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Relative Motion and Crustal Deformation estimated from Geodetic Data of Southern Sagaing Fault in Myanmar

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Background

Plate motion between India, Eurasia, Sunda and Burma plates is responsible for the formation of major geological processes in Myanmar. One of the major active geological structure is the Sagaing Fault, >1200km long, a north-south trending right-lateral strike slip fault. Most of the major cities in Myanmar as Yangon, Mandalay, Nay Pyi Taw, Bago, Sagaing, Taungoo, Meiktila, etc. lie near-by and along the Sagaing Fault.

There are significant historical earthquakes along the Sagaing Fault. The recent one is the M_w 6.8, Thabeikkyin earthquake, 11 Nov 2012, which claimed more than 20 casualties and more than 200 injuries during in this earthquake (Tun & Watkinson, 2017).

Some seismologists (Hurukawa and Maung, 2011) previously suggested that there are two seismic gaps along the Sagaing Fault. There would be large future earthquakes (M>7.5) anticipated from those seismic gaps. Therefore, we need to understand crustal deformation along the Sagaing Fault segments for evaluation of earthquake potential.

The data of continuous GNSS (Global Navigation Satellite System) networks which constructed by collaboration between Earth Observatory of Singapore (EOS), Myanmar Earthquake Committee (MEC), Department of Meteorology and Hydrology, Myanmar (DMH) and Myanmar Survey Department (MSD) and campaign GNSS data are used to estimate crustal deformation in this analysis.

Data Analysis and Method

We analyzed the data for both 18 continuous and 44 campaign GNSS stations in this study. We used the time span for continuous data is between 2016 and 2019 except for coseismic and postseismic periods of the 2012 Thabeikkyin earthquake and campaign data was included from previous surveyed data with 1998, 2000, 2005, 2016, 2017, 2018, 2019 to estimate crustal deformation around the southern Sagaing Fault. We also collected data for nearby 8 International GNSS Service (IGS) stations and estimated velocities of these stations in our processing.

We applied the latest realization of the International Terrestrial Reference Frame (ITRF 2014) by using GIPSY-OASIS ver 6.4 software to calculate coordinate position. Ocean tide loading was calculated using FES2014b model by the Onsala Space Observatory (http://holt.oso.chalmers.se/loading/) with respect to the joint mass center of solid Earth and ocean combined in our analysis data (Carrère et al., 2016). We used only horizontal components (EW and NS) of coordinates in this analysis. We divided the southern Sagaing Fault into five main segments, i.e., Sagaing (hereafter as SGs), Meiktila (MTLs), Nay Pyi Taw (NPTs), Phyu (PYUs) and Bago (BGOs) segments, respectively. Our geodetic analysis clarifies crustal deformation along the Southern Sagaing Fault in three segments, that is, SGs, MTLs and BGOs based on available data.

We fitted a 2D dislocation model (Savage & Burford, 1973) to estimate fault slip rates, locking depths along the fault segment by using fault parallel velocities within 150 km from each side of the fault with respect to CUSV station, which is in the stable Sunda plate. We also predicted shear strain distribution and dip angle for each segment along the Sagaing Fault based on the estimated model. And we clarified the maximum earthquake potential for each segment of the Sagaing Fault.

Discussion and Result

We confirmed that the present-day relative motion and the direction of movement at the GNSS stations are consistent with the dextral strike slip of this fault system. The stations on the eastern side of the Sagaing Fault show smaller velocities with respect to the station on the Sunda plate than those on the western side of the Sagaing Fault. There would be assumed that the eastern side is a part of the stable Sunda plate and the western side (Burma plate) have experienced their own micro-plate motion and/or combining with the motion affected by the western subduction zone (Arakan Trench).

The estimated slip rate of the fault is in the range of ~16 – 24 mm/yr and the optimal locking depth is ~10 – 16 km at the central to southern Sagaing Fault in this analysis. The fitting shows that the locking depth, and slip rate are deeper and higher in MTLs where the seismic gap is located.

The currently predicted shear strain rate is the highest in SGs where a prominently earthquake occurred. The predicted shear strain rates are ~0.35 μ strain/yr in SGs, ~ 0.25 μ strain/yr in the MTLs and BGOs respectively.

We calculated a dip angle of each segment from the estimated offset between the dislocation source and the surface trace of the fault. The predicted dip angle is ~71° E in SGs, ~78° W in MTLs and ~48° W in BGOs, respectively. The calculated dip angle direction has changed the eastern to western side in the central Sagaing Fault between SGs and MTLs located in the seismic gap area. Our estimated potential magnitude of earthquakes for each segment are M_w ~7.4 in MTLs, M_w ~7.3 in SGs and BGOs, respectively, as of 2021.

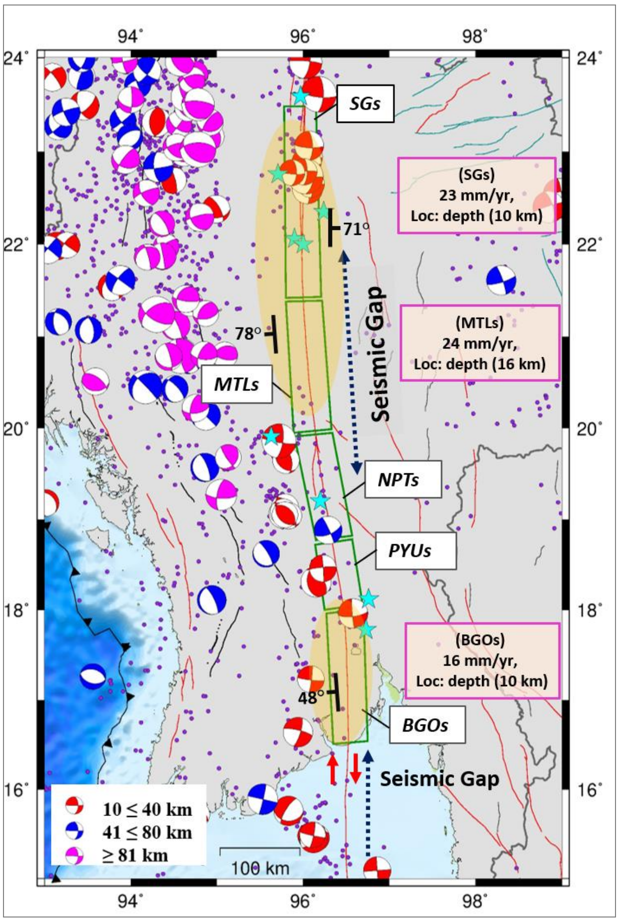

Fig. Calculated dip direction along each segment of the Sagaing Fault from the geodetic data analysis. Shaded yellow circular regions indicate predicted dip angle changing between SGs and MTLs in a central part of the Sagaing Fault, located in the seismic gap area. Purple text boxes show a slip rate and locking depth for each segment in this study. Significant historical earthquakes along the Sagaing Fault are plotted from Y. Wang et al. (2014) (light blue stars). Purple dots denote epicenter of M ≥ 3 and depth ≤ 200 km earthquakes during 1908 - 2020 from the USGS earthquake catalog. Focal mechanisms are from GCMT reviewed ISC Bulletin M ≥ 5 (1969 – 2018). Dark blue dash arrows denote 2 seismic gaps from Hurukawa and Maung (2011). SGs, Sagaing segment; MTLs, Meiktila segment; NPTs, Nay Pyi Taw segment; PYUs, Phyu segment; BGOs, Bago segment.

Keywords: GNSS, Sagaing Fault, 2D dislocation model, slip rate, locking depth, dip angle.