UNCERTAINTY IN STRAIN-RATE FROM FIELD MEASUREMENTS OF THE GEOMETRY, RATES AND KINEMATICS OF ACTIVE NORMAL FAULTS: IMPLICATIONS FOR SEISMIC HAZARD ASSESSMENT

CLAUDIA SGAMBATO
DR JOANNA FAURE WALKER
 PROF GERALD ROBERTS

OVERVIEW

Strain rate values, calculated by discretising the fault on a grid with boxes of 200 m x 2 km size. When using only one value of throw (values on the left), the calculated strain rate shows a high variability.

The surface offsets across active normal fault scarps in the Italian Apennines have formed since the Last Glacial Maximum (LGM-12-18 ka), allowing the calculation of average throw rates across the active faults in the Apennines over the last 15 kyrs [6].

To measure the variations in throw rates along the fault, we constructed the scarp profiles using a systematic approach, avoiding biases due to exclusion of sites of minimum throw, using a meter ruler and centimeter to record the slope inclination.

Thirteen strain rates in a regular 100 m x 2 km grid, calculated using all available data and degraded dataset. Using one value of throw changes the strain rate value.

The surface offsets across active normal fault scarps in the Italian Apennines have formed since the Last Glacial Maximum (LGM-12-18 ka), allowing the calculation of average throw rates across the active faults in the Apennines over the last 15 kyrs [6].

To measure the variations in throw rates along the fault, we constructed the scarp profiles using a systematic approach, avoiding biases due to exclusion of sites of minimum throw, using a meter ruler and centimeter to record the slope inclination.

Figure showing a detailed geological and structural map of the southeast section of the fault scarp. Note the high variability of fault geometry; throw and slip vector are influenced by such variations.

CONCLUSIONS

Data on the geometry, rate and kinematics of deformation across the active Avellino normal fault scarps in the Southern Lucania region is presented, in order to determine:

- how accurately the mapping of those parameters and the fault trace need to be in order to calculate a representative strain rate;
- what aspects of the geometry and kinematics would introduce critical variability in the strain rate calculation if not measured in the field.

METHODS

STRUCTURAL MAPPING

- To understand the relationship between the geometry, kinematics and rates of deformation, we collected structural field measurements, such as fault strikes, dips, dip vector azimuth and plunge, and the throw 15-63 ka after across the scarps.
- The kinematics of the faulting was measured at 20 locations across the whole fault trace and correlative scarp profiles of the fault plane.
- The data has also been averaged along 8 sections of the fault (in figure above), these values are used for the strain rate calculations.

SCARP PROFILES

- The surface offsets across active normal fault scarps in the Italian Apennines have formed since the Last Glacial Maximum (LGM-12-18 ka), allowing the calculation of average throw rates across the active faults in the Apennines over the last 15 kyrs [6].
- To measure the variations in throw rates along the fault, we constructed the scarp profiles using a systematic approach, avoiding biases due to exclusion of sites of minimum throw, using a meter ruler and centimeter to record the slope inclination.

STRAIN RATE

- To understand the importance of detailed throw rate profiles, we calculated the strain-rate across the Avellino fault, using all the measurements of throw, and then progressively removing one measurement, re-calculating the strain rates for each degradation step.
- Then, we calculated the strain rates by imposing bascule or triangular slip distributions, following a method by Faure Walker et al. (2018)[5].

RESULTS

The surface offsets across active normal fault scarps in the Italian Apennines have formed since the Last Glacial Maximum (LGM-12-18 ka), allowing the calculation of average throw rates across the active faults in the Apennines over the last 15 kyrs [6].

To measure the variations in throw rates along the fault, we constructed the scarp profiles using a systematic approach, avoiding biases due to exclusion of sites of minimum throw, using a meter ruler and centimeter to record the slope inclination.

Figure showing a detailed geological and structural map of the southeast section of the fault scarp. Note the high variability of fault geometry; throw and slip vector are influenced by such variations.

Average values calculated within 8 sections of the fault, based on variations of the fault plane. The figure shows variations of throw along the fault.

MORE INFO

Full article: Sgambato et al., 2020
Email: claudia.sgambato.17@ucl.ac.uk

Full article: Sgambato et al., 2020
Email: claudia.sgambato.17@ucl.ac.uk

Full article: Sgambato et al., 2020
Email: claudia.sgambato.17@ucl.ac.uk

Full article: Sgambato et al., 2020
Email: claudia.sgambato.17@ucl.ac.uk
Map of the Auletta fault. All the data collected have been averaged along 8 sections of the fault; figure above shows the average strike, dip, slip direction and plunge. These values, along with the throw measurements, are used for the strain-rate calculations.
RESULTS: STRUCTURAL MAPPING

- Map of the southeast section of the Auletta fault. The map highlights the variability of strike, which is attributed to the natural corrugations affecting the fault plane both at small and large scales.

- Values of strike for the whole fault are in the range of $088^\circ - 139^\circ$, and dip $45^\circ - 76^\circ$.

- Mean slip vector is $61^\circ -> 209^\circ$, suggesting a dip-slip or slightly sinistral oblique motion, towards SSW.
RESULTS: THROW VARIATIONS

- Figure showing the location of scarp profiles 1-11.
- The throw has a minimum value of 2.9 m, measured at the NW section of the fault (loc. 1), suggesting that at this location we are closest to the tip of the fault.
- The throw does not show a maximum in the centre of the fault section, because the entire fault probably includes the Vallo di Diano fault to the SE (see map in Overview section), so our data only covers the area close to the NW tip of this overall structure.
The throw gradually decreases towards the NE tip of the fault, from a maximum value of 10.1 m.

Variations are observed along the fault; for example, a local increase at about 2200 m, where throw is 7.7 m. These anomalies coincide with structural complexities, such as along-strike bends in the fault plane, where the fault dip is greater.

The throw-rate is as low as 0.19 ±0.04 mm/yr for a minimum value of 2.9 m, and 0.67 ±0.14 mm/yr, using the maximum measured throw value of 10.1 m; thus, the rates of deformation differ by a factor of ~3.5.

Modified from Sgambato et al., 2020
RESULTS: STRAIN RATE

- Figure (a) shows strain rate values, calculated by discretising the fault on a grid with boxes of 200 m x 2 km size.

- To compare the uncertainty relating to the use of different scales of observations, we calculated the strain rate using boxes of 2 km x 2 km size (b).

- Note the convergence of the strain-rates towards the all data model, as more throw measurements are progressively added.

- When using only one value of throw, the calculated strain-rate shows a high variability.

- With strain-rates differing ~2.8 and ~0.8 times the ‘all data’ case, this shows that using a single value is not a rigorous way to measure strain-rate.

Sgambato et al., 2020
Calculations of strain-rate in a 100 m x 2 km grid boxes, by imposing boxcar or triangular slip-distributions show variations of 237%, 105%, 72%, 120% of the 'all data' profile.

This shows that degrading data by extrapolating a single throw value along a fault changes calculated strain-rates across the fault.

Thus, the strain-rate is highly affected by the local changes in throw, which are strongly dependent on the fault structural complexity.
REFERENCES


