Edaphics, tectonics and animal movements in the Kenya Rift: implications for early human evolution and dispersal

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Research Questions:

Do edaphics and active tectonics control animal movements?

Can knowledge on edaphics and the paleolandscape help to better understand the role of the Kenya Rift as a habitat for early hominins?

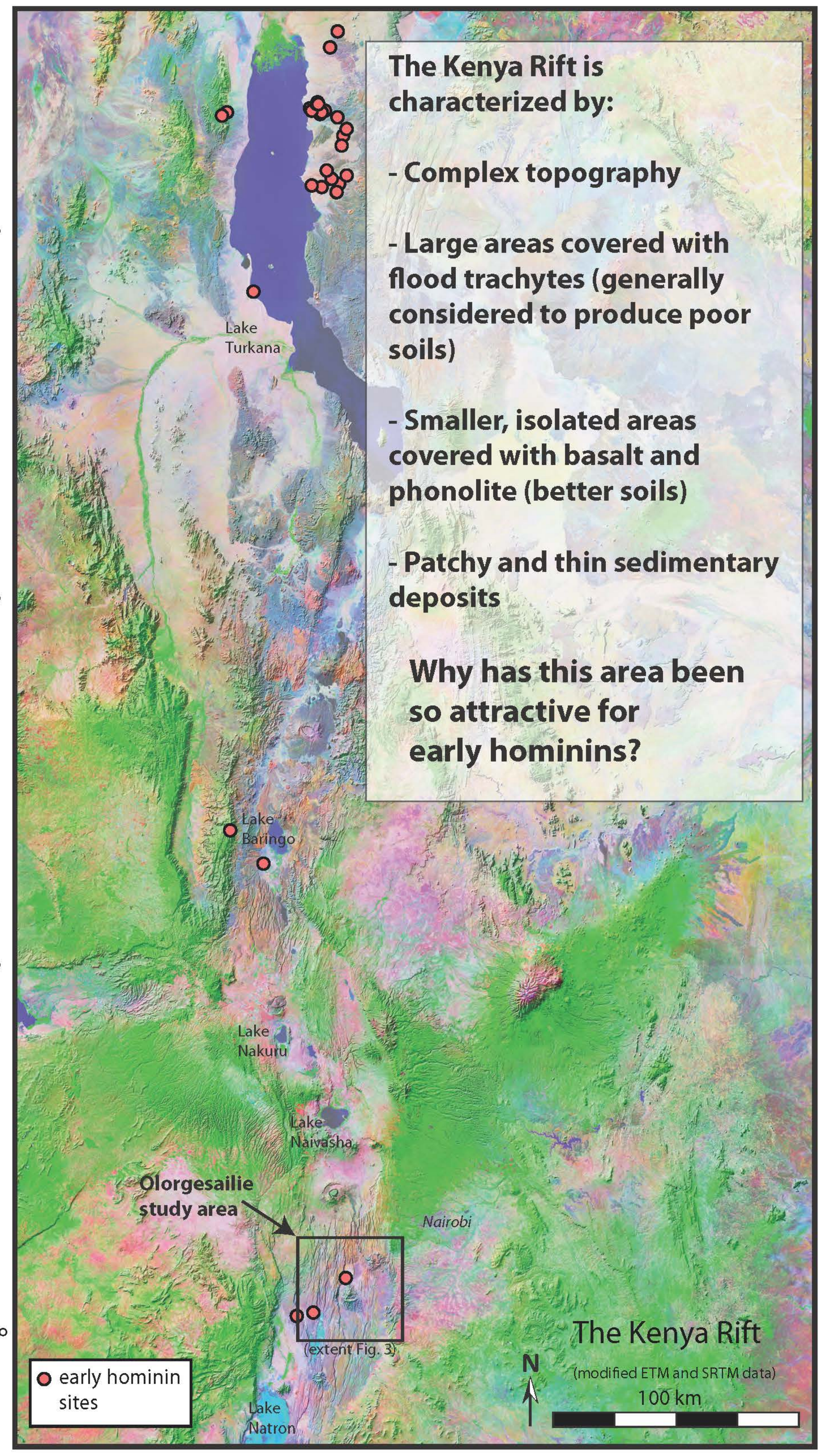

Figure 1: Satellite image of the Kenya Rift, East Africa (modified ETM+ and SRTM imagery) showing the distribution of early hominin sites. Extend of the Olorgesailie study site indicated by the black box.

