1. Introduction

The study of sedimentary provenance interfaces some of the mainstream geological disciplines. A range of increasingly sophisticated techniques is now available concerned with sediment provenance. Provenance data can play a critical role in assessing paleogeographic reconstructions, in constraining lateral displacements in orogens, in characterizing crust which is no longer exposed, in testing tectonic models for uplift at fault block or orogen scale and in mapping depositional systems (Haughton et al., 1991). In addition to the framework composition study of sandstones (e.g. Dickinson et al., 1983), the analysis of chemical compositions of detrital heavy minerals is carried out to infer the provenance. Amphibole, pyroxene, epidote, staurolite, monazite, zircon, garnet, spinel, chloritoid, mica and tourmaline are all amenable to this sort of the analysis. The development of an approach using detrital heavy minerals is discussed by Morton (1991). Recently, the ages of single detrital grain such as muscovite and zircon became to be determined using techniques of Ar-Ar, LA-ICPMS, fission-track and CHIME (e.g. Copeland and Harrison, 1990; Hirata and Nesbitt, 1995).

One of the topics, for which the provenance study is most useful, is to deal with an active plate margin such as collisional zone. In the collisional zone, the provenance study is very useful for two objectives. The first one is to reconstruct the uplift history of the collisional zone. The provenance of clastic rocks changes in a short time in the collisional zone. The second one is to reconstruct the paleogeography before a collision. An intense deformation by the collision results in diminishing information of the pre-collisional paleogeography.

It is known that the Izu arc is colliding to the Honshu arc at present. Sugimura (1972) first mentioned about the collision in this area. He insisted that the Kan-nawa Fault is the plate boundary between the Eurasian Plate and Philippine Sea Plate. Afterwards, several models on the collisional history have presented.

Amano (1986, 1991) considered that the Koma, Minasa, Tanzawa and Izu massifs collided to the Honshu arc in different timing (Fig. 1). However, his model has not been always accepted by investigators (e.g. Matsuda, 1989). Some authors (e.g. Sakai, 1990) asserted that the word not "collision" but "subduction inside the arc crust" should be used for these events. The historical review of the study about the collision of the Honshu and Izu arcs were compiled by Amano et al. (1999) and Aoike (1999). There are few studies about the provenance in and around this collisional zone.

It is also known that the Indian subcontinent is colliding to the Eurasia Plate and the Himalayas have uplifted (e.g. Molnar and Tapponnier, 1975). There are many provenance studies in and around the Himalayas (Fig. 2) such as in the Transhimalaya (e.g. Aitchison et al., 2002), Tethys Himalaya (e.g. Garzanti et al., 1987), foreland basin of the Himalayas (Siwalik Group) (e.g. Burbank, et al., 1996) and Bengal Fan (e.g. Johnson and Nur Alam, 1991; Amano and Taira, 1992). However, there are only some studies about the chemistry of detrital chromian spinels in the northwestern Himalayas (Fig. 2; Chulung La Formation: Garzanti et al., 1987; Muree Formation: Bossart and Ottiger, 1989), and there are no studies about the chemistry of detrital garnet around the Himalayas.

The purpose of this study is to check the availability of the chemistry of detrital heavy minerals in the provenance study. For this purpose, the provenances of two collisional areas were studied and the paleogeography before the collision of the Honshu and Izu arcs and uplift history of the Himalayas were reconstructed. The first collision of the Honshu and Izu arcs is considered to have occurred in the early Middle Miocene (Aoike, 1999). The Mineoka area is sited to the east of the collisional zone, and the Setogawa area is sited to the west (Fig. 3). The sediments in both areas have records of a change of the tectonic setting around the collisional zone. In this paper, the latest Oligocene to early Middle Miocene strata in the Boso Peninsula, and the late Eocene to early Middle Miocene ones in the Akaishi Mountains were investigated.

