

Mass movement in northeast Afghanistan

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ABSTRACT

Mass movements of nearly all types occur in Afghanistan but in the high relief, rugged Pamir and Hindu Kush mountains of northeastern Afghanistan, mass-movement threats to lives and property necessitated study to elucidate problems to development. Twenty-two different mass movements in bedrock in the Badakhshan Province of northeastern Afghanistan were studied for this paper, including large rock falls and rock slides, along with massive slope-failure complexes with many types and rates of movement. Where higher altitudes prevail in the region, ice-cemented and ice-cored rock glaciers are also common and overlie some of the other mass movements. Inasmuch as seismic energy sources in the Eastern Hindu Kush are maximal in southern Badakhshan, and relief, slope angles and precipitation all increase from west to east as well, the causes of the pervasive mass movement are plentiful enough, although direct cause and slope-failure effect are not known. Some weak sedimentary lithologies downfaulted into, or draped across crystalline rocks, also failed. Some intermixed tills also occur but are not easily differentiated, even with analysis on the ground.

Using high resolution satellite imagery and digital elevation models, we assessed geomorphologic parameters to characterize spatial-organization structures related to zones of erosion, deposition and further hazard potential. Analyses indicate that many of the massive slope failures can be characterized and differentiated into various process domains and chronologic-development zones with their different impacts upon the landscape. Mass movements in Afghanistan can exhibit unique topographic signatures that can be used to better assess hazards in other mountain areas, especially where landslide-dam break-out floods threaten. Development of roads, bridges, buildings, and irrigation networks should be done with care in these regions of Afghanistan.

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1. Introduction

General mass movement and slope failures have been known to a limited extent in Afghanistan in the past but it was not until Shroder's (1989;1998a,b) work that an initial investigation was made of the phenomena nation-wide. He noted that the country was a mosaic of sutured and uplifted crustal fragments whose widely varying rock types, great relief, and high seismicity caused many slope failures. Rock falls and rock slides were observed to be among the most common type of mass movement, but debris falls and slides were also noted. Slump and flow landslides were noted in some unstable sedimentary rocks. Finally, Shroder (1989) also noted that slope-failure hazards were an important constraint on Afghan development although little data have been collected to confirm this supposition to date.

Rock falls and rock slides from the profuse cliffs of Afghanistan into the many valleys have been noted by many researchers (Bruckl,

1935; Desio, 1975; Grötsbach and Rathjens, 1969; Mirzad, 1970; Shank et al., 1977; Shroder, 1989; Weippert, 1964). Some of these mass-movement events have dammed up rivers to produce lakes throughout the country. As occurs in many other parts of the world, there is some danger of eventual catastrophic breakout flooding associated with this type of lake. This commonly happens when the water impoundments rise to the top of the mass-movement dam and the resulting overflow erodes the dam face to cause failure (Costa and Schuster, 1988). In Afghanistan, however, the generally small river discharges in the water-deficient country, coupled with apparently high hydraulic conductivity ($\sim 10^2 \text{ cm}^{-1}$) through the presumably relatively open matrices of the landslides, has allowed them to remain largely in place in many locations. Long-term weathering of minerals, or infiltration of fine clastics into such dams, however, could reduce water transmissibility over time and thereby increase dam instability.

Additional types of mass movement in Afghanistan are those wherein various mixtures of fine and coarse clastics (debris) move downslope as variable amounts of water enter pre-existing deposits on slopes and either add a surcharge load, or dissolve binding

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matrices, or produce hydrostatic head in the ground water, or add seepage pressures; any or all of these causes of failure together can result in different types of slope movements. Velocities of movement can be highly variable, depending upon slope angles, amounts of water, and proportions of fine clastics. Rapid debris avalanches and rapid wet debris flows can occur as a result of monsoonal rains. Slower debris-flows and earth-flows can result in areas where there is less water. Some of those discussed herein probably occurred as glacial ice retreated in the last deglaciation

(probably the Little Ice Age (LIA) of a few centuries ago), and the permafrost came out of the ground as well.

