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Forum Comment

Direct U-Pb dating of Cretaceous and Paleocene dinosaur bones, San Juan Basin, New Mexico

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Fassett et al. (2011*)* claim to have accomplished the "first successful direct dating of fossil vertebrate bone," providing "a new methodology with the potential to directly obtain accurate dates for any vertebrate fossil" (p. 159). There are shortcomings, however, with the method used to extract U/Pb ages from the U/Pb isotopic analyses.

CORRECTION FOR COMMON Pb

The Pb in the analyzed samples is mostly "common" (that is, Pb unrelated to the radioactive decay of uranium in the samples), having a typical $^{206}Pb/^{204}Pb$ of ~24. How the very large correction for common Pb was made is not mentioned in Fassett et al., and most readers will assume that the usual method of using ^{204}Pb as the index isotope was followed (an isochron approach is seemingly ruled out, as only individual sample ages and errors are presented). However, examination of Fassett et al.'s data reveals that the common Pb index isotope was ^{207}Pb, requiring an estimate for the common $^{207}Pb/^{206}Pb$ ratio, and solving for the age that forces the $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ages into concordance. But two questions are left unanswered by Fassett et al., each of which is essential to evaluation of the accuracy and precision of their ages:

1) Why use the ^{207}Pb correction method (generally reserved for analyses with very imprecise or missing ^{204}Pb measurements) when the precisions of both the $^{206}Pb/^{204}Pb$ ratios and associated ^{204}Pb-corrected ages are, if anything, somewhat better than that of the $^{207}Pb/^{206}Pb$ ratios and associated ^{207}Pb-corrected ages? Note that Fassett et al. nowhere indicate that their $^{206}Pb/^{204}Pb$ measurements and precisions are any less valid than those of $^{207}Pb/^{206}Pb$.

2) Given that any ^{207}Pb-corrected ages calculated from the Fassett et al. data are very sensitive to the choice of common $^{207}Pb/^{206}Pb$ values, what values were actually used, and how they were selected? Without such information, the objectivity and reliability of the claimed ages is impossible for any but the most dedicated and specialized reader to evaluate.

However, back calculation of the data in Fassett et al.'s table DR1 shows that, for the control bone, three values for the common $^{207}Pb/^{206}Pb$ ratios were selected—0.794, 0.821, and 0.836 (give or take 0.001). There is every indication that, rather than being assigned on the basis of some (unmentioned) objective criterion such as $^{238}U/^{204}Pb$ ratios, sample location, chemistry, or mineralogy, the three common $^{207}Pb/^{206}Pb$ values were obtained by extracting arbitrary subgroups of the control analyses that clustered along different linear regressions (isochrons) on the $^{238}U/^{207}Pb$-$^{207}Pb/^{206}Pb$ diagram. The Y-intercepts of these regressions were then recycled for calculation of the individual ages reported in the Fassett et al. tables. The same type of approach seems to have also been used for sample BB-1, though in this case all analyses were used to determine the common $^{207}Pb/^{206}Pb$ intercept.

Such a procedure, however, is mathematically circular. If the common-Pb ratios used for calculation of individual ages are derived from an isochron fit to the data suite as a whole, complex sample-to-sample error correlations are forced on the individual ages. In fact, no amount of recycling of the isochron results into individual sample ages followed by simple weighted-mean calculations can improve upon the precision or accuracy of the isochron age.

EXTREME DATA CULLING

Out of 127 U-Pb analyses for the control bone (Fig. 1), 55 were rejected for falling outside an arbitrary 70–80 Ma age window (not 60–80 Ma as stated in Fassett et al.), and 47 rejected for having $^{238}U/^{204}Pb$ >500. The remaining 25 analyses are referred to as "unaltered parts of bone" (p. 160), implying that the other 102 samples are altered—in most cases based solely on the failure of their ages to fall within their entirely arbitrary 70–80 Ma acceptance window.

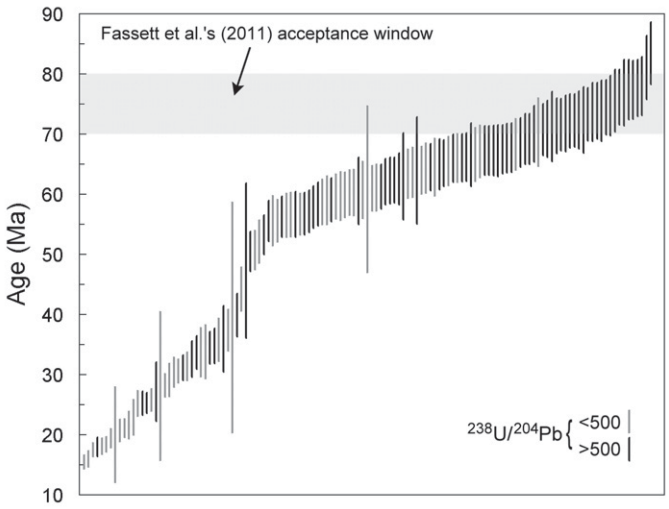

Figure 1. U/Pb ages from Fassett et al. (2011) of control bone 22799-D. Similar to Fassett et al.'s figure 3B, except that all samples are plotted. Note the lack of any discontinuity at the 70 Ma cutoff imposed by Fassett et al.

It is not surprising that exclusion of all ages falling outside a window whose midpoint is close to the desired age target of 73 Ma, and whose half width is similar to the individual age errors, yields a mean close to the target age, and a mean square of weighted deviates near 1. However, to regard the resulting age and uncertainty as meaningful, and a validation of their technique on any other such sample, cannot be justified.

DATA FOR SAMPLE BB-1

Concerns regarding common-Pb correction also affect sample BB-1. In common with analyses on the control bone, the BB-1 $^{206}Pb/^{204}Pb$-$^{238}U/^{204}Pb$ ratio pairs give very different results than the $^{238}U/^{206}Pb$-$^{207}Pb/^{206}Pb$ system used for Fassett et al.'s calculations. For example, the $^{206}Pb/^{204}Pb$-$^{238}U/^{204}Pb$ isochron age for the BB-1 longitudinal samples is 55 ± 3 Ma, compared to Fassett et al.'s 64.8 ± 0.9 Ma (which is essentially a $^{238}U/^{207}Pb$-$^{207}Pb/^{206}Pb$ isochron age). This discrepancy (which must arise either from unrecognized analytical problems, a history of open-system behavior, or highly variable common Pb) is neither acknowledged nor discussed in Fassett et al.

REFERENCES CITED

Fassett, J.E., Heaman, L.M., and Simonetti, A., 2011, Direct U-Pb dating of Cretaceous and Paleocene dinosaur bones, San Juan Basin, New Mexico: Geology, v. 39, p. 159–162, doi:10.1130/G31466.1.