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A paleoseismic investigation of a frontal foreland thrust in the Greater Caucasus, Georgia

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1. Introduction

The Caucasus defines the northern margin of the Arabia-Eurasia collision zone between the Black and Caspian Seas, within the Alpine Himalayan collision. Most orogen-perpendicular convergence within this sector of the Arabia-Eurasia collision is absorbed within the Greater Caucasus, as indicated by seismicity, GPS velocity gradients and geomorphic evidence. GPS data indicate 2-10 mm/yr of convergence across the Greater Caucasus, and earthquake focal mechanisms here generally have thrust mechanisms. There has been significant historical seismicity in the region including the Lechkhumi-Svaneti earthquake of 1350 (Ms 7.0, Io=9) and the Alaverdi earthquake of 1742 (Ms 6.8, Io=9). ***However, active faults with the potential for seismogenic rupture remain poorly characterized***.

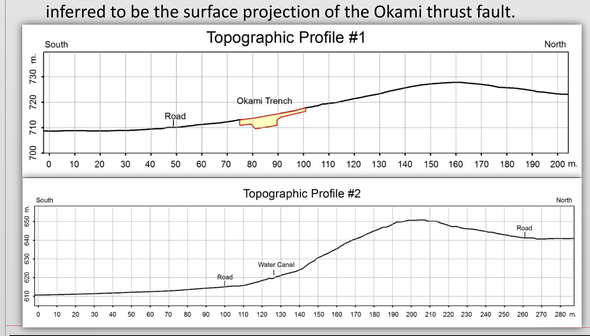
Here we present one of the first attempts to conduct a modern paleoseismic investigation of an active fault in the Caucasus foreland near the capital city Tbilisi. Geochronologic constraints on faulting are provided by radiocarbon dating of gastropod shells preserved in buried colluvium and paleosols.

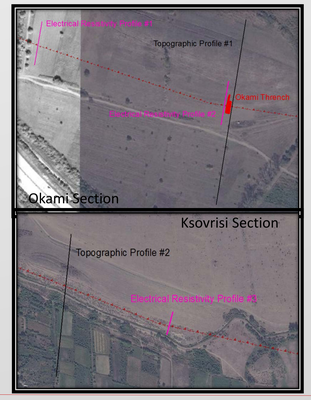
2. Geological and Tectonic Overview of Region

- The study area is located at the northern edge of Kartli basin near the town of Okami, in the frontal part of the Caucasus fold and thrust belt. The central part of the basin is composed of deformed Quaternary alluvial and colluvial sediments. On the periphery of the basin, Neogene and Paleogene terrigenous sediments comprise NW and SE-trending folds. There have so far been no paleoseismic studies on faults within the basin.
- The trench site is located on a frontal thrust of an asymmetric, south-vergent anticline. The structure is part of a fault system with a potential rupture length of >30 km, making this a significant earthquake hazard for the nearby city of Tbilisi, ~40 km to the south.

3. Topographic Survey

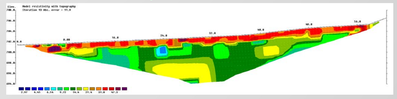
- The frontal fold is 20-40 m high with a north-dipping backlimb, based on our RTK GPS topographic survey prior to subsurface investigation.
- Our paleoseismic trench is located at the slope inflection point, which was inferred to be the surface projection of the Okami thrust fault.



