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Identification of Possible Tsunami Earthquakes along the Mexican Subduction Zone

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Tsunami earthquakes are defined as large earthquakes in subduction margins accompanied by large tsunamis in which the observed tsunami heights are larger than that expected from the seismic magnitude calculated from observed strong ground motion (e.g. Geersen, 2019). Some tsunami earthquakes have been observed in the last few decades with recent seismic networks. These earthquakes share many seismological characteristics, such as deficiency in high-frequency energy radiated from the fault; they have a significantly long source duration and a large amount of slip near the trench.

Despite their seismological similarities in these tsunami earthquakes, there is, however, no commonly accepted model with the structural or morphological conditions around these faults, which are conducive to large tsunamis with no strong ground motion. As one of the ideas, Sallares and Ranero (2019) proposed that a depth-dependent upper-plate elastic property can change rupture property as depth. The depth of faults possibly controls slow and fast rupture speed and depletion of high-frequency energy for earthquakes at the shallow domain without changing fault mechanics themselves.

Okal and Borrero (2011) conducted a detailed seismological study of the large earthquake in Colima, Mexico. The mainshock occurred on June 3rd, 1932, followed by aftershocks on June 18th and 22nd of the same year. The aftershock on June 22nd generated a more devastating tsunami than that of the mainshock despite having much smaller seismic magnitudes. Okal and Borrero (2011) suggests that this aftershock had the characteristics of a tsunami earthquake. Newman and Okal (1998) demonstrated that the scaled energy (E_S/M_0) calculated observed waveform is one of the powerful discriminants for tsunami earthquakes. Tsunami earthquakes typically show the scaled energy from $7x10^{-7}$ to $3x10^{-6}$ (Venkataraman and Kanamori, 2004). For instance, the scaled energies were calculated as $1.5x10^{-6}$, $0.6x10^{-6}$ and $2.6x10^{-6}$ for the recent tsunami earthquakes of Nicaragua (2 September 1992, M_W 7.6), Java (2 June 1994, M_W 7.8), and Peru (21 February 1996, M_W 7.5), respectively (Venkataraman, 2002).

On April 18th, 2002, an earthquake with M_W 6.7 occurred about 55 km from the coast of Guerrero, Mexico. The hypocenter of the earthquake was located near the trench of the northwest Guerrero seismic gap. Despite being relatively small in magnitude, the earthquake has all the characteristics of a tsunami earthquake [Flores, 2018]. In this work, we comprehensively calculate the scaled energy of moderate or large earthquakes in the Mexican subduction zone. We also analyze the differences in the scaled energy of some events and their implications. By examining and comparing their scaled energy, we aim to gain insights into the seismological characteristics of tsunami earthquakes in this region and propose a new model of tsunami earthquakes.

At the moment, we have found three relevant ones. The first occurred on February 24th, 2020. This shares a similar scaled energy to tsunami earthquakes. The second event was on July 19th, 1997. It is the shallowest, and its scaled energy is near the value proposed for tsunami earthquakes. Finally, the event that occurred on July 19th, 1997, shares many characteristics with tsunami earthquakes.