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Review of *The Ends of the World: Volcanic Apocalypses, Lethal Oceans, and Our Quest to Understand Earth's Past Mass Extinctions* by Peter Brannen

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The Ends of the World: Volcanic Apocalypses, Lethal Oceans, and Our Quest to Understand Earth's Past Mass Extinctions. By Peter Brannen. New York: HarperCollins Publishers, 2017. 322 pp. \$27.99 cloth.

Most of us have read or seen reports that the so-called Age of Dinosaurs ended about 66 million years ago at the end of the Cretaceous Period. That end was due to the worldwide effects produced by an asteroid collision with the Earth in the Gulf of Mexico in the vicinity of Chicxulub, today a town in the coastal northern Yucatan Peninsula of Mexico. This major extinction event in Earth history, produced by the impact, resulted in huge volumes of debris blown into the atmosphere that reduced light transmission and decreased temperatures for many months, in tsunamis in the Gulf of Mexico and adjacent waters that flowed over adjacent land areas, in impact-generated shock waves in air, water, and Earth that traveled worldwide triggering earthquakes and volcanic eruptions along tectonic plate margins, and in forest fires in the Americas sparked by heat from the impact. It reportedly killed off about 75% of the plant and animal species on Earth that were major parts of ecosystems including the nonbird dinosaurs. The actual overall death toll may have been more or less than 75% because there is no way to estimate the percentage of species that died that had no preservable hard parts, but it certainly killed off many of those species too.

In the words of television pitch people, "But wait, there's more." In his new best-selling book, Peter Brannen, award-winning science writer, takes you on a fascinating trip through the run-up to the end-Cretaceous extinction event and the K-Pg (Cretaceous/Paleogene) boundary, formerly called the K-T (Cretaceous/Tertiary) boundary. That run-up includes the eruptions of the lavas preserved as volcanic rocks of the Deccan Traps in India. The lavas alone covered an area the size of the lower 48 states, but their greatest worldwide effect was the major increase in atmospheric temperatures after the initial cooler climate due to the release of CO₂. That increase lasted millions of years and produced major warming globally.

Brannen interviewed many scientists who studied these events and went on field trips with them to major Cretaceous sites and to those where earlier and later extinction events happened. He presents clear explanations of what is known and not known about all of these events in a largely error-free book.

Brannen details the other four big extinction events in geologic history: the End-Ordovician (about 443 million years ago); the Late Devonian (374 and 359 million years ago); the *really* big one, the End-Permian (252 million years ago); and the End-Triassic (201 million years ago). You might think that all these extinctions were triggered by the effects of bolide impacts, but if you did you would be wrong. The End-Ordovician one was triggered by an oxygen increase and proportionate CO₂ decreases as volcanism declined, by the weathering of exposed rocks that tied up CO₂ in other rocks, and by continental glaciations triggered by global temperature decreases during atmospheric cooling. The Late Devonian extinction was also due in major part to continental glaciations and their effects. These glaciations were triggered by the evolution of land plants and the spread of forests on the lands with concomitant CO₂ declines in the atmosphere.

The End-Permian is another story entirely. There were major glaciations on the continents in the Late

Carboniferous (Late Pennsylvanian in the US) and the earlier Permian, but they didn't result in big die-offs of species. What did in more than 96% of all marine species, some 70% of land vertebrates, many insect species, and the decline of land plant species was probably not impact events, but rather the release of CO₂ from the continental eruptions that produced the Siberian Traps, a vastly larger outpouring than the Deccan, and from the burning of coal deposits beneath the lava flows. This CO₂ enrichment led to global warming on a scale not seen before or after. Volcanism on a lesser scale and its effects also led in part to the End-Triassic event as well.

You might be tempted to ask what these extinctions have to do with us on the Great Plains. All of them impacted what would become the Great Plains we know today and to one not mentioned previously, the End-Pleistocene mass extinction of the so-called megafauna (50,000 years ago to the present), which was mostly a man-made event. We humans do love to eat, after all, and large meat animals were the first to be eliminated, at least in part, by our search for food. But we humans have now long passed that point and are all now taking part in personally funded gigantic experiments in ecosystem change by agricultural displacement of natural ecosystems on land, in enrichment of CO₂ and other gases in the atmosphere, and in the dumping of pollutants like nitrogen compounds on the land that wind up in the oceans and lead to ocean dead zones. No citizen would ever vote to fund such experiments.

Some scientists have named the current age the "Anthropocene," which I think, as some others do, began in 1712 CE with the invention of the steam engine. Those scientists think that our impact will be as big on life as the other big extinction events. Let's hope that they are wrong, but please read Peter Brannen's book to get some better idea than you have currently of what has gone on in the past and what is happening today.

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