

FROM CHARLES DARWIN'S PORTFOLIO: AN EARLY ESSAY ON SOUTH AMERICAN GEOLOGY AND SPECIES

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ABSTRACT

This work is an analysis and edition of a previously unpublished essay by Charles Darwin entitled "Reflection on reading my Geological notes." The original draft of the essay appears to have been written in 1834, that is, during Darwin's voyage on H.M.S. *Beagle* (1831-1836). In the essay Darwin developed a theory of the geological formation of South America that included a narrative framework for the history of life on the continent. His treatment of the history of life is not yet transmutationist, but it is highly sequential.

INTRODUCTION

One of the elements contributing to the magnitude of Charles Darwin's impact as a scientist was his methodical practice as a writer. During his travel aboard H.M.S. *Beagle* from the end of December 1831 through October 1836, he not only observed and collected in natural history, he also labelled specimens, recorded their date and place of collection in specimen books, and wrote up more general notes as to observations and specimens in two parallel series of notes, one geological, the other zoological.¹ Occasionally, however, in addition to writing centered on objects, Darwin would pause to write at length in a more reflective vein. The document presented here is one such essay, Darwin entitled it "Reflection on reading my Geological notes." It is a piece from the portfolio of a young geologist.¹

The document is presently filed under the label, written on a piece of paper in Darwin's own hand, "Scraps to end of Pampas chapter."² Darwin's label identifies the essay as of potential use to him in writing a chapter on the Pampas for the third volume of his geology from the voyage.³ Among the other "scraps" in Darwin's file on the Pampas chapter are also to be found several excised pages from two of his notebooks (the "Red Notebook" and "Notebook A") and a note on geology and species dated "Feb 1835."⁴

Darwin's essay is significant, for it shows him developing a theory of the geological formation of South America that included a narrative framework for the history of life on the continent. His presentation of the history of life is not transmutationist, but it is highly sequential. For those familiar with Darwin primarily

through the *Origin of Species*, his treatment of the subject of species in this essay is comparatively more focused on geological issues and more concrete, in that species figuring in the sequential history of life in Patagonia are referred to by name.⁵ For those who associate Darwin's work on the species question during the *Beagle* voyage with his visit to the Galápagos Islands in 1835, this essay will suggest the seriousness of his interest in the subject more than a year earlier.

Darwin's essay was not organized for rhetorical effect. Of its ten folios, the first and five and one half are diverse in subject matter and exploratory in tone. Half-way down folio 6 Darwin's tone changes to one of assertion. From this point on to the end of the folio 10 Darwin's logic is focused and sharp.

The essay opens with a discussion of the large extent of the "Tosca," a "red earthy clay" formation running for eleven hundred miles in a north-south line from the Río Colorado in the south to north of Asunción, and for seven hundred miles in an east-west direction. As he did frequently in this essay, Darwin considered questions of origins. In this case he speculated that the sea in which the Tosca was formed would have been a "little sheltered" by the ridge of the Andes and the mountains of Brazil. Also, characteristically, Darwin took up the question of fossils, in this case the geological limits of "Megatherium relics." (fol. 1^a)

On folio 2 Darwin considers the sequence of deposition of several beds, and brings up the question of greatest interest, the relative age of the "vast numbers of fossil bones of very large quadrupeds." Folio 3 continues the subject with the question "Whether these animals existed after the final elevation of the Tosca plains. . . ." Darwin then raised the obvious next question: "what country supported these numerous & vast animals. . . ." One situation that particularly interested him was the "animal (of which I found skeleton nearly entire)" at Bahía Blanca that appeared to have lived "near about" to modern beds (fol. 3).⁶ He was then led

¹I wish to thank George Pember Darwin and the Syndics of Cambridge University Library for permission to publish the essay. I also wish to thank Sarah Lavelle of the Darwin Correspondence Project for checking my transcription.

to ask: "But then we have the puzzle how could these most sterile plains support such large animals: . . ." Eventually he was to draw the conclusion, and make it part of the core of his understanding of the history of life, that large quadrupeds did not necessarily require luxuriant vegetation in order to survive.⁷

Folio four through the beginning of the last paragraph on folio 6 treat three subjects. First, there is the question of the number of elevations undergone by the Pampas. (fol. 4) Then there is a question of ecology and deposition: whether in situations "where gypsum is dissolved in water shells do not flourish." (fol. 4) In the remaining long passage (fols. 4–6) Darwin considers the relative age and identity of certain beds. Of chief interest are the great Patagonian oyster shell bed and a gravel bed that included porphyry pebbles. He was prepared to adduce elevatory movements to explain the present position of the porphyry pebbles. (fol. 6)

In the last paragraph on folio six Darwin stood back to take the wider view: "Looking at this whole part of Eastern side of S America. we must consider [sic] it as one grand formation.—" Thereafter follows the most interesting passage in the essay (fol. 7):

We shall presently . . . run over the proofs of repeated elevations: . . . May we conjecture that these . . . began with greater strides, that rocks from seas too deep for life (. . . were rapidly elevated & that immediately when within a proper depth, life commenced.

Darwin concluded this passage on a cyclical note by suggesting that beds were now forming beneath the sea "ready when . . . compelled to give their evidence in the open day-light." (fol. 7)

Darwin then turned to consider possible structures of the earth that might have produced both the Andes and the plains he had observed during his travels in the southern part of South America. He began by considering the Andes as "Perhaps the first opening of the N. & S. crack in the crust of the globe, forming the Cordilleras." (fol. 7) He imagined the crack as part of "a swelling of the Globe." (fol. 8) The image does not quite suffice, however, and he sees the difficulties: "It becomes a problem. how much the Andes owes its height, to Volcanic matter pouring out?— how much to horizontal strata tilted up? how much to these horizontal elevations of the surface of continents?—" Despite uncertainty over their causation, Darwin is convinced of the importance of elevatory movements. In South America, as compared to Europe, he believes them to be "regular and simple." (fol. 9)

Darwin's last question in the essay is perhaps the most startling to the present-day reader for the condensed time-scale it implies. Nonetheless, the logic is valid, and became a familiar sort of argument for him as he considered the subject of temporal succession. He framed his question this way:

As Patagonia has risen from the waters in so late a period, it may be interesting to consider whence came its organized being [sic].— I have conjectured the absence of trees in the fertile Pampas & rich valleys of B. Oriental, to be owing to no Creation having taken

place subsequently to the formation of the superior Tosca beds: (fols. 9–10)

The observation on trees was his own and reappears in his account of the voyage.⁸ But here, while writing this essay, he was eager to test the general applicability of his hypothesis that Patagonia should have no or few recent indigenous species. To do so, he chose to look at larger animals as "being of easier knowledge." He also considered only animals from south of the Río de la Plata, so that the possibility of migration ("communication") from Brazil could be more easily discounted. In his survey he relied on his own observations and on the literature he had with him aboard ship including Edward Griffith's edition of Georges Cuvier's *Animal Kingdom*.⁹ His survey produced only "two good exceptions." (fol. 10) These were the Patagonian cavy and the armadillo called "pichiy." In a rough way, his hypothesis was viable.

Overall in this essay Darwin suggested a view of the formation of the eastern portion of southern South America that integrated a provisional understanding of the history of life in the region with speculation concerning the structure of the globe. These were strong views, and given Darwin's career, it is important to know their date.

To date this essay one must distinguish its original form from later additions. The original draft would appear to be the material on the rectos of the ten folios together with Darwin's own set of footnotes which he keyed into his text by alphabet letters. This original draft can be dated by considering it in the light of his itinerary and by comparing it with his other work from the voyage.

