Rock Stars

Darwin the Geologist

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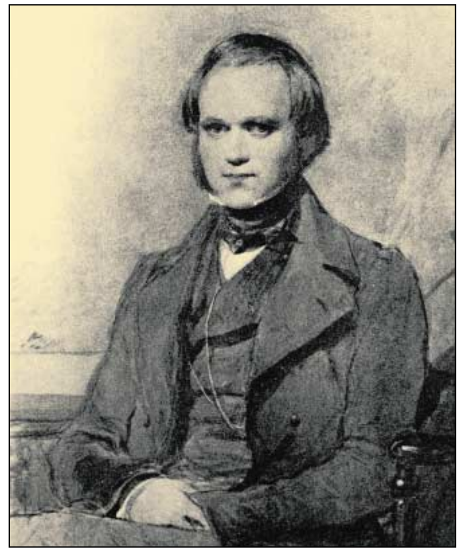


Darwin in 1840 (age 31), painted by George Richmond. From de Beer (1964, p. 116).

On January 16, 1832, shortly before Charles Darwin's 23rd birthday, *H.M.S. Beagle,* with the young Darwin aboard, made its first stop at São Tiago in the Cape Verde islands off the west coast of Africa. Years later, Charles Darwin wrote:

> The geology of St. Iago is very striking yet simple: a stream of lava formerly flowed over the bed of the sea, formed of triturated recent shells and corals, which it baked into a hard white rock. Since then the whole island has been upheaved. But the line of white rock revealed to me a new and important fact, namely that there had been afterwards subsidence round the craters, which had since been in action, and had poured forth lava. It then first dawned on me that I might write a book on the geology of the countries visited, and this made me thrill with delight. That was a memorable hour to me.… (*Autobiography,* p. 81).

Today, few people are aware that Charles Darwin (1809–1882) was an accomplished geologist before becoming renowned as a biologist with *On the Origin of Species* in 1859. Despite his lack of formal training as a geologist, Darwin published major works on the structure and distribution of coral reefs (1842) and geological observations on volcanic islands (1844) and on South America (1846).

INFLUENCES

The irony of Darwin's success as a geologist was that he had little formal instruction in the subject. In his second year at the University of Edinburgh—before he dropped out—he attended the lectures of Robert Jameson, a champion of Werner's Neptunist theory, "but they were incredibly dull. The sole effect they produced on me was the determination never as long as I lived to read a book on Geology or in any way to study the science. Yet I feel sure that I was prepared for a philosophical treatment of the subject" (*Autobiography,* p. 52).

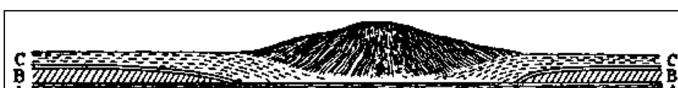
Disgusted by medicine in the days of surgery performed without the benefit of anesthesia, Darwin went on to Cambridge from Edinburgh to complete a degree that would prepare him for the Anglican clergy. At the same time Darwin continued his extracurricular pursuit of natural history and met various distinguished scholars, including John Stevens Henslow (botany), Adam Sedgwick (geology), and William Whewell (astronomy and philosophy). Darwin's enthusiastic interest in science impressed these men, for they became his mentors in various ways. Thus, despite his initial antipathy for geology, Darwin spent the better part of August 1831 on a geological tour of Wales with Adam Sedgwick, who was studying the rocks that he would later define as the Cambrian System.

> On this tour I had a striking instance of how easy it is to overlook phenomena, however conspicuous, before they have been observed by anyone. We spent many hours … examining all the rocks with extreme care … but neither of us saw a trace of the wonderful glacial phenomena all around us. (*Autobiography,* p. 70).

VOYAGE OF THE *BEAGLE*

At the end of August, Darwin returned home to discover that he had been recommended by his Cambridge professor and mentor, John Henslow, as the naturalist for the forthcoming *Beagle* voyage under Capt. Robert FitzRoy. Darwin was thought suitable for the position more because he was a well-bred gentleman who could socialize with the *Beagle's* captain than because of his skills as a trained naturalist. As a welcoming gift, FitzRoy gave Darwin the first volume of Charles Lyell's *Principles of Geology,* which had been published the year before. Closely reading this volume and the next two sent to him while on the voyage, Darwin became self-taught in geology. "I am proud to remember," he said, "that the first place, namely St. Iago, [where] I geologized, convinced me of the infinite superiority of Lyell's views over those advocated in any other work known to me" (*Autobiography,* p. 101).

