

What Caused the Megafaunal Extinctions? The Case Against Bolide Impact.

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Abstract

Firestone has hypothesized that a comet or asteroid may have impacted North America, 12,900 years ago. The impact hypothesis, and the data marshaled in support, do not offer a complete or compelling explanation of the century-long Younger Dryas onset, the delayed megafaunal extinction in the Caribbean, South America, and Arctic islands, or evident expansion of human occupation in the northeastern US soon after the purported event.

Firestone (2009) has compiled a large body of data which he believes provides an explanation for the century-long Younger Dryas onset and the extinction of mammoths and other megafauna. Firestone's case for an impact, however, suffers from a number of internal inconsistencies which will be addressed in this paper. Contrary to Firestone's (2009) interpretations of the data, the impact hypothesis appears to be refuted when we examine the events surrounding the extinction of megafauna and the purported demise of the Clovis culture, particularly in reference to chronology, archaeology, and paleoecology.

Firestone (2009) restricts his focus to North America. However, even more giant mammal species disappeared in South America than in the north, and it seems that they went extinct at least a few hundred years later than the northern animals (Cione et al. 2009, Borrero 2009). How can this be attributed to the same impact hypothesized to have instantaneously caused the North American extinctions? If the megafauna of Florida were killed off by the blast, why weren't the medium-sized ground sloths on the nearby Caribbean islands wiped out until after 5000 cal BP (Steadman et al. 2005, MacPhee et al. 2007)?

If the heat wave generated by a blast in eastern Canada was powerful enough to ignite fires on Santa Rosa Island off the coast of California and immolate the dwarf *Mammuthus exilis* which resided there, why did it not also finish off the

small mammoths of Wrangel Island off Siberia, or those living on the Pribilofs who did not die out until ca. 5000-4000 cal BP (Vartanyan et al. 1995, Martin and Stuart 1995, Arslanov et al. 1998, Guthrie 2004, Crossen et al. 2005)? Caribou around the Great Lakes were not wiped out at the YD onset, nor were bison or deer, cougar, wolves, or bears farther south. Elk (wapiti) and possibly moose appear to have entered the US from Beringia (Guthrie 2006) via an ice-free corridor at the same time humans did (just prior to the YD). If the impact debris can be seen in the Usselo soils of western Europe (a claim rejected by European specialists (van der Hammen and van Geel 2008), why weren't human and animal populations wiped out there, too? I suppose, arguably, that the ostensible cultural and demographic effects of the Laacher See eruption, 200 years prior to YD onset (Litt et al. 2003, Riede 2008), might instead be attributed to the impact).

The people who made Clovis points did not perish, as Firestone (2009) implies, at 12,800 cal BP. They continued to make fluted points of slightly divergent styles in different regions (Folsom, Barnes, Debert, Dalton styles) throughout the ensuing Younger Dryas. In the Northeast and Great Lakes region, closest to the hypothetical impact location, fluted point numbers suggest greater population density in the early years after the YD onset. If this region could support an expanding population of human hunters so soon after an impact, its local ecological effects cannot have been profound or long-lasting. In the Plains, too, Folsom points far outnumber Clovis points.

Firestone (2009) is correct in asserting that the extinction of 35 North American megafaunal genera, and even more genera in South America, was very rapid (Fiedel 2009). Climate change no longer seems a plausible explanation. Hyperdisease is an intriguing possibility that may be unprovable; predation by expanding human hunters (Martin 1967, 2005), and their use of fire to modify the landscape (see Pinter et al. n.d.) appear to be the most likely causes. People with much less sophisticated weaponry seem to have been responsible for extinction of Australian megafauna ca. 46,000 cal BP; a period with no bolide impact and no significant climate changes (Miller et al. 1999, 2005, Gillespie 2008). Overkill admittedly has some untidy loose ends, but so does the impact theory.

Linkage of the supposed blast to the YD onset is problematic. What exactly is being designated as the YD onset? The moment of wind-shift in Europe (Brauer et al. 2008)? Deuterium shift or oxygen isotope changes, or dust changes, in Greenland? These did not happen at exactly the same time, as the NGRIP core now reveals. NGRIP suggests that YD onset was a process that took over a century (Rasmussen et al. 2006, Steffensen et al. 2008).

Adding an impact trigger to the chain of events that has been widely accepted as the cause of the YD --ice sheet melting, sudden massive discharge of meltwater from Lake Agassiz into the North Atlantic, disruption of thermohaline circulation-- (Broecker et al. 1985, 1989, Broecker 1991, 1997) does little to enhance the

credibility of the standard model, which is now looking rather wobbly. No appropriately dated eastern outlet from the lake or megaflood-eroded scablands can be recognized in the region (Lowell et al. 2005).

The Laurentide ice sheet did not fragment and melt catastrophically. It seems to have retreated slowly and persisted as a shrunken mass over Labrador until about 8000 cal BP (Dyke 2004). That would suggest that the main impact, if there was one, was not over this sheet of ice. Most of the Great Lakes, except Superior, had formed prior to 12,900 cal BP; they were not created by an impact at that time.

Let us suppose, with Firestone (2009), there was a major blast over the ice, or the Great Lakes. First, according to this scenario, there would be a great heat/shock wave pulsing out from the point of impact, frying all in its path, then spherules and dust (with nanodiamonds) would waft into the atmosphere and stratosphere and settle out across the Earth over the following months and for a few years thereafter. The carbon spherules (and copal spherules, which I think are a new addition to the literature) in the YDB are, Firestone (2009) says, basically gobs of burnt conifer sap; many are loaded with nanodiamonds both on the outer surface and inside. How could a tree have lived long enough to extrude sap that slowly collected nanodiamonds from the air *before it was burned in the initial shock wave*? The sequence seems inexplicably reversed. And why is a carbon spherule from Santa Rosa Island off California dated to 11,440 $\pm$ 90 (Kennett et al. 2008)? That is several hundred years before the YD onset.

Firestone (2009) might reply that this is just one of many inconsistent radiocarbon dates for the event, atmospheric ^{14}C having been chaotically altered by the blast. There is no obvious explanation for the weird (contaminated?) ^{14}C -enriched dates Firestone reports here on samples from Carolina bays. At an early stage in the development of this hypothesis, Firestone and Topping (2001) proposed that a solar flare or supernova shockwave may have re-set the radiocarbon clock somehow--a proposal refuted by Southon and Taylor (2002). It must be emphasized that, where stratigraphy is undisturbed and contexts are secure, radiocarbon dates from the years before and after the YD onset are not grossly erratic (e.g., the consistent dating of Clovis occupation at the Shawnee-Minisink site in eastern Pennsylvania) (Waters and Stafford 2007).

In conclusion, Firestone (2009) has marshaled considerable data, which are not easily explained in conventional terms, in support of the hypothesis of a bolide impact at 12,900 cal BP. However, it is far from certain whether the basic geological data are replicable (see Surovell et al. 2009). Even if they prove to be so, the hypothesized impact would not explain the staggered, delayed extinction of megafauna in regions peripheral to the impact zone, and the transformation (rather than purported abrupt demise) of the Clovis culture into regionally diversified, descendant Paleoindian cultures.

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