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AN OVERVIEW OF PAST HISTORY BASED ON SEISMICITY PATTERN OF KASHMIR REGION, AN INTERPRETATION FROM 2005 EARTHQUAKE

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ABSTRACT

Kashmir region is one of the most seismic prone area lies on the Eurasian and Indian plate boundary. It has been the host of many great earthquakes from centuries including last 8th October 2005 earthquake. This study involves the seismicity pattern of Kashmir region before and after 8th October 2005 earthquake. Although the spatial and temporal seismicity patterns in an earthquake-prone Kashmir region are closely related to both tectonic regime and fault structures. It is the most difficult to quantify the relations in a way which allows large events in the seismic region to be predicted. However, regular and persistent studies regarding seismic activities are most important phenomena for the future recurrence and magnitude of earthquakes. Seismicity time properties of Kashmir region are investigated through a systematic pattern recognition analysis. Statistical methods have been applied to a long time database of instrumental data recorded from 1904 – 2006. The seismicity pattern of this region reveals that this activity remains very high just after earthquake and continues till 31st December 2006 after that it calm down. It also shows the comparison of seismicity pattern that are high from 8th October 2005 to 31st December 2005 while shows lessened trend afterwards during the year 2006. The purpose of this study was to determine the future strain buildup, uplift rates, slip rates, recurrence intervals, and seismicity along different faults needed to be monitored continuously to avoid major human disaster like the 8th October 2005 Muzaffarabad earthquake, in the Kashmir region.

Key words: Seismicity pattern, statistical analysis, earthquake and Kashmir region

INTRODUCTION

The study area lies between 33°N to 35°N and 73° E to 75° E. It spreads over an area of 13,297 sq.kms. It is the land of the scenic beauty with high mountains and lush green valleys. Administratively, Azad-Kashmir is divided in to seven districts, Muzaffarabad, Rawlakot, Pullandre, Kotli, Mirpur, Bhimber and Bagh. Muzaffarabad is the capital city of this region. The territory is mostly highlands, drained by the Jhelum, the Neelum and the Poonch rivers. There are small plains of Mirpur, Kotli and Bhimber.

Kashmir region is seismically active earthquake prone area. The region has a long history of strong earthquakes. There are two tectonic plates colliding, thus creating the Great Himalayas. As the Indian plate continues to push into Eurasian plate, stresses accumulate at the faults [Fig. 1] marking the boundaries between these two gigantic plates. For long geological periods these plates remained locked together when suddenly strain became too much to bear near the breaking point, the fault ruptured, setting off an earthquake. A belt of strong earthquake is located on southern edge of the Tibetan Plateau along the small circle with a radius of 1695 Km, (Bendick and Bilham, 2001). The 1878 Kohat-Peshawar earthquake, 1885 Kashmir earthquake, 1905 Kangra earthquake, 1974 Pattan and 2005 Kashmir earthquake. appear to sequence along this small circle Pakistan Meteorological Department (PMD), (1983, 2006). This line indicates a smoothed small circle that approximates the Himalayan arc and follows a line of river incision and moderate earthquakes defined by Seeber and Gornitz (1983). According to them, this small circle includes the topographic front between the Lesser and High Himalayas, the narrow belt of intermediate-magnitude thrust earthquakes, the Main Central Thrust zone (MCT). These features define a small circle in the central portion of the Himalayan arc.

Structural features in northern Pakistan are dominated by syntaxial bend of the Himalayas and are associated with convergence of the Hindukush and Karakorum mountains. These two faults, Murree thrust (which separate the territory Murree formation from overriding carboniferous Panjal formation) and the Panjal thrust (which separate the carboniferous rocks from the overriding Precambrian Salkhalla formation) bend sharply around the syntaxis at about 32.5°N to 35.5° N and 73.5°E to 75°E. Generally, the trend of the most features in northern Pakistan reflects the existence of the Western Himalayan Syntaxes. The MBT (main boundary thrust) forms a continuous boundary of all postcollisional rocks along the entire Himalaya. These structures in the Kashmir region are complex due to its proximity to the NW Himalayan syntaxis and the presence of salt and anhydrites in the syntaxial region. According to USGS the recent earthquake occurred in the Kashmir gap region and its epicenter located in the syntaxis (Gansser 1964, Bilham and Wallace 2005; Nath 2005)

