Partners :

EGU General Assembly 2020

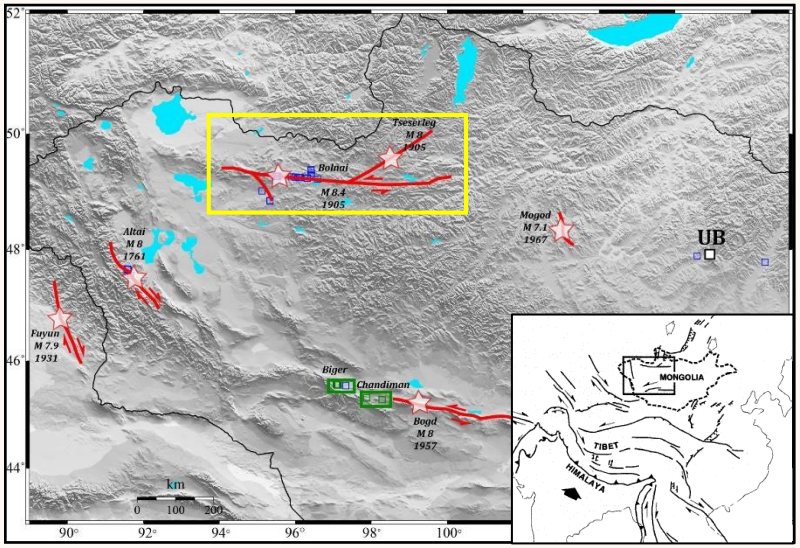
EGU2020-5325

Analysis of surface rupture complexity sheds light on coseismic slip during the last earthquakes along the Bulnay-Tsetserleg fault zone (Mongolia)

Yacine Benjelloun, Yann Klinger, Solène Antoine, Ganbold Baatarsuren, Laurent Bollinger, Yungbeom Cheon, Jin-Hyuck Choi, and Ganzorig Davaasuren

Contact : benjelloun@ipgp.fr
Webpage : http://www.ipgp.fr/en/benjelloun-yacine
Find me on ResearchGate

Context : a very slow deformation intraplate zone

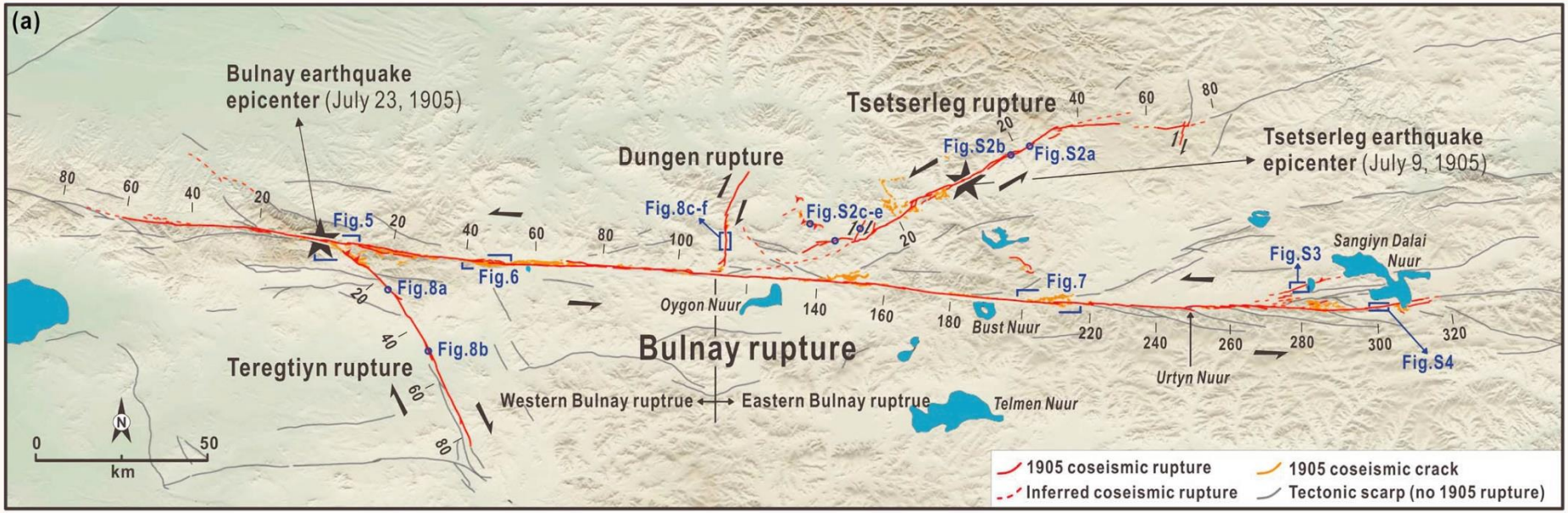


The 1905 Bulnay-Tsetserleg earthquakes

The largest continental strike-slip sequence documented

Two M~8 left-lateral strike-slip earthquakes

- Starting along Tsetserleg fault in the N
- Second event 14 days later along Bulnay main fault + Teregtiyn and Dungen secondary branches



