

October 8 Kashmir Earthquake: Impact on Geoenvironment and Structures in the Karnah and Uri Tehsils of Kashmir (India)

A relief-come-earthquake investigation team of the Centre for Disaster Studies and Research, University of Jammu, Jammu (India) visited the Karnah Tehsil of Kupwara district for the purpose of distribution of relief goods provided by the University of Jammu and the Red Cross. Professor Amitabh Mattoo, Vice-Chancellor, University of Jammu, flagged off the team on 2nd November from Jammu. Professor Mattoo also accompanied the team upto Srinagar. The earthquake investigation team surveyed the area for collection of the first hand information on the geological aspects and impact of the October 8 earthquake in the Karnah and Uri Tehsils. The relief team surveyed the villages around Tangdhar area and accordingly the relief goods were distributed among 500 households in the villages of Tad, Nalchian, Sadana (Nastachhun), Drangyare, Tangdhar and Rangwar on 4-5 November 2005.



Tangdhar-Tithwal valley



Landslides on the PAK Neelam Valley Road

Besides distribution of the relief goods among the worst affected people in the area the team members interviewed a cross-section of populace in these villages to know about their future needs and problems they are likely to face. The team found that shelter is the main problem these people would be facing on the onset of winter in the area. The team also observed that the distribution of relief goods in the Karnah Tehsil was not according to the need of the people. Some areas received too much of the relief that people started choosing among the goods that were distributed among them while other areas (comparatively inaccessible areas) either did not receive the relief at all or if received it was inadequate.

A Team Comprising of the following members

Ghulam M. Bhat (Reader in Geology)*, Sandeep K. Pandita (Lecturer in Geology), Yudhbir Singh (Scholar - Landslides), Vinay Sharma (Scholar – Engineering Geology), Sham Singh (Scholar - Sedimentology) and Gulshan R Bhat (Scholar in Geography) visited the quake affected areas in Kashmir from Nov 2nd to 12th, 2005. The report is based on the investigations carried out by this team in Karnah and Uri Tehsils and was compiled in 3rd week of November, 2005.

*Post Graduate Department of Geology, University of Jammu, Jammu – 180 006

E-mail

* bhatgm@rediffmail.com

There are 54 villages in the Karnah Tehsil and most of them are totally destroyed by the quake. Hundreds of people lost their lives, and thousands have been badly injured. About 50000 people have been rendered homeless by the quake in Karnah Tehsil alone. The area still trembles with aftershock tremors being felt every day. Most houses in the area have collapsed into heaps of rubble, and the remaining few that are left standing have developed severe cracks and can easily crumble due to aftershocks or under the weight of snow. Almost all people in the villages are now staying in tents and makeshift shelters made of tin sheets and wooden logs. They have lost almost all their personal possessions, stocks of food and domestic animals. Almost all shops and schools in the area have been destroyed. Roads and footpaths leading to the villages off the main highway have also been blocked by huge boulders and debris falls. Agricultural fields have developed deep cracks and the irrigation channels have been clogged. The earthquake investigation team visited Uri and villages beyond in the Baramulla district from 7-12 November. The situation in this area is as stark as in Karnah. All the villages have been completely flattened, with almost every single building destroyed. More than 514 people have lost their lives in this area in the quake. Almost all families living there have been rendered homeless.



Ruined Thamni village (Karnah)



Flattened Ibkot village (Karnah)

Although the government claims providing of relief to all the affected people, but there are numerous complaints from the villagers about the distribution of relief by the government. For each person killed by the quake the kith and kin have received a sum of Rs. 50,000 only. The government also claims that it has supplied a single, one-month ration of 11 kg of rice, 700 gm of sugar per person and tea leaves, cooking- and kerosene oil. Although some villagers have received rice and sugar, but many others said that they have not received any relief from the Government. Almost every body in the area made a complaint that tea leaves, kerosene- and cooking oil have not reached the villages even after three weeks of the quake. People leveled allegations of large scale corruption in the distribution of the relief and accusations of local level officials misappropriating relief funds and material. The team was told of the politicisation of relief, with different political parties providing relief to their own supporters and vote-banks. Many people in these areas have lost foodgrains they had stored for the winter and they need supply of grains and other food articles for at least four to five months. This part of Kashmir witnesses severe winter and the temperature falls below minus 15 degrees Celsius and experiences snowfall of six feet and more.

The government has also announced a sum of Rs. 100,000 for each damaged house payable in two instalments (Rs. 40,000 and Rs. 60,000). However, this exgratia relief has not yet been given to each and every house owner. Even some of the damaged houses are yet to be registered, people claim. Those who have received this relief complain that this amount is too little, and is not even enough to hire labour to remove the rubble and to purchase and transport material to build temporary shelters, let alone for reconstructing their homes. They want that the amount be substantially increased and also insist that it should be paid in one instalment. Receiving it in two instalments, as many of them argue, would mean that they might have to bribe the local officials twice, instead of once. The army has played commendable role in the relief work at some places, particularly immediately after the quake by transporting victims to hospitals, and providing relief material (food, shelter, etc.) and medical assistance.



Downslope tilting of the structures Tithwal



Flattened Batpura Kandi (Karnah)

