TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

SPECIAL PAPERS ON THE HISTORY OF SCIENCE – II

THE MAKING OF A GEOLOGIST — IN THE FOOTSTEPS OF DARWIN IN SOUTH AMERICA

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TULANE UNIVERSITY

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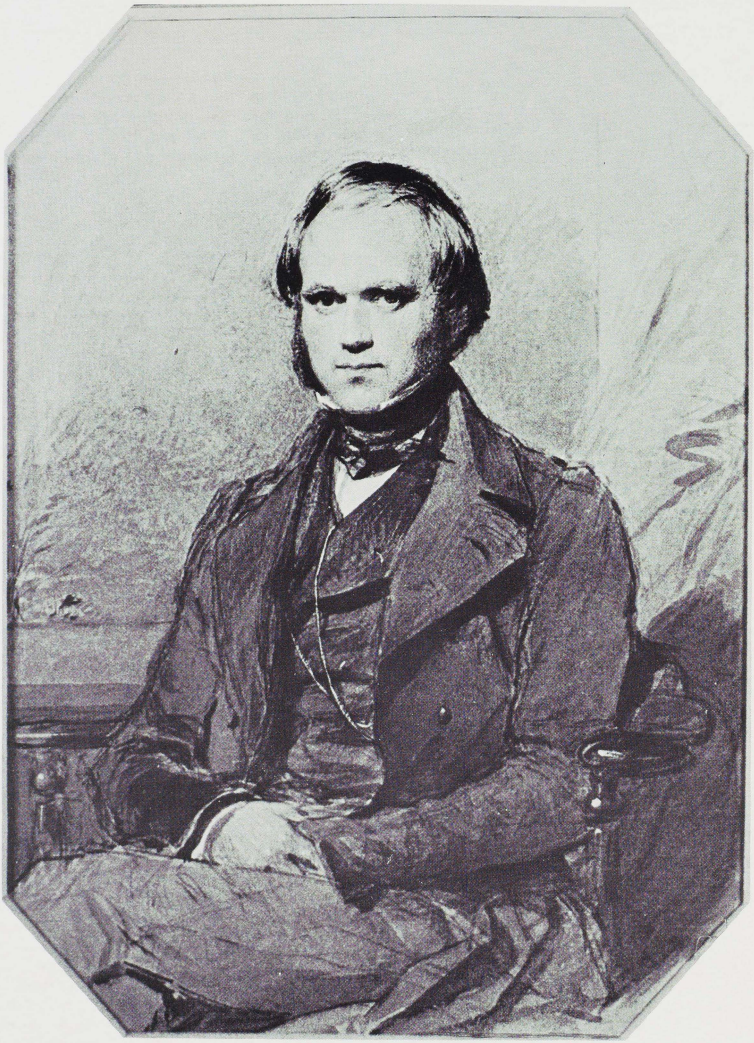

CHARLES ROBERT DARWIN
12 February 1809 — 19 April 1882

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THE MAKING OF A GEOLOGIST — IN THE FOOTSTEPS OF DARWIN IN SOUTH AMERICA

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Almost everyone is acquainted with the name of Charles Darwin, and is aware of his enormous contributions to the life sciences. These resulted, in large measure, from his experiences during the five years he served as naturalist on HMS *Beagle* during its long voyage around the world. Not so well known, however, are his considerable geological contribution, set forward in his "Journal of Researches into the Geology and Natural History of the Various Countries Visited by the *Beagle*" (1839), in his "Structure and Distribution of Coral Reefs" (1842), and his "Geological Observations on South America" (1846).

To appreciate the real significance of Darwin's geological observations fully, one must view them in the context of the state of knowledge of the science that existed when they were made. The voyage of HMS *Beagle* began in 1831. It was during this year that Adam Sedgwick, President of the Geological Society of London, made a most effective speech as he awarded the first Wollaston Medal of that Society to William Smith, acclaiming and greeting him as the Father of Stratigraphic Geology. Then, in the summer months of the same year, Sedgwick began the program of field work in northern Wales that led to his proposing the Cambrian System in 1835. His field assistant during that first summer was a young man just graduated from Cambridge University-Charles Darwin.

1831 — Stratigraphy was in its infancy. The geologic time scale consisted of only three units: "Primary," "Secondary," and "Tertiary," with finer subdivisions just beginning to be considered. Those named were of local significance, with such terms as "The Old Red Sandstone," "Carboniferous Strata," and "Liassic," being applied in the areas known to Darwin but not yet extended elsewhere. The scientific thinking of the day was dominated by concepts of the "Universal Deluge" and of an earth that had been created, according to Bishop Ussher, in 4004 B.C.

To bring it closer to home, James Hall was just beginning his Senior year at Rennselaer Polytechnic Institute. Timothy Abbott Conrad was studying fossils and preparing engravings on stone with which to illustrate the first parts of his work on fossil shells of the Tertiary Formations of North America, which began appearing in 1832 and finished in 1837. When this work was republished in 1893 by Professor G. D. Harris, he referred to it as "the beginning of systematic research into this period of our continent's history." Geology as a science was in its infancy.