History of Earthquakes in Pakistan and Kashmir region: Pakistan has a history of severe earthquakes in the past. There are also evidences of major earthquakes in Debal (24.8° N 67.8° E) in 893-894 A.D. killing around one hundred eighty thousand peoples. A catastrophic earthquake in Kashmir occurred in 1555 but there is no data to assign it a magnitude or location. Its severity suggests that it may have been larger than the recent earthquake. In 1885, the Kashmir earthquake occurred near Srinagar, the epicenter of which was around (34.1°N, 74.8°E).The total affected area was 1 00,000 sq.miles which includes Baramulla and Pattan (Lawrence, 1895). Approximately 3000 people perished and some villages were completely destroyed. Another major earthquake of magnitude 7.8 hit the Kangra region (33.0°N 76.0°E) in 1905 and caused 20,000 fatalities. Another deadly earthquake in recent history was witnessed in Quetta (29.5° N 66.8° E) on May 31, 1935. Its magnitude was 7.6 and it killed more than 30,000 inhabitants in the city. On December 28, 1974 an earthquake of magnitude 6.2 occurred in Kohistan (35.1°N 72.9°E) just north of the recent quake's epicenter causing 5,300 causalities. On February 27, 1997 an earthquake of magnitude 7.3 struck near Harnai, Baluchistan and killed nearly 100 people in the cities of Quetta, Sibi and Harnai. Another seismic activity took place in Gilgit-Astore region near Nanga Parbat in November 2002. With its main shocks of magnitude 6.3, the earthquake triggered a series of aftershocks, which continued for about a month and caused massive landslides leaving thousands homeless. Nanga Parbat was directly responsible for this seismic activity as geologists had already discovered a magma pool beneath the mountains and feared it could produce an earthquake at any time. (Bilham *et al.,* 2001; Lynn *et al.,* 1999; Nath *et al.,* 2005).

Most significant earthquakes occurred in the history are shown below;

Month &Year	Magnitude	Location
May, 1668	7.6	Shahbunder Lower Sind)
June, 1819	7.5	Allahbund(Indopak border region)
September, 1827	6.5	Lahore
January, 1852	6.6	Kahan(Baluchistan)
December, 1892	6.8	Chaman (Pak. Afghan border)
October, 1909	7.0	Loralai and Sibi(Baluchistan)
February, 1929	8.0	Buner and Hazara
August, 1931	7.2	Mach (Baluchistan)
May, 1935	7.6	Quetta
November, 1945	7.9	Makran coast (Baluchistan)

According to the Meteorological Office Peshawar, October 8th 2005 earthquake was the second major earthquake since 1929 in this region. The February 1929 shock in northern district of Buner had magnitude 8.0 at the Richter scale but due to sparse population losses were minimum due to this earthquake. (Ambraseys and Jackson, 2003).

Hindukush mountain range in Afghanistan [near Pak-Afghan border (30.9°N 66.4°E) north to Chitral] has been the origin of many strong earthquakes in the past. Many damaging earthquakes occurred in December, 1983 of magnitude 7.4, July 1985 of magnitude 7.4, January 1991 of magnitude 6.7, and August, 1993 of magnitude 7.0, (Nandy, 2001; Ni and Barazangi, 1984). The most recent earthquake epicentred in Hindukush(36.2°N 71.0°E) occurred in December 13, 2005. Its magnitude was 6.7. The earthquake was strongly felt in northern Pakistan and in most of the Punjab. It killed five people and caused landslides blocking several roads near Chitral. A strong earthquake with magnitude 6.2 struck the Hindukush Mountains in Badakhshan, Afghanistan (36.5°N 70.6°E) on 3 April 2007. It has been widely felt in North-East Afghanistan, Northern Pakistan, North India and Central Asian Republics. It resulted several injuries in northern Pakistan and in Jammu and Kashmir.

Tectonic overview: Himalayan mountains that separates India along its north-central and northeastern frontier from China (Tibet) and extends between latitudes 26.2 and 35.4°N, and between longitudes 74.5 and 95.4°E. The base of the Himalaya marks the surface boundary between the Indian Plate and the overriding Asian Plate. The front of the range is narrow and abrupt from the plains below to the Tibetan Plateau. The western end is marked by the addition of the Kohistan volcanic arc at the front of the collision. This makes a major indentation that is marked by the deep gorges of the Indus and Gilgit Rivers as they outline the margin of the arc. The Chaman and Karakoram faults frame a wedge that drives the Pamirs ahead of the Kohistan arc. This wedge drives the Tibetan Plateau to the east resulting in the steepest slopes being along the eastern margin of the plateau. The boundary of Indian and Eurasian plates has been the host for many large earthquakes in the past**.** The largest of India's earthquake, (Kangra earthquake with magnitude 7.8) however, occurred on the northern boundary of the Indian plate where it descends beneath southern Tibet Plateau.

