3. Geological fragments from Tierra del Fuego

by

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With plates 9—12.

As a member of the Swedish Antarctic Expedition I was able in Sept.—Nov. 1902 to spend some time in studying the geology of several places in Tierra del Fuego. Although the range of my excursions was very limited, I was fortunate enough to make some finds of noticeable interest. If my collections of fossils and rocks had reached home and been closely examined, I might have been able to clear up some points in the geological history of this region. But the most important fossils — those from Bahia Tekenika — I collected just as we were about to leave the archipelago on our way to the South; all collections were kept on board the *Antarctic* and were lost with it in the Erebus and Terror Gulf. Now there remains of the material once in my possession, only the field notebook with some few lines and sketches which I publish mainly as hints to the two young Swedish geologists, Messrs. Halle and Quensel, who, during their present voyage to the Magellan Territories, will resurvey the localities visited by me.

The age of the Fuegian cordillera.

Of the age of the rocks forming the constituents of the Fuegian cordillera, very little is known, as only a very few scattered fossils of a doubtful character have been found in this region.

In 1839 JAMES D. DANA, as geologist of the United States Exploring Expedition under the command of CHARLES WILKES, visited Nassau Bay in the southern part of the Fuegian archipelago. Here he found, on the east coast of the Hardy Peninsula, a series of sedimentary rocks consisting of finegrained argillaceous shale alternating with sandstone and coarse conglomerate.

These sedimentary beds are seldom horizontal, but dip from some few degrees to a vertical position, the amount of dip being dependent, in part, on the intersecting dykes of greenstone and trachyte.

»Only a single species of fossil was observed in this formation. It was found on the shores of Nassau Bay, about half way from Orange Harbour to the head of the bay, and occurred in a compact argillaceous shale, where the rock was passing to an argillaceous sandstone.» The fossil was named by DANA *Helicerus fuegiensis* and considered to be allied to *Belemnites*.

In Orange Bay (the southernmost part of Nassau Bay) where DANA had made his geological observations, the French *Romanche*-expedition passed the year 1882—1883. The rock specimens collected during this time, described by Dr. HYADES,[1] give a good idea of the variety of igneous rocks contained in this region. But only little attention was paid to the sedimentary constituents, and it is surprising that the French naturalists did not during their prolonged stay at the place, rediscover the fossiliferous bed found by DANA during a day's excursion.

I think it very probable that the fossiliferous beds which I found a little further to the north, in Tekenika Bay, are nearly allied to those described by DANA.

In some places within the southern Fuegian archipelago the French expedition collected specimens of slaty or schistose rocks which were found to contain traces of *foraminifera*. These localities are Cape Webley on the north side of the mouth of Tekenika Bay (schiste argileux), Button Island on the west side of Navarin Island (schiste ardoisier) and Ushuaia Peninsula on the north coast of the Beagle Channel (schiste quartzeux). Concerning the foraminifera found on Button Isl. it is stated: »On puisse y reconnaître des formes anciennes (carbonifères ou permiennes) rappelant celles des *Textularia* ou de *Climacammina*. Nous ne pensons pas qu'une détermination paléontologique aussi incertaine permette d'arriver à des conclusions nettes relativement à l'âge de ces roches.»[2]

In an appendix to Dr. HYADES' volume on the geological collections of the *Romanche*-expedition, is published a description of the rock-specimens collected 1882 in Tierra del Fuego by M. D. LOVISATO. On the north side of Staten Island, at Cape Conway and the adjacent New Year Islands he found in slaty, partly calcareous beds, some indistinct fossils which are compared with *Phymatoderma coelatum* SAPORTA of the jurassic beds of France, *Palæospongia prisca* BORNEMANN and *Coscynocyathus calathus* BORNEM. of the Cambrian formation of Sardinia.[3] It is evident that these determinations do not settle the age of the beds in which they were found.

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[1] Mission scientifique du Cap Horn. Tome 4. Géologie par HYADES. Paris 1887.
[2] HYADES, l. c. Pag. 130.
[3] HYADES, l. c. Pag. 223.

In the Straits of Magellan, in that part of this large inland water-way where it curves from southward to northwestward, in the vicinity of Mount Tarn, have been made some important fossil finds, which throw a much clearer light upon the age of the Fuegian cordillera than the doubtful traces of fossils above mentioned.

CHARLES DARWIN during his voyage on the *Beagle*, collected, some few miles north of Port Famine and on the summit of Mount Tarn in beds belonging to his »clay-slate formation», the following fossils: *Ancyloceras simplex* D'ORBIGNY, *Hamites elatior* SOW., *Fusus, Natica, Lucina exentrica* SOW., *Venus*, *Turbinolia?*, *Pentacrinus*.[1]

Some more fossils were collected at Mont Tarn in 1837 by HOMBRON and GRANGE belonging to DUMONT D'URVILLE'S Antarctic expedition. These fossils were determined by D'ORBIGNY as *Ancyloceras simplex* D'ORB., *Plicatula* and *Modiola* and considered as being of Neocomian age.[2]

More recently, some further fossil finds were made in the vicinity of Mount Tarn, on the small islands of St. Paul's and St. Peter's by CH. H. TOWNSEND during the voyage of *U. S. S. Albatross* 1887—1888. These specimens were determined by CH. A. WHITE as *Hamites elatior* FORBES? and *Lucina Townsendi n. sp.* and considered to be most probably of Cretaceous age.[3] These same species were recognized together with several others by WELLER in a small collection brought home by STOKES from the Swedish Antarctic Expedition and explained by WELLER as originating from middle or upper Cretaceous beds.[4] Moreover *Lucina Townsendi* is reidentified by WILCKENS as having been collected in great numbers by the Swedish Expedition on Snow Hill as well as on Seymour Island. All the Cretaceous beds of these two islands are considered by KILIAN and WILCKENS as belonging to the upper part of that system (Cenomanian-Senonian).[5]

The above mentioned fossils are, as far as I know, the only ones hitherto recorded from the region of the Fuegian cordillera. They prove that Cretaceous beds occur on both sides of the Straits of Magellan in the vicinity of Mount Tarn, but concerning the whole Fuegian archipelago, the question as to the age of the rocks is left unsettled; in the first place, there are no facts known to indicate the time during which the region underwent mountain-folding.

