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Deformation and exhumation of the Salina del Fraile, NW Argentina: Anatomy of a hinterland basin

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The Puna Plateau of the Central Andes is an arid region of high elevation characterized by a compressional basin and range topography. In the southern Puna, the Salina del Fraile, a large endorheic depression, ∼300 square km in area and up to 1 km deep, exposes over 1.5 km of Oligocene to Pliocene strata, but its origin is enigmatic. The sigmoidal shape of the basin, along with its flat floor and smooth sidewalls, led some researchers to interpret it as a sinistral pull-apart basin. Others mapped the basin as the core of a large anticline. These two scenarios are incompatible and imply very different kinematics for the deformation of the southern Puna Plateau.

To address these questions, we present new geologic maps and structural cross-sections for the Salina del Fraile and surrounding region. No basin-bounding faults, such as would be required if the basin were transtensional, were observed. In contrast, major structures are compressional and consist of a series of folds and thrust faults striking NNW to NNE. A large anticline exposes Paleozoic metasedimentary units in the northern part of the basin, while the southern part exposes more broadly folded Cenozoic strata. We map a similar trend of folds and thrust faults in the Quebrada Honda basin, 20 km to the west. Published geochronologic data indicate that these compressional structures were active between 17.1 and 9.8 Ma. The basin was later eroded into the crests of these anticlines. To the east of the Salina del Fraile, many small normal faults trending ENE offset a high-elevation desert pavement surface; this fault trend cuts ignimbrites and flows dated to 3.6 Ma. We thus document regional E-W compression during the mid-late Miocene, followed by exhumation of the Salina del Fraile and NW-SE extension during the late Pliocene to Quaternary. Exhumation of the Salina del Fraile exposed the anatomy of the hinterland Antofalla basin: faults and folds that would have otherwise remained hidden under later volcanic cover.

These observations support an erosional origin for the Salina del Fraile, but the internally drained basin lacks evidence of large-scale fluvial incision, such as dendritic networks of elongated valleys. Our observations suggest wind as the dominant agent of erosion. Flat-lying surfaces are mantled by desert pavements that consist largely of ventifacts. Tilted sedimentary strata crop out in a large area on basin floor as hogbacks, many of which have been streamlined into yardangs. Terraces capped with primary evaporites and evaporite-rich sandstones and conglomerates, interpreted as remnants of former basin floors, indicate significant scouring of the basin since 2.6 Ma. These terraces are also eroded into streamlined forms. While it is impossible to completely rule out fluvial incision in the geologic past, these landforms are most consistent with eolian abrasion and deflation in an arid climate. Although important questions remain, this work suggests that wind may be able to erode significant amounts of material in arid regions such as the Puna Plateau.