Hydrological analysis in the SW Ethiopian Highlands – Case study in understanding water availability and prehistoric settlement in the Late Pleistocene

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Introduction

Today's landscape of the south western Ethiopian Highlands was formed by tectonic stress, late Quaternary-Holocene eruptive activity and the constant increasing influence of human activity (see fig. 1). Ethiopia and the Main Ethiopian Rift represent a key area for debating and understanding the migration of Anatomically Modern Humans (AMH) across the African continent and beyond its borders. At all times the availability and accessibility to fresh water formed a main focus for the existence and survival of mankind in this diverse environment. According to the Mountain Refugium Hypothesis the Southwestern Highlands are hypothesized to have been an environmental refuge during phases of environmental stress – e.g. Last Glacial Maximum (LGM) or Younger Dryas (YD) – enhanced hyper arid conditions in the lowlands (Brandt et al. 2012, Vogelsang & Wendt 2018).

Rock shelters at the volcanic Mt. Damota and Mt. Sodicho preserved comprehensive archaeological sequences and offered protection from environmental forces since the Late Pleistocene (see fig. 2). The Bisare River Catchment, located close to Mt. Damota, exposed during thousands of years of erosion numerous surface scatters of archaeological finds and raw material sites (Vogelsang & Wendt 2018). Main objects of this research are the attempt to answer the question of current and potential water availability for AMH during different climatic phases in prehistoric times. For this we use the knowledge of today's fluvial dynamics and the spare records of human occupation; transferring this to ancient times and to shed light on human-environment interaction.

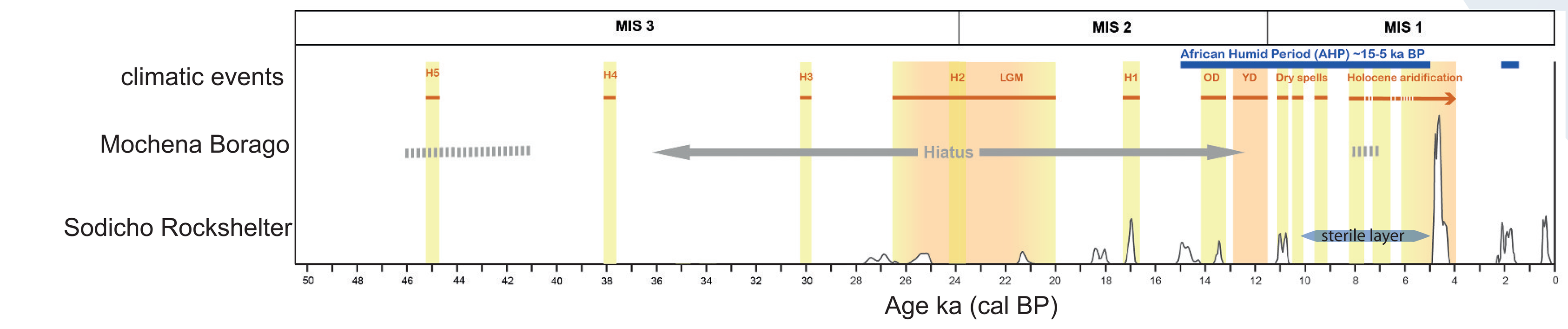


Fig. 2: Calibrated dates from the Sodicho Rockshelter sequence & dated settlement phases of Mochena Borago compared to climatic events (modified by an illustration of R. Vogelsang, climate record by Foerster et al. 2015).