(Choi et al., 2018 – JGR)

https://doi.org/10.5194/egusphere-egu2020-5325

The Tsetserleg rupture: Questions and goals

(Choi et al., 2018 – JGR)

Rupture width (km)[a]	Rupture section	Length (km)	Slip (m)	MO X 1,027 (dyne cm^2) with shear modulus of 30 GPa	Mw
Tsetserleg earthquake					
10	Tsetserleg rupture	114	2.57	0.879	**7.26**
25				2.197	**7.53**
50				4.395	**7.73**
80				7.032	**7.86**

- The seismological magnitude (Mw 8) is larger than the magnitude derived from coseismic geomorphic offsets

- How to explain this discrepancy ?
  - May local offset measurements underestimate the total coseismic displacement ?
  - Is there a vertical slip component ?
  - Did the rupture extend more than what was mapped ?

- Good preservation allows detailed analysis of the 1905 Tsetserleg surface rupture
  - Insight into rupture dynamics
  - Impact of fault geometry on surface rupture style and development
  - Preserved traces of previous earthquakes ?

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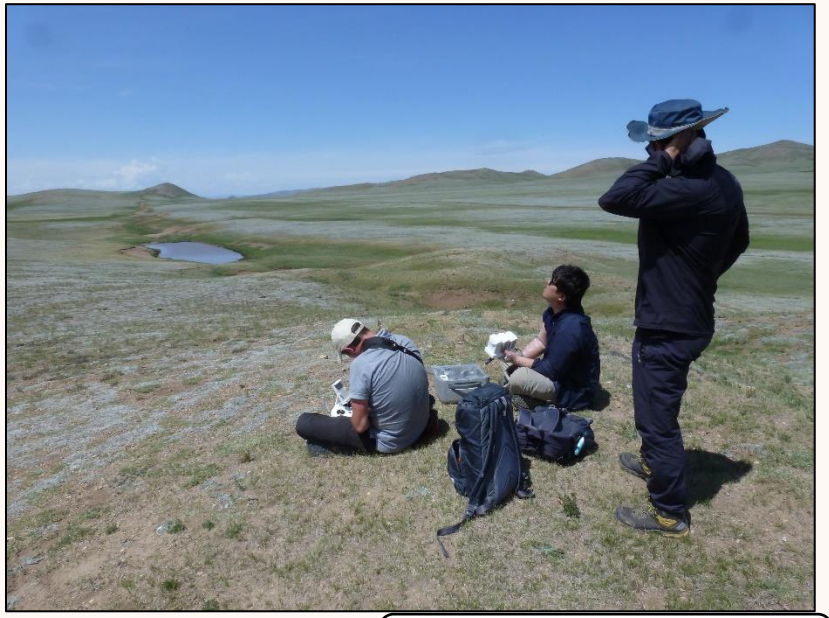
Methodology



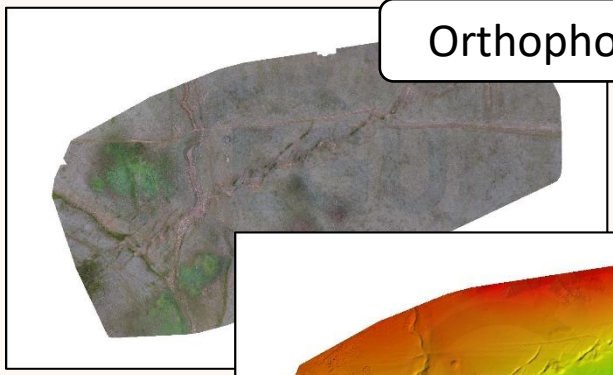
On the field (16/06 – 07/07/2019)

- HR image acquisition with DJI Phantom 4 drone

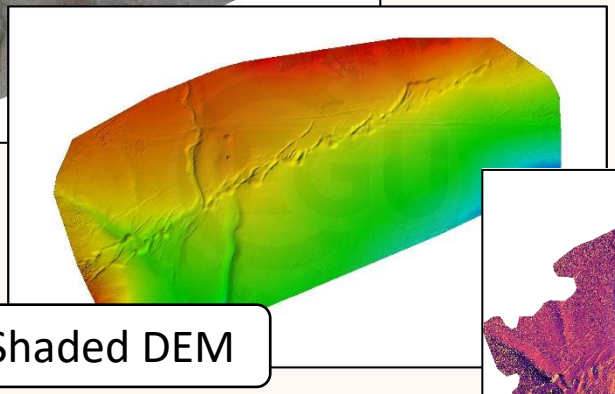
Back home

- Image processing: photogrammetry (MicMac and Agisoft Photoscan softwares)

