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Thailand's crustal properties from tele-seismic receiver function studies

Sutthipong Noisagool [a], Songkhun Boonchaisuk [c], Patinya Pornsopin [d], Weerachai Siripunvaraporn [a,b,*]

[a] Department of Physics, Faculty of Science, Mahidol University, 272 Rama 6 Road, Rachatawee, Bangkok, Thailand
[b] ThEP Center, Commission on Higher Education, 328, Si Ayutthaya Road, Rachatawee, Bangkok, Thailand
[c] Geoscience Program, Mahidol University, Kanchanaburi Campus, Saiyok, Kanchanaburi, Thailand
[d] Seismological Bureau, Thai Meteorological Department, 4353 Sukumvit Road, Bangna, Bangkok, Thailand

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ABSTRACT

Thirty-three seismic stations throughout Thailand were used to infer the crustal thickness, Vp/Vs ratio and Poisson's ratio of Thailand using the receiver function technique. The crustal thickness increases from around 31 km in the Shan-Thai terrane (STT) in the west to around 38 km in the Khorat Plateau (KP-ICT) located in the Indochina terrane (ICT) in the east. Similarly, the mean Vp/Vs and Poisson's ratios derived here show that Vp/Vs increases from 1.69 to 1.73 from the STT to the KP-ICT, while Poisson's ratio increases from 0.23 to 0.25 from the STT to the KP-ICT. Our results are well supported by geological evidence found at the surface. In addition, we incorporate gravity and magnetic data to constrain the crustal properties of Thailand. The low Poisson's ratios show that the crust of Thailand is mostly felsic. Only the lower crust of KP-ICT is different as it is thicker, denser and has higher mafic composition than the other terranes of Thailand. This special feature in the KP-ICT is required to explain the lower Bouguer anomaly in the KP-ICT. In addition, we interpret the crustal evolution and deformation of these terranes and compare our results with the results from the Vietnam network of the ICT.
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1. Introduction

The tectonic evolution of Thailand from Gondwana time to the present is very complicated. At present, Thailand is divided into two major terranes (Fig. 1): (1) the Shan-Thai terrane (STT; or Sibumasu or Sinoburmalaya on the larger scale) covering the western and southern parts of Thailand and also the neighboring eastern Myanmar and (2) the Indochina terrane (ICT) in the northeast covering the entire Khorat Plateau (KP) and the Indochina countries (Laos, Cambodia and western Vietnam) (Achache et al., 1983; Barr and Macdonald, 1978, 1991; Bunopas, 1981; Bunopas and Vella, 1983; Chaodumrong and Burrett, 1997; Charusiri et al., 1993, 2002). Both of them originally were part of Gondwana-land before the rift separated them after the Cambrian. Since then there were others tectonic evolution events such as the subduction which occurred on the west of the ICT and on the east and west of the STT (Burrett and Stait, 1986; Charusiri et al., 2002; Metcalfe, 1996; Metcalfe, 2002; Sangsomphong et al., 2013). The Shan-Thai and Indochina terranes are separated by the Chiang Mai, Nan, Loei Suture zones in the north, and the Srakaew Suture zones in the southeast (Fig. 1; Sangsomphong et al., 2013). All of these suture zones are oriented almost in the North–South direction. The Chiang Mai and Nan Suture zones enclose the Lampang–Chiang Rai (LCB) block, while the Nan and Loei Suture zones enclose the Nakorn–Thai (NTB) block (Fig. 1).

The division of these STT and ICT terranes and the suture zones are evidently supported by the geological, paleomagnetic and paleontological studies at the surface (Barr and Macdonald, 1987; Metcalfe, 2011; Ridd et al., 2011; Ueno and Hisada, 2001). Just recently, strong evidence in the mafic lower crust for past subduction on the Shan-Thai terrane in the western part of Thailand was revealed by a magnetotelluric survey (Boonchaisuk et al., 2013). Since the crustal thickness results from this study (shown in Section 4) show some differences between the Khorat Plateau (KP) and the rest of the ICT, we refer to the area of the Khorat Plateau in Thailand which also belongs to the ICT as the KP-ICT. Because the tectonic evolution of Thailand is still under debate, the “exact” tectonic boundaries (or sutures) between these terrains are still uncertain (Charusiri et al., 2002; Metcalfe, 2002, 2011; Searle et al., 2007). Here we followed the tectonic lines drawn by Sangsomphong et al. (2013) and Charusiri et al. (2002) as shown in Fig. 1.

In addition to geological evidence, some geophysical data also shows differences between the STT and KP-ICT. The magnetic anomalies of Thailand (Fig. 2a) are relatively small (in the vicinity of -200 nT to around 200 nT; DMR, 1989; Ridd et al., 2011). The most intense anomalies occur around the border of the KP-ICT and are associated with the area of the Nan suture zone (Fig. 2a). The high and low anomalies continue to the entire KP-ICT in northeastern Thailand (Fig. 1). Magnetic anomalies mostly around −15 nT are observed in the STT (DMR, 1989; Milsom, 2011; Ridd et al., 2011; Sangsomphong et al., 2013;

* Corresponding author at: Department of Physics, Faculty of Science, Mahidol University, 272 Rama 6 Road, Rachatawee, Bangkok, Thailand. Tel.: +66 2 2015764; fax: +66 2 3547159.
E-mail address: wsiripun@gmail.com (W. Siripunvaraporn).

