The Hunt for Surface Rupture From the 1889 Ms 8.3 Chilik Earthquake, Northern Tien Shan, Kyrgyzstan and Kazakhstan

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ABSTRACT

The 1889 Ms 8.3 Chilik earthquake in the Northern Tien Shan Mountains of Kyrgyzstan and Kazakhstan is one of the largest historic intraplate reverse-faulting events. Documentation of slip distribution and fault geometry for major historic earthquakes, such as the Chilik event, provide important data on their source physics, seismotectonics, and hazard. These data also provide insight into potential mechanical interaction with other large regional earthquakes, notably the 1887 Ms 7.3 Verny and 1911 Ms 8.2 Kebin (Chon Kemin) events.

Despite the importance of the Chilik event, very little is known about the earthquake's epicenter and the presence of associated ground rupture. Isoseismal's from historic shaking intensity data gathered immediately following the event were used to estimate the event magnitude and suggest an epicentral location in the northern foothills of the Kungey Ala-too range, 80-100 kilometers east-southeast of Almaty. Researchers who have visited this area report no evidence of ground rupture, suggesting that the event either did not rupture the ground surface or that the isoseismal data do not provide a sufficiently focused estimate of epicentral location. We have reanalyzed the shaking intensity data to update the estimate of the epicentral location.

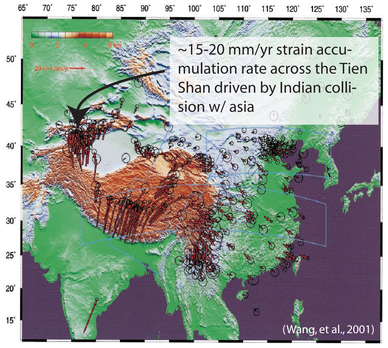
During June 2007 field work and in review of aerial photography, we observed extensive east-west trending and morphologically youthful km-long and 1-5 m high fault scarps on the eastern crest of the Kungey Ala-Too Range along the Kygyz-Kazak border north of Tyup. Contemporary reports of the 1911 Kebin earthquake did not document these structures, despite the thorough investigation of rupture to the west and northwest. The scarp lengths and their offsets indicate that they did not form in the M6.6 1978 Djalanash Tyup earthquake. Although located to the south of the isoseismal epicenter for the Chilik earthquake, the scarps observed near the range crest must be considered as possible candidates for Chilik ground rupture.

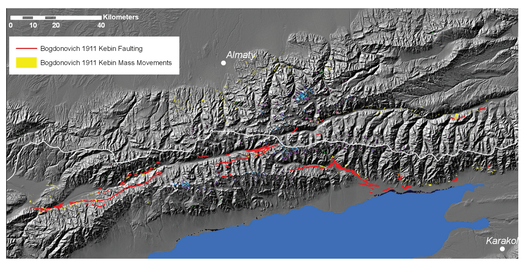
BACKGROUND

- The 1889 Ms 8.3 Chilik earthquake was the middle event in a sequence of high moment releasing events that included the 1887 Ms 7.3 Verny and 1911 Ms 8.2 Kebin (Chon Kemin) earthquakes. This anomalous sequence of earthquakes is of interest because of its intraplate setting and the possible data it may yield on earthquake hazards, source physics and potential fault interactions.

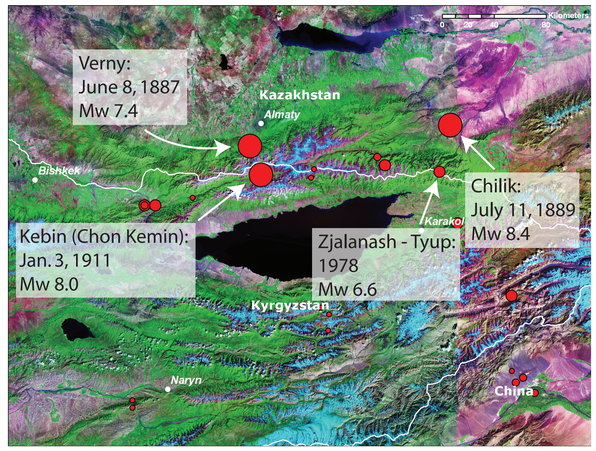
- Despite the importance of the Chilik event, very little is known about the earthquake's epicenter and the presence of associated ground rupture. The 1911 Kebin event is relatively well documented thanks to the work of Bogdonovich et al., 1914 who documented surface faulting and mass-wasting associated with the event, but similar data does not exist for either the Chilik or Verney earthquakes.

- Since 2004, we have been working to document at high-resolution ground rupture, slip distribution and associated mass-movements from these three large earthquakes.

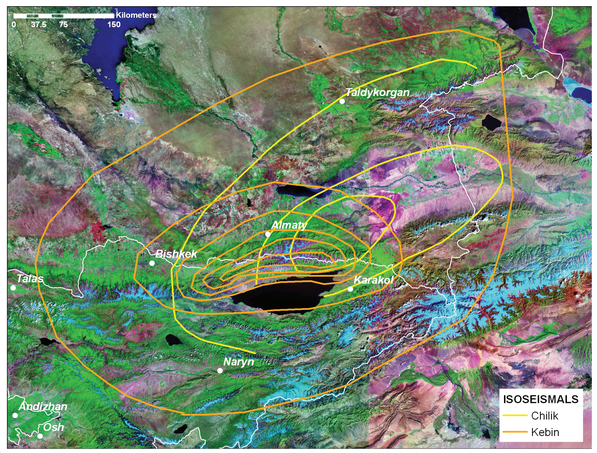




Extent of ground rupture and mass movements associated with the 1911 Chon Kemin earthquake. Mapping from Bodgonovich, et al. 1914.