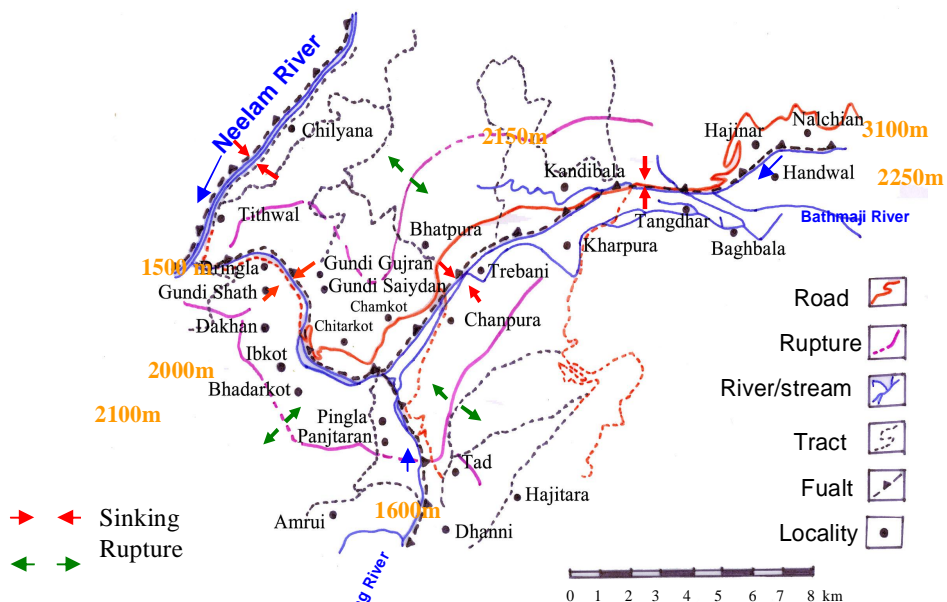
The team noticed that relatively a few NGOs are involved in providing relief in the quake hit areas, particularly in Tangdhar and Uri. People in general complain that these NGOs visit villages that are located on the main road, leaving out villages situated high up in the mountains. The team met many people who had trekked from remote villages to Tangdhar and other villages on the main road in the hope of getting some food or clothing from passing relief vehicles. The powerful and influential people get much more while the poor get inadequate relief and sometimes nothing. There are several instances of looting the relief trucks on their way to Tangdhar and Tithwal.

In several villages (near the main roads and main towns) large piles of clothes supplied by relief organisations have been thrown around. In some places people were using them to light bonfires to keep themselves warm. The relief organisations should send the materials of immediate use to the people, such as blankets, jackets, coats, socks and shoes, and kerosene oil. Most importantly, tin sheets are needed to build temporary shelters to tide over the severe winter that awaits them.

Geological Investigation

The Karnah Tehsils falls within the Kupwara district while the Uri Tehsil falls under the administrative control of the Baramulla district. The Tangdhar-Tithwal valley (Karnah) is drained by two main streams (the Batmaji River and the Qazinag River) which together confluence with the Neelam River (Kishanganga River) at Tithwal. On

either side of the Bathmaji and Qazi Nag Rivers are lofty mountain ranges which are cut into narrow gorges and deep defiles. The terrain is rugged and remains snow covered during the winter months. The famous Sadana Pass, which lies at an elevation of 10417 feet above msl, cuts off the Karnah valley from the main Kashmir valley. The Tangdhar Tithwal valley hosts a population of about 50 thousand, which is mainly dependent on agriculture. A portion of the population works in public and private sectors within and outside the state. There are 54 villages, which are situated in the two subsidiary river valleys. Geologically the entire landmass of the Karnah Tehsil can be categorized in the three stratal categories including the older alluvium, older river terraces and the mountain and hill slopes. Agriculture is being practiced on the older alluvium and at places the settlements also exist on these deposits. Most of the settlements in the entire Karnah valley are confined either to the older river terraces or to the mountain and hill slopes. As a rule the mountain and hill slopes are vulnerable to landslips, landslides, debris flows and shooting stones, as is the case with the Karnah valley. Also the older terraces are highly vulnerable to debris flows and slips during flash floods and earthquakes. The Karnah valley is prone to flash floods as is evident from the recent records and the geological evidences in the area. Our investigation reveals that in the past the entire area has witnessed the earthquake comparable with the October 8 earthquake and even of more intensity. This fact has been confirmed by the local people who claim that their elders have revealed to them the furry of flash floods in the entire valley in the past that compelled them to shift their settlements to the mountain slopes. The furry of nature did not spare them even at the higher elevations when severe earthquake struck the region in the past killing most of the inhabitants settled on the mountain slopes. The skeletons of the buried human beings are sometimes brought out of the debris due to landslides and slips at a depth of about 20-m in both the Karnah and Uri areas.



Ruptures developed on the mountain ridges in Karnah Area
(G. M. Bhat et al., University of Jammu, 2005)

Fig. 1: Tectonic map of the Tangdhar-Tithwal sector, Karnah

The October 8, 2005 earthquake shook the entire Karnah Tehsil damaging almost 100% structures, killing about 270 human beings and thousands of animals. The earthquake has devastated the mountain cliffs, ridges, slopes and even the agricultural fields. The road network in the entire Karnah Tehsil traverses through the unstable zones. The only construction materials available in the area are rocks and timber. Almost all the residential and official buildings are multistoried and made up of rocks and timber. These structures are susceptible to collapse even at moderate earthquakes. It is because of the poor foundations and unstable ground conditions of the area that almost all the buildings within a radius of 60 km of the epicenter collapsed and within the radius of 100 km of the epicenter all the buildings were partially damaged.



Liquefaction at Karalpura (Kupwara)

