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An 1830s View from Outside Switzerland: Charles Darwin on the "Beryl Blue" Glaciers of Tierra del Fuego

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Key-words: Charles Darwin, Louis Agassiz, Glaciers, Tierra del Fuego

ABSTRACT

By the late 1830s the views of the Swiss glaciologists Ignace Venetz, Jean de Charpentier, and Louis Agassiz had been published in English translation. These views included the idea of an active role for glaciers in transporting erratic boulders and the idea of ice ages. In 1839 the young geologist Charles Darwin published a brief but uncharacteristically passionate attack on these views. In 1833, while serving as naturalist aboard H.M.S. *Beagle*, Darwin had seen the glaciers of Tierra del Fuego, which he valued as spectacles, or as the parent to icebergs, rather than as major geological forces. Using Darwin's unpublished geological manuscripts from the voyage of H.M.S. *Beagle*, as well as his published writing stemming from the voyage, this paper reconstructs Darwin's earliest approach to the subject of glaciers. It shows him applying what he learned at Tierra del Fuego to the Swiss case, seeking to find there a similar explanation for the distribution of erratic boulders, namely their transportation by icebergs. Finally, the paper suggests that, once his account of the voyage was published, Darwin quickly began to reconsider more positively the work coming out of Switzerland, altering but not abandoning his own early conclusions drawn from his observations of glaciers in Tierra del Fuego.

ZUSAMMENFASSUNG

Gegen Ende der 1830er Jahre wurden die Ansichten der Schweizer Glaziologen Ignaz Venetz, Jean de Charpentier und Louis Agassiz ins Englische übersetzt. Diese Veröffentlichungen schrieben den Gletschern eine aktive Rolle beim Transport erratischer Blöcke zu und gingen von der Annahme einer Eiszeit aus. 1839 veröffentlichte der junge Geologe Charles Darwin einen kurzen, aber für seine Verhältnisse ungewöhnlich leidenschaftlichen Angriff auf diese Ansichten. 1833, als Naturwissenschaftler an Bord der H.M.S. Beagle, hatte Darwin die Gletscher von Feuerland gesehen, die für ihn eher ein Naturschauspiel darstellten, oder den Ursprung von Eisbergen, aber keine wesentliche geologische Kraft. Unter Benutzung unveröffentlichter geologischer Aufzeichnungen während der Reise mit der H.M.S Beagle und von Veröffentlichungen nach dieser Reise, wird hier Darwins erste Auseinandersetzung mit dem Thema Gletscher rekonstruiert. Es wird gezeigt, wie er seine Erfahrungen von Feuerland auf die Schweiz anwendete und dort eine ähnliche Erklärung für den Transport erratischer Blöcke suchte, nämlich durch Eisberge. Es wird hier die Ansicht vertreten, dass nach der Veröffentlichung der Reiseberichte Darwin sehr bald die Arbeiten aus der Schweiz positiver beurteilte, seine ursprünglichen Schlussfolgerungen aus den Beobachtungen an den Gletschern von Feuerland modifizierte, aber doch nicht ganz aufgab.

Introduction

Glaciers were for Charles Darwin (1809–1882) one of nature's grand spectacles when he first viewed them in 1833 during the H.M.S. *Beagle* voyage of 1831–1836.[2] Only later, gradually, and through a tortuous route, did glaciers become for him a geological agency of major significance. The tortuous route of refined understanding spanned several decades. In this paper I will consider Darwin's views as they developed over three stages: first, during the voyage itself; second during the period in 1837 when he was writing his account of the voyage for publication; third, in 1838, after the 1837 Neuchâtel address of Louis Agassiz (1807–1873) had been published in English (L. Agassiz 1838), which prompted a response from Darwin in an addendum he wrote to his own volume recounting the voyage.

The development of glacial theory by Swiss authors has been well treated by A. V. Carozzi (L. Agassiz 1967), and serves as a background to my narrative. Early work in Switzerland by Ignace Venetz (1788–1859) and Jean de Charpentier (1786–1855) anchored the modern scientific understanding of glacial phenomena by arguing for the former great extension of glaciers and their role in transporting erratic boulders, and in polishing and striating rocks. Once convinced of the accuracy of their work, Agassiz added the notion of ice ages. As Carozzi remarked, it took the *"conjugate efforts"* of Venetz, Charpentier, and Agassiz over a twenty-five year period to overcome the old belief in the transportation of great boulders by huge water and mud currents. Of course Venetz, Charpentier and Agassiz had forerunners and co-contributors. On the Swiss side these included such mountaineers as Jean-Pierre Perraudin (1767–1858), as well as the botanist Karl Schimper (1803–1867), who coined the term *Eiszeit* (Ice Age). Outside

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[2] See Darwin's diary in Keynes 1988 and the official narrative of the voyage, FitzRoy 1839, vol. 2 (FitzRoy's account) and vol. 3 (Darwin's account). Vol. 1 contained the account of the first voyage of 1826–1830. Vol. 3 was also printed separately as Darwin 1839a.

