Preliminary results from teleseismic tomography of the upper mantle beneath northern Borneo

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We present preliminary P-wave tomographic results of the upper mantle beneath northern Borneo (Sabah) using teleseismic earthquake data. Sabah underwent diachronous double-polarity subduction, one dipping to the southeast (terminated in the early Miocene) and the other to the northwest (terminated 5-6 Ma). With the goal of better understanding post-subduction processes in Sabah, 24 permanent seismic stations of MetMalaysia were augmented by the deployment of 46 temporary stations of the nBOSS network (Figure 1), which ran from March 2018 to January 2020.

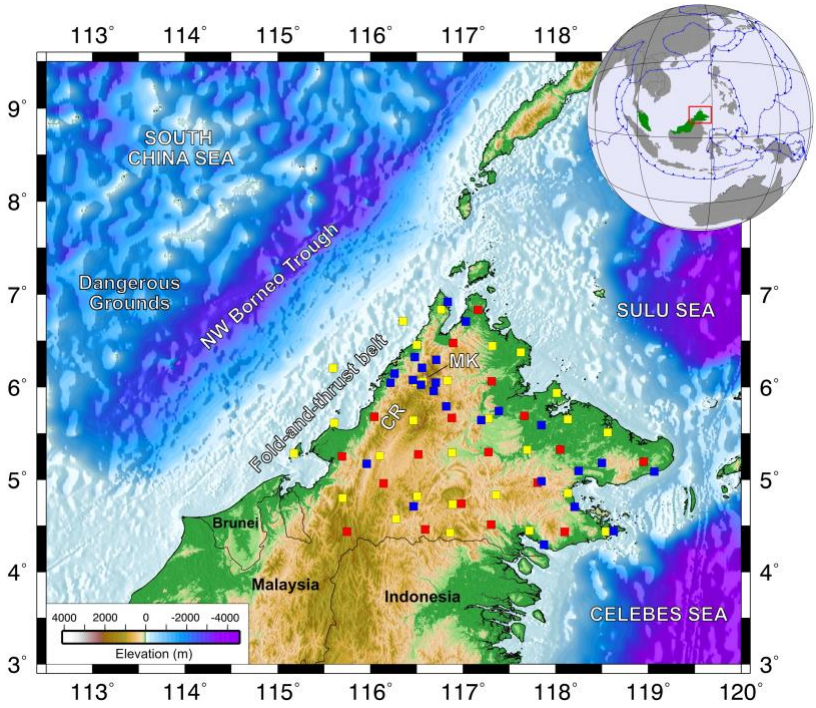

Figure 1: Seismic stations in northern Borneo. Yellow and red squares indicate CMG-6TD and CMG-3ESPD sensors, respectively, deployed by the nBOSS research team. Blue squares are permanent stations from MetMalaysia. The upper right inset shows the location of Malaysia (green), while the blue lines depict tectonic plates boundaries. Red rectangle highlights the location of Sabah.

P-wave traveltimes (including P, PP, Pdiff, ScP, PcP and PKiKP phases) from 570 teleseismic events (Figure 2) have been initially aligned using the ak135 model (Figure 3) and stacked to produce an initial reference trace. Relative P-wave traveltime residuals have been subsequently extracted using an adaptive stacking technique, which uses the coherency of global phases across the entire network (Figure 3). This implies iterative improvement of the

