Tectonophysics 472 (2009) 124–134

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Crustal structure of southwest Japan, revealed by the integrated seismic experiment Southwest Japan 2002

Tanio Ito [a,*], Yuji Kojima [b], Shuichi Kodaira [c], Hiroshi Sato [d], Yoshiyuki Kaneda [c], Takaya Iwasaki [d], Eiji Kurashimo [d], Noriko Tsumura [a], Akira Fujiwara [e], Takahiro Miyauchi [a], Naoshi Hirata [d], Steven Harder [f], Kate Miller [f], Akihiro Murata [g], Satoshi Yamakita [h], Masazumi Onishi [i], Susumu Abe [i], Takeshi Sato [c], Takeshi Ikawa [i]

[a] Department of Earth Sciences, Graduate School of Science, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba 263-8522, Japan
[b] Daiwa Exploration & Consulting Co., Ltd, 2-2-11 Furuishiba, Koto-ku, Tokyo 135-0045, Japan
[c] Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2-15 Natsushima-machi, Yokosuka 237-0061, Japan
[d] Earthquake Research Institute, University of Tokyo, 1-1 Yayoi, Bunkyo-ku, Tokyo 113-0032, Japan
[e] Geosys Inc., 1-5-18 Otsuka, Bunkyo-ku, Tokyo 112-0012, Japan
[f] Department of Geological Sciences, University of Texas, El Paso, 500 W University Ave, El Paso, Texas 79968-0555, USA
[g] Faculty of Integrated Arts and Sciences, Tokushima University, 1-1 Minami Josanjima, Tokushima 770-8502, Japan
[h] Faculty of Education and Culture, Miyazaki University, 1-1 Gakuenkibanadai-nishi, Miyazaki 889-2192, Japan
[i] JGI, Inc., 1-5-21 Otsuka, Bunkyo-ku, Tokyo 112-0012, Japan

ARTICLE INFO

Article history:
Received 26 March 2007
Accepted 8 May 2008
Available online 23 May 2008

Keywords:
Seismic reflection
Southwest Japan
Crustal structure
Outer zone
Inner zone
MTL

ABSTRACT

A multi-purpose seismic experiment named the 2002 integrated seismic experiment Southwest Japan was conducted in 2002 along a more-than-240-km-long line across southwest Japan from the Pacific coast to the Japan Sea coast. Its profile provides the first crustal-scale cross section across the Japanese island arc, which highlights a number of significant points related to the structural development of the arc. Major outstanding points are that the Japanese island arc is composed of two completely different crusts juxtaposed by the Median Tectonic Line (MTL), and that the MTL started its activity associated with lower crustal thinning and formation of an upper crustal-scale half-graben in Late Cretaceous.

1. Introduction

Southwest Japan is an island arc system with the Nankai trough as a trench and the Japan Sea as a back-arc sea (Hashimoto, 1991). The Philippine Sea (PHS) plate is subducting beneath southwest Japan, which belongs to the Eurasian plate (Fig. 1). The basement of southwest Japan is composed mainly of late Paleozoic to Neogene accretionary complexes, but the deep structure is unknown due to paucity of available seismic reflection data. Yoshikawa et al. (1987) obtained the first seismic reflection profile of the Median Tectonic Line (MTL), the most significant fault in Japan, which divides the Japanese island arc into the Inner (Japan Sea-side) and the Outer (Pacific-side) zones. That study dispelled the traditional idea that the MTL dips at a high angle, and demonstrated clearly a gentle northward dip down to about 2-km depth. Since that pioneering work, a number of influential seismic reflection experiments across the MTL have improved dramatically our knowledge of the crustal structure of the Japanese island arc (e.g., Yoshikawa et al., 1992; Ito et al., 1996; Kawamura et al., 2003.).

Based on these groundbreaking experiments conducted since the late 1980s, a multi-purpose seismic experiment was designed along the more-than-240-km-long line across southwest Japan from the Pacific coast of Shikoku to the Japan Sea coast of Chugoku (Fig. 1). The experiment, named the 2002 integrated seismic experiment Southwest Japan (hereafter Southwest Japan 2002), was conducted in 2002 as a collaborative project involving the Earthquake Research Institute (ERI) of the University of Tokyo, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the Chiba University, and the University of Texas, El Paso (Iwasaki, 2006). One of the major goals of the experiment was to obtain a crustal profile of southwest Japanese island arc with the subducting PHS Plate. The southern end of the profile connects with another profile obtained by the JAMSTEC experiment in 1999 (Kodaira et al., 2002). Important information in the experiment Tottori 2001 (Tottori Prefecture, 2002) can be also

* Corresponding author.
E-mail address: tito@earth.s.chiba-u.ac.jp (T. Ito).

0040-1951/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.tecto.2008.05.013

