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Post-October 08, 2005, Muzaffarabad earthquake scenario

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Abstract

An earthquake of magnitude 7.6 Mw occurred 100 km NE of Islamabad at 0850 local time (0350 GMT) on October 08, 2005. The epicenter of the main shock was located 19 km northeast of Muzaffarabad. Designated as the deadliest earthquake in Pakistan, it took a death toll of more than 80,000 human lives. It also caused a widespread destruction in Kashmir and northern Pakistan, particularly in Muzaffarabad, Bagh, Rawalakot, Mansehra, Balakot and Batatgram. Based on the epicentral distribution of 300 aftershocks, focal mechanism solutions and depth distribution, the activation of more than one fault and the Indus Kohistan Seismic Zone seem to be the cause of this seismic activity. About 100 large landslides, caused mostly by active faulting, have been observed through field studies and satellite images, in the rupture zones near Balakot, Muzaffarabad, Kardalla, Hattian Bala, Sarain, Sunddangali and Bagh. The earthquake catastrophe had a profound psychological, social, and economic impact. The World Bank and Asian Development Bank assessed a preliminary estimation of US$ 5.2 billion for an effective relief, recovery and reconstruction strategy. Several workshops and conferences have been held. The ministry of Housing and Works revised and updated the seismic building code of Pakistan (SBC-07) in March 2007. The Earthquake Reconstruction and Rehabilitation Authority made efforts to restore the basic infrastructure in the quake-affected areas, it is building a new Balakot city at Bakrial, whereas many structures in Muzaffarabad and Bagh cities were also built on modern lines.

1. Introduction

A massive earthquake of magnitude 7.6 Mw occurred 100 km NE of Islamabad at 0850 local time (0350 GMT) on October 08, 2005. Its tremors were felt across the region from Kabul to Delhi, and parts of northern Pakistan and Kashmir were decimated (Fig. 1). The towns of Muzaffarabad, Balakot, Bagh, Alai and Battagram were damaged severely. Collapse of some buildings (including a twelve storey tower in Islamabad) in addition to minor damage was reported from Islamabad, Lahore, Sialkot and Gujranwala, located 100 to 200 km from the epicenter. The earthquake was also felt in central Afghanistan and in most parts of northern India. More than 80,000 people have been killed and millions affected by this earthquake. Due to its widespread destruction, it is considered to be the worst of all the earthquakes that occurred in the region (Fig. 2). The present paper presents an overview of this tragic event.

The epicenter of the earthquake was located 19 km NE of the city of Muzaffarabad. The earthquake damaged an area of 30,000 km^2 across the line of control in India and Pakistan. Balakot, Muzaffarabad, Bagh, and many villages were razed to the ground. Mountain sides fell into rivers, villages disappeared, and civil facilities (roads, telecommunications, electricity, water connections, health units, schools) were severely affected. Some 70% of the dwellings were destroyed (472,000 houses) and the remaining 30% damaged, including school buildings (Fig. 2). The disaster is amongst the deadliest in the region in living memory. Official death count was 73, 276 in Pakistan (79,000 unofficial), and 1, 307 in India, with over 85,000 reported as injured.

The earthquake catastrophe was further compounded by disruption of communication due to closure of roads and delay in relief work. Thus, there was a profound psychological, social, and economic impact on the entire population. Survivors were gripped by grief, fear, uncertainty, bewilderment, and trauma. In addition to loss of life and damage to property, many suffered livelihood. And, as usual, the weakest of the population, i.e., elderly, women, and children, suffered more.

