative terrace, also at a height of *6* m. Other terraces of about the same height were seen in the vicinity, but there was no opportunity to obtain an exact figure.

It is tempting to connect these shore-marks with those discovered by ANDERSSON near Harberton on *3,5* m. and supposed by him to rise towards the west. The distance from Gable Island to Harberton is, however, only *13* km. from the same place to Rio Grande *48* km. Considering also that these terraces cannot — from what I have found in other parts of Tierra del Fuego — well represent the highest postglacial marine limit, their connection is at least very questionable. At any rate, these low terraces do not afford any unquestionable evidence of an unequal upheaval.

[1] J. G. ANDERSSON, l. c. p. 182.

On a little higher level there are in the same places some terraces which are probably also of marine origin. They are not, however, as distinct as those on the lower level. At Rio Grande I found the height to be *20* m. and on Gable Island QUENSEL obtained the same figure. It is worthy of note, if only as an occasional coincidence, that both the lower and the higher terraces have the same height in both places.

There is a special interest attached to the rare occurrence of raised beach-lines in the Patagonian Channels. In these regions the glaciers come to-day down to the sea, and during the great glaciation the ice-shed most probably was situated in this part. (This question has been more fully discussed by QUENSEL in his paper in the present volume). The absence of raised beaches here would indicate a comparatively recent recession of the ice to its present extension, after the emergence of the land had been already completed. In fact old beach-lines are remarkably rare in all the western channels. As mentioned above, NORDENSKJÖLD has observed on O'Brien Island a terrace, cut out in solid rock at *25—40* m. above sea level. He considers this terrace to be a true shore-line. On the north side of the channel, opposite O'Brien Island, I observed from the steamer a marked shore-line, the height of which QUENSEL and I estimated to *12—15* m. These are the only beach-marks known from the western part of the channel, and none of them appear to be satisfactory as a proof of submergence. The rare occurrence of old shore-marks may be, however, accounted for by the geographical features of this region. The shores are mostly formed by precipitous cliffs, and the channels are of great depth close to the sides. In such parts even the present sea-level would not leave any traces, if the land were raised. In other places the slopes are covered by a luxuriant vegetation, and the thick peaty accumulations of decaying vegetable matters would certainly conceal any raised beach-lines.

The terraces occurring at the Beagle Channel on a higher level than those now mentioned are generally not very distinct. There is, however, one remarkable exception. In the steep slope of the Martial mountains I found above Ushuaia on *100—110* m. the most distinct terrace that I have seen in these parts. It is perfectly level, some *30—40* m. broad in places, and I followed it for more than *1* km. Owing to the absence of sections, it is not quite clear, whether it is of the accumulative or the erosive type. The surface is, however, covered by shingle-accumulations. Somewhat below the terrace I observed in a section layers of stratified gravel and shingle. Notwithstanding the splendid development of the terrace it is not certain that it should be regarded as a raised sea-shore. From whole Tierra del Fuego no sure terraces have been reported of anything like this height. The highest terrace of a trustworthy nature is the one recorded by NORDENSKJÖLD at Bahia Inútil on *50—60* m., but even this terrace has not been proved to have been formed by the sea. As the fine terrace at Ushuaia may quite well be of glacial origin, it affords at present no proof that the postglacial submergence reached this high level.

On the Atlantic coast of Tierra del Fuego traces of land-rising occur in several places. At the Mission-station north of the mouth of Rio Grande two very distinct terraces are seen (fig. 1). The settlement lies on a low shingle-terrace several hundred metres broad, *3* m. above high-water mark. Further inland rises a steep *barranca* which forms the rand of a level plateau, *18* m. above sea-level. This plateau has a great extension and forms the greater part of the low land between the Mission-station and the lower part of Rio Grande. In the barranca the structure of this plateau is well displayed. The uppermost layers consist of shingle and this is underlain by a fine-grained sand. In the sand occur abundantly shells of the common recent mollusca, mostly *Mytilus chilensis* HUPÉ and *Nacella magellanica* GMELIN. The plateau evidently represents a delta of Rio Grande, formed at a time when the sea reached at least *18* m. higher than at present. Its great extension and level surface indicate that the sea stood at this height for some considerable time.

This is the highest level on which I have found fossiliferous marine deposits, but some questionable traces of a greater submergence of the

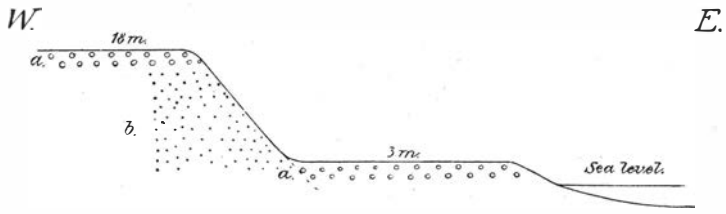

Fig. 1. Coast section at the Mission-station near Rio Grande. *a* shingle, *b* sand with marine shells.

Atlantic coast were also noted. In the steep slopes of Cabo Domingo I noticed in several places beds of shingle. It is, however, not impossible, that these are only fluvio-glacial deposits of somewhat unusual appearance. Further south, there is on the top Cabo Inez at a height of *42* m., a shingle-bed, which strikingly suggests a raised beach. North of Cabo Inez I observed in several places terraces at a height of about *15* m. above sea-level.

On Dawson Island some not very distinct terraces are to be seen near the Mission-station. The one best developed has a height of *29* m. Another one, not so well marked, occurs at about *50* m. Opposite this locality, on the main island of Tierra del Fuego, I saw from the steamer a very distinct raised shore-line of great extension, but no observations of the height were obtained. On the east side of Brunswick Peninsula terraces have been observed in several places, but they are generally not quite indubitable. On a comparatively low level there occur, however, in several places very distinct terraces. At Rio Amarillo the height of a well developed accumulative terrace was found to be *7—8* m. This terrace is certainly of marine origin. Between Punta Carrera and Port Famine I

noticed some marine shells at a height of *15* m., and probably in primary position imbedded in sand.

The late development of Otway and Skyring Waters.

(See the map, Pl. 5).

Round the coasts of these large bays old shore-lines occur in many places.[1] Owing partly to the geographical features, the late development has been here somewhat complicated and will require detailed explorations in the field for a better understandig. At present even the orography is not sufficiently well known.

Both Otway and Skyring occupy the bottom of great preglacial depressions, in every respect corresponding to those of the Patagonian lakes further north, only now submerged below the level of the sea. Like these lakes their western parts lie within the reach of the Cordillera, and deep and narrow fiords stretch far inland between high forest-clad ridges. Two of these fiords cut through the whole Cordillera, separating the inland waters from the Straits of Magellan. These are the *Canal Feró-nymo*, the entrance of Otway Water, and the *Canal Gajardo* which connects Skyring Water with the western part of the Straits. In both Otway and Skyring there is a marked decrease of depth towards the east, partly due to the filling up of the depressions by glacial and fluvioglacial deposits. The eastern parts of the depressions are connected by another preglacial valley separating the Tertiary plateaus of the Beagle Mountains from Cordillera Riesco. This valley is now, for the most part, land, only the narrow Fitz Roy Channel connects the two great bays. Also the isthmus separating the east end of Otway from the Straits of Magellan consists of loose Quaternary deposits and certainly represents another preglacial depression between the Tertiary hills in N. and S.