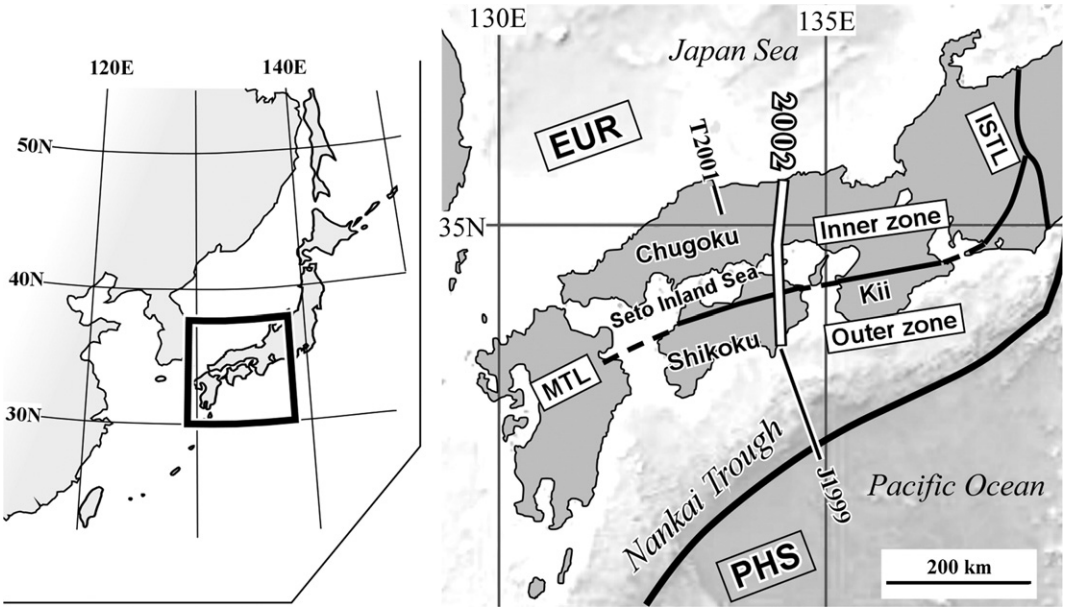

Fig. 1. Seismic line of Southwest Japan 2002 indicated by the outline letter 2002. Seismic line of JAMSTEC experiment in 1999, J1999. Seismic line of Tottori Prefecture in 2001, T2001. MTL, Median Tectonic Line. ISTL, Itoigawa–Shizuoka Tectonic Line. EUR, Eurasian plate. PHS, Philippine Sea plate.

projected onto the profile. Thus a whole crustal-scale cross section can be constructed from the Nankai trough to the Japan Sea coast crossing southwest Japan.

In this paper we present the results and interpretations of Southwest Japan 2002, and discuss their significance.

2. Geologic setting

The seismic line of Southwest Japan 2002 runs from the Muroto Peninsula across the Seto Inland Sea to the Japan Sea coast, transecting the Inner and the Outer zones which are juxtaposed at the MTL. The surface geology is shown in Fig. 2.

2.1. Outer zone

The Outer zone is characterized by an along-arc zonal arrangement of geological belts, namely the Sambagawa, the Chichibu, the Northern Shimanto, and the Southern Shimanto belts from north to south, which have different ages and lithologies. The Sambagawa belt is composed mainly of the high *P*/*T* Sambagawa metamorphic rocks (pelitic, and psammitic schists, and greenschist) derived probably from a Jurassic to Cretaceous accretionary complex. The Chichibu belt is composed of the Chichibu supergroup whose main constituent is a Jurassic accretionary complex. Between the Sambagawa and the Chichibu belts, occur the Mikabu green rocks of gabbro-peridotite complex with middle Jurassic to early Cretaceous chert (Faure et al., 1991; Sakakibara et al., 1993). The Northern Shimanto and the Southern Shimanto belts consist of the Cretaceous to early Paleogene Northern Shimanto and the middle Paleogene to the early Miocene Southern Shimanto groups, respectively. Both groups are made up of accretionary complexes with coherent and mélange units. The coherent unit consists mainly of alternating beds of sandstone and mudstone, and subordinately of chert and green rock beds. In contrast, the mélange unit consists mostly of muddy matrix dominant mélange with the fragments of abundant chert and green rocks. Both units are structurally repeated in an alternating sequence by north-dipping thrusts and form an accretionary structure. An Albian to Cenomanian coherent, a Santonian to Campanian mélange, a Campanian to Maastrichtian coherent, and a Maastrichtian to Paleocene mélange units are arranged structurally downward in the northern Shimanto group. In the southern Shimanto group, an Eocene to Oligocene coherent and an Oligocene to early Miocene mélange units are arranged structurally downward (Muramatsu, 1986; Yamakita's unpublished data).

Most of these belts are bounded by major north-dipping boundary faults: the Butsuzo Tectonic Line (BTL) along which the shallower Chichibu supergroup and the deeper Sambagawa metamorphic rocks are thrust over the Northern Shimanto group; and the Aki Fault (AF) along which the Northern Shimanto group is thrust over the Southern Shimanto group. The Southern Shimanto group is thought to structurally overlie a middle Miocene to the present accretionary complex along a fault whose surface trace runs off Shikoku. The surface geology suggests that the Sambagawa metamorphic rocks are gently folded and form a broad anticlinorium, and that Chichibu supergroup overlies both the Sambagawa metamorphic rocks and the Northern Shimanto group forming a broad syncline.

2.2. MTL

The sense of lateral motion along the MTL has changed repeatedly in response to plate tectonic setting since its birth in about 100Ma (Takagi and Shibata, 2000). The net displacement probably reached several hundreds of kilometers in a left-lateral sense (Yamakita and Otoh, 2000). Recent seismic profiling studies have revealed that the MTL dips northward at about 40° down to about 10km depth (Ito et al., 1996; Kawamura et al., 2003). As the deeper structure of the MTL has not been revealed yet, still the MTL as a whole is generally believed to be vertical or subvertical as proposed by Fitch (1972).

2.3. Inner zone

The Inner zone is composed of the Ryoke belt in the Seto Inland Sea area, and the nappe group in Chugoku (Hayasaka, 1987; Isozaki and Maruyama, 1991; Ishiwatari, 1991).

The Ryoke belt is composed of the Ryoke metamorphic rocks and Cretaceous granitic rocks. The Ryoke metamorphic rocks are originally derived mainly from alternating beds of sandstone and mudstone with chert, which constitute a Jurassic accretionary complex. They