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Major issues in relating climate change and hominin evolution, with an example from the Olorgesailie Basin, Kenya.

How much of the evolutionary history of the hominins was shaped by climate? From a theoretical standpoint, there are two opposite poles to the argument: 1) climate change and hominin evolution were independent of one another, or 2) climate forcing was responsible for all major events in hominin evolution. Between these poles is fertile ground for developing and testing hypotheses about the interaction between morphological and behavioral changes in the hominins, local ecosystems, and global climate change over the past 7 million years. Such hypotheses typically involve an assumption that synchronous events in the geological and paleontological record suggest a cause-effect relationship. However, establishing such relationships in the geological past also requires: A) carefully defining the meaning of "synchronous," B) explaining how a climatic cause could have produced the observed evolutionary effect, and C) developing multiple lines of evidence to support paleoclimatic trends or events. Matters of spatial/temporal scale also affect climate-evolution hypotheses; evidence from the land-based fossil record is dominated by local- to regional-scale paleoenvironmental signals while the marine paleoclimatic record is dominated by continental- to global-scale signals. Land records also are discontinuous and variable in temporal resolution, and each rock sequence provides only limited windows on the space-time continuum of hominin evolution. In order to relate climate trends and cycles documented in marine or lake cores to major events and trends in human evolution, it is first necessary to understand basin- and regional-scale environmental signals in strata that contain the hominin fossil record. These signals typically represent both tectonic and climatic processes.

The Olorgesailie Basin in the East African Rift of southern Kenya provides an example of how analysis at different temporal scales can help to sort out tectonic versus climatic controls on basin history. At the scale of the past million years, Olorgesailie Basin deposition can be divided into two distinct intervals, the first half in a relatively stable, subsiding basin, the second in an unstable, tectonically active basin with marked alternation of erosional and depositional conditions. At the scale of 105 yrs, lacustrine vs. subaerial deposition represented by the Olorgesailie Formation was controlled by subsidence and accommodation space for sediment (primarily diatomite). At the scale of 103-4 yrs, transgressive-regressive cycles of the lake during the Olorgesailie Formation (between 1.2 - ~0.5 Ma) were controlled by climate and, in a few cases, by influxes of volcanic materials that overfilled the basin and caused temporary lake regressions. The later phase of basin history (Olkesiteti Fm. and Oltepesi Beds between ~0.5 – 0.0 Ma) was controlled primarily by faulting in the Koora Graben and along the basin margins, coincident with increased tectonic and volcanic activity in the southern part of the Kenyan Rift Valley during the late Pleistocene. Although the 80 m thickness of the Olorgesailie Fm. is dominated by diatomites, this does not mean that the climate was continuously wet for ~700 kyr. Instead, it means that during phases of tectonic subsidence, a lake was present and diatomites rapidly filled the available accommodation space. Careful study of the lithostratigraphy reveals that many lake – land cycles were recorded within these diatomaceous deposits, testifying to a complex interplay of tectonic and climatic processes throughout the history of the basin. It is possible, even likely, that some of the transgression-regression cycles as well as longer-term trends at Olorgesailie are linked to global-scale climate cycles. The continuing challenge in such land-based outcrop records is to recognize the complexity of each stratigraphic sequence and to work with this complexity to distinguish tectonic and climatic signals to understand them in the context of different temporal scales.