

MICROTEXTURES OF QUARTZ GRAINS FROM AN ARID FLUVIAL ENVIRONMENT: THE LUNI RIVER FLOODOUT ZONE, SOUTHEASTERN THAR DESERT, INDIA

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Background and Rationale

Aeolian processes are commonly thought to dominate dryland landscapes but occasional flow in normally dry ephemeral or intermittent rivers also can create or modify geomorphic landforms. In many drylands, characterising fluvial-aeolian interactions is key to advancing palaeoenvironmental, geomorphological and sedimentological knowledge, including through use of modern analogues for interpretation of the rock record (e.g. Priddy and Clarke, 2020). In some drylands, alterations in the size, morphology and position of channels approaching a river terminus, technically known as a ‘floodout’, preserve a range of geomorphic landforms and sediments that can serve as “geoproxies” (Thomas, 2013; Tooth et al., 2022). Floodouts provide key locations to reconstruct past river changes and assess the relative influence of external drivers such as climate change, tectonic activity and human impacts (e.g. Tooth, 1999), but many remain to be fully investigated.

The Luni River floodout zone (LRFZ), located on the southeastern margin of the Indian Thar Desert (Fig. 1), represents a critical zone for investigating fluvial-aeolian interactions. The LRFZ is marked with various active, partially active and inactive fluvial landforms, including meanders, anabranching and distributary channels, and in many locations is bordered by aeolian dunefields. The region has undergone significant transformations due to weakening of the Indian Summer Monsoon (ISM) and associated aridification, particularly during the mid to late Holocene (Ponton et al., 2012), but has also been subject to tectonic activity and rising anthropogenic activities like canal-fed irrigation agriculture and mining. My PhD research

project primarily focuses on deciphering the coupled geomorphological and sedimentological development of the LRFZ through reconstruction of the channel and palaeoenvironmental changes that have occurred over time. Luminescence (OSL) dating will provide geochronological evidence of channel evolution (e.g. depositional history, palaeohydrology and channel shifts) over the late Quaternary. The QRA’s New Research Workers Grant funded scanning electron microscope (SEM)-based microtextural analyses of quartz grains, including from some of the key OSL sampling locations. The preliminary findings form the basis of this report. The microtextures on quartz grains, such as surface etching, abrasion patterns, and other mechanical features, will help to infer the prevailing environmental conditions (e.g. relative importance of aeolian and/or fluvial process activity) during sediment transport and deposition (Smith et al., 2018). Detailed findings will contribute new insights for regional palaeogeography and archaeology, potentially including development of the palaeo-Saraswati River (Alok and Pant, 2020) and fall of the Indus Valley Civilisation (Dutt et al., 2019).

Results

A JEOL JSM-IT 200 bench-top SEM at Aberystwyth University was used for the study. A secondary electron detector (SED) has a focused beam of electrons to create high-resolution detailed images of grain surfaces. Prior to SEM analysis, crucial steps involve cleaning (chemical treatment with HCl, H₂O₂ and distilled water), mounting on stubs (using a conductive black adhesive tape) and platinum/palladium coating. The cleaning procedure eliminates surface residues (e.g. carbonates and organic matter)

