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Landslides in Southern Kyrgyzstan: Understanding Tectonic Controls

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Frequent landsliding is one of the greatest natural hazards facing the inhabitants of Central Asia's Fergana Basin and the surrounding mountain ranges. Active tectonics in the region is rapidly building the Tien Shan, one of the highest mountain ranges on Earth, and the extreme topographic relief promotes frequent landslide activity, which causes major losses of life and property. In southwestern Kyrgyzstan alone, on average 10 people die and seven houses are destroyed each year in these sudden and rapidly moving landslides.

Landslides are mainly concentrated in the foothills along the eastern rim of the Fergana Basin, which span Kyrgyzstan and Uzbekistan. Potentially river-damming landslides pose an additional threat: Radioactive waste rock and tailings from Soviet-era uranium mining (e.g., in Mailuu-Suu) could be washed out and subsequently contaminate large areas of the Fergana Basin, which is currently inhabited by about 11 million people [*Havenith et al.,* 2006].

Because of the Fergana region's high landslide hazard, coupled with the potential for these landslides to disrupt the lives of so many people, scientists in Germany and Kyrgyzstan operated a yearlong seismic monitoring effort to better understand what controls landslide occurrence in the Fergana region.

A Closer Look at Landslides in the Fergana Basin

Landslide activity in southern Kyrgyzstan is controlled by complex interactions among tectonic, geological, geomorphological, hydrological, and meteorological factors. Rock and soil type influences the style of landslide motion [*Roessner et al.,* 2005]. Most of the landslides develop as rotational slides in weakly consolidated sediments of the Cenozoic era (younger than 65 million years). They are mainly mobilized during the rainy season between fall and spring, suggesting that precipitation and hydrogeological processes are the main triggering factors for landslides. Figure 1 shows an exemplary landslide that occurred on 3 May 2010, close to the settlement of Oi-Tal.

Geological field investigations in combination with satellite remote sensing analysis suggest that recent tectonic activity is the main factor controlling locations of landslides [*Wetzel et al.,* 2000]. Some areas along active fault zones in the Tien Shan have larger and, likely, more frequent bedrock landslides [*Strom et al.,* 2005]. However, the recent activity and the exact positions of the main structural elements and their relation to the centers of landslide activity are not understood, due in part to the limited number of permanent seismic stations in the region.

Temporary Seismic Network

The region around the Fergana Basin is presently characterized by moderate seismicity. However, four events of $M > 7$ have occurred since 1900. According to global catalogs, seismicity appears diffuse, with depths between 10 and 40 kilometers. Instrumentally detected activity on the Talas-Fergana fault, the dominant tectonic structure of the region, is low [*Xu et al.,* 2006].

To examine the distribution of local seismicity and potentially active tectonic structures in the Fergana region, researchers operated a temporary local seismic network from September 2009 to September 2010 (Figure 1). In total, the network had 21 continuously running broadband seismic stations covering an area of 32,400 square kilometers. The data are being used to identify and locate seismic events through interdisciplinary cooperation that combines seismology, structural geology, and remote sensing.

Preliminary analysis indicates that the yearlong temporary network observed more than 10 local or regional earthquakes per day. The low detection threshold of the network and the increased accuracy due to the small interstation distances (compared to data from regional or permanent networks) should yield an image of the active tectonic structures with kilometer-scale resolution.

Perspectives on Landslide Hazards

At least one major landslide occurred during the observation period, on 3 May 2010 (Figure 1c); understanding what seismic factors predisposed the area to generate this landslide as well as others will be an important focus. To this end, public seismic data from permanent networks in the region as well as from other agencies and projects will be included in the analysis of controlling factors of landslides in Kyrgyzstan. Additionally, the distribution of local (micro) earthquakes and tectonically active structures will be analyzed in the next few months in relation to landslide occurrence and the structural geological setting derived from satellite remote sensing and field investigations. The influence of precipitation, which can saturate hillslopes, will also be evaluated in a later stage of the study.

