Characteristics of subevents and rupture processes of the 2015 Mw 7.8 Gorkha Nepal earthquake from multiple-array back Projection

*Weize Qin[1], Huajian Yao[1]

1. USTC

On 25 April 2015 an Mw 7.8 earthquake occurred in Nepal and caused about 9000 casualties. This earthquake ruptured part of the Main Himalaya Thrust fault, which is due to the convergence of the subducting Indian plate to the overriding Eurasian plate, and showed thrust mechanism with a very small fault dip angle (about 7–10 deg). We apply teleseismic multiple-array back projection analysis to study the rupture process of this earthquake and find 6 clear high frequency radiation sources (subevents). Our results illustrate a simple unilateral eastward rupture of about 160 km with relative stable rupture speed of ˜2.8 km/s and duration of 56 s. The entire rupture processes can be divided into 3 stages. The high frequency radiation appears to be mainly located at the edge of the large slip area, but the subevents have different characteristics in the western and eastern rupture areas. For this 2015 Nepal earthquake, the scales of asperities appear to be mainly controlled by depth, which dominates the overall patterns of slip and high frequency radiation. We finally propose a multiple-scale asperity model with stress and structural heterogeneities along the rupture direction to explain the distribution of high frequency subevents, co-seismic slip, and aftershocks. However, there exist some differences in the back projection results from different arrays. We attribute it to the 3-D structural heterogeneity in the source area. To solve this problem, referring to the former work of travel time calibration with aftershocks, we propose a new traveltime calibration strategy using aftershocks with a spatial smoothing function in the inversion. This new method can produce results accounting for more reasonable velocity structures in the source area. We will further investigate the Gorkha earthquake rupture process with this new method to improve the multiple array back projection results.

Keywords: Nepal earthquake, Back projection, High frequency seismic radiation, Subevents, Rupture process

Source rupture imaging using regional strong motion records

*Tristan Deleplanque[1], Jean-Pierre Vilotte[1], Pascal Bernard[1], Claudio Satriano[1]

1. Institut de Physique du Globe de Paris

The dynamic rupture of large earthquakes generates complex radiation with a large frequency range. The radiation complexity is induced by the fault geometry and the properties of the fault interface. For large earthquakes (Mw > 7.5), teleseismic methods are used to study the rupture process at different frequency scales. For low frequency (LF) signals (50s -- 5s), inversion methods using kinematic models are well-established to determine the space-time distribution of the fault slip. On the contrary, for high frequency (HF) signals (1Hz -- 5Hz), even though models are more difficult to simulate, we can identify emission zones by the back projection method.

Large band spectral models of seismic sources are mainly kinematic. The slip distribution along the fault interface is modelled as a spatial and temporal stochastic process. At the fault scale, there is an effective rupture front propagation; and at small scale, we adjust the process to produce a spectrum which is consistent with the known seismic radiation. One of these models is the k-square model which superimposes a large number of asperities to produce one over k square final slip spectrum. The size of the asperities follows a power law distribution, they break with the rupture front passage and have a rising time proportional to their dimension.

Here, we want to improve the detail level of the HF images by using a regional network instead of a teleseismic one. The goal is to make our understanding of the rupture process better and to well-identify the link between HF radiation and the variability of strong ground motion. However, at regional scale, the heterogeneity of the crust implies a difference between the signals emitted along the fault from the point of view of one station; and the network aperture leads to a deformation of the phase shape of the Green function between stations. That is why there is not phase coherence anymore between two records. Therefore, by using characteristic functions (envelopes, kurtosis or Green functions), we want to extract the consistent information that lasts in the signal.

To do that, a known kinematic rupture, which is able to produce a correct HF radiation, is generated using a stochastic process. The different features of the rupture control the different frequency components of the source. We try to recover those features by back projection and have to deal with station distribution dependency or ghost signals.

References:
C. Satriano, V. Dionicio, H. Miyake, N. Uchida, J.-P. Vilotte and P. Bernard (2015)
Structural and thermal control of seismic activity and megathrust rupture dynamics in subduction zones: Lessons from the Mw 9.0, 2011 Tohoku earthquake
Earth and Planetary Science Letters,
doi: 10.1016/j.epsl.2014.06.037

J. A. Ruiz, D. Baumont, P. Bernard and C. Berge-Thierry (2011)
Modelling directivity of strong ground motion with a fractal, k^{-2}, kinematic source model
Geophysical Journal International,

doi: 10.1111/j.1365-246X.2011.05000.x

Keywords: large earthquake, earthquake rupture, regional network, imaging

Microseismicity adjacent to the locked, late-interseismic Alpine Fault, New Zealand.