Before my visit to Tierra del Fuego, as I was studying the geological map of the Magellan Territories drawn up by NORDENSKJÖLD,[6] my at-

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[1] DARWIN. Geological observations on South America. London 1846. Pag. 152.

[2] Voyage au Pole Sud sur les corvettes L'Astrolabe et La Zélée sous le commendement de J. Dumont d'Urville. Géologie par J. Grange. Paris 1848. Pag. 174—175.

[3] Proceedings of the U. S. National Museum. Vol. 13. 1890. P. 13—14.

[4] Journal of Geology. 1903. P. 413—419.

[5] See my paper on the geology of Graham Land. Bull. Geol. Inst. Upsala. Vol. VII. 1906. P. 34—40.

[6] NORDENSKJÖLD. Geolog. map of the Magellan Territories. Stockholm 1899.

tention was attracted by the small isolated occurrence of Tertiary beds in Slogget Bay at the eastern mouth of the Beagle Channel, a locality that is reported already by POPPER [1] as containing lignite and plant-remains. Because of its position in the cordillera-region, I expected it to prove the relation of the Tertiary beds to the mountain-folding.

During my stay in these tracts, I was able to spend some few hours on shore in Slogget Bay, but as unhappily all my collections from this place are lost, I can give but a very incomplete description of its geology.

Bahia Slogget is a broad bay, without any shelter, directly exposed to the dreadful swell, that makes the landing difficult even in fine weather

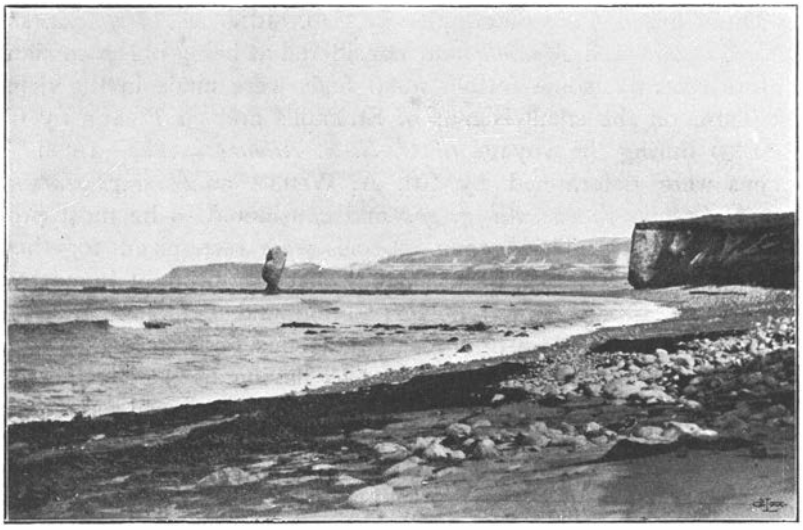

Fig. 1. **Slogget Bay.** Part of coastal cliff and rocky plateau with isolated rock-pillar. Near the place from where the photograph was taken is the occurrence of Tertiary beds.

The deposits of sand and gravel on the beach are auriferous and at the time of my visit a party of gold-diggers were occupied at the place. On the east, as well as the west side of the bay, there rise above the sea cliffs of moderate height and composed of dipping strata belonging to the cordillera series. The head of the bay is continued inwards by low land covered to a large extent by coarse gravel of fluvio-glacial origin and bordering the Lopez river. To the east of the mouth of this small river there rises a low coastal cliff, about 15 m. in height and composed of a rock that evidently belongs to the cordillera series, but which is so deeply disintegrated, that its original character could not be recognized. Outside this cliff (part of which is seen on fig. 1) there stretches a rocky plateau cut out by the action of the waves. Above this rocky bottom, which is laid bare at low water

[1] POPPER in Bol. del Inst. Geogr. Arg. VIII. 1887.

and covered at high tide, there rises some 75—100 m. away from the cliff an isolated monolite of about the same height as the cliff itself (fig. 1 and 2). The lithological character of this rock-pillar is identical with that of the cliff and evidently it forms but a small resistant remnant of an earlier vaster extension of this cliff.

To the east, the disintegrated rock forming the cliff is overlaid by a conglomerate containing pebbles of the underlying mass. A little further to the east, after a short interruption in the section, the low barranca is built up of quite a different series, sandy and slaty beds with insignificant lignite-seams. The dip of these beds is somewhat variable in different parts of the section, one observation showing a dip of 40° E 10° N. In the beds enclosing the lignite-seams, I collected a number of plant-remains, which seemed to remind me of some types in DUSÉN'S paper on the Tertiary flora of the Magellan Territories.[1]

Fig. 2. **Slogget Bay.** Isolated rock-pillar (compare fig. 1).

The extent of the Tertiary beds inland I did not follow in detail, but it seemed to me that they do not continue for more than at most some few hundred meters, and the whole occurrence seems to be a subsided body, limited by faults. Evidently the dip of the strata is due to this kind of dislocation, as they do not exhibit any influence from the dynamo-metamorphic processes which have so deeply affected the cordillera-rocks forming the surroundings of Slogget Bay. Moreover, there is hardly any doubt that the Tertiary beds with a bottom-conglomerate of considerable thickness here rest upon a deeply disintegrated basement of rocks belonging to the cordillera-series. According to this interpretation, the rocks forming this part of the cordillera were not only folded but also deeply disintegrated (and partly worn away), before the Tertiary beds were deposited. As my collections of plant-remains from this locality were lost, the age of these lignite- and plant-bearing beds cannot be definitely settled. Still, I think it most probable that they are approximately contemporaneous with those beds in northern Tierra del Fuego, at Punta Arenas and in the Baguales Mountains, which have yielded the flora described by DUSÉN and which are considered by

[1] P. DUSÉN. Über die tertiäre Flora der Magellansländer. Stockholm 1899.