Seismicity patterns in Pakistan and northwestern India is associated with continental collision. The data from a local array of 12 short-period seismic stations(where GPS are installed) located near the Tarbela reservoir in the lesser Himalayas of northern Pakistan were analyzed to estimate the anomalous thickness of the crust at the boundary between the colliding Indian and Eurasian subcontinents in the western Himalayas and Baluchistan arc. The main difference is that teleseismic events with large magnitudes occur more scattered and often fall off major faults. Several seismic gaps in the present seismicity along the Himalayas and the Baluchistan are identified. At some gaps the corresponding fault segment appears to be at a low stress level because it has recently undergone a major stress relief, while in other gaps stresses may be high and, hence, the fault may be in preparation for a major stress relief in near future. (Bilham and Wallace, 2005).

The Kashmir earthquake, which affected Kashmir, Jammu and the North West Frontier Province of Pakistan, is associated with the great plate boundary region where Indian Plate is subducting under the Eurasian Plate. The tectonic movement in the region is responsible for the creation of the Himalayan mountain ranges through compressive and bending stresses. The subduction mechanism has triggered a few great and several intermediate earthquakes in a band of about 50-80 km width and an arc length of about 2500 km. (Bilham 2004; Molnar, 1992; Molnar and Tapponnier, 1975). The recent Kashmir earthquake occurred at the western tip of the active subduction Himalayan belt.

Faults of Pakistan including Kashmir: Fig. 1 shows the tectonic overview and major faults of Pakistan. According to Takashi *et al*. (1991), the main faults in Pakistan seem to be seismically quite (locked) except at times of the large damaging earthquakes .It seems that this silence is more true for the Himalayas than for many other seismically active areas, and in terms of seismicity it represents the problem that locked areas may appear inactive for longer time periods than monitoring record.

Abbotabad (34.1^{o}N 73.2^{o}E) active faults are concentrated around the sharp bend of the Jehlum River at Muzaffarabad (34.3^{o}N 73.4^{o}E). On the northern side of the river at Muzaffarabad, quaternary terraces are tilted at least 15° to east. On the right bank of the river southeast of Tanda, Pleistocene fan surfaces along the foot of an anticlinal ridge are vertically dislocated by a NW- SE striking fault. West of Muzaffarabad, another active fault extends N-S for 10 km. along this fault, terraces of the Jehlum River and its tributaries are vertically dislocated to form clearly reverse displaced scarplets and fault sags. Lateral displacements along these faults have been confirmed during this study.

Rawalpindi (33.6^{o}N 73.0^{o}E) active faults are located in a quite limited region between the hilly terrains around the Jehlum river mouth and the plain north of Maira. They are West North West to East South East (WNW-ESE) or East North East to West South West (ENE-WSW) trending faults. One might expect to find lateral slip along them, but only dip slip is recorded by tectonic features along their active traces. Maira fault-2 is a class-1 fault along which Pleistocene river terraces were displaced up to the south and reverse Scarplets were formed.

Jhelum Fault (32.9^{o}N 73.7^{o}E) along eastern margin of the salt range, northwest of Jhelum city, short intermittent active fault traces of the Jhelum fault-2 trend NE-SW. They dislocate Pleistocene river terraces and fan surfaces forming distinctive fault scarplets. They may lie on the extension of the salt range front fault-1. A concentration of seismic activity is seen along the Jhelum River North of Mangla. This seismicity is observed to align not only along the mapped portion of Jhelum Fault, but also extended north of this mapped fault, towards the southern side. Based on seismicity observations this fault is active. (Armbruster *et al.,* 1978); Khurshed *et al.,* 1984).

