Archaeoseismological investigation of the deformation of the ruin of the crusader fortress Ateret, Israel with 3DEC
Archaeoseismology

• Damages from pre-instrumental earthquakes in archaeological sites
• Extending the database for earthquake catalogues
• New insights into contemporary history
Working area Israel

(after Schewppe et al. 2017)
Working area Israel

(after Scheppe et al. 2017)

(after Hinzen et al. 2017)
(Photo left: Hinzen)
Earthquake history of the site

- Abandoned in 1179
- 25. May 1202
  - $M_s$ 7.4
  - Offset 1.25 m
- 30. October 1759
  - $M_s$ 6.6
  - Offset 0.5 m

(after Ellenblum et al. 2015)
Questions addressed to the site

• Does the dislocation velocity affect the deformation pattern of the fortification walls?

• Is it possible to decide, based on the deformation pattern of the wall, whether the total offset is the result of a rapid coseismic movement or does slow creep movement have to be considered as well?

• Can new insights be gained on the dislocation velocity of the individual events?

• Is it possible to discern the amount of slip by which the two sides of the fault contributed to the total displacement? And in the case of a coseismic displacement, a follow up question is: Is it possible to distinguish between the effects of the two earthquakes?
Reconstruction

(after Hinzen et al. 2017)
Model Creation
Simulations

- In total 58 Simulations
- Separated into two scenarios
First Scenario

• Only one movement

• Four different movement directions with slip velocities ranging from 0.1 – 5.0 m/s

Results
Results

- Eastern plate moved in northern direction
- 1.75 m with 3 m/s
Second scenario

- Simulation of the two earthquake
  - First offset 1.25 m
  - Second offset 0.5 m
  - Slip velocities between 1.0 and 5.0 m/s
Results

- Offset: 1.25 m Velocity: 3.0 m/s
  - Intensity IX\(^1\) (Lit: VIII-IX\(^2\))
  - \(M_S\) 7.4\(^2\) (Lit: \(M_S\) 7.6\(^2\))
- Offset: 0.5 m Velocity: 1.0 m/s
  - Intensity VII\(^1\) (Lit: IV-VIII\(^3\))
  - \(M_S\) 6.7\(^2\) (Lit: \(M_S\) 6.6\(^4\))

\(^1\) Wald *et al.* 1999 \(^4\) Ambrasyes and Barazangi 1989
\(^2\) Ambrasyes and Melville 1988
\(^3\) Sbeinati *et al.* 2005
Conclusion

- DEM good possibly to quantify parameters of past earthquake
- In certain situations (as in Ateret) information about tectonic movement is possible
  - Good documentation of the archaeological site
  - Option for the reconstruction (archaeological, historical information)
  - Knowledge of the used building materials
Thank you very much!