In 1832 and 1833 H.M.S. *Beagle* was engaged in surveying work along the eastern coastline of South America and in Tierra del Fuego. By June 1834 the ship was working its way up the western coast of South America. The sequence of dates for the end of 1833 and 1834 is as follows:

- 1833 Dec 6th. Sailed for last time from Rio Plata [23 December–4 January 1834. Port Desire.]
[1834 26 January. Strait of Magellan.]
[2 February. Port Famine.]
[5 March. Sailed from Tierra del Fuego.]
[10 March–7 April. East Falkland Island.]
[18 April–8 May. Expedition up the Santa Cruz river]
[1–8 June. Port Famine.]
1834 June 10th. Sailed for last time from Tierra del Fuego [Arrived west coast via Magdalen channel.]¹⁰

Port Desire is mentioned in Darwin's essay (fol. 6^v). Port Famine in Tierra del Fuego and the Santa Cruz River in Patagonia are not. Possibly Darwin would not have referred to Port Famine, even if he had visited there before writing his essay; the subject matter of the essay would not have required it. However, Darwin's expedition up the Santa Cruz River was a major ex-



Figure 1. Alexander Calkdleigh's "Map of the Country between Buenos Ayres and the Pacific Ocean, with a Specification of the different Geological Formations." The five categories of geological formations listed in the legend include "Primitive" (pink), "a very new Stalactiform Limestone" (yellow), "Red Marl" (green), "Pebbles & Sand" (salmon), and "Clay" (blue). This photograph is courtesy of the Oliveira Lima Library of the Catholic University of America. (See note 26.)



Figure 2. A map of the "Southern Portion of South America" from the narrative of the *H.M.S. Beagle*. (See note 7.) This photograph is courtesy of the Library of Congress. Nearly all the place names mentioned in Darwin's essay appear on this map.

curion into Patagonia and would have been mentioned had it taken place before the essay was written. In a related essay by Darwin, entitled "Elevation of Patagonia," the Santa Cruz expedition figures prominently, and this essay has been dated to mid-1834.¹¹ On the basis of place names mentioned, therefore, Darwin's essay "Reflection on reading my Geological notes" can be dated to the period during or after the stay in Port Desire, from 23 December–4 January 1834, and sometime before the expedition up the Santa Cruz River began on 18 April 1834.

Darwin's letter of March 1834 written from East Falkland Island to his Cambridge mentor John Stevens

Henslow allows for a narrower dating. The letter and Darwin's essay overlap in content. Further, two works Darwin received while at East Falkland are mentioned only in the material added to the original draft of the essay.¹² Thus the original draft of the essay was probably written before the *Beagle* arrived at East Falkland Island on 10 March 1834. Such a dating is consistent with the content of Darwin's zoological and geological notes from the voyage. In the zoology notes from Santa Cruz in accounting for the infertility of the region Darwin referred to "no creation having taken place since this country was elevated" though, with qualification now, "(I yet think this applies to the Northern parts);

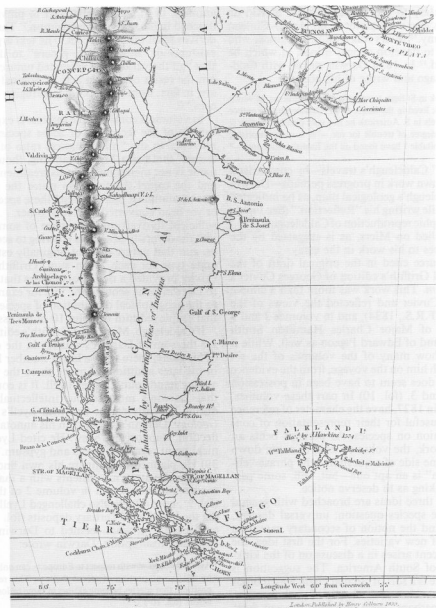


Figure 3. An enlargement of a portion of the map that appears as Figure 2.

...¹³ In his geological notes from Santa Cruz Darwin referred to the “concentric” elevation of the globe as an “enlargement of the curve of the world.”¹⁴ This sentiment is similar to that expressed in “Reflection,” (fol. 8) With respect to Darwin’s work on the species question during the voyage, Darwin’s approach in “Reflection” is clearly prior to his dated notes of February 1835. These notes play off the notion of life spans for species, an idea that in turn derived from Darwin’s study of the grafting of apple trees at the island of Chiloé, which he visited from 28 June–18 July 1834.¹⁵

In sum, all evidence suggests the early months of 1834 as the date for the composition of the essay.

What of Darwin’s sources in writing the essay? Only three works are cited in the original draft. Yet they are significant since they are contemporary sources, relatively unknown, and suggest something of the context of Darwin’s work. Two of the sources are works of travel by British authors of scientific interests: Alexander Caldcleugh (d. 1858, F.R.S. 1831) and John Miers (1789–1879, F.R.S. 1843). Both had business interests in mining, as well as in science. Caldcleugh served as

a private secretary to the British minister at Rio de Janeiro; he was also a promoter of the Anglo-Chilean Mining Company.¹⁶ Miers was a mining engineer who came to Chile to develop copper mines, at which he did not succeed.¹⁷ In 1835 Darwin stayed with Caldecleugh in Santiago and wrote of his host:

I staid also a week in St Iago, to rest after the Cordilleras, of which I stood in need & lived in the house of Mr Caldecleugh (the author of some bad travels in S. America): he is a very pleasant person & took an infinite degree of trouble for me.— It is quite surprising how kind & hospitable I have found all the English merchants.—¹⁸

However “bad” Caldecleugh’s travels—by comparison with Darwin’s own work in progress perhaps—Darwin did value Caldecleugh’s geological map, as he indicated by his use of while writing his “Reflection.” (See Figure 1 for a photographic reproduction of Caldecleugh’s map.) Darwin also relied on Miers, as is suggested by the several references to his work in the essay.

The third source cited in the original draft of the essay is Edward Griffith’s edition of Georges Cuvier’s *Animal Kingdom*. This work was more than a simple translation of Cuvier and reflected the views of the editor Griffith (F.R.S., 1834), and in volumes 2 and 3 on mammals, of Major Charles Hamilton Smith (F.R.S., 1824) and of Edward Pigeon as well. While it is not known how many of the volumes of the set Darwin had with him on the voyage, from the evidence in the essay he does seem to have been in possession of volumes 2 and 3. (fol. 10) In part these volumes, both published in 1827, have the character of reference works and are useful for their representation of contemporary opinion on species. As perhaps befits an encyclopedic work, the volumes tend to come down on more than one side of a question—the phrase “climate of opinion” is an apt one—but, still, some passages are so striking as to deserve notice.

In volume 2, three ideas are broached with general relevance to the species question: universal descent, development, and the notion of secondary causation for the origin of new varieties. For the first idea, the question of descent arises in a discussion of the kinkajou, a native of South America. The suggestion is made that “there is a sort of circular chain which binds the numerous branches of the family of earth together, and indicates, perhaps, their universal descent from one common origin.”¹⁹ The suggestion of development is taken up in the context of a discussion of dogs, and begins:

It has been conjectured that the Creator produced only the germs of existing beings, and that these have been conformed by surrounding influences, so as to produce the result we see before us. The development of these germs, it is said, is proportioned to the more or less favourable state of these influences, and animals of the most simple organization, as the Polypes, are in fact nearer the immediate work of the Creator than those less imperfect, as Man and the Mammalia.²⁰

This suggestion is called back on the same page, however, with the assertion that “the tendency to variety seems almost exclusively confined to the more perfect

animals, or at least is observed to prevail less as we descend in the scale of organization.” The third notion derives from that of descent. The text argues from the existence of “intermediate genera” to the conclusion that “all the varieties of animated nature before us are not the result of distinct acts of original creation, but are, in fact, from time to time, springing up before our eyes.”²¹

In volume 3 considerable interest is expressed in the subject of the fecundity of some species. There is a reference to the “mathematical ratio of ordinary increase” that has a Malthusian ring, though Malthus’s name is not mentioned.²² In its treatment of the horse and the camel the text also states the sharply anti-transmutationist opinion that “these species have never yet been converted into each other. . . . This fact is sufficient to overturn the system of some naturalists, that the diversity of species is owing to accidental causes, and that nature did not originally establish a separate type for each.”²³ In sum, Griffith’s edition of Cuvier provided a rich pool of ideas that were present to Darwin as he scouted the text for examples relating to the geographical distribution of species, the subject that employed him on folio 10 of his essay.

