Forum Comment

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

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Based on U-Pb dating of two dinosaur bones from the San Juan Basin of New Mexico (United States), Fassett et al. (2011) claim to provide the first successful direct dating of fossil bones and to establish the presence of Paleocene dinosaurs. Fassett et al. ignore previously published work that directly questions their stratigraphic interpretations (Lucas et al., 2009), and fail to provide sufficient descriptions of instrumental, geochronological, and statistical treatments of the data to allow evaluation of the potentially complex diagenetic and recrystallization history of bone. These shortcomings lead us to question the validity of the U-Pb dates published by Fassett et al. and their conclusions regarding the existence of Paleocene dinosaurs.

Nearly all fossilized bone is recrystallized after burial; however, the durations of recrystallization are typically poorly constrained. Modeled durations range from hundreds to millions of years (Herwartz et al., 2011; Koenig et al., 2009, and references therein). Kocsis et al. (2010) and Herwartz et al. (2011) present Lu-Hf geochronology data for 72 bones that showed prolonged episodes of trace-element uptake and open system behavior during recrystallization. Both studies demonstrate that the chemical complexity of fossilized bones led to a wide range of ages. Fassett et al.'s failure to present geochemical data that provide insight into the process and duration of recrystallization undermines their conclusion that their age estimates are closely associated with time of death and early fossilization of the dinosaurs in question. Without greater knowledge of the recrystallization process and its duration, it is difficult to interpret what useful information, if any, can be derived from U-Pb or Lu-Hf dating efforts on fossil bone.

Fassett et al. present the first use of laser ablation–multicollector–inductively coupled plasma–mass spectrometry (LA-MC-ICP-MS) U-Pb dating of fossil bone, but their reference to U-Pb dating studies of igneous zircon and titanite as being similar to the methods for recrystallized apatite is unsupported. Chew et al. (2011) present the detailed methodology required to ensure valid LA-MC-ICP-MS U-Pb geochronology of apatite. In addition, details regarding the statistical treatment and rejection of outliers for bone 22799-D, which clearly shows open U-Pb system behavior, are insufficient. Moreover, Fassett et al.'s choice of data points used to produce the mean $^{238}U/^{206}Pb$ date of 73.6 ± 0.9 Ma seems arbitrary, and no criteria for rejecting analyses with identical $^{238}U/^{204}Pb$ values and dates >80 Ma and <70 Ma are given. The paper uses ^{238}U-^{206}Pb ages but provides no details on the common-Pb correction and its associated uncertainty. Relatively low measured $^{206}Pb/^{204}Pb$ ratios in dinosaur bone BB1 (a median value of 24.1) will result in significant ^{238}U-^{206}Pb age biases if an inaccurate common-Pb correction is applied. To avoid this, a $^{238}U/^{204}Pb$-$^{206}Pb/^{204}Pb$ isochron approach not requiring a priori knowledge of the appropriate common Pb should have been used. A $^{238}U/^{204}Pb$-$^{206}Pb/^{204}Pb$ errorchron for the longitudinal section 1 of the reference sample 22799-D of Fassett et al. (2011, their Table DR1 in GSA Data Repository item 2011069) gives an apparent age of 47.1 ± 8.1 Ma with a mean square of weighted deviates (MSWD) value of 140. This indicates that points scatter beyond analytical errors, and confirms the open-system behavior of U-Pb. The $^{238}U/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ isochron method applied to dinosaur bone BB1 yields a calculated age of 60.9 ± 3.5 Ma (2σ, MSWD = 11.9) and initial $^{206}Pb/^{204}Pb$ of 20.43 ± 0.17. This errorchron age is younger and less precise than the Fassett et al. value of 64.8 ± 0.9 Ma. Judging from the reported percentage of radiogenic ^{206}Pb, we estimate that the $^{206}Pb/^{204}Pb$ ratio for the common-Pb correction was ~19.9. The difference between the two estimates of common Pb causes an appreciable bias in the ages reported by Fassett et al.

Finally, bone BB1 is from the Naashoibito Member of the Ojo Alamo Sandstone, which yields many index taxa of vertebrate fossils known from Upper Cretaceous units elsewhere, notably in Texas and Utah. No convincing biostratigraphic data establish a Paleocene age for this bone (Lucas et al., 2009). Fassett (2009, p. 12) states that bone BB1 came from a stratigraphic level "in the lowermost part of Chron C29n," and BB1 lies just above strata dated at 65.2 Ma. Lucas et al. (2009) published a detailed critique of Fassett's (2009) interpretation of the magnetostratigraphy across the Cretaceous-Tertiary (K/T) boundary in the San Juan Basin. Fassett et al. fail to address the conclusions of Lucas et al. (2009) and the consensus view that the K/T boundary in the San Juan Basin is well above the stratigraphic level of dinosaur bone BB1.

Given the importance of accurate and precise age determinations for assigning a Paleocene age to dinosaur bones, we contend that there should have been a more rigorous validation of the dating methods and verification of ages from additional samples beyond those presented by Fassett et al. These weaknesses, combined with the large uncertainty of recrystallization duration of the bones in question, and the contradictory biostratigraphic and magnetostratigraphic placement of the K/T boundary in the San Juan Basin, provide enough doubt to reject the results and interpretations of Fassett et al. We conclude that Fassett et al. have failed to provide the extraordinary evidence needed to support the extraordinary claim that dinosaurs survived the K/T impact event and lived into the Paleocene.

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