During the time of maximum glaciation the land-ice extended over the whole of Otway and Skyring and for some distance further east. In the vicinity of the Fitz Roy Channel the glacial deposits attain a great thickness, and well developed marginal moraines indicate that the ice-border was stationary here for some time. Some 50 km. SW. from here i. e. in the direction towards the probable ice-shed, we discovered on the NW. side of Otway Water a series of stratified deposits covered by a thick bed of boulder-clay. The small river called *Rio Grande*, which comes from the hills of *Cerro Yunque* of the Chilean chart, has cut, some *4 km.* from its mouth, a fine section through the glacial deposits on the left hand side. The structure of the barranca will be seen from the schematic section fig. 2.

[1] The occurrence of raised shore lines at Skyring Water, was briefly reported by COPPINGER in 1880, but no figures were given (Visit to Skyring Water etc. Proc. Geogr. Soc. New Ser., II. 1880 p. 552—556.

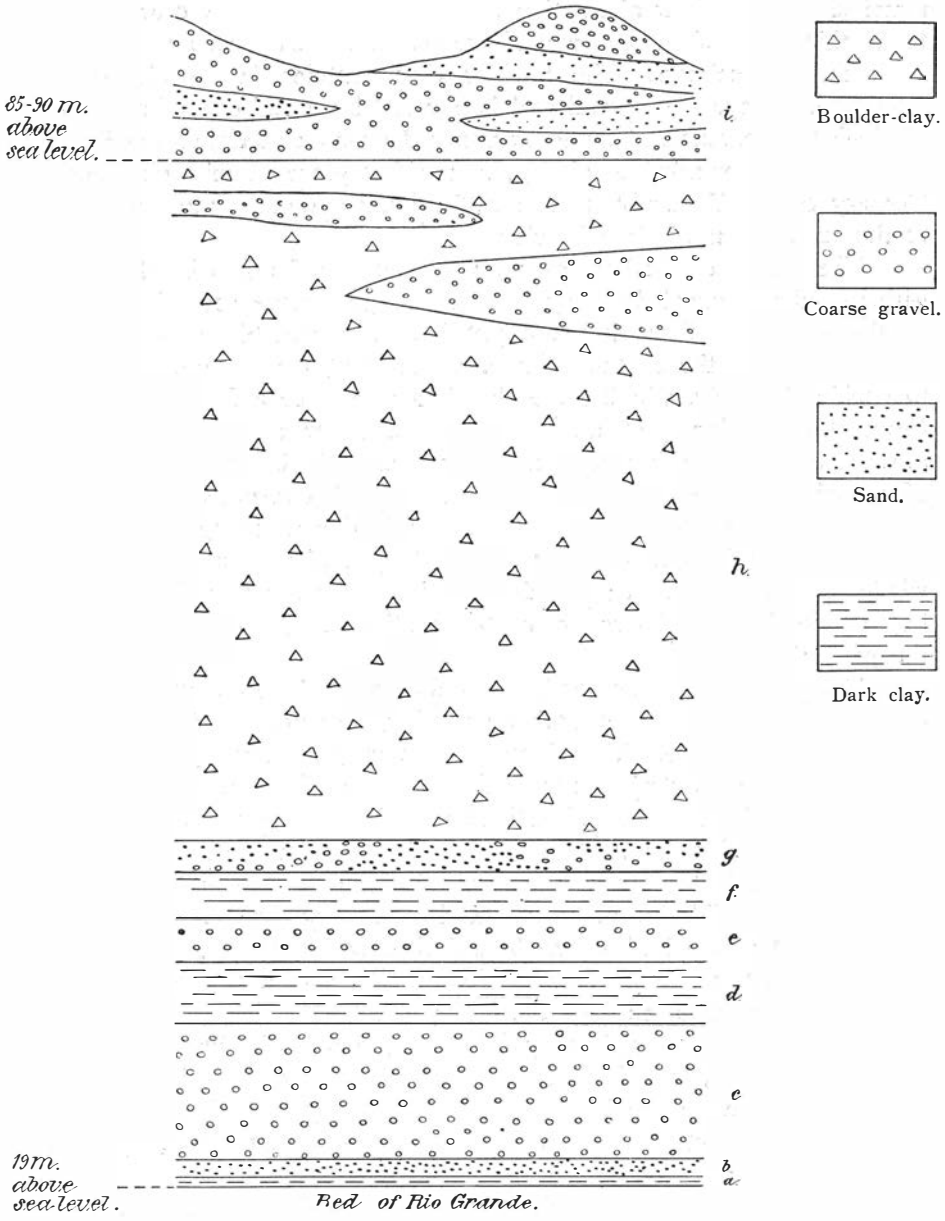

Fig. 2. Ideal section of glacial deposits in the left bank of Rio Grande, Isla Riesco.

The bottom-layer (a), displayed in the very bed of the river, is a tough, dark gray clay with a visible thickness of 0,5 m. It contains numerous plant-remains, mostly twigs, grasses and mosses. The next layer is a fine sand, containing rhizomes and other indeterminable plant-

remains. Then follow alternating beds of barren clay and coarse gravel, to a thickness of *21* m. and above this a typical glacial boulder-clay, *45,5* m. in thickness. The boulder clay contains in the higher parts interstratified layers of gravel and is covered by a bed of sand and gravel of similar appearence. The sedimentary deposits underlying the boulder clay are of a remarkable solidity; at the first glance I mistook them for Tertiary beds. No doubt their consolidation is due greatly to the pressure of the superincumbent boulder-clay.

The fossils of the bottom-clay were not of a kind to be determined without microscopical investigation. I brought home several specimens of the clay, but there has not yet been any possibility to have them examined as to the content of microorganisms. I am therefore not able to decide definitely, whether the clay is a marine or a freshwater-deposit. From the abundance of all sorts of vegetable matters, such as mosses, grasses, twigs and rhizomes, etc. it seems most probable that the clay is of fluvial or lacustrine origin, but at present this can not be regarded as proved. In any case the occurrence of this deposit at *19* m. above the present sea-level is noteworthy. Everything indicates a position of the whole series *in situ*, and a definite decision of its nature will be of some importance for the discussion of the relation of the changes of level to the glaciation.

The age of the deposit is not quite clear. The basement was not displayed, and it is not altogether excluded, that the stratified beds may be of preglacial age. The deposit has a very sheltered position in the valley, which runs straight across the direction of general ice-movement, and it is possible that it could have escaped destruction even when exposed for the whole glaciation. It is worthy of note, that the layers have not been disturbed in the least, notwithstanding the great pressure which has caused the consolidation of the material. Probably the deposit only marks an oscillation of the ice-border. The dark clay (a) and the sand (b) with their abundant contents of vegetable matters have in any case been deposited at some distance from the ice-border.

