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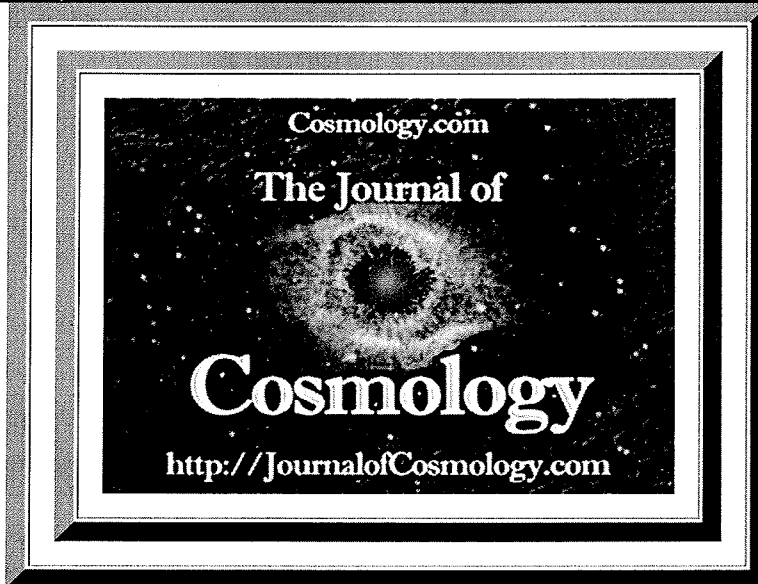
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Desperately Seeking a Cosmic Catastrophe 12,900 B.P.

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Abstract

A catastrophic bolide impact at 12.9 ka has been proposed by Firestone and colleagues to explain Younger Dryas cooling and megafauna extinction in North America. Radiocarbon dating of carbon spherules supposedly formed during this ET event do not support the hypothesis.

Several recent conference abstracts and published papers speculate that an extraterrestrial impact 12,900 years ago (12.9 ka) caused the Younger Dryas cold snap, decimating the Clovis culture and sending the Rancholabrean megafauna in North America extinct (eg. Firestone, et al. 2007; Kennett, et al. 2008; Firestone 2009). This could be judged as another catastrophic ET impact hypothesis in the tradition of Alvarez, et al. (1980) and Hoyle and Wickramasinghe (2001), or as another climate change hypothesis for Late Pleistocene megafauna extinction, in the tradition of Leakey (1966) and Guthrie (2006).

In counterpoint to these and other hypotheses that catastrophic impacts and consequent rapid climate change in geologically recent times caused megafauna extinctions and the decimation of established human cultures, Martin (1973) suggests that "Unless one insists on believing that Paleolithic invaders lost enthusiasm for the hunt and rapidly became vegetarians by choice as they moved south from Beringia, or that they knew and practiced a sophisticated, sustained yield harvest of their prey, one would have no difficulty in predicting the swift extermination of the more conspicuous native American large mammals." Such a 'blitzkrieg' of megafauna extinction by newly arriving modern humans appears to have taken place ~13 ka in North America, ~45 ka in

Australia, and ~1280 AD in New Zealand (e.g. Haynes, 2008; Roberts et al., 2001; Grün, et al., 2006; Wilmshurst et al., 2008), which was certainly catastrophic for the now-extinct megafauna in those locations.

Both the ET impact/climate change and anthropogenic/blitzkrieg extinction hypotheses seem distinctly unpalatable for different subgroups of commentators. My views on these matters can be seen to support Martin's 'blitzkrieg' model in reviews of megafauna extinction (Gillespie, Brook and Baynes, 2006; Gillespie, 2008) and in the popular science book *The Bone Readers: Science and Politics in Human Origins Research* (Tuniz, Gillespie and Jones, 2009). I also support numerical modelling (eg. Brook and Bowman, 2005; Brook and Johnson, 2006) which demonstrates that human predation in formerly human-free lands inevitably leads rapidly to large-body- mass-biased faunal extinction.

Garnering sufficient, and sufficiently compelling, evidence for any of these hypotheses has always been a challenge. In an entertaining saga, Baillie (2003, 2007) follows a convoluted path with many diversions, from frost-damaged treerings through volcanic dust veils, ancient legends, comets and ice cores, to ET events in AD 539, 1014 and 1491. Differently-flavoured sorties in the anthropogenic/climate change extinctions battle have been keenly observed by Fiedel and Haynes (2004) and Haynes (2007).

