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FAST TRACK PAPER

Non-volcanic tremor beneath the Central Range in Taiwan triggered by the 2001 M_w 7.8 Kunlun earthquake

Zhigang Peng and Kevin Chao

School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA 30332*, USA. E-mail: zpeng@gatech.edu*

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SUMMARY

Non-volcanic tremor (NVT) is an extended-duration and non-impulsive seismic signal observed away from volcanic regions. Although NVT has been found along the circum-Pacific subduction zones and the transform plate boundary in California, it is not clear whether NVT occurs in other tectonic environments. NVT is often associated with slow-slip events, and can be triggered instantaneously during the surface waves of teleseismic events. However, the underlying mechanisms of tremor generation remain mysterious. Here we show clear evidence of NVT beneath the Central Range (CR) in Taiwan triggered by the 2001 M_w 7.8 Kunlun earthquake in northern Tibet. Tremor occurs when the Love wave displacement is to the southwest (the lateral motion direction for the CR), suggesting a simple frictional response to the driving force. We hypothesize that tremor occurred on the weak basal detachment fault beneath the CR. Our observations indicate that tremor may exist at a wide range of active tectonic environments.

Key words: Earthquake interaction, forecasting, and prediction; Dynamics and mechanics of faulting; Rheology and friction of fault zones.

1 INTRODUCTION

Non-volcanic tremor (NVT) represents seismic signal observed away from volcanic regions with long durations, no clear body wave arrivals, and spectra depleted in high-frequency energy compared with regular earthquakes of similar amplitude. NVT was originally identified in the subduction zone southwest of Japan (Obara 2002), and subsequently found at many places along the circum-Pacific subduction zones (Rogers & Dragert 2003; Kao *et al.* 2005; Schwartz & Rokosky 2007), and along the San Andreas fault (SAF) system in California (Nadeau & Dolenc 2005). Recent studies also show that NVT can be triggered instantaneously during the surface waves of teleseismic events (Miyazawa & Mori 2005, 2006; Rubinstein *et al.* 2007; Gomberg *et al.* 2008; Miyazawa & Brodsky 2008; Peng *et al.* 2008).

So far NVT has been observed only in subduction zone and transform-fault environments. Some studies have proposed that NVT is generated by fluid migration due to dehydration from the subducted slabs (Obara 2002; Kao *et al.* 2005). Other recent studies suggested that much of tremor activity is superposition of many simple shear failure events on the plate interface (Shelly *et al.* 2007). Additional observations of tremor in diverse tectonic environments would help to better quantify the underlying mechanisms and necessary conditions for tremor generation.

Inspired by the recent observations of NVT in Vancouver Island (Rubinstein *et al.* 2007) and California (Gomberg *et al.* 2008; Peng *et al.* 2008) triggered by the surface waves of the 2002 M_w 7.8 Denali earthquake, we examined seismic records in Taiwan (Fig. 1) generated by the 2001 M_w 7.8 Kunlun earthquake in northern Tibet. This earthquake was associated with a predominately unilateral rupture on the western segment of the Kunlun fault with a total length of more than 400 km (Lin *et al.* 2002). All these conditions help to generate large-amplitude surface waves in the rupture propagation direction.

We focus on the Island of Taiwan (Fig. 1) because of the following reasons. First, it is seismically active and has high-density seismic and geodetic networks, which provide ideal conditions for NVT and slow-slip events to be generated and observed. However, it is worth noting that ambient tremor and slow-slip events have not been observed before around Taiwan. In addition, the tectonic configuration around Taiwan is rather unique. The collision of the Chinese continental margin and the Luzon Arc results in the creation of the Central Range (CR) in Taiwan. Part of the deformation is consumed by left-lateral and thrust faulting along the Longitudinal Valley fault (LVF), which is a 160-km-long NNE-striking suture marking the boundary between the two plates in eastern Taiwan. The rest is accommodated by the fold-thrust belt that forms the Western Foothills (WF) of the CR (Fig. 1b). Observing NVT in an arc-continental type collision environment such as Taiwan would not only help to better understand necessary conditions relevant to tremor occurrence, but also improve our understanding of fault mechanics at the bottom of the seismogenic layer and of earthquake physics.