If Caldecleugh, Miers, and Griffith’s edition of Cuvier are the sum of Darwin’s sources in the original draft of his essay, there were a larger number he would cite in his later additions. Among these the name of one author stands out: Charles Lyell. It is commonly held that Darwin’s most serious intellectual engagement during his early career was with Lyell’s *Principles of Geology*. Darwin’s remarks in his annotations to “Reflection” support this view. He cited Lyell on a technical point regarding shells and gypsum. (fol. 9^v, note 39) He planned to compare his own findings on Patagonian elevatory movements with a map on the European situation found in volume 2 of the *Principles*. (fol. 9^v, note 40) He also challenged Lyell, first regarding the location of Tertiary deposits (fol. 10^v, note 42) and second on what seemed to Darwin Lyell’s methodical presumption. Darwin wrote:

Age of Pat: bed <with respect to Europe> can only be ascertained by relative proportion of recent shells.— This rests on the supposition, that species become extinct in same ratios over the whole world. (fol. 10^v)

Darwin was taking aim at Lyell’s uniformitarianism. Nonetheless, despite his criticism of various points, Darwin was working within a Lyellian context. The following is a citation from Lyell’s third volume of the *Principles of Geology*, which Darwin read after returning from the Santa Cruz expedition. It suggests the geological orientation of Lyell’s setting of the species question that is so apparent in Darwin’s “Reflection.” The passage from Lyell reads:

We endeavoured to show, in the last volume, that the hypothesis of the gradual extinction of certain animals and plants, and the successive introduction of new species, was quite consistent with all that is known of the existing economy of the animate world; and if it be found the only hypothesis which is reconcilable with

geological phenomena, we shall have strong grounds for conceiving that such is the order of nature.²⁴

EDITORIAL POLICY AND PHYSICAL DESCRIPTION OF THE DOCUMENT

The essay is written on five large sheets of paper (438 mm × 314 mm). (The last dimension varies because the edges of the paper are feathered.) Each sheet has been folded in half, providing ten rectos and ten versos. The paper is cream-colored, chain-lined, and bears an incomplete watermark. The primary run of text on the ten rectos is written in brown ink, though some later additions are in pencil. Material on the versos is written in brown ink and in pencil. The first four sheets, folios 1–8 in Darwin's numbering, are presently stored in folios 49–52 of volume 42 of the Darwin papers at Cambridge University Library. The fifth sheet, folios 9–10 in Darwin's numbering, is stored in folio 73 of the same volume of Darwin papers.

In transcribing Darwin's text an attempt has been made to indicate the order of composition. The logical flow of the relatively brief text suggests that it was written out in a circumscribed period or periods of time, possibly over the course of a few days, or even a single day. This text appears on the ten rectos and in the alphabetically keyed footnotes on the versos. This material is represented by regular faced type. Deleted material is shown within single angled brackets. Inserted remarks that appear to have been contemporary with the surrounding text are indicated by double-angled brackets. Examples of insertions appear at the head of the first folio. From the physical appearance of the first folio it would seem that Darwin first wrote "(1)" and then "The Tosca. . . ." He then changed the beginning of the first sentence to "We have seen" so that the sentence now reads "<We have seen> The Tosca." He also squeezed in a title for the essay above his original first line, and this has also been treated as an insertion. One could argue that this title line was a later addition, written after an interval of time had elapsed following the original composition of the essay. However, just as easily the title line might have been written as Darwin was finishing up his original draft. Either way, the case would be difficult to prove and, rather than draw a distinction where none might be warranted, the line has been represented as an insertion rather than an addition.

Also problematic is the text on the versos of the document that is not part of alphabetically lettered notes. Since Darwin's practice while writing the essay seems to have been to key in notes alphabetically, it would seem a proper inference that all other notes on the versos, not so alphabetically lettered, should be taken as later additions. These later additions have been indicated by bold-faced type in the transcription. The advantage of this method of representing the text is that it lifts out Darwin's original draft from later work. However, it should be borne in mind by the reader that entries in bold-faced type are a heterogeneous group with regard to date. Some seem from their

content and physical appearance to have been written soon after the original draft of the essay; others date from much later. Among the bold-faced entries are some written in ink and some in pencil. The original draft of the manuscript was written in ink, as were all entries signified as insertions.

In transcribing Darwin's text his spelling has been followed. British spelling was then in flux. For example, the move from "z" to "s" in such words as "characterize/characterise" was not yet complete. This is clear from the Spanish-English dictionary that Darwin had with him aboard the *Beagle*.²⁵ Thus at points Darwin's spelling may seem more in keeping with present-day American practice, which remained with early Victorian conventions in orthography, than with present-day British practice. On another point, in transcribing Darwin's text the vertical scorings that mark all but two passages of text have been omitted. Darwin scored passages to signal to himself that he had no further use of the material. The two passages not so marked include the sentence written sideways on the page on fol. 2^v and the first paragraph on the top of fol. 10^v. Darwin's horizontal lines indicating paragraphs have been retained. As a matter of convention his line breaks have been standardized into short, medium, and long.

Symbols Used in the Transcription of the Text

< >	Darwin's deletion
<< >>	Darwin's insertion
bold type	Darwin's later annotation
[]	editorial remark

DARWIN'S TEXT

(1) <V. Caldcleugh. Geological Map.²⁶ Reflection on reading my Geological notes:

>>
<<We have seen>> The Tosca formation²⁷ commences near the R. Colorado from conversations with individuals. It is said to <think it> extends to <many> <some> many miles north of Assumption in Paraguay, which gives about⁽¹⁾ 1100 miles in a N. & S. line.— I should not be surprised if it extended much further northward; keeping a mean distance from the Cordilleras, & being bounded to the East by the mountains of Brazil.— Miers Chili states that near S. Luis there is a ridge, with gypsum & I see in chart "los Gigantes". To the Westward there appears to be the Traversia.—²⁸The Banda oriental. Tosca. I think certainly is of same age with the great plains.— <Assuming this> We have then the greatest breadth of about 700 miles. This <great> <immense> formation is probably bounded on the S. S.W. W NW by the sandstone plains or Traversia.— (to the N. we know not its limit) to the NE. by the Mountains of Brazil. (Perhaps a line from the laguna de los Patos. in a NW line may mark the

separation). to the E & SE.— the ocean.— The sea in which this was formed would <probably be partly [illeg.]> <be a little> sheltered by the ridge of the Andes. & the mountains of Brazil: <the> <its> origin doubtless arises from <the> Volcanic agency of the Cordilleras.— its saline ingredient, <its> gypsum its calcareous nodules & : the uniformity of the red earthy clay (or Tosca) is problematical. I imagine from Miers Chili.²⁹ there are such beds in the very mountains.— These are several points very curious with respect to these beds.— The very general

[verse of folio 1]

a. The actual limits in N & S line of *Megatherium relics* is 550 in E & W.— 300.