Gilgit Fault, (35.9^{o}N 74.2^{o}E) thrust zone is the suture between the marginal fold and thrust belt to the south and the Kohistan volcanic belt to the north. Raikot fault-3 offsets the trace of MMT on the right bank of Indus, dislocating fluvioglacial sediments along oblique thrust planes. Bilham *et al.* (2001); Crawford (1974). Near Raikot, the fault offsets talus cones. The trace of the fault is commonly the location of hot springs. It is, however, hard to find traces of it on aerial photographs. No lateral displacement has been detected on these features. Aerial photographs of the mountainous north contain major inherent distortion due to the extreme relief. Therefore, this kind of reconnaissance study is less rewarding in such places. The Chhamongarn-1 and Thelichi-2 faults are topographically well defined with fault scarplets on mountain slopes and Holocene fan surfaces. These are good indicators of recent activity. The expression of the Thelichi fault is complicated by a line of Aeolian sans coincident with the fault trace. Nath (2004); Takashi *et al.*, (1991).

These are the seismicity data, which have served as a basis for the quantification in each of the source zones defined and analyzed in the present study. Table 1 shows the data of significant earthquakes from 1904-2005, almost 101 years of the Kashmir region. During these years 99 earthquakes occurred in this region. But the quakes with magnitude 4.5 and more are included in table 1.

Data collection, analysis and discussion of aftershocks: The 8th October earthquake struck at 8:50:40A.M. (Pakistan Time) and on 03:50:40 Universal Time Coordinated (UTC). According to USGS the magnitude was 7.6, and the location coordinates were 34.493(35°N)-73.629(74°E), with a focal depth of 26kms (16.2 miles).

Fig. 2, table 1 shows the data of 102 years (from 1st January 1904- 7th October 2005), with the number of earthquakes and magnitude more than 7.0. Out of these 102 years 66 years have no event of such magnitude, while 19 years with one earthquake/year, 3 years with 2 events, 1 year with 3 events, 5 years with 4 events, no or zero years with 5 events, 2 years with 6 events, 1 years with 7 and 8 events each and 2 years with 9 events respectively.[Respective events 66,19,3,5,1,0,2,1,1,2; years, 0,1,2,3,4,5,6,7,8, and 9].

A large number of aftershocks of magnitude up to 0.6, more than 100/day were recorded in the proceeding week, the details are as below.

Fig. 3 shows the data of aftershocks from 8th October 2005 – 31st December 2005 with maximum aftershocks recorded on 9th October that are 122 while minimum aftershocks recorded on 22nd December that is 1 only and 12th December with zero or no aftershock. In Figs. 2-7, the day 281 represents the 8th October while the day 365 represents the 31st December respectively.

Fig. 4 shows aftershock data from 1st January 2006- 31st December 2006. The results of the aftershocks data show that the maximum no. of aftershocks/day occurred on 18th May 2006 that are 13 while 9 aftershocks /day occurred twice in a year, one during the 1st and 2nd week of January 2006, similarly 8 aftershocks/day occurred twice during the first two months (January and February 2006) while 7 aftershocks/day occurred for four times during the first three months, 6 aftershocks/day occurred for 10 time during the first six months of the year while 5 aftershocks/day occurred in thirteen days during the first 10 months of the year and number of very large aftershocks from 4-1/day occurred during the whole year and after 31st December this activity calm down.

Fig. 5 and 6 shows the comparison of aftershocks of 2005 and 2006, the maximum aftershocks during the 2005 are on 9th October that are 122 while during the 2006 are on 8th May that are 13 only. While the Fig. 7 shows the comparison of aftershocks from 8th October- 31st December of 2005 and 2006 respectively. It represent that the maximum – minimum trend of aftershocks from 2005-2006. The data available for the year 2005 is from 8th October to 31st December 2005 so for the parallel comparison of both the years Fig. 7 is added; otherwise Figs. 5 to 7 show the comparison of aftershocks for the both years.

Fig. 8 shows the seismicity pattern of Kashmir region from 8th October 2005 - 31st December 2006.The seismicity pattern interpreted from this figure shows that aftershocks slowdown with increasing time and increasing distance. Aftershocks pattern uses to make real time predictions about the probability of ground shaking. It also highlights the direction of ground shaking from the main shock. Deep earthquakes are much less likely followed by aftershocks than shallow earthquakes and very large number of aftershocks spanning a time of more than one year indicates that Kashmir earthquake has a shallow focus i-e 26 km. (16 miles).