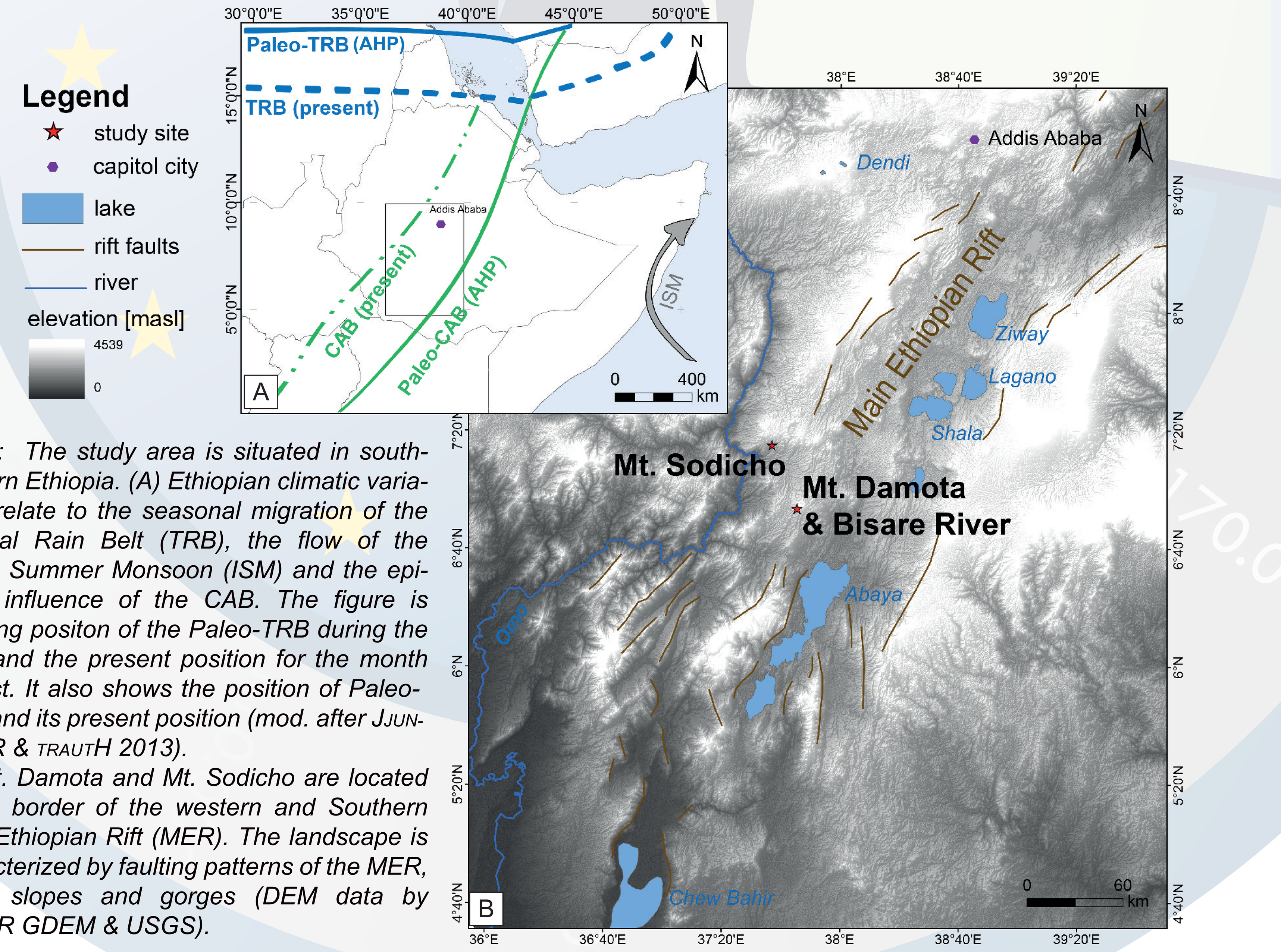


Fig. 1: The study area is situated in south-western Ethiopia. (A) Ethiopian climatic variations relate to the seasonal migration of the Tropical Rain Belt (TRB), the flow of the Indian Summer Monsoon (ISM) and the episodic influence of the CAB. The figure is showing positon of the Paleo-TRB during the AHP and the present position for the month August. It also shows the position of Paleo-CAB and its present position (mod. after Junginger & Trauth 2013). (B) Mt. Damota and Mt. Sodicho are located at the border of the western and Southern Main Ethiopian Rift (MER). The landscape is characterized by faulting patterns of the MER, steep slopes and gorges (DEM data by ASTER GDEM & USGS).

Methodological approach

Digital elevation models (DEM) in high-resolution (Astrium's Pléiades) and middle-resolution (ASTER GDEM*) were extracted by the image analysing software ENVI. Further research methods comprise geomorphological and hydrological analyses via remote sensing to understand the current and ancient fluvial dynamics within the catchment areas of the study sites. We demonstrate this by mapping flow direction and stream networks with the modelling tool from ArcHydro (ArcGis ESRI). For a better understanding of human occupation history and cultural adaptation to this diverse environment the obtained data will be connected to signs of human occupation. Artifact occurrences and obsidian raw material exposures were mapped during survey by De la Torre in 2007 and Vogelsang and Wendt in 2018.