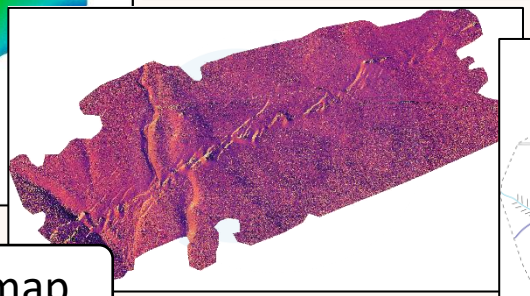
- Image analysis and measurements
  - Surface features mapping
  - Crack width projected along fault strike
  - Topographic profile extraction…



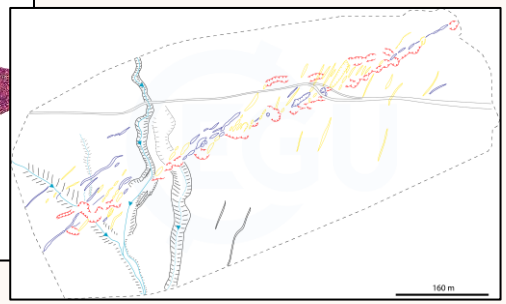
Orthophotomosaic



Shaded DEM



Aspect map



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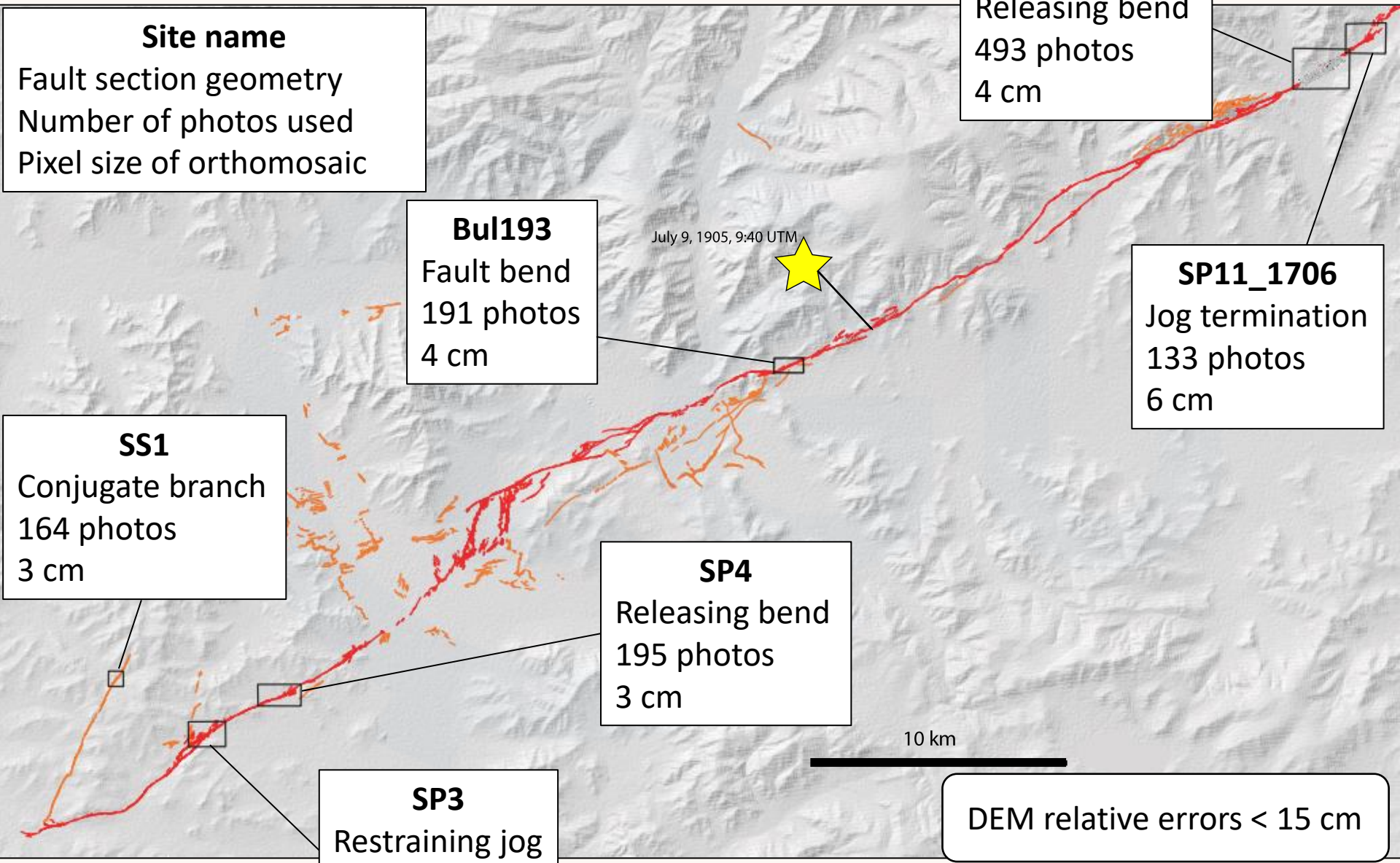
Drone acquisition sites and datasets