Throughout the remainder of the voyage, Darwin "geologized" with excitement and enthusiasm. Writing home to his sisters, he remarked, "There is nothing like geology; the pleasure of the first day's partridge shooting … cannot be compared to finding a fine group of fossil bones, which tell their story of former times with almost a living tongue …" (*Correspondence,* v. 1, p. 379), or that he "literally could hardly sleep at nights for thinking over my [geology]." (*Correspondence,* v. 1, p. 445).



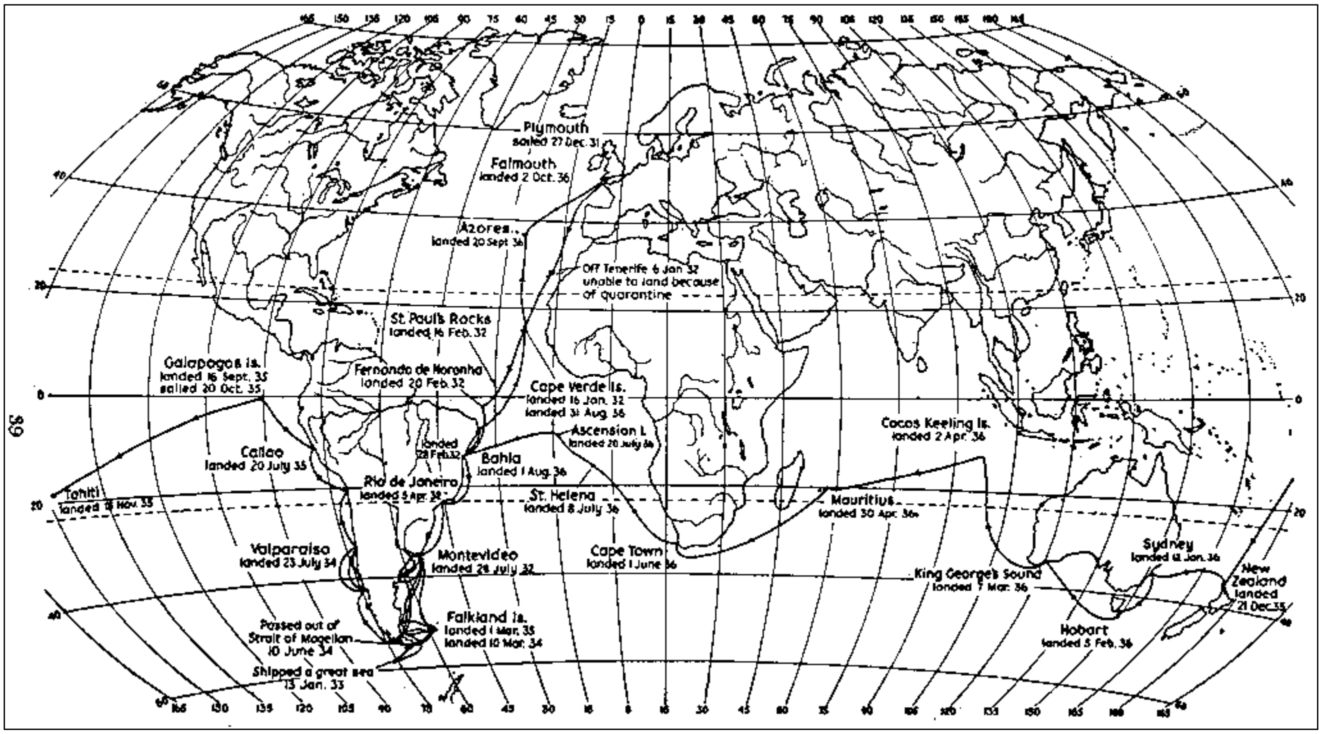
Darwin's diagram of the geological structure of the coast of St Iago, Cape Verde Islands. A, substratum of ancient volcanic rocks. B, bright white layer of limestone, originally deposited below the sea but now raised. C, recent basaltic lava. Near the extinct volcano shown, the limestone and overlying basaltic layers dip beneath the sea, evidence of local subsidence. From *Geological Observations on Volcanic Islands,* 1844.

From de Beer (1964, p. 58).

INTRODUCTION

Bernard of Chartres, an 11th-12th century philosopher and teacher, said that we are like dwarfs on the shoulders of giants, so that we can see more than they and for a greater distance, not by any virtue of our own but because we are carried high and raised aloft by their stature.