In this connection it may be noted, that in the barrancas of the *Fitz-Roy Channel*, a little south of *Caleta Los Amigos*, beds of boulder-clay rest upon a series of coarse gravel and shingle. This is probably a fluvioglacial deposit, and it is very similar in consistency to the corresponding layers at Rio Grande.

During the early stages of the recession of the land-ice, the hydrographic conditions of Otway and Skyring must have differed greatly from the present state. With the scanty data available at present it would be futile to attempt to sketch out, even in rough outlines, the different stages of development. So much is, however, sure, that after the ice had left the valley, between the *Beagle Mountains* and *Cordillera Riesco*, this valley was the only possible outlet of the depression now occupied by Skyring Water. (At an earlier stage of recession, there was perhaps an outlet

between the Beagle Mountains and the plateau south of *Laguna Blanca*.) At this time the ice certainly covered the central parts of the Cordillera and blocked both the low pass (about *20* m.) from *Estero Excelsior* to *Obstruction Sound* and the *Gajardo Channel*, the present connection with the Straits. — Even now the narrow *Gajardo Channel* is sometimes almost blocked by numerous icebergs from the neighbouring glaciers. — The preglacial valley between the Beagle Mountains and Cordillera Riesco was filled up during the early stages of recession of the ice by glacial deposits of considerable thickness. As these have been later eroded and even cut through till below the present sea-level, the height of the original threshold between Otway and Skyring is not known. It is impossible therefore — even were the level of the sea at that time known — to decide whether Skyring formed then a bay or a lake, emptying by a river through this valley. But, as the rising of the land proceeded, Skyring was (if not from the beginning) cut off from the sea, and its outlet commenced to erode the valley of the Fitz Roy Channel. At this time — speaking still about the early stages of recession of the ice — the present entrance of Otway Water, the Canal Jerónymo, would also have been blocked by the ice, but on the other hand there was probably a connection with the Straits over the low land west of Cabeza del mar. Even here the topography is not sufficiently well known to enable us to determine the height of the threshold, but it certainly does not exceed *30* m. and probably not *20* m. In any case Otway would still have been connected with the sea at the time when Skyring was cut off by the upheaval of the land — all this provided, that the raised shore lines of Patagonia and Tierra del Fuego date from early postglacial time and that the land was from that time in rising.

From this follows, that the raised shore-lines round Skyring Water do not, as a rule, mark the level of the sea. Most of these shore-lines probably represent different stages of the eroding of the Fitz Roy Channel, which was, however, itself dependent of the gradual lowering of the base-level by the upheaval of the land.

The highest shore-line, which I observed at the Fitz Roy Channel, lies on *50* m. above sea-level. It is situated somewhat S. of Caleta los Amigos, immediately at the bank of the channel. At the south end of the channel, near estancia Kurtze, there is another terrace on *30* m. South of Caleta los Amigos, near the shore-line on 50 m., occur on both sides of the channel several terraces of different heights. On the west side I obtained the following figures: *40* m., *30* m., *27* m. (two terraces), *24* m.

Of these terraces, the one on *24* m. is best developed. Also on the other side of the channel the most distinct terrace occurs on *24* m. I followed it for several hundred metres and found it to be everywhere equally well developed. In places it is *40—50* m. broad. These two terraces on both sides of the channel evidently mark a comparatively constant level.

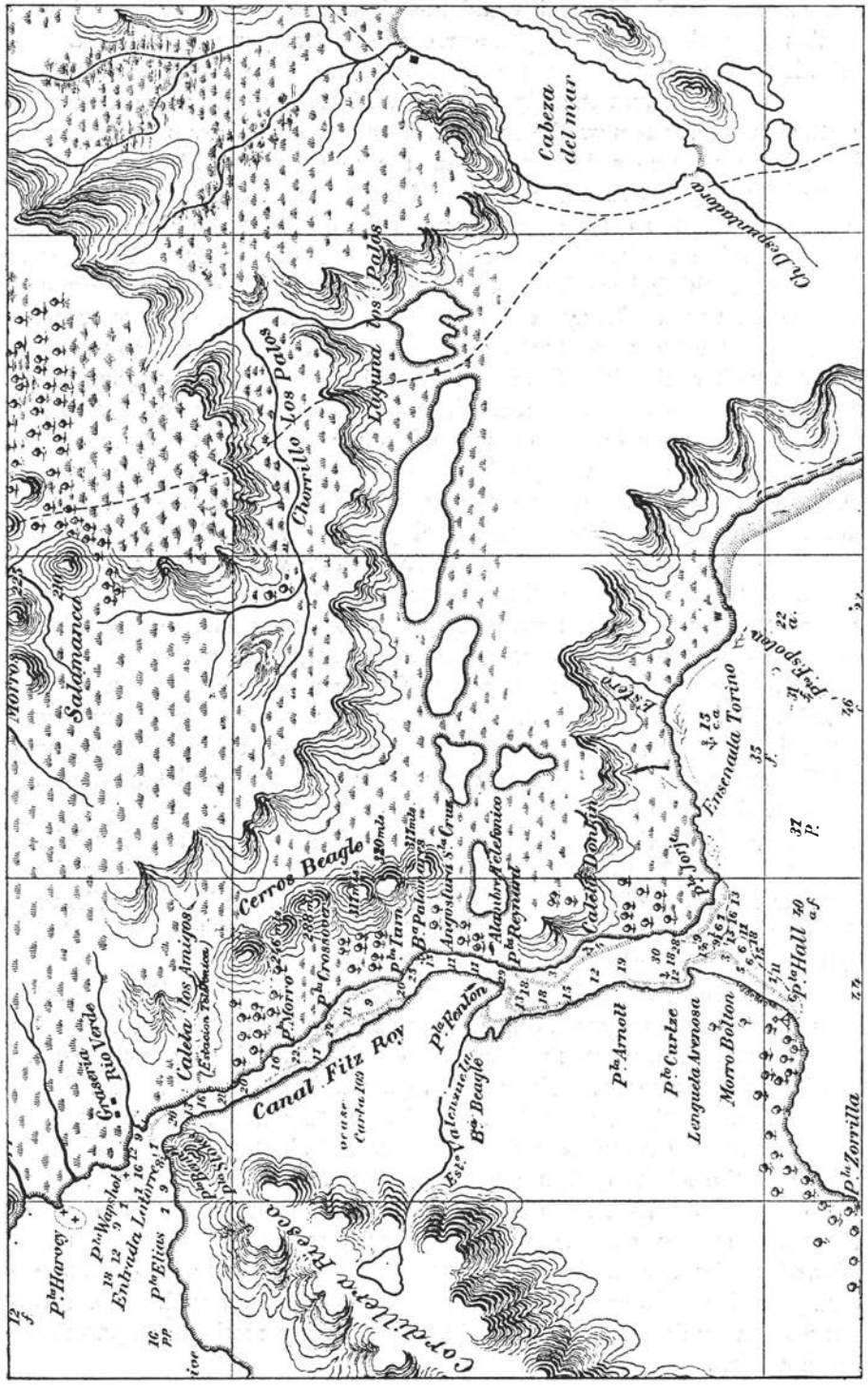

Fig. 3. The Fitz Roy Channel. Copy from the Chilean Admiralty chart.

