

# **Geoarchaeology in semi-arid landscapes: A case study from the Kgalagadi**

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Pleistocene research from southern Africa has provided evidence for significant milestones in human evolution, such as fossils of anatomically modern humans, the engraving of ochre pieces, shellfish exploitation, and the use of pigments. Historically, research has focused on cave and rock shelter sites in coastal and near-coastal areas with fine stratigraphy and good preservation, often overlooking the potential of open-air sites in the semi-arid interior of southern Africa. Research at open-air sites poses analytical difficulties, such as poor preservation of organic materials, which has led to a neglect of the archaeological potential of open-air sites. This also creates a gap in understanding human adaptations to semi-arid landscapes in the Late Pleistocene. One such region is the southern Kalahari Basin, previously believed to be too arid to support human habitation for extended periods during the Pleistocene. New research suggests that the Pleistocene environment in the Kalahari was dynamic, with fluctuating periods of aridity and increased moisture availability, and that humans were not only present during these wetter periods.

Geoarchaeological analyses are effective for reconstructing the palaeoenvironmental conditions that humans had to navigate and adapt to, as well as identifying site formation processes that impacted the behavioural evidence they left behind. This thesis combines field and lab-based approaches to examine the site formation processes and palaeoenvironmental contexts of pans (seasonal water bodies) and associated archaeological materials in the southern Kalahari Basin of Botswana, near the town of Tsabong in the Kgalagadi District. Pans are important geoarchives that act as sediment catchment areas and would have offered humans a temporary source of water. Abundant lithic surface scatters provide evidence of human presence in the landscape. These lithic scatters are often found near quartzite outcrops and on the pan surfaces. Multiple pan sites with archaeological material were analysed, with a greater focus on Maralaleng Pan (MAR Pan).

Three main site formation processes were identified in the Tsabong area, namely deflation, runoff, and duricrust formation. Deflation of the pan surfaces is one of the most prominent formation processes, and contributed to the accumulation of another dominant landscape feature associated with the pans, namely lunette dunes. The lunette dunes often occur on the southern leeward side of the pans and consist mainly of deflated pan sediment. The lunette dunes are indicative of more recent

(Holocene) drying phases. Aeolian deflation has also led to the exposure of lithics on the surface of the landscape, as this removed finer sediment particles, leaving lithics and gravel clasts behind. The lithics are predominantly found near quartzite outcrops, which would have been the raw material source for lithic manufacture. The lithics were moved downslope from the quartzite outcrops over time during runoff events, thus suggesting that stone tools on the pan edges and on the inner dunes are unlikely to represent their original depositional context.

Duricrust formation is a dominant process in the southern Kalahari landscape, and these features are often present in the pans.

The majority of the duricrusts at the analysed sites were calcretes, indicating that calcium carbonate was the main cementing agent. At MAR Pan, the duricrusts were mostly pedogenic calcretes, meaning that near-surface moisture fluctuations and illuviation processes had a greater effect on their formation compared to groundwater input. The formation of duricrusts created a deflation-resistant surface for archaeological artefacts to settle onto during wetter periods. This type of deflation-resistant surface has been recorded at other sites (such as the Makgadikgadi Palaeolake), where humans were present on the dry pan floor during the Stone Age. This can also be observed in the Marine Isotope Stage (MIS) 5 record of MAR Pan, where a lens of artefacts relating to the Middle Stone Age was excavated, further confirming human presence in a fluctuating lacustrine environment. The greatest moisture availability at MAR Pan was identified in sediment dating to MIS 3; however, no evidence of human presence in the landscape during this time was identified. The results presented in the three scientific articles contribute to a growing body of geoarchaeological knowledge surrounding the adaptation of humans during the late Pleistocene in the under-researched semi-arid interior of southern Africa.