But to come back to Darwin — when he returned to his home following his field season with Sedgwick on 29 August, 1831, he found a letter from his old Cambridge professor, mentor, and friend, John Henslow, that bore with it an offer to Darwin of the post of naturalist [unpaid] for the forthcoming voyage of the *Beagle*. Despite objections from his family, Darwin went to London and, early in September, he met with Captain Robert Fitzroy and the plans were underway. While in London, Darwin attended some of the parades and festivities attendant upon the coronation of William IV as king of England [William was the father of Victoria]. But mainly he was engaged in making preparations for the departure of the ship, then scheduled for late October. Darwin went on board on 24 October, but with delays the voyage did not begin until 27 December. One good aspect of this was that Darwin had time to receive, as a present from Henslow, the first volume of Lyell's "Principles of Geology" — just off the press.

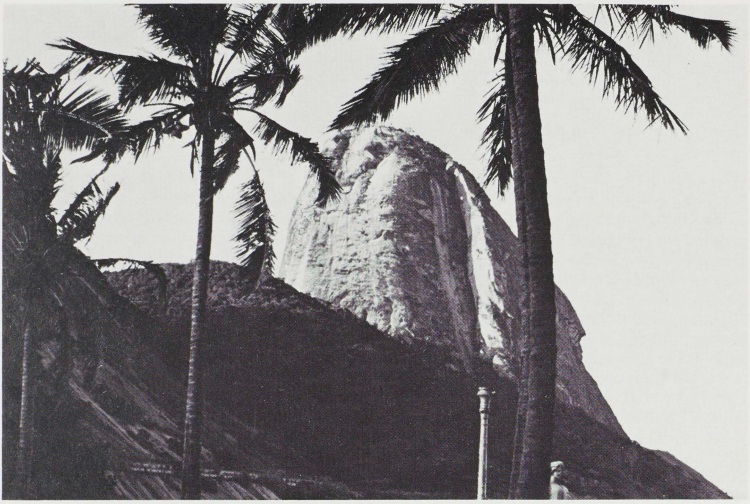

Figure 1. "Pão de açucar," or "Sugar-loaf," Rio de Janiero, Brazil.

Figure 2. Ilha Grande, near Rio de Janiero, Brazil.

Let us travel around South America with the young man and share with him, in his own words, his thoughts as he investigated the natural history of the area. He looked at everything — the plants, the animals, the insects, the people, the weather, the scenery, and especially the geology. It is fascinating to observe his realization of the vast extent of geologic time. This latter aspect is of extreme importance in his subsequent development of the theory of natural selection, for only with the availability of an almost unlimited amount of time in which to effect minute changes can this theory actually work.

For weeks the *Beagle* crossed the Atlantic Ocean, stopping only briefly at the Cape Verde Islands and at St. Paul's Rocks, where Darwin made most astute observations on this inconspicuous rockpile that is composed of deep oceanic material — pillow-basalts and serpentinite — in contrast to the normal volcanic island.

16th February 1832*

"This cluster of rocks . . . is 540 miles distant from the coast of America, and 350 from the island of Fernando Noronha. The highest point is only fifty feet above the level of the sea, and the entire circumference is under three-quarters of a mile. This small point rises abruptly out of the depths of the ocean. . . . It is a remarkable fact, that all the many small islands, lying far from any continent, in the Pacific, Indian, and Atlantic Oceans, with the exception of the Seychelles and this little point of rock, are, I believe, composed either of coral or of erupted matter. The volcanic nature of these oceanic islands is evidently an extension of that law, . . .

*This and succeeding quotations are taken verbatim from the "Journal of researches into the natural history and geology of the countries visited by H.M.S. Beagle" (Second Edition, 1845).

Figure 3. The "Pampean" Formation, Península Valdés, Argentina.

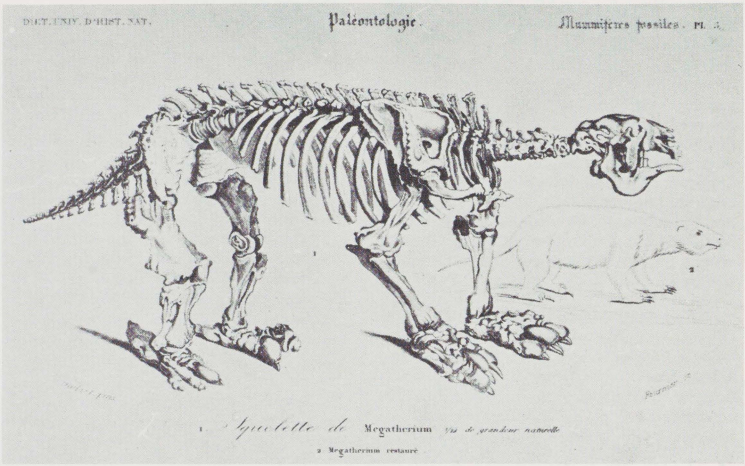

Figure 4. *Megatherium* — Dictionnaire Universel d'Histoire Naturelle.

Figure 5. *Glyptodon* in the La Plata Museum, Argentina.

from which it results that a vast majority of the volcanoes now in action stand either near sea-coasts or as islands in the midst of the sea."

Finally, nine weeks out of England, the *Beagle* arrived in Brazil. Darwin, who had been seasick for most of the time, immediately went on shore to recuperate and begin his studies. He writes in his diary:

29th February 1832

"It has been remarked, with much truth, that abruptly conical hills are characteristic of the formation which Humboldt designates as gneiss-granite. Nothing can be more striking than the effect of these huge rounded masses of naked rock rising out of the most luxuriant vegetation [fig. 1] . . . Along the whole coast of Brazil, for a length of at least 2000 miles, and certainly for a considerable space inland, wherever solid rock occurs, it belongs to a granitic formation. The circumstance of this enormous area being constituted of materials which most geologists believe to have been crystallized when heated under pressure, gives rise to many curious reflections. Was this effect produced beneath the depths of a profound ocean? or did a covering of strata formerly extend over it, which has since been removed? [fig. 2] Can we believe that any power, acting for a time short of infinity, could have denuded the granite over so many thousand square leagues."