On the other hand, the collision of the Eurasia Plate and the Indian Subcontinent has occurred since earliest Eocene time (e.g. Garzanti et al., 1996). It is known that the

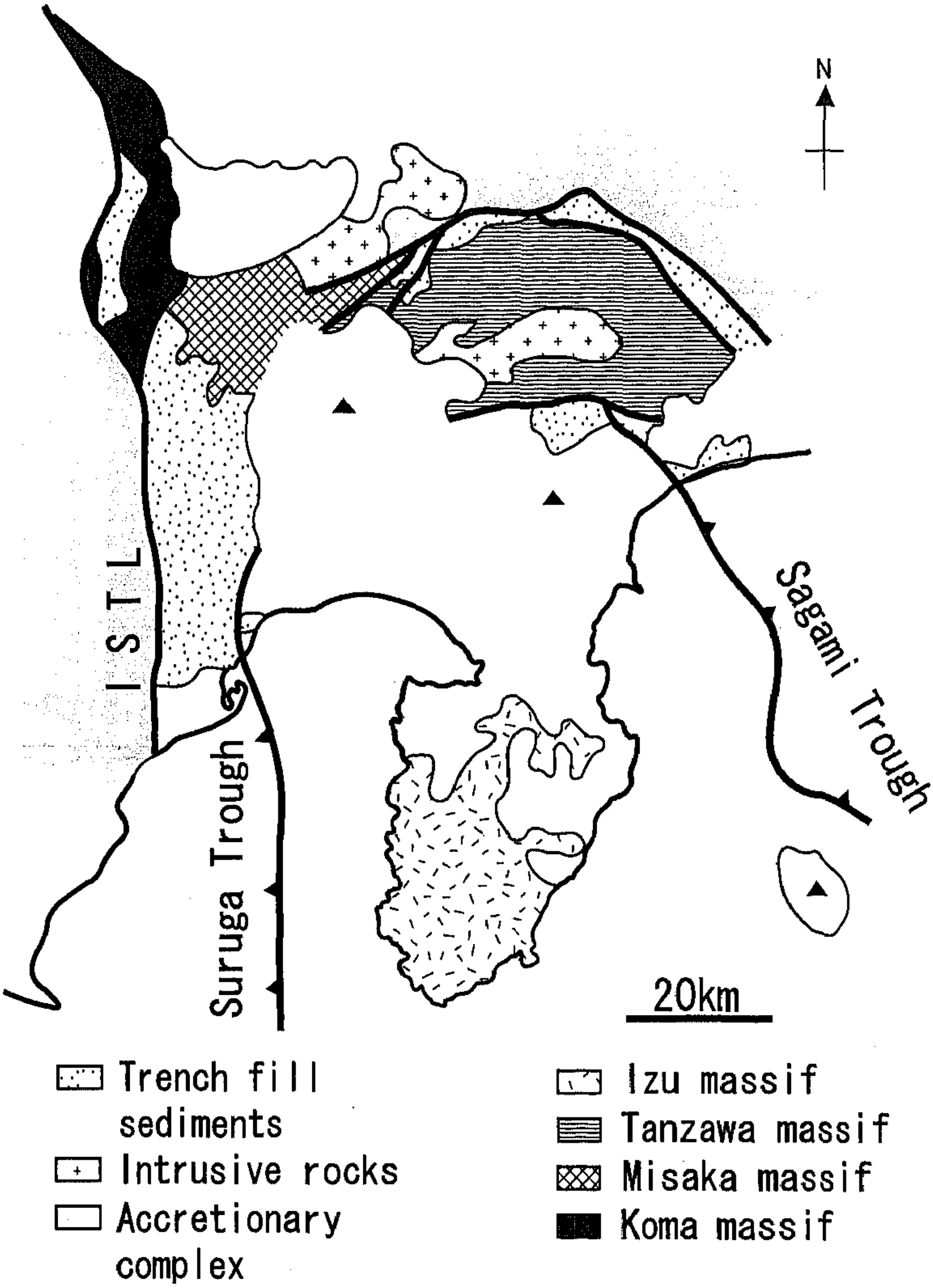

Fig. 1. Geologic map around the Izu collisional zone.
Simplified from Martine and Amano (1998).