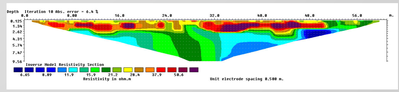


4. Electric Resistivity

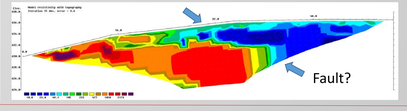
Electrical Resistivity Profile #1



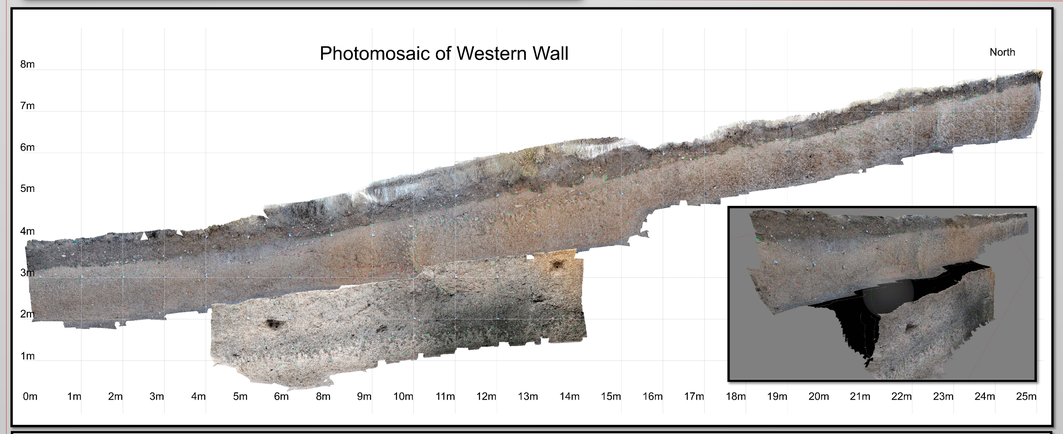
Electrical Resistivity Profile #2

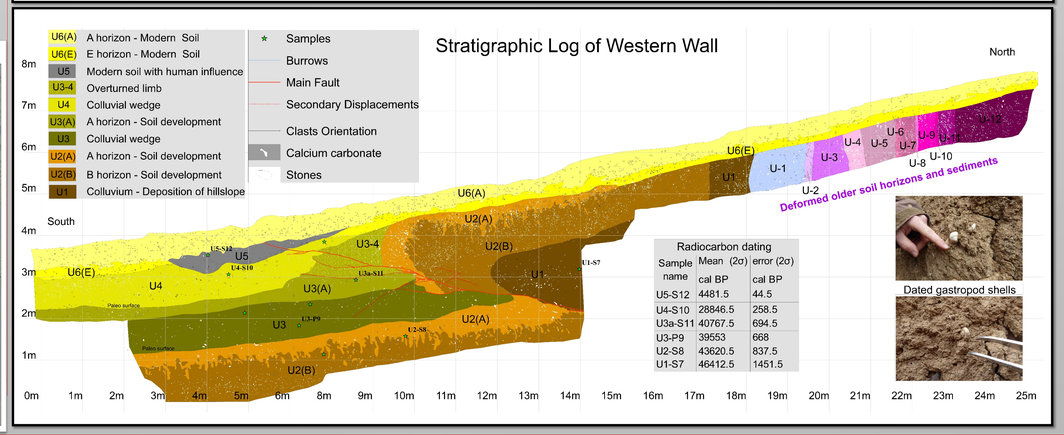


Electrical Resistivity Profile #3



- Units in the hanging wall and footwall differ in their electrical resistivity by up to ~10 Ω (Profile #2), although some results from the excavated site are ambiguous.
- A N-dipping resistivity contrast is observed on the Ksovrisi section (Profile #3) to the east of the trench, which might indicate shallow faulting.





Radiocarbon dating

Sample name	Mean (2σ) cal BP	error (2σ) cal BP
U5-S12	4481.5	44.5
U4-S10	28846.5	258.5
U3a-S11	40767.5	694.5
U3-P9	39553	668
U2-S8	43620.5	837.5
U1-S7	46412.5	1451.5

Dated gastropod shells

5. Paleoseismic Trenching

In 2015 we excavated a 24 m long and 5 m deep trench near the village Okami. An overturned fault-propagation fold and several synthetic and antithetic thrusts displace and deform paleosols and colluvial wedge packages. We identify 3 events from stratigraphic and structural relationships observed in the trench, with age control from radiocarbon analysis of gastropods (stratigraphic Log):

(1) One event between deposition of units 2(A) and 3 (after 43,621 +/- 838 calBP and before 39,553 +/- 668 calBP)
(2) Penultimate event between deposition of Unit 3(A) and before Unit 4 (i.e., between 40,768 +/- 695 and 28,847 +/- 259 calBP)
(3) A most recent event (MRE) following deposition of Unit 5 (i.e., after 4,482 +/- 45 cal BP).

6. Conclusions

- Trenching revealed evidence of 3 paleoearthquakes on a shallowly dipping thrust fault with a preliminary recurrence interval of ~25-35 ka. The long term slip rate is ~ 0.1 mm/yr since 40 ka.
- Electrical resistivity surveys may be useful in determining the location of future trench sites on buried thrust faults, which are capable of producing >Mw 7 earthquakes in the Caucasus foreland
- The Okami fault is one of several active structures in the Tbilisi area that warrant further paleoseismic investigation

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