Many studies suggest that static stress changes trigger aftershocks, but recent work suggests that shaking (dynamic stresses) may also play a role. Here we measure the decay of aftershocks as a function of distance from magnitude 2–6 main shocks in order to clarify the aftershock triggering process. We find that for short times after the mainshock, when low background seismicity rates allow for good aftershock detection, the decay is well fitted by a single inverse power law over distances of 0.2–50 km. The consistency of the trend indicates that the same triggering mechanism is working over the entire range. As static stress changes at the more distant aftershocks are negligible, this suggests that dynamic stresses may be triggering all of these aftershocks. We infer that the observed aftershock density is consistent with the probability of triggering aftershocks being nearly

Table 1; Data from 1st January 1904- 7th October 2005 with Mw < 7.6

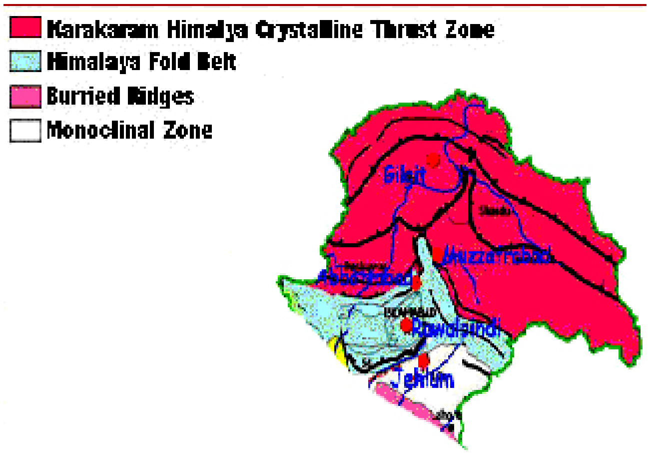
Years	No.	Years	No.	Years	No.	Years	No.	Years	No.	Years	No.
1904	1	1921		1938		1955		1972	4	1989	
1905		1922		1939		1956	1	1973	8	1990	
1906		1923		1940		1957		1974	3	1991	
1907	1	1924		1941		1958		1975	4	1992	1
1908		1925		1942		1959	1	1976	4	1993	
1909		1926		1943		1960		1977	9	1994	
1910		1927		1944		1961		1978	9	1995	
1911		1928		1945		1962		1979	4	1996	
1912	1	1929		1946	1	1963	2	1980	4	1997	
1913		1930		1947		1964	1	1981	2	1998	
1914		1931		1948	1	1965	1	1982	2	1999	
1915		1932		1949	1	1966	1	1983		2000	
1916		1933	1	1950	1	1967	1	1984		2001	
1917		1934		1951		1968	1	1985		2002	
1918		1935		1952		1969	1	1986		2003	4
1919	1	1936		1953		1970	6	1987		2004	6
1920		1937	1	1954		1971	7	1988		2005	1

Table 2. Data from 1st January 1904- 7th October 2005 with Mw> 7.6

Date	Latitude	Longitude	Depth	Magnitude
24/09/1904	34.8	74.6	88	4.6
26/03/1933	36	73.8	53	4.6
27/03/1937	34.4	74.5	50	4.5
26/05/1946	35	74.7	53	4.5
2/9/1963	33.9	74.7	33	5.1
3/7/1964	33.9	74.5	94	4.9
23/05/1965	35.8	73.5	19	5.2
6/4/1966	35	73	38	5.1
3/7/1968	34.8	74.6	88	4.6
2/12/1969	34.5	73.9	96	4.9
28/04/1970	32.8	74.9	116	4.8
1/3/1970	33.9	73.7	96	4.8
11/6/1970	33.9	75	72	4.8
5/12/1970	33.1	74.5	75	4.8
29/07/1970	33.3	74.8	101	4.9
28/04/1971	34.4	73.6	43	4.8
28/04/1971	34.4	73.6	13	4.8
21/12/1971	35.6	74.3	15	5
9/4/1972	35.2	74.7	53	4.5
13/01/1973	34.6	73.9	33	4.8
18/07/1973	33.1	75.5	63	4.6
16/12/1973	34.3	74.1	40	5.1
20/05/1974	34.6	74.2	48	4.8
1/8/1974	33.4	74.5	0	4.5
23/03/1975	35.5	74.8	33	4.7
25/02/1976	33.3	74.9	51	4.5
22/03/1976	35.9	73.5	42	5.2
2/3/1977	33.3	74.2	33	5.2
3/3/1977	33.7	73.7	33	5.2
5/3/1977	33.8	73.8	33	5.2
31/03/1977	34.2	74.1	33	4.6
5/4/1977	34.6	74.2	33	4.6
9/4/1977	33.3	73.8	4	4.7
17/05/1977	35	74	33	4.7
6/1/1978	33.3	75	66	4.5
3/3/1978	33.4	75	33	4.7
9/4/1978	35.5	74.6	33	5
7/5/1978	33.6	73.6	25	5
8/5/1978	33.6	73.8	33	4.7
5/8/1978	33.3	74.5	33	4.7
4/3/1979	33.9	73.2	42	4.7
1/6/1979	33.1	73.6	33	4.8
2/7/1979	34.5	74.4	33	4.5
13/02/1980	36.5	76.9	63	6.1
20/03/1980	36.3	70.7	146	5.2
13/09/1981	35.5	73.7	70	4.6
31/09/1981	35.5	73.6	71	4.5
24/01/1992	35.5	74.5	---	5.4
24/05/2003	35.4	74.5	---	4.7
14/02/2004	34.8	73.3	---	5.7
14/02/2004	34.8	73.2	---	5.5
22/02/2004	34.8	73.5	---	5
31/10/2004	35.3	74.4	---	5.5
31/10/2004	35.5	74.4	---	5.4
5/2/2005	34.4	73.2	---	4.8