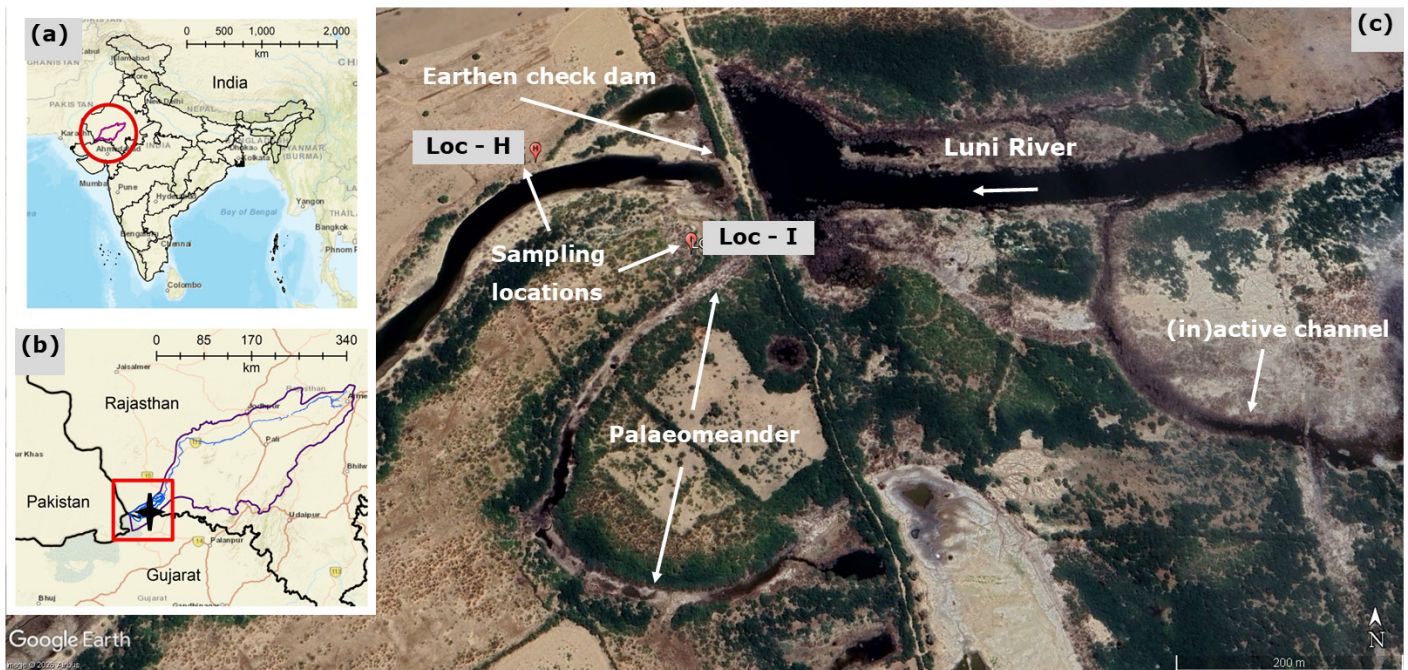


Figure 1. (a) The Luni River is situated along the eastern margin of the Thar Desert near the India-Pakistan border. (b) The river begins in the Aravalli Ranges near Ajmer and dissipates as a system of distributary channel approaching its floodout, which adjoins the endorheic salt flat of northeastern Rann of Kutch (or Kachchh) in northern Gujarat. (c) The location, geomorphic landforms (e.g. palaeomeander, inactive channel) and anthropogenic modifications (e.g. earthen check dam) adjoining the sampling locations H and I in the LRFZ.

while preserving the original microtextures. Figure 2 illustrates the preliminary results from some of the quartz grains collected from locations H and I (see Fig. 1c).

A complex suite of microtextures documents both mechanical and chemical processes in the dryland setting. Mechanical features including grooves, v-shaped pits, bulbous edges, elongated depressions, large conchoidal fractures, and abrasion features indicate high energy transportation and grain–grain collision under episodic fluvial flow. Straight steps further indicate brittle fracture under stress. Etch pits, solution channels and pits, and more general etch features are suggestive of post-depositional chemical alteration, likely linked to fluctuating wet and dry cycles and the prevailing saline conditions found across the LRFZ. Clay attachments and silica precipitates likely highlight periods of diagenetic overprinting during low energy conditions under fluctuating groundwater conditions and evaporation, which elevate dissolution and lead to re-precipitation of silica and other minerals. Therefore, the observed microtextural features provide a valuable insight into the prevailing transport conditions and depositional environments, indicating a complex interplay between aridity, evaporation, and sediment reworking.

Significance

Further microtextural analysis of quartz grains from a wide range of sampling locations in the LRFZ (24 samples total) will provide additional inferences regarding shifts in dominant transport and depositional processes, including the relative importance of fluvial versus aeolian-derived sediments during palaeochannel infilling. Combined with OSL dating, the approach will help to infer shifts in the relative importance of fluvial-aeolian activity in response to climatic fluctuations, particularly ISM weakening and aridification trends (Ponton et al., 2012) that have been observed elsewhere in the Thar during the mid to late Holocene. The findings will help provide a more nuanced understanding of the changing palaeoenvironmental conditions in the LRFZ.

