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Title	**Mass movements along the routes to the Holy Cave of Amarnath, Jammu & Kashmir**
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Authors	Geosciences Group
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Abstract	This document describes the mass movements interpreted from IRS LISS IV data of September 2011, along the pilgrimage routes (Pahalgam-Chandanwari-Panchtarani-Amarnath and Sonamarg-Baltal-Amarnath) to the Holy cave of Amarnath. The landslides, run-out paths, unstable scree slopes and the road-cut debris areas have been mapped through visual interpretation approach. The digital database of the mass movements gives the type and areal extent of the features.
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Mass movements along the routes to the Holy Cave of Amarnath, Jammu & Kashmir

The Holy Cave of Amarnath is an important pilgrimage destination situated in the Srinagar district of Jammu and Kashmir. Every year tens of thousands of devotees visit this shrine at high altitude (~ 3900m). The pilgrimage season generally starts in the last week of June and ends in the first week of August. Incidentally this also overlaps with the rainfall season and hence is associated with landslides and other related slope failures. Casualties are reported many years due to landslides or rock falls and there are also disruptions in the pilgrimage at times when landslides cause damage to the roads.

There are two pilgrimage routes to the Amarnath Cave. One is the traditionally used path which is longer and gradationally climbing up. This is the Pahalgam-Chandanwari-SheshnagTal-Panchtarani-Amarnath route extending for about 46 km in the Anantnag district. The second route is the Sonamarg-Baltal-Amarnath route (in the Sindh valley, Srinagar district), involves trekking from Baltal to Amarnath (~14 km) and is relatively tougher due to steeper up-climbing.

Geologically this area consists of bluish grey limestone inter-bedded with quartzites and slates (Upper Triassic), Shale and Phyllites with inter-bedded limestone (Middle Triassic) and also Panjal Traps (Lower Triassic to Permo-Carboniferous). The Panjal volcanics are massive, fine grained and dark green to pale green in colour (Gupta, 1963).

The landslides and the locations of unstable scree slopes along these routes have been delineated using IRS Resourcesat-2 LISSIV data of 30th September 2011. The landslides along these routes are by and large shallow type involving the thin topsoil and upper weathered horizon. However some of the slides are deep, involving the bedrock also. The landslides and the run-out paths have been delineated and indicated in the maps. In addition to the landslides there are zones along the routes where the steep slopes are covered by extensive scree material. These materials present a dark appearance and very fine texture, probably due to the bluish grey parent material. Frost weathering could be the reason for extensive scree deposits. When the slope of such deposits exceeds the angle of repose, they could become potential zones for slope failures. Additionally, high intensity rainfalls could wash them as mudflows or debris flows. So the unstable scree slopes have also been mapped from the remote sensing data. There are some channels which are loaded with debris consisting of boulders detached from intensely jointed slopes on high elevations and also the frost weathered finer materials. Locations where these debris channels intersecting the road are also potential threat to the traffic and also for the roads in case heavy rainfall transports the debris at high velocities. Hence the debris channels have also been delineated. At places it has been observed that the road cutting has resulted in the dumping and down-slope fall/flow of debris down to the roads in the lower elevations, especially in serpentine type routes (e.g. Near Baltal). These road-cut debris locations are visible in the satellite image and have been mapped. The mapping has been restricted from ridge crest to ridge crest on either sides of the valley and where the valley sides are very extensive, it has been restricted to about 6km width on either sides. In the Sonamarg-Amarnath route, the mapping has been done from immediate downstream of Kullan to Amarnath and in the Pahalgam route, the mapping has been done from Phraslun and upstream upto Amarnath (figure 1).