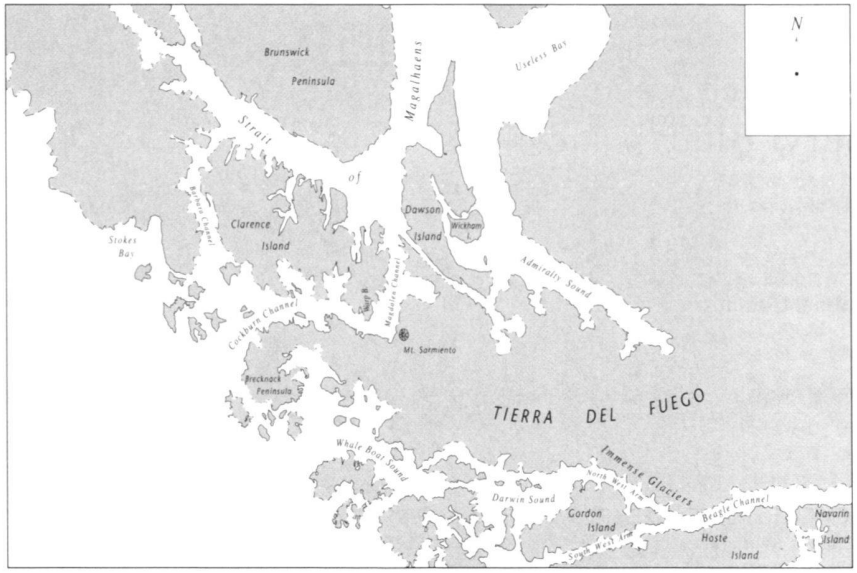

Fig. 1. Simplified portion of chart labelled *"The Strait of Maglhaens commonly called Magellan. Surveyed by the Officers of His Majesty's Ships Adventure and Beagle. Under the direction of Captains Phillip Parker King, F.R.S., Pringle Stokes & Robert FitzRoy 1826–1834."* Darwin first saw the "Immense Glaciers" of the "North West Arm" of the Beagle Channel on 29 January 1833. The painting by Conrad Martens in Figur 3 was done from the perspective of Warp Bay in Magdalen Channel looking towards Mt. Sarmiento.

Switzerland, early authorities included John Playfair (1748–1819), whose book describing glacial action (1802: 388–389) accompanied Darwin on the *Beagle* voyage. However, Darwin was ignorant of the Swiss work until after the voyage, and did not fully engage Playfair's views on glaciers during the voyage.

Stage 1: Darwin's Encounter with Glaciers

After the end of the Napoleonic wars, the British Admiralty through its hydrographic office assembled charts for the world's oceans, sending forth numerous expeditions to survey many unknown or little known coastlines (Ritchie 1967). Among the coastlines the Admiralty surveyed were those in the southern portion of South America. During the first expedition organized for this purpose, lasting from 1826 through 1830, the Beagle Channel in Tierra del Fuego was identified and given an English name (FitzRoy 1839, vol. 1). During the second expedition devoted to this purpose, lasting from the end of 1831 through 1836, young Darwin was present aboard ship as gentleman companion to the captain and as naturalist. As a result of his experience aboard H.M.S. *Beagle*, Darwin thus first viewed glaciers in the setting not of the Alps, but of Tierra del Fuego.

The climate of Tierra del Fuego was so wretched – windy, wet and cold even in summer – that for all aboard the H.M.S. *Beagle* the months passed in surveying the intricate waterways were difficult ones. Even the astonishing presence of the native Fuegians posed danger. The glaciers stood out amidst the gloom. On 29 January 1833 Darwin first saw them as one of the small surveying boats entered the north arm of Beagle Channel. (Fig. 1) Darwin wrote in his small pocket field notebook on first sighting: "many glaciers beryl blue *most beautiful* contrasted with snow" (Barlow 1945: 175). The name for the color: "beryl blue" would seem to have been drawn from *Werner's Nomenclature of Colours* by Patrick Syme (1821), a book Darwin carried with him aboard the *Beagle*. Syme's chart represented a traditional comprehensive view of natural history: the categories of animal, vegetable, and mineral are linked by the possession of common colors. Darwin chose the name "beryl" – derived from beryl, the mineral – from Syme's chart (Fig. 2). Presumably Darwin had left Syme's book on the *Beagle* during the expedition in the smaller boats that were used for exploration, for in the expression "beryl blue" Darwin borrowed from Syme without repeating him exactly.