*Calum John Chamberlain[1], Carolin M Boese[1], John Townend[1]

1. Victoria University of Wellington

New Zealand's Alpine Fault is the major on-land expression of the Australian-Pacific plate boundary, forming a dextral-reverse transpressional fault. The Alpine Fault is expected to fail in a great (M~ 8.0) earthquake in the coming decades, with a conditional probability of a large ground-rupturing earthquake in the next 50 years of 27%. The Deep Fault Drilling Project (DFDP) aims to study conditions on the Alpine Fault at depth prior to such a rupture. Motivated by the DFDP-2 drilling we conducted a focused study of microseismicity around the drill site, and subsequent real-time monitoring of seismicity during drilling. DFDP-2 was drilled in 2014-2015 in the Whataroa Valley, an area known to have low rates of seismicity, with few earthquakes above M_L 3.0.

To detect microseismicity in this seismically quiet region we used data from a dense local network of shallow borehole seismometers alongside data from the New Zealand national seismic network (GeoNet). We generated an initial catalog using standard energy-based detection techniques and manual phase-picks. From this initial catalog, 63 well recorded earthquakes within 20km of the DFDP-2 drill-site, and 14 explosions from a nearby quarry were selected for use as templates. These were used in a subsequent matched-filter detection routine through 2.25 years of continuous data. The resulting catalog contains 283 earthquakes of M_L<1.8 within 5km of the Alpine Fault surface trace. For all earthquakes, correlation pick-corrections were calculated to provide precise relative arrival times for use in double-difference hypocentre calculations. For highly similar earthquakes, precise magnitudes were calculated using the singular-value decomposition method. The resulting catalog of microseismicity is dominated by clustered, non-repeating seismicity in the vicinity of the main plane of the Alpine Fault, however the seismicity does not define a single fault structure. Based on evidence from this study and nearby geodetic studies, we infer that the Alpine Fault at the location studied is currently locked and accumulating stress throughout the seismogenic zone. Following this work we conducted real-time monitoring of seismicity around the DFDP-2 drill-site during drilling to study whether any changes in seismicity occurred during drilling. Little seismicity during drilling was detected around the borehole (4 earthquakes detected within 10km of the borehole), with no response observed due to drilling.

Keywords: Seismology, Deep-Fault Drilling Project, Alpine Fault

Seismicity Rate as an Indicator of Stress Change: Case of the Northern Ibaraki Prefecture Area

*内出 崇彦[1]
*Takahiko Uchide[1]

1. 産業技術総合研究所 地質調査総合センター 活断層・火山研究部門
1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)

Seismicity rate is sensitive to the change in the stress applied on the fault.
I studied the northern Ibaraki prefecture area, where two large earthquakes in March, 2011 and a large normal faulting earthquake (Mj 6.3) on December 28, 2016 struck probably due to the coseismic and postseismic deformation of the 2011 Tohoku-oki earthquake [*Uchide et al.*, this meeting]. The GNSS data from GEONET of Geospatial Information Authority of Japan (GSI) infers a rapid extension in the east-west direction right after the Tohoku-oki earthquake and a slow east-west compression for a couple of years, which seems to contradict the generation of the large normal faulting event. The GNSS data is the measurement on the ground surface, and the strain rate at depth may be different. Therefore we examine the stress change using the seismicity rate based on the ETAS model [*Ogata*, 1988].

Using etas_solve program [*Kasahara et al.*, 2016], the Japan Meteorological Agency (JMA) Unified Earthquake Catalog, I estimate the ETAS parameters for the 100-500 days from March 11, 2011 on which the Tohoku-oki earthquake occurred. I converted the JMA magnitude into the moment magnitude as proposed by *Uchide and Imanishi* [submitted]. A preliminary result suggested that the seismicity rate is more attenuating than the prediction by the ETAS model with the estimated parameters. This may indicate the attenuation in the shear stress on the fault.

キーワード：ETASモデル、茨城県北部地域
Keywords: ETAS Model, Northern Ibaraki Prefecture Area