Site name
Fault section geometry
Number of photos used
Pixel size of orthomosaic

SP11_1701
Releasing bend
493 photos
4 cm

Bul193
Fault bend
191 photos
4 cm

SP11_1706
Jog termination
133 photos
6 cm

SS1
Conjugate branch
164 photos
3 cm

SP4
Releasing bend
195 photos
3 cm

SP3
Restraining jog
75 photos
6 cm

DEM relative errors < 15 cm

Fault map from Choi et al. (2018)

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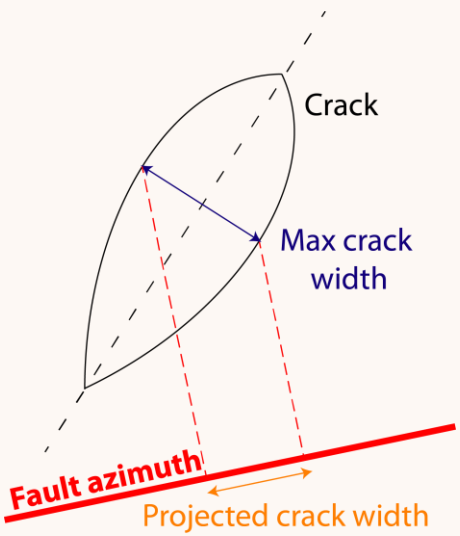
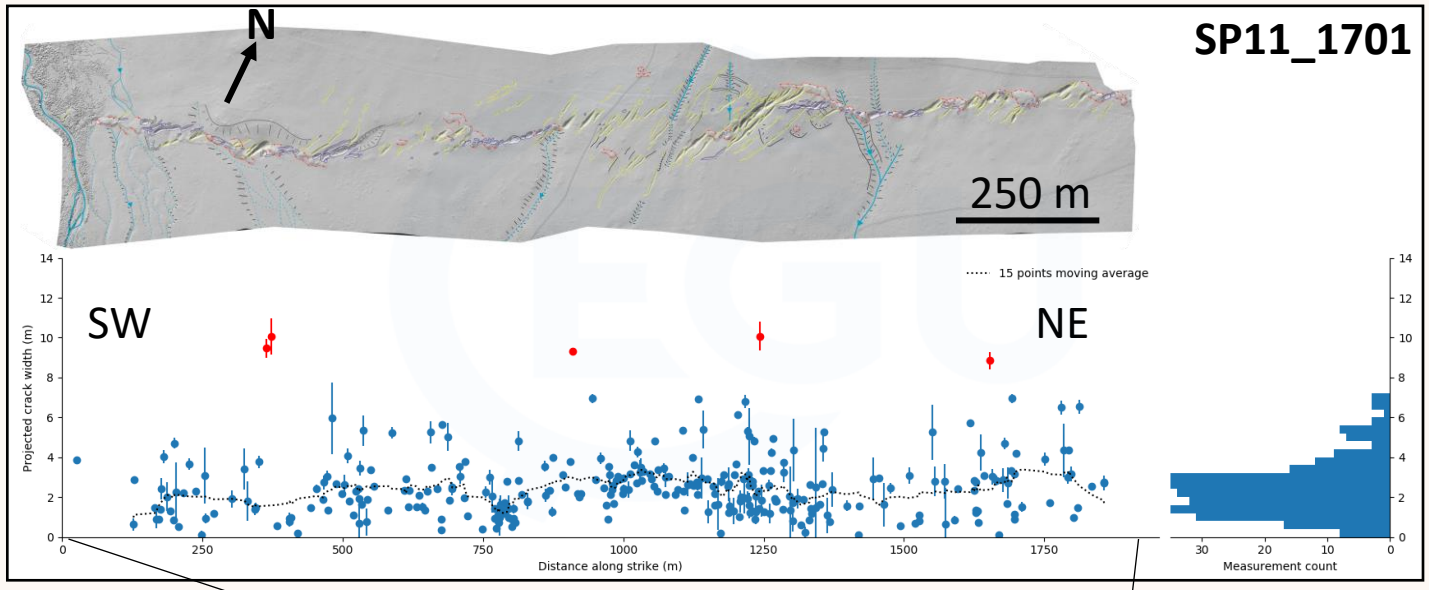
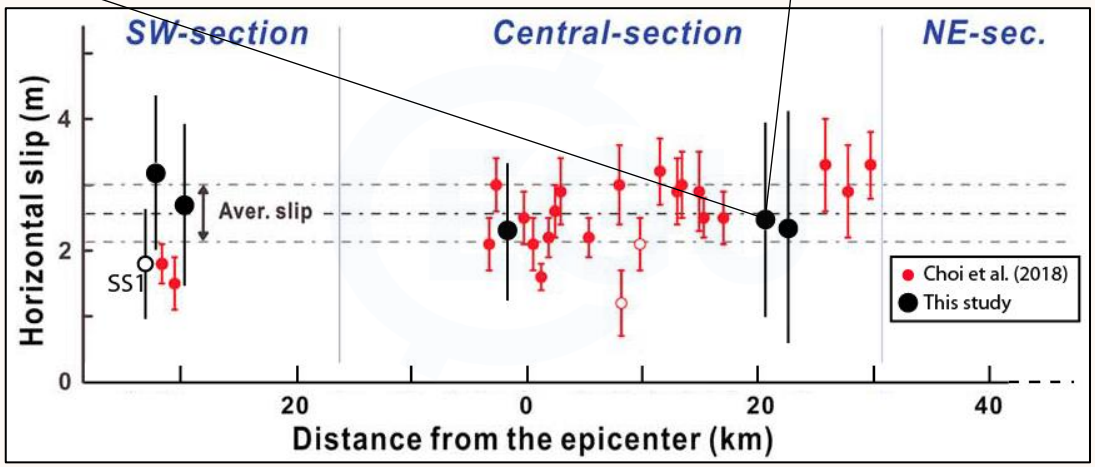
Horizontal slip from crack measurements