Edaphics and Animal Movements

Edaphics can be described as the relative ability of the soils, via plant take-up, to supply the necessary nutrients for animal growth and health. The main controlling factors on soil quality are parent material (bedrock or sediment) and climate. Here, we try to understand how edaphics control movements of present-day animals (goats, sheep, cattle and wild animals, Figure 2) to infer information on where wild animals - in particular large mammals that provide a most important food source for early hominins - occurred in the past. This has already been proven successful in previous studies in Greece (Sturdy et al., 1997) and the Levant (Devés et al., 2014).

Figure 2: Wildebeest migration in the Serengeti is one example for animal movement controlled by edaphics. The wildebeests will give birth to their young in this period of time and need to cross the river to get to a place that provides large quantities of soluble phosphate, which is most important for bone growth.

Photograph provided by mighty tours and travel, Nairobi.

Hypothesis:
Hominins were able to use the Kenya Rift to their strategic advantage, because the edaphics of the rift are predominantly poor with only few exceptions. This required animals to visit specific localities in the landscape during the course of the year and made their movements predictable. The complex topography further limited their migration routes to narrow pathways along which early hominins could develop effective hunting strategies.

Edaphics of the Olorgesailie Area

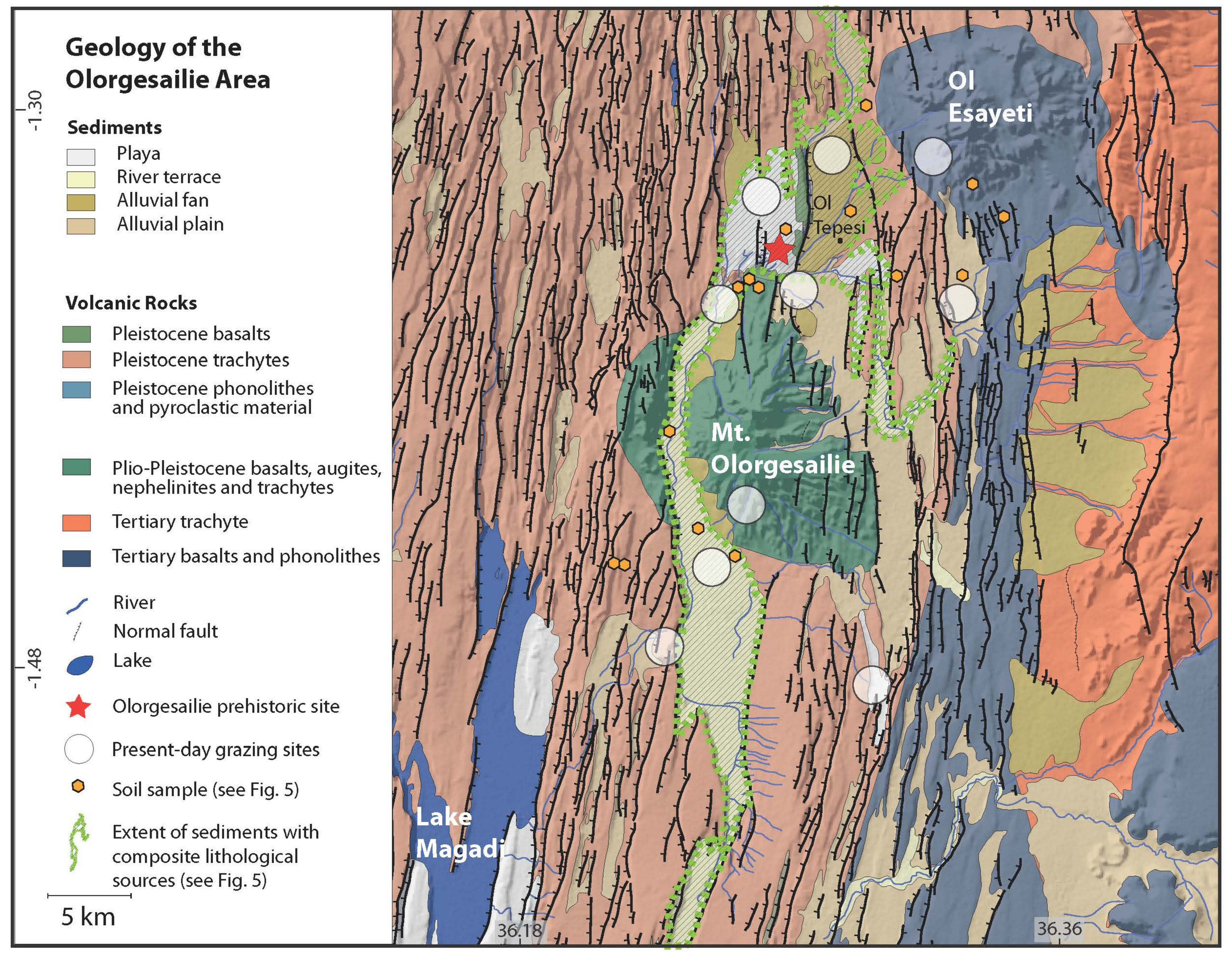

Figure 3: Simplified geological map of the Olorgesailie region (modified from Guth, 2014). Geomorphological and sedimentary features have been added from mapping on satellite images. White circles indicate areas claimed by local shepherds to be good grazing sites.

Figure 4: Discussion with local farmers (upper and lower left image) where the present-day good grazing is found aided by a questionnaire compiled by Peter Owenga (4th from the left, upper image). Lower left image shows healthy goats browsing on alluvial sediments north of Mount Olorgesailie.

Interviewing local shepherds

We interviewed local shepherds to learn about good and bad grazing areas in the Olorgesailie area (Figure 4).

The main results were:

Animals have to move to different regions during the year (Figure 3).

Animals find good grazing sites independently.

Trachyte regions are very poor grazing.

Sediments surrounding Mount Olorgesailie provide good grazing.

