ROCK STARS

James Dwight Dana (1813–1895): Mineralogist, Zoologist, Geologist, Explorer

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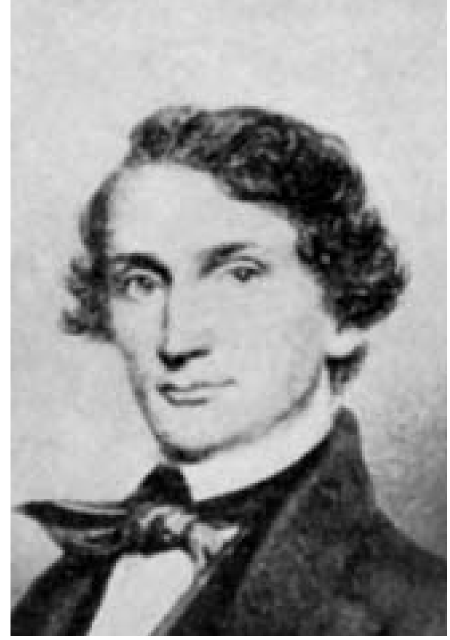

James Dwight Dana at the time when he was most actively engaged in coral reef research (from W.M. Davis, 1928, The Coral Reef Problem: American Geographical Society Special Publication 9, Fig. 1).

To many of his contemporaries, James Dwight Dana was the foremost American geologist of the nineteenth century. His *Manual of Geology*, in its fourth edition when he died in 1895, was on the shelf of almost every American geologist, and he used it to teach two generations of students while a professor in the Sheffield Scientific School at Yale. Dana was celebrated for his *System of Mineralogy* (1837), for his report on the geology of the U.S. Exploring Expedition (1849), for monographs on crustaceans and corals, and for a seminal text on volcanology he wrote in his 70s.

Dana came from a religious family. His father owned a hardware store in Utica, New York, and Dana, the eldest of four children, became adept with tools. He was musical—piano and guitar—and artistic. His mother ran the household, and her emphasis on religiosity had a lifelong influence on Dana. He liked to "tramp" and began collecting rocks, plants, and insects at an early age. He entered the sciences when opportunities for both travel and communication grew in response to the industrial revolution, and in his case, with the size, wealth, and influence of his own nation.

Dana trained in several disciplines at Yale under his future father-in-law, Benjamin Silliman, founder and editor of the *American Journal of Science*. After Yale, Dana served as an instructor on a U.S. Navy vessel that sailed to the Mediterranean, where he saw Vesuvius in eruption and pursued entomological studies. His account of the eruption in a letter, published by Silliman in the *Journal*, was Dana's first scientific paper. In 1834, Dana returned to Yale, where he developed a new mineral classification based on chemistry and crystallography and using Silliman's cabinet of minerals and his own childhood collection. The resulting *System of Mineralogy*, published when Dana was just 24, ran to four editions in his lifetime.

Dana took up geology mainly when he became geologist and mineralogist of the U.S. Exploring Expedition (1838–1842). This expedition was charged with charting islands in the Pacific—potential way stations for American clipper ships and whalers—and venturing to Antarctica. Besides Dana, the civilian "scientifics" included specialists in botany, vertebrate zoology, conchology, and philology, plus two artists. Dana, however, felt deficient in geology and looked on the expedition as an opportunity to learn it and other branches of natural history. The expedition took Dana to the Andes, to the atolls and reefed volcanic islands of the Pacific, and to the active volcano of Kilauea in Hawaii.

Dana was only 25 when the expedition sailed in August 1838, under Acting Captain Charles Wilkes. For American science, the expedition was without precedent—the first blue-water oceanographic expedition funded by the U.S. Navy. With six ships, it was far larger than earlier European ventures to the Pacific. It was also the first American exploration on land or sea to make systematic geological observations. Only Darwin, whose career Dana's paralleled in many ways, had done geological work on volcanic islands and reefs (on the *Beagle* a few years earlier). On sailing, Dana had Darwin's *Journal of Researches*, now usually called *Voyage of the Beagle*, but it provided only glimpses of geology in South America and elsewhere. The Pacific was still virtually terra incognita and a magnificent opportunity for a young scientist.

The trip was not always convivial. In one letter, Dana described it as "Naval servitude," and the imperious Wilkes eventually sent one scientist home after a disagreement and ordered Dana to assume his responsibilities. The expedition was also hazardous. Dana's ship was nearly lost in a storm in the Straits of Magellan. Unfriendly natives daunted the work in Fiji. Later, another vessel had to be abandoned, along with many of Dana's samples, after running aground at the mouth of the Columbia River. On Dana's return, his adventurous tales charmed the 19-year-old Henrietta Silliman, and within a month they were engaged.

Dana's Pacific synthesis is presented in several chapters of his expedition report on geology, which Dana drew on for the rest of his career. The expedition's scale prompted him to think globally. Each facet of Pacific geology—atolls, the radially dissected volcano of Tahiti, the islands of Samoa that are studded with small volcanic cones, the grand natural theater of the cauldron at Kilauea—is given a chapter, and the whole is concluded almost from the perspective of one looking at a globe in a study. The islands occur in concentric chains, each active only at one end. Toward the other end, the deeply eroded volcanoes eventually disappear beneath the waves. Only tiny coral resists, and sustains a reef, first at the shore of the volcano, then farther away, and finally bounding only the waters of an atoll lagoon. Darwin, of course, said this first, as Dana always acknowledged, but Dana actually had the idea independently, and in Sydney, Australia, he was nonplussed to read a newspaper account of Darwin's first publication on the evolution of reefs.

