ARGENTINE IMPACT RECORD: IMPLICATIONS FOR THE LATE CENOZOIC CRATERING RATES

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INTRODUCTION: Impact glasses occur in at least six different stratigraphic horizons within the Pampean sediments of Argentina. Radiometric dates accurately establish their contrasting ages consistent with their stratigraphic setting, and various studies are documenting key shock indicators in each set of glasses [1-5]. The seemingly large number of distinct ages of impact glasses could reflect, at least in part, a Northern hemisphere perspective where repeated Pleistocene glaciations eroded, buried or erased the true impact cratering record. But it also may reflect either an incomplete understanding of atmospheric entry or perhaps even an increased flux rate of interplanetary debris during the late Miocene.

IMPACT RECORD: Diagnostic shock features occur within impact glasses of Pleistocene (6ka, 115ka, 450 ka), Pliocene (3.27 Ma), early Miocene (5.28 Ma), and Miocene (9.3 Ma). These glasses occur at specific stratigraphic horizons in various exposures throughout southern Buenos Aires Province and are the result of objects of sufficient size to survive atmospheric entry at velocities sufficient to generate high temperatures (melting), shock features, and mixing with subsurface units in at least two four cases. The nature of the Pampean sediments (loess) provides a unique setting for capturing and preserving proximal and distal glasses over the last 10 m.y..

CRATERING RATES: Disparities between predictions for terrestrial crater production rates depend on different approaches and assumptions: above-atmosphere flux rates as a basis for the cratering production rate [6-8]; downward extrapolation of the terrestrial cratering record [1,7]; rates of observed atmospheric bursts [e.g., 9]; and theoretical models of atmospheric disruption and survival [e.g., 10-11].

Each approach for assessing the likelihood of melt-generating impacts has limitations. The use of either the lunar cratering rates or observations of Near-Earth crossing Asteroids (NEA's) cannot be simply extrapolated to the surface of the Earth without model assumptions for the survival during atmospheric entry. Estimates of the expected production of craters subject to models of atmospheric disruption [10] yield cratering rates a factor of 100x less than the above-atmosphere rate, 20x less than predictions by [7], and still about 10x less than extrapolations from large to small craters.

When specifically applied to the cratering rate in all of South America, Bland et al [11] estimated that 18 craters > 10 km, 1 crater > 1 km, and 200 Campo del Cielo events should have occurred. About 200 small asteroids larger than 50 m across should have encountered the upper atmosphere over the last 10 m.y. over an area covered by the Argentine Pampean sediments (~106 km2) based on rates in [12]. Their best-fit atmosphere-disruption model predicts, however, that a 50m object would strike the surface with only a 1-in-5 chance in 10 m.y. over 106 km2. Although 100 objects greater than 3–5 m across could have actually impacted over 10 m.y., most (95%) of them would have been irons (possible forming 100 m-diameter craters). For comparison, other studies of the observed flux of bolides (atmospheric bursts) from satellite data [e.g.,9] yield about 20 objects > 50 m in diameter (Tunguska-class), 6 objects > 75 m, and 3 objects > 100 m over an area of 106 km2 in the last 10 m. y.

If the observed production rate of larger craters (> 20 km) is simply extrapolated downwards to smaller craters (1-10 km), then higher cratering rates since the Miocene in Argentina naturally result [e.g., 1]. For example, more than 900 craters with diameters (D) greater than 10 km should have occurred globally over the last 100 m.y. based on the asteroid flux rates [6]. If the production rate depends on D-2, then the Pampean sediments covering one million square kilometers could contain ~ 20 craters larger than 1.0 km in diameter over the last 10 m.y., 7 craters over the last 2.5 m.y. and perhaps 3 in the last 1.0 m.y. An even larger number of craters would be expected if the dependence has a larger exponent (D-2.5).

It is possible that impact melts (glasses) can be generated from craters as small as 0.5 km in diameter due to soft sediments; for example, Aeouellel, Monturaqui, and Wabar craters all have large quantities of impact glass. This observation, however, still does not address the role of atmospheric disruption, which is believed to prevent the most likely objects (small stony meteoroids) from contributing to the crater population [10].

IMPLICATIONS: The discovery of at least six occurrences of impact melt preserved in relatively continuous deposits over the last 10 Ma in Argentina may have implications for: a) re-considering models of objects surviving entry to produce craters; b) a better understanding of melt generation from soft sediments; c) or additional evidence for an enhanced flux rate over the last 10 m.y. The last suggestion would be consistent with evidence for increased flux of interplanetary dust. Concentrations of ^{3}He relative to ^{4}He are found in ocean floor sediments between ~ 3 and 10 Ma [12]. The unique depositional record of Argentina may be preserving a land record of an enhanced flux of larger objects during this time as well.

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