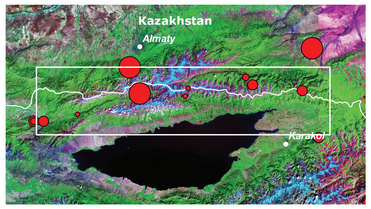


Map showing estimates of epicentral locations for all three events in the 1887-1911 sequence. Spatial and temporal clustering of the earthquakes suggests possible fault interaction. All events shown, including smaller events shown, come from catalog of hsitoric earthquakes in the TienSha compliled by E. Mamyrov.



Isoseimal contours for both the Chilik and Kebin earthquakes. Thesee data have been used to estimate the epicentral location of the earthquake. Note that the area of maximum shaking intensity (MMI 9) associated with the event is large and thus the epicentral location is likely poorly constrained.

PRELIMINARY OBSERVATIONS



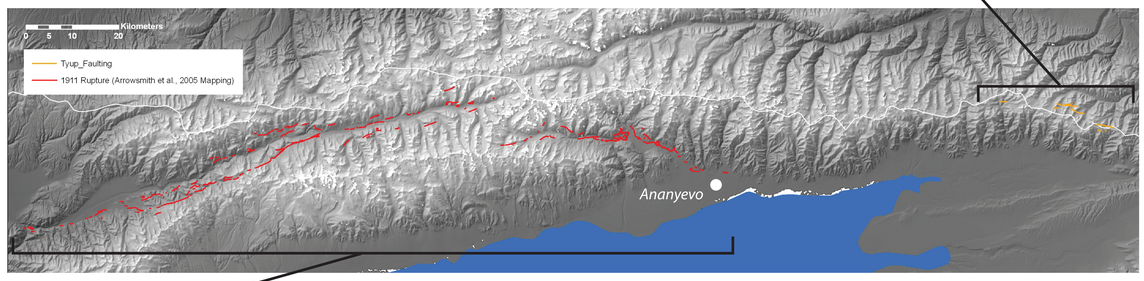
- Reconnaissance mapping during summer of 2007 focused on evidence of ground rupture from the 1889 Chilik event as well as smaller, more recent earthquakes.

- Informal reports of the epicentral location of the Chilik event (K. Abdrakhmatov, personal communication, 2007) suggest that there is no ground rupture present. This observation is surprising given the reported magnitude of the event. Either (1) the rupture was completely blind, or (2) the earthquake epicenter is mislocated.

- Large (0.5-3 m), geomorphically youthful scarps, located on the ridge crest of the Kungey Ala Too range NE of Tyup appear to have been produced in a relatively large and recent event.

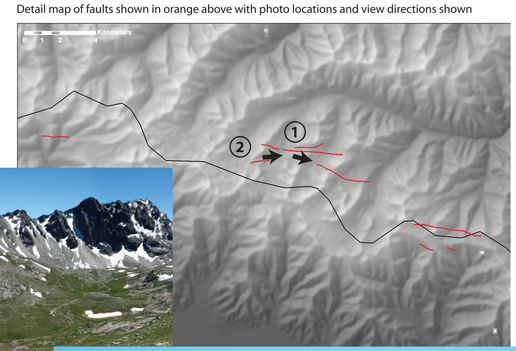
- These scarps are in the s epicentral area of the 1978, Ms=6.6 Zjalanash-Tyup earthquake, and it is possible that the scarps are a product of this event. However, this area also falls within the highest MMI contour from the Chilik event and therefore the scarps could be a product of the larger earthquake.

Extent of map shown as white box above

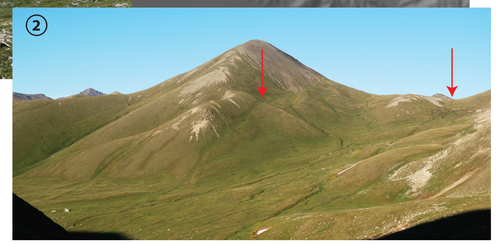


Our feld work in 2004 and 2005 focused on mapping the 1911 Kebin earthquake rupture extent and slip distribution. It appears that the eastern most rupture from the 1911 event, based on both our mapping and that of Bogdonovich et al., 1914 was just east of Ananyevo.

Detail map of faults shown in orange above with photo locations and view directions shown



ABOVE: Photo looking east, just north of the Kyrgyz/Khazak border, at parallel, steeply dipping fault-traces. Note the dammed pond on the northern trace. The area between the two faults appears to have been down-dropped, forming a range-top graben.



RIGHT: Photo looking northeast, towards the saddle from which the photo above was taken. Again, two parallel fault traces are visible.

FUTURE WORK

- In order to better evaluate whether the scarps documented during the 2007 field season are related to the Chilik event will require significantly more work:
  - Reconnaissance mapping in the published Chilik epicentral area to determine if ground rupture is present.
  - Additional field and aerial photo mapping in the area visited in summer 2007 (shown above) to document the full extent spatial extent of the scarps.
  - Attempt to acquire age control for the scarps shown above via either paleoseismic excavation or dating of offset landforms.

- Re-evaluation of macroseismic data from the Chilik earthquake using the relationships established by Bakun and Wentworth, 1997 to better constrain the area of greatest shaking intensity and thus, epicentral area.