Round the eastern shores of Skyring Water there are numerous marks of the old water-level. The low land bordering the sea between Caleta los Amigos and Rio la Descarga consists of sedimentary layers, sand and gravel, no doubt deposited in the ice-dammed lake of Skyring. These deposits form two very distinct and perfectly level plateaus, the lower on *13—14* m., the higher on *22,5* m. above sea-level. The accumulative terrace on *22,5* may well correspond to the erosive terrace on *24* m. at the Fitz-Roy Channel. The difference in height is not too great to be accounted for by the difference of origin and error of observation. It is also possible that the upheaval has been unequal — increasing towards the ice-divide. The distance between the two localities does not, however, exceed 2—3 kilometres. In the present coastal cliff there are fine sections showing the structure of the lower terrace (on *13—14* m.). For the most part the terrace is built up of sand and gravel. Some few hundred meters north of Caleta los Amigos we discovered at the base of the cliff a fine banded clay of the type well known in the glaciated parts of Northern Europe. Each stratum shows a gradual transition from yellowish brown to grey colour and then a distinct limit to the following higher stratum. At the limit of two strata there is generally a thin layer of sand which makes the specimens fall to pieces when drying. Later on Mr. QUENSEL obtained a section of the clay and counted 58 strata on a thickness of the clay of *2,7* m. without reaching the bottom. This banded clay forms the lower part of the sedimentary series building up the lower terrace. On the surface of this terrace, resting on beds of fine sand, big boulders of south-westerly origin occur. Locally, these boulders were so numerous as to form ridges projecting considerably over the surface of the terrace. The size and the great number of the blocks make it most probable that they have been brought here by icebergs from the land-ice, then ending somewhere further west in the lake of Skyring. The abundant occurrence of boulders in the layers of sand and gravel and in accumulations on the surface of the lower terrace, seems to indicate, that glacial conditions prevailed in Skyring Water during a considerable time, at least until the level of the lake had been lowered to little more than *14* m. above sea level.

Round the shores of Skyring I observed marks of a higher level of the water in several places. Here follows a list of some more distinct shore-lines at Skyring Water and at the Fitz Roy Channel, inclusive those described above.[1]

Fritz Roy Channel, Estancia Kurtze *30* m., erosive terrace; aneroid obs.
» **6** m., accumulative terrace; levelled.
S. of *Caleta los Amigos*, east side *50* m., erosive » aner. obs.
24 m., » » » »
» . . . . . west » *40* m., » » » »

[1] The best developed shore-lines marked by fat figures.

	30 m.,	erosive terrace;	aner. obs.	
	27 m.,	»	»	»
	24 m.,	»	»	»
	5 m.,	accumulative terrace;	approx.	
Skyring Water, eastern shore, near Rio Verde	**22,5** m.,	accumulative terrace;	aneroid obs.	
	13-14 m.,	»	»	»
Mina Magdalena; east of mines	*6* m.,	erosive	»	levelled.
Mina Marta, east of mines	*15* m.,(?)	»	»	»
	10 m.,	»	»	»
west of mines	*9* m.,	levelled		
	8 m.,	»		
Puerto Altamirano, east side	**4,5** m.,	accumulative terrace;	levelled.	
west side	*11* m.,	»	»	approx.
	8 m.,	»	»	»
	6 m.,	»	»	»
	3 m.,	»	»	»

West of Puerto Altamirano I did not observe any shore-lines. This may be due to the different nature of the western parts of Skyring Water, which is not favourable for the preservation or the observation of raised beaches. (In dealing with the land-rising of the Beagle Channel district I have called attention to this matter.) But I am not quite convinced that these facts are sufficient for explaining the remarkably rare occurrence of raised beaches, not only in the western parts of Skyring, but within the Cordillera in general. It is also worthy of note that at Puerto Altamirano and the coal-mines — at present the most westerly localities for raised shore-lines — all terraces hitherto recorded occur on a comparatively low level. Though my own observations on these matters are very scanty and no other data available at present, I cannot help suggesting the possibility that the upheaval of the land may have been comparatively rapid as compared with the recession of the ice. The abundant occurrence of erratic boulders on the surface of the accumulative terrace only 13—14 m. above sea-level at the east end of Skyring is noteworthy in this connection. These questions will form an interesting subject for detailed future exploration.

Before leaving the question of the changes of level in these parts, I will draw attention to some rather obscure facts concerning the formation of the Fitz Roy Channel. Already at the first glance at the map this channel presents itself as a drowned river-valley. As already mentioned above, the præglacial depression, which connects the basins of Otway and Skyring, has been to a considerable depth filled up by glacial and fluvio-glacial deposits. The Fitz Roy Channel is without doubt an erosive valley cut down in these deposits. It is very narrow, less than *500* m. in the narrower part, and on both sides the eroded banks rise to at least *50* m. The fig. 5 is a section of the bank south of Caleta los Amigos.

It is evident that the valley in its present condition must be of postglacial origin, but it is difficult to account for its great depth and present submergence below the level of the sea. As will be seen from the map fig. 3, a copy from the Chilean Admiralty chart and from the diagrammatical section in fig. 4, drawn on the base of the same chart, the depth of the channel is very varying. If each figure given on the chart represents really the deepest part of the section at that point, the ridges between the depressions would be due to a later accumulation of sediments. In any case a line connecting the deepest points will represent approximately the old bottom of the river. As appears from the fig. 4, this line dips gradually towards Otway Water. The greatest depth of the channel is *30* m. near the south entrance.

I fail to see how this river-valley could have been converted into a sound if the postglacial emergence of land was not followed by a second submergence. All facts seem to demand that the upheaval of the land continued till the present sea-level was not only reached, but considerably exceeded. At the time of maximum upheaval the land has been elevated

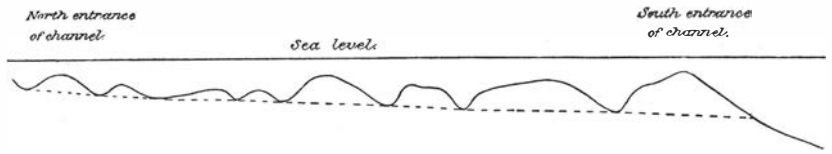

Fig. 4. Diagram showing the depth of the Fitz Roy Channel. — Horizontal scale 1: 250000; Vertical scale 1: 4000.

sufficiently to allow the valley to be eroded to a depth of *30* m. below the present sea-level. Whether at that time the Canal Gajardo, the present entrance of Skyring Water, was still blocked by the ice or not, is not evident. The channel reaches, in its shallowest part, only a few metres in depth and would under the above supposition have been interrupted by land.