Sand Blows at Simbal Camp, Jammu

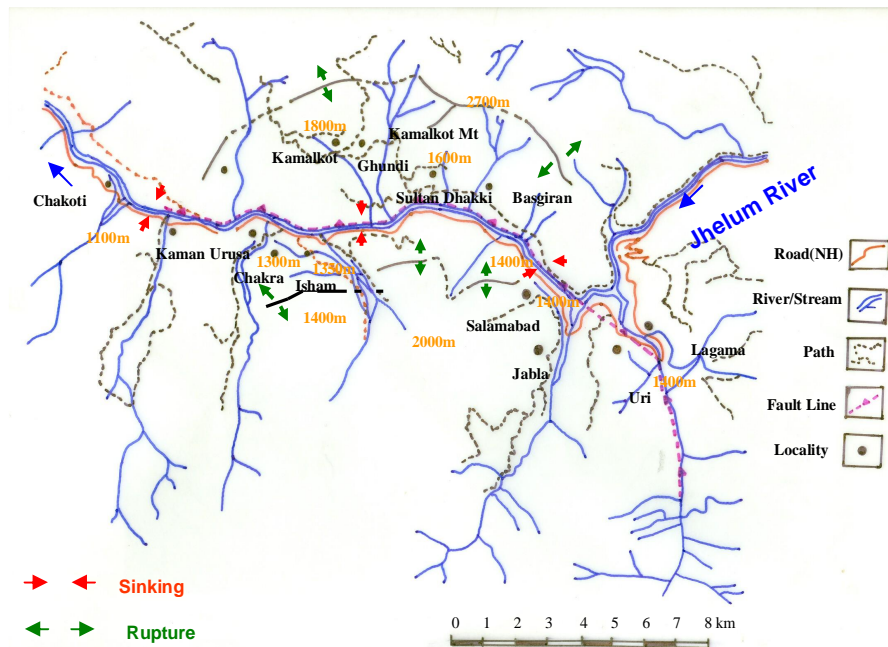
The Batmaji- and Qazinag Rivers are flowing along the fault lines in the Tangdhar-Tithwal area. The October 8 earthquake that occurred on the Main Boundary Thrust has activated these subsidiary fault lines in the area. The evidences are seen on either side of these fault lines along the mountain ridges whose expression is visible on the mountain slopes in the form of longitudinal cracks. These cracks are a few meters in aperture and a few meters deep on the mountain ridges. At places a vertical slip of about 1-m is seen in these mountain ridge cracks. We noticed these ridge cracks from Tithwal through Green Patch, Dhaken, Amrui, Tad, Sadana Pass, to Chokibal and from Tithwal through Tangdhar Bakhain, Rangwar and Karalpura to Nutnusa. The salient features of these fractures and the field notes taken on these displacements are briefly described here.

Karalpura

An earthquake of magnitude 4.4 with its epicenter at lat 34.59° N and long 73.62° E on 3rd of November, 2005 at 0625 hours produced liquefaction in the village of Karalpura. On our return from Tangadhar on 7th of November the process was on and the area of activity had spread over to about 4 square km in the vicinity. There are a number of other sites in this area where water was oozing out of the paddy fields and in the Dar Mohalla of the Karalpura town. On the 3rd of November the water gushed out at three spots in the Dar Mohalla and ejected black sand in large quantity which was thrown into the air upto 1.5 m. Liquefaction is a process that occurs when a loosely packed grain framework is suddenly broken down; the grains become temporarily suspended in the pore fluid, and settle through the fluid, displacing it upward, until grain-supported

structure is re-established. The lower threshold of shaking intensity of about MM VI can produce liquefaction in sensitive deposits. Liquefaction can be developed at earthquake magnitudes as low as about 5, but that a magnitude of about 5.5 to 6 is the lower limit at which liquefaction effects become relatively common.

At Karalpura the sand blow craters are 0.7 m in diameter and have ejected black sand in large quantity. It is located at about 100-km aerial distance from the epicenter of the earthquake. The ejected sand suggests the alluvial fan deposits at depth. It is interesting to note that the Karalpura liquefaction initiated due to an earthquake of magnitude 4.4 and after one months period from the main quake. The liquefaction associated with the October 8 earthquake and aftershocks offers an opportunity to develop relations to constrain the magnitude of the past earthquakes in the same tectonic setup. It is also the best reference to compare its dimensions with the palaeo-liquefaction and thereby to assess the recurrence interval for larger events for the same seismic source or an average interval for a region. The liquefaction process can help to identify the earthquake prone areas and contribute to the earthquake hazard assessment.



Ruptures developed on the mountain ridges in Uri-Kaman Post sector
(G. M. Bhat et al., Geology Department, University of Jammu, 2005)

Fig. 2: Tectonic map of the Uri-Kaman Post Sector, Kashmir



Loss of Agricultural fields (Patti Thamni) Karnah



Building on the older alluvium (Karnah)

Green Patch

Green patch is the mountain ridge at an elevation of about 1900-m above msl. Below this ridge is situated the villages of Beari and Dringla on its western and eastern slopes respectively. These villages host about 100 households with a population of about 700. The entire settlement has been razed to the ground. The mountain slopes have been cracked both longitudinally and transversely. The cracks run parallel to each other for a few hundred of meters and are often cut across by subsidiary cracks. The aperture of the main cracks ranges from 1 m to 4 m and a visible depth of about 3-m. At the ridge of the Green Patch there exists a large crack which runs all along the ridge for about 1.0 km till it coincides with the another crack developed in the adjoining mountain ridge cutting across the Green Patch ridge. On either slope of the Green Patch Mountain longitudinal and transverse cracks of different sizes have developed. The Longitudinal cracks run parallel to the main ridge crack. The vertical slip of the Green Patch ridge is about 1.0 m with the crack aperture approaching 4 m.



Cracks in Green Patch Mt. ridge



Shattered rocks on the Green Patch Mt. ridge

Dakhen

The Dakhen Mountain is about 2000 m above msl and on its eastern side are situated the villages of Ibkot, Pati Dakhen, Pati Thamni and Bahadarkot and on its western side is situated the Green Patch. The mountain ridge is fissured all along the ridge for a few kilometers in the NNE-SSW direction. Main lithology of the mountain is

quartzites and phyllites. On either side of the ridge occur a number of parallel fractures on the slopes whose aperture ranges from 15 cm to a maximum of 1.0 m. These fractures are deep and the visible depth is 1.5 m. At the mountaintop the vertical slip of about 0.75 m has taken place. There are about 90 households situated on both the sides of this mountain with a population of about 400. Almost all the houses are razed to the ground with heavy human casualty and tremendous loss to the livestock. The slopes are vulnerable to the landslips and debris flows, which can trigger during rains and future earthquakes.

Tithwal Mountain Ridge

The Tithwal Mountain ridge is also fissured and has resulted in the rock falls, which has inundated the Tithwal town. The road section beyond Tithwal town has been scrapped out into the Neelam River. Tithwal village is almost 100% damaged. A few buildings are standing but are unsafe for living. Settlements in the foot of the mountain range are highly vulnerable to future landslips and shooting stones.