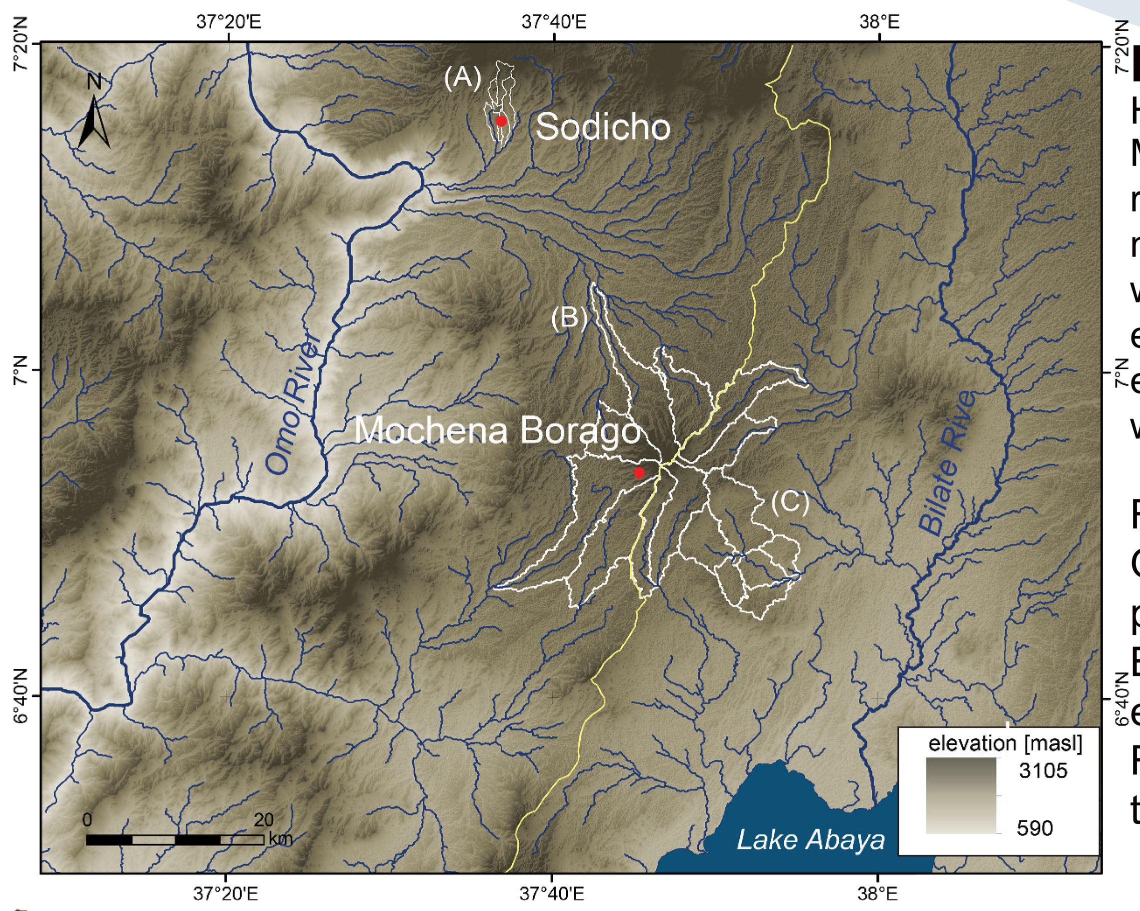
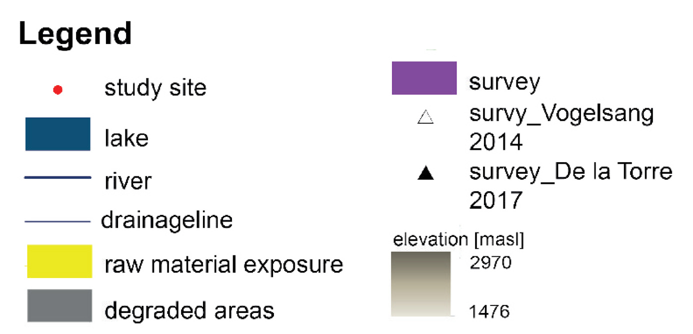
