

Recurrent large subduction zone earthquakes in the Nankai-Suruga trough: evidence from submarine liquefactions

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Subduction zones are generally characterized by large earthquakes that contribute about 90% of the total seismic moment worldwide, and can cause great damage from tsunamis such as the 2004 Sumatra Mw 9.0 earthquake. The Nankai-Suruga trough is well known as a Chilean-type subduction zone characterized by its low dip, enormous accretionary prism, and presence of great earthquakes. Historical and archeological evidence documents more than twenty large earthquakes occurred in the past thirteen centuries, including nine instrumentally-recorded earthquakes of M (larger than) 6.9 along the Nankai-Suruga subduction zone (e.g., Ando, 1979; Sugiyama, 1994). The eastern Nankai-Suruga trough suffered an M 7.9 earthquake in 1923 which produced high-intensity shaking felt throughout the central Japan island of Honshu including Tokyo. A major gap in the great interplate earthquakes is identified in the eastern segment of the Nankai-Suruga trough where an M 8 class earthquake is expected to occur along the eastern segment of the Nankai-Suruga subduction zone in the near future (Ishibashi, 1981). However, the absence of co-seismic ruptures and compelling geological evidence associated with past large earthquakes in this gap area has hindered further assessment of past long-term behavior of subduction zone earthquakes and related seismic hazard for the densely populated Nankai-Suruga coastal region. Seeking for the direct seismic record, we conducted a paleoseismic study by a field search for earthquake-induced liquefaction feature generated in the eastern Nankai-Suruga trough.

Here, we report recurrent large subduction zone earthquakes revealed by extensive submarine liquefactions formed in the Nankai-Suruga trough where the Philippine Sea plate is subducting beneath the Eurasian plate (Lin, 2006). The liquefaction-related sediments are composed of a series of silt-sand-mud-gravel sequences, which are considered to have been deposited along a delta front trough in the forearc basin of the Nankai-Suruga subduction zone during the Pleistocene at a shallow depth of a few tens of meters under sea level owing to the presence of submarine fossils such as coral and clam. Field evidence and grain-size analysis of liquefied deposits show that the multiple-liquefactions were repeatedly induced by strong earthquake shaking during the Pleistocene in the eastern Nankai-Suruga subduction zone. The recognition and analysis of submarine liquefactions provide reliable paleoseismic evidence in the Nankai-Suruga subduction zone where co-seismic surface ruptures produced by large historic earthquakes are not found.