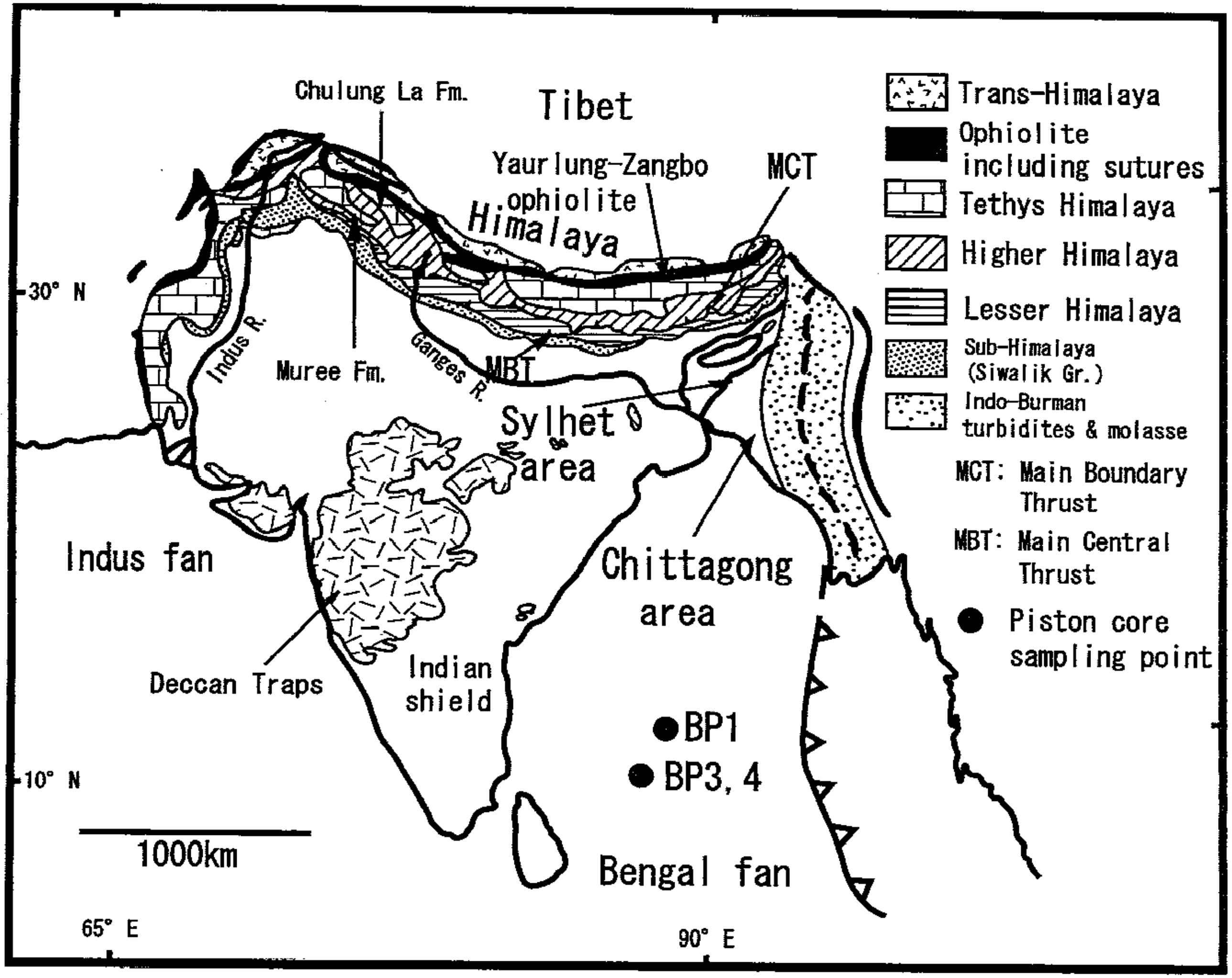

Fig. 2. Geologic map around the Himalayas and sites of piston core sampling points.
Compiled from Uddin & Lundberg (1998), Garzanti et al.(1987) and Krishnamurthy & Cox (1977).