Darwin drew no pictures of the glaciers himself, but the artist Conrad Martens (1801–1878), who accompanied the *Beagle* during this portion of its mission, painted several stunning watercolors that include glacial views. Martens chose perspectives that included Mt. Sarmiento, which lies to the northwest of Beagle Channel. The painting (Fig. 3) was done from a sketch made on the 9th of June 1834, on the ship's second swing through Tierra del Fuego, from a location called Warp Bay in the Magdalen Channel facing Mt. Sarmiento. Darwin said of the glaciers in his notebook that their color was "blue by transmitted and reflected light" – and Martens captured both. Artist and scientist were thus joined in appreciating the spectacle of the glaciers.

On 29 January 1833 as Darwin viewed what were labelled on the chart reproduced in Figure 1 as the *"immense glaciers"* of the northern arm of the Beagle Channel, he also experienced danger from a glacier. In FitzRoy's words:

> *"We stopped to cook and eat our hasty meal upon a low point of land, immediately in front of a noble precipice of solid ice; the cliffy face of a huge glacier, which seemed to cover the side of a mountain, and completely filled a valley several leagues in extent ...."*

Then a *"thundering crash"* shook us as the *"whole front of the ice cliff"* came crashing down (FitzRoy 1839, vol. 2: 216– 217). The wave the ice caused threatened to carry away the surveying boats. Darwin aided in their rescue. Disaster was averted. Glaciers had become more than spectacle; they had become experience.[3] Darwin was witness to the creation of icebergs.

Darwin's recorded observations on the glaciers of the northern arm of the Beagle Channel were brief but careful. In recording his observations he was continuing the tradition of those on the first surveying expedition, as where rock-bearing icebergs had been noted (FitzRoy 1839, vol. 1: 337). (The second expedition had on board the manuscript of the records from the first expedition.) Darwin did not actually climb on any of the glaciers. In manuscript notes (DAR 32.2: 122)[4] he made reference to the *"glacier, which I was able to approach nearest to,"* and, later, in published work (1842b) wrote, *"I had no opportunity of landing on any glacier, but we passed in the Beagle and Magdalen channels within two miles of several."* In his notes (DAR 32.2: 121) he remarked on *"the great difference of structure in the tongue of land formed by mountain torrents & by glaciers. –"* The torrents produced a *"bank of pebbles; but with the glacier it is a pile of enormous boulders."* He noted one boulder averaged *"6 feet above the sand ... & 30 yards in circumference"* (DAR 32.2:122). Such a large amount of material was brought down by torrents, and by glaciers, that he wondered why the Beagle Channel had not filled up (DAR 32.2: 122[v]). In his notes, like FitzRoy, Darwin compared masses of ice falling from glaciers into the Channel to *"a miniature of the icebergs of the Antarctic seas"* (DAR 32.2: 122; FitzRoy 1839, vol. 2: 216). In his Diary from the voyage (Keynes 1988: 139–140) he repeated this analogy and added a note comparing the distribution of glaciers in the northern and southern hemispheres:

> *"The occurrence of glaciers reaching to water's edge & in summer, in Lat: 56° is a most curious phenomenon: the same thing does not occur in Norway under Lat. 70°.–"*

Darwin gleaned his information on Norway's snow line, and hence glaciers, from his reading of Leopold von Buch's *Travels through Norway and Lapland* (1813: 305), a work that accompanied him on the voyage.

In Darwin's longer set of geological notes on Tierra del Fuego there is a rich interplay of observation and hypothesis, which he later drew on in his published work. For example, he remarked (Darwin 1842b),

> *"I cannot more accurately describe the appearance of the cliffs around Navarin Island [in Tierra del Fuego], than by the remark, which, at the time, I entered in my note-book, 'that a vast debacle appeared to have been suddenly arrested in its course.'"*

For background, Darwin began with a good short treatment of Tierra del Fuego done by Philip Parker King (1793–1856), Commander of the *Adventure* and *Beagle* on the first surveying expedition of 1826–1830. King's 1831 article identified what he called a transverse section of the continent in the sharply differing rock types in Tierra del Fuego: granite and greenstone on the west, clay-slate in the center, and recent formations on the eastern portion (King 1831). Similarly, while in the northern arm of the Beagle Channel, Darwin – building on King – reserved his closest attention for rock types, and particularly for the junction between the micaceous rocks and those of clay-slate. In Darwin's geological specimen notebooks one can trace these interests, as where he noted for specimen #952, *"Mica Slate. with Garnets: grand chain in North arm of Beagle Cha."* At this time Darwin did not collect boulders simply for their shape, or for their similarity to, or distinctness from, the surrounding rock. Later, in 1834 at the Santa Cruz River, he did do so, as indicated by his description in his specimen notebook of specimens 1994 and 1995 as *"Immense blocks."*