Chhamkot-Sikh Bridge

The villages between Chhamkot and Sikh Bridge include Pingla-Haridal and Chitarkot. At Pingla-Haridal is situated a hydroelectric power project of 2 MW capacity on the Qazinag River. This power project lies just below the confluence of the Batmaji River with the Qazinag River and has been severely damaged by the earthquake. The massive debris flow has occurred in this stretch of the valley and a large piece of agricultural land has got lost. Two human bodies are still buried under the huge debris fall deposit near the powerhouse site in the Qazinag Riverbed. The paddy fields on either side of this stretch of the valley have developed parallel cracks running along the river course (NNW-SSE) whose aperture ranges from a few centimeters to 0.5 m. The visible depth of these cracks is about 2 m. A large fissure cuts across the National Highway at Chitarkot. The aperture of the fissure is 1.0 m and its visible depth is almost 3 m. From Chitarkot towards Sikh Bridge a number of debris fall deposits have destroyed the National Highway.



Fissures in the Green Patch Mountain



Building on the older river terrace

Kandi

The Kandi village lies on either side of the highway and has been devastated by the earthquake. It hosts a population of about 1500 confined to about 350 households. On the hill side of this township emanates a spring on the mountain slope, which ejects black and creamy slurry at regular intervals. The water content of the springs in the area has also increased after the earthquake. Below the township of Kandi are situated the villages of Chanpura and Trebani which together hosts a population of about 200 in about 40 households. The earthquake has destroyed all the households and has ruptured the paddy fields. Liquefaction has occurred during the main earthquake at a number of places in the area. The mountain slope on the eastern side of these villages has been fissured at the ridge and at a number of places on its slope. The slip is about a meter at the ridge. At a number of places debris and rock falls have inundated the houses situated at the foot of the mountain and a few houses are totally buried under the debris. Opposite the Kandi Bala a tipper has been buried under the debris which has fallen from this mountain.

Tangdhar Bakhain

The Bakhain Ridge is also fissured which runs parallel to the Tangdhar nar in the vicinity of Tangdhar town. On either side of this ridge are situated number of villages and an army camp. The rocks of the mountain are mainly quartzite and form its steep slopes on either side. The whole mountain has developed fissures of different sizes, which run parallel to the main ridge fissure. The main fissures are 3 m deep having an aperture of 1 m. The vertical displacement is about 0.5 m. On either side of the mountain slope rock falls have taken place and scarps have developed. Boulders as big as a building have slipped down the mountain and hit the buildings situated at the foot of the mountain. There is high risk of falling of these hanging rock blocks and can be of serious consequences. Evidence of the past human settlements exists on this mountain. It is said that Dub Wali Mosque was situated on this mountaintop in the past. An earthquake of severe intensity destroyed the settlement. There are a few Okhalies scattered on the mountain slopes and its top, which have been carved out in huge rock blocks of quartzites. Besides, a number of earthen parts (broken) are scattered on the slopes and mountaintop, a few of them embedded in the topsoil of the mountain.



Fissure at the Tangdhar Bakhain



Okhali found at the Bakhain Mt ridge

Sadana Pass (Nasta Chhun)

On the left side of the Sadana Pass lies the snow-covered mountain known as Eagle top on which was situated an army post. On the day of earthquake rock fall occurred on this mountain resulting in the burial of the army post killing 12 jawans who are buried there for ever. On the ridge of this mountain fissures have developed which are in continuity with the fissures developed in the mountain ridges of the Karnah valley. On the National Highway 4 km before the Sadana Pass fissures have occurred on the mountain slopes which traverse the highway also. In the same direction and in its continuity lies the mountain at Rangwar, which has developed large fissures similar to those of the Karnah Valley Mountains. The Rangwar village has been totally devastated and a population of about 100 people has shifted from the village to the roadside (a walk of about 2 hours). In this locality parallel fissures have resulted in rock- and debris falls inundating the settlements and the agricultural fields.

Below this location towards Kupwara the intensity of damage is progressively decreasing. However, it is not known whether fissures have developed in the mountain ridges and slopes of this belt or not. Evidences of rupture in the agricultural fields and around the settlement at Karalpura suggest that fissures may have also developed in the vicinity of these areas.

We observed liquefaction at Armpura, Nutnusa, and Badarkal on its journey to Uri via Kupwara-Handwara-Baramulla road. The local residents said that on the earthquake day blue coloured water ejected out of these liquefaction craters and at a few places brownish water emanated. The craters have dried up since but the scars are still present in these areas. People also revealed that water in the springs in these areas has increased due to the earthquake. We were told by the local people in the entire Karnah valley about the abnormal animal behavior (dogs and jackals) one day before the earthquake struck the area. They say that at the mountain ridges and slopes flames were seen emanating at the places where ruptures have occurred. This was followed by the dust bursts into the air. The intensity was so severe that for the full day the visibility was very poor. It was not until the rains started on the evening of October 8 that settled the dust clearing the atmosphere. During our stay in the Karnah valley 3-4 aftershocks were felt daily whose intensity was enough to cause further damage to the hanging structures, walls and tilting of the trees. The area is still experiencing the aftershocks and none of them of magnitude above 6 (IMD).



Kaman Post bridge



The inner walls intact in a mud mortar house (Karnah)

On the way to Uri from Baramulla we observed fissures developed on the banks of the Jhelum River near Sheeri. The fissures are continuous along the riverbanks whose aperture varies from a few centimeters to more than meter. The visible depth of these fissures is more than 2 m. On the left bank of Jhelum River at this location there are cracks in the mountain slopes which can be traced upto Tangamerg and beyond.



Jhelum River bank near Kichhama



Buildings on the bed rock near Red Bridge, Uri

The spring situated near the mountain foot at the village Kichhama has completely dried up immediately after the October 8 earthquake. The spring water was used to irrigate about three hundred kanals of paddy land in the area. The fissures are traceable from this locality through the villages of Malpura, Dangapura, Sultanpura Kandi, Dudhbug, Nilasar, Chunti Pathri, Babarishi upto Tangmarg. In this belt the intensity of damage to the buildings increases towards the mountain slopes and their foot belt. Most of the buildings are not safe for living in this belt.

