

Spatiotemporal evolution of deep seismicity beneath the central Himalayas

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Background information

Intermediate depth earthquakes (40-100 km) have been identified beneath the central section of the Himalayan orogen since the 1980s (*e.g., <u>Chen et al.</u>, <u>1981</u>, <u>1983</u>).*

Studies related to these events (e.g., <u>Chen et al., 1983</u>; <u>Jackson, 2002</u>) have improved the current understanding of the rheology of the continental lithosphere. Eclogitization processes have been linked to the existence of these events (e.g., <u>Jackson et al., 2004, Hetényi et al., 2007</u>, <u>Alvizuri and Hetényi, 2019</u>).

Current knowledge of the seismicity characteristics and evolution of these events are limited. Regional seismicity studies have mostly focused on shallow seismicity (*e.g., Pandey et al., 1995, 1999; Monsalve et al., 2006*).

Here, we compile a high-quality earthquake catalog to examine the temporal evolution of seismicity and provide improved insights into the processes and mechanisms that control seismogenesis at depths near the roots of the central Himalayan orogen.





Map of seismic sites

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We start with candidate events from existing catalogs.

We complement with additional earthquakes using automatic earthquake detection (i.e., <u>EQTransformer</u>) and matched-filter detection (i.e., <u>EQcorrscan</u>) methods.

We estimate local magnitudes in a consistent way (formula of <u>Adhikari et</u> <u>al. 2015</u>).

Figure 1. Distribution of seismic networks operating in the Himalayas between late 2001 and mid 2013. Red and blue inverted triangles show the HIMNT and BPE seismic sites, respectively. Blue triangles depict Hi-CLIMB. Black cross indicates the location of M. Everest. Focal mechanism solutions are obtained from previous studies and Global CMT catalog.





Map of intermediate depth seismicity

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We detect ~1,000 potential intermediate depth earthquake. We locate events using <u>NonLinLoc</u> and a 1D velocity model.

Quality control:

1) At least eight phases (at least two of which are S picks); 2) RMS value smaller than 1.0; 3) Distance to closest station smaller than earthquake's hypocentral depth.

After applying quality criteria we retain **414 high-quality locations.**

Figure 2. Epicenters of 414 high-quality intermediate depth earthquake locations. We use NonLinLoc and a 1D velocity model.









Spatial distribution of seismicity





Spatial distribution of seismicity





Spatiotemporal evolution of seismicity



Figure 5. Map showing the locations of the **414 intermediate depth earthquakes** (colored according to their hypocentral depths). Panels on bottom and right show longitude and latitude versus time, respectively.

Seismic activity between South Tibet and easternmost Nepal is continuous throughout the examined time period.





Figure 7. Cumulative number of events versus date (UTC) for the three clusters.





Temporal behavior of seismicity

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Figure 8. Interevent times of events versus date (UTC) for the three clusters.

Frequency magnitude distribution

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3.0

2.5

2.0

1.5

1.0

0.5

0.0

-0.5

3.0

2.5

2.0

1.5

1.0

0.5

0.0

4.5

4.0

-0.5

 (\mathbf{i})

-og10 of cumulative density

4

-og10 of cumulative density





Magnitude vs time distribution

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Figure 10. Magnitude vs time plots of events from the three clusters.

Magnitude vs time distribution

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Magnitude vs time distribution

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Figure 10. Magnitude vs time plots of events from the three clusters.

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Figure 11. Distance of earthquakes along E-E' versus time.

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Figure 11. Distance of earthquakes along F-F' versus time.

Contributions and future work

- We present the longest high-quality catalog of 414 intermediate depth earthquakes that occurred in the central Himalayas between late 2001 and middle 2003.
- We calculate local magnitudes in a consistent way.
- Intermediate depth earthquakes are mainly concentrated on an east-west oriented linear feature in South Tibet adjacent to easternmost Nepal (clusters 1 and 2) at depths between 60 and 80 km (within uncertainties).
- Seismicity there presents the following characteristics:
 - absence of mainshock-aftershock sequences,
 - small largest to next largest magnitude differences,
 - relative constant rates,
 - interevent times mostly >1 day
- These preliminary results suggest that seismicity is more swarm-like in character throughout the examined time period and given the seismic data available.
- We intend to calculate relative earthquake locations (double-difference techniques and waveform cross-correlation to refine the accuracy of the hypocenters).
- We also intend to further examine the migration patterns.
- And finally perform modeling of fluid flow and possible metamorphic reactions (i.e., eclogitization) given these time evolution patterns.

