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Ronnie Ellenblum; Shmuel Marco; Amotz Agnon; Thomas Rockwell; Adrian Boas

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The Crusader castle of Vadum Jacob, an outpost overlooking the Jordan River, was

deformed during a destructive earthquake triggered by motion along the Dead Sea Transform. The  $M > 7$  earthquake occurred at dawn, 20 May 1202, and offset the castle walls by 1.6 m. This exceptional precision in dating and estimating displacement was achieved by combining accounts from primary historical sources, by excavating the Dead Sea Transform where it bisects the castle, and by dating faulted archaeological strata. The earthquakes of October 1759 and/or January 1837 may account for the remaining 0.5 m out of a total 2.1 m of offset. Our study exploits the potential embodied in interdisciplinary historical-archaeological-geological research and illustrates how detailed histories of seismogenic faults can be reconstructed.

## First Page Preview

# Crusader castle torn apart by earthquake at dawn, 20 May 1202

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## ABSTRACT

The Crusader castle of Vadum Jacob, an outpost overlooking the Jordan River, was deformed during a destructive earthquake triggered by motion along the Dead Sea Transform. The  $M > 7$  earthquake occurred at dawn, 20 May 1202, and offset the castle walls by 1.6 m. This exceptional precision in dating and estimating displacement was achieved by combining accounts from primary historical sources, by excavating the Dead Sea Transform where it bisects the castle, and by dating faulted archaeological strata. The earthquakes of October 1759 and/or January 1837 may account for the remaining 0.5 m out of a total 2.1 m of offset. Our study exploits the potential embodied in interdisciplinary historical-archaeological-geological research and illustrates how detailed histories of seismogenic faults can be reconstructed.

## INTRODUCTION

The amount and timing of slip in historical earthquakes can be reconstructed with exceptional precision by combining evidence from archaeological observations and historical accounts. Excavation of ruins located along active fault traces (e.g., Noller et al., 1994) can also serve to address key questions in earthquake mechanics and aid in assessment of local seismic hazard. Archaeology, however, has had a different agenda, and harnessing this labor-intensive discipline for seismic studies requires a special effort. Guidoboni (1996, p. 7) states, for example, "It is only very rarely that the archaeological identification of traces of earthquakes has gone beyond conjecture, even on those occasions where admittedly a geophysicist has been called in." Our effort, focused on archaeological remains along the Dead Sea Transform (Fig. 1), has yielded the first direct evidence of surface rupture accompanying the earthquake of 20 May 1202. This earthquake, widely reported by contemporary historical sources (Mayer, 1972), was felt in a region extending for more than 3000 km, between Iraq in the east and Sicily in the west. On the basis of eyewitness accounts, Ambraseys and Melville (1988) assigned a magnitude of 7.6 to the earthquake.

The systematic offset of pre-Miocene geologic features across the Dead Sea Transform reveals that motion takes place primarily by left-lateral shear. Many large-magnitude earthquakes have occurred in the region throughout recorded

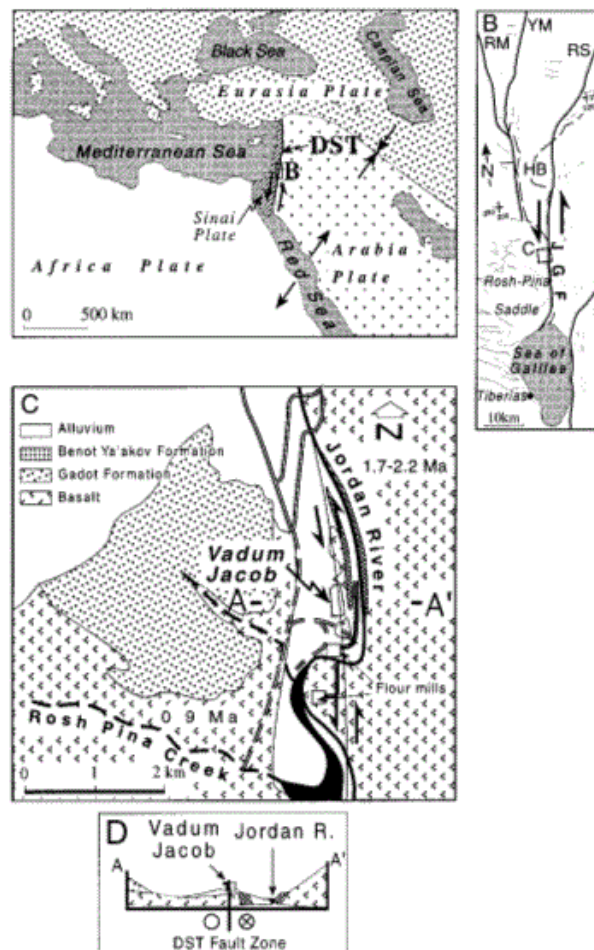


Figure 1. Location maps: A. Tectonic plates of Middle East. Dead Sea Transform (DST) is boundary between Sinai and Arabia plates. B. Dead Sea Transform zone showing main faults (solid lines) and secondary, mostly normal, faults (slim lines). JGF—Jordan Gorge Fault, RM—Room Fault, YM—Yammuneh Fault, RS—Rashaya Fault, HB—Hula Basin (after Bartov, 1990). C. Geologic map of Vadum Jacob area showing Pliocene to Pleistocene basalt flows with K-Ar ages (Goren-Inbar and Belitzky, 1989; Heimann and Ron, 1993), Quaternary lacustrine sediments of Gadot and Benot Ya'akov Formations, and Holocene alluvium (partly after Belitzky, 1987). D. East-west section across Vadum Jacob showing a fault through fortress. Circles indicate out-of-plane motion: empty circle—toward, crossed circle—away.

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