GROUND FAILURE DURING KINNAUR EARTHQUAKE OF JANUARY, 19, 1975 HIMACHAL PRADESH, INDIA

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January 19, 1975 Kinnaur earthquake (M=6.8) caused major ground failures in Kinnaur and Lahaul-Spiti districts of Himachal Pradesh, India and the region across the Indo-Tibetan border. Seismic stress waves, associated with body waves, incident at the frozen brittle ground in the epicentral tract (along steep hill slopes and narrow valleys, in the rugged terrain of the area at more than 3000m elevations above mean see level) which on reflection as tension shriveled and blighted the frozen ground and rock masses. The resulting scabbing and slabbing of rock surfaces along joints partings and other weak zones caused loosening, dilation and crumbling of hill sides, often with deafening sound, in heap of debris. The waves reflected through discontinuity surfaces filled with frozen ice and weathered material caused separation, dislodging and uplift of rock boulders; and rock fragments on fracture at intact rock surfaces flew off and hit telegraph poles (Fig. 1), trees and roof tops of the houses in the valley. Some of these flying fragments pierced through telegraph poles. Large boulders at hill tops were reported to toss up and down and disloged (Fig. 2). Large dislodged boulders at many places rolled down and fell on road disrupting traffic and damaging hillside and roadside houses.

The amount of loose rock formed due to the reflected tension normal to the frozen ground or intact rock surface, plus possibly the tengential tension due to the inclination of the wavefront, depended on the nature of rocks, and spacing and attitude of the pre-existing discontinuity planes and other weak zones in relation to the surface slopes. With the onset of strong ground shaking due to the seismic waves the loosened tabular and prismatic slabs of clay, carbonaceous shales, phyllitic schists, quartzites, schists, gneisses and other formations and fractured ice and frozen soil cascaded along the hill slopes (Fig. 3) and caused extensive damage to the Hindustan-Tibet road, which disrupted rescue and relief operations. Landslides and rockfalls in such loose and dilated rock masses rendered incompetent by fractures and partings continued for several days along hill slopes. Strong shaking of the rock masses also produced, fractures along pre-existing joints and partings, and caused opening and widening of relief joints along steep slopes. Extensive fissures were developed in glacial moraine (Fig. 4) and river bed deposits (Fig. 5) parallel and subparallel to the Spiti river course, due to vibration of these surficial strata. At places lurching of the ground was noted due to rotation of strata producing step like fissures.

A major landslide dammed the Parachu Valley (Fig. 6) creating a reservoir behind it. The dam was approximately 60m in height and 150m in length. In about six days the impounded water started flowing from the opposite bank and carved out a new meander which joined the original river course 500m downstream of the dam. Loosening of the rock masses and readjustments resulted in changing the seepage outlets from higher levels to lower levels in some of the surface springs in the area.

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FIG. 1 – TELEGRAPH POLE BENT DUE TO IMPACT OF A FLYING ROCK FRAGMENT

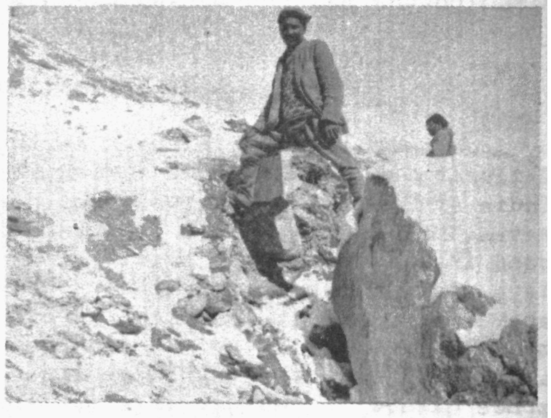

FIG. 2 – DISLODGING AND SHIFTING OF A BOULDER AT THE TOP OF A BRIDGE AT LEO

FIG. 3 – CASCADED QUARTZITE FRAGMENTS ALONG HINDUSTAN-TIBET ROAD BETWEEN CHANGO AND SHALKAR

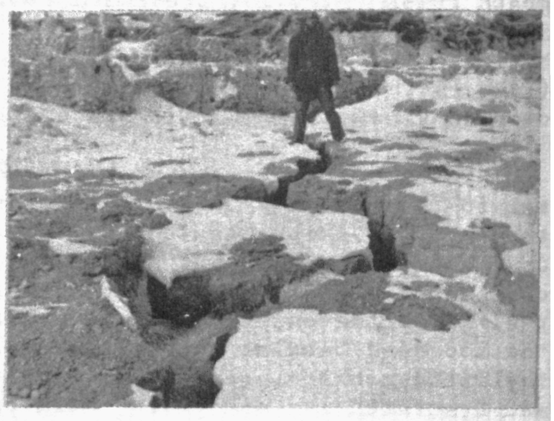

FIG. 4 – GROUND FISSURES IN GLACIAL MORAINE CUTTING ACROSS KAURIK

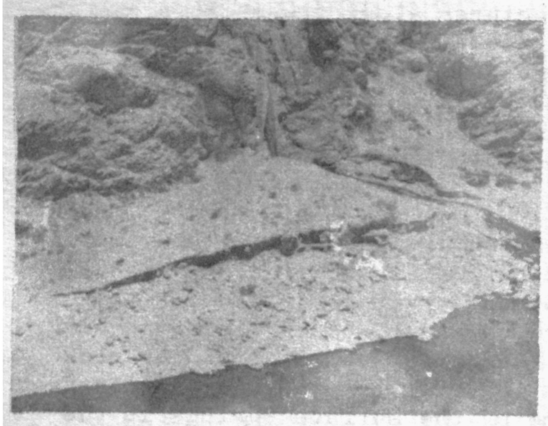

FIG. 5 – GROUND FISSURES IN SPITI RIVER BED TRENDING N 20° BETWEEN CHANGO AND MALLING

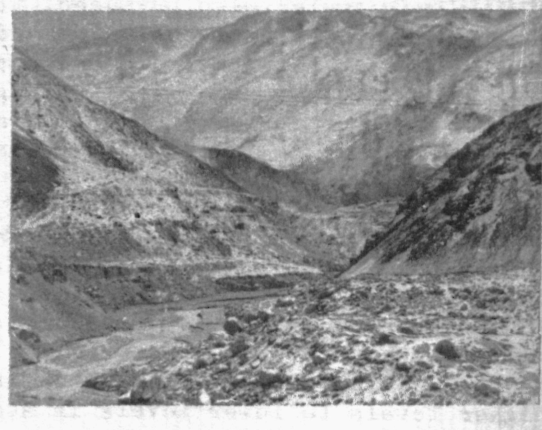

FIG. 6 – DAMMING OF PARACHU DUE TO A HEAVY LANDSLIDE BETWEEN SUMDOH AND KAURIK