The mean value per site is close to the average slip deduced from offset markers.

All measured offsets ● fall in the range of projected crack width data ●



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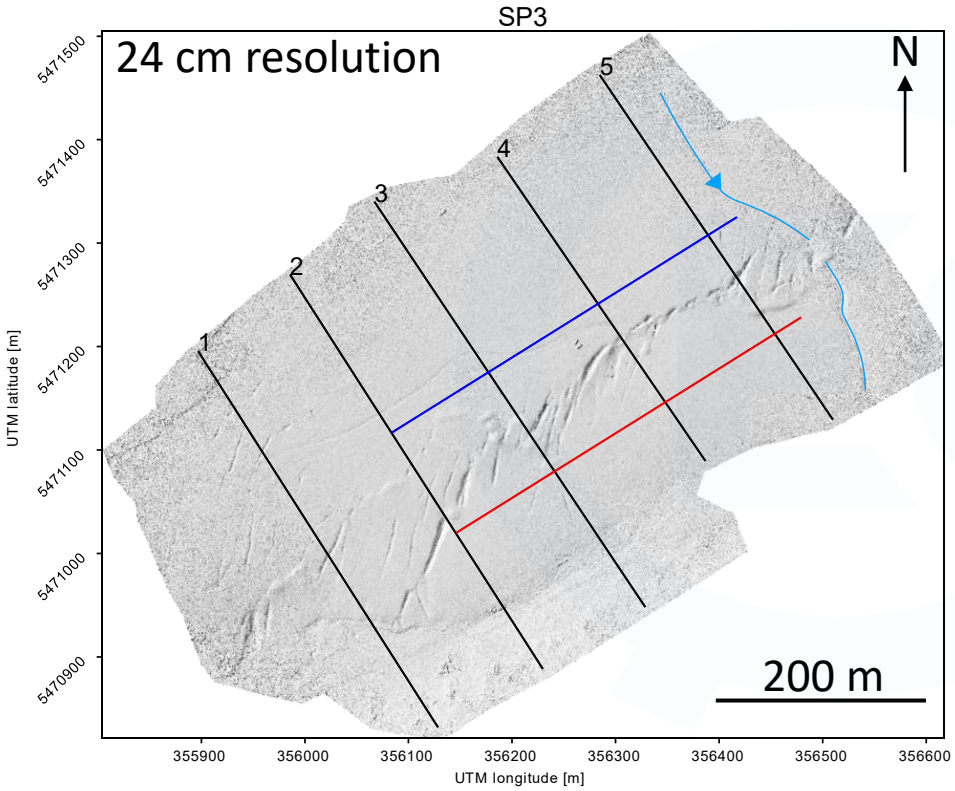
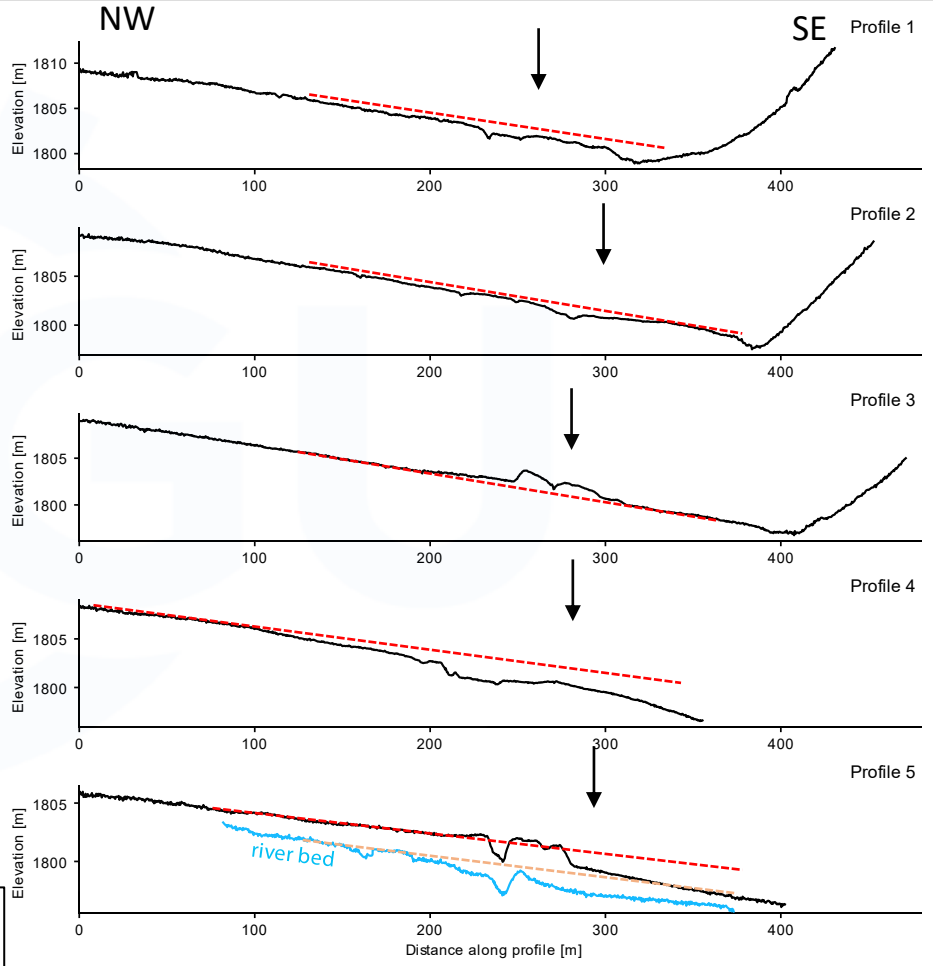
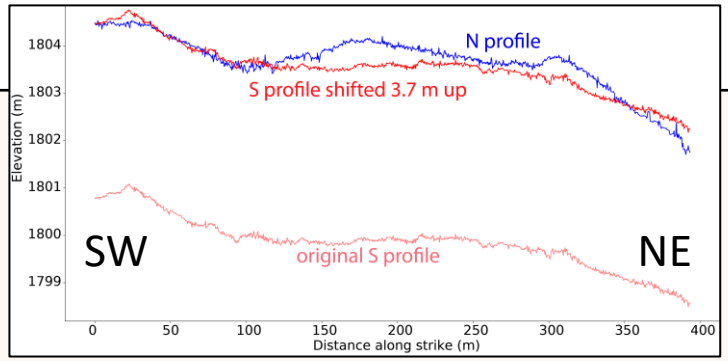
A vertical component ?