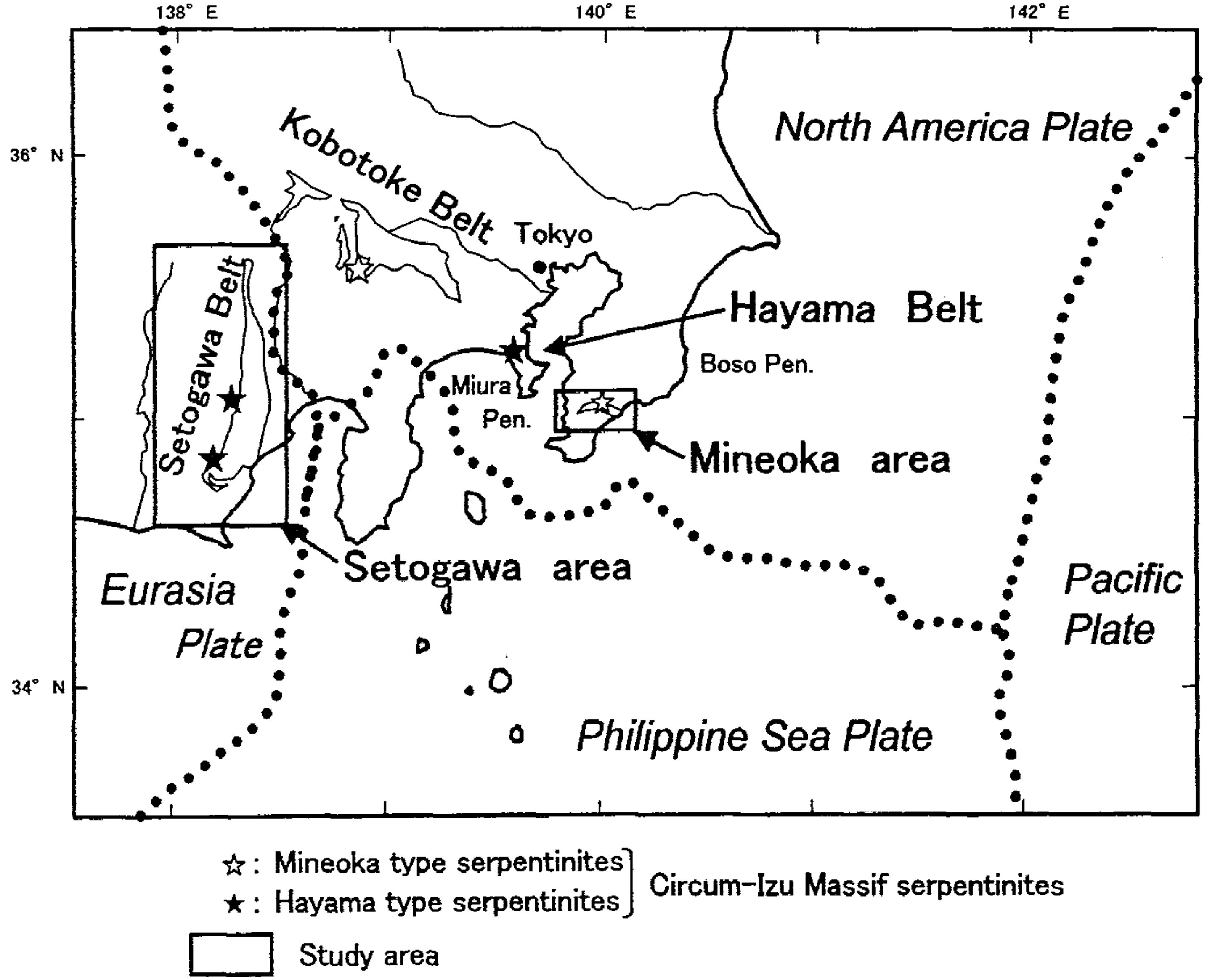

Fig