From this part of South America I know of no other data which indicate that the land has been, at any time after the recession of the ice, higher than at present. Under such circumstances it would be rash to attach too much importance to a single fact, but matters seem to be very clear in this case.

There are at the Fitz Roy Channel some other deposits which render the late development of the channel still more complicated. As mentioned above (p. 107, list of shore-lines) there occur, at least in two places at the channel accumulative terraces on a comparatively low level. South of Caleta los Amigos I found the surface of one terrace to be *5* m. above the high water mark. It leans against the steep cliff cut in the fluvioglacial deposits (fig. 5). It consists of shingle of a recent aspect, containing numerous shells of common marine mollusca such as *Mytilus*,

Nacella etc. Near Estancia Kurtze there is another similar terrace, also containing marine mollusca, at *6* m. Now these deposits must be of a later date than the formation of the valley, which requires a higher position of the land than at present. After the maximum of upheaval, the land would then have been submerged to a height of at least *6* m. above sea-level, before reaching definitely its present position. As a circumstance of minor importance, it may be noted that these fossiliferous shingle-accumulations have a strikingly recent aspect as compared with other shore-lines on only a little higher level. This difference corresponds well to the supposed *hiatus*.

The complicated changes of level which would result from the foregoing explanation are of a somewhat startling nature and, as already remarked, they need to be confirmed by further observations. It is, however, of some importance that these matters should be discussed already

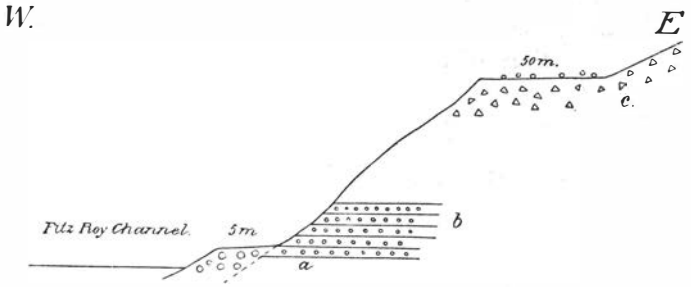

Fig. 5. Section of the east bank of Fitz Roy Channel, S. of Caleta los Amigos.

now in order to attract the attention of future explorers. I have supposed here, that the postglacial submergence reached its maximum at an early epoch, i. e. that the land was submerged till above the present sea-level during the early stages of ice-recession. This may seem probable from what we know of the relation of submergence and glaciation in other parts of the world but it is by no means proved as regards Patagonia and Tierra del Fuego. The only fact which seems to afford any evidence in this direction is the occurrence of marine fossils underneath the moraine on Gable Island. But on the other hand there is nothing that indicates that the land had, during the recession of the ice, a higher position than now. Should this, however, have been the case, the eroding of the Fitz Roy Channel could have been accomplished before the submergence, and it would not be necessary to assume the second submergence, represented by the fossiliferous marine deposits on *5—6* m. at the same channel. This seems, however, highly improbable.

Quaternary deposits of Chiloé and adjacent regions.

(See map, Pl. 6.)

The great longitudinal valley of central Chile dips gradually to the south, and at Puerto Montt on lat. 41° 30′ S. it reaches the level of the sea. From here southwards it continues as a submarine depression, forming the inland sea between the island Chiloé and the continent. In its supramarine parts the valley is filled up to a considerable depth by loose sedimentary deposits. South of Puerto Montt, deposits of a similar kind occur round the coasts of the inland sea, and as isolated remains forming the archipelago east of Chiloé.

In the following, reference will be made only to the region south of Lago Llanquihue, which I know from my own observations during a short visit. Further north the general features of the valley are most probably of a similar nature, but trustworthy observations are still very scarce.

The *Cordillera de la costa*, which forms the western border of the longitudinal valley, consists also in this part mostly of metamorphic schists. Leaning against this range narrow stripes of frequently interrupted Tertiary sediments occur. In these beds both marine shells and plant-remains have been found, leaving no doubt as to their geological age. — The Tertiary formation will be dealt with in a following paper.

The loose deposits of the central valley are generally barren of fossils which renders it very difficult to settle their age. The thickness of this series is very varying but it seems not to exceed 200 m. above the present sea-level. The bedding is always horizontal, a fact worthy of note in these regions of late disturbations. In lithological character there is a great variation displayed within short range, both vertically and horizontally. Clay, sand and conglomerates, often containing huge boulders, occur in alternating layers, often exhibiting a beautiful current-bedding. The consistency of the material, varying as it is, may be said to be in general intermediate between that of the Tertiary sediments in the west, and the recent deposits of a similar kind. Notwithstanding the great local variation in lithological character, the formation remains on the whole very uniform within the region here dealt with, and has probably been formed under the same conditions.

The first reference made to this formation dates a long time back, and in fact very little has been added to our knowledge in recent times. To DARWIN[1] we owe the first account of this formation as well as of so many other important points in the geology of southern South America. He gives an instructive description of these deposits and notes the occurrence of boulders lying on the surface of the land, but also included in

[1] On the distribution of erratic boulders etc. l. c. p. 423. See also: Geological observations on South America, p. 27.

the gravel beds. He compares the formation with the boulder-clay of the Magellan-Territory and considers it like this to be of marine origin. By several authors of a later time, such as FONCK, DOMEYKO, VIDAL GORMAZ, JULIET etc.[1] numerous observations have been made on the terraces and plateaus characteristic of this formation, but very few facts are communicated bearing on its age and origin. The most important data in this respect we owe to F. FONCK,[2] who was for some time a physician of the German colony in the province of Llanquihue. He gives a very accurate description of the lithological characters of the formation, and also mentions the occurrence of poor seams of lignite containing half-carbonized wood. He confuses, however, these softer deposits with the Tertiary formation in the west, and thereby some of his statements become less reliable. The coal-seam of *Isla Lemuy* occurs, for instance, in the older Tertiary beds. On the other hand, there is no doubt, that some fossil plants recorded from the vicinity of Puerto Montt really belong to the younger series. It is of great interest to note that he regards them as identical with or very similar to living forms. He believes he has recognized a fern, a beach and a cypress, but no attempt is made at a specific determination. FONCK also mentions the occurrence of boulders and attributes their wide distribution to the action of glacier-ice. As they were found also embedded in the underlying deposits the whole formation was referred to the »Drift-period» or the youngest Pliocene. Though neither DARWIN nor FONCK distinguished the real boulder-clay and the stratified boulder-bearing beds — both being regarded as marine deposits — and the existence of an Ice-age was not proved at that time, they have given in essential points the best explanation of facts. The results obtained by them seem, however, not to have attracted the attention which they have deserved. In later publications the age of this formation is left undecided or considered with hesitation as Tertiary.[3] My own observations in these parts are very scanty and will serve mainly to confirm those of DARWIN and FONCK, which I did not know at the time of my visit. It is also of importance that the opinions of these authors should be revived and brought into accordance with present investigations.