WILCKENS as belonging to the Patagonian molasse, which is according to this author of Upper Oligocene or Lower Miocene age.[1]

During our stay in Tierra del Fuego I was told that a Chilean man-of-war had reported the occurrence of coal at Tekenika Bay in the southern

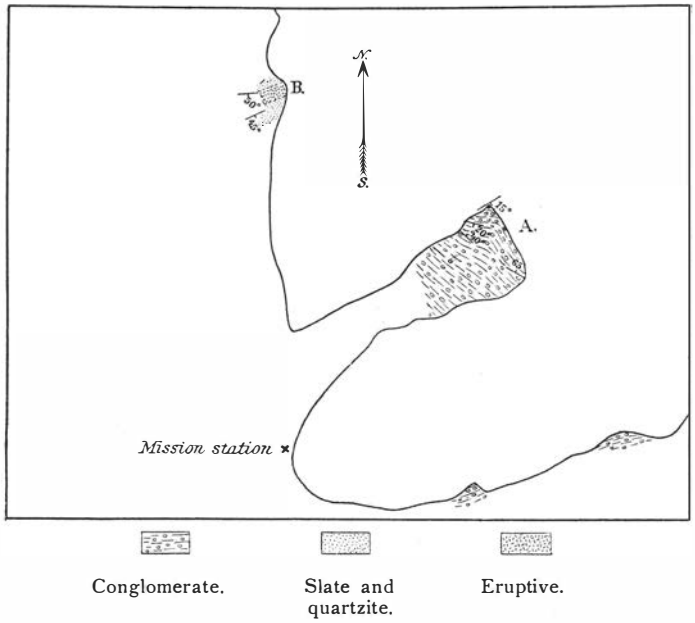

Fig. 3. **Sketch-map of the mission station bay. Bahia Tekenika.**

part of the Fuegian archipelago. I supposed it to be a lignite-seam in Tertiary beds, a parallel to what I had already studied in Slogget Bay, but on visiting Bahia Tekenika on our way to the south, I found there to my very great surprise a totally different fossiliferous formation. The sketch-map fig. 3 and the section fig. 4 illustrate the principal geological features of this place.

The promontory A., NE. from the mission station, exhibits the best exposures of the fossiliferous beds. The strata are here, in general, steeply inclined, but the dip and strike are variable, as shown by the sketch-map.

The prevailing rock is a coarse conglomerate with pebbles of 0,05—0,5 m. in length. In some places the conglomerate is less coarse, with intercalations of greywacke. In this last mentioned type of rock, as well

[1] WILCKENS, Die Meeresablagerungen der Kreide- und Tertiärformation in Patagonien. Neues Jahrb. f. Min. Beilageband 21. 1905. Pag. 164—171.

as, though less commonly, in the conglomerate, there occur thin and changeable slices (only some few cm. in thickness) and small lenticular bodies of coal. The conglomerate, as well as the greywacke, are fossiliferous with scarce and mostly fragmentary marine shells, principally mussels, and trunks of wood, evidently driftwood, inasmuch as many of the trunks were pierced by bore-mussels.

Some small outcrops of conglomerate were observed also on the opposite side of the mission station bay.

At B there is another small promontory, only about 5 m. high, with an interesting outcrop of rocks. The centre of the point is occupied by an igneous rock, the true character of which I am, owing to the loss of my specimens, unable to determine. B_1 consists of a quartzite-like, distinctly stratified rock with intercalations of greywacke, similar to the more fine-grained greywacke in the promontory A. B_2 is a slaty rock without intercalations of greywacke. The contact with the eruptive dyke, is here very clear:

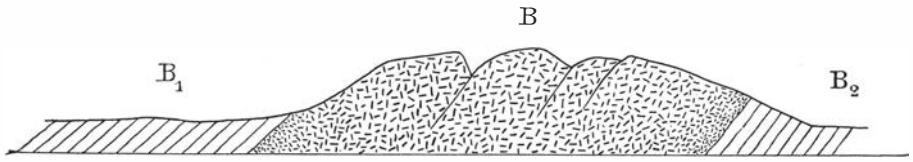

Fig. 4. **Section across point B, N. from the mission station, Bahia Tekenika.** Height of the point about 5 m.

it follows partly a bedding-plane of the slate; partly irregular bodies (the largest of which are 2 m. in length) of the slate project into the eruptive. At the contact with its sedimentary surroundings, the dyke was found to be more fine-grained than in its centre, and at the very contact there was also observed a parallel arrangement of the mineral particles of the igneous rock, a beautiful flow-structure that followed all minute irregularities of the contact.

The evidence bearing upon the problem of the age of the Fuegian cordillera still remains very imperfect, but, from the present scattered facts some preliminary conclusions may be drawn.

At the Straits of Magellan, there occur in the cordillera rocks containing fossils of Upper Cretaceous age, proving that there the mountain-folding is Post-Cretaceous.

On the other hand, at Slogget Bay there rest sandy, unaltered beds probably belonging to the Oligocene or Miocene Patagonian molasse upon highly metamorphized, disintegrated and denuded rocks of the cordillera-

series. To judge from the state of things at this locality, the process of regional metamorphism which has so strongly affected the rocks of the cordillera-series was terminated long before the deposition of those plant-bearing beds at Slogget Bay.

From Graham Land, a part of the Antarctic regions, which is, as to its geological structure, so identical with southernmost S. America that the conclusions attained in the one region may be applied to the other, I recall a fact that, in my opinion, strongly supports my conception of the Pre-Miocene age of the cordillera-folding. In the molasse-beds of Seymour Island, there occur conglomeratic intercalations with numerous small pebbles of crystalline rocks (granite, granophyre) which have evidently been carried by running water to this place from some adjacent area of crystalline rocks; this area may be supposed to have been nearly the same as the present mountain-range of Graham Land. Unfortunately, we paid all too little attention to collecting specimens of these pebbles, so now we are not able to present any indubitable specimen belonging to the Andine granites, but still, the occurrence of these crystalline pebbles in the molasse-beds of Seymour Island is an indication pointing in the same direction as the facts mentioned from Slogget Bay.[1]

When all facts known are taken into consideration the question of the age of the cordillera seems to be a complicated problem. The highly important explorations carried out by HAUTHAL on the eastern side of the Patagonian cordillera between Lago Argentino and Ultima Esperanza, the results of which are known through publications by HAUTHAL himself and by WILCKENS, seem to some extent to contradict the interpretation given above. Especially in WILCKENS' papers, we find several remarks bearing upon this problem:

»Ob die patagonische Molasse vielleicht am Rande der Anden noch von der Gebirgsbildung mitergriffen ist, wissen wir nicht genau. Völlig horizontal liegen ihre Schichten auch an der atlantischen Küste nicht, und es erscheint möglich, dass diese Störung noch mit der Bildung der Kordillere in Zusammenhang steht.»[2]

As to the origin of the rock-material forming the Patagonian molasse, he makes the following remark:

»Das Material für die mächtigen und im einzelnen sehr mannigfaltigen Sedimente, die in diesem Meere zum Absatz gelangten, mag, wenigstens teilweise, von der im Anfang ihrer Hebung begriffenen Kordillere stammen.»