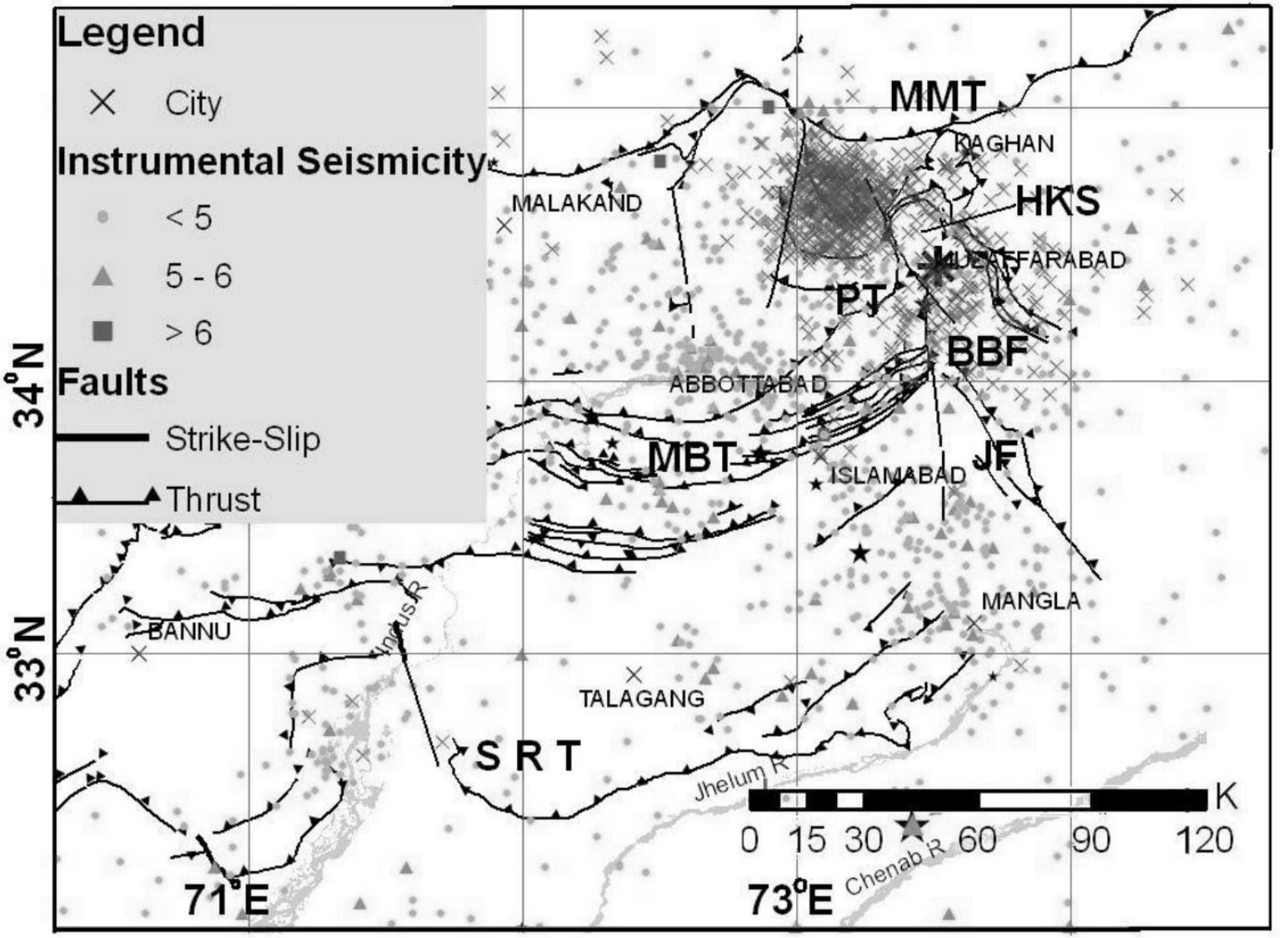

Fig. 1. Seismotectonic map of the area showing seismicity, structure and aftershock distribution of October 8, 2005 Muzaffarabad Earthquake. MMT: Main Mantle Thrust; MBT: Main Boundary Thrust; JF: Jhelum Fault; SRT: Salt Range Thrust; PT: Panjal Thrust; BBT: Balakot-Bagh Fault; IKSZ: Indus Kohistan Seismic Zone (after MonaLisa, 2009).