My focus here is on Firestone (2009) and will be mainly about radiocarbon dating, starting with his Table 3 list of calibrated ^{14}C ages for carbon spherules, glassy carbon, charcoal and woody debris recovered from sediments at the Clovis-age archaeological sites Gainey and Chobot, and from sediments at several of the Carolina Bays. These include the first direct dates on material (carbon spherules and glassy carbon) postulated to result from an ET explosion event over North America at 12.9 ka. Firestone's list contains negative ages as well as the usual positive numbers, which may confuse some players. Reimer et al. (2004a) comment on the negative age output given by some calibration programmes: "While this works mathematically, it is philosophically objectionable, because the decay of ^{14}C used to calculate the ^{14}C age is unrelated to time of formation of a post-bomb sample." Firestone claims that his negative ^{14}C dates on carbon spherules imply that they "are enriched by a factor of »5 in ^{14}C ", presumably because they are supposed to be 12.9 ka cal BP from the ET explosion.

Alternatively, noting that Firestone's carbon spherules differ significantly from the saturating ^{14}C abundance in meteorites (eg. Jull, et al., 2000) and $^{13}\text{C}/^{12}\text{C}$ ratios are not given, we might reasonably assume that Firestone's samples are derived from terrestrial biogenic sources, whether there was an ET event or not. Carbon-rich spherules, glassy carbon and charcoal are all known products of high-temperature combustion, including wildfires, and taking into account that atmospheric radiocarbon abundance almost doubled in the 1960s (due by the detonation of nuclear weapons, known as the 'bomb effect'), the most parsimonious interpretation of the carbon spherule ^{14}C dates is that they were produced by wildfires within the last 100 years (four are postbomb, one early 20th century). Firestone's ^{14}C dates have impressively small uncertainties (± 15 or 20 years), which implies that small sample size was not a problem, and some of these 20th century carbon spherules have found their way to a depth of 20 cm in the Paleoindian site at Gainey. Similarly, post-bomb ^{14}C results from the Carolina Bays suggest that 20th century terrestrial biogenic material has penetrated to a depth of 163 cm at Myrtle Bay (woody debris) and 145 cm at Blackville Bay (charcoal), and there is no sensible age/depth relationship for any of the sites.

All radiocarbon labs have numerous examples like this, and further work usually points the finger at incorrect sampling or faulty decontamination chemistry, but the data provided in Firestone (2009) is insufficient to judge if there problems like these exist. Given the large numbers of spherules found by Firestone and colleagues at many well-dated Clovis-age archaeological sites, it would be a valuable exercise to measure their carbon isotope abundances and determine if the spherules were formed by the 12.9 ka impact or not. Modern AMS dating facilities can measure very small samples, and it would be feasible to measure the ^{14}C ages of individual high-carbon spherules, similar to the way modern luminescence dating facilities measure single sand grains to estimate age populations for sediments (eg. Roberts et al., 2000).

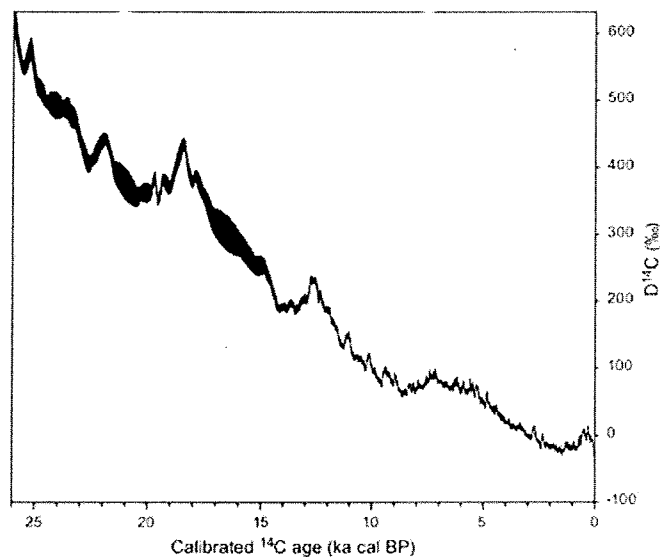


Figure 1 The IntCal04 radiocarbon calibration curve 0–26 ka plotted from data referenced in Reimer et al. (2004b), showing 1 std. dev. envelope of uncertainty.

