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Blowholes' in the Nullarbor limestone, Australia: frequent collapse features or rare solution pits

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The Australian Nullarbor Plain (~200,000 square km) is thought to be the world's largest exposed limestone plateaux. For its size, it exhibits relatively limited surface karst features. A few dozen collapse dolines exist, where upward stoping of deep cave passages has punctured the surface and, in some cases, allows access to extensive cave systems. More common features are the perhaps several thousand blowholes; dm-m scale vertical tubes of up to several m depth, which can display strong barometric draughts and in some cases have acted as traps for mammals and birds over millennia. Little is known about the origin and distribution of these blowholes, but they are thought to be common across the plain and have been speculated to originate from downward dissolution along rootholes and/or salt weathering.

Here we report on the results of geological, geomorphological and geophysical observations aimed at elucidating the origin of blowholes and their draughts. Over 20 blowholes were examined at a variety of southern and central locations on the plain using (i) morphological and geological mapping incl. Schmidthammer hardness tests to elucidate their mode of formation, (ii) high-resolution paired draught and atmospheric pressure loggers to investigate draught velocities, volumes, fluctuations and synchronicity, and (iii) microgravity measurements to explore the nature and extent of the voids providing the underground air reservoirs from which barometric draughts originate.

Many blowholes lead to small or, in some cases, extensive, but typically shallow cavities that exhibit numerous bellholes (vertical cylindrical tubes with a dome shaped ceiling). Blowholes appear to occur where bellholes happen to punctuate the surface. Statistical arguments suggest that shallow cavities with bellholes are common, but

in comparatively few cases do bellholes protrude through to the surface. Hardness measurements indicate that salt weathering does not play a major role in their genesis or punctuation. We speculate that shallow caves and bellholes were formed under phreatic or semi-phreatic conditions at higher ground water levels stands in the past. Root penetration, condensation corrosion from below and perhaps surface weathering may eventually puncture a bellhole situated close to the surface. Draught measurements show velocities $>$ 80 km/h and air reservoir volumes connected to blowholes of 1-10 million cubic m. At all draughting blowholes where microgravity measurements were carried out, we found large gravity anomalies. The nature of these anomalies, together with draught characteristics and petrological observations in deeper caves, suggest that the draughts originate at least in part from extensive cave systems in the underlying Wilson Bluff and/or Abrakurrie limestones that are sufficiently connected to the blowholes to exchange large air volumes. The formation of blowholes is discussed in the relation to (a) cavernous development in the Nullarbor Plain and other karst regions, and (b) the likelihood of them puncturing the surface.