»Die noch zur Miocänzeit wieder erfolgte Regression des patagonischen Molassemeeres steht zweifellos in innerem Zusammenhang mit der Bildung der Kordillere.»[3]

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[1] See my paper on the geology of Graham Land. P. 44 and 61.

[2] WILCKENS, Die Meeresablagerungen etc. P. 155.

[3] WILCKENS, Die Meeresablagerungen. P. 190.

In his explanatory notes to HAUTHAL'S map, WILCKENS positively states that the molasse-beds have taken part in the mountain-folding. »Sie sind mit aufgerichtet.»[1] Unfortunately HAUTHAL'S observations are stated in such general terms, that it is not possible to attain a clear idea of the tectonic features of the molasse-beds. The transverse section accompanying his map exhibits no real folding, but only a gentle dip of the Tertiary beds outwards from the cordillera.

On HAUTHAL'S map and section there is an observation which may be found to be of the utmost importance for the explanation of the relation of the Tertiary beds to the mountain-folding. On the east side of the upper part of Rio de los Baguales, some small occurrences of diorite are seen traversing the molasse-beds. If this diorite belongs to the series of igneous rocks, which have been named Andine eruptives because of their near connection with the formation of the cordillera, then the occurrence of the diorite traversing the molasse-beds strongly supports the idea of the mountain-folding being later than the deposit of these Tertiary beds. But no definite conclusion can be drawn from this observation before the igneous rocks of the region surveyed by HAUTHAL have been more fully described.

At my request Dr. WILCKENS in a letter of Febr. 2 of this year kindly communicated to me his conception of the age of the Patagonian cordillera:

»Die Aufrichtung der patagonischen Molasse am Rande der Kordillere hängt nach meiner Meinung allerdings mit der Entstehung der Kordillere zusammen. Ob aber der Vorgang, der diese Aufrichtung bewirkte, allein auch gleichzeitig die ganze Auffaltung der Kordillere bewirkte, und ob diese letztere nicht in einem langen Zeitraum erfolgte, ob es also vielleicht nicht nur der letzte Akt der ganzen Kordillerenbildung war, der die Aufrichtung der patagonischen Molasse bewirkte, darüber lassen sich nur Vermutungen aussprechen.»

In accordance to Dr. WILCKENS' opinion it seems to me very well possible, that, as has been found to be the case with several other mountain-ranges, the geotectonic processes which have built up the Magellanian and Antarctic cordilleras went on during a succession of geological periods, the slight displacement of the Patagonian molasse being only its last stage. At any rate the above described observations made at Slogget Bay in Tierra del Fuego and on Seymour Island at the coast of Graham Land indicate that in these tracts a mountain-range already existed in Miocene time.

[1] R. HAUTHAL, Croquis geológico de la region entre el Lago Argentino y el Seno Ultima Esperanza. Mit Erläuterungen von O. Wilckens. Ber. der Naturforschenden Gesellschaft zu Freiburg i. Br. Bd. XV. 1907. P. 94.

Observations on glacial and fluvio-glacial deposits in the Beagle Channel and at Lago Fagnano.

The southernmost of those far-extended and narrow submarine longitudinal valleys, which form such a remarkable feature of the Magellanian cordillera, is the Beagle Channel, which divides the southern archipelago from the big island of Tierra del Fuego. This channel runs from its eastern mouth at Picton Island with an average width of only about five kilometers in almost a strait westerly direction for a distance of 170 kilometers to Divide Point where it separates into two very narrow branches. For its larger extent, the depth is considerable (100—300 m.) and on both sides the mountains rise from gently sloping wood-lands to narrow crests and lofty peaks.

In its eastern part, on the north side of Navarin Island, the Beagle Channel is nearly cut off by a large island, Gable Island, that through its low undulating surface and its composition of loose Quaternary sediments forms a striking contrast to the mountainous surroundings of the channel. The highest point of Gable Island is according to the new Argentine chart 92 m. Only on the NE side, I noticed some small projecting outcrops of solid rock: the remainder of the island was found to consist of boulder-clay, gravel and sand. The surface of the island is, as already mentioned, strongly undulating, with numerous rounded hills of varied shape, and, between them, gently sloping depressions. The material met with everywhere on these hills and slopes is boulder-clay, and the observer might feel disposed to consider the whole island as built up merely of this glacial deposit, were there not, in the coastal cliffs, especially on the west side of the island, splendid opportunities of studying its interior structure. Plate 9 reproduces a part of this western barranca which by its gable-like sculpture may have suggested the name of the island. At the place where the barranca reaches its highest point, it was measured and found to rise 39 m. above the sea. Only the uppermost 15 m. here consist of boulder-clay, underneath which were exposed fluvio-glacial deposits, sand and gravel, to a visibel thickness of 24 m.

The bed of till covering the fluvio-glacial deposits and forming the upper part of the barranca as a cover of the fluvio-glacial deposits is a most typical boulder-clay with the clayey matrix very abundant in comparison with the enclosed stones, which are generally small, boulders exceeding a meter in length being totally absent or at least very rare.

In the southernmost part of this barranca, in the boulderclay I made a find, that seems to me of considerable interest, namely worn and broken shells of *mussels* and *barnacles*. The larger shells were very scarce and fragmentary, but a closer examination of the fossiliferous till will cer-

tainly yield also microscopical organisms of marine origin, foraminifera etc. The mode of occurrence of these rare and broken fossils makes it evident that they appear here in a secondary position and that they originate from an unknown marine bed that was eroded by the glacier which once filled the Beagle Channel and deposited the bed of boulder-clay. It is to be hoped that within a short time new evidence collected from this interesting locality will settle whether the age of the mentioned fossils be Tertiary or early Quaternary (pre- or possibly inter-glacial). In either case they offer considerable interest.

The fluvio-glacial deposits underlying the boulder-clay consist of gravel and sand in alternating layers with strongly developed current-bedding. The coarseness of the gravel is very variable, but in general it is not perfectly washed and sized, but somewhat impure with intermixture of fine rockpowder. The sand is partly extremly fine-grained (*mo* according to the Swedish terminology). Pl. 10 gives a good idea of the alternation of gravel and sand.