I have noticed in several places the occurrence of plant-remains in this formation, but they are generally not in a good enough state of preservation to be determined specifically. On Isla Peluque there is, on the

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[1] Numerous papers published mostly in the *Anales de la Universidad de Chile.* For reference see SUESS: *Antlitz der Erde,* Vol. 2. p. 675—676 (Bibliography).

[2] F. FONCK: Sobre la Jeolojia de las inmediaciones de la colonia alemana de Puerto Montt. — Extracto de una carta del Dr. D. Francisco Fonck a D. Ignacio Domeyko. Anales de la Universidad de Chile. 1859. p. 318.

— Naturwissenschaftliche Notizen über das Südliche Chile. Petermanns Mitteilungen. 1866. p. 462.

[3] Conf. H. STEFFEN. Beiträge zur Topographie und Geologie der andinen Region von Llanquihue. Richthofen-Festschrift. Berlin 1893. p. 319.

east side, a thin bed of lignite, covered by clay, sand and shingle. In this bed are found pieces of wood, not yet carbonized, but in about the same state of preservation as the trunks in our Swedish peat-bogs. I have not yet been able to obtain a determination of the wood, nor of the micro-organisms which may occur in these layers.

Near *Quemchi*, on the east coast of Chiloé, the coastal cliff is formed in one place by a somewhat indurated clay a few metres in thickness. In the clay I found some indistinct impressions of dicotyledone leaves. In one of the fragments I thought I recognized a *Nothofagus*, but this determination is not to be relied on. The clay was covered (perhaps not immediately, as the contact was not displayed) by a coarse conglomerate containing big boulders, only little rounded.

Some better preserved plant-impressions were obtained at *Queilen*, further south on the east coast of the island. On the west side of the peninsula I found, just north of the little town, in a section not reaching 10 m. in height, the following layers, from above:

1. *Sand and gravel*, of soft consistency, current-bedded,
2. *clay*, somewhat indurated,
3. *conglomerate*, fairly well consolidated, with rounded pebbles.

In my note-book I find the remark that the loose consistency of the material suggests a Quaternary age of the deposits. In the clay, which is nearly white in colour, occur numerous plant-impressions, without any trace left of the vegetable tissue. Of dicotyledone leaves at least three different species are represented. Besides, I found a fern, some mosses and also an impression of a feather. Of these remains I have as yet only been able to determine two species: *Berberis microphylla* FORST. and *Blechnum pinna marina* (POIR.) P. DUS. These are the most common of the fossils, and the preservation is sufficiently good to render the determination tolerably certain. Both species exist to-day in this region, but are by no means characteristic of the present type of vegetation, which is a luxuriant forest of evergreen trees. They have a wide range of distribution and play a more prominent part in the vegetation of southern Patagonia and Tierra del Fuego, where *Berberis microphylla* is one of the few bushes that reach the *regio alpina*.

The fact that the only fossils hitherto recorded from the whole series belong to living species, renders a Quaternary age of the formation very probable. My collections will, when worked out, possibly give some more information in this respect, and it is also to be hoped that new and more extensive material will be procured, as vegetable remains are evidently not of very rare occurrence. At present the evidence of the fossils is at least more in favour of a Quaternary than of a Tertiary age.

The lithological character of the series has been described in some detail by DARWIN and FONCK (l. c.). The great boulders, mentioned

already by DARWIN, I had occasion to observe in many localities. They occur mostly lying on the surface of the land, but also, as mentioned above, embedded in the sedimentary deposits. They seem to be more numerous in the northern parts and especially in the vicinity of the east entrance of the Canal Chacao, and on the coast E. and S. from here. As noticed already by DARWIN, the boulders consist af andine eruptive rocks, and evidently have been brought to their present localities from the opposite coast of the mainland.

There is hardly any doubt, from what we know to day of the glaciation in Patagonia, that the boulder-bearing stratified series in the provinces of Chiloé and Llanquihue has been formed during the Ice-age as an extra-marginal facies to the maximum glaciation. Unfortunately, there are as yet not many observations concerning the maximum extension of glaciation in these parts. DARWIN has described, from two places in the southern part of Chiloé, (no localities mentioned), and from one locality on the inner side of one of the Guaitecas Islands, some deposits which he compares with the *till* of the Magellan Territory, and which appear really from his descriptions to be true moraines. The origin of the *fiord's* of the coast opposite Chiloé has been connected by several authors with the action of land-ice. In a recently published paper, Dr. P. KRÜGER [2] mentions that glaciated rocks have been found on the east coast of one of the Guaitecas Islands. Further south, in the Patagonian Channels, there are numerous proofs that the glaciation reached the present coast.

During a short visit to the coast opposite Chiloé, Mr QUENSEL found at Punta Chumilden, S. of Estero Reñihue on lat. 42° 30′ S. distinctly glaciated rocks a little above sea-level. Still further north, on the southern shore of Lago Llanquihue, he observed splendid moraines resting on a striated floor, in several places between Puerto Varras and the east end of the lake. These traces of glaciation occur at a considerable distance from the Cordillera and at less than 50 m. above sea-level.

Considering the fact that the coast of the continent opposite Chiloé was once glaciated, we may be justified in concluding that the stratified formation was deposited in front of the ice-border and that the boulders were transported to the archipelago and to Chiloé by floating ice-bergs. The distribution of the boulders coincides with the region in which the ice reached the bottom of the longitudinal valley. Chiloé has certainly for the greater part not been covered by ice. No morains have been found, with exception of the *till* described by DARWIN from the southern part of the island, and the thick red-coloured sheet of waste, which covers the weathered rock is in itself conclusive in this respect. The interior limit of the boulder-bearing stratified deposits would be roughly determined by the position of the stationary ice-border, as at least the

[1] On the distribution of erratic boulders etc. l. c. p. 425—426.

[2] P. KRÜGER. Die Patagonischen Anden zwischen dem 42 und 44. Grade südlicher Breite. Petermanns Mitteilungen. Ergänzungsheft Nr. 164. 1909, p. 24.

greater part of the series appears to have been formed before the ice receded much from its most advanced position. This accounts for the somewhat abrupt disappearance of the formation towards east and south. The same has not been recorded, except in the northernmost part, from the foot of the Cordillera, nor from the Canal Moraleda and the other channels further south. — It is in good agreement with the view adopted here that the only fossils hitherto found in the series belong to living species of a hardy character.