East of SP3: local uplift of northern block in compressive area

No significant vertical offset on other sites

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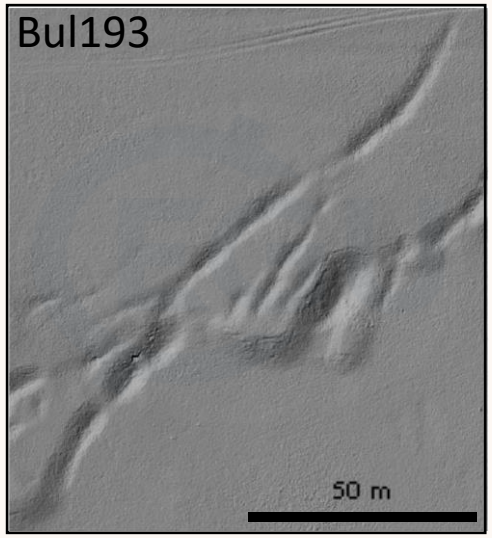
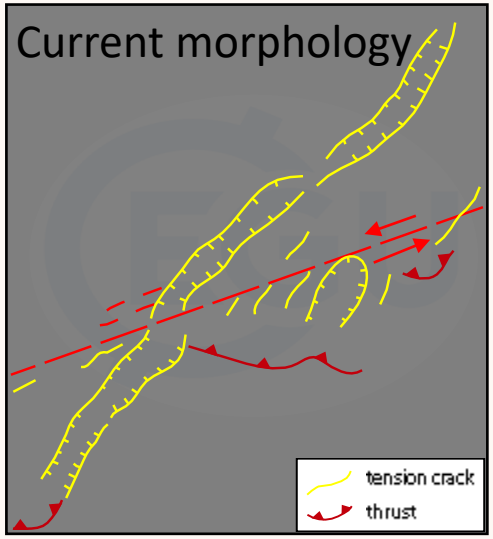
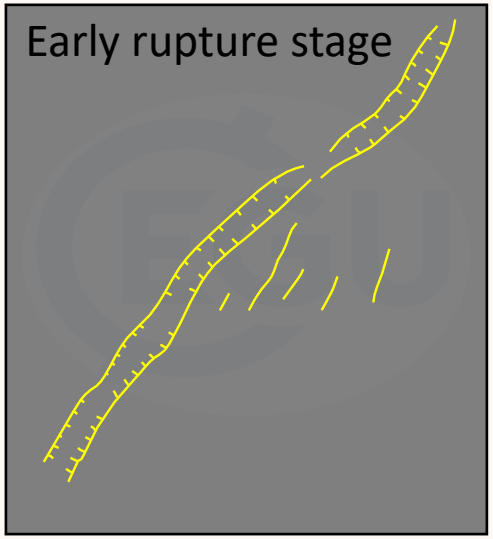
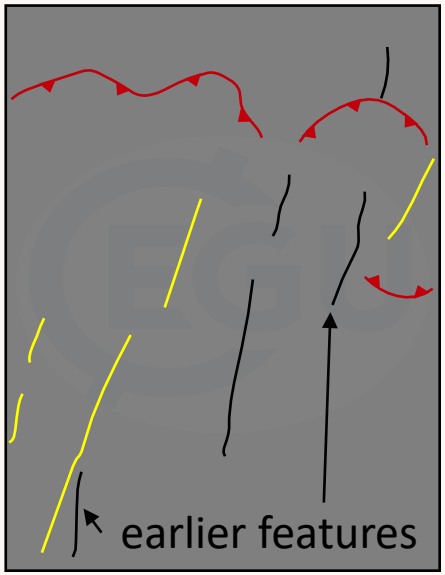
Insight on 1905 rupture propagation







2 m lateral offset of previously aligned, oblique cracks



Cracks crosscut by thrusts

