

A Late Eocene date for Late Triassic bird tracks

ARISING FROM R. N. Melchor, S. De Valais & J. F. Genise *Nature* **417**, 936–938 (2002)

Bird-like tracks from northwest Argentina have been reported as being of Late Triassic age¹. They were attributed to an unknown group of theropods showing some avian characters. However, we believe that these tracks are of Late Eocene age on the basis of a new weighted mean ²⁰⁶Pb/²³⁸U date (isotope dilution–thermal ionization mass spectrometry method) on zircons from a tuff bed in the sedimentary succession containing the fossil tracks. In consequence, the mentioned tracks are assigned to birds and its occurrence matches the known fossil record of Aves.

The redbed sequence of the former Santo Domingo Formation yielded several-hundred bird-like footprints, which were assigned to *Gruipeda dominguensis* (the most common ichnotaxon), cf. *Alaripeda* isp., and another taxonomically indeterminate bird-like footprint². The age of the stratigraphic unit was considered to be Late Triassic on the basis of known fossil wood remains and geochronological information from basalt lava flows thought to be interbedded in this unit^{1,3,4}. Further geological studies revealed that the Santo Domingo Formation contains several thrust sheets of different ages, and that the trace-fossil-bearing horizons belong instead to the recently proposed Laguna Brava Formation, in a thrust sheet separate from the one that contains the dated basalt and fossil wood remains⁵. A 12-cm-thick crystal-rich ash-fall tuff within the thrust sheet with the bird-like footprints was sampled for this study for U–Pb zircon geochronology (supported by US National Science Foundation grant EAR 0931839 and ANPCyT PICT 13286 from Argentina). This tuff lies 38 m below the first layer with definite *G. dominguensis* and 124 m below the main horizon with hundreds of *G. dominguensis*⁶. There is no stratigraphic discontinuity between the tuff bed and the footprint-bearing levels. Zircon grains were separated from the tuff using conventional methods and were dated using high-precision chemical abrasion–isotope dilution–thermal ionization mass spectrometry (CA-ID-TIMS)^{7,8}. The tuff yielded abundant clear, long bipyramidal (150 μm and 250 μm) and sharply faceted zircons. The five youngest analyses from a total of nine form a coherent cluster with a weighted-mean ²⁰⁶Pb/²³⁸U date of 37.222 ± 0.018/0.024/0.047 million years (Myr) ago (internal uncertainties/with tracer calibration uncertainties/with decay constant uncertainties; mean square of weighted deviation = 1.6) (Fig. 1 and Table 1).

Therefore, we suggest that the maximum age for the bird tracks of the Laguna Brava Formation of northwest Argentina (including *G. dominguensis*) is Late Eocene (Bartonian/Priabonian⁹), and matches the known fossil record of birds. Recent studies¹⁰ documenting possible

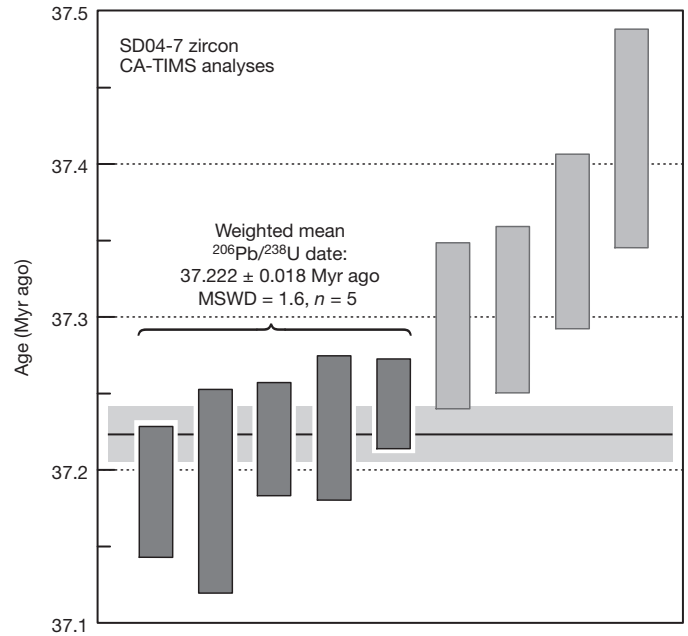


Figure 1 | Date distribution plot for analysed zircons from tuff sample SD04-7 from the former Santo Domingo Formation (now considered as part of the Laguna Brava Formation). The y axis shows measured ²⁰⁶Pb/²³⁵U age (see Table 1 for complete analytical data). Data acquisition, reduction, error propagation and plotting were done using EARTHTIME supported statistical methods¹² and the U-Pb_Redux software package¹³. Bar heights are 2σ analytical uncertainties; dark/light grey boxes signify analyses included/excluded from age calculation, respectively. The shaded horizontal band and its width represent the calculated weighted mean age and its 2σ analytical error. MSWD, mean square of weighted deviation; n, number of analyses included in the calculated date.