On 24 August, 1833, the *Beagle* landed at Bahia Blanca, Argentina, and Darwin left the ship to make an overland trip to Buenos Aires, where he would meet it.

"The plain, at the distance of a few miles from the coast, belongs to the great Pampean formation [fig. 3], which consists in part of a reddish clay, and in part of a highly calcareous marly rock. . . . At Punta Alta we have a section . . . which is highly interesting from the number and extraordinary character of the remains of gigantic land animals embedded in it. . . . First, the *Megatherium,* [fig. 4] the huge dimensions of which are expressed by its name . . . [also] a large animal, with an osseous coat in compartments, very like that of an armadillo [fig. 5] . . . *Macrauchenia,* a huge beast with a long neck like a camel, . . . lastly the *Toxodon,* perhaps one of the strangest animals ever discovered: in size it equalled an elephant or megatherium, but the structure of its teeth, as Mr. Owen states, proves indisputably that it was intimately related to the Gnawers, the order which, at the present day, includes most of the smallest quadrupeds."

23rd December 1833

"We arrived at Port Desire, situated in latitude 47°, on the coast of Patagonia . . . The same evening I went on shore. The first landing in any new country is very interesting, and especially when, as in this case, the whole aspect bears the stamp of a marked and individual character. At the height of between two and three hundred feet . . . a wide plain extends, which is truly characteristic of Patagonia. The surface is quite level, and is composed of well-rounded shingle mixed with a whitish earth. Here and there scattered tufts of brown wiry grass are supported [fig. 6], and still more rarely, some low thorny bushes . . .

"The geology of Patagonia is interesting. Differently from Europe, where the tertiary formations appear to have accumulated in bays, here along hundreds of miles of coast we have one great deposit, including many tertiary shells, all apparently extinct. The most common shell is a massive gigantic oyster [fig. 7], sometimes even a foot in diameter. These beds are covered by others of a peculiar soft white stone, including much gypsum, and resembling chalk, but really of a pumiceous nature. It is highly remarkable, from being composed, to at least one-tenth part of its bulk, of Infusoria . . . at Port St. Julian its thickness is more than 800 feet! These white beds are everywhere capped by a mass of gravel, forming probably one of the largest beds of shingle in the world: it certainly extends from near the Rio Colorado to between 600 and 700 nautical miles

southward; at Santa Cruz (a river a little south of St. Julian), it reaches to the foot of the Cordillera; halfway up the river its thickness is more than 200 feet . . . We may consider its average breadth as 200 miles, and its average thickness about 50 feet. If this great bed of pebbles, without including the mud necessarily derived from their attrition, was piled into a mound, it would form a great mountain chain! . . . Yet all this gravel has been transported, and probably rounded, subsequently to the deposition of the white beds, and long subsequently to the underlying beds with the tertiary shells . . . The mind is stupified in thinking over the long, absolutely necessary, lapse of years.

"Everything in this southern continent has been effected on a grand scale: the land from the Rio Plata to Tierra del Fuego, a distance of 1200 miles, has been raised in mass within the period of the now-existing seashells . . . Nor has Patagonia been affected only by upward movements: the extinct tertiary shells from Port St. Julian and Santa Cruz cannot have lived, according to Professor E. Forbes, in a greater depth of water than from 40 to 250 feet; but they are now covered with sea-deposited strata from 800 to 1000 feet in thickness: hence the bed of the sea, on which these shells once lived must have sunk downwards several hundred feet, to allow the accumulation of the superincumbent strata. What a history of geological changes does the simply-constructed coast of Patagonia reveal!"

Darwin was an extremely astute geological observer but even he was a victim of his times, which did not admit to rivers cutting their own valleys, thus he erred in certain

Figure 6. Patagonian plain, near Península Valdés, Argentina.

Figure 7. Fossil oysters, near Comodoro Rivadavia, Argentina.

Figure 8. Rio Gallegos, southern Argentina.

Figure 9. Volcán Osorno (2661 meters), from Lago Todos Los Santos, Chile.

Figure 10. Cerro Aconcagua (7021 meters), from Paso de Bermejo, Argentina.

geological conclusions. For example, he recorded his thoughts on the formation of the valley of the Rio Santa Cruz, as he and the crew of the *Beagle* made a trip toward the headwaters of this Patagonian stream.