The contact-line between the fluvio-glacial beds and the superincumbent boulder-clay, seemed to me in this barranca approximately to follow the undulations of the land-surface, thus rising in the hills and descending in the valleys. If this is a general feature of the island, evidently its hilly surface is due to the undulations of the fluvio-glacial deposits hidden underneath a sheet of boulder-clay.

To the north and east of Gable Island there are some smaller islands marked as Isla Upu, I. Waru, I. Martillo and I. Yunque on the Argentine chart. These islands are formed of one or several rounded hills and certainly they consist, at least to the greater part, of boulder-clay. With the same drumlins-like scenery I was very well accustomed in the environments of Bahia Harberton on the north side of the channel, ENE from Gable Island. Between a series of small bays, Bahia Thouctof, Puerto Harberton, Bahia Varela and Bahia Cambaceres, there extend in a SE direction four peninsulas, all consisting of the same type of rounded hills which form such a characteristic feature of Gable Island. In these drumlins-shaped hills in the vicinity of Harberton, I found but few and insignificant sections, exhibiting only boulder-clay. Whether there are kernels of fluvio-glacial sediments underneath these hills, I was unable to decide.

From the facts mentioned above, it appears that in the region here described the Beagle Channel is to a large extent filled up with Quaternary sediments, fluvio-glacial gravel and sand covered by a sheet of boulder-clay. Between the occurrence of these deposits and the depths in different parts of the Beagle Channel, there seems to exist a remarkable relation (See Pl. 11). In the westernmost part between Divide Point and Ushuaia, the average depth is about 250 m.; S. from Ushuaia there is a crowd of small islets, but along the south coast the depth of the channel is about 130 m. Also between Ushuaia and the vicinity of Gable Island there are considerable depths, in one place 216 m. But round Gable Island and on

the way to the eastern mouth of the channel at Picton Island, the water is shallow, not considerably exceeding 50 m. It seems quite natural to connect this shallowing up of the eastern part of the channel with the plenteous deposit of sand, gravel and till. Possibly its western and larger part was during a considerable part of the ice-age occupied by a large glacier, which prevented the channel being filled up with sediment; in the meantime, mighty beds of gravel and sand were being washed from the edge of the glacier and deposited at the place of the present Gable Island. Evidently the ice during a later time proceded eastwards, covering the fluvio-glacial sediments with a sheet of boulder-clay.

On the north side of the cordillera-range that occupies the southernmost part of the main island of Tierra del Fuego there is another longitudinal valley, Admirality Sound—Lago Fagnano. In October 1902, I went from Harberton to the eastern end of Lago Fagnano following a road that was cut through the woods by some energetic colonists, the brothers Bridges, and traversed the cordillera through a pass which I have proposed to name the Ona-pass.[1]

From the cordillera in a northerly direction to Lago Fagnano there flows a river, the native name of which is Henuen-shiki. In the upper part, between Heurh-gooyen and Monte Arh, its bed is shallow and its course meandering. But after having left the mountain-valley, the river while traversing the hilly lowland, forms a deep gorge in glacial and fluvio-glacial deposits. Fig. 5 illustrates a section in this gorge, consisting, to the lower and larger part, of till that is overlaid by distinctly stratified beds of sand and gravel.

The eastern end of Lago Fagnano is bordered by low land that separates the lake from the mountains rising in the S. and N. In an easterly direction this lowland joins the vast plain of northern Tierra del Fuego. In some places the shore of the lake is low and bordered by small lagoons, but in general there rises above the beach a low barranca (about 10 m. high where I studied it). On the beach, there are masses of striated boulders evidently washed out of the cliff in which the boulder-clay was noticed in several places. Amongst these scratched stones there was one of gneiss or granite indicating a westerly origin of the ice that deposited the till. The larger part of the barranca consists of stratified

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[1] The names on the sketch-map (Pl. 12) accompanying this paper are mostly Indian names which were kindly noted down for me by Mr. W. Bridges. Halupai, the native word for Rio Varela is derived from the language of the Yaghans, a tribe that formerly inhabited the Beagle Channel. All the names put down on my map for mountains etc. on the north side of the cordillera are still in use amongst the Onas, the inland Indians of Tierra del Fuego. Cami is the Ona name of Lago Fagnano.

deposits, coarse gravel, partly cemented into a kind of conglomerate, fine gravel and sand with current-bedding and, at least at one place, distinctly stratified clay. The relation between these different kinds of sediment was not quite clear, but it seemed to me that in some cases the fluvio-glacial sand and gravel were overlaid by boulder-clay.

Possibly all these deposits may originate from glaciers which once extended from the cordillera-valleys on the south side of the lake, but on the other hand, it seems quite probable that the whole Fagnano valley was once occupied by a large glacier. An examination of the barranca that

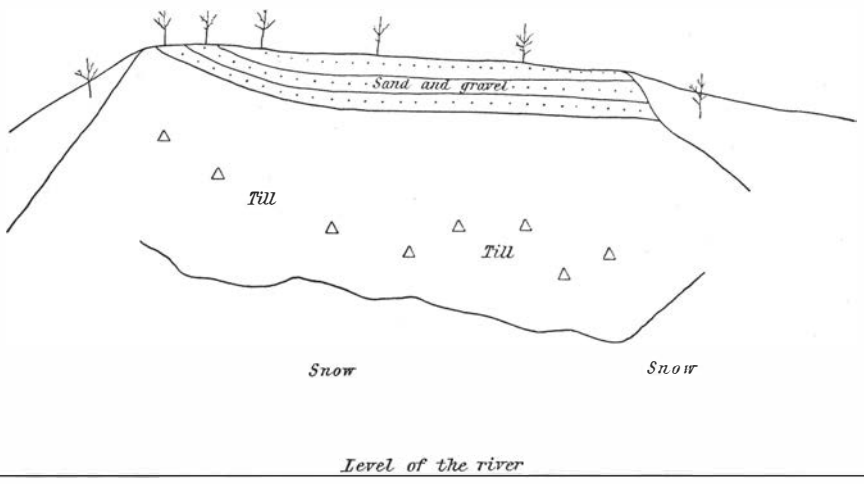


Fig. 5. Section in glacial and fluvio-glacial deposits traversed by the river Henuen-shiki. Altitude of the barranca above the level of the river 55 m.