The question how the series was deposited to a height of at least *180* m. above the present sea-level is not easily answered. The big boulders of andine rocks, often found embedded in finer sediment, must have been brought to their present position in the Archipelago and on the coast of Chiloé by floating icebergs. This fact, and the wide and uniform distribution of the formation, show that this cannot represent merely a series of river-deposits. DARWIN considered this formation, as well as the boulder-clay of the Magellan Territory, as deposited in the sea. Traces of a corresponding great submergence of the land he believed he had found in raised beaches and in the occurrence of marine shells on high levels. However, as has been pointed out by FONCK and others, the shells have certainly been carried up from the shore by the natives. Though FONCK considers other facts related by DARWIN as sufficient proofs of submergence, he expresses some doubt as to the marine origin of this formation. Through the explorations of DOMEYKO, PISSIS, and others the difference between coast- and inland-terraces in Chile was well established. SUESS[1] draws attention to these facts and to the striking absence of marine fossils in the sedimentary deposits of the longitudinal valley. As he remarks, this applies also to the southern submerged part of the valley. I have also nowhere found any traces of marine fossils. On the other hand, plant-impressions, lignite seams and other vegetable remains occur abundantly. As far as the fossils are concerned the formation has, accordingly, more the nature of a freshwater deposit. It should also be mentioned that there are, on the outer coast, no definite proofs in the shape of true marine terraces or shell-accumulations of a submergence of the land in Quaternary time, sufficient to account for the great height, to which the boulder-bearing series has been accumulated.

It would then be necessary to assume that the boulder-bearing formation was deposited in a great lake. But this other alternative does not agree very well with the geographic features. The *Cordillera de la Costa*, which would have formed, together with the adjacent high land of the Tertiary formation, the western shore of this hypothetic lake, is interrupted in several places by transverse valleys. One of these is the Canal Chacao, and north of that valley the land is comparatively low as far as to Rio Maullin. The height of the threshold is, however, not known.

[1] Antlitz der Erde. Vol. 2. p. 665—669.

The depression occupied by the lakes Huillinco and Cucao forms another interruption. Chiloé is separated from the Islas Guaitecas by the deep and broad entrance of the Golfo de Corcovado, and farther south the coast range is split up into an archipelago of small islands separating the Canal Moraleda from the sea. Especially the existence of the present entrance of the Golfo de Corcovado at the time of the formation of the boulder-bearing beds seems to be irreconcilable with the idea that these beds were formed in a lake. — On the other hand, if the land was submerged sufficiently to explain how the sediments were deposited to a height of at least *180* m., this transverse depression presents some difficulty, as certainly salt water would have entered sufficiently to permit the existence of a marine fauna in the inland sea. — And there is no doubt that this deep and broad depression was prior to the deposition of the boulder-bearing series. As to the origin of the narrow Canal Chacao and its relation to the boulder-bearing series, there are not yet sufficient data to permit of any opinion. Concerning the Golfo de Corcovado, it is tempting to suggest the possibility that it may have been during the deposition of the boulder-bearing series blocked by the ice. We know that the ice reached at least the present coast as far north as at Estero Reñihue. Further south it had a greater extension, and, as appears from the observations quoted above, it certainly reached the Guaitecas Islands. If DARWIN'S comparison of the above-mentioned deposits on southern Chiloé with the true till is correct, this would afford a definite proof that the ice reached actually so far to the west as to block the entrance.

As to the formation of the terraces which occur now on the coast of the inland sea on different levels, I have not obtained any new data of importance. This question, as well as that of the outlet of the ice-dammed lake or inland sea, whichever it may have been, must be postponed till more facts be obtained. So much is, however, evident that there has been at some time during the prevalence of glacial conditions an outlet through the Canal Chacao. Here erratic boulders in large numbers occur as far west as on the Peninsula Lacuy, i. e. on the Pacific coast.

The above discussion of the mode of deposition of the boulder-bearing formation is based on very few data and has been entered upon merely in order to call attention to these questions. So much seems, however, to be evident that the greater part of the series is not of Tertiary, but of Quaternary age and was formed outside the ice-border during the maximum of glaciation. It is possible, that the deposition of the sediments commenced at a somewhat earlier date, and it should be remembered that reference has been made here only to the southernmost part of the longitudinal valley. Further north, the accumulation of sediments may have been going on during a greater space of time, as in the case of the Pampas-formation on the east side of the Andes.

Finally, I will add a few observations on terraces on both sides of Chiloé. Near Castro several well developed terraces, noted already by

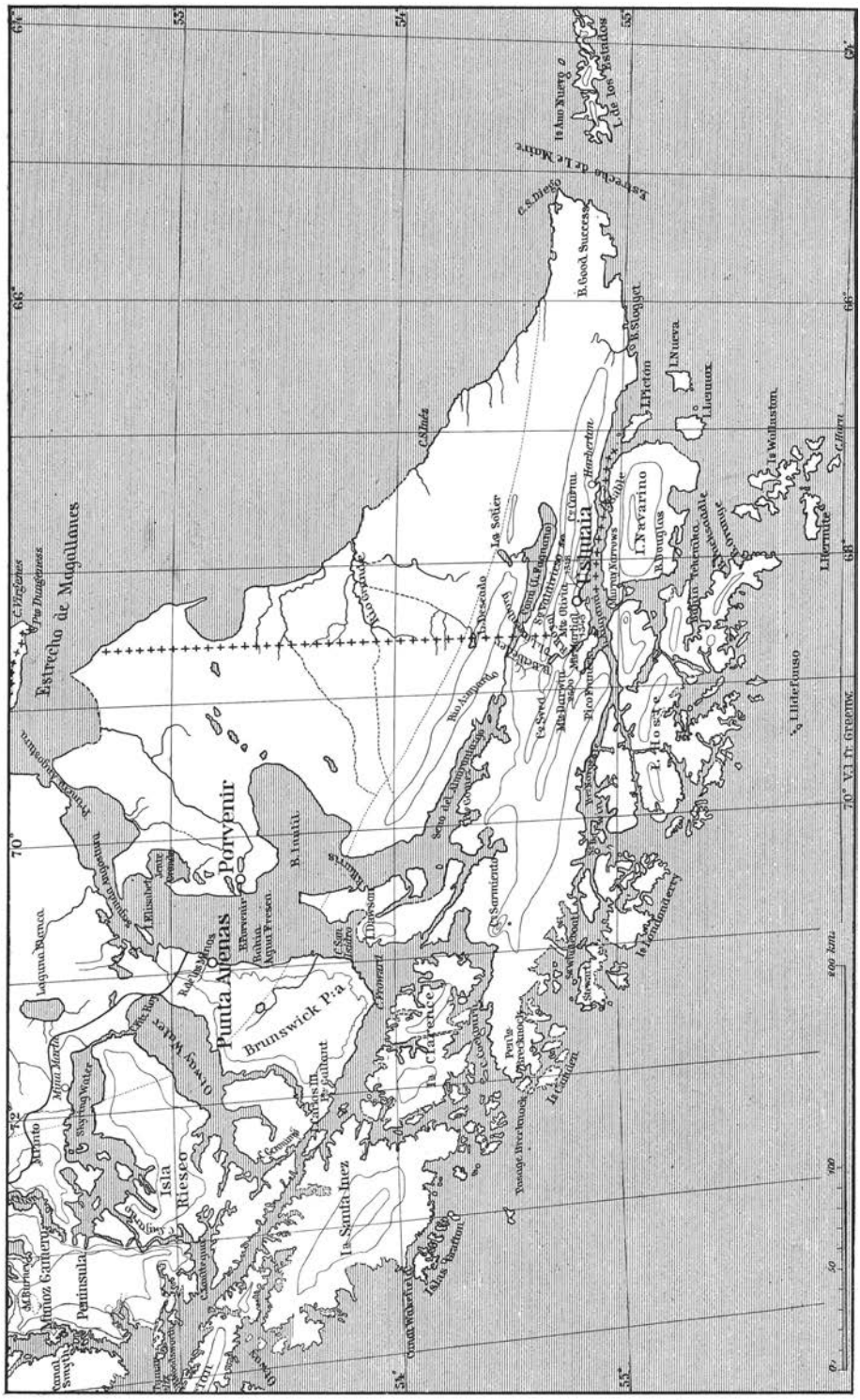
DARWIN, occur.. The little town stands on a fine terrace, *25* m. above sea-level according to QUENSEL. The new road between Castro and Ancud passes farther north over some very distinct plateaus, covered by shingle. The highest one is about *180* m. according to barometrical observation. On the Pacific coast of Chiloé I have measured shore-lines only at Bahia Cocotué, where two well-developed accumulative terraces occur at approximately *15* m. and *34* m. above sea-level.