26th April 1834

"At the first glance of the basaltic cliffs on the opposite sides of the valley, it was evident that the strata once were united [fig. 8]. What power, then, has removed along a whole line of country a solid mass of very hard rock, which had an average thickness of nearly three hundred feet, and a breadth varying from rather less than two miles to four miles? The river, though it has so little power in transporting even inconsiderable fragments, yet in the lapse of ages might produce by its gradual erosion an effect, of which it is difficult to judge the amount. But in this case, . . . good reasons can be assigned for believing that this valley was formerly occupied by an arm of the sea. . . . If I had space I could prove that South America was formerly here cut off by a strait, joining the Atlantic and Pacific oceans, like that of Magellan. But it may yet be asked, how has the solid basalt been removed? Geologists formerly would have brought into play the violent action of some overwhelming *débâcle;* but in this case such a supposition would have been quite inadmissible; because, the same step-like plains with existing sea-shells lying on their surface, which front the long line of the Patagonian coast, sweep up on each side of the valley of Santa Cruz. No possible action of any flood could thus have modelled the land, either within the valley or along the open coast; and by the formation of such step-like plains or terraces the valley itself has been hollowed out. Although we know that there are tides, which run within the Narrows of the Strait of Magellan at the rate of eight knots an hour, yet we must confess that it makes the head almost giddy to reflect on the number of years, century after century, which the tides, unaided by a heavy surf, must have required to have corroded so vast an area and thickness of solid basaltic lava."

Darwin and the Beagle moved south, visiting Tierra del Fuego, then passing through the Straits of Magellan. At the island of Chiloe, from the town now known as Ancud, he observed the volcano Osorno, which is about 90 miles (airline) away.

26th November 1834

"The day rose splendidly clear. The volcano of Osorno [fig. 9] was spouting out volumes of smoke. This most beautiful mountain, formed like a perfect cone, and white with snow, stands out in front of the Cordillera . . .

"On the night of the 19th [January] the volcano of Osorno was in action. At midnight the sentry observed something like a large star, which gradually increased in size till about three o'clock, when it presented a very magnificent spectacle. By the aid of a glass, dark objects, in constant succession, were seen, in the midst of a great glare of red light, to be thrown up and to fall down. The light was sufficient to cast on the water a long bright reflection. . . . In the morning the volcano became tranquil.

"I was surprised at hearing afterwards that Aconcagua in Chile, 480 miles northwards, was in action on this same night; and still more surprised to hear, that the great eruption of Coseguina (2700 miles north of Aconcagua), accompanied by an earthquake felt over 1000 miles, also occurred within six hours of this same time. This coincidence is the more remarkable, as Coseguina had been dormant for twenty-six years: and Aconcagua most rarely shows any signs of action. It is difficult even to conjecture, whether this coincidence was accidental, or shows some subterranean connection. If Vesuvius, Etna, and Hecla in Iceland (all three relatively nearer each other, than the corresponding points in South America) suddenly burst forth in eruption on the same night, the coincidence would be thought remarkable; but it is far more remarkable in this case, where the three vents fall on the same great mountain-chain, and where the vast plains along the entire eastern coast, and the upraised recent shells along

Figure 11. The Andes as seen from near Chillan, Chile.

Figure 12. Paso de Bermejo, Chile-Argentina.

more than 2000 miles on the western coast, show in how equable and connected a manner the elevatory forces have acted."

The *Beagle* landed in Valparaiso, the chief port of Chile. Darwin was ecstatic.

23rd July 1834

"When morning came everything appeared quite delightful. After Tierra del Fuego the climate felt quite delicious — the atmosphere so dry, and the heavens so clear and blue with the sun shining brightly, that all nature seemed sparkling with life . . .

"The volcano of Aconcagua [fig. 10] is particularly magnificent. This huge and irregularly conical mass has an elevation greater than that of Chimborazo; for, from measurements made by the officers in the *Beagle*, its height is no less than 23,000 feet. The Cordillera, however, viewed from this point, owe the greater part of their beauty to the atmosphere through which they are seen. When the sun was setting in the Pacific, it was admirable to watch how clearly their rugged outlines could be distinguished, yet how varied and how delicate were the shades of their colour.

"The appearance of the Andes was different from that which I had expected. The lower line of the snow was of course horizontal, and to this line the even summits of the range seemed quite parallel. Only at long intervals, a group of points or a single cone, showed where a volcano had existed or does now exist. Hence the range resembled a great solid wall [fig. 11], surmounted here and there by a tower,

Figure 13. Andes near Portillo, Chile.

and making a most perfect barrier to the country . . .

"Two days afterwards I set out to cross the Cordillera . . . In this part of Chile there are two passes across the Andes to Mendoza: the one most commonly used — namely that of Aconcagua or Uspallata — is located some way to the north; the other, called the Portillo, is to the south, and nearer, but more lofty and dangerous . . . We set out for the Portillo pass . . .

"In this part of the valley, the mountains on each side were from 3000 to 6000 or 8000 feet high, with rounded outlines and steep bare flanks. The general colour of the rock was dullish purple, and the stratification very distinct. If the scenery was not beautiful, it was remarkable and grand . . .

"The lofty mountains, their summits marked with a few patches of snow, stood well separated from each other; the valleys being filled up with an immense thickness of stratified alluvium [fig. 12]. The features in the scenery of the Andes which struck me most, were . . . the smooth conical piles of fine and brightly-coloured detritus [fig. 13], which sloped up at a high angle from the base of the mountains, sometimes to a height of more than 2000 feet.

"I frequently observed, both in Tierra del Fuego and within the Andes, that where the rock was covered during the greater part of the year with snow, it was shivered in a very extraordinary manner into small angular fragments.

"The road, which as yet had been good with a steady but very gradual ascent, now changed into a steep zigzag track up the great range [fig. 14], dividing the republics of Chile and

Figure 14. Highway from Santiago, Chile, to Mendoza, Argentina.