proportional to seismic wave amplitude. The data are not fitted well by models that combine static stress change with the evolution of frictionally locked faults (Felzer and Brodsky, 2006)

Fig. 9 shows the affected area of Kashmir region is about 90 km that lies between 33 ° N to 35.5°N and 72°E to75.5°E as a result of 8th October 2005 earthquake. This figure also shows that the maximum energy has been released from N to NE in the study area.The Kashmir earthquake 2005 caused a widespread destruction in the area of Muzaffarabad, NWFP, and western and southern parts of Kashmir in India. Muzaffarabad, Bagh and Rawalakot in Kashmir, while Mansehra, Balakot, Abbottabad, Batgram in NWFP and Islamabad, the capital city of Pakistan are the most affected towns and cities.



Fig; 1: Tectonic map of Pakistan including Kashmir Seismicity of Kashmir Region before 8th October 2005

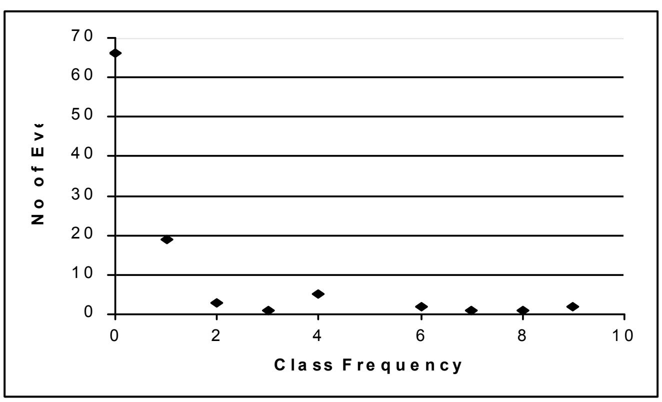


Fig: 2 Numbers of years in which n number recorded. X-axis shows frequency class while Y-axis is showing number of years within n event occurs

Epicentral distribution of these aftershocks indicates that more than one tectonic subdivision of the fold belt has experienced instability. Focal depth indicates that most activity is confined to a shallow depth range. The shallow focus is considered to a depth range of 0-70 km and supposed to be a most devasting earthquake and the places near the epicenter are more badly damaged as the death toll as a result of Kashmir earthquake is 80,000.

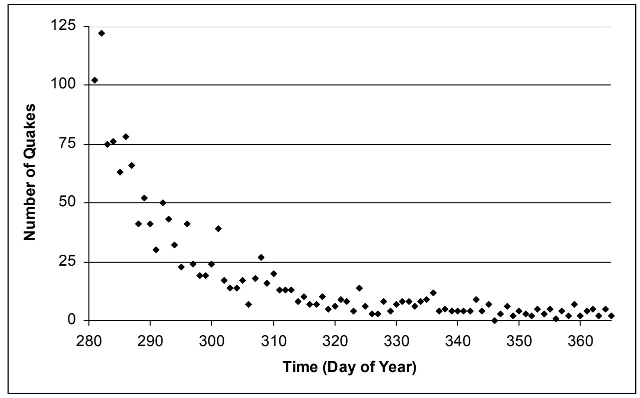


Fig: 3 shows number of days of aftershocks and daily frequency (number of quakes)