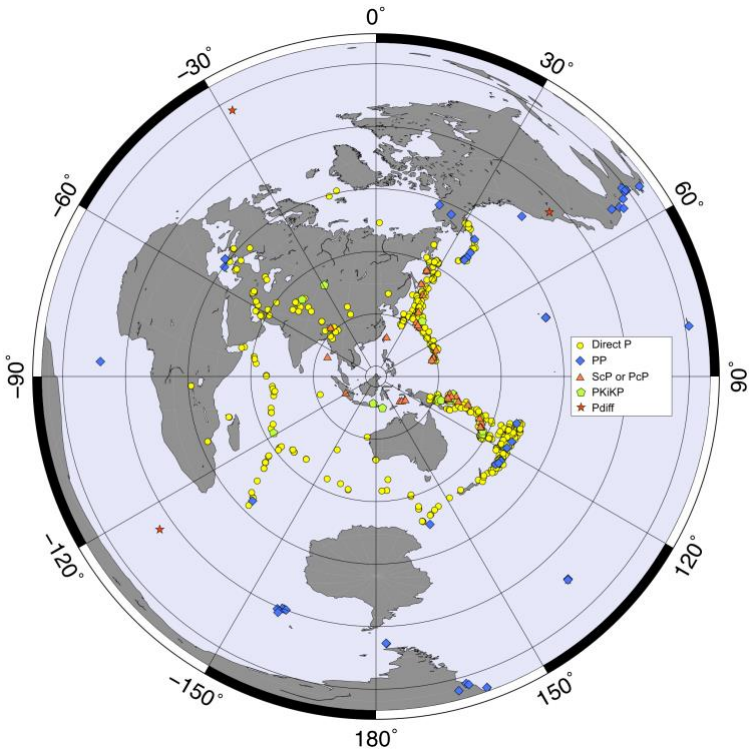

Figure 2: Epicentral distribution of 570 teleseismic sources used in the tomographic inversion. Circle lines represent equidistant curves from the centre of the seismic network contoured at 30˚ intervals.

alignment by comparing the reference trace with each station trace, which eventually leads to an estimate of the residuals and associated picking error. An example of residual map derived from an earthquake in northern New Zealand is shown in Figure 4. After careful selection of high quality traveltimes, these are used to invert for 3-D velocity structure. Using a grid-based eikonal solver and a subspace inversion technique implemented in FMTOMO, relative arrival time residuals are mapped as 3-D P-wave perturbations.

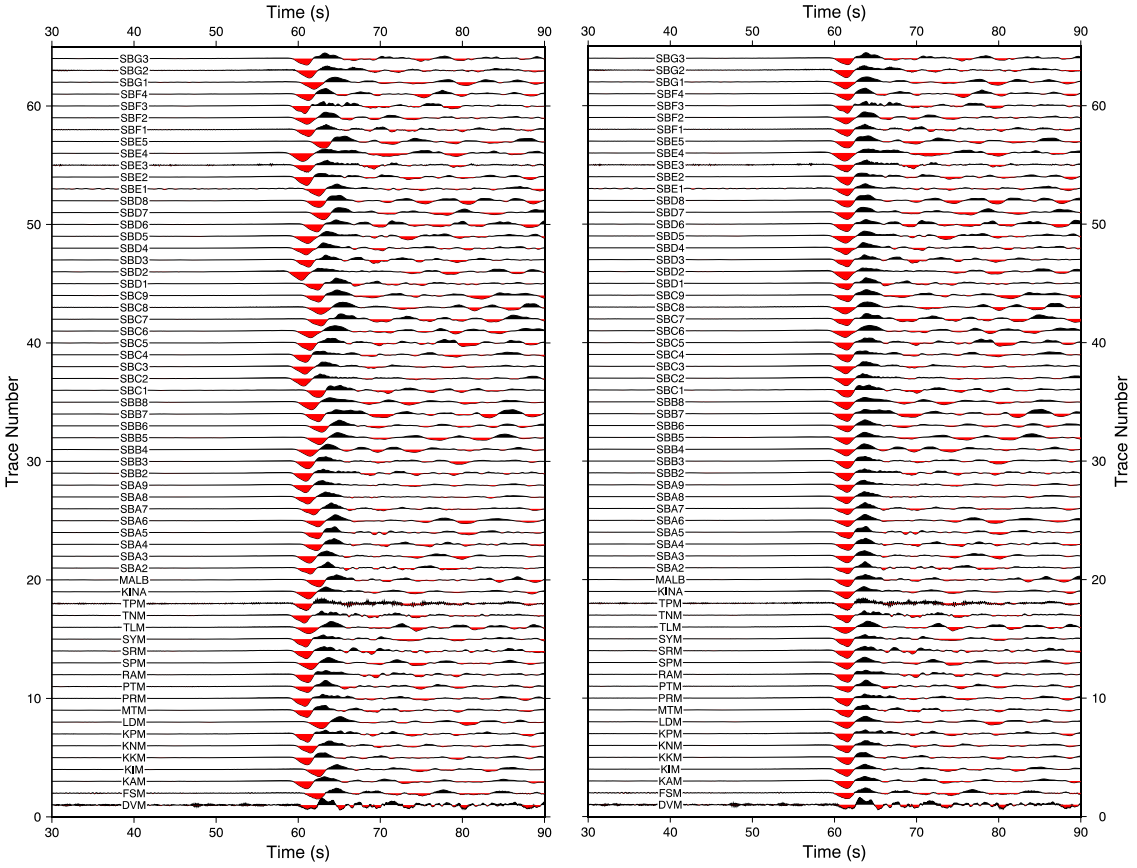

Figure 3: Seismic records of an earthquake located in northern New Zealand (see Figure 4 for location and mapped residuals). Left – Seismic traces aligned using the reference model ak135. Right – Trace move out corrected for using an adaptive stacking technique.