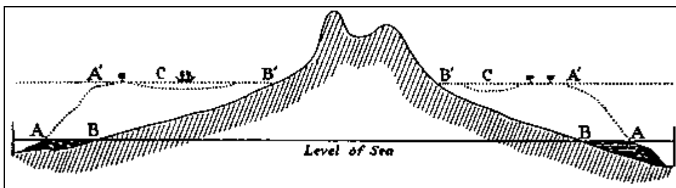
All of us have our geological heroes, those giants on whose shoulders we stand. To encourage recognition of these luminaries and to provide inspiration for students and young professionals, the GSA History of Geology Division presents Rock Stars, brief profiles of our geological giants. If you have any comments on this or subsequent profiles, please contact Robert N. Ginsburg, University of Miami, RSMAS/MGG, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, E-mail: rginsburg@rsmas.miami.edu.



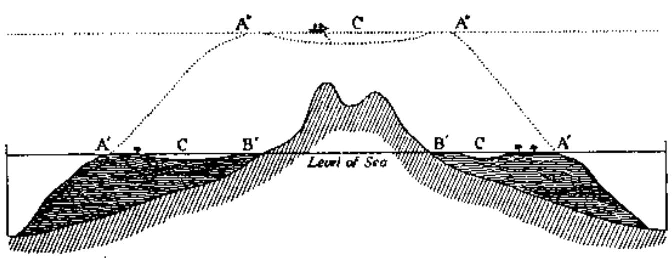
Voyage of the Beagle. From de Beer (1964, p. 39).

In Chile, on February 20, 1835, Darwin experienced a very strong earthquake and shortly afterward saw evidence of several feet of uplift in the region. Because one important aspect of Lyell's principles was the concept of a steady-state, nondirectional earth whereby uplift, subsidence, erosion, and deposition were all balanced, Darwin coupled in his mind this dramatic evidence of elevation with accompanying subsidence and deposition. Thus he hypothesized, before actually seeing them, that coral reefs of the Pacific developed on the margins of subsiding land masses, passing through the three stages of fringing reef, barrier reef, and atoll.

> No other work of mine was begun in so deductive a spirit as this; for the whole theory was thought out on the west coast of S. America before I had seen a true coral reef. I had therefore only to verify and extend my views by a careful examination of living reefs. But it should be observed that I had during the two previous years been incessantly attending to the effects on the shores of S. America of the intermittent elevation of the land, together with the denudation and deposition of sediment. This necessarily led me to reflect much on the effects of subsidence, and it was easy to replace in imagination the continued deposition of sediment by the upward growth of coral. To do this was to form my theory of the formation of barrier-reefs and atolls. (*Autobiography,* p. 98, 99).



Darwin's diagram showing the formation of an atoll as a result of subsidence. The vertical section is taken through an island (shown shaded) bordered by a coral-reef (shown dark) the outer edges of which are at AA, while the shores of the island are at BB. If the land be imagined as sinking, the relative level of the sea will rise and the shores of the island will then be at B′B′. The coral-reef will have grown upwards, keeping pace with the relative rise in sea-level, and its outer edges will be at A′A′, bordering a narrow strip of dry reef bearing trees, separated from the shores of the island by a shallow circular lagoon-channel CC, on which a ship is shown. From *Structure and Distribution of Coral Reefs*, 1842.



The final stage in the formation of an atoll. The edges of the coral-reef at A′A′, the shores of the island at B′B′, and the lagoon-channel CC, are as in Fig. 9. If subsidence continues and the relative level of the sea rises still further, the island will be completely submerged and the coral-reef will grow upwards and form a circular ring of dry land at A″A″, enclosing a circular shallow lagoon at C on which a ship is shown. From *Structure and Distribution of Coral Reefs*, 1842.

From de Beer (1964, p. 68).

When the *Beagle* visited the Cocos Islands in the Indian Ocean more than a year later, Darwin was able to test his hypothesis of reef formation "by examining the very interesting, yet simple structure and origin of these islands.… These low, insignificant coral-islets stand and are victorious … thus do we see the soft and gelatinous body of a polyp … conquering the great mechanical power of the waves…" (*Voyage,* p. 457, 459).

In his 1842 book on coral reefs, Darwin published a map of the southwest Pacific showing the distribution of fringing, barrier, and atoll reefs. Darwin noted that fringing reefs were concentrated along the coasts of continents that "are for the most part rising areas" whereas barrier and atoll reefs are found in the "central parts of the great oceans [that] are sinking areas" (*Voyage,* p. 478). (Knowing what we know about plate tectonics, we explain such subsidence by the cooling and accompanying increase in density of submarine volcanic rock as it moves away from active ridges or hot spots.)