Azara

Vol I Azara p 55 All countries east of Parana non-saliferous Salinas in Chaco on coast of Vermejo p. 56 ["p. 56" encircled] Bright coloured clays abundant towards confines of Brazil.³⁰

Starting

[pencilled entry below scored in brown ink]

The Bajado bed would look like marine deposits: eventually covered by the old Plata. Alluvium or rather the site where marine & alluvial deposits alternated.—

(2)

absence of shells.— we see them in an <included> bed included in the Tosca. from <the Tosca> Colonies to Bajada in a N W. line (perhaps which turns more Western to Cordova): This from the <pebbles> <particles> of quartz. <in the Limestone> & pebbles of granite. in the red sandstone we may imagine to have been nearer to the old coast of Brazil mountains.— (The <greater> abundance of Lime here in pure form. may perhaps arise from springs percolating the granitic rocks. which to the North of Maldonado we see contain so much marble?—) Another point is the vast numbers of fossil bones of very large quadrupeds.— Their age with respect to the shells I cannot make up my mind; That the view, which I took, respecting the relation of these shells. with the Patagonians one is correct viz. that they existed a short time subsequently to the more Southern ones being destroyed by the Porphyry pebbles; but that now the greater numbers of these species do not exist; perhaps <destroyed> themselves perishing during the <elevation> deposition of the superior Tosca. <Those sp> It is certain that during & before the existence of these shells Tosca <in its> <truest> features. <precisely resembling> was deposited (surrounding circumstances similar) but that the Tosca which contains in <some> <many> instances fossil bones was posterior to the shells.— I have already stated. that the Tosca (for instance) of the Salado) which contains bones is more closely allied to that inferior to the shells. but its real relation I cannot say.— I think we may be

certain. that <during> <before> the deposition of the superior Tosca (with bones), the bottom of the

[verse of folio 2]

Compare the great extent of some mineralogical beds of Patagonia—with secondary of Europe: Here mineralogical evidence tells in this quarter of the globe (perhaps across the Andes) quite useless when compared to Europe.—

Would depression of Continent by covering up Salina bear comparison with the Salt of Europe.?

[the following written sideways on the page]

The passage of the Tosca to fossiliferous beds, by Tosca rock at Bajada important.—

(3)

sea. had undergone some elevations. I think this from the great denudation of the ferruginous sandstone in B. Oriental.— <There arises a question> Whether these animals existed after the final elevation of the Tosca plains, must remain doubtful; of the fossil remains certainly a small proportion, if any belong to alluvial formations subsequent to the <superior> Tosca. There arises a question. what country supported these numerous & vast animals: in the country. bordering on Brazil (or B. Oriental) it is obvious: but it is more difficult to answer. when we find skeletons, with their bones in groups in such situations as at the R.— Salado.— Where the whole country for 100s of miles belongs to the same formation & <near to where> for same distance there is no higher land.— I can only account for it on the principle of putrid Carcasses floating. <as> mentioned in the grand Seco.— <How vastly numerous must these animals have been for their bones to cover such an area> At. B. Blanca. I suppose the animal (of which I found skeleton nearly entire) must have lived <previous> <near about> to <that late & trifling elevation> modern beds: It as well as the Cavies <M. Hermoso> <might have lived> & Megatherium remains might have lived in the Tosca. rock plains. which I have supposed to be elevated before the deposition of these beds.— But then we have the puzzle how could these most sterile plains support such large animals: The very same puzzle & explanation of occurrence, refers to the bones at Port St. Julian

(4)

In the central Pampas. perfect uniformity in nature of bed (which is not the case at B. Blanca) & very little, but regular height above the sea.— cannot admit of many separate elevations, for upon the former of which animals resided.—

I may add with respect to absence of shells. as a conjecture, that where gypsum is dissolved in water shells do not flourish. at Port Desire, St. Julian & St Jose

above highly conchiferous strata. there was Gypsum but no shells. (excepting one vestige of a Univalve). (The Bajada. appears an exception. but I am not sure in which bed the Gypsum occurred. for what I <chiefly> saw (& was told) was at bottom of the cliff.— V English Geology. & Paris

With respect to the R. Negro. my views, I think are correct. I believe it essentially to be the same with the Patagonian Oyster bed.— Sand in this case (as it seems in so many formations) preventing the <cha> calcareous deposits being converted into organized shells.— The shells on the surface at Port St. Antonio. where in all probability the Sandstone extends. proves what I think. there can be no doubt. of that the sandstone was beneath the ocean & arose from it at same period with the Patagonian beds.—

(5)

The great oyster bed extends from 20 (or more) miles North of St. Joseph to [] in distance [] miles.— Some difference in the organic remains must be expected where we have so many degrees of Latitude.— The leading features are the same. the Ostreae. & Pectens. & the Turitellae at Lax Bay & St. Julian.— It is remarkable to see⁶⁷ the great similarity of the beds at the extreme points; the conchiferous bed. <covered by> the aluminous beds. with gypsum. are universal & then again by Gravel.— We must attribute this to some change taking place in the Cordilleras some period of activity commencing: these superior beds. although evidently not favourable to life. yet permitted some few alternations of the shells. as seen at P. St. Julian.— But the great change. was effected at the pouring forth of the Porphyry pebbles.— I have never seen the Parent rock: the stream from the Southern parts. must (I think) have come from the NW. because. the Andes in these Parallels I believe to resemble Tierra del Fuego.— That they came in a <body> short period I think probable from their not being encrusted by stony small corallines.— (Which I always have noticed to be the case in these seas) They must have been already rounded at their source.— Were they lying in masses on the West foot beach of the Cordilleras & during

[verso of folio 5]

(Z) From the little I know about recent shells. I have not grounds enough to go on; but I have found one shell alive in Tierra del Fuego which is found in these beds <perhaps some of the Pectens>.— Again I do not believe the great Oysters are now alive; <[illegible]> so remarkable a shell could not escape observation.

(6)

an early & vigorous elevation. carried by the retreating waters to a deeper sea?—Whatever their origin. they

mark a great change in the inhabitants of the ocean: during a succession of elevations. such shells as now exist—flourished on the successive lines of beach & were scattered over the bottom.—

Gravel [word appears on fol. 5^v]

This gravel bed. <⁶⁸> shows signs of force. filling up inequalities probably of its own making. its extent is very great from N. of the Colorado to a distance of miles: On the coast of Tierra del Fuego. (C Tres) there were many such Porphyry pebbles & even some small ones off Staten Land. which I believe to owe their origin to this bed.— though perhaps washed by currents to these distant points.—

Looking at this whole part of Eastern side of S America. we must consider it as one grand formation.— In the Northern parts it seems to repose on the Crystalline rocks. some of which in their lines of cleavages & elevation. & mineralogical nature are allied to the Transition formations of Falkland Is⁶⁴. & Tierra del Fuego.— at Port. Desire & Northern Parts of St. Georges <Gulf> <Bay>. there is much Porphyry.⁶⁰ which from its mineralogical nature & included Conglomerates. I imagine to be secondary.—

[verso of folio 6]

(X): This gravel in its Northern limits seems to mingle with another set of phenomena.— the formation of the great Tosca rock formations; it. &c <fills> follows the inequalities in Salinas in R. Negro Sandstone

(M). Secondary (?). the Quartz at C. Blanco & N. of St. George. is most probably closely allied to Porphyries if so all Transition: N.B. Conglomerates at C. Remarkable in T. del F

It may be doubted whether Porphyry of P Desire has any immediate connexion with the Andes? V. those of Maldonado & still more of P. Alegre

V. Caldcleugh. for limits of Tosca¹¹
Volcanic rocks (concealed) in M. Video. R. Negro Mem. supposed do. R. Grande M^r Fox³²

(7)