Uri to Kaman Post

The National Highway 1A from Uri to Kaman Post, a stretch of 17.2 km, is totally damaged by the earthquake. The highway stretches have been washed away completely at a number of places. Culverts, bridges and other infrastructures have been damaged. It was in this sector of the highway that 66 Beacon personnel, who were at work, got killed during the earthquake. A number of vehicles including those of Beacon and private

sector have got damaged on this highway. Landslips, debris- and rock falls and shooting stones have struck most of the road sections. Almost total stretch of the highway has developed cracks along and across its entire length from Uri to Kaman Post. The main bridges, which have been damaged, include those of Red Bridge, Twin Bridge and the Aman Sethu. The most damaged bridge is the Aman Sethu whose one abutment on the PAK side and one panel of 70 m in length has been completely destroyed. All the buildings from Uri onwards have been damaged and the intensity of damage is complete beyond the Uri town. The area hosts a population of about 115 thousands.

On either side of the Jhelum River the mountain ridges and their slopes have been fissured. The fissures run parallel to the river axis. The most devastated ridges include those at Sultan Daki, Kamalkot on the rightbank of the Jhelum River. The left bank mountain ridges and slopes fissured occur at Kaman Post, between km 8-10 to Kaman Post, Salamabad and Uri.



Damaged and blocked Uri-Kaman Post-Muzzaffarabad Road sections

Sultan Dhaki and Kamalkot

On the mountain ridge above the township of Sultan Daki a large fissure has occurred on the eastern slope due to the October 8 earthquake. Black and brownish coloured water emanated from a number of spots which gushed out into the air a few tens of feet on the day of earthquake, said one soldier posted at a near by army post. Earlier the quantity of water emanating from this spring was a few inches, which is now flowing in the form of a large stream capable to run a few mills. The quantity of black water emanated from this fissure can be judged from the fact that the colour of the Jhelum River water from this point downstream turned black for about 15 days. The rocks on the mountain slopes over which the stream is flowing have turned either black or brown, which can be seen from the distant location on the National Highway. A similar water ejection has taken place on the same mountain ridge at Kamalkot about 5 km downstream. Both the areas have suffered a great damage as far as the buildings, livestock and the human casualties are concerned. These two townships have become most vulnerable to future landslips, rock- and debris falls and shooting stones. The

fissures developed on these mountain ridges and slopes are 4 to 5 m in aperture, more than 6 m in visible depth and are continuous for a few kilometers. There are a number of transverse cracks, which have developed across the longitudinal fissures. There is visible movement along these cracks in the entire area, which has frightened the local populace in general. At many places in this belt the agricultural land has been washed away by the landslips and debris falls. It is in this area that skeletons of human beings get exposed from the old debris, which has accumulated over them for the last few centuries. Possibly a strong earthquake may have struck this area devastating the settlements on these mountain slopes which got buried under the falling debris at that time. Similar is the situation today that at a number of places in the entire sector many of human bodies are lying under the huge mass of debris, which fell on them during the recent earthquake.



Sultan Dhaki Mt. rupture (Kamalkot)



Upslope tilting of the structure at Kamalkot

Kaman Post

The abutment of the Kaman Post Bridge (Aman Sethu) has been completely damaged on the PAK side. It is completely grounded and one of the three panels on that side is also completely destroyed. The central two piers have developed cracks at the foundation level and are unsafe for future use. On the Indian side abutment being partially built on the bed rock has sustained the shock. However, the complete bridge should be reconstructed on the firm foundation preferably at a new location. The bridge is located over the Khaliane de Kas (dry nala) through which runs a subsidiary fault of the Jhelum Tear Fault. The older river terrace at the Kaman Post on the PAK side has fallen into the nala over which the bridge is erected. The whole highway stretch on the PAK side is also destroyed.

National Highway at Km 8 to 10

At this location the highway is damaged and a portion of it has been washed away. There exist a number of longitudinal cracks on the highway, which run parallel to the fissures, which have developed on the mountain ridges and their slopes. The fissures are about 1 m in aperture and a few meters deep. There is a vertical slip of about 1-m along these cracks. These displacements have resulted in rock- and debris falls and shooting stones in this sector of the highway. The settlements on these mountain slopes have been completely destroyed. Water in the springs emanating on these slopes have increased due to the earthquake. However, slowly and steadily is now decreasing. We

observed cracks cutting across the main fissures on the mountain slopes along which vertical displacement has taken place.

Red Bridge

Both the abutments of the Red Bridge have developed cracks. One of the abutments has partially fallen. There are severe cracks developed on the road and fissures occur at the mountain slopes at this location. These fissures are in continuity with other fissures developed on the mountain ridges in the area.



Cracks on the slope at Jula village, Uri



Twin Bridge, Uri

Twin Bridge

The earthquake has also destroyed the Twin Bridge. Both of its abutments have been damaged and the cracks are developed on the road section. These cracks are also expression of the main fissures developed on the mountain ridges and their slopes in the area. Besides the main bridges on the highway sector from Uri to Kaman Post a number of culverts have been partially damaged. Mention may be made of these damaged bridges and culverts i. e., Red Bridge, Twin Bridge, Kaman Post Bridge, Lagama culvert, Salamabad, Urusa, Bhim Post, etc.

Structures

The intensity distribution estimated and interpreted by the Pakistan Geological Survey is closely associated with the rupture zone (Hussain et al., 2006). Within the rupture zone, the city of Muzaffarabad suffered great damage (IX-X on MMI scale), and the city of Balakot was almost totally destroyed (X on MMI scale). Outside the narrow (5-10 km) width of the rupture zone, the signs of damage appeared to be fairly minor. While damage has been reported in more distant locations such as Abbottabad (35 km from rupture zone), Islamabad (64 km), and Lahore (> 250 km distant), and has been attributed to local site effects or poor construction rather than direct intense shaking from the earthquake.

