Paleoseismology of the Philippine fault zone in central Luzon, Philippines

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The Philippine fault zone is an arc-parallel left-lateral strike-slip fault zone related to oblique subduction of the Philippine Sea plate beneath the Philippine island arc. The fault zone extends for about 1300 km from the Luzon Island southward to the Mindanao Island. This fault zone has been seismically active with more than 10 earthquakes greater than M7 in the last century. The July 16, 1990, Luzon earthquake was the largest event and produced 120-km-long surface rupture along the Digdig fault. The coseismic displacement was predominantly left-lateral strike-slip with maximum slip of about 6 m. The Philippine fault zone in the Luzon Island consists of four left-stepping en echelon faults: the San Manuel, San Jose, Digdig, and Gabaldon faults from north to south. Historical documents and geomorphic data suggest that the San Manuel and Gabaldon faults ruptured most recently during historic earthquakes in 1796 and 1645, respectively (Nakata et al., 1990). However, paleoseismic activities and slip rates for these faults were poorly constrained. In order to reconstruct chronology of surface-rupturing earthquakes, we excavated multiple trenches across these faults. To date, we have obtained paleoseismic data for the Digdig and San Jose faults that constrain recurrence intervals and rupture patterns associated with historic and prehistoric earthquakes.

We have excavated two sites, San Gregorio and Puncan sites, across the Digdig fault. At the both sites, we identified near vertical fault zones that contain evidence for four surface-rupturing earthquakes during the past 2000 years, including the 1990 rupture. The timing of the penultimate earthquake is constrained to prior to 1400 AD, suggesting that the Digdig fault did not rupture during the 1645 earthquake; the Gabaldon fault to the east appears to have ruptured independently during the earthquake as Nakata et al. (1990) suggested. The average recurrence interval of the Digdig fault is about 600 years. This interval is slightly longer than the recurrence interval of 270˜440 years based on 3.5 m of offset during the 1990 earthquake and 8˜13 mm/yr geological slip rate obtained at San Juan in the middle part of the fault. For the San Jose fault, we excavated two trenches north of downtown San Jose. The sediments exposed on the trench walls were warped into a monocline by moderately west-dipping fault strands. We identified evidence for three faulting events during the past 2500 years. The timing of the most recent event is constrained sometime during the 15th and 19th century. It thus appears that the San Jose, Digdig, and Gabaldon faults ruptured independently of one another in the last seismic cycle, although the left-stepping jogs separating these faults are less than 1.5 km wide, considerably smaller than the jogs that impeded rupture propagation during historic earthquakes worldwide. We plan to excavate the Gabaldon fault in February and March, 2006. If the recurrence interval of the individual segments of the Philippine fault zone is longer than 500 years as we revealed for the Digdig and San Jose faults, the occurrence of about ten earthquakes greater than M7 during the past century may be interpreted as a temporal clustering of activity along the fault zone.