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Seismic Risk in the Inner Tien-Shan: Lessons from the Suusamyr Earthquake

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The Inner Tien-Shan was classified as a little seismic area until the M=7.3 1992 Suusamyr earthquake [Bogachkin et al., 1997]. A new peak ground acceleration map has been constructed on the basis of movements of active faults, estimates of highest earthquake magnitudes associated with these faults and earthquake sources mechanisms Calculations were carried out according to the Aptikaev's attenuation model made for the Northern Tien-Shan and adjacent territories [Aptikaev, 1999]. The Suusamyr earthquake appears to be far from the strongest possible event in the area, with a geographically southward increasing seismic risk. As a series of hydroelectric power stations is planned on the Naryn River, seismotectonic studies should be given importance in this area.

INTRODUCTION

Though the time-forecast of seismic events is very chancy, places of occurrence are known with a higher degree of probability. The M=7.3 1992 Suusamyr earthquake occurred in an unpopulated region and involved a relatively small number of casualties. However, it weakened confidence in the Tien-Shan seismic hazards assessment. Before this event, many expressed arguments supported the idea of Inner Tien-Shan being a negligible seismogenic area. Arriving against any prediction, the Suusamyr earthquake attracted much international interest. Thanks to the SCOPES-SNSF support (project No IB7320-110694) data on neotectonics, seismic faults and seismicity of the Inner Tien-Shan have been combined to gain a reliable understanding of seismic hazards in this region.

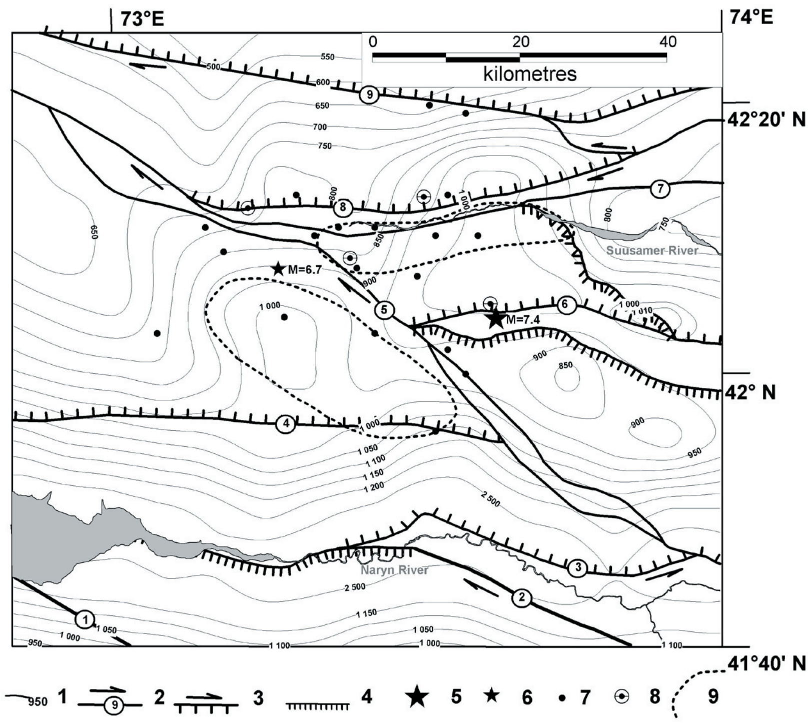

Fig. 1. Peak Ground Acceleration (PGA) map of the M=7.3 1992 Suusamyr earthquake source area.

1 – PGA values, 2 – strike-slip faults (names as in text), 3 – thrust – strike-slip, 4 - thrust, 5 –epicenter of the Suusamyr main shock, 6 –epicenter of the largest Suusamyr aftershock, 7 –epicenters of the Suusamyr aftershocks (M≥4.5), 8 – mud eruption, 9 –area of the Suusamyr earthquake.

Maximal magnitudes of the earthquakes and type of motion on the faults

The area is located to the north-east of the Talas-Fergana dextral fault (1, fig. 1). The Suusamyr-Toluk Fault (5, fig. 1) is parallel to and synthetic with the Talas-Fergana Fault. The Karakol fault (8, fig. 1) strikes nearly E-W with evidence for both dextral and sinistral movements. Paleomagnetic data on Paleozoic rocks of Central Tien-Shan reveal up to 90° counterclockwise rotation of crustal blocks. This rotation is consistent with sinistral movements along the EW fault system during Late Permian –Trias times. Dextral movements are recent reactivations.

The Suusamyr main shock is compressive with a dextral component. Aftershocks with M≥3.3 were studied. Their focal mechanisms differ regionally. In the southern area, the thrust component is similar to the motion of the main shock. To the north, thrust components occurred on shallower dipping planes whilst strike-slip components are important. Normal motions took place in the eastern area. 7 strike-slip, 5 thrust and 3 normal fault events were recorded over the last 15 years along the central part of the Talas-Fergana Fault [E.Book, 1990-2005].

The existing faults associated with a Mмах evaluation were taken as potentially dangerous zones. Strike-slip motion on the Talas-Fergana Fault (1, fig. 1) and thrust motion over the region were used for calculation of seismic hazard. The largest possible Mмах for the Suusamyr area is 7.7; M= 7.3 for the South-Aramsu (6, fig. 1) and M=6.9 for the Suusamyr-Toluk faults (5, fig. 1) were accepted in accordance with magnitudes of the main shock and the largest aftershock of the Suusamyr earthquake, which are associated with these faults. Possible magnitudes of M= 8 for the Talas-Fergana Fault (1, fig. 1) and M=7.7 for the Northern-Kavak Fault (3, fig. 1) were calculated. According to established relationships between scale, type of faulting and earthquake energy, these results characterize earthquakes with intensity Io= 10-11.

Peak ground acceleration map

According to the Gutenberg-Richter law, events with M=8 have a recurrence of about 500 years. The probability of occurrence in the next 50 years is 10-%.

For calculation of the peak ground acceleration map we used Aptikaev's attenuation model [Aptikaev, 1999] which is expressed as:

$$\lg A = 0.28M - 0.8 \lg R + 1.7 + C_1 \qquad \text{for } A \geq 160 \text{ sm/sek}^2,$$

where A – peak ground acceleration value,

M – earthquake magnitude,

R - distance from initial movement point,

C_1 – correction for a movement type in the earthquake source or in a fault plane.

C_1 = +0.2 for thrust, +0.1 for thrust – strike-slip, 0.0 for strike-slip, -0.1 for normal – strike-slip and

-0.2 for normal type.

Calculations show that, ground acceleration may exceed 1 g along the Talas-Fergana Fault and to north up to the south branch of the Suusamyr earthquake area, 0.8-0.9 g and 0.7-0.8 g are expected for the central and northern areas, respectively.

Conclusions

The Suusamyr earthquake was unexpected for the scientific community. Our work shows that seismic events stronger than the Suusamyr event are possible in Inner Tien-Shan. The seismic risk increases southward from the Suusamyr area. Seismic hazards in the Inner Tien-Shan are therefore important and Mmax are comparable to those of Northern and Southern Tien-Shan, where numerous destructive events in the XIXth and XXth centuries have been documented.

Taking into account that on the Naryn river construction of the hydroelectric power stations cascade is planned, seismotectonic researches should be promoted in this area.

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