Field Notes from the Editor

A Deeper Look at Uniformitarianism

by Mark A. Gonzalez

May and June are months when my colleagues and I must complete last year's geologic maps before embarking on new assignments. Over the winter months, we invariably discover some discrepancies or problems, which require that we revisit a few places in the spring before we submit our maps and reports. I enjoy this part of the study when I transcribe geology from a field map to an office map or the computer. I retrace traverses across the contours of the map and, with photographic precision, flash back to specific outcrops, vistas, sights, sounds, and smells. My field maps are diaries—much of what I write on the field map is never incorporated into the published map and report. The margins are crammed with notes on everything from geologic observations and wildlife observations to field expenses and mileage logs. For example, one notation reads "Sprague's Pipit heard larking, May 5." Another symbol with a date means "Nest, Long-eared Owl," or "Nest, Golden Eagle." Another scribble reads "Pasque flowers in profuse bloom, April 27." Other symbols mark outstanding copses of juneberries, chokecherries, or wild plums, which will be harvested at the appropriate time. Some buddies ask me to obtain Global Positioning System (GPS) coordinates of trophy deer and elk. I decline as that denies them the pleasure of self-discovery; it takes the hunt out of a hunt.

While reviewing field notes from my current mapping project, I was struck by the frequency with which certain strata were noted, such as rip-up clasts, flood deposit, convolute bedding, volcanic ash deposit. Each represents a sudden, momentous event in geologic time. The stratigraphic record is definitely biased toward catastrophe. The products of ordinary, every-day forces are not the norm in most stratigraphic sequences. Consider this bias when contemplating one of the most fundamental principles of geology, *uniformitarianism*.

Virtually every student is introduced to uniformitarianism at the beginning of an introductory course in geology. The Scotsman Sir Archibald Geikie is credited with the most succinct and most oft repeated description of uniformitarianism: "The present is the key to the past." Geikie's definition serves as a model of how uniformitarianism is used to interpret geologic features and to reconstruct geologic events. For example, by carefully observing the landforms and deposits of a modern-day margin of a continental glacier, geologists can ostensibly locate the margin of now extinct glaciers by recognizing similar deposits and/or landforms even where no ice exists today. Similarly, the features of modern lava flows and volcanic deposits permit geologists to reconstruct past volcanic eruptions, even in areas where volcanic activity has been dormant for all of human history.

But uniformitarianism was not always a central concept of geology, and today, it has some faults and limitations. A thorough appreciation of uniformitarianism is not only beneficial to the field geologist, for it opens the mind to many alternate possibilities, but also to the lay geologist, who looks at a landscape with a mix of awe and wonder and tries to connect the disjointed fragments of geologic history.

Pre-Uniformitarianism: Catastrophism

In the embryonic days of modern geologic thought, there was no uniformitarianism. Instead, the central geologic paradigm was *catastrophism*. This was the notion that the earth was created and altered to its present state by a series of catastrophic events. Inherit in catastrophism was the notion that the earth was relatively young and earth history was fairly straight-forward, the result of a limited set (as few as one!) of short-lived cataclysmic event(s).

Two schools of catastrophism developed in Europe during the eighteenth century: the Neptunists and the Plutonists. *Neptunism*, derived from Neptune, the Roman god of the seas, basically held that most rocks at the earth's surface precipitated out of the Noachian floodwaters. *Plutonism*, derived from Pluto, the Roman god of the underworld, recognized and emphasized the importance of the earth's heat in the formation of igneous rocks, those rocks formed from volcanic lava or cooling of magma beneath the earth's surface.

The Neptunists were obviously influenced by literal readings of the Old Testament of the Bible and also by the nature of the rocks that were found locally. For example, the German Abraham Gottlob Werner (A.D. 1750-1817), who studied in the mining district near Freiberg, the Italian Giovanni Arduino (1713-1795), who studied sedimentary rocks surrounding Tuscany, and the German Johann Gottlob Lehman (1700-1767), who studied rocks from the Alps to the raised marine platform of northern Germany, all interpreted the rock

sequence as a series of progressively younger sediments deposited from the one great biblical flood of Noah. This interpretation was done without the benefit of modern rock-dating methods and without any recognition of the orderly evolution of plants and animals in the stratigraphic record.

Plutonists, led by their insightful proponent, French geologist Nicolas Desmarest (1725-1815), pointed to all the rocks that had obvious origins in nearby volcanoes. Desmarest had the benefit of studying the volcanic rocks from the Auvergne volcanic field in France. Plutonists advanced geologic thought in two important ways. First, their recognition of igneous rocks meant that "the flood" could not explain the formation of all rocks; and second, Earth's geologic history was far more complex than anything depicted in the Bible, which was never intended to be a geologic textbook.