Similar features were reported on other ruptures (e.g. Klinger et al., 2005 BSSA on Kunlun)

Linked to faster propagation of the rupture front at depth -> surface cracks open first and later affected by strike-slip

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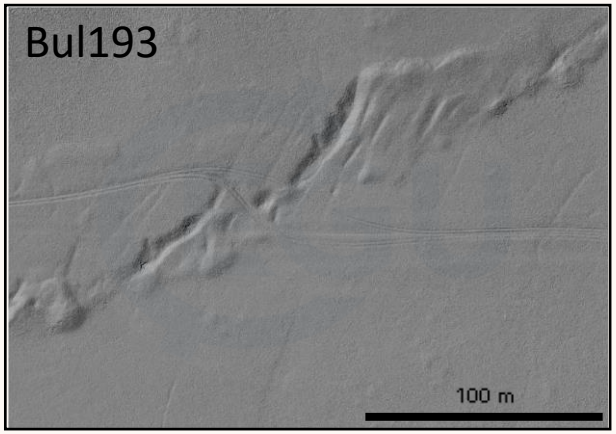
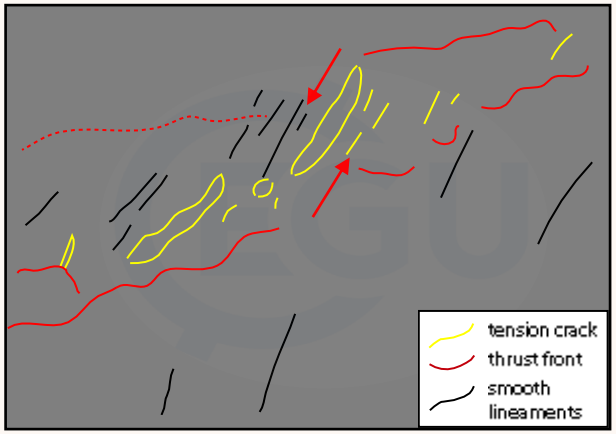
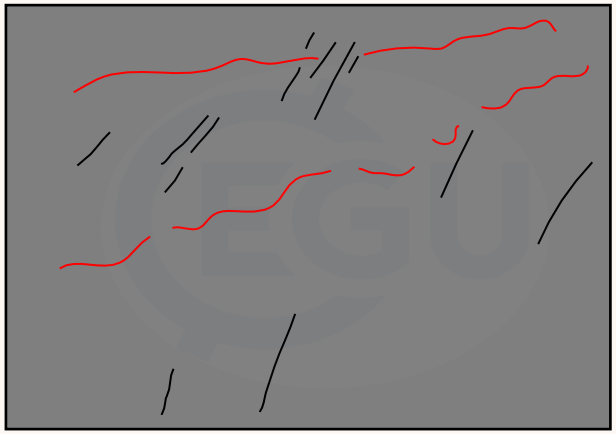
Cumulative features of successive earthquakes