While at Tierra del Fuego, Darwin's most keenly felt theoretical interest lay with working out the relation of cleavage and stratification in Tierra del Fuego. Toward the end of the voyage he summarized his views on the relation of the laminated structure of the slates in relation to the form of the land, views he later developed in print (DAR 32.2: 111–117; DAR 34.2: 177; Darwin 1846: 151–156). Considerably further down the line in his hierarchy of interests, were his observations on glaciers and on what he termed "alluvium."

Under the heading of "alluvium" Darwin grouped all the superficial loose deposits, including boulders. Darwin wanted to leave behind biblical-sounding term "diluvium," coined by William Buckland (1784–1856), though the term sometimes occurs in Darwin's notes (Rupke 1983: 81–88; Herbert 1992). There are several surprising aspects to Darwin's extensive contemporary notes on alluvium in Tierra del Fuego. First, his later-used mechanism of icebergs transporting rock appears only briefly as a possibility. It is not the dominant idea of the notes. Indeed there is little association of ice of any kind, whether glacial or in icebergs, with his accounts of the alluvium.[5] Second, Darwin was not a simple-minded uniformitarian. For example, as mentioned earlier, in notes he used the term "debacle" to describe forces sufficient to move great bodies of rock. Third, Darwin expressed frustration with his subject of alluvium in his notes, especially during his second visit to Tier-

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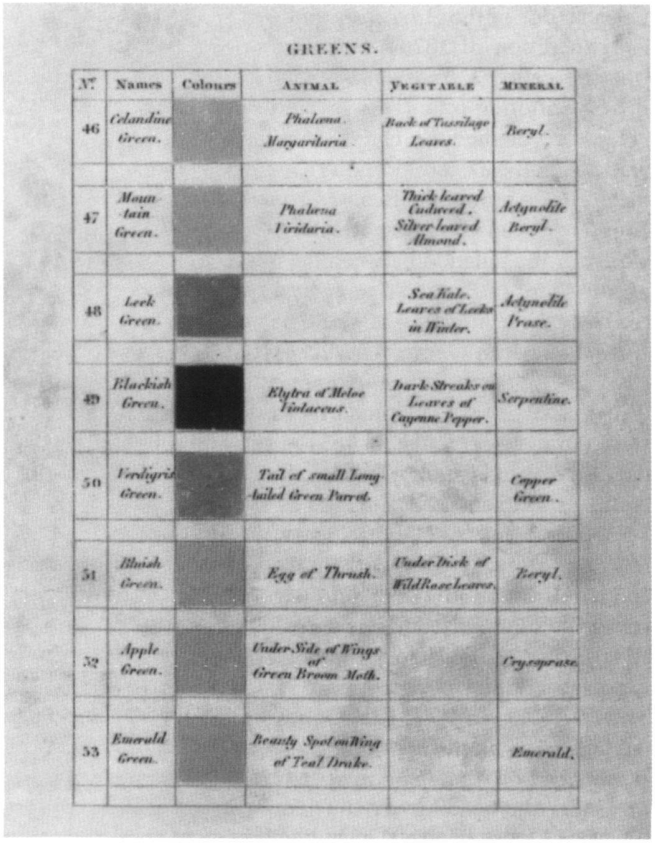
[3] As a sidepoint, Venetz's first publication in English described an avalanche that occurred on 27 December 1819. Venetz described the mass that descended from the avalanche as *"nearly 150 feet high; so that the whole body of ice precipitated is about 360,000,000 cubic feet."* (Venetz 1820, p. 276)

[4] Darwin's geological notes from the voyage, together with his specimen notebooks, are stored in the Darwin Archive at Cambridge University Library. "DAR" numbers represent manuscript volumes; they alone will be cited in subsequent notes.

[5] One contrary example should be cited from DAR 34.2:143[v]: *"Glaciers & floating Icebergs have frequently been brought forward as the means of Transportal."* This comment, however, appears as a later addition, of uncertain date, to Darwin's original run of manuscript notes.



GREENS.