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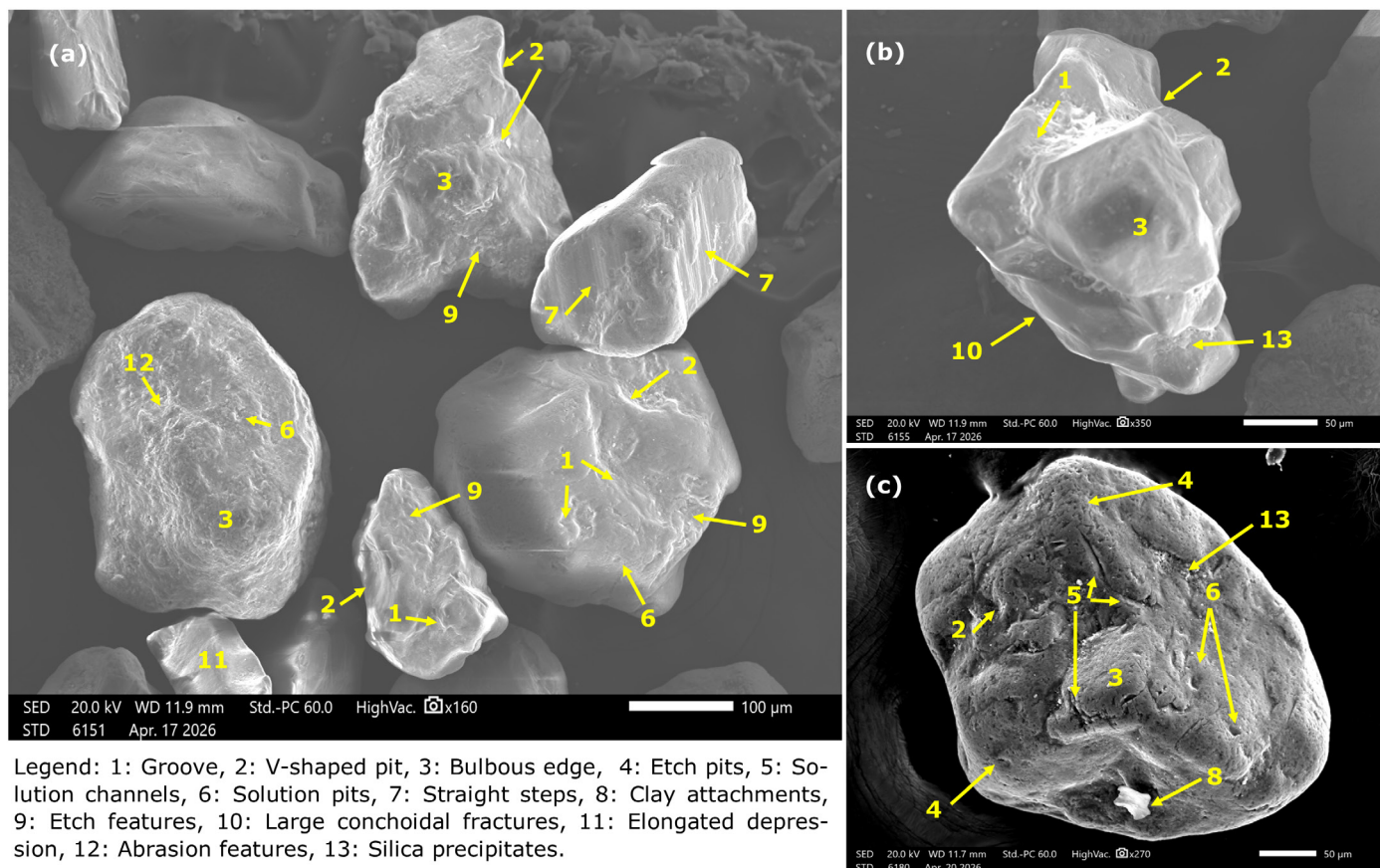


Figure 2. SEM micrographs showcasing various quartz grain microtextural characteristics from sediments collected at locations H and I (see Fig. 1c).

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