Addendum.

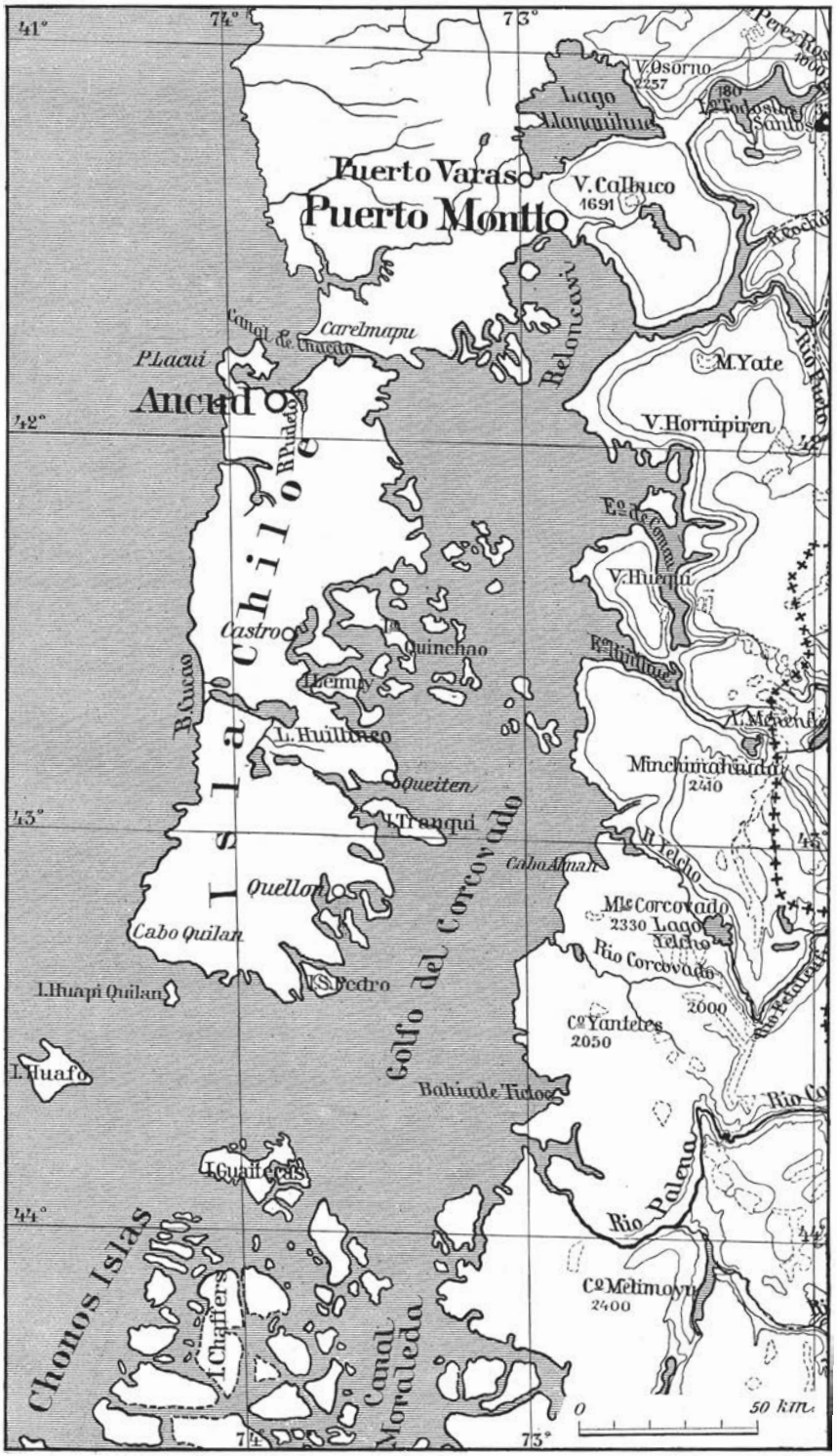
After the foregoing was printed, Mr. HÄGG has examined the shells from the locality between Port Famine and Punta Carrera and found the following species represented: *Trophon geversianus* PALLAS, *Mytilus chilensis* HUPÉ var. *hypeanus* MAB. et ROCHEBR., *Venus antiqua* KING, *V. Gayi* HUPÉ.

Concerning these species Mr. HÄGG makes the following statement.

»As a general remark on the fauna it may be said, that it is decidedly a shallow-water fauna of species occurring, with one exception, still in the vicinity of the locality. None of the species has its main distribution in colder seas. *Venus antiqua,* on the other hand, occurs only in warmer regions. Its proper range of distribution embraces Peru and Northern and Central Chile. Besides it has been found at Chiloé and the Gulf of Peñas in West Patagonia and at Port Madryn in the northern part of East Patagonia. The occurrence of the species at the latter locality, which is perfectly isolated, can only be explained if assuming that a warmer climate has prevailed in postglacial time in the interwening region (Southern East Patagonia, Magellan Straits and Southern West Patagonia). The occurrence of the species in fossil state at the Straits of Magellan affords a definite support of this view. This is the first indication of the occurrence in postglacial time of a warmer climate than the present in southern South America, the evidence in this direction being of both zoo-geographical and geological nature.»



Map of Tierra del Fuego.



Map of Chiloe and surroundings