There is also a problem with Figure 9 in Firestone (2009), which misleadingly shows only a small part of the IntCal04 radiocarbon calibration curve; the curve runs from 0-26 ka cal BP (shown here in Figure 1, plotted from data referenced in Reimer et al. 2004b) and has many wiggles. The peak in question does not imply that atmospheric ^{14}C abundance doubled or tripled at 12.9 ka cal BP, as Firestone claims; the curve plots ^{14}C measurements on natural samples of independently known age (eg. tree-rings, corals and sediments with annual to decadal resolution) relative to the oxalic acid modern standard, reflecting mainly geomagnetic field variation which affects the production rate of ^{14}C in the atmosphere, as well as atmospheric abundance variations due to global carbon-cycle changes. Firestone et al. (2007) provide more analytical data from many sites in support of an ET event at 12.9 ka, but Firestone (2009) insists that his ^{14}C dates on carbon-rich materials from Gainey, Chobot and the Carolina Bays must be wrong because they don't fit either the stratigraphy or his assumed association with the cosmic catastrophe.

Baillie's historical comets are much too young to be relevant for the Younger Dryas, but what about the one proposed by Hoyle and Wickramasinghe (2001)? The problem here is that a comet was supposed to have landed in the ocean, creating a water-vapour greenhouse effect sufficiently strong to terminate the YD at 11.7 ka b2k, whereas Firestone's bolide exploded in the atmosphere, melting the Laurentide ice sheet to initiate the YD at 12.9 ka cal BP. Incidentally, I find the 50-year difference between the cal BP (^{14}C -based, AD 1950 is zero) and b2k (ice corebased, AD 2000 is zero) timescales to be a counterproductive nuisance, which needs to be resolved by the relevant organisations. After all, both are projections on the same calendar scale we all use in daily life, and 50 years could mean looking in the wrong stratigraphic layers for debris from these proposed bolides which either started or ended the YD cold snap.

Reimer and Hughen (2008) illustrate the significant ^{14}C dating problems around the start of the YD interval, which unfortunately falls just off the end of the absolutely-dated tree-ring record running to 12,400 cal BP. Depending upon which calibration curve and computer programme you choose, the resulting calendar age could lead or lag an event precisely dated by other means. There are many dating problems with the ice cores too (eg. Southon, 2002), and I have strong reservations about some of the conclusions Firestone et al. (2007) and Firestone (2009) draw from the ice core analytical results. But it also seems remarkable that the carbon-rich materials found so abundantly at Clovis-age sites and the Carolina Bays have not been noticed in the Greenland records. A lot of ice has been melted for high-resolution analysis, and if North America was on fire spreading combustion products throughout the USA, the Channel Islands off California and across the Atlantic to Belgium (Firestone, et al., 2007; Kennett, et al., 2008), one might be forgiven for thinking that a black carbon signal should be strong in Greenland ice cores of appropriate age.

On the other hand, archaeological sites are exactly where you expect to find carbon-rich materials, so the analysis of accurately dated terrestrial sediments from non-archaeological sites in the 12.9 ka age range might also be instructive. Laminated varve sequences in Europe offer sub-annual resolution across the Allerød to Younger Dryas

transition (e.g. Brauer, et al., 2008), and no doubt similar sediments occur in North America.

Of course it may turn out that Firestone and colleagues are right: there really was an ET event which kick-started the Younger Dryas cooling, decimated the Clovis culture and caused the Rancholabrean megafauna extinction. However, I support the archaeological and logical criticisms of the YD bolide hypothesis in Surovell, et al. (2009), Hamilton and Buchanan (2009) and Fiedel (2009), and the impeccable stratigraphic analysis of Clovis-age sites by Haynes (2008), all of which make the case look decidedly wobbly. My interpretation of results from the best test of the hypothesis so far, the ^{14}C dates on carbon spherules in Firestone (2009), discredits it even further.

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