Table 1: Locality-wise intensity of earthquake affected areas in Jammu and Kashmir

Locality	Intensity	Locality	Intensity
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Simbal Camp (Jammu)*	IX	Trebani	IX
Uri Tehsil		Chanpura	IX
Kamalkot	X	Tad	IX
Sultan Dhaki Village	IX	Chitarkot	X
Sultan Dhaki Hill	X	Chamkot	X
Urusa	IX	Pingla Haridal	X
Jabla	IX	Bahadarkot	X
Salamabad	VIII	Ibkot	X
Lagama	VII	Dakhan	X
Kichhama	IX	Gundi Saiyidan	IX
Nambla	IX	Gundi Gujuran	IX
Sadwanian	IX	Gundi Shath	IX
Isham	IX	Thamni	X
Karnah Tehsil		Dringla	X
Rangwar	IX	Tithwal	X
Drangyare	IX	Beari	X
Nastachhun	VII	Green Patch	IX
Bagh Bella	IX	Kupwara and Handwara	
Nalchian	IX	Karalapura*	IX
Tangdhar	VIII	Natnus*	IX
Tangdhar Bakhain	VIII	Armpura*	IX
Kandi Bala	X	Badarkal*	IX

* Intensity measured on the basis of liquefaction only

Table 2: Locality-wise building types and percentage of damages

Simbal Camp (Jammu)	A & B	2-3%
Kamalkot	C & D	90-95%
Sultan Dhaki Village	B, C & D	90-95%
Urusa	B, C & D	60-70 %
Jabla	C & D	60-70%
Salamabad	B & C	65-75%
Lagama	B & C	40-50%
Kichhama	B	30-40%
Rangwar	C & D	80-90%
Tangdhar	A, B, C&D	50-65%
Tangdhar Bakhain	B&C	60-80%
Kandi Bala	B&C	80-90%
Chanpura	B&C	80-90 %
Tad	C&D	100%
Chitarkot	B&C	80-90 %
Chamkot	B&C	75-80 %
Pingla Haridal	B&C	80-90 %
Bahadarkot	C&D	90-95%
Ibkot	C&D	100%
Dakhan	C&D	100 %
Thamni	D	100 %
Dringla	B, C&D	80-90%
Tithwal	B, C&D	100%
Beari	C&D	100%

The damage by the earthquake in Karnah and Uri areas has been severe close to the epicenter in the range of 50 km and progressively decreasing away. The intensity of

damage at various localities in the surveyed areas on the revised MMI Scale (ABAG, 2003) is given in Table 1. The type of the houses and the percentage of damages are shown in Table 2. In both the areas of Uri and Karnah most of the villages are built either on the older river terraces or on the hill slopes. The constructed houses in these areas are mostly single or double storey un-reinforced earthen wall stone masonry buildings. Stone masonry buildings are more common in these villages. The stone masonry walls consisted of irregularly placed undressed/dressed stones, rectangular and rounded, that were laid in cement sand and mud mortar. A significant number of casualties and injuries were associated with the total collapse of these structures. Un-reinforced one or two storey brick masonry buildings with roofs constructed with wood and CGI tin sheets are also seen in these areas. These structures were also razed to the ground within the 10 km range of LOC. The area affected by major shaking lies within a radius of 50 km from the epicenter with the destructiveness of the shaking reducing quickly as one move away from the LOC. The intensity of the shaking has been severe in Karnah- and Uri Tehsils in the vicinity of LOC. In these areas a 1.0 to 1.5 m vertical slip component has caused the extreme damage to the structures. These structures mostly collapsed in place, rather than being thrown over or developing diagonal tension cracks.

Our observations in Kashmir reveal that three types of ground conditions prevail in the earthquake affected areas. We also observed four types of building structures including Masonry A, B, C, and D in these areas. The intensity of damage varied in the three types of ground conditions even for the same type of masonry structure (both vernacular and modern engineered structures). In case of concrete block construction, the problems include poor block strength, weak mortar and lack of seismic detailing. In whole of the Karnah area we noticed two buildings constructed following the building codes. These buildings have behaved different to the earthquake shaking due to the different ground conditions. In general fire-clay brick masonry wall buildings have performed better than the other types of wall construction. A number of buildings in the area are wooden frame structure filled block or brick wall with either cement or mud plaster finish. Either type of buildings has suffered damages different one another according to the ground conditions in the area.

The Jammu and Kashmir State has been classified in the zone-IV with two patches placed in zone V in the seismotectonic map of India 2002. These estimates are based on scanty earthquake record of the area. The northwestern part of Himalaya has been neglected regarding the studies on earthquakes and crustal deformation as compared to other parts of India. A series of active thrusts and faults are running across the state. Seismic hazard is not given a great deal of attention in urban planning and policy decisions, and seismic design does not appear to be high priority in the state. There is no code enforcement in the region. The observations mentioned above should be kept in view while formulating building codes for these and other similarly situated areas in Jammu and Kashmir. We also suggest that micro-zonation of the major cities and towns are taken up at priority basis before the building codes are formulated for the state.

Other Aspects

In addition to the geological investigations we collected data on other aspects including village-wise death toll of human and livestock and loss of structures. The villages and towns surveyed include Tangdhar, Kandi, Ibkot, Dringla, Tithwal and Uri. The salient features of this study based on questionnaire filled up by the randomly selected 87 householders are given in Tables 3 to 6.