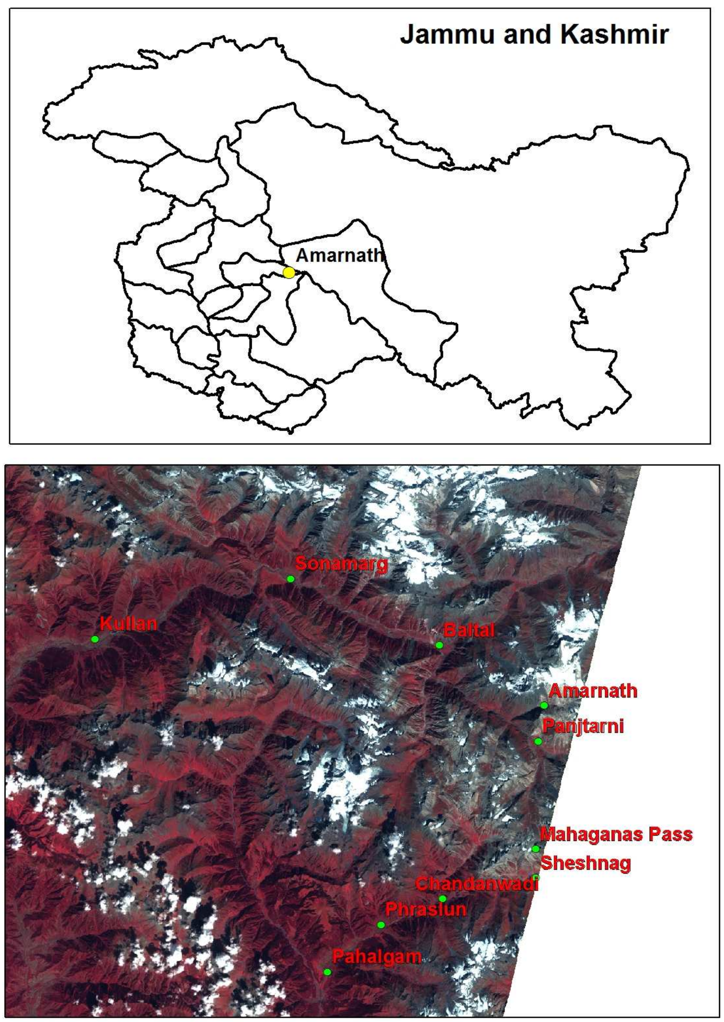

Figure1. Important places along the pilgrimage routes

Pahalgam-Amarnath route passes through moderate to densely vegetated and moderate to steep slopes from Pahalgam to Chandanwari. Not many slope failures are observed along this route, except after Chandanwari where the route is passing through very steep slopes (figure 2) where a series of landslides intersecting the route are seen. The Pahalgam-Amarnath route is relatively safer in terms of landslides. Extensive scree slopes are found along this route.

