Historical and Paleo-seismicity of the Dead Sea Transform in northern Israel

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We test earthquake recurrence and slip models via high-resolution three-dimensional trenching along and across the Jordan Gorge fault (JGF), part the Dead Sea Transform (DST) in northern Israel. We extend the earthquake history of this segment to establish slip rate for the past 3-4kyr, to determine the amount of slip per event and to study earthquake spatio-temporal behavior on the JGF and in northern Israel. To this end we opened more than 900m of trenches, mapped 8 buried channels and dated more than 80 radiocarbon samples. By mapping buried channels, offset by the JGF on both sides of the fault, we obtained for each an estimate of displacement. Coupled with fault crossing trenches to determine event history, we construct earthquake and slip history for the fault for the past 2kyr. We observe evidence for a total of 9-10 surface-rupturing earthquakes with varying offset amounts. 6-7 events occurred in the 1st millennium, compared to just 2-3 in the 2nd millennium CE. A 4kyr old buried channel yields a slip rate of 3.5-4mm/yr, consistent with GPS rates for this segment. Yet in spite of the apparent agreement between GPS, Pleistocene to present slip rate, and the lifetime rate of the DST, the past 800-1000 year period appears deficit in strain release. Thus, in terms of moment release, most of the fault has remained locked and is accumulating elastic strain. Furthermore, there exists a discrepancy between measured rate of small-magnitude earthquakes for the last 30 years and large earthquake rates obtained from the paleoseismic record. In contrast, the preceding 1200 years or so experienced a spate of earthquake activity, with large events along the Jordan Valley segment alone in 31 BCE, 363, 749, and 1033 CE. Thus, the return period appears to vary by a factor of two to four during the historical period in the Jordan Valley as well as at our site, and the fault's behavior is neither time- nor slip-predictable. The JGF seems to be affected by both its southern and northern neighboring segments, and there is tentative evidence that earthquakes nucleating in the Jordan Valley (e.g. 749 CE) can rupture through the Galilee step-over to the south of Beteiha, or trigger a smaller event on the Jordan Gorge segment, in which case the historical record will tend to amalgamate any evidence for it into one large event. We offer a model of earthquake slip for this segment, in which the overall slip rate remains constant, yet differing earthquake sizes can occur, depending on the segment from which they originated and the time since the last large event. The rate of earthquake production in this model does not produce a time predictable pattern over a period of 2kyr, and the slip rate varies between the 1st and 2nd millennia CE, as a result of the interplay between coalescing fault segments to the north.