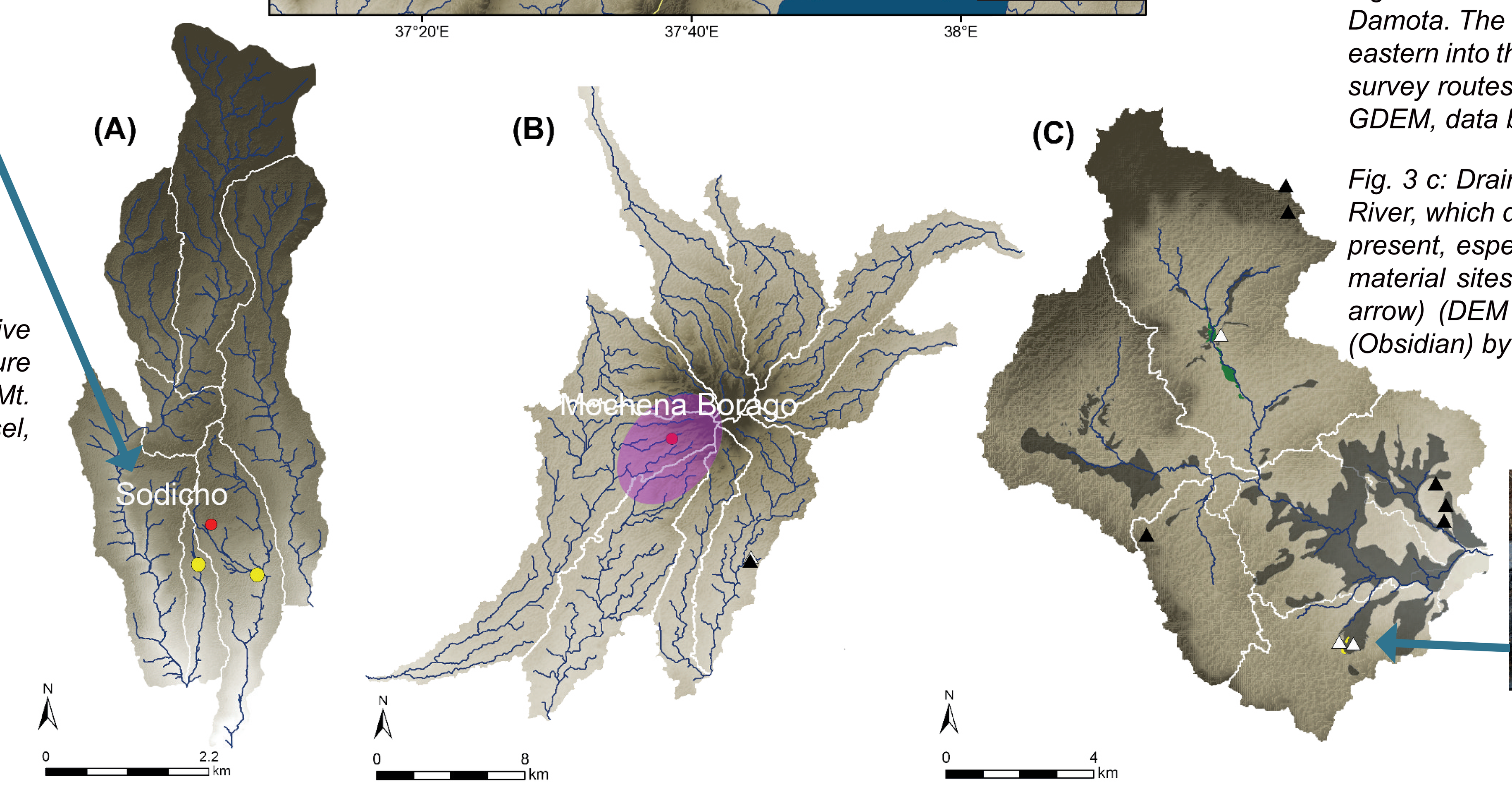