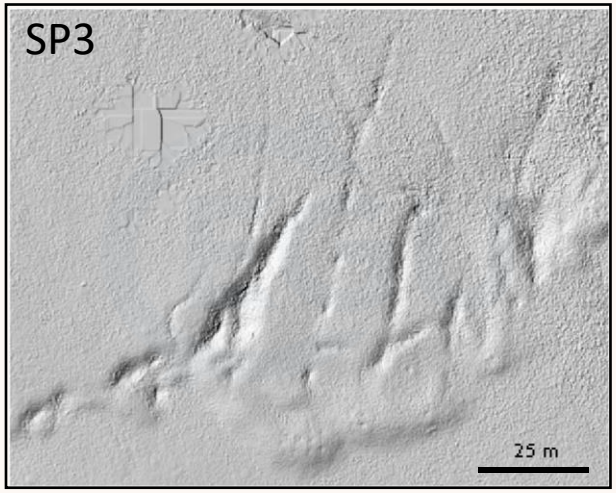
Post-1905

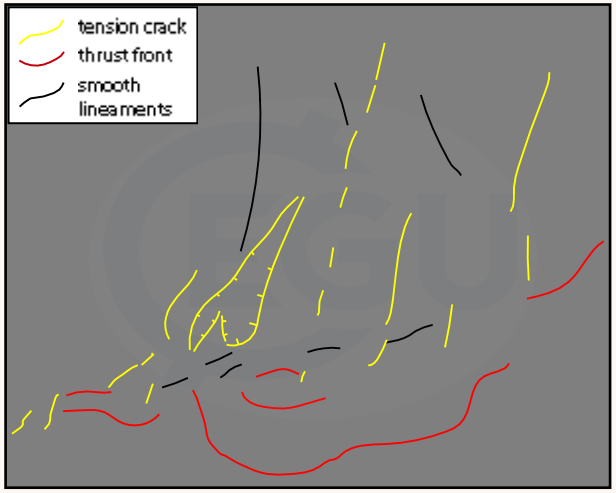
Pre-1905 reconstruction

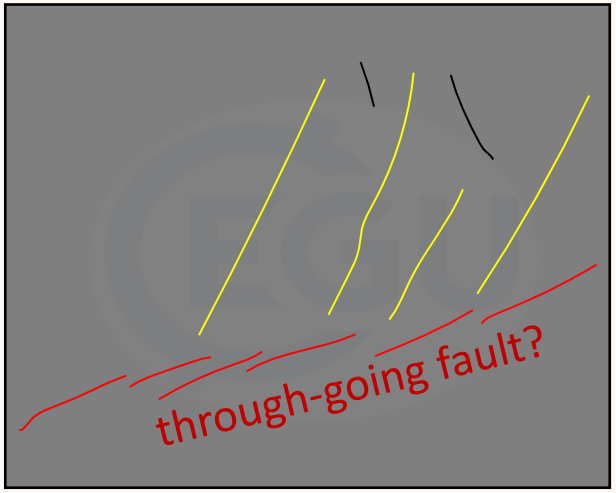












Network of smooth features from previous event(s), crosscut by last event

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Key points

- Performance of UAV image photogrammetry:
  - Acquisitions on fault sections between 0.15 and 0.65 km^2
  - Best resolutions of 3 cm for output photomosaic, 12 cm for DEM
  - Relative vertical precision between 8 cm and 15 cm

- Revisiting the coseismic slip of the 1905 Tsetserleg earthquake
  - Offset markers and crack width measurements provide similar average slip values
  - No significant vertical slip component

  -> Possibility that surface rupture underestimates real faulting length

- Several generations of tectonic features are preserved

  -> Reconstruction of 1905 earthquake's propagation

  -> Identification of previous earthquake markers

  -> Variability of rupture path through several earthquake cycles