

Landslide protection in Kazakhstan

Tony Waltham

A spur of the massive Tian Shan range, the Alatau Mountains form a high barrier between Kazakhstan and Kyrgyzstan in the heart of Asia. Their snowy peaks create a beautiful frontier, but are also the source of numerous debris flows, which threaten and destroy the villages and towns along their flanks.

Almaty, the major city of Kazakhstan, is built on a huge alluvial fan with the Alatau rising directly from its southern fringe. At the head of the fan, the Malya Almatinka canyon rises steeply to Medeu, a winter sports centre at an elevation of 1700 m, less than 10 km from the Almaty suburbs and 800 m above them. Just 5 km further up the valley, the ski resort of Shymbulak has ski lifts rising to 3200 m, below the Komsomola peaks which reach 4375 m.

The big feature at Medeu is the huge ice-rink stadium, which was the top Soviet venue for speed skating before Kazakhstan broke away from Russia in 1991. And rising high above the stadium is a massive rockfill dam – which holds no water. It is a giant debris catch.

In 1959, many people died in a debris flow that destroyed villages in the Issyk valley, on the Kyrgyz side of the range. This prompted creation of the Kazakh Landslide Protection Organization, to address any future potential hazards. The debris flows of the Alatau are the most mobile type of landslides. They are formed of the loose soils, colluvium, weathered rock and glacial till that plaster the steep slopes of these youthful mountains. This material is mobilized when it is saturated by heavy rain, rapid snow-melt or lake-burst flood events. Not only does it descend into the valleys, but the flows then hurtle many kilometres down the valley floors where houses and people are at serious risk.

The first part of the Medeu dam was built in 1966-7. A barrier 80 m high, with a crest length of 270 m, was built with 2.5 million cubic metres ($M m^3$) of broken rock, largely derived from blasting down rock spurs on each side of the dam site. The river was piped beneath the rockfill, and the dam just stood there – waiting, just in case a debris flow came down from the upper valley. In 1972 the ice stadium was built.

Then in 1973 the precautionary engineering paid off. A debris flow arrived, and was totally restrained by the dam. Nearly $4M m^3$ of debris half-filled the basin behind the dam, along with $1.5M m^3$ of floodwater, which then drained off slowly and harmlessly.

With the giant debris catch now only half empty, Medeu and Almaty were again at risk. So the dam was enlarged. It is now a seriously huge structure, 150 m high with a crest length of 530 m, built of $8.5M m^3$ of rockfill. Its catch basin can



The Medeu ice stadium protected below the downstream face of the rockfill dam which acts simply as a catch for debris flows.

hold $12.6M m^3$ of inflowing debris, and a multilevel ladder of overflow tunnels is designed to drain off $30 m^3/s$ of water from whatever level the debris reaches (Fig. 2). Today, the basin is still waiting, because there have been no debris flows since 1973. In part this is due to engineering works that have controlled the outflows from lakes ponded behind retreat moraines in the upper valleys; failure of their marginally stable till dams was a potential source of debris flows, posing one type of hazard now largely eliminated.

Debris flow protection works continue below Medeu, where smaller flows could be generated on slopes downstream of the big dam. Open steel-frame barriers reach across the valley floor, broken only by gaps for the river in normal flow, and for the road. These are similar to lahar barriers on some of Japan's volcanoes. They are designed to trap the large debris and take some of the destructive power out of any flow events – a welcome defence for the upper suburbs of Almaty. Today they stand unused, but could be more than appropriate if debris flows increase in frequency in a new climatic regime caused by global warming.

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Upstream face of one of the more modest debris-catch-barriers downstream of the Medeu dam.



Looking downstream across the Medeu catch basin, with the rockfill dam across the far side. The flat floor is the debris of the 1973 flow, which the dam successfully stopped. On the left, the ladder of dark holes forms the outlets for water above any level of new debris fill.