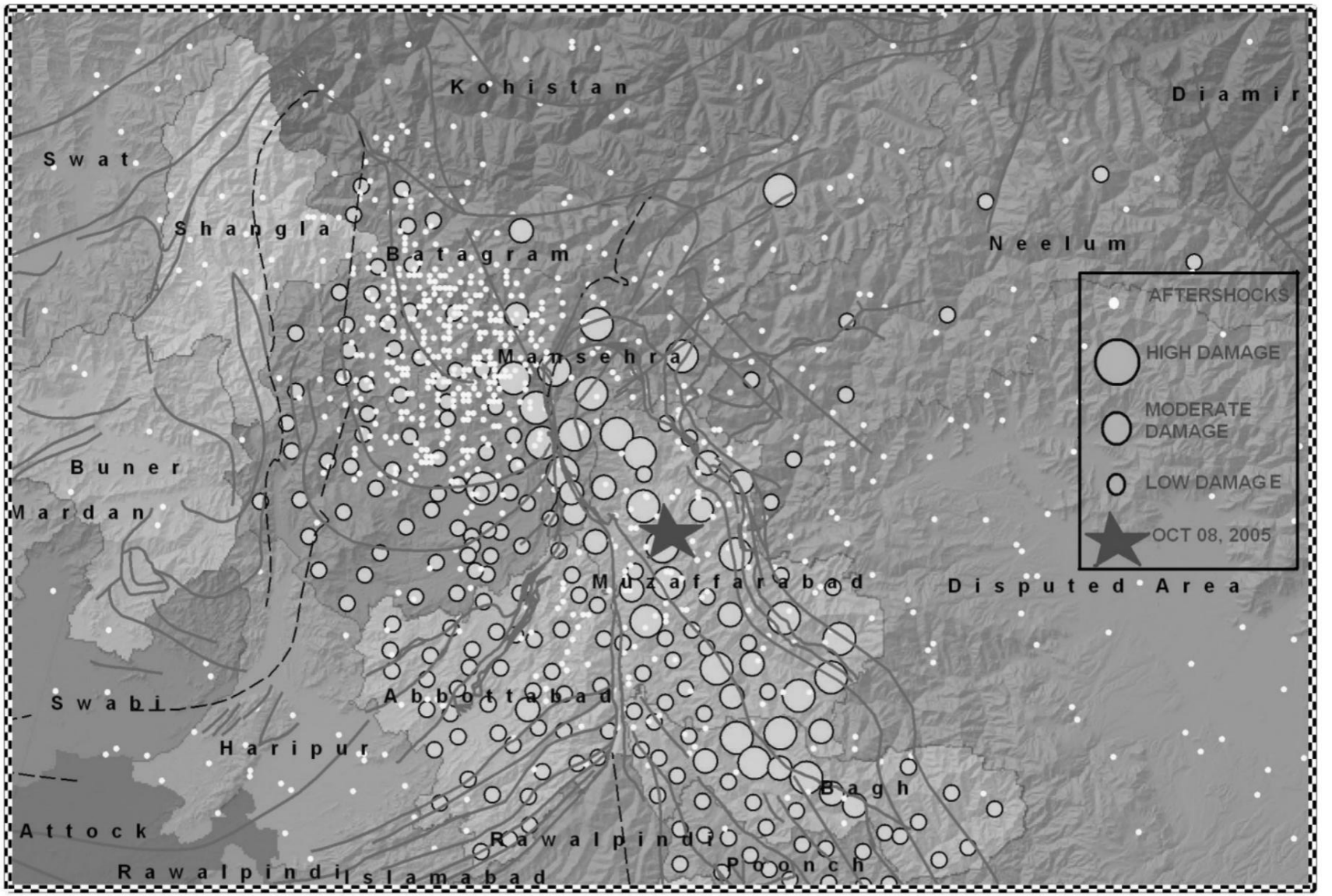

Fig. 2. Damage and destruction map of 100 km area within the main shock epicentral location.

2. Seismology/Geology

The seismicity of the area is related to the collision between the Indian and Eurasian Plates. Active tectonic features (Fig. 1) within the area, e.g., the Main Boundary Thrust (MBT), Jhelum Fault, Panjal Thrust (MonaLisa et al., 2007), Indus Kohistan Seismic Zone (IKSZ, Armbruster et al., 1978; MonaLisa, 2009), and the surface expression of the IKSZ, i.e. Muzaffarabad or Balakot-Bagh Fault (BBF) as indicated by MonaLisa et al. (2008b), provide evidences for the ongoing collision.

Northern Pakistan is a region where moderate to major plate boundary earthquakes are common, e.g., the 1974 Pattan Earthquake of m_b 6.0; the 1977 Rawalpindi Earthquake of m_b 5.2; the two 2002 Bunji earthquakes of m_b 5.3 and 6.0; and 2004 Battagram earthquakes of m_b 5.3 and 5.5. Earlier workers (Bilham et al., 2001; Bilham and Wallace, 2005; MonaLisa et al., 2004) hinted at the possibility of occurrence of a long overdue great earthquake in the area before the occurrence of October 08, 2005 catastrophe. It has also been suggested (Bilham, 2005; MonaLisa et al., 2007; MonaLisa, 2009) that in spite of its widespread destruction, the October 08 earthquake has not released the energy that has been developed since the previous great earthquake of 1855.