Table 1 | U–Pb data for analysed zircon from tuff sample of the Laguna Brava Formation

| Sample fractions† | Composition | | | | | Ratios | | | | Age (Myr ago) | | | | Corr. coef. | | |
|-------------------|------------------------|----------------------|------|---------------------------------------|--|--------------------------------------|-------------|--------------------------------------|-------------|---------------------------------------|-------------|-------------------------------------|--------------|-------------|-------------------------------------|--------------------------------------|
| | Pb _c ‡ (pg) | Pb*‡/Pb _c | Th/U | ²⁰⁶ Pb‡/ ²⁰⁴ Pb | ²⁰⁸ Pb / ²⁰⁶ Pb | ²⁰⁶ Pb¶/ ²³⁸ U | Error (2σ%) | ²⁰⁷ Pb¶/ ²³⁵ U | Error (2σ%) | ²⁰⁷ Pb¶/ ²⁰⁶ Pb | Error (2σ%) | ²⁰⁶ Pb/ ²³⁸ U | Error (2σ) | | ²⁰⁷ Pb/ ²³⁵ U | ²⁰⁷ Pb/ ²⁰⁶ Pb |
| SD04-7 | | | | | | | | | | | | | | | | |
| z2 | 0.8 | 7.8 | 0.90 | 441.2 | 0.287 | 0.005821 | (0.19) | 0.03811 | (2.31) | 0.04750 | (2.27) | 37.417 | 0.071 | 37.98 | 74 | 0.23 |
| z3 | 1.4 | 21.1 | 0.74 | 1,211.7 | 0.238 | 0.005804 | (0.15) | 0.03765 | (0.83) | 0.04707 | (0.81) | 37.305 | 0.054 | 37.53 | 52 | 0.26 |
| z4 | 0.7 | 21.8 | 0.65 | 1,281.5 | 0.207 | 0.005785 | (0.12) | 0.03728 | (0.90) | 0.04676 | (0.87) | 37.186 | 0.043 | 37.16 | 36 | 0.32 |
| z5 | 0.5 | 48.2 | 0.67 | 2,792.1 | 0.214 | 0.005791 | (0.10) | 0.03753 | (0.39) | 0.04702 | (0.36) | 37.221 | 0.037 | 37.41 | 49.4 | 0.33 |
| z7 | 0.5 | 22.1 | 0.62 | 1,305.7 | 0.198 | 0.005802 | (0.15) | 0.03752 | (0.82) | 0.04692 | (0.80) | 37.295 | 0.054 | 37.40 | 44 | 0.27 |
| z8 | 1.3 | 11.2 | 0.59 | 673.2 | 0.190 | 0.005792 | (0.13) | 0.03747 | (1.52) | 0.04694 | (1.49) | 37.228 | 0.047 | 37.35 | 45 | 0.27 |
| z9 | 0.7 | 26.5 | 0.62 | 1,561.8 | 0.199 | 0.005811 | (0.15) | 0.03737 | (0.72) | 0.04666 | (0.69) | 37.350 | 0.057 | 37.25 | 31 | 0.32 |
| z10 | 1.6 | 13.7 | 0.73 | 791.2 | 0.234 | 0.005785 | (0.18) | 0.03727 | (1.83) | 0.04674 | (1.73) | 37.187 | 0.066 | 37.15 | 35 | 0.60 |
| z11 | 0.5 | 46.6 | 0.59 | 2,756.2 | 0.189 | 0.005794 | (0.08) | 0.03728 | (0.44) | 0.04669 | (0.41) | 37.244 | 0.029 | 37.17 | 32.4 | 0.43 |

Corr. coef., correlation coefficient. Pb* is radiogenic Pb concentration. Age calculations are based on the decay constants of ref. 11.
 †All analyses are single zircon grains and pre-treated by the thermal annealing and acid leaching (CA-TIMS) technique. Data used in age calculations are in bold.
 ‡Pb_c is total common Pb in analysis.
 §Measured ratio corrected for spike and fractionation only.
 ||Radiogenic Pb ratio.
 ¶Corrected for fractionation, spike, blank and initial Th/U disequilibrium in magma. All common Pb is assumed to be blank. Total procedural blank was less than 0.1 pg for U. Blank isotopic composition: ²⁰⁶Pb/²⁰⁴Pb = 18.42 ± 0.35; ²⁰⁷Pb/²⁰⁴Pb = 15.36 ± 0.23; ²⁰⁸Pb/²⁰⁴Pb = 37.46 ± 0.74.

BRIEF COMMUNICATIONS ARISING

landing trace fossils and probing marks closely associated with *G. dominguis* strongly suggested a younger age for the host sedimentary succession. Re-definition of stratigraphic units in this region and further supporting geological and palaeomagnetic evidence have been published elsewhere⁵.

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