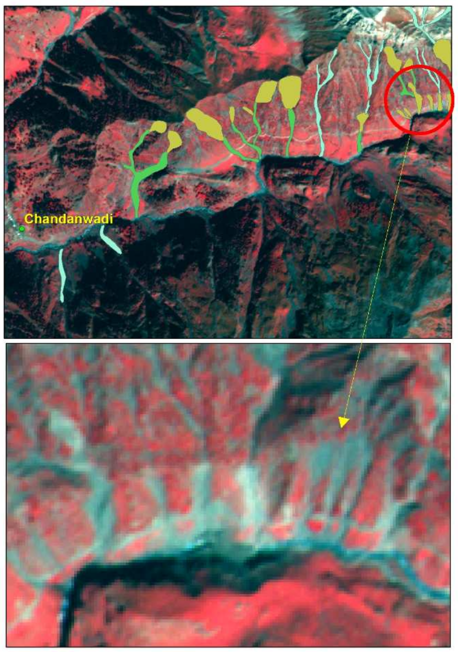

Figure 2. Landslides E of Chandanwari

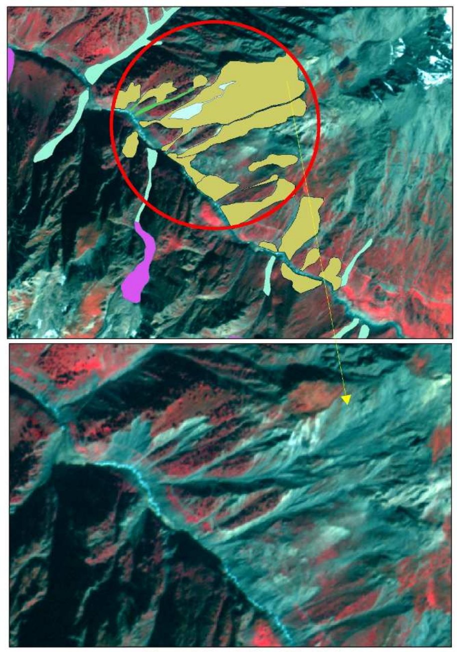
Figure 3. Landslides SE of Baltal

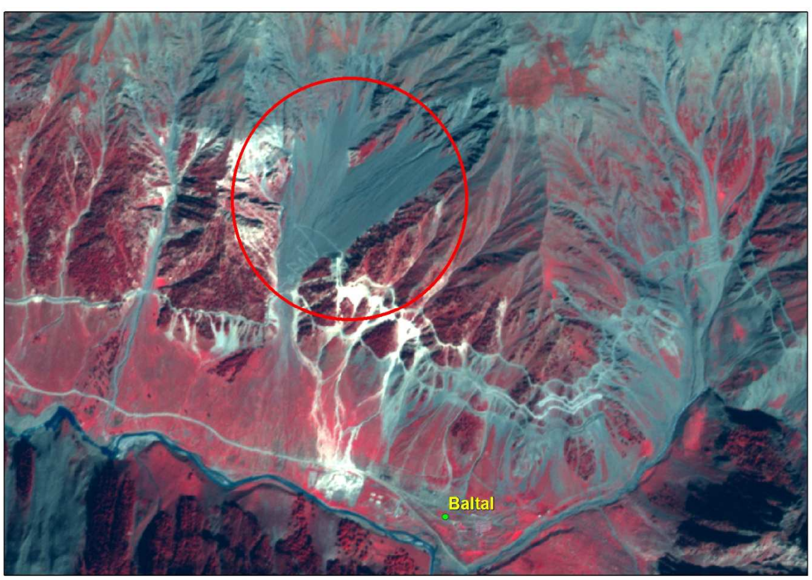

Figure 4. Unstable scree slope encircled

The Sonamarg-Amarnath route has relatively more number of landslides. The intensity of landsliding is visible after Baltal towards Amarnath where there are a series of large landslides (figure 3) on the right bank (slope where the trekking track is located) of the valley. Extensive scree slope is found near Baltal (figure 4) and also at many places. The mapped features are shown in figure 5.

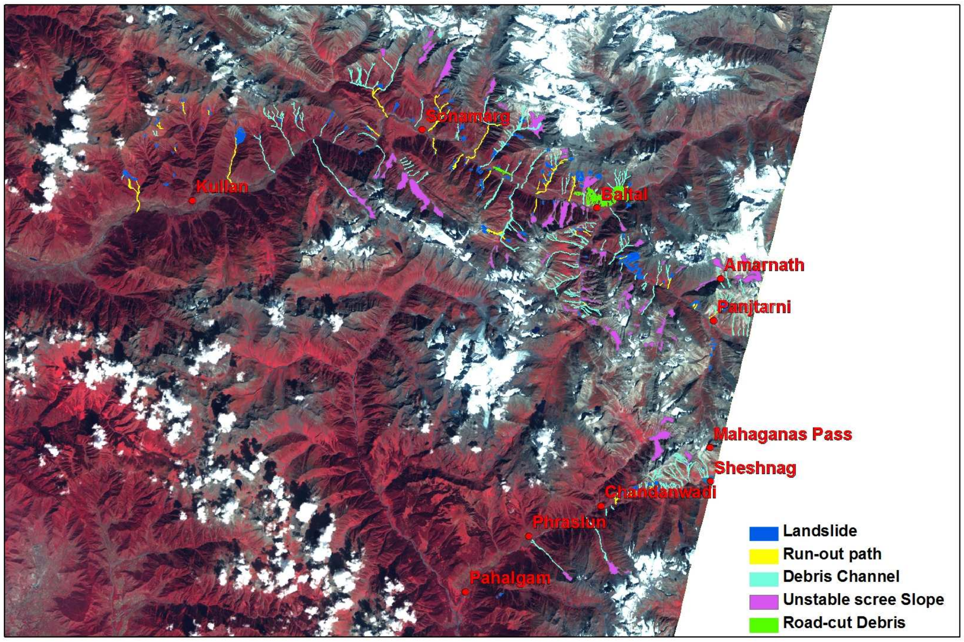

Figure 5. Landslides and scree slopes along the routes

Disclaimer: ***The landslide locations, unstable scree slopes and debris channels are demarcated by visual interpretation of IRS LISSIV data dated 30th September 2011, having 5.8m resolution. This inventory does not imply the locations of future landslides. Smaller slides beyond the resolving capacity of the data (~600 sqm) might have been missed out. This interpretation does not indicate present or future rock fall locations and the inventory needs to be ground verified before integrating it for any management plan.***

Reference:

Gupta, B D (1963). Progress report of the geological mapping in the Sindh Valley, Srinagar district, J&K for field season 1962-63.