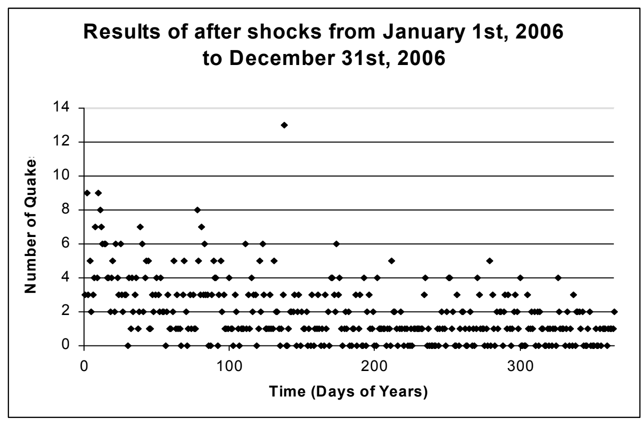


Fig: 4. The aftershocks recorded X-axis shows number of days of aftershocks and Y-axis is the daily frequency (number of quakes)

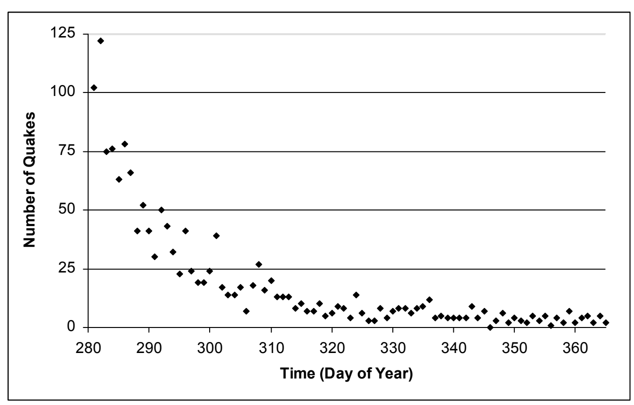


Fig. 5 showing aftershocks data of 2005

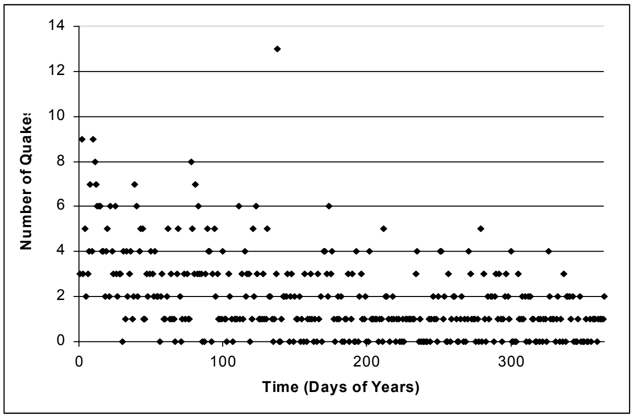


Fig. 6 showing aftershocks data of 2006

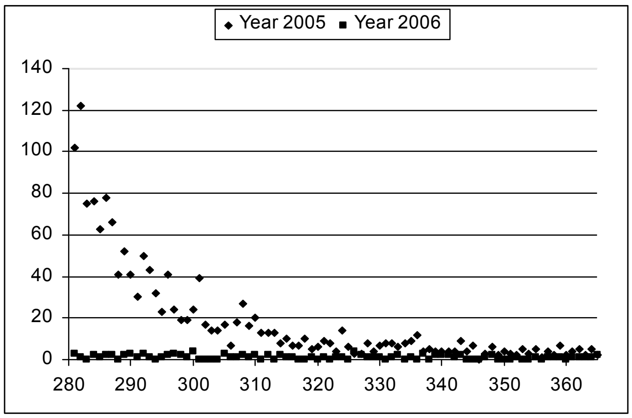


Fig.7. Comparison of aftershocks from 8th October - 31st December. Blue dots show the aftershocks results of the year 2005 while red dots show the aftershocks results of the year 2006.