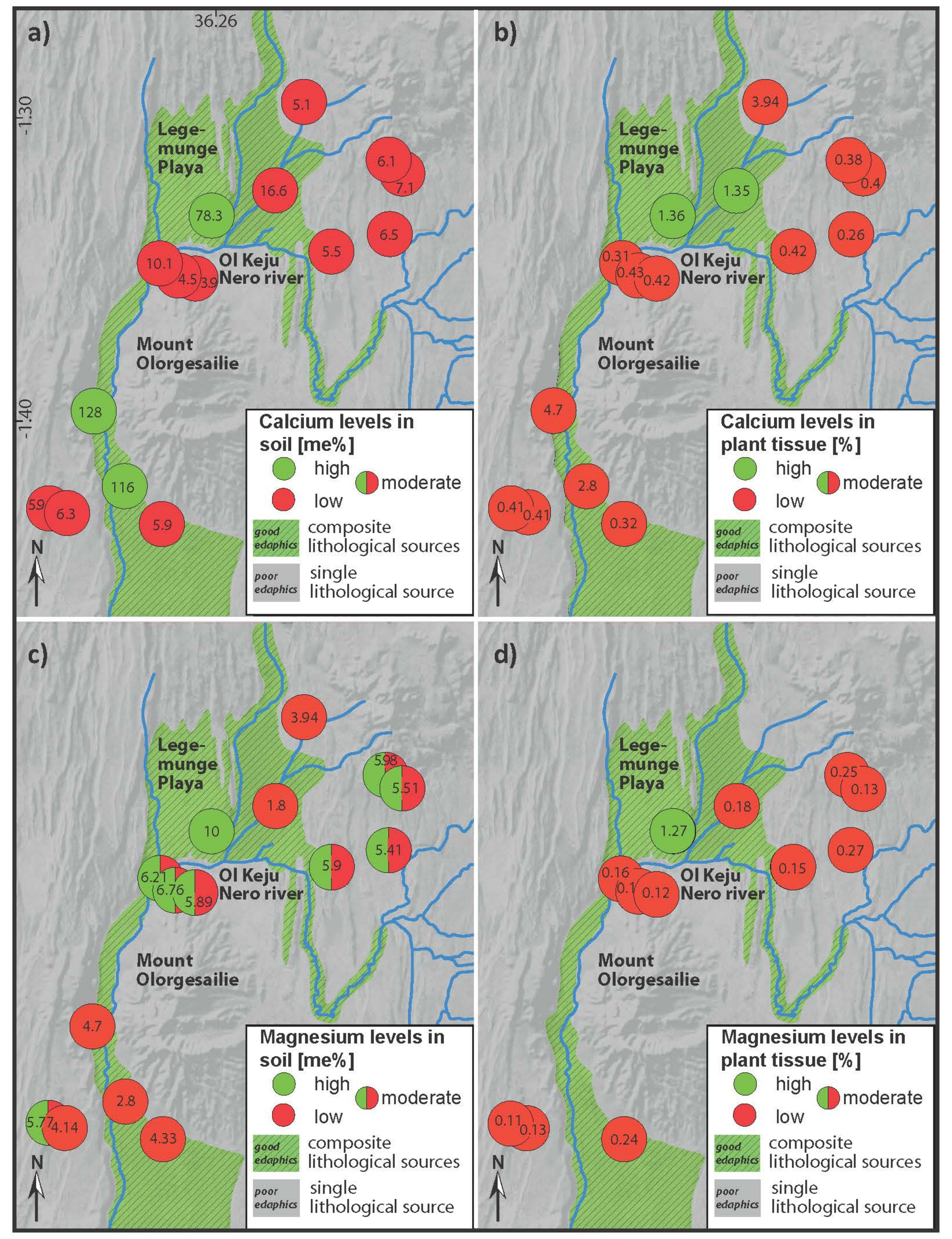

Figure 5: Nutrient levels of soil and plant samples at Olorgesailie. Green shaded area indicates regions of generally good edaphics, which applies for sediments of composite lithological sources as shown by soil analysis and interviewing local shepherds; red shaded area indicates regions of generally poor edaphics. a) Calcium levels determined for soil samples; b) Calcium levels determined for plant tissue; c) Magnesium levels determined for soil samples; d) Magnesium levels determined for plant tissue.

Soil Analysis at Olorgesailie

The aim of soil analysis at Olorgesailie was to determine the nutrient levels in soils and vegetation, which developed on different rock types (trachyte, phonolite, basalt) and sediments (colluvium, alluvium, lake beds). Soils were analyzed for pH-values, electric conductivity and cation exchange capacity. Nutrient levels in soils and plant tissue were obtained for calcium, copper, iron, phosphorus, manganese, magnesium, nitrogen, potassium, sodium, total organic carbon, and zinc.

We took soil samples at 15 locations on soils developed on bedrock (trachyte, phonolite, basalt) and sediments (colluvium, alluvium, lake beds) around Mount Olorgesailie (Figure 3). At 12 of the 15 locations we additionally took vegetation samples for plant-tissue analysis.

Results:

- Copper, iron, phosphorus, manganese, nitrogen, potassium, sodium, total organic carbon, and zinc are sufficient in all samples (Kabata-Pendia, 1992).

- Calcium levels are low (Barker et al., 2010) in all soil samples except in those from alluvial and lacustrine sediments derived from composite lithological sources (basalt, trachyte, phonolite).

- Calcium is deficient (Barker et al., 2010) in all plant tissue samples except in those sampled from soils on the Legemunge playa and the alluvial plain north of Olorgesailie.

- Magnesium levels are moderate to high in the majority of soil samples but magnesium is deficient in all plant-tissue samples except the one from Legemunge playa.

Paleo-Landscape of the Olorgesailie Area

To reconstruct the landscape back to earlier conditions when a lake was present north of Mount Olorgesailie, one has to:

- slip back two normal faults that caused the tilting of the Legemunge playa (Figure 6a) to reconstruct the original surface
- undo the caldera collapse that presumably caused subsidence of the southern lake barrier leading to outflow to the south (Figure 6b)

