Active Tectonics of Himalayan Faults/Thrusters System in Northern India on the basis of recent and Paleo Earthquake Studies

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Himalaya rises as a consequence of the collision of Indian Plate with Asian Plate.
WIHG Seismic Networks
GPS convergence rates
Histogram of the local Seismic activity

Period: April 2009 to March 2010

Magnitude ML

527
SEISMICITY OBSERVED DURING 2007-2017

DEPTH SECTION
Study of attenuation mechanism for Sikkim Himalaya form analysis of coda of 212 aftershocks of September 11, 2011 Sikkim earthquake (M:6.9).
Continuance data recording

2007-Cont. for earthquake precursory research.
Some observations

Epicenter distance from MPGO: 636 km

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (hrs) (UTC)</th>
<th>Mag</th>
<th>Lat.</th>
<th>Long.</th>
<th>Dep</th>
<th>Epicentre Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.04.15</td>
<td>06:11:26</td>
<td>7.9</td>
<td>28.1</td>
<td>84.7</td>
<td>15</td>
<td>636</td>
</tr>
</tbody>
</table>

Map source: USGS
Precursory Signatures observed in Radon data and hydrological effects
Magnetic field variations as observed by the Overhauser Magnetometer at MPGO

Wednesday, March 21, 2018
India-Japan Workshop on Disaster Risk Reduction on 19-20 March, 2018
M7.9

Period 24/04/2015 to 26/04/2015

Gravity variations as observed by the Superconducting Gravimeter
- Himalayan frontal zone is the active deformation zone that lies between the MBT and the HFT.
- Deformation and thrusts have migrated to the south. HFT zone show quaternary-Holocene deformation.
Active tectonics of Himalayan frontal zone

In the frontal active zone between the MBT and HFT, there active frontal anticlined like Mohand and Janauri anticline and the HFT.
Dun is a synclinal valley. South is Mohand anticline. These active faults, out of sequence Bhauwala fault. HFT demarcate a physiographic tectonic break between the frontal Himalaya and Ganga alluvial plain.
Cross-section across Dehradun structures  (Thakur et al. 2007)

This is a cross-section along Dehradun and Mohand based on seismic profiling:

a) There is HFT dipping NE . In the front is Mohand anticline of Dehradun in both.
b) Shortening and slip rates have been estimated on the HFT using uplifted stretch terraced . The shortening ratio is $14 \pm 2 \text{ mm/yr}$.
The Himalayan Frontal Thrust (HFT) zone marking the termination of Himalaya is identified on the basis of topographic break.

Location of HFT. Dating of strata terrace gravel, used for calculating convergence rate.
South of Himalayan front (HFT) another fault called “Piedmont fault” has been recognised in the piedmont zone.
These are OSL dating of the piedmont zone south of the HFT.
Six trenches have been extended on the Himalayan front along the HFT for paleo-seismological study.
C-14 dating constraints on timing of displacement

The data obtained from six trenches have been analysed to constrain the timing of earthquake event. Based on this paleo-earthquake dating 1500 AD has been found. This earthquake shows evidence of surface ruptured fault extending some 250 km along strike.
This is the summary of rupture zones located along the Himalayan front.
This is the rupture areas of historical earthquakes, and slip rates estimated at the Himalayan front.
Seismotectonic Model of Gharwal Himalaya

TS- Tehri Synform, UA-Uttarkashi Antiform, VT- Vaikrita Thrust

BT- Bhatwari Thrust, ST- Srinagar Thrust, MHT- Main Himalaya Thrust
Summary

Seismotectonic model of the NW Himalaya (Garhwal Himalaya) represent that:

1) Segment between HFT and southern extent of Micro-seismicity zone is locked as per GPS measurement.

2) Microseismicity zone represents elastic strain is accumulating there.

3) We get evidence of surface rupture earthquakes in the HFT zone.

4) Inferences that large to great earthquakes take place in locked segment. The rupture produced by the earthquake propagated to south and recorded on the HFT as recorded in the trenches.

5) Future next large to great earthquakes may take place in this locked zone.
Station Locations

- Triangles: Univ. Memphis
- Diamonds: NGRI
- Squares: India-Japan Joint Team
Result

Relocated Hypocenters & Station Corrections

Correlation of station corrections

\[ y = -0.37966 + 1.739x \]

\[ R = 0.97262 \]

P to S ratio; standard Vp/Vs value
Result

1-D velocity structure

P and S wave velocity

Depth (km)

Velocity (km/s)

Vp

Vs

Vp/Vs

Depth (km)

1.55

1.6

1.65

1.7

1.75

1.8

1.85

1.9

1.95

Aftershocks

Main
Analysis for 3-D velocity modeling
(based on Zhao and Negish, JGR, 1998)

- Grid modeling
- Raytracing: Pseudo-bending
  (modified for low-velocity layers existence)
- Determine Vp and Vs simultaneously
- The result of 1-D inversion is used as an initial model
- Data for Optimum damping and iteration number are determined by “Simplified Cross Validation Method”
  (Inoue et al., PEPI, 1990)
Result

3-D velocity model

Depth = 25.5 km

Vp perturbation (%)  
Vs perturbation (%)  
Vp/Vs perturbation (%)
Vp/Vs perturbation -7.0% to +7.0%
THANK YOU for your kind attention