I saw at a distance on the north side of the lake, will most likely contribute to clear up this question.

At any rate there is a noteworthy analogy between the Beagle Channel and Lago Fagnano. The former we have found to be deep in its western part but shallow and to a large extent filled with glacial and fluvio-glacial deposits near its eastern mouth.

The western part of Lago Fagnano is narrow, with the mountains rising steeply on both sides. Here the depth of the lake is said to be 300 m. The eastern part, on the other hand, is bordered by a lowland built up merely of Quaternary deposits. Here the lake itself is comparatively very shallow. At a considerable distance from its south shore, I found not more than 30 m. depth.

Probably the features here described are partly due to the pre-quaternary orography of the two longitudinal valleys. At least it seems likely that Lago Fagnano was originally shallow in its eastern part where it approaches the Tertiary plain. But on the other hand, it cannot be doubted

that the deposition of glacial and fluvio-glacial beds has highly contributed to make the eastern parts of the two valleys shallow.

Postglacial emergence of land in Beagle Channel.

At the base of the moraine-hills round Harberton there is a very distinct old beach-terrace to be seen at a height of 3.5 m. above the present level of the sea, developed as a terrace cut out by action of the waves. On the flat land between the hills this raised beach is developed as a wall or a series of walls consisting of shingles and gravel accumulated by the waves. At one place I noticed such a wall with a small lagoon

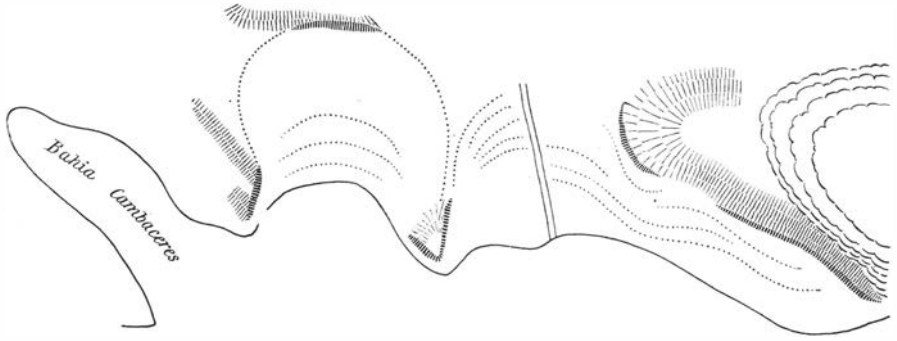


Fig. 6. Part of the N. coast of Beagle Channel E. from Puerto Harberton. On the slopes of the moraine-hills are old cliffs and on the lowland between the hills shingle-walls.

inside. On the top of the wall is a shell-mound heaped up by natives, evidently at a much later period than that of the formation of the raised beach. The sketch-map fig. 6 gives an idea of the common combination of the abrasive and accumulative types of this old shore-line. Its height is, as already mentioned, round Harberton about 3,5 m. above the present sea-level. As I have not found the least trace of marine action on any higher level of the well exposed moraine-slopes, I am forced to consider this 3.5 m. beach-line as the post-glacial marine limit.

The same strongly developed raised beach, I caught a glimpse of also on Gable Island and on the north coast of Navarin Island opposite Harberton, but had no opportunity of studying it closely at these localities.

As the steamer was proceeding westwards in the Beagle Channel, I noticed that at Punta Remolino, about halfway between Harberton and Ushuaia, the raised beach had reached a visibly higher position, and at Ushuaia I saw terraces at a still higher level though I got no opportunity of measuring their altitude.

NORDENSKJÖLD states that on Ushuaia Peninsula there is a very marked terrace at about 10 m. above sea-level.[1]

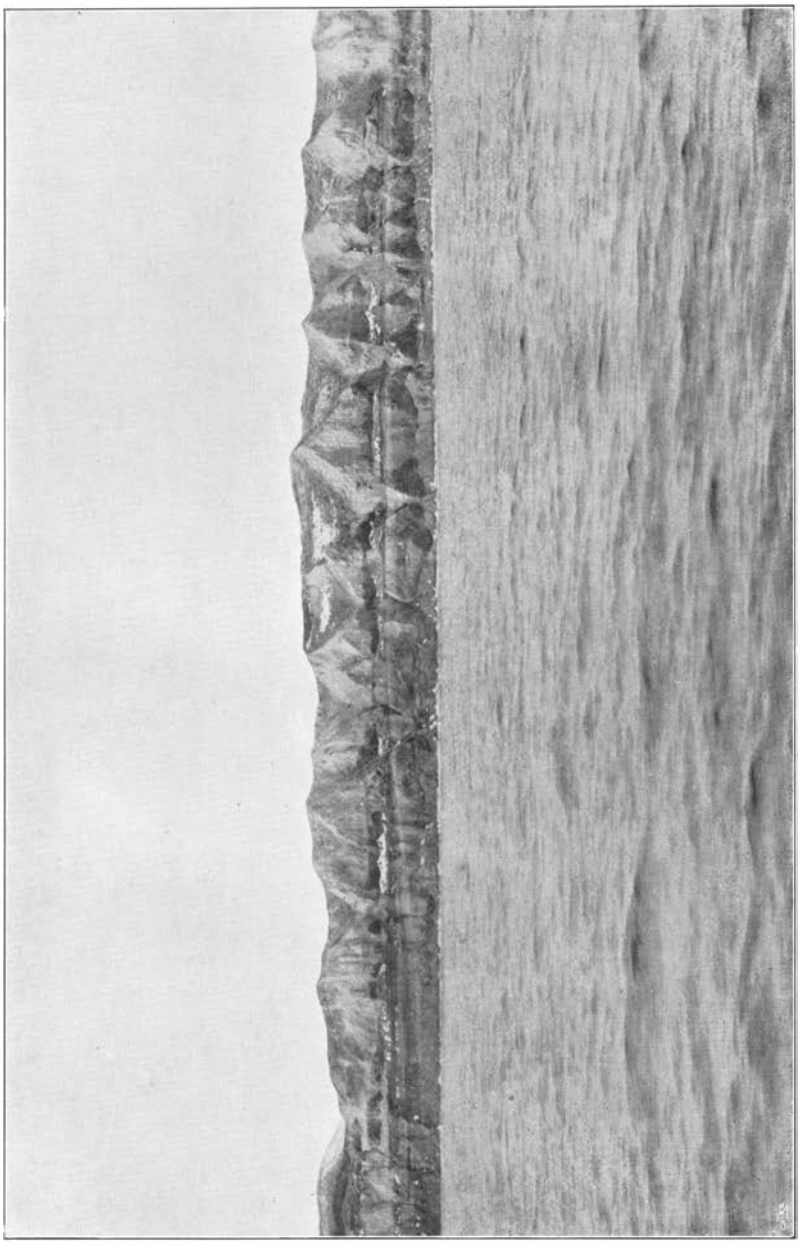
I think that when the facts mentioned above are taken into consideration, it can hardly be doubted that we meet here with an unequal upheaval of land, probably of the same kind as the emergence of Scandinavia which has been so splendidly elucidated by DE GEER'S researches. But on this point my observations are so imperfect, that I have only been able to point out that here is an almost untouched but most attractive field for exploration.