It is the purpose of this paper to describe and characterize multiple mass movements in northeastern Afghanistan in order to better understand distributions, modes of emplacement, and causes. As Afghanistan continues to be developed, to improve the life of its people and to help pacify the ongoing insurgency by increasing employment, protection of the transportation routes, bridges, fords, water supplies, and places of habitation must be developed

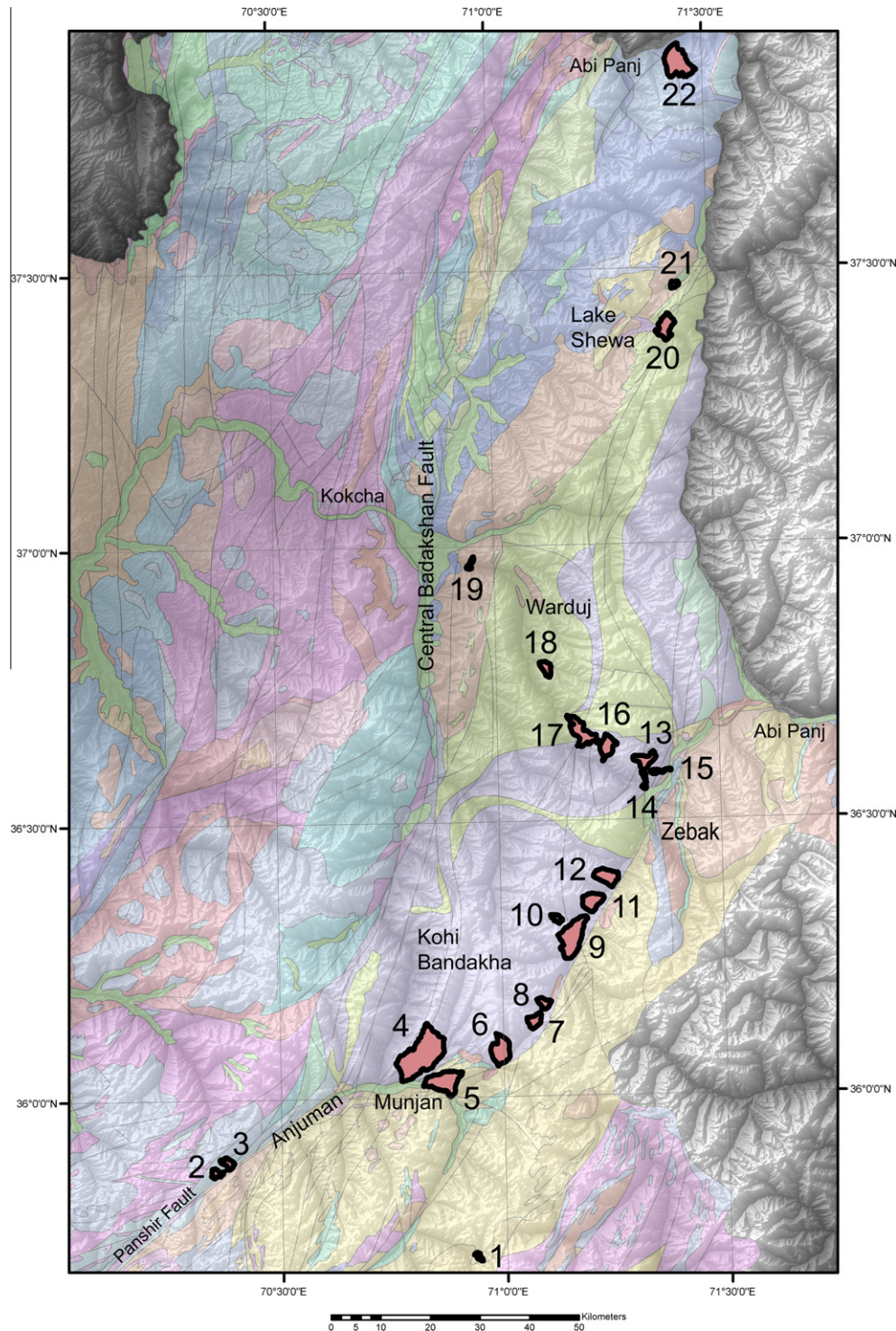


Fig. 1. Index map of study area of northeast Afghanistan. Slope failure types of large slope-failure complexes, together with a few rock falls/rock slides and slow debris flows are the chief mass movements mapped in this study. The slope failures are plotted over an underlying geology map of Afghanistan by Wandrey and Law (1997). Numbered slope-failure names are listed by name and number in Table 1.

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