These investigations will build on the results from remote sensing investigations in combination with spatially differentiated evaluations of landslide hazard in southern Kyrgyzstan based on geographic information systems (GIS [see *Roessner et al.,* 2005]). The expected findings for this area should be a useful guide to understanding other regions of comparable high topographic relief and high tectonic activity in Central Asia.

So far, the network used in this study has been limited to Kyrgyz territory due to the political situation and thus does not cover the central part of the Fergana Basin, which is situated in Uzbekistan. To gain this expanded coverage, broader partnerships with research groups working in Kyrgyzstan and neighboring countries would help scientists more fully understand regional tectonics and related landslide processes in this region.

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References

Chedia, O. K. (1986), *Morphostrukturi i Noveishi Tektogenes Tian-Shana* (in Russian), 313 pp., Ilim, Bishkek, Kyrgyz Republic.

Engdahl, E. R., and A. Villaseñor (2002), Global seismicity: 1900–1999, in *International Handbook of Earthquake and Engineering Seismology, Int. Geophys. Ser.,* vol. 81A, edited by W. H. K. Lee et al., chap. 41, pp. 665–690, Academic, London.

Havenith, H. B., I. Torgoev, A. Meleshko, Y. Alioshin, A. Torgoev, and G. Danneels (2006), Landslides in the Mailuu-Suu Valley, Kyrgyzstan—Hazards and impacts, *Landslides, 3*(2), 137–147, doi:10.1007/s10346-006-0035-2.

Judachin, F. N. (1983), *Geofisisheskije Polja, Glubinnoe Stroenie i Seismichnost Tien-Shana* (in Russian), 247 pp., Ilim, Bishkek, Kyrgyz Republic.

Osmonbetov, K. O., J. V. Shukov, T. S. Samaletdinov, and R. M. Israeleva (1989), Tectonical maps (in Russian), scale 1:500,000, sheets K-43A, K-43-C, K-J-43-A, Goskartografia, Bishkek, Kyrgyz Republic.

Roessner, S., H.-U. Wetzel, H. Kaufmann, and A. Sarnagoev (2005), Potential of satellite remote sensing and GIS for landslide hazard assessment in southern Kyrgyzstan (Central Asia), *Nat. Hazards, 35*(3), 395–416, doi:10.1007/s11069-004-1799-0.

Strom, A. L., O. Korup, K. E. Abdrakhmatov, and H.-B. Havenith (2005), Investigating rock-slope failures in the Tien-Shan: State-of-the-art and perspectives of international cooperation (M111), in *Landslides: Risk Analysis and Sustainable Disaster Management,* edited by K. Sassa et al., chap. 12, pp. 109–112, Springer, Berlin.

Wetzel, H.-U., S. Roessner, and A. Sarnagoev (2000), Remote sensing and GIS based geological mapping for assessment of landslide hazard in southern Kyrgyzstan (Central Asia), in *Management Information Systems 2000: GIS and Remote Sensing,* edited by C. A. Brebbia and P. Pascolo, pp. 355–366, WIT Press, Southampton, U. K.

Xu, Y., S. W. Roecker, R. Wei, W. Zhang, and B. Wei (2006), Analysis of seismic activity in the crust from earthquake relocation in the central Tien Shan, *Bull. Seismol. Soc. Am., 96*(2), 737–744, doi:10.1785/0120030220.