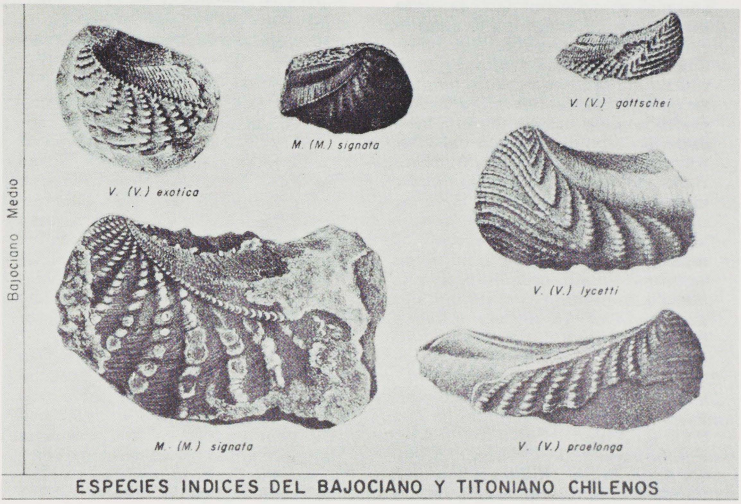

Figure 15. Trigoniidae de Chile: Reyes and Perez, 1979, Revista Geológico de Chile, no. 8, pl. 2.

Figure 16. Andes near Portillo, Chile.

[Argentina] . . . About noon we began the tedious ascent of the Peuquenes ridge, and then for the first time experienced some little difficulty in our respiration . . . The short breathing from the rarified atmosphere is called by the Chilenos 'puna;' . . . the only sensation I experienced was a slight tightness across the head and chest . . . There was some imagination even in this; for upon finding fossil shells [fig. 15] on the highest ridge, I entirely forgot the puna in my delight . . . The inhabitants all recommend onions for the puna; as this vegatable has sometimes been given in Europe for pectoral complaints, it may possibly be of real service: — for my part I found nothing so good as the fossil shells!"

Darwin gives a brief account of the geology of the Cordillera, concluding:

"The shells in the Peuquenes or oldest ridge, prove . . . that it has been upraised 14,000 feet since a Secondary period [fig. 16], which in Europe we are accustomed to consider as far from ancient; but since these shells lived in a moderately deep sea, it can be shown that the area now occupied by the Cordillera, must have subsided several thousand feet — in northern Chile as much as 6000 feet — so as to have allowed that amount of submarine strata to have been heaped on the bed on which the shells lived . . . Daily it is forced home on the mind of the geologist, that nothing, not even the wind that blows, is so unstable as the level of the crust of this earth."

The truth of this statement was most forcefully brought home to Darwin the following year, when he was ashore at Valdivia and experienced a severe earthquake.

20th February 1835

"A bad earthquake at once destroys our oldest associations: the earth, the very emblem of solidity, has moved beneath our feet like a thin crust over a fluid;—one second of time has created in the mind a strange idea of insecurity, which hours of reflection would not have produced."

The *Beagle* arrived at Concepcion, some 200 miles to the north, to learn that the same earthquake had totally devastated the area.

4th March 1835

"The next day I landed at Talcahuano, and afterwards rode to Concepcion. Both towns presented the most awful yet interesting spectacle I ever beheld . . . In Concepcion each house or row of houses stood by itself, a heap or a line of ruins . . . It is generally thought that this is the worst earthquake ever recorded in Chile; but . . . this cannot easily be known; nor indeed would a much worse shock have made any great difference, for the ruin was now complete.

"The town of Concepcion was built in the usual Spanish fashion, with all the streets running at right angles to each other; one set ranging S.W. by W., and the other set N.W. by N. The walls in the former direction certainly stood better than those in the latter . . . The different resistance offered by the walls, according to their direction was well exemplified in the case of the Cathedral [fig. 17]. The side which fronted the N.E. presented a great pile of ruins . . . the side walls . . . though exceedingly fractured, yet remained standing; but the vast buttresses (at right angles to them, and therefore parallel to the walls that fell) were in many cases cut clean off, as if by a chisel."

In particular he noted the means by which the gradual uplift of the Andes had been achieved.

"The most remarkable effect of this earthquake was the permanent elevation of the land; it would probably be far more correct to speak of it as the cause. There can be no doubt that the land round the Bay of Concepcion was upraised two or three feet; . . . At the island of S. Maria (about thirty miles distant) the elevation was greater; on one part, Captain Fitz Roy found beds of putrid mussel-shells *still adhering to the rocks*, ten feet above high-water mark: the inhabitants had formerly dived at low-water spring-tides for these shells. The elevation of this

province is particularly interesting, from its having been the theatre of several other violent earthquakes, and from the vast numbers of sea-shells scattered over the land, up to a height of certainly 600, and I believe, of 1000 feet. At Valparaiso, as I have remarked, similar shells are found at the height of 1300 feet: it is hardly possible to doubt that this great elevation has been effected by successive small uprisings, such as that which accompanied or caused the earthquake of this year, and likewise by an insensibly slow rise, which is certainly in progress on some parts of this coast . . .