N°	Names	Colours	Animal	Vegitable	Mineral
46	Celandine Green.		Phalæna Margaritaria.	Back of Tussilage Leaves.	Beryl.
47	Mountain Green.		Phalæna Viridaria.	Thick leaved Cabbage, Silver-leaved Almond.	Actynolite Beryl.
48	Leek Green.			Sea Kale. Leaves of Leeks in Winter.	Actynolite Prase.
49	Blackish Green.		Elytra of Meloe Violaceus.	Dark Streaks on Leaves of Cayenne Pepper.	Serpentine.
50	Verdigris Green.		Tail of small Long-tailed Green Parrot.		Copper Green.
51	Bluish Green.		Egg of Thrush.	Under Disk of Wild Rose leaves.	Beryl.
52	Apple Green.		Under Side of Wings of Green Brown Moth.		Chrysoprase.
53	Emerald Green.		Beauty Spot on Wing of Teal Drake.		Emerald.

Fig. 2. Color Chart from Patrick Syme, *Werner's Nomenclature of Colours* (1821). The precise phrase "beryl blue" does not appear on the chart but the colors numbered 46, 51, 58 and 60 are all associated with "Beryl" in the "minerals" column.

Fig. 3. Conrad Martens's painting "Mount Sarmiento from Warp Bay." The painting originally appeared, reproduced in black and white, in FitzRoy 1839, vol. 2, facing p. 359. A color reproduction of the painting appears in Keynes 1979, p. 113. The pencil sketch from which it derived reads, "*The grand glacier, Mount Sarmiento. The mountain rises to about 3 times the height here seen, but all is here hidden by dark misty clouds – a faint sunny gleam lights the upper part of the glacier, giving its snowy surface a tinge which appears almost of a rose colour by being contrasted with the blue of its icy crags – a faint rainbow was likewise visible to the right of the glacier, but the whole was otherwise very grey & gloomy. June 9 1834.*" Initialled top right: RF [Robert FitzRoy] (Keynes 1979: 398).

ra del Fuego in 1834, after he had seen the distribution of large lava blocks in the area of the Santa Cruz River. For example, in 1834, after considering two alternate hypotheses of imagining how material could be transported from the west to the east in Tierra del Fuego, whether by the action of ordinary tides and currents, or by sudden rushes of water, he remarked in his notes (DAR 34.2:171), *"It is clear my data are insufficient to come to any satisfactory conclusions.–"* On the same page of notes he added that the ocean was very deep at some points off the east coast of Tierra del Fuego: 660 feet about a mile Pt. S. Anna, and no sounding at 1536 feet east of Cape Froward in midchannel. This depth made water transport for rocks difficult to imagine. Overall Darwin was aware that the subject of the transportation of rocks was a matter of interest among geologists. In his notes (DAR 34.2:169) he mentioned Robert FitzRoy (1805–1865), Captain of H.M.S. *Beagle*, having received inquiries on the subject from Charles Lyell (1797–1875). At some point – possibly as a later addition – he also referred in his voyage notes (DAR 34.2:150^{v}) to Buckland's work on diluvial valleys (1824), suggesting a relevance for the interpretation of the valley of River Santa Cruz. Beyond that, Darwin's notes on alluvium in Tierra del Fuego are difficult to summarize. At one point in 1834 he ventured the claim (DAR 34.2:171^{v}) that *"Generally however the Boulders may be attributed to the alluvium.–"* But this was a thin assertion. From his *Beagle* period notes, it is clear that Darwin believed these were not settled questions.

Stage 2: 1837. Darwin's Manuscript of the *Journal of Researches*

In 1837, three years after Darwin left Tierra del Fuego for the last time, he spent seven months transforming his Diary from the Beagle voyage into a book (FitzRoy 1839, vol. 3; Darwin 1839a). The three years from 1834 and 1837 had been full of developments, for Darwin, and for the field of geology as it related to glaciers. With regard to superficial deposits, following his last visit to Tierra del Fuego, he had read volume 3 of Lyell's *Principles of Geology* (1833: 148) which used the imported term "erratic blocks." That phrase became part of Darwin's everyday vocabulary, which it had not been earlier, though the phrase appeared elsewhere in his library aboard ship, as in De la Beche (1831). After the voyage, as he was writing up his results, Darwin also largely dropped use Buckland's term "diluvium" as a descriptive term.

Darwin in 1837, the prospective author, was a different man from Darwin in 1834, the explorer and field naturalist. His ambition as a geologist had solidified around the topic of crustal motion: elevation and subsidence. In private, in 1837 he had also adopted an evolutionary hypothesis. Thus, as he was writing up his Diary for publication even seemingly unrelated issues often had ties, sometimes hidden, to his larger views.