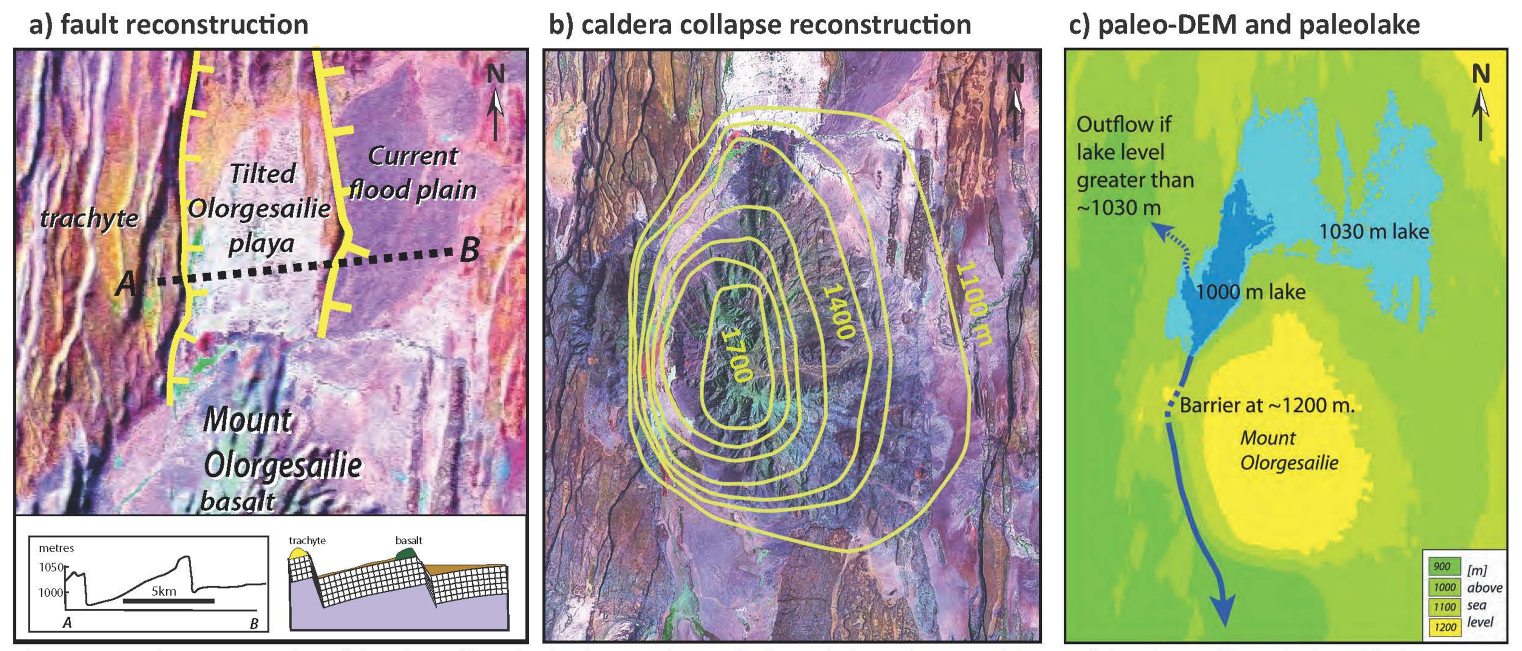

Figure 6: Stepwise reconstruction of the Olorgeailie paleo-landscape. a) ETM+ (Enhanced Thematic Mapper) image of the Olorgesailie study site with slope shading from an SRTM - DEM (Digital Elevation Model). Two faults are shown that have moved to cause the Olorgesailie playa to be tilted (Inset lower left). A simple model (lower right) shows how this occurred. Fault dip is assumed to be 70°, fault depth extent 7 km. b) ETM+ image of Mount Olorgesailie at present-day. Yellow contour lines represent Mount Olorgesailie before caldera collapse occured to cause the northern and western part to subside and downwarp and allow outflow to the south. c) Map view of a simplified paleo-DEM of Olorgesailie showing two different lake levels and possible outflow scenarios.