Dana, however, added key facts, establishing that embayments of the volcanic stumps within the lagoons are drowned, deeply subsided remnants of river valleys that could not have been carved by waves. Also, the corals finally die, and the atolls slip beneath the waves. Later, in his volume on corals, Dana predicted the existence of deeply submerged, drowned atolls, today's guyots, in the far western Pacific. In 1849, Dana also contrasted the linear chains with the arcuate ones bounding the Pacific basin, which generally occur in regions of uplift, and are active all along their lengths.

Dana was adept at grand geological synthesis. His four most important concepts were: (1) understanding the patterns of age progression and subsidence of linear volcanic chains in the Pacific based on extents of erosion and relationship to offshore reefs; (2) the geological distinction between continents and ocean basins, and the doctrine that both are permanent features of the globe; (3) the place of geosynclines (a term he coined) in orogeny; and (4) the concentric accretion of mountain belts about the ancient interior of the North American continent. All of these are foreshadowed in his report *Geology*.

To Dana, the principal physiographic features of the Pacific basin are geologically young, although they rest on ancient rock, and there are two dynamic domains. One is in the middle of the basin—the linear, volcanically active ridges; the other is at the edges of the continents—the arc volcanoes and active mountain belts. The arcs bound much older, inactive interiors. The arrangement results from contraction of a cooling globe. The Pacific basin is that portion of the globe where hot volcanic material has long vented to the surface and is resisting contraction; the continents are cold and disrupted at their margins, where the surface of Earth is currently taking up the shrinkage. Continental interiors carry the ancient history of this process and gradually increased in area as Earth shrank throughout geological time. The ocean basins and continents are thus separate, permanent, and very different geologically. Dana doubted the existence of submerged continents beneath the great oceans, believing them to grow outward at their edges *toward* the ocean basins, which are mainly basaltic constructs. This was decidedly at odds with contemporary thinking, and even with much later tectonic theory, especially that of the eminent Austrian tectonicist, Eduard Suess.

With the decade-long writing of the expedition reports, Dana established the program for his life's work. Still to come were the documentation of accretion of continental crust, formation of geosynclines at the disrupted continental margins, and a role in the complicated Taconic controversy. He wrote thousands of pages, preparing many of the illustrations himself. He suffered vicissitudes of health, including a physical breakdown in his late 40s. Nevertheless, he recovered and actively pursued his science, returning (in more comfort) to Hawaii in his 70s to prepare for his volume on volcanoes, revising his texts, answering a huge correspondence, and writing papers until a few days before he died.

Even with the hindsight of plate tectonics, Dana's concepts are surprisingly modern. He contributed the core observations that form the basis of the Wilson-Morgan hypothesis of the passage of plates over hot spots, producing linear island chains in their wake. Only after his death did geophysics firmly dispose of the idea of contracting Earth. After that, no other tectonic hypothesis held as much sway until the advent of plate tectonics. Plate tectonics confirmed the contrast in age and structure between continents and ocean basins, and their permanent, albeit shifting, configuration. It finally involved the distinctive character of the ocean basins in a truly global synthesis.

Dana held no strictly uniformitarian view of Earth history. A devout Christian, Dana had a New Englander's properly Protestant view of the direction of Earth history. At one scale, he saw this in the progressive volcanism, erosion, and subsidence of linear volcanic chains. At another, the continents themselves have grown, and life itself has changed form in many ways; always, in Dana's view, becoming more complex, accordingly as the area of land increased and global climate became more rigorous. This was plan, not chance. The paleontologist in Dana saw this, from a very nineteenth century phrenological perspective, in the growth and shape of the skulls of vertebrates. Thus a benevolent creator, whom Dana termed the "Power Above Nature," prepared Earth for the benefit of His children, who are at the present end point of history. Such sentiments pervade Dana's writing, as one might expect from a man who led Bible studies, played the piano for his church choir, and prayed with his family over meals.

One's system of beliefs often contributes to scientific hypothesis. Dana had outlooks that are difficult to reconstruct and experiences that are impossible to re-create. Dana's work is remarkable because he was able to make so much out of what we today would consider so little. His mind arched broadly and with great discipline over many topics. Within his final, chosen field of geology, his influence was pervasive and extends even to us today.

Acknowledgments

This summary is drawn mainly from Gilman (1899), Prendergast (1978), Viola and Margulis (1985), and Dana's Geology (1849) of the Exploring Expedition. I thank Michele Aldrich, R.H. Dott, Gerard Middleton, and R.N. Ginsburg for thoughtful comments on the manuscript.

Further Reading

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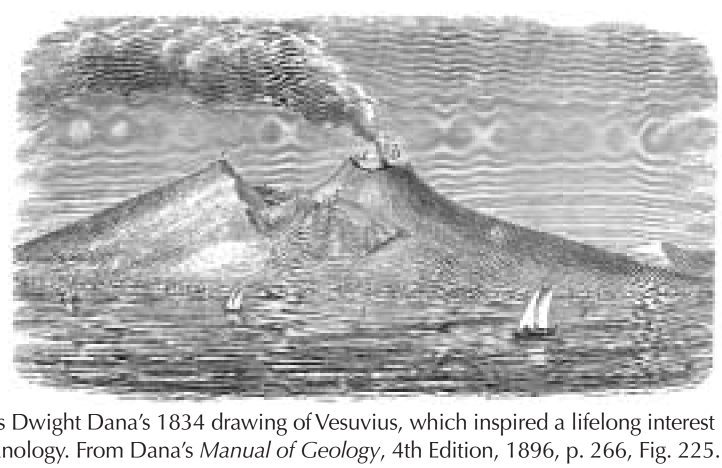

James Dwight Dana's 1834 drawing of Vesuvius, which inspired a lifelong interest in volcanology. From Dana's *Manual of Geology*, 4th Edition, 1896, p. 266, Fig. 225.