One of the last of the famous catastrophists was the Frenchman Baron Georges Cuvier (1769-1832). Cuvier was a fairly accomplished paleontologist for his days and began to see that the fossil record was far more complex than the literal readings of Genesis with its story of a single Noachian flood. But being a close personal friend of the Cardinal, and perhaps eager to escape labeling as a heretic, he devised intricate explanations for the discrepancies between his observations of nature and stories of the Bible. His explanations or rationalizations became known as *Cuvier's compromise*. In his compromise, Cuvier suggested that all extinct life forms found in the many layers of rock formed in a dark, mysterious antediluvian period (ante, Latin for before; and diluvium, Latin for deluge or flood). He described the antediluvian time as a period of numerous floods, each of which destroyed life forms with other life forms evolving only to be destroyed in the next flood. Cuvier purposefully defined the antediluvian as a period of unknown duration, which made it compatible with the uniformitarianist's view of deep time. However, Cuvier was careful to distinguish historical time as that time recorded in the Bible. The great deluge was the boundary between historical and geologic times, between natural and supernatural forces, between living and extinct forms of life. Cuvier did not seem to mind that no one had ever found conclusive evidence of the Noachian deluge.

James Hutton and the Birth of Uniformitarianism

James Hutton (1726-1797) was a Scottish physician, gentleman farmer, and an astute observer of nature. He, like Desmarest and other Plutonists, recognized that igneous rocks, such as basalt and granite, formed from molten lava or magma. Hutton used his observations of natural processes to argue that gradual and long-lived erosion of mountains would eventually bevel mountains to little hills, would eventually fill seas with the eroded minerals of continents, and would eventually bury rocks at the surface to such great depths that they would eventually melt and deform from the resultant heat and pressure. Other forces would eventually exhume long-buried rocks and expose them at the earth's surface. None of these processes could be completed without immense time. In a previous *Field Notes* column (*NDGS Newsletter*, vol. 29, No. 2, pp. 3-4), I mentioned that Hutton was a champion in recognizing the immensity of geologic time.

Hutton's observations, augmented by the writing of a successor, Sir Charles Lyell (1797-1875), steered geologists away from the idea of a young earth created by purely catastrophic events to an old earth with a long, complex history. Uniformitarianism held that the results of small geologic events, repeated over vast time, could be quite enormous and phenomenal in scope.

Lyell, a lawyer by training, was so enamored with Hutton's ideas that he argued the case of uniformitarianism versus catastrophism to an absurd degree. Lyell not only espoused Hutton's ideas of uniformity of natural laws and processes (also known as *actualism*), but also argued for uniformity of rates (known as *gradualism*). Lyell's biggest gaff was to argue that earth history, like the Rock Cycle model, was cyclical, with geologic events repeating in time. Carried to an extreme, Lyell argued that even the fossil record was cyclical and that extinct life forms would eventually reappear. Lyell eventually did see the errors of his overzealous proselytizing.

Uniformitarianism and Modern Geology

As the overstated, radical, and indefensible parts of Lyell's interpretations of uniformitarianism were dropped and Sir Geikie's succinct summary became a model for using and interpreting uniformitarianism, geologists began to look at rocks and landforms with an appreciation of both the enormity of time, the awesome effectiveness of a seemingly inconsequential amount of change when repeated over countless millions of years, and the catastrophic nature of the stratigraphic record. Indeed, a careful examination of almost any stratigraphic column in the field or any suit of landforms in a landscape will show that it is not the everyday events of ebb and flood tide, channel flow, or gentle breeze that is preserved in the rock record. Instead, it is the episodic ferocity of hurricanes, the momentary maelstrom of floods, the instantaneous results of volcanic eruptions that leave the greatest mark on the depositional record.

The British stratigrapher, Derek Ager, describes the relative effects of gradualism and catastrophism on the stratigraphic record as the 'Phenomenon of Quantum Sedimentation' (Ager, 1993, p. 84). His proposition is that periodic catastrophes may have a greater net effect than vast periods of gradual change on the geologic record. I liken it to the battlefield mantra, "Long periods of boredom, separated by brief moments of terror." And that description of war is pretty much the essence of the stratigraphic record.

When examining a stratigraphic section, note the types of events that are generally preserved in the geologic record. Everyday events, whereas they are major contributors to

change over geologic time, are eclipsed by the immense forces of short-lived catastrophic events. Years of gradual change are typically ineffective in erasing or obliterating the catastrophic events from the geologic record. Conversely, the shear energy of catastrophic events can obliterate hundreds and thousands of years of gradual change. Therefore, geologists must account for the inherent bias in the stratigraphic record and must reconstruct the everyday processes that are largely missing from or highly fragmented in the geologic record.

The geologic record is little different than human history. Historians say little about common people and ordinary, daily events—the mundane, but wax extensively about extraordinary people and events. Geologic maps and stratigraphic columns contain the scripts of numerous catastrophes spread over immense time. To know what the everyday history and features of the land are like between catastrophes, you'll have to get a hold of the geologists' field maps and field notes, where the locations and dates of ripening fruit trees, larking pipits, nesting raptors, and blooming wildflowers are recorded. You'll have to decipher sometimes cryptic notes scribbled along the margins. You'll have to filter the completely extraneous notes and creatively interpret from a few, sketchy fragments. And, you'll have to hunt for the trophy bucks yourself.

References

I drew heavily upon the following two sources for much of the information in this article:

Ager, Derek V., 1993. The Nature of the Stratigraphic Record (third edition): John Wiley and Sons, New York, 151 p.

Prothero, Donald R., 1990. Interpreting the Stratigraphical Record: W.H. Freeman and Company, New York, 410 p.