"From the intimate and complicated manner in which the elevatory and eruptive forces were shown to be connected during this train of phenomena, we may confidently come to the conclusion, that the forces which slowly and by little starts uplift continents, and those which at successive periods pour forth volcanic matter from open orifices, are identical. From many reasons, I believe that the frequent quakings of the earth on this line of coast, are caused by the rending of the strata, necessarily consequent on the tension of the land when upraised, and their injection by fluidified rock. This rending and injection would, if repeated often enough (and we know that earthquakes repeatedly affect the same areas in the same manner), form a chain of hills; and the linear island of St Mary, which was upraised thrice the height of the neighbouring country, seems to be undergoing this process. I believe that the solid axis of a mountain, differs in its manner of formation from a volcanic hill, only in the molten stone having been repeatedly injected, instead of having been repeatedly ejected. Moreover, I believe that it is impossible to explain the structure of great mountain-chains, such as that of the Cordillera, where the strata, capping the injected axis of plutonic rock, have been thrown on their edges along several parallel and neighbouring lines

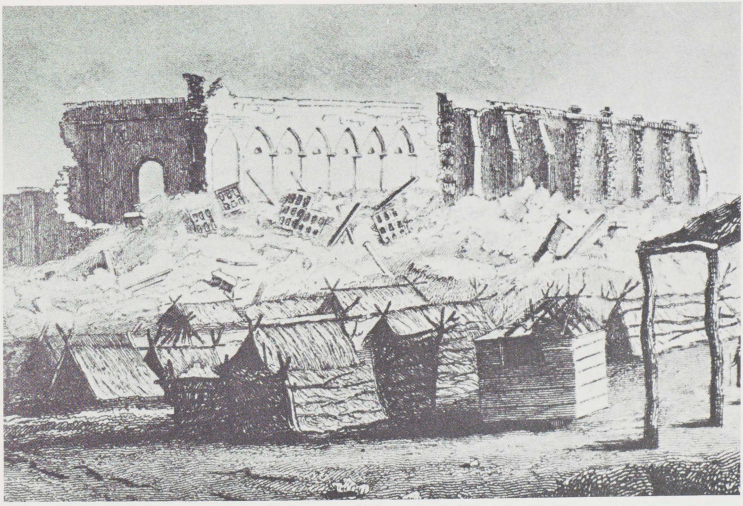

Figure 17. Sketch of Cathedral in Concepcion, made by J. C. Wickham, from *Narrative of the surveying voyages of HMS Adventure and Beagle.*

Figure 18. Cliffs at Navidad, Chile.

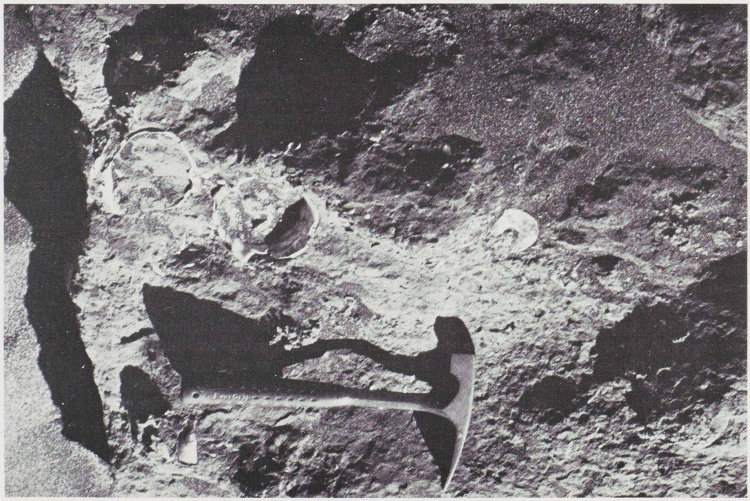

Figure 19. Fossiliferous sandstone at Navidad, Chile.

of elevation, except on this view of the rock of the axis having been repeatedly injected, after intervals sufficiently long to allow the upper parts or wedges to cool and become solid."

During August and September Darwin took a "geologising" excursion out of Valparaiso.

"We followed this valley till it expanded into a great plain, which reaches from the sea to the mountains west of Rancagua. We shortly lost all trees and even bushes; so that the inhabitants are nearly as badly off for firewood as those in the Pampas . . . The next day we arrived at a house near Navedad, on the seacoast, where a rich Haciendero gave us lodgings. I stayed here the two ensuing days, and although very unwell, managed to collect from the tertiary formation some marine shells."

Darwin may have been unwell but he managed to observe the following:

"The cliffs here are about 800 feet in height [fig. 18]; they consist, wherever I could examine them, of fine grained, yellowish, earthy sandstones, with ferrugineous veins, and with concretions of hard calcareous sandstone [fig. 19] . . . The sandstone contains fragments of wood, either in the state of lignite or partly silicified, sharks' teeth, and shells in great abundance, both high up and low down the sea-cliffs. *Pecturnculus* and *Oliva* were most numerous in individuals, and next to them *Turritella* and *Fusus*. I collected in a short time, though suffering from illness, 31 species [fig. 20], all of which are extinct, and several of the genera do not now range nearly so far south.*"

From Valparaiso Darwin also made an excursion into the Atacama desert of northern Chile. He traveled to Copiqpó, 420 miles to the north, where he was picked up once

*This passage is from "Geological Observations."