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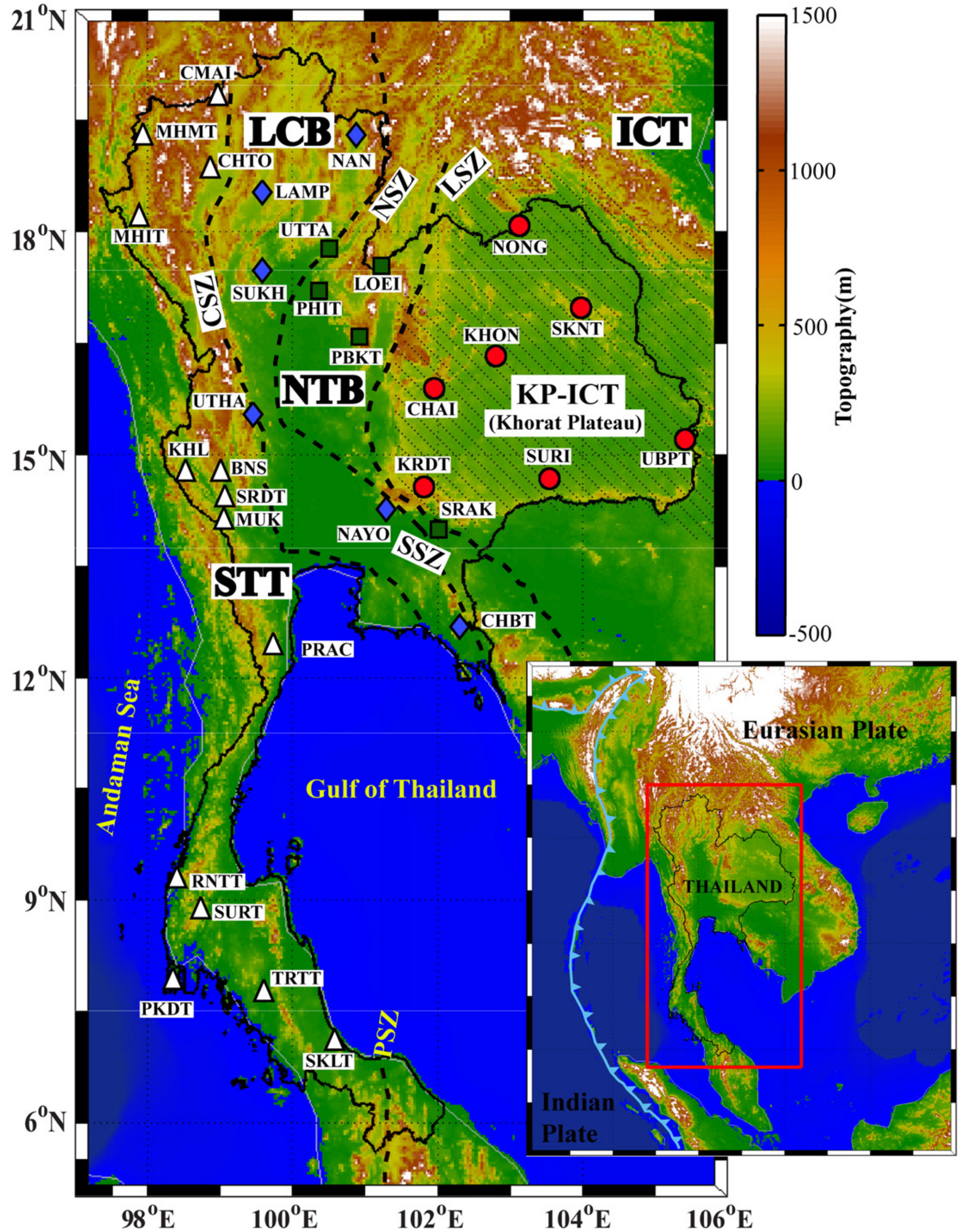

Fig. 1. Topography map of Thailand tectonics showing Shan-Thai terrane (STT) in the west to south, and Indochina terrane (ICT) in the east (after Charusiri et al., 2002; Sangsomphong et al., 2013). In between both terranes are Lampang–Chiang Rai (LCB) and Nakorn–Thai (NTB) blocks. Separating them are the Chiang Mai Suture (CSZ), Nan Suture (NSZ) and Loei Suture (LSZ) zones from west to east in the north, while Srakeaw Suture (SSZ) is in the southeastern Thailand. Inside the ICT, there is the Khorat Plateau covering the whole northeastern part of Thailand indicated here as KP-ICT. Seismic stations used in this analysis are plotted on top of the map where white triangles are used to label stations that are located in the STT, blue diamonds for stations in the LCB, green squares for stations in the NTB, and red circles for stations in the KP-ICT. The same symbols are used in Figs. 6–8.

Tulyatid and Fairhead, 1999). The cause of the high and low magnetic anomalies around KP-ICT is still unknown (Ridd et al., 2011).

In contrast to the magnetic anomalies, a clear contrast between both terranes is not apparent in the map of the Bouguer anomalies of Thailand displayed in Fig. 2b (Bonvalot et al., 2012). The overall values of the Bouguer anomalies are relatively low in the global scale and range between −150 mGal in the north to less than 50 mGal in the south (Fig. 2b). The low Bouguer anomalies in the north and west of the country are associated with the high elevation topography there. The low values in the south are also associated with low topography (Figs. 1 and 2b). The contrast between the Bouguer anomalies and the non-isostatic topography again occurs in the KP-ICT region (Fig. 2b). The elevation of the Khorat Plateau is just 100–250 m which should produce the Bouguer anomalies of around −10 to −20 mGal (Milsom, 2011) but their actual mean values are lower at around −50 mGal. Milsom (2011) suggested that the overcompensation of the Khorat Plateau may be due to the fact that it is rising at present.

Another geophysical study was from the tele-seismic receiver functions and surface wave dispersion studies (Bassin et al., 2000; Tadapansawut et al., 2012; Wongwai, 2011). All show different Moho

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