An interesting feature of Darwin's work is its timing in relation to the new work on glaciers coming from Switzerland. The work of Venetz and Charpentier probably reached Darwin first through its presentation in Lyell's presidential address (1836) to the Geological Society of London, where Lyell spoke noted that:

> *„M. Charpentier has lately proposed another theory which he informs us is merely a development of one first advanced by M. Venetz. ... According to this hypothesis ... the erratic blocks are monuments of the greater magnitude and extent of the ancient glaciers under a different configuration of the surface."*

However, even though Darwin did know of the glacial hypothesis, in its Venetz-Charpentier version, before writing up his voyage account, he, like Lyell, did not adopt its conclusions. Lyell himself used his next presidential address to the Geological Society (1837) to present his own interpretation of the Swiss situation that relied on icebergs to transport rock:

> *„I now believe that by far the great part of the dispersion of transported matter has been due to the ordinary moving power of water, often assisted by ice, and cooperating with the alternate upheaval and depression of land."*

Darwin's presentation of material related to the glaciers of Tierra del Fuego took two forms in the main body of text of his *Journal of Researches*. In Chapter 11, he recounted much of the material drawn from his Diary. (The color of the glaciers was now described as "beryl-like blue," rather than "beryl blue" – a minor change.) He compared the Beagle Channel to the valley of Loch Ness in Scotland. In so doing, he was drawing an analogy between the landscape of Tierra del Fuego and that of other locales around the world. Tierra del Fuego had thus become his model for understanding a certain set of climatic, geographical, and geological circumstances.

In Chapter 13 of the book Darwin presented an analytical view of what he had seen in Tierra del Fuego. His analysis had two parts. First, he now adopted the notion that icebergs, broken off from glaciers, had deposited erratic blocks, particularly the angular ones, seen across the eastern region of Tierra del Fuego.

He wrote (Darwin 1839a: 288):

> *„When the land was elevated, the fragments of rock would be found deposited on the eastern side of the continent, in bands representing the ancient channels. Whether or not the hypothesis of their transport be true, such is the position of the erratic blocks in Tierra del Fuego."*

In his discussion Darwin also differentiated sharply between semi-rounded boulders, as he had found near Port Famine, for which he was not willing to offer an explanation, and angular boulders. When, towards the end of the voyage, in his Red Notebook (Darwin 1980: 36), he did turn to De la Beche's account of erratic blocks, he criticized him for not drawing *"suf-*

ficient distinction" between angular and rounded boulders. In any case, for Darwin the presence of angular erratic blocks in eastern Tierra del Fuego now had an explanation.

The second portion of Darwin's analysis pertained to climate. Darwin's approach can be traced to the work of Alexander von Humboldt (1769–1859), as it was interpreted by Lyell. Humboldt's article entitled "On Isothermal Lines, and the Distribution of Heat over the Globe," published in its English version in 1820–1821, was Lyell's chief theoretical source in writing the section on climate in the first volume of the *Principles of Geology*. Lyell began his treatment of climate by summarizing Humboldt's work. The key ideas (Lyell 1830: 106) were that *"zones of equal warmth ... are neither parallel to the equator nor to each other ..;"* that *"the same mean annual temperature may exist in two places which enjoy very different climates, for the seasons may be nearly equalized* [„insular" climates] *or violently contrasted* [„excessive" climates];" and that determining these differences were *"a multitude of circumstances, among the principal of which are the position, direction, and elevation of the continents and islands, the position and depth of the sea, and the direction of currents and of winds."* Following Humboldt, Lyell also noted the moderating effect of the ocean on climate, as in the Southern hemisphere with its greater proportion of ocean to land.

Darwin adapted this Humboltean/Lyellian view of climate to an account of the distribution of erratic boulders worldwide. In his *Journal of Researches* (1830: 291), he asked rhetorically,

> *"what are the circumstances in the southern hemisphere that produced such results? [That is, of glaciers descending to the sea.] Must we not attribute them to the large proportional area of water; and do not plain geological inferences compel us to allow, that during the epoch anterior to the present, the northern hemisphere more closely approached to that condition, than it does now?"*

Darwin had only to turn to Lyell's *Principles* (vol. 2, facing p. 204) to see a fold-out colored *"Map shewing the extent of surface in EUROPE which has been covered by Water since the commencement of the deposition of the older TERTIARY strata."* A pictorial depiction of a partly submerged Europe was readily at hand.