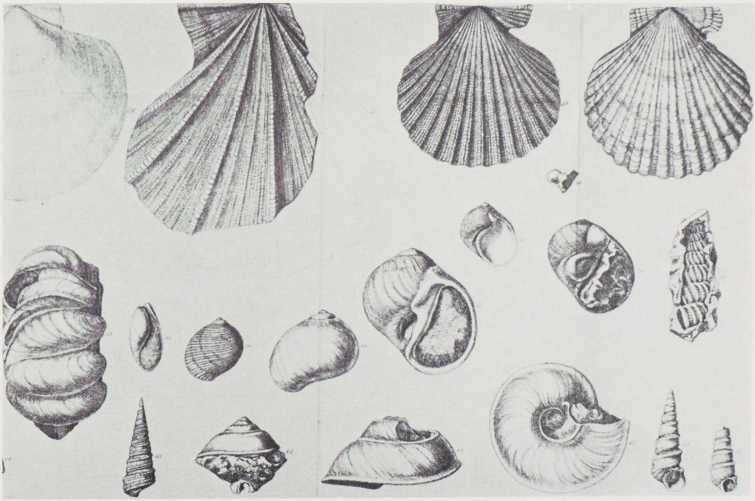

Figure 20. Tertiary fossil shells from South America. Plate 3, *Geological Observations* (1846).

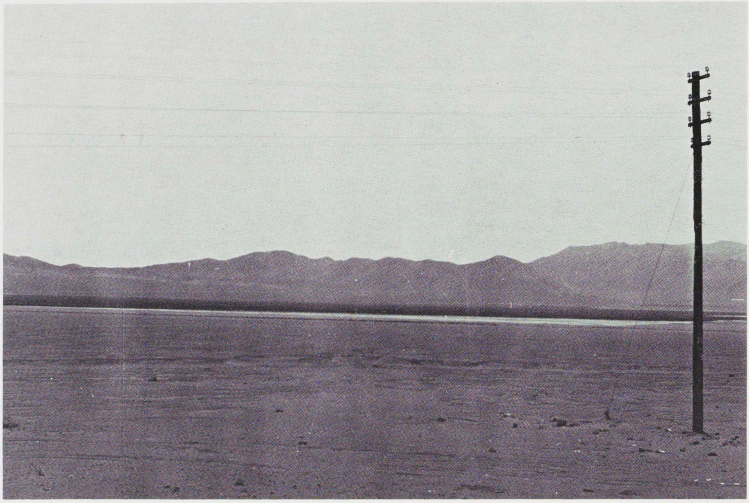

Figure 21. The Atacama Desert, near Antofagasta, Chile.

Figure 22. Train station at Cere, near Chuquicamata, Chile.

again by the *Beagle*. Due to seasickness Darwin traveled by land as much as possible.

> "During each day's ride further northward, the vegetation became more and more scanty . . . I am tired of repeating the epithets barren and sterile [fig. 21]. These words, however, as commonly used are comparative; I have always applied them to the plains of Patagonia, which can boast of spiny bushes and some tufts of grass; and this is absolute fertility, as compared with northern Chile.
>
> "The appearance of the country was remarkable, from being covered by a thick crust of common salt, and of a stratified saliferous alluvium . . . The existence of this crust . . . shows how extraordinarily dry the climate must have been for a long period."

However it does occasionally rain even in the Atacama, and when it does the effects are disastrous.

> "After two or three very dry years . . . a rainy year generally follows; and this does more harm than even the drougth. The rivers swell, and cover with gravel and sand the narrow strips of ground, which alone are fit for cultivation . . . Great devastation has thus been caused three years ago" [fig. 22].

From Copiapó Darwin sailed to Lima, about which he had very little good to say. From here the *Beagle* turned westward, next putting in the Galápagos Islands. It was here, as we all know, he first began the musings upon species differentiation that would ultimately lead to his theory of evolution. However, at the time, his sole observation on the finches was limited to a short paragraph.

> "The most curious fact is the perfect gradation in the size of the beaks in the different species of *Geospiza* . . . Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species had been taken and modified for different ends."

From the Galápagos Islands the *Beagle* headed across the Pacific Ocean, stopping at Tahiti, New Zealand, and Australia, but spending only a little time at each place. His geological interest was not excited again until the ship arrived at the Cocos-Keeling Islands in the Indian Ocean. Here he discovered the wonders of the coral atoll and formulated his theory of atoll formation, which, had it not been subsequently so totally overshadowed by his biological achievements, alone would have earned him a permanent place among the ranks of the great geologists.

12th April 1836

> "I am glad we have visited these islands: such formations surely rank high amongst the wonderful objects of this world. Captain Fitz Roy found no bottom with a line 7200 feet in length, at the distance of only 2200 yards from the shore; hence this island forms a lofty submarine mountain, with sides steeper even than those of the most abrupt volcanic cone. The saucer-shaped summit is nearly ten miles across; and every single atom, from the least particle to the largest fragment of rock, in this great pile, which however is small compared with very many other lagoon-islands, bears the stamp of having been subjected to organic arrangement. We feel surprise when travellers tell us of the vast dimensions of the Pyramids and other great ruins, but how utterly insignificant are the greatest of these, when compared to these mountains of stone accumulated by the agency of various minute and tender animals! This is a wonder which does not at first strike the eye of the body, but, after reflection, the eye of reason."

The effects of this trip upon Darwin were manifold, not the least of which was his discovery of the wonders of geology. While a student at the University of Edinburgh he had found lectures in geology by Jameson "incredibly dull" and he left the University with the determination "never as long as I lived to read a book on geology or in any way study the science." Only five years later, in South America he raved:

> "Geology carries the day. I find in geology a never failing interest, it creates the same grand ideas respecting this world which astronomy does for the universe."