The NW-SE oriented thrust/reverse focal mechanism solution of the aftershocks of the Muzaffarabad earthquake is indicative of the reactivation of the Indus Kohistan Seismic Zone, whereas the right-lateral component, supported by surface evidence, suggests the involvement of Balakot-Bagh fault. In sharp contrast to previous Himalayan earthquakes, a surface rupture of 90 km developed between Bagh and Balakot, with mean vertical separation of 3-4 m right-lateral slips. The Balakot-Bagh fault, largely blind, lies at the base of the ridge on the left (Fig. 3). Damage on the terrace was near total, with 85% of the population, (more than 1,600 people), losing lives. However, damage in the footwall (fields to far left) was limited, indicating the importance of mapping potentially-active faults prior to an earthquake (MonaLisa et al., 2008b; Hussain et al., 2008). The earthquake also triggered hundreds of landslides in the area, majority of which occurred along the active faults, but also along natural slopes and road cuts.

3. Post-earthquake scenario

The tragedy generated immediate response in the entire country in the form of monetary and material donations, especially warm clothing. Various volunteer groups, individuals, and professionals reached out to survivors for comfort and care, but the process of psychological recovery in such cases is slow and requires long attention. Unfortunately, relief could not be very effectively provided during the very early days after the earthquake because of 1) immense magnitude of the disaster, 2) unpreparedness for the catastrophe, 3) inaccessibility to many parts of the high relief terrain, and 4) closure of many roads due to damage, landslides and rock falls.

The World Bank and Asian Development Bank assessed a preliminary estimation of US$ 5.2 billion for an effective relief, recovery and reconstruction strategy. The Government of Pakistan arranged an international donor conference on November 19, 2005, in Islamabad to discuss the medium and long term reconstruction needs. Several countries, international agencies and non-government organizations offered relief aid in the form of funds, helicopters, technical personnel, doctors as well as medical aid, such as medicine, tents, blankets, etc.

3.1. Institutional development

The disaster acted as a wake up call for the country. Several workshops and conferences have been held (e.g., Kausar and Karim, 2006; MonaLisa et al., 2008a). Various universities and organizations have started paying serious attention to earthquake-related studies through improved facilities, e.g., installation of seismic simulator and strong motion instrument program (University of Engineering and Technology, Peshawar), establishment of national network of seismic sensors (Pakistan Meteorological Department), paleoseismic studies (Geological survey of Pakistan), geodetic measurements using GPS (National Center of Excellence in Geology, University of Peshawar), seismic hazard assessment (Earth Sciences Department, Quaid-i-Azam University, Islamabad), and establishment of Earthquake Studies Centre (National Centre for Physics, Quaid-i-Azam University, Islamabad).

Indeed, earthquake-related studies and publications have seen an unprecedented surge in the context of Pakistan over the past four years.

3.2. Physical infrastructural development

The Earthquake Reconstruction and Rehabilitation Authority (ERRA), Government of Pakistan, started functioning soon after the occurrence of the disaster in the earthquake affected areas in twelve major socio-economic sectors, especially the housing and town planning. The following were the immediate goals of ERRA (http://www.erra.gov.pk).

- Rebuild to an enhanced level of functionality than existed before the earthquake.
- Ensure improved social delivery.
- Rebuild not just the physical infrastructure, but also the social infrastructure of the city such as the economy, environment, and social services.
- Improve the quality of life of the residents.
- Develop urban infrastructure which is more resistant to natural disasters, and can take care of enhanced needs in the next 25-30 years.

ERRA initially concentrated on some of the immediate tasks, such as saving lives and securing the dignity of affected population, appropriate arrangements of winterized tents and shelters in high altitude mountains, and making schools and health facilities functional. By now, roads, telecommunication, electricity, water, medical and other facilities have been restored considerably: most schools have been re-opened in old or new buildings. In its later stages, ERRA started constructing a new Balakot city at Bakrial, whereas Muzaffarabad and Bagh cities were also built on modern lines. Muzaffarabad looks better than before, with a brand new university campus and many other buildings.

Fig. 3. Oblique aerial photograph of terrace of Kunhar River at Balakot, Pakistan, in the hanging wall of the Balakot-Bagh fault, source of the October 2005 M 7.6 earthquake, taken a few days after the earthquake. (http://www.geo.oregonstate.edu/alumni/newsletter2007.pdf).

The ministry of Housing and Works revised and updated the seismic building code of Pakistan (SBC-07) in March 2007. Countrywide implementation of SBC-07 will go a long way in reducing the seismic risk in Pakistan.

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