The Strategic Role of Olorgesailie for Early Hominins

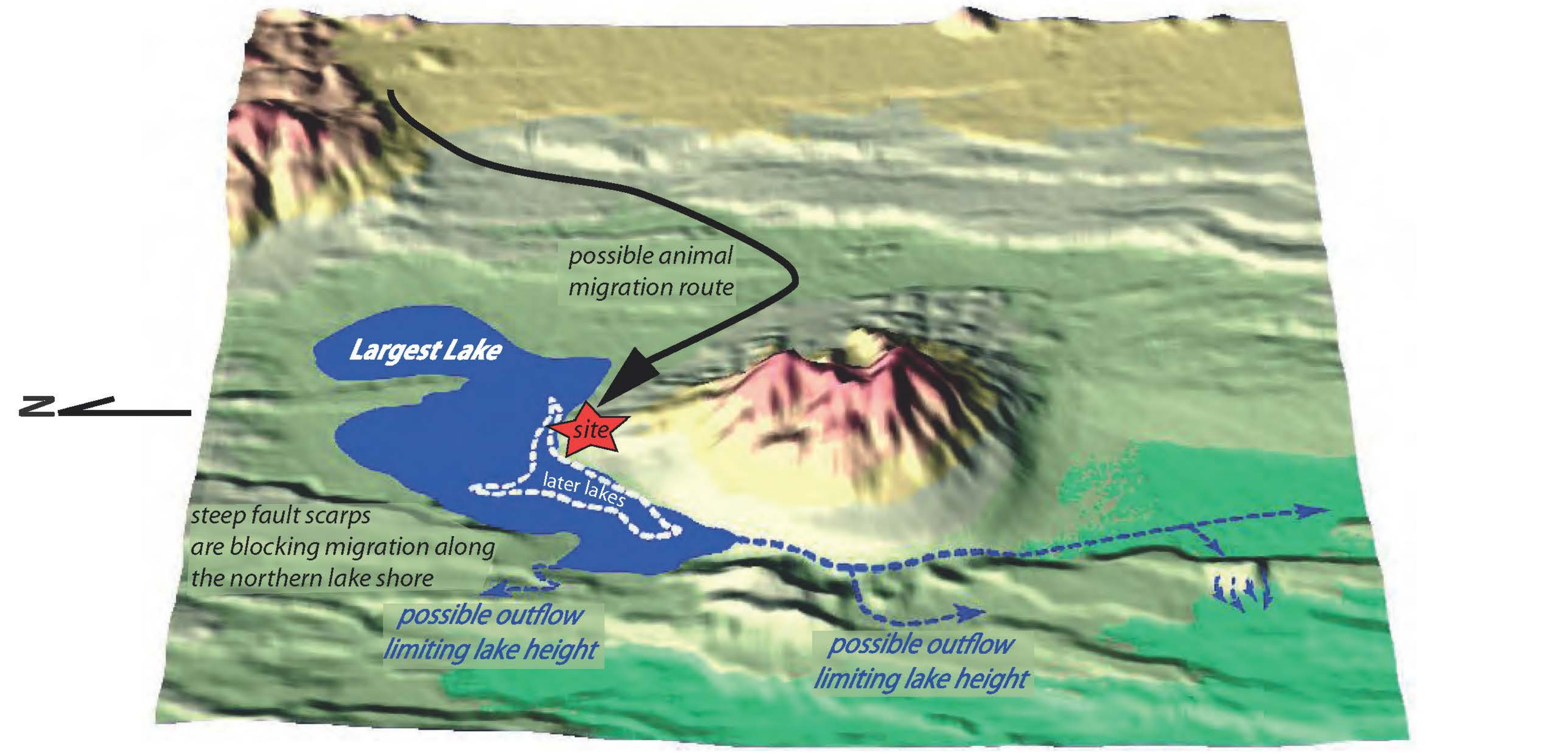

Figure 7: 3D-reconstruction of the Olorgesailie area showing the location of the site in relation to the paleolake and a suggested animal migration route.

The Olorgesailie site is situated at a critical point:

→ The surrounding volcanic rocks provide bad grazing.

→ The sediments at the lake shore provide the only sufficient source of calcium once the outflow to the south is blocked.

→ Steep fault scarps limit animal migration to a narrow pathway along the southern lake shore.

Conclusions

Edaphics and active tectonics are the key to understanding the site at Mount Olorgesailie. With a lake in the past the site represents a prime example of how early hominins may have used strategic advance of the landscape. While steep fault scarps blocked the northern pathway, the southern lakeshore represented one of the few accessible places for animals to get sufficient amounts of nutrients. This was therefore an excellent location for hominins to stalemate and hunt down prey.

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