But with this exception the hiatus (as compared to Europe) between the Crystalline & Tertiary beds: (Videlicet. B Oriental) is very remarkable.— We shall presently <mention the illeg.> run over the proofs of repeated elevations:

May we conjecture that these <have long been going [illegible], that for some.> began with greater⁶⁹ strides, that rocks from sea to deep for life (. <or if any> were rapidly elevated & that immediately when within a proper depth. life commenced. <(Port Desire rocks before this period>). & its signs are now present in the great oysters &c &c The elevations rapidly continued; land was produced. on which great quadrupeds lived: the former inhabitants of the sea perished (perhaps an effect of th<is>ese changes) <& were scattered on

the surface on the new beaches > the present ones appeared.— The present quadrupeds roamed about <the increased surface> <<on the new plains>>; fresh elevations destroyed, the continuity of this plain <s> & elevated (<V. Tierra del Fuego. I anticipate for the sake of connexion>) beds containing leaves of the present trees & inhabitants of the present deep: And such beds are doubtless now forming beneath the ocean. ready when <comm> compelled to give their evidence in the open day-light.—

[verso of folio 7]

⁶³ Perhaps the first opening of the N & S. crack in the crust of the globe, forming the Cordilleras

(8)

The study of this Geology is very instructive from the consideration of the greatness in extent, & perfect <to> horizontally, <of the> & number of the Elevations: We have nothing here like anticlinal tilting on each side the strata into highly inclined position: it rather a swelling of the Globe, on the largest & most regular manner. for an extent of latitude equal <perhaps> to 2000 miles, or even more. (& certainly <from> to the extent of 1000 miles <but is narrow in proportion &>, & that in this latter (& without doubt for all) within a period in which a. <2 species> *Muscles* & a *Balanus* has retained. exposed to the atmosphere <its> <their proper> colors:—The Andes have been supposed to be a <longitudinal> crack. would not this probably occur during an elevation of such <an> a longitud-e-inial enlargement.—

But after this crack was opened, the matter which came <out>. <from the newly formed mountains> was formed into beds & <gain & again.> elevated: V X [letters appear on fol. 7*]

It becomes a problem, how much the Andes owes its height, to Volcanic matter pouring out?— how much to horizontal strata tilted up.? how much to these horizontal elevations of the surface of continents?— Another problem is how long will shells exposed, as I have stated <will> retain <ed> their color?—(V other side of Page)

V. According to this crack from stretching, the beds ought not to be tilted up excepting on the edges, when near the flowing matter which would be produced by explosion of central metal & oxygen //: If otherwise plains would increase rapidly in height as approaching the Cordilleras:

[verso of folio 8]

(Z). There is one fact which appears to me preeminently curious the <entire> absence of all Quartz pebbles, on the Tosca rock plains surrounding lofty, but broken ridges of the Ventana.— It proves the extreme quietness with which these plains have been elevated, & shortly after their hardening.— **Any few shells or gravel**

would be washed away with retreating water The degree of force (& perhaps number) of elevations has differed in different parts of the coast. the sea-like low Pampas.— & the <plains> pieces of table land of different altitudes in St <Georges> Gulf. some reaching to 1500. feet.— at St Julian to 900.. yet all to the eye most truly horizontal.—

It may be remarked, that the increased elevation above the sea in these Southern Plains may partly be explained being near seat of violence (??) <&> <not>. at Mendoza & San Luis plains are said to be 3000. ft Miers Chili.³³

When the Sierra Ventana plain was elevated any small pebbles &c lying on the surface would be carried away by the retreating waters

Dessalines, D'Orbigny has given account of Pampas: Where?³⁴ Caldclough, has geological map of Pampas in Travels.—³⁵M. Bonpland. do—³⁶

(9)

It is impossible not to be struck with the vast scale on which geological facts take place in S. America—Granitic <rocks> from the Orinoco to the Plate—(45° degrees of Latitude.—) with <nearly the same> cleavage not widely different.— Within this we have the 1<0>100 [1100] miles of Tosca, then [] of the great oyster formation, covered by the [] of Porphyry gravel: With the exception of the Granite, this vastness (is in comparison to other countries) more apparent than real.— In Europe. We have the chalk from Ireland to Poland &c &c.— The real difference, consists perhaps, in what I have alluded to, a greater rapidity in the elevation. In Europe, they were slow; formation after formation paved the bottom of the ocean: <the> <each> raised land was has been exposed to a greater length of alluvial action, & to the denuding effects of coasts.— Moreover, many lines of elevation have crossed it—breaking & confusing the strata.— In this country all its regular & simple.— As Patagonia has risen from the waters in so late a period, it may be interesting to consider whence came its organized being.— I have conjectured the absence

[verso of folio 9]

Is not the Entomology similar to Northern Traversia. V Ann. des. Science?³⁷

Botany with Cordilleras & do.

Shells of rivers: S. Cruz. Negro. Sauce

Any Plants <of/> productions of whole Patagonia remarkably similar

Porph. pebbles. Falkland. Sound.— & <between> <off> Staten Land:— <Pebbles owe their origin N. of S. Cruz. judging from numerous boulders in S. Cruz & Tierra del Fuego.>—

at S. Cruz. I have a Cat.— *Capt King procured other <sort> from the Indians*³⁸

Strata without shells owing to Gypsum??? Yet at S Cruz. in close proximity.— ossiferous gypsum at Paris no shells: In Sicily Blue clay with do without shells Lyell. Vol. III. P. 64.— Crystals of selenite & some shells base of Etna. P 77.³⁹

Compare the certain & recent Elevations of Patagonia with M^r. Lyell map. of under water parts of Europe.— <for extent & size.>—⁴⁰

The gravel over R. Negro <plain> is one of the re-depositions after some elevations: therefore much posterior to Shingle bed & gr oyster: formation.— Tosca plain coeval with it.— Yet St. Fe limestone with similar shells.— shows perhaps. a quick succession of events & earlier death of same shells in Southern parts of hemisphere.—

I cannot quite see. how the Mastodon lived on Patagonian Plains?—(is it Mastodon?—

(10)

of trees in the fertile Pampas & rich valleys of B. Oriental. to be owing to no Creation having taken place subsequently to the formation of the superior Tosca bed: with respect to the Plants. I know nothing.— The <Insects are few probably> larger animals being of easier knowledge. best deserve observation.— We will consider only those animals South of the Plata.— (∴ less immediate communication with Brazil) It appears they <nearly> all are <more> characterized by a large Geographical range.— & therefore may easily have travelled from their Northern original homes.— For instance the Mephitis or Skunk The Canis jubatus (found at the R. Negro) <otter> & common Fox (tricolor?). Jaguar. Puma. Gato pajero. found at B. Blanca & B. Oriental (there are other Cats. but I do not know them) even to St^r of Magellan.— <Rats> Mice my knowledge is not sufficiently accurate. about.— Nutria.— Toco Toco (& that sort with line on incisors). Cavia Cobaya.— (that is if the R. Negro & St of Ma-

gellan species are same with B. Ayres. & Paraguay.). Biscatche. Chili. & Brazil. <Molina> (Azara) the Dasytus. hybridus villosus. uncinctus).— Pecari. (found at R. Negro) Guanaco.— Cervus Campestris.— The only two good exceptions. which I could not find out, or see in books to occur further N. than 37°. 30'. is the Cavia Patagon[ica]—& Dasytus pichiy: (Azara says Latitude between (35°-36°).—⁴¹

[verso of folio 10]

The double Arg: Calc: white bed is seen single. at San José. — ; Non-occurrence of Shells owing to Gypsum?— state cases

Uniformity & extent of Porph. gravel bed is so modern formation.#—

Tertiary formation of Patagonia not in Basin as supposed by Lyell to be generally the case but Attached to the Andes⁴²