Addendum.

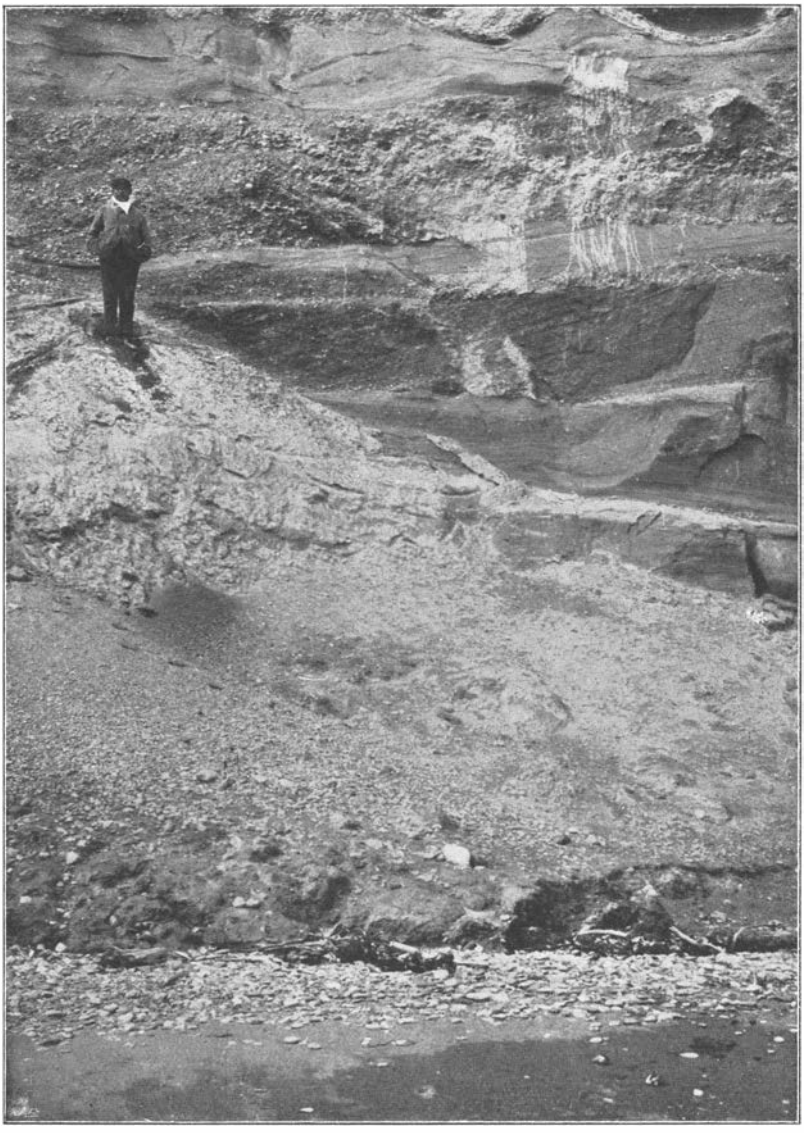
When this paper was already in press Prof. G. STEINMANN published a most important note on the fossils collected by LOVISATO; he states that the objects named in HYADES' work *Coscynocyathus* are most probably fragments of *Inoceramus*, the rock thus being of Cretaceous age.

Centralblatt für Min., Geol. und Pal. 7, 1908. P. 193—194.

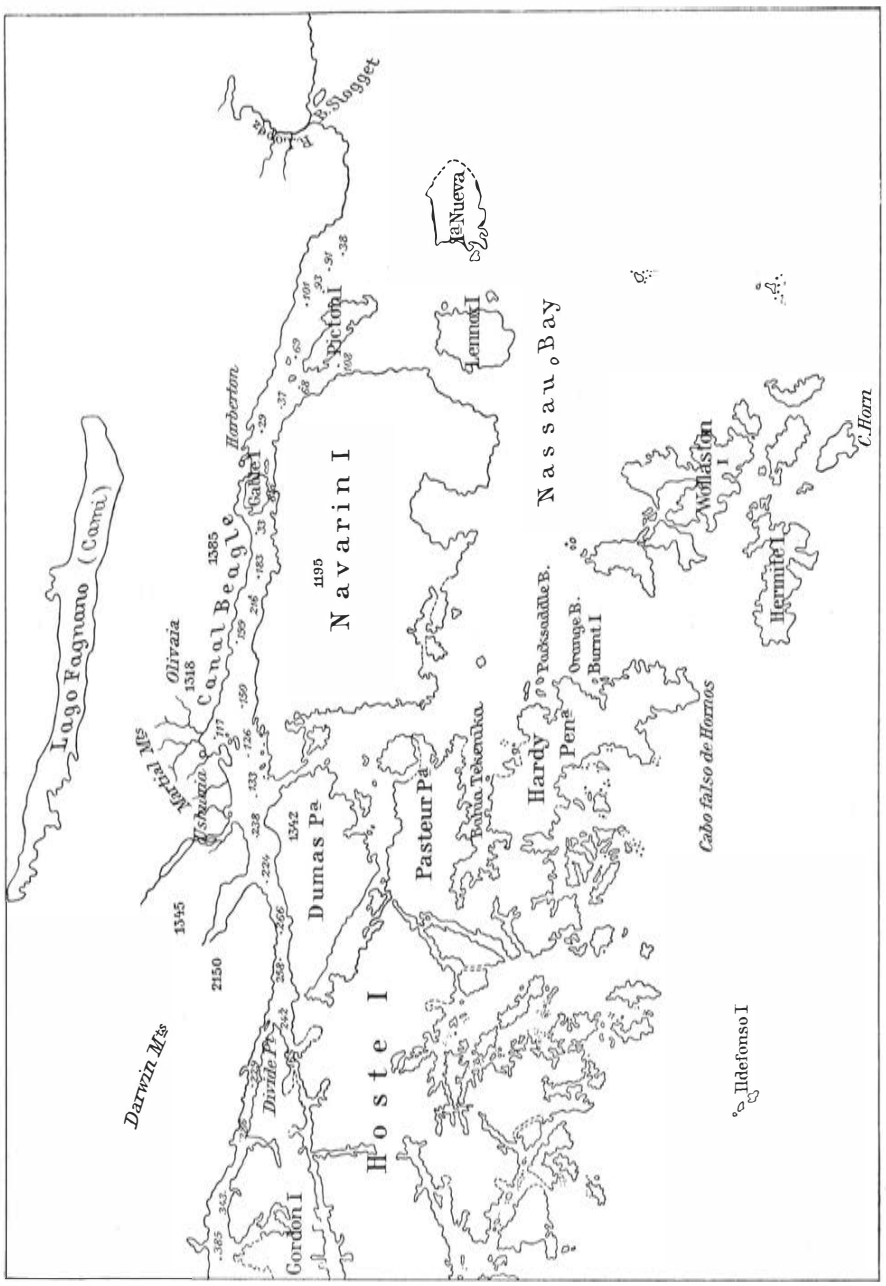
[1] NORDENSKJÖLD. Über die posttertiären Ablagerungen der Magellansländer. Stockholm. 1898. P. 59.