Stone masonry building on the bed rock at Kandi Concrete Building on the older alluvium (Tribuni)

Table 3: No. of Deaths in the households of the Surveyed villages

Area	Villages	Deaths	Percent (%)
Uri	Sultan Dhaki	26	38.80
	Kamalkot	09	13.45
Tangdhar	Ibkot	07	10.45
	Kandi	08	11.94
	Panjtaran	15	22.38
	Beari	02	2.98
Total	06	67	100.0

Table 4: Demographic Change in the Population of the Surveyed Area

S.No	Sex & Age	Past population	Present population	Dead
1	Male Child	141	121	20 (29.85)
2	Female Child	107	102	05 (7.47)
3	Male Adult	165	143	22 (32.83)
4	Female Adult	143	123	20 (29.85)
Total		556	489	67

Figure 1: Past & Present Population Status

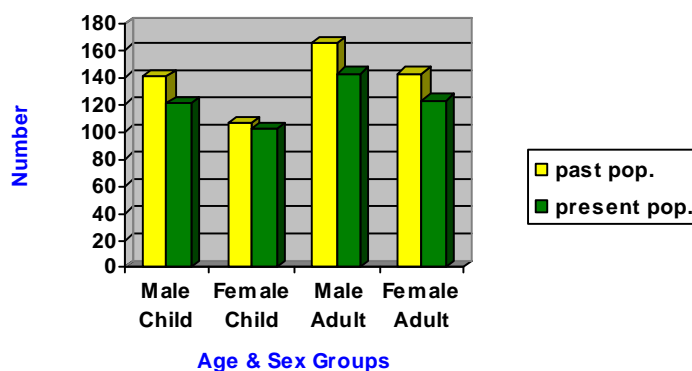


Table 5: Availability of amenities in the Surveyed Population

Amenities	Uri			Tangdhar		
	Available	Not Available	Partially Available	Available	Not Available	Partially Available
Electricity	25	00	00	16	46	00
Water	05	20	00	14	48	00
Education	00	05	20	00	60	02
Ration	00	20	05	14	46	02
Medical facility	00	00	25	00	38	24

It can be viewed that about 31 percent of the households have got full-fledged Govt./Social amenities and 69 percent of the households are partially benefited. The educational facility in both the areas has come to standstill. The list of village-wise deaths reported from Uri Tehsil is given in Table7.

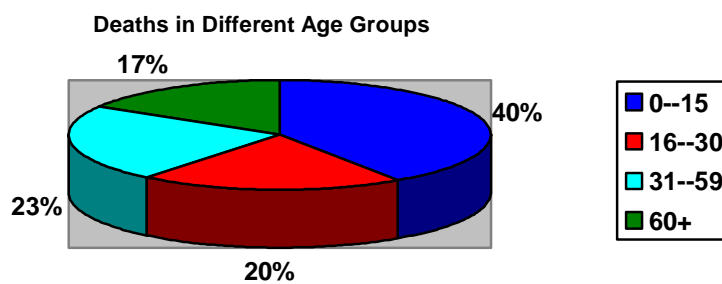
Table 6: Status of loss from the total households of the surveyed area

Parameter	Property (%)	Livestock (%)
Loss	85 (97.7)	22 (25.28)
No loss	02 (2.3)	65 (74.72)
Total	87 (100.0)	87 (100.0)

Conclusions

In the Karnah valley the mountain ranges on either side of the Batmaji and Qazinag Rivers have developed fissures at their ridges and their subsidiaries on their slopes. The fault line lies along these rivers, which has got activated by the recent

earthquake. This has resulted in a net vertical slip in the entire area, which has its expression in the development of fissures on the ridges of the mountains. The area is witnessing the aftershocks of intermediate magnitude daily whose frequency varies between 2 to 3. The expression of this fault line is traceable beyond the Karnah valley across the Sadana Pass in the Kupwara Tehsil through Chokibal, Rangwar, Nutnusa, and beyond. The ongoing liquefaction process at and around Karalpura should be closely monitored because it involves more areas with the passage of time. This is also necessary because this location is the only one that has got involved in this process after the main earthquake of October 8. Its intensity increases with the increase in the magnitude of the earthquakes taking place in the region.



Similarly the mountain ranges in the Uri-Kaman Post sector of the Uri Tehsil have developed fissures on the ridges with subsidiaries on their slope. These fissures are developed on either side of the Jhelum River. In this area the Jhelum Tear Fault runs all along the river axis and has got activated by the recent earthquake. Evidences suggest that the readjustment of the rocks is still in progress and results in earthquakes whose epicenter is located around this area. The USGS observatories have also recorded the seismic activity in its vicinity. This fault line needs to be closely monitored during the times to come.

Of all the surveyed households 71.3 percent have received relief material in terms of money and clothes, tents, blankets etc. but 28.7 percent of the households are yet to receive the relief material from the government agencies. From the total surveyed households more than half of the households i.e. 58.6 percent want to migrate from their native areas, while as a total of 41.4 percent want to hold back there. From the surveyed households it was observed that 62.1 percent of the people are in a state of high mental stress and 37.9 percent had been affected to a moderate extent. Of the total 41 injured people from the surveyed households 17 people were seriously injured while as 24 people were partially injured. The households also received a serious loss in terms of their livestock i. e., a total of 22 households had their livestock completely perished.