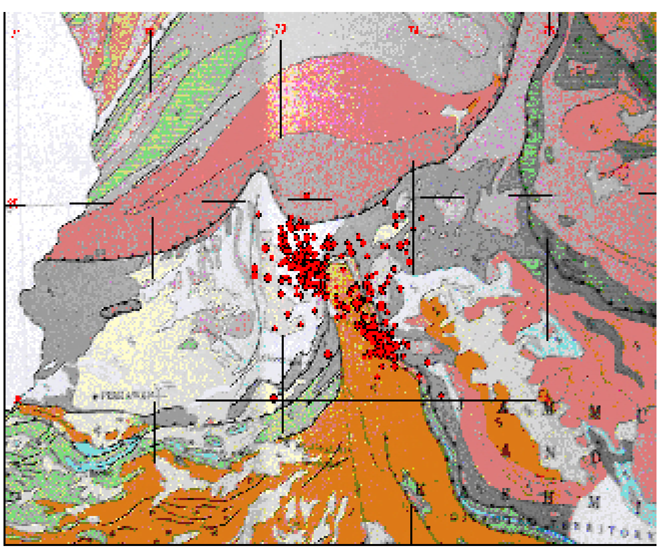


Fig. 8 The seismicity pattern of Kashmir region after 8th October 2005-2006

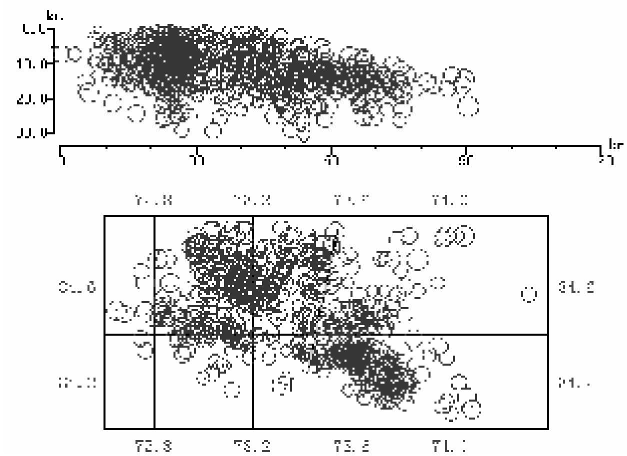


Fig: 9 Affected area of Kashmir region about 90 km lies between 33 ° N to 35.5°N and 72°E to75.5°E

Conclusion: Kashmir region is very important related to seismic activity in the Great Himalaya. The history of earthquakes goes back to 1505 in this region. Feldal and Bilham (2006). The seismic activity of Kashmir region is divided into two phases. The first phase is before 8th October 2005 (i.e., January 1st 1904 to October 7th 2005) and the second phase is after 8th October 2005 (i.e., October 8th 2005 to December 31st 2006). The analysis of the last 102 -year's data show that the Kangra earthquake (1905) of magnitude 7.8, was the disastrous earthquake but unfortunately complete recording of aftershocks for that earthquake are not available. Before 8th October, 2005 earthquake, the trend of seismicity has been shown in figure 2. Low seismicity observed in the study area beside the presence of complex fault system induction of accumulation of strain energy that released during 8th October 2005 disastrous Kashmir earthquake. Aftershock analysis shows that the earthquake triggered the Indus-Kohistan Seismic Zone (ISKZ) and maximum aftershocks received as shown in Fig. 9 and the length of fault was found about 90 Km which is significant for this study. The data set used in this study gives the detailed and unique information about the statistical analysis of seismicity pattern for the further studies of this region. Moreover this study can be used as a catalogue to determine the seismicity and microseismicity patterns of any vulnerable area to disseminate more accurate results for future earthquake prediction. These findings show that the maximum energy has been released from N to NE in the study area. This study can be extended to get accurate future results i-e seismicity pattern to make real time prediction, for future. Similarly a thorough study of earthquake- generating area is also the urgent need of the time and the present study is an important step to resolve this issue. If this study is continued with GPS installation on the bed rocks for geodynamical investigations than it can be expected to understand the mechanisms which produce and shift the seismic activity to other regions. Particularly this study will provide a milestone for further studies governing many new ideas for seismicity. Accurate prediction of earthquake in advance is a still a question of controversy. Earthquake prediction over the years has been a controversial issue (Lynn *et al.*, 1999). Earthquake prediction can be categorized on the basis of time scale involved in the prediction process like short-term, intermediate and long-term i-e from months to years to several years. The earth interior is much more complex and even the crustral movements are independent to any time interval. But with the continuous struggle of scientific advancements, it is possible to understand the mechanisms going on beneath the earth surface. This research is important to study the fault networks and energy carried by the stress field. This is also important to highlight the active faults and chances of earthquake occurrences in future.

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