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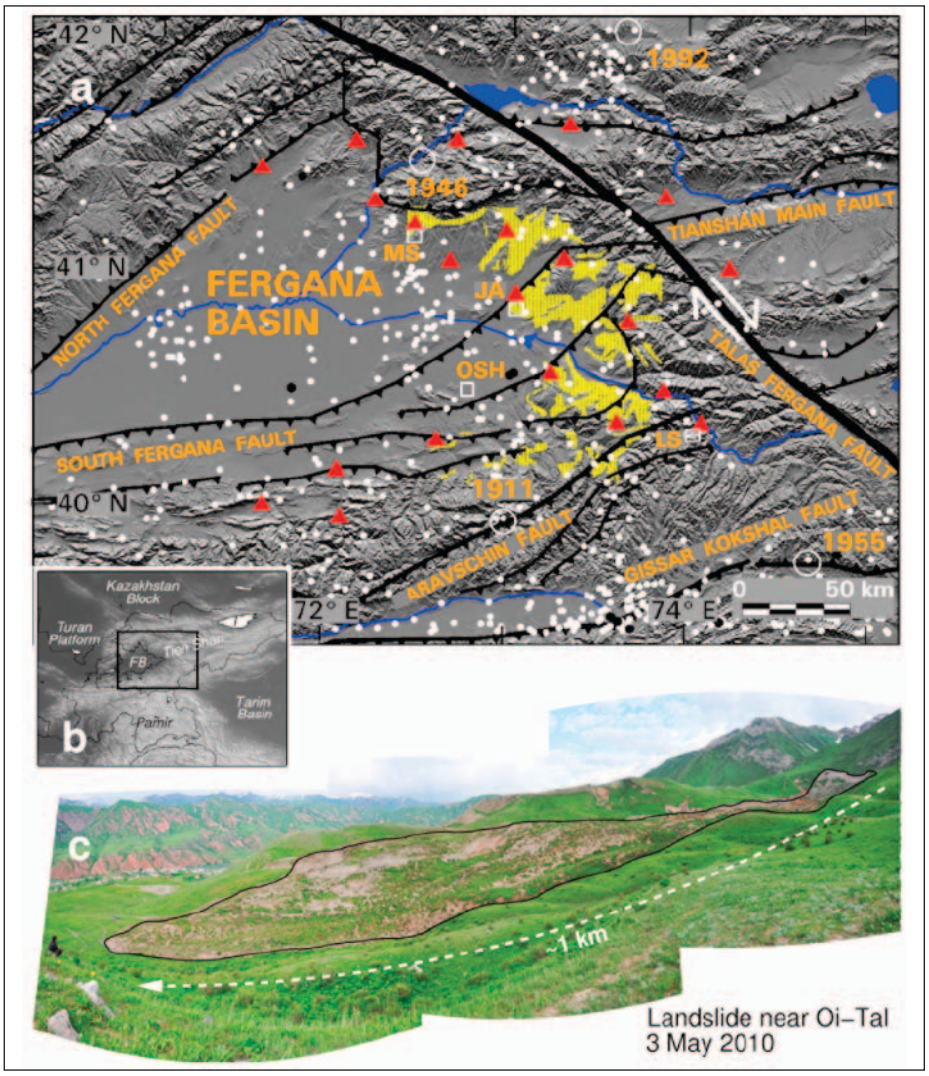

*Fig. 1. (a) The station network (red triangles) covers the region around the Fergana Basin mainly in the Osh and Jalal-Abad provinces. Faults are indicated by black lines [*Chedia, *1986;* Judachin, *1983;* Osmonbetov et al., *1989]. The main landslide area under investigation is shown in yellow (according to* Wetzel et al. *[2000]). White dots depict historic epicenters (according to the Preliminary Determinations of Epicenters (PDE) catalog; http://earthquake.usgs.gov), and black dots depict epicenters of* M > *4 earthquakes during the deployment period. Open white circles indicate epicenters of* M > *7 earthquakes since 1900 [*Engdahl and Villaseñor, *2002]. Squares indicate locations of interest. (MS, Mailuu-Suu, site of radioactive waste rock; OSH, Osh; JA, Jalal-Abad; LS, landslide on 3 May 2010). (b) The regional tectonic setting (FB, Fergana Basin; I, Lake Issyk-Kul). (c) A view of the large landslide (length > 1.0 kilometer) that occurred on 3 May 2010 near the settlement of Oi-Tal.*