A reflection of this can be seen in the fact that, as Sir Gavin de Beer noted in his Introduction to the 1957 Edition of the "Journal of Researches," there is a title change between the first and second editions of this work, indicating that his initial enthusiasm was geological and only after long retrospection was it replaced by Biology. The first edition (1839) carries the subtitle "into the geology and natural history. . ." but the second edition (1845) reads: "into the natural history and geology. . ." It is also made obvious when one reads the last pages of the Journal, as Darwin takes a retrospective look over what he termed "the advantages and disadvantages, the pains and pleasures, of our circumnavigation of the world."

> "In calling up images of the past, I find that the plains of Patagonia frequently pass cross before my eyes; [fig. 23] yet these plains are pronounced by all wretched and useless. They can be described only by negative characters; without habitations, without water, without trees, without mountains, they support merely a few dwarf plants. Why, then, and the case is not peculiar to myself, have these arid wastes taken so firm a hold on my memory? . . . I can scarcely analyse these feelings; but it must be partly owing to the free scope given to the imagination. The plains of Patagonia are boundless; . . . they bear the stamp of having lasted, as they are now, for ages, and there appears no limit to their duration through future time."

Darwin had become a geologist.

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This paper is the result of a trip around South America, made possible by an invitation to teach one semester at the Universidade Federale do Rio Grande do Sul, Porto Alegre, Brazil. This kind invitation was made by Darcy Closs, then Director of the Department of Paleontology at that institution. and mere words cannot express our gratitude to him for having provided us with such a marvelous experience. After leaving Porto Alegre, we were additionally helped by Jose Stuardo, then at the University of Concepcion, Chile, whose gracious hospitality included not only living accommodations, the loan of Maria Villaroel (then a graduate student) as a guide to Darwin's fossil localities, but included, above and beyond the call of duty, meeting a train that arrived several hours late at the unholy hour of 3 a.m. Not since Robinson Crusoe discovered Friday, has the sight of another human being been so welcome (we arrived in Chile the day Nixon declared the U. S. was off the gold standard and no banks would accept U. S. traveler's checks!).

To all these people, as well as an array of nameless people such as taxi drivers, who helped us find strange places where we might collect fossils and who then helped us collect the fossils, train clerks who took a chance on U. S. funds, little old ladies who fed us strange and wonderful food, museum guards who opened the La Plata Museum on Sunday so that we might photograph the skeletons, and many others who remain only a warm glow in our memory, we say — Muchísimas gracias!

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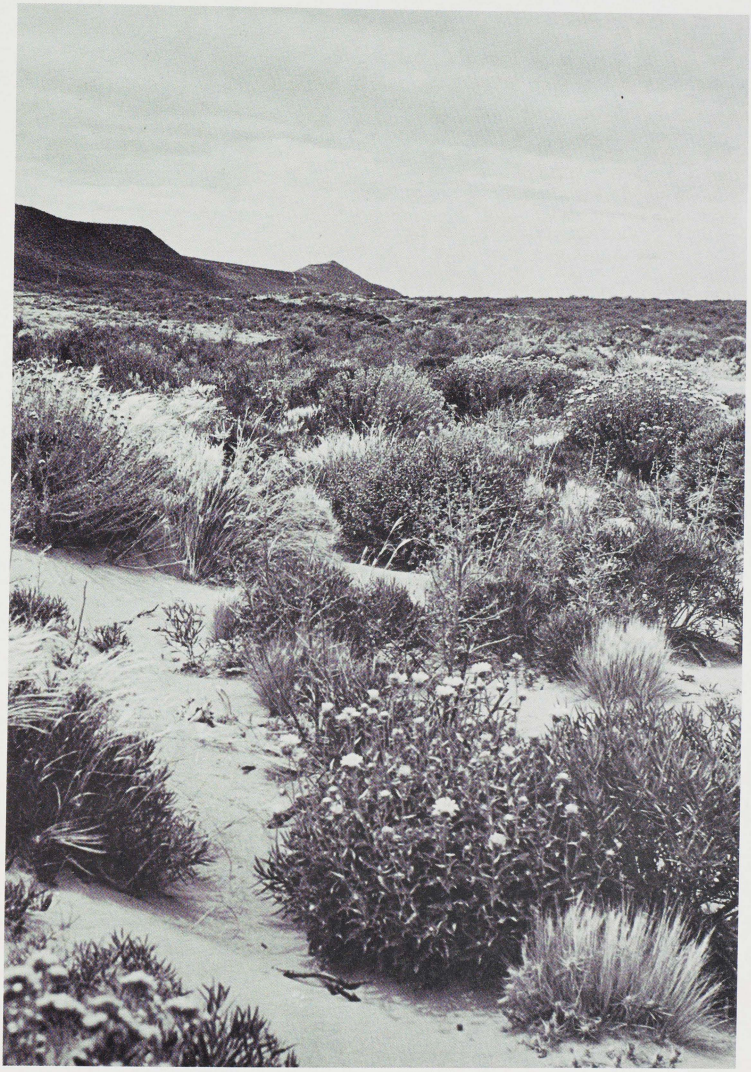
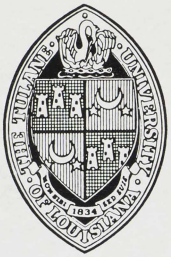


Figure 23. Wildflowers in the Patagonian Spring, near Comodoro Rivadavia, Argentina.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