In Bengal. (*Mouth of Ganges*). red clay. with Calc. Concretion (Kun <c> kaer?)⁴³ (Mastodons bones?)— Mem: La. Plata!.— in connection with present few banks & necessarily small epoch since the shells.— <Andes line. South Part).Brazil. gneiss red Clay:—>

Age of Pat: bed. <with respect to Europe> can only be as-certaind by relative proportion of recent shells.— This rests on the supposition. that species become extinct in same ratios over the whole world⁴⁴ Now. the Porph bed <seems> or rather the Arg beds seems to have destroyed them suddenly: though in the South allowing partial re-appearances: if not destroyed highly injurious. such a cause <would> acting for such an extent must produce great & sudden alterations.—

Mem: Report of Geolog: Paraguay Sandstone is said to be a Tertiary Molasse(?) (Nature? & Authority?)⁴⁵ if so. continuation R. Negro.— Mendoza beds:—

Where the Salinas. grandes are. West of Ventana. does not Falkner there are Spiny bushes? if so. Sandstone.—

There is a probability from. Mastodons bones. in the low cliff, which I think must have been under water. when the three hundred was above that the Mastodon has lived within a period. in which shells. have not lost their color

B.Blanca.— Animal & (Megatherium?) prove same thing

NOTES

- Darwin's specimen books from the voyage are stored at Down House, his former home and now a museum in his honor in Kent. The major repository of his manuscripts is held by Cambridge University Library. See the *Handlist of Darwin Papers at the University Library Cambridge* (Cambridge: Cambridge University Press, 1960). Zoological notes from the voyage are stored in volumes 30 and 31 (DAR 30 and DAR 31); geological notes in DAR 32-38. Some specimen lists are also in DAR 29. Also pertinent to the discussion is Sandra Herbert, "Charles Darwin as a Prospective Geological Author," *British Journal for the History of Science*, 1991, 24:159-192.
- The essay is stored in DAR 42:49-52 + 73, Darwin Archive, Cambridge University Library.
- Charles Darwin, *Geological Observations on South America. Being the Third Part of the Geology of the Voyage of the "Beagle," under the Command of Capt. FitzRoy, R.N. during the years 1832 to 1836* (London, 1846).
- For the "Table of Location of Exposed Pages" from Darwin's notebooks see Paul H. Barrett, Peter J. Gautrey, Sandra Herbert, David Kohn, and Sydney Smith, *Charles Darwin's Notebooks, 1836-1844: Geology, Transmutation of Species, Metaphysical Enquiries*, (London and Ithaca, New York: British Museum (Natural History) and Cornell University Press, 1987), pp. 643-652. The "Feb 1835" note has been published by M. J. S. Hodge in "Darwin and the Laws of the Animate Part of the Terrestrial System (1835-1837): On the Lyellian Origins of His Zoonomical Explanatory Program," *Studies in History of Biology*, 1983, 6: 1-106, on pp. 19-20.
- Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (London, 1859). Geology does not form part of the core of the theory as presented in the first four chapters of the book but enters the argument in chapter 9 entitled "On the Imperfection of the Geological Record" and in chapter 10 entitled "On the Geological Succession of Organic Beings." The abstract diagram illustrating Darwin's conception of the descent of species faces p. 117.
- The animal was later named the *Scelidothierium leptoccephalum* by Richard Owen, "in allusion to the disproportionate size of the thigh-bone," in Charles Darwin, *The Zoology of the Voyage of H.M.S. "Beagle" under the Command of Captain FitzRoy, R.N. during the Years 1832-1836*, 5 pts., (London, 1839-1843). Hereafter *Zoology*. Part I, *Fossil Mammalia*, by Richard Owen with a Geological Introduction by C. Darwin, (London: 1838 [sic]-1840), p. 73.
- Robert FitzRoy, *Narrative of the Surveying Voyages of His Majesty's Ships Adventure and Beagle*, 3 vols. + appendix, (London, 1839), Vol. 3 by Charles Darwin, *Journal and Remarks: Journal of Researches into the Geology and Natural History of the Various Countries Visited by H.M.S. Beagle . . . from 1832 to 1836*, pp. 98-104. P. 98: "That large animals require a luxuriant vegetation, has been a general assumption, which has passed from one work to another. I do not hesitate, however, to say that it is completely false; and that it has vitiated the reasoning of geologists, on some points of great interest in the ancient history of the world." The map of the "Southern Portion of South America" that appears with this text was published in fold-out format as the last map in volume 3 of the *Narrative*. See Figures 2 and 3 for photographic reproductions of this map.
- Darwin, *Journal and Remarks*, p. 53, "... we are therefore driven to the conclusion that herbaceous plants, instead of trees, were created to occupy that wide area, which within a period not very remote, has been raised above the waters of the sea."
- Georges Cuvier, *The Animal Kingdom Arranged in Conformity with Its Organization . . . with Additional Descriptions of All the Species Hitherto Named, and of Many Not before Noticed*. By Edward Griffith and others. 16 vols., (Edinburgh, 1827-1835).
- This listing is taken from Frederick Burkhardt and Sydney Smith, eds., *The Correspondence of Charles Darwin*, 9+ vols., Vol. 1 (Cambridge: Cambridge University Press, 1985), p. 541. Bracketed material is the contribution of the editors. Hereafter *Correspondence*.
- On the content and dating of Darwin's essay "Elevation of Patagonia" see Herbert, "Charles Darwin as a Geological Author," pp. 174-175.
- Correspondence* 1:370-371, 398-399. The two works are the report of the second meeting of the British Association (see note 43) and, in all probability, the third volume of Charles Lyell's *Principles of Geology, Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes now in Operation*, 3 vols. (London, 1830-1833).
- DAR 31.1:260', Darwin Archive, Cambridge University Library.
- DAR 34.2:110'. Darwin Archive, Cambridge University Library.
- The "Feb 1835" note is published in Hodge, "Darwin and the Laws of the Animate Part of the Terrestrial System," pp. 19-20; Darwin's notes on apple trees appear in DAR 31.1:266-267, Darwin Archive, Cambridge University Library.
- Michael G. Mulhall, *The English in South America* (Buenos Aires and London: 1878), p. 459; Bernard Naylor, *Accounts of Nineteenth-Century South America: An Annotated Checklist of Works by British and United States Observers* (London: Athlone Press, 1969), p. 4.
- Mulhall, *The English in South America*, pp. 446-447; Naylor, *Accounts of Nineteenth-Century South America*, p. 6.
- Correspondence* 1:446.
- Cuvier, *Animal Kingdom* 2:264.
- Cuvier, *Animal Kingdom* 2:320.
- Cuvier, *Animal Kingdom* 2:444.
- Cuvier, *Animal Kingdom* 3:111.
- Cuvier, *Animal Kingdom* 3:438.
- Lyell, *Principles* 3:30-31.
- Correspondence* 1:564 suggests that the dictionary in use on ship was probably: M. Scoane, ed., *Neuman and Baret's Dictionary of the Spanish and English Languages*, 2 vols. (London, 1831). (The Darwin Archive has volume 2 only.)
- Alexander Caldcleugh, *Travels in South America, during the Years 1819 . . . 21*, 2 vols, Vol. 2 (London, 1825): foldout insert, "Map of the Country between Buenos Ayres and the Pacific Ocean, with a Specification of the different Geological Formations." The five categories of geological formations listed in the legend and colored on the map include "Primitive" [pink], "a very new Stalactiferous Limestone" [yellow], "Red Marl" [green], "Pebbles & Sand" [salmon], and "Clay" [blue].
- "Tosca" was the local name for a formation characteristic of the Pampas. Darwin noted its existence throughout his travel. He described its appearance at Buenos Aires in DAR 32:75, Darwin Archive, Cambridge University Library. "The Tosca, as at B. Blanca, contains <horizontal> layers of concretionary nodules of white indurated marl; . . ." Also see Darwin, *Geological Observations*, p. 77, "For convenience sake, I will call the marly rock by the name given to it by the inhabitants, namely, Tosca-rock; and the reddish argillaceous earth, Pampean mud. . . The plain on which Buenos Ayres stands is from thirty to forty feet in height. The Pampean mud is here of a rather pale colour, and includes small nearly white nodules, and other irregular strata of an unusually arenaceous variety of tosca-rock."
- John Miers, *Travels in Chile and La Plata*, 2 vols., (London,