Fig. 3 a: The Highlands are still a preferred place for live and subsistence farming. The intensive agriculture supports slope erosion at the mountain flanks of Mt. Sodicho (blue arrow) (Image and data base by E. Hensel, DEM data by Astrium's Pléiades).





Preliminary Results

Hydrological analyses:

Mt. Sodicho runoff drains completely into the Omo River. Several south running streams from the Wagebeta Caldera Complex flow around the mountain (see fig. 3). Mt. Damota has a comparable larger catchment which crossed by a watershed. Western streams drain the Omo River; eastern stream drain Lake Abaya separation the runoff in a west and east direction. The Bisare River Catchment flows into the Bilate River, which is the main contributory of Lake Abaya.

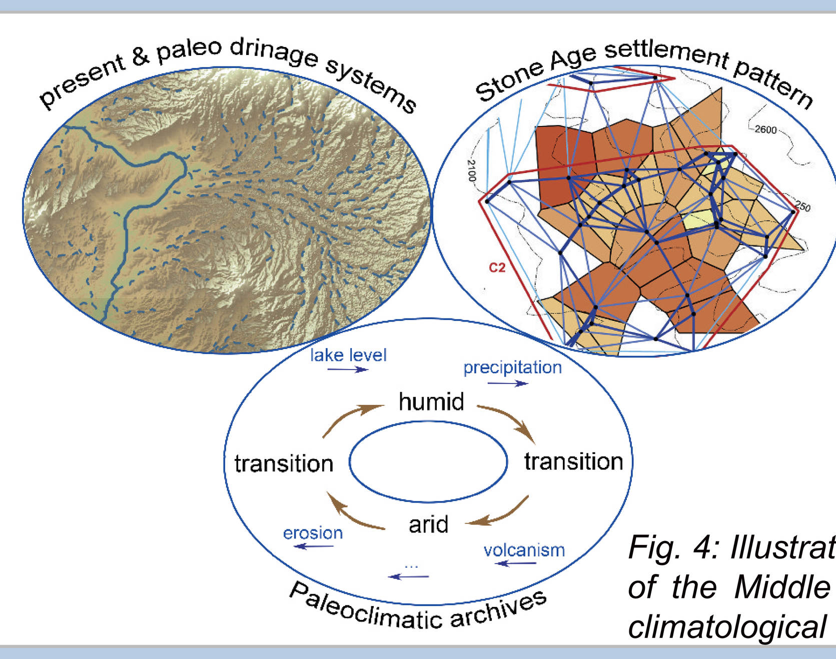
Raw material exposure:

Obsidian raw material and stone tool production localities are exposed by gully erosion and badland formation - mainly at the Bisare River Catchment (see fig. 3 c). The raw material provenance for the lithic artefacts at Mt. Sodicho are still not clear. Raw material localities are limited to river banks - with signs of transport.

Fig. 3 b: Drainage systems and calculated catchment of Mt. Damota. The western drainage runs off into the Omo River and the eastern into the Bilate River. Violet marker illustrates the location of survey routes by Vogelsang & Wendt 2018 (DEM data by ASTER GDEM, data base S. Meyer).

Fig. 3 c: Drainage system and calculated catchment of the Bisare River, which drains into the Bilate River. Gully and sheet erosion is present, especially at the southern part of the river. Obsidian raw material sites are exposed by this degradation of the area (blue arrow) (DEM data by Astrium's Pléiades, data base and Image (Obsidian) by S. Meyer).

Preliminray Conclusion & Outlook



The results show a relationship between the mapped drainage systems and the archaeological sites but a further assessment is needed. The preserved evidence for repeated settlement in the Middle and Later Stone Ages - at Sodicho and Mochena Borago - indicates that the southwestern Highlands provided a refugia during hyper arid phases. The adaptation to different, elevation bound eco-systems enabled the access to faunal resources and the accesses to freshwater.

However the humid-arid transitions during the past have led to pronounced erosion and badland formation combined with the human impact, which will lead to further degradation to the preserved archaeological material. The future demands profound investigations of these yet preserved archaeological open-air sites and the comparison with further high resolution palaeoenvironmental archives (see fig. 4). In the near future sedimentological investigations, e.g. element & mineralogical composition and total organic content (TOC) will be conducted on the sediment samples of the percussion drilling cores taken at the Bisare River Catchment. Following field research at the Sodicho Rockshelter will be conducted in the following years. This includes archaeological excavations and geoarchaeological survey of the surrounding area.

Fig. 4: Illustration of future research: a combination of geo- and hydromorphological investigation and the knowledge of settlement patterns of the Middle Stone Age and Later Stone Age. This will be enhanced by suitable terrestrial and fluvial archives to understand past climatological circumstances. (Image E. Hensel, DEM data by Astrium's Pléiades, settlement data by Vogelsang & Wendt 2018).

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