Table 7: Village-wise death toll in the Uri Tehsil

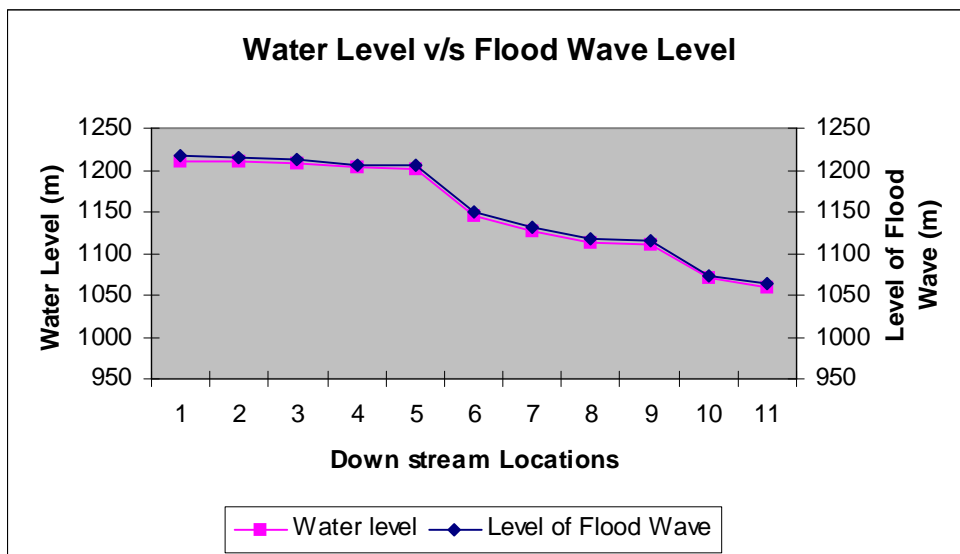
S. NO.	NAME OF VILLAGE	DEATHS	S.NO	NAME OF VILLAGE	DEATHS
1	KAMALKOTE	86	17	URI	17
2	BANDI SARAI	53	18	MOHURA	18
3	CHAPPAR	10	19	LIMBER	19
4	KUNDI BARAJALA	39	20	BANDI BRAHMANA	20
5	SADARA	19	21	MACHI	21
6	SULTAN DHAKKI	46	22	SUKHDHAR	22
7	BASGRAN	21	23	DARAGUTILAN	23
8	DACHI	4	24	DAWARAN	24
9	NAWA ARUNDA	22	25	DHANI SYDAN	25
10	URDOSA	7	26	CHOO LAN	26
11	CHAKRA	10	27	ZAMORPATTAN	27
12	ISHAM	24	28	THAJAL	28
13	BATGRAN	7	29	GINGAL	29
14	GOHALAN	7	30	GAWALTA	30
15	CHRUNDA	31	31	NAMBLA	31
16	TILWARI	1	-	TOTAL	514
17	URI	13	-	-	-

Suggestions and Future Plan

The Uri-II hydroelectric (HE) Project is under construction, which is a concrete straight gravity dam across the Jhelum River, at 1 km upstream of Dachhi Bridge near Salamabad village. During the recent earthquake the buildings of the project have been severely damaged and some damage has been caused to the dam structure as well. The project is a run of the river scheme with its weir near Dachhi village where from the water will be diverted through 540 m open channel followed by 4.275 km long HRT to underground power house (PH) at Sadwanian village on the left bank of Jhelum River. The discharge from the PH will be diverted to the Jhelum River through a 3775-m TRT with its fallout in Gosalta *nala* near Urusa. The catchment area of Jhelum River up to dam site of Uri-II HE project is 13400 km² comprising 12743 Km² catchment area up to Uri-I head works and 657 km² intermediate catchment area up to Uri-II dam site. The Design Flood (PMF) has been calculated as 4850 m³/sec. The Full Reservoir Level (FRL) is at 1241 m and the gross storage at FRL is 634.31 ha m.

The downstream areas vulnerable to inundation by dam break flood should be shown in the inundation map. The inundation map should be prepared with the help of water surface elevation profile, which has been computed for maximum flood elevation and discharges at various downstream locations. The detailed inundation map on 1:2,000-scale should be prepared and displayed at all the downstream flood prone locations depicting maximum water level that would be attained. The elevation also should be marked on the inundation maps depicting the topographic and geographical details of downstream areas.

Both the areas (Karnah and Uri) fall in the transition zone between seismic zones IV and V. From north to south three main thrusts occur in the region. They include the Main Karakoram Thrust, which separates the Hindukush-Karakoram belt from the Island Arc of Kohistan. In the south the Main Mantle Thrust separates the latter from Peshawar and Kashmir basins. The southern most is the Main Boundary Thrust, which separates the Lesser Himalaya from the Outer Himalaya. Panjal- and Murree Thrusts are the main tectonic planes that traverse the area. Besides, the Jhelum Tear Fault running in the N-S direction upto Muzaffarabad and then E-W upto Baramulla separating the Peshawar- from the Kashmir basin is the most active tectonic plane in the area. Though the area of downstream impact of the Uri-II is only spread over for about 15 km on the Indian side of the LOC but a population of about 7600 people is settled within the reach of dam break flooding. Besides, large population and agricultural and forestlands are at risk in case of dam failure beyond 10 km downstream reach in the PAK. Dam break would also adversely affect these areas. Therefore, monitoring of the RIS and seismic activity in the area is of utmost importance. The water level v/s flood wave has been worked out for project by one of us (GMB) which is given in figure below.



S. No	Distance from Dam site (d/s)	S. No	Distance from Dam site (d/s)
1	Dam Axis	7	8225m
2	200m	8	10100m
3	700m	9	11475m
4	2950m	10	12919m
5	3110m	11	14915m
6	6100m		

The area has experienced earthquakes of moderate to severe intensity in the past. The epicenters of major earthquakes in Kashmir are related with the mega- (more than 200 km) and intermediate lineaments (100-200 km). However, there is no documentation of seismic activity along the thrusts cutting across the project area. Therefore, a plan of seismic surveillance of the area by establishing a network of seismic monitoring stations is proposed preferably jointly by India and Pakistan. There are evidences of neotectonic

activity along the thrusts in the area; these thrusts should also be kept under the surveillance for such activities. The area is traversed by Panjal- and Murree Thrusts and Jhelum Fault and, falls in the transition zone between seismic zones IV and V. Besides, a number of lineaments transversely cutting across this thrust- and fault imbricate make the area more prone to neotectonic activity. These structural discontinuities coupled with joint systems and foliation in the rocks of the area makes it more prone disasters.

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**The Members of the Relief – come - Earthquake Investigation Team
University of Jammu**



Sitting First Row left to right

Kanchan Sharma, Sanjeev Sharma, Shahnawaz, Iftekhar

Sitting Second Row left to right

Sham Singh, Vinay Sharma, Rashid Choudhary, Yudhbir Singh

Standing from left to right

Vikrant Singh, Prof. Ashok Aima, Prof. V. K. Kapoor, Dr. G. M. Bhat, Dr. S.K. Pandita,
Ajay Kumar, Gulshan Rashid Bhat