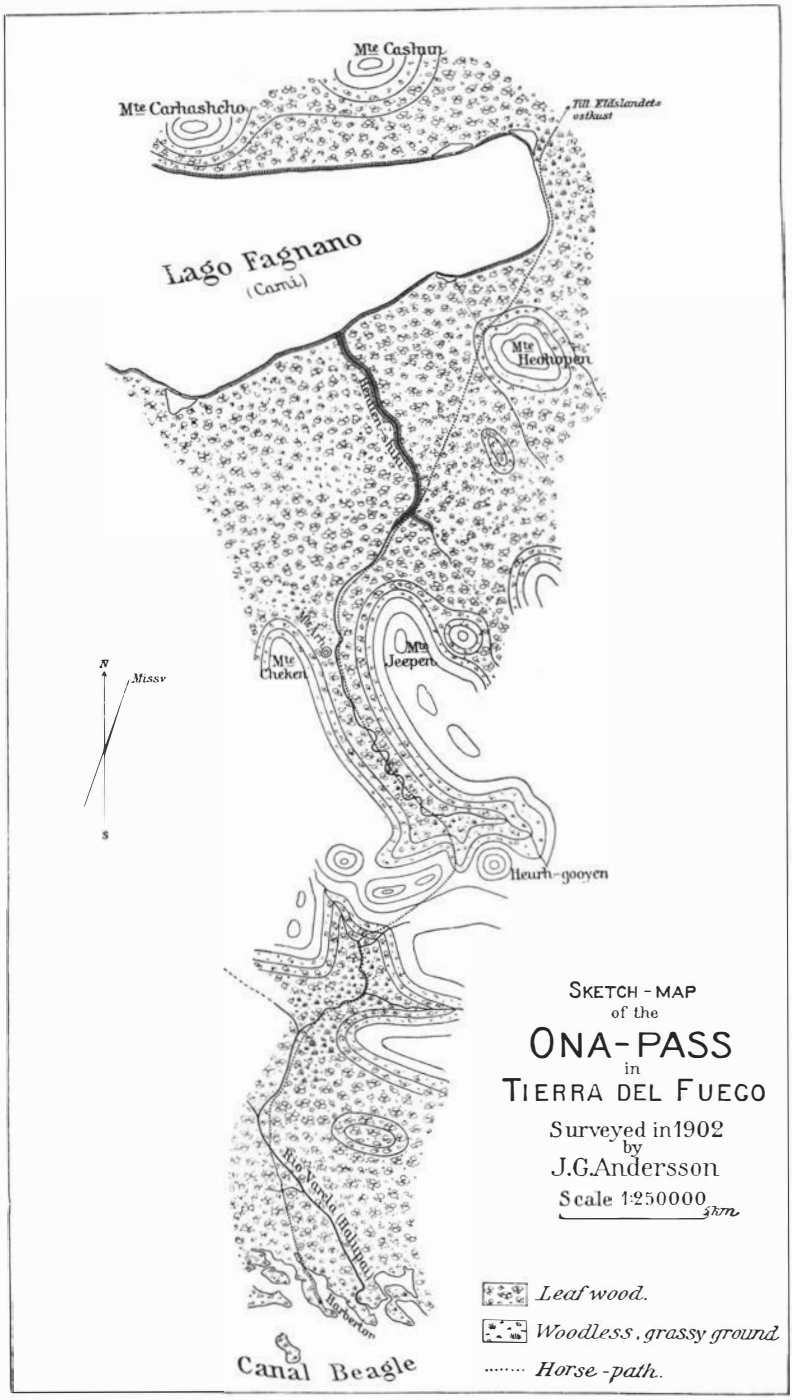
Western barranca of Gable Island.
Fluvio-glacial deposits covered by a bed of boulder-clay.



Fluvio-glacial deposits in the western barranca of Gable Island.
Alternating layers of sand and gravel, partly current-bedded.



Southern part of the Fuegian archipelago. Depths in meters.


Mte Cashun
Mte Carhashcho
Till Eldslandets ostkust
Lago Fagnano
(Cami)
Mte Hechippen
Heuren-kuh
Mte Cheken
Mte Jeepen
N
Missv
S
Heurn-gooyen
Rio Varela (Inalhuat)
Hyperton
Canal Beagle
SKETCH-MAP
of the
ONA-PASS
in
TIERRA DEL FUEGO
Surveyed in 1902
by
J.G.Andersson
Scale 1:250000
5km
Leaf wood.
Woodless, grassy ground.
Horse-path.