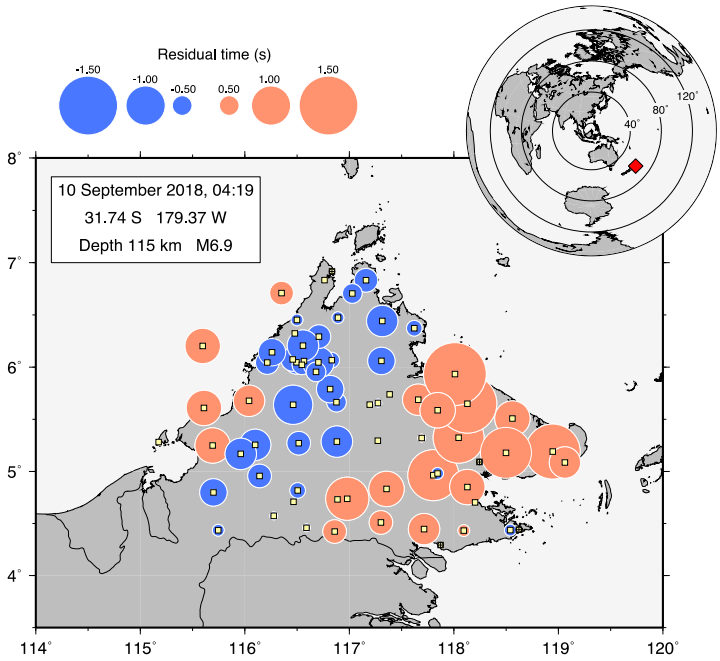

Figure 4: Relative arrival time residual patterns (in seconds) from a source located in northern New Zealand (see upper right inset for location). Alignment of the seismic traces for each station are shown in Figure 3. Stations that did not record usable data are denoted with a cross.

will be in the future incorporated in the tomographic inversion in order to obtain an integrated view of the crust-mantle system beneath Sabah.

The most intriguing feature of the final tomographic model is a north-east trending lithospheric structure running across northern Borneo and separating relatively low to high wavespeeds to the west and east, respectively (Figure 5). This structure possibly indicates the suture between pre-Cenozoic lithosphere to the east and the Cenozoic accreted material to the west.

Results from receiver function analysis (i.e., crustal thickness) and crustal velocities from ambient noise tomography

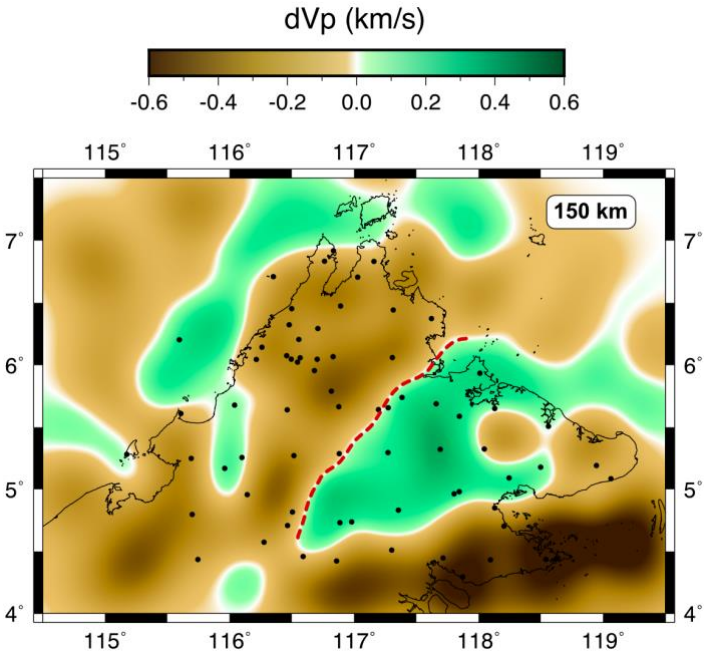

Figure 5: Horizontal slice at 150 km taken from the final tomographic model. Velocities are shown as perturbations from the ak135 model. The red dashed line indicates the possible location of the suture between pre-Cenozoic lithosphere to the east and the Cenozoic accreted material to the west.