Darwin invited his readers (pp. 291–292) to join him in thinking of *"what is actually taking place in the southern hemispheres, only transporting in imagination each part to a corresponding latitude in the north."* Darwin then brought his analogy to bear on the most famous site for erratic boulders in Europe, the Alps and the Jura. He posited that icebergs charged with granite *"would be floated from the flanks of Mont Blanc, and then stranded on the outlying islands of the Jura."*

Darwin did not refer directly to the work of Venetz and Charpentier in the main text of his *Journal of Researches*. However, in that work Darwin did juxtapose the situation of glaciers in Switzerland to that in Tierra del Fuego. He wrote (p. 286):

> *"Every one has heard of the mass of rubbish propelled by the glaciers of Switzerland, as they slowly creep onwards. In the same manner in Tierra del Fuego, on a still night the cracking and groaning of the great moving mass may be distinctly heard. The same force, which is known to uproot whole forests of lofty trees, must, when grating over the surface, tear from the flanks of the mountain many huge fragments of rock."*

In his argument he also made one point that they could all share: that it was philosophically acceptable to posit the existence of glaciers where they do not exist at the present time. But their understanding of glaciers remained distinct and incompatible.

May I suggest that, on Darwin's side, something of that incompatibility owed itself to his initial approach to glaciers primarily as spectacle. Glaciers were to be viewed, with appreciation of their beauty, especially in regard to their color and their reflection and transmission of light. In emphasizing the visual, something of the bulk and weight of glaciers went unrecognized by Darwin. In his summary remarks to his *Journal of Researches* (p. 606), note how he separated glaciers from those spectacles that have geological power. He listed six *"remarkable spectacles":* the stars of the southern hemisphere, the water-spout, the *"glacier leading its blue stream of ice in a bold precipice overhanging the sea,"* a lagoon island formed by coral, an active volcano, and an earthquake. Of the six spectacles on the list, he emphasized the coral island, the volcano, and the earthquake, because of their *"intimate connexion with the geological structure of the world."* The land-bound glacier retained its interest primarily as spectacle. The glacier became effective as a geological agent only as a parent to icebergs.

What factors affected Darwin's experience of glaciers? Certainly one must consider Darwin's disadvantage as a traveller who could not return to the same site year after year. Also, as noted earlier, Darwin himself did not climb onto any glacier. His experience in the field was at a distance, albeit a short distance. In this Darwin differed from the early Swiss glaciologists, and from most later British ones as well (Hevly 1996). His first-hand experience with glaciers was primarily a visual one. Another possible explanation for Darwin's limited sense of the power of glaciers was that, within the division of labor aboard ship, Darwin operated in the context of the natural historical tradition. Kinds of things mattered: animal, vegetable, and mineral. This was a world still consistent with Syme's color chart. Darwin's specimen notebooks reflect his collecting practice in honoring this traditional division. Darwin's work was systematic, but it was not particularly mathematical. Darwin was not the keeper of extended series of numerical measurements aboard ship, though he did use these measurements. Darwin did not himself take the measurements from which weight might have been inferred. In contrast, it was King on the first surveying mission (1826–1830), who provided an estimate of 3,500 feet for the line of perpetual snow in the Strait of Magellan (FitzRoy 1839, vol. 1: 574). One can at

least speculate that had Darwin been more intimately involved in measuring the bulk of glaciers, or, in this case, of the related matter of snow lines, he might have moved more quickly and easily to consider the potential force of glaciers as geological agents.

Stage 3: 1838. Darwin's Challenge to the Swiss Glaciologists

Louis Agassiz and Charles Darwin were contemporaries, Agassiz born in 1807, Darwin in 1809. They devoted themselves to the very largest questions in geology and natural history. Their personal experience with existing glaciers did not overlap at the obvious point. Unlike many of his British contemporaries, Darwin never visited Switzerland. (As his biographer Edward Lurie described [1988: 371–377], Agassiz did see the glaciers at the Strait of Magellan in 1872, a year before his death, but he never wrote about the experience himself.) It was Agassiz who first entered Darwin's world, in print. As already mentioned, in April 1838 the Edinburgh New Philosophical Journal carried a translation of Agassiz's famous Neuchâtel address of July 1837. It is not known exactly when Darwin first read the address, either in the Edinburgh journal, or referred to elsewhere, possibly in the French scientific literature, but by the 27th of October 1838 he had written a passionate attack on Agassiz's work, and that of Venetz and Charpentier. From the publishing point of view, this attack appeared under odd circumstances. Darwin's volume in the *Narrative* from the *Beagle* voyage had been set in print but held until FitzRoy was finished with his own work. As time went on, Darwin found material he wished to add to his text, and in the fall of 1838 he wrote a series of extended notes, or addenda, for his volume. I mention the circumstance because it may account for the invective tone of Darwin's remarks, which were likely thrown off and published without the benefit of any solicitous editorial eye.