- 1826). As a frontispiece to vol. 1 there is placed a "Map of the Country between the Rio de la Plata and the Pacific Ocean between the Parallels of 29°45' and 36° South Latitude by John Miers 1825." In the Provincia de San Luis there is a ridge "El Alto del Yeso" (literally, high ground of gypsum) that the text on p. 250 describes as "a little gypsaceous range which lies to the westward of San Luis." This range is also labelled on the map "Los Gigantes"—the giants, presumably referring to gigantic fossil bones. An area to the southwest of the range is designated on the map as "Travesia or Level Sandy Desert thinly covered with low Thorny Trees and Bushes."
29. Miers, *Travels*, Vol. 1, p. 195, "... the Tosca, which extends in a stratum of variable but considerable thickness throughout the province of Buenos Ayres."
30. Félix de Azara, *Voyages dans l'Amérique méridionale... depuis 1781 jusqu'en 1801*, 4 vols. & atlas, Vol. 1, (Paris, 1809), p. 55 refers to the area east of the Paraná River as "les pays privés de sel." Also pp. 55-56, "... dans tout le Chaco ou dans la partie située à l'ouest des rivières du Paraguay et du Paraná, et depuis la rivière de la Plata vers le sud. Dans tout ce pays, il n'y a ni ruisseau, ni lac, ni puits, qui ne soit saumâtre, en été ou quand les pluies sont rares; car la pluie diminue nécessairement leur salure. Les rivières mêmes, telles que le Pilcomayo et le Vermejo se ressentent de cette salure, quand elles sont très-basses, ..." On the bright color of clays towards Brazil, p. 51, "On rencontre en général des argiles de couleur vive, en beaucoup d'endroits; mais elles paraissent être plus abondantes vers la frontière du Brésil, et je doute qu'il y en ait au Chaco."
31. Caldcleugh, *Travels*, vol. 1, p. 145: "The upper soil round Buenos Ayres is chiefly of a light nature, approaching to marl, and covering a stiff clay subsoil, called by the inhabitants, tosa. As far as my observations went, this appearance did not extend many miles from the city."
32. The British diplomat Henry Stevens Fox (1791-1846), stationed in Buenos Aires (1831-1832) and Rio de Janeiro (1833-1836), corresponded on geological topics and exchanged geological specimens with Darwin during the *Beagle* voyage. In his letter to Darwin of 31 October 1833, Fox described the presence of greenstone on the island of Flores off Montevideo and of volcanic porphyry at Porto Alegre, where the "main fundamental rock of that Country is granite." *Correspondence*, 1:347. Fox suggested the province of Rio Grande in southern Brazil as of interest to geologists (p. 348), and Darwin apparently did ask for more details (p. 403), though Fox's reply, if he made one, has not been located. Greenstone is "a variety of trap [a volcanic rock], composed of hornblende and felspar." Lyell, *Principles*, 3:Glossary.
33. Miers, *Travels*, 1:223. "The town of Mendoza is situated at an elevation of 2600 feet above the level of the sea, upon the margin of a great traversa... which here presents a very gentle declivity, sloping both northward and eastward." Pp. 233-234. "It will be seen, on inspecting the map, that from Buenos Ayres, following the course of the Parana, as far as the Esquina, thence to San Luis, and thence to Mendoza, in a westerly direction, there extends a long way to the southward a vast extent of level country, void of trees, producing only coarse grass—a country distinguished by the name of Pampas: it is scarcely ever interrupted by perceptible undulations, and is covered with numerous lakes, drained underground through the sandy soil from one to another; the waters of which, proceeding from several rivers, are lost and absorbed in the level of these sandy plains."
34. Alcide Charles Victor Dessalines d'Orbigny, *Voyages dans l'Amérique... pendant les années 1826-1833*, 7 vols. + atlas in 2 vols., (Paris, 1835-1847). From the tentative tone of Darwin's question it would seem likely that he was referring to the earliest published section of d'Orbigny's voyage, the first part of the historical narrative. For d'Orbigny's comments on the Pampas see vol. 1, pp. 77, 469, 471, 558. P. 77 provides a definition of the Pampas, "Le rivière de San-Juan sert, pour ainsi dire, de limite entre les terrains primitifs de la province de la Banda orientale, et le commencement de argile calcaire durcie, qui forme tout le fond du bassin proprement dit des Pampas..." D'Orbigny's full treatment of the Pampas appeared in volume 3, part 3, devoted to geology, published in 1842. In his own later writing Darwin would range himself against d'Orbigny's interpretation of the origin of the Pampas. Thus Darwin, *Geological Observations*, pp. 98-99, "Three theories on the origin of the Pampean formation have been propounded.—First that of a great debacle by M. d'Orbigny;... A second theory, first suggested, I believe, by Sir W. Parish, is that the Pampean formation was thrown down on low and marshy plains by the rivers of this country before they assumed their present courses.... The third theory, of the truth of which I can not entertain the smallest doubt, is that the Pampean formation was slowly accumulated at the mouth of the former estuary of the Plata and in the sea adjoining it." Also see *Correspondence*, 1:463, n. 4.
35. Caldcleugh, *Travels*, as cited in note 26.
36. No geological map of the Pampas by the team of Aimé Bonpland and Alexander von Humboldt has been identified. For a map of the Andes that indicates the location of the Pampas see "Esquisse Hypsométrique des Noeuds de Montagnes et des Ramifications de la Cordillère des Andes... 1827-1831" in Alexander von Humboldt, *Atlas Géographique et Physique des Régions Équinoxiales du Nouveau Continent* (Paris, 1814-1834), p. 5. Darwin, *Geological Observations*, p. 94, in the chapter on the Pampean formation, contains the information that "Still farther north, near S. Anna, where the Parana makes a remarkable bend, M. Bonpland found some singular amygdaloidal rocks, which perhaps may belong to this same epoch." Darwin cited d'Orbigny, *Voyage*, vol. 3, pt. 3 [1842], p. 29 on this point.
37. Jean Théodore Lacordaire, "Mémoire sur les habitudes des coléoptères de l'Amérique méridionale," *Annales des Sciences Naturelles*, 1830, 20:185-291; 1830, 21:149-194. Vol. 20, p. 216 emphasizes that the physical barrier of the Andes divides the South American continent into two geographical districts with regard to the distribution of insects, "... en Amérique, où la nature a travaillé sur un plan gigantesque, les Andes servent de séparation à deux régions presque entièrement différentes sous tous les rapports, et l'Orénoque, la rivière des Amazones et la Plata forment des espèces de mers dont chaque rivère présente des différences spécifiques sensibles avec l'autre, tout en conservant une physionomie pareille." This passage appears on p. 33 of a separately paginated reprint in the Darwin Archive at Cambridge University Library. The reprint was probably given to Darwin by Frederick William Hope before the voyage. See *Correspondence* 1:349-350.
38. The cat would appear to be the specimen Darwin numbered as 2036 and which he described in DAR 29.1:17 as "Cat. — in a bushy valley: when encountered, did not run away but hissed.—S. Cruz [added in pencil: Patagonia]." Darwin Archive, Cambridge University Library. The cat was fully described in the zoology from the voyage where it was identified by G. R. Waterhouse as *Felis pajeros*, the Pampas cat. See Darwin, *Zoology*, pt. 2 [1839] *Mammalia* by G. R. Waterhouse with a notice of their habits and ranges by C. Darwin, pp. 18-19 + plate. Hereafter *Mammalia*. The cat procured by Capt. P. P. King on the *Beagle*'s surveying voyage of 1826-1830 is also described as *Felis pajeros* in the published version of the voyage. See FitzRoy, *Narrative*, Vol. 1, *Proceedings of the First Expedition, 1826-1830*, by P. P. King, pp. 116-117, 530. (Manuscripts from the first voyage were available to Darwin on the *Beagle*'s second

