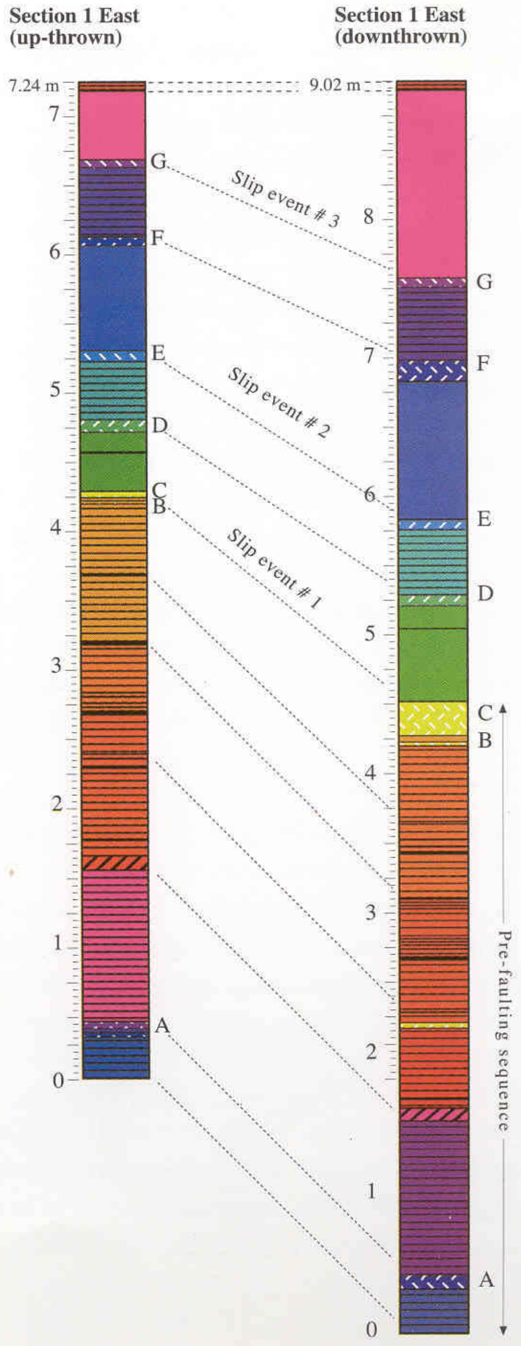
RESEARCH NOTES: The Seismic Prehistory of Lake Lisan

Today's Dead Sea is but a vestige of the much larger Lake Lisan, which stretched along the earthquake-prone Jordan Rift Valley in the Pleistocene Age, ten-thousand to 1.8 million years ago. Although modern seismic stations are scarcely a century old, much information on ancient earthquakes is buried in the rocks. When the fault zones (the discontinuities at which the Earth's tectonic plates slip past each other) cross a lake-bed, rapid sedimentation can preserve geological information on such earthquake events with exceptional clarity. Such is the case with Lake Lisan, whose 220 kilometer chain of finely laminated outcrops, some 50,000 years old, may represent the longest continuous seismic record on Earth.

A. Agnon and colleagues at the Hebrew University have been studying the geology and chemistry of this ancient layered record at a site near Masada, with detailed vertical resolution. The thin (few millimeter) light-colored layers seem to represent the annual precipitation of aragonite at the lake bottom in the summer, while the darker layers represent the annual winter flooding. The extremely dry climate of the Dead Sea Valley was essential to preserving the aragonite, which otherwise hydrates and turns into calcite.

This placid history reflects samples below and between the first two "mixed layers" (A, B in the figure) which represent the geological disturbances, including fluidization, induced by two earthquakes that took place on some other nearby seismically active fault. The first earthquake-induced "slip event" on the Masada fault itself (C) shifted the rocky records on the "up" and "down" sides of the slip zone with respect to each other. Sediments eventually buried the cliff-like discontinuity (scarp), leaving a permanently thicker sediment layer on the "down" side.

The Lake Lisan seismic record, which stretches back 50,000 years into our past, stretches into our future as well.



Two subsequent remote (off-fault) earthquakes (D, F) and two more on-fault, earthquake-induced slip events (E, G) were also uncovered, before reaching modern times. The rapid burial of the scarps by sediments preserves detailed features that cast considerable light on the physics of what happens when a seismic fault ruptures a lake bed.

The investigators also carefully collected, cleaned and preserved ancient sediment samples for subsequent detailed chemical analysis. So far over a hundred layers have been analyzed by inductively coupled plasma atomic emission spectrometry to determine their elemental content. The investigators found dramatic increases of Barium (Ba) associated with earthquake events. The Ba/Ca ratio typically doubled at the beginning of a mixed layer, and then shot up to 10-15 times background values during the subsequent half of the mixed layer.

Since the springs and waters of the current Dead Sea are Barium-rich (up to 5 ppm), the Barium concentration of Lake Lisan may have been similar. Barium would remain soluble in oxygen-depleted lake-bed sediments; but earthquakes could squeeze these Barium rich brines from their protective sheath, via faults and cracks. Once exposed to "regular" Lake Lisan water with normal SO_4 and oxygen concentrations, this Barium would then precipitate out as the mineral barite and appear, as observed, in the earthquake-induced mixed layer.

Our ability to predict future earthquake hazards depends on our ability to understand basic earthquake physics. Detailed long-term earthquake data is a valuable part of this effort. Thus the Lisan record, which stretches back 50,000 years into our past, stretches into our future as well.