In an addendum to his *Journal of Researches* Darwin declared that the problem of the placement of erratic boulders had been solved by the theory of iceberg transport. In this context, he attacked the new glacial theory with passion. Fueling his passion, but hidden from view, was undoubtedly his unannounced belief in transmutation, and his gradualist view of species extinction, both of which differed sharply from the views Agassiz presented in his Neuchâtel address. In his attack in the *Journal of Researches* (p. 616), Darwin accepted as factual the description of moraines and of the *"polished and scratched surface of the rocks"* provided by Venetz, Charpentier, and Agassiz. But he sought to accommodate these facts by his notion of iceberg transport. He claimed (p. 619) to make only two assumptions in doing so: (1) that an arm of the sea extended between the Alps and the Jura during the period when the area had a more tropical character, and (2) that the elevation of Switzerland, whenever it took place, was slow and gradual. In retrospect, it is clear that numerous assumptions were embedded within these assumptions, leaving Darwin (and Lyell's) position on climate and erratic placement exposed. Thus, for example, Lyell assumed (1830: 112) that the *"proportion of dry land to sea continues always the same."* Of his own theory, derived from Lyell's, Darwin credited his use of strong analogies, and his theory of a climate change *"shown by reasoning, independent of the existence of erratic blocks, to be probable in a high degree."* His statement on glacial theory in the addendum to his *Journal of Researches* (p. 621) concluded with a condescending understatement: *"whether this is the case with the theory of M. Agassiz, I leave the reader to decide."*

In all this, glaciers themselves are rather offstage: climate, erratic boulders, icebergs – these are Darwin's chief concerns in 1838. But, within the year, Darwin did begin to acknowledge a view of glaciers distinct from his own. In 1838 he did field research at Glen Roy in Scotland, where erratic boulders also came into play (Rudwick 1974). In his long article (1839b) stemming from that research Darwin touched only briefly on the subject of glaciers. But, when he did, he included his own characterization of them – *"glaciers, the parents of icebergs"* and the second view, *"glaciers of the Alps"* that he can now imagine, not descending to some former sea, but as *"appendages on a greater mass of snow accumulated on far loftier chains."* The beryl-blue glaciers of Tierra del Fuego were no longer the only models for glaciation. By 1839 Darwin had allowed some geological role for glaciers that did not reach down to the sea. He had begun to acknowledge the glaciers of Switzerland.

Coda

Darwin soon regretted his intemperate words about Agassiz. In 1841, he attempted to right the wrong in an apologetic note – praising Agassiz's *"most valuable labours on the action of Glaciers"* – sent together, surprisingly, with a copy of his own *Journal of Researches*, which included the potentially offensive addendum (Burkhardt & Smith 1986: 284). Agassiz seems not to have responded. In any case, the two men never established an ongoing correspondence. Eventually, Darwin was the first to yield ground to Agassiz, as he, among other British geologists, began to at least consider the possibility of former glaciation on their own islands.[6] Darwin himself revisited Wales in June 1842, spending ten days *"examining glacier action,"* and published his findings. (Burkhardt & Smith 1986: 435; Darwin 1842a). Roberts (1998) has carefully retraced Darwin's fieldwork.

[6] For background see Herries Davies 1969. An important recent article that demonstrates both the initial great receptivity towards glacial theory among British geologists, following Agassiz's trip to Britain in the autumn of 1840, and then the backtracking from that position, is Boylan 1998. Boylan also emphasizes the importance of Buckland's visit to Neuchâtel in 1838, and his conversion by Agassiz to the glacial hypothesis. For Boylan's supplementary "English and Scottish Glacial Localities of Agassiz, Buckland and Lyell, 1840" consult the World Wide Web document (http://www.city.ac.uk/artspol/glaclocs.html).

In contrast to Darwin's move towards Agassiz's position on glaciers, only towards the end of his life did Agassiz begin to reconsider Darwin's contributions to science. By then Agassiz indicated a new regard for Darwin (Lurie 1988). That regard was shown towards Darwin's work generally, rather than towards evolutionary theory considered on its own. Agassiz's willingness to look again at Darwin's work was recounted by his second wife Elizabeth Agassiz (1822–1907). When she wrote a brief account of the Agassiz party's excursion in 1872 to Cape Horn, she remarked sympathetically on *"Darwin's delightful narrative of his journey through the Straits of Magellan"* (E. Agassiz 1872). Here she was representing her husband's view, as well as her own. Further along in the same article, she also signalled a comparative theme that may serve as our conclusion.

> *"Every characteristic feature known in the Alps as the work of the glaciers was not only easily recognizable here, but as perfectly preserved as anywhere in Switzerland."*

The view from Switzerland and the view from Tierra del Fuego had come together.

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