Darwin *continued on p. 10*

Institute for Environmental Education

Interdisciplinary Scientific Opportunities at the Newly Consolidated U.S. Geological Survey and National Biological Service—Part 2

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BACKGROUND

On October 1, 1996, the National Biological Service (NBS) was merged into the U.S. Geological Survey (USGS), thereby becoming the new Biological Resources Division (BRD) of the USGS. The BRD has as its mission "to work with others to provide the scientific understanding and technologies needed to support the sound management and conservation of our Nation's biological resources." This mission is fully consistent with the USGS's broader mission of providing "the Nation with reliable, impartial information to describe and understand the Earth." Consolidation and fulfillment of these missions will require not only the administrative merger of the NBS and USGS, but also the development of a framework for scientific investigation and information management that promotes the application of integrated knowledge of biological, physical, and socioeconomic processes and forces.

To help foster this goal, the Geological Society of America, the Ecological Society of America, and the Keystone Center sponsored two workshops to identify new interdisciplinary opportunities relevant to the mission of the merged agencies. Here, we summarize the results and findings of the second workshop, held in Silverdale, Washington, in July 1996. (For a summary of the first workshop, see the October issue of GSA Today.) We address the general problem of how interdisciplinary opportunities can be fostered—a pervasive concern throughout the workshop—and then outline a series of specific interdisciplinary initiatives that emerged from the workshop deliberations. Participants included scientists and natural resource managers from a wide range of sectors, including academia, private companies, state and federal agencies that work with the USGS and NBS, and the USGS and NBS themselves. Our report presents the major ideas discussed during the workshop and is neither a consensus document nor a comprehensive workshop proceedings.

ENABLING INTERDISCIPLINARY SCIENCE

The administrative, professional, and intellectual culture of science encourages and reinforces disciplinary boundaries. Successful integration of the USGS and the NBS will require administrative action aimed at breaking down barriers to interdisciplinary science. Imposing such cultural change is not easy; assessment of other interdisciplinary projects, programs, and organizations would help the USGS to recognize and define characteristics of successful efforts and past failures. Workshop participants identified a range of organizational attributes that might encourage development of a truly interdisciplinary USGS:

1. Strong research investigation leadership, including explicit mandates for integrated, interdisciplinary planning and products.
2. Standardized and integrated data management protocols that allow for the compilation of multidisciplinary data sets and a comprehensive view of physical and biological attributes. (In many cases, an integrated information infrastructure is a necessary prerequisite for effective interdisciplinary activity.)
3. An organizational demand for studies that lead to generalizable principles, rather than simply local case histories and assessments.
4. An organizational demand for comprehensive, integrated historical baselines and trends to support environmental assessments and predictive modeling.
5. Effective lines of communication between researchers and information users, including clear articulation of uncertainties dictated by data sources and interpretive procedures.
6. Problem-oriented interdisciplinary research teams. More co-location of USGS and NBS facilities and scientists will be necessary.
7. Participation of engineers and social scientists. (Humans are major agents of geological and ecological change, and efforts to understand and respond to such

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GEOLOGICAL OBSERVATIONS

Although Darwin's theory of coral reefs is his best known geological contribution, he made others of equal interest. For example, he observed how rocks are altered by contact with hot lava; marked surface rupture and displacement from earthquakes; fossilization of extinct organisms; cleavage and foliation in metamorphic rocks and their relation to the formation of mountains; evidence for differing climates in the past based on fossils and glacial deposits; and dramatic changes in geography, particularly those related to fluctuations in sea level.

For Further Reading

Darwin, C., Journal of researches, 1839; The structure and distribution of coral reefs, 1842; Geological observations on volcanic islands, 1844; Geological observations on South America, 1846 (all Smith Elder, London). Autobiography, 1958, Nora Barlow, editor, W.W. Norton, New York; The voyage of the Beagle, 1962, Doubleday, New York; The correspondence of C. Darwin, F. Burkhardt and S. Smith, editors, 1985, v. 1, Cambridge, UK, Cambridge University Press.

de Beer, G., 1964, Charles Darwin: A scientific biography: New York, Doubleday (see especially the chapter "Geological results of the voyage of the Beagle," p. 56–77).

Ghiselin, M., 1969, The triumph of the Darwinian method: Los Angeles, University of California Press (see especially the chapter "Geology," p. 13–31).

Herbert, S., 1985, Darwin the young geologist, *in* Kohn, D., ed., The Darwinian heritage: Princeton, N.J., Princeton University Press, p. 483–518 (with commentary by M. J. S. Rudwick). ■