- voyage. See *Correspondence* 1:561.) There had been some uncertainty over the physical appearance of the Pampas cat. See Cuvier, *Animal Kingdom* 2:486–487 + plates.
39. Lyell, *Principles* 3:63–64 contains a description of the formations of Val di Noto, “a district which intervenes between Etna and the southern promontory of Sicily.” The lowest formation in the district is said to comprise “Blue clay and gypsum, &c. without shells.” (See diagram, p. 64) Pp. 76–77 suggest a connection between the formations of Val di Noto with those lying beneath the volcano of Etna. (Diagram, p. 76) Of the strata at the southern base of Etna Lyell commented (p. 77), “Crystals of selenite are dispersed through the clay, accompanied by a few shells, almost entirely of recent Mediterranean species.”
40. Lyell, *Principles*, vol. 2, the map facing p. 304 described as “Shewing the extent of Surface in Europe which has been covered by Water since the Deposition of the older Tertiary Strata. (Strata of the Paris and London Basins, &c.)”
41. In compiling the above list of animals Darwin stated that he was relying on his own knowledge—what he could “find out”—and on “books.” The following is Darwin’s list together with suggestive references. Cuvier, *Animal Kingdom*, volume 5, is a synopsis of mammalian species, usually including mention of geographical ranges, and hence seems to have been particularly useful to Darwin in this survey.
- | | |
|------------------------------|--|
| Mephitis or Skunk | <i>Animal Kingdom</i> 5:126–127. |
| Canis jubatus
((otter)) | <i>Animal Kingdom</i> 5:144–145. [Red Wolf]
<i>Animal Kingdom</i> 5:130. |
| common Fox
(tricolor?) | <i>Animal Kingdom</i> 2:44, 367; 5:148. |
| Jaguar | <i>Animal Kingdom</i> 2:452–459; 5:164. |
| Puma | <i>Animal Kingdom</i> 2:436–440; 5:163. |
| Gato pajero | See note 38. Also <i>Animal Kingdom</i> 2:
486–487; 5:170. |
| (Rats) Mice | <i>Mammalia</i> , pp. 33–78. <i>Correspondence</i>
1:351. |
| Nutria | Miers, <i>Travels</i> 1:217. |
| Toco Toco | Darwin, <i>Journal and Remarks</i> , pp. 58–
60; <i>Mammalia</i> , pp. 79–82; Azara,
<i>Voyages</i> 1:324–326. |
| Cavis Cobaya | <i>Animal Kingdom</i> 3:93, 234–237; 5:270–
271; <i>Mammalia</i> 2:89 [Guinea Pig]. |
| Biscatche [Viscaché] | <i>Animal Kingdom</i> 5:272–273; 3:230–232.
On p. 230 Azara is cited as an authority. Also see Caldecleugh <i>Travels</i>
1:152. |
| Dasytus hybridus
villosus | <i>Animal Kingdom</i> 5:276–277.
<i>Animal Kingdom</i> 5:278–279. |
| unicinctus | <i>Animal Kingdom</i> 5:277–278. (Under
<i>Dasytus Tatouay</i> , the Twelve-banded
Armadillo.) |
| Pecari | <i>Animal Kingdom</i> 3:333–334; 5:289–290. |
| Guanaco | <i>Animal Kingdom</i> 4:5–6; 5:299–300. |
| Cervus Campestris | <i>Animal Kingdom</i> 5:317 [Guazuti Deer]. |
| Cavia Patagonica?] | <i>Animal Kingdom</i> 5:272, “Inhabits Patagonia.” Also, 3:243–247 + plate;
<i>Mammalia</i> , pp. 89–91 [Patagonian
Cavy]. |
| Dasytus pichiy | <i>Animal Kingdom</i> 3:292–294. P. 292,
“These Armadillos are not found in
Paraguay, or north of the River Plate,
and only in the open country. D’-
Azara, in one excursion between
thirty-five and thirty-six degrees of
south latitude, found them by [the]
thousands” |
42. Lyell, *Principles*, 3:23. Chapter 3 under the heading “Different circumstances under which the secondary and tertiary formations may have originated” contains the sentence, “It is evident that large parts of Europe were simultaneously submerged beneath the sea when different portions of the secondary series were formed, because we find homogeneous mineral masses, including the remains of marine animals, referrible to the secondary period, extending over great areas, whereas the detached and isolated position of tertiary groups, in basin or depressions bounded by secondary and primary rocks, favours the hypothesis of a sea interrupted by extensive tracts of dry land.”
43. William Daniel Conybeare, “Report on the Progress, Actual State, and Ulterior Prospects of Geological Science,” *Report of the British Association for the Advancement of Science* (Meetings at York, 1831, and Oxford, 1832), 1833, 1(a):364–414, on p. 396, “The soil throughout Bengal is often occupied by deposits of clay, containing concretionary lumps of limestone called Kunkaer: this, which affords the principal supply of lime in India, is probably of very recent origin.” On p. 395 reference is made to the presence on much of the Indian subcontinent of a “thin crust of laterite,” “a [red] ferruginous clay.”
44. Here Darwin is responding to the method of dating recent strata suggested in Lyell, *Principles*, 3:58, “We derive one great advantage from beginning our classification of formations by a comparison of the fossils of the more recent strata with the species now living, namely, the acquisition of a common point of departure in every region of the globe. Thus, for example, if strata should be discovered in India or South America, containing the same small proportion of recent shells as are found in the Paris basin, they also might be termed Eocene. . . . There might be no species common to the two groups; yet we might infer their synchronous origin from the common relation which they bear to the existing state of the animate creation.” In his own copy of the *Principles* Darwin wrote beside this passage, “if the rate of change is everywhere the same.” Darwin Archive, Cambridge University Library.
45. Conybeare, “Report,” p. 398, “As to South America, the completion of that part of Humboldt’s Travels which relates to Peru is announced; while on the eastern side we have the works of Spix and Martius*” To this last point Conybeare added the footnote, “*These geologists describe a sandstone, considered by them as equivalent to the German keuper, as prevailing in the basin of the Amazons; and they assign the same formation, as the matrix of the diamond mines, a near approximation to the geological site of the Indian mines of this gem; the sandstone of the plains of Paraguay is however said to be tertiary molasse.”
46. The Sierra de la Ventana is a mountain range in SW Buenos Aires province, Argentina. A foldout map in Thomas Falkner, *A Description of Patagonia, and the Adjoining Parts of South America* (London, 1774) shows “Salt Pitts” to the northwest of the area in which the mountain range exists, though the range is not labeled on Falkner’s map. References to salt deposits abound in Falkner’s text, as noted in Darwin, *Geological Observations*, p. 72. There is no reference in Falkner that corresponds exactly with Darwin’s “Spiny bushes,” but see p. 70 for reference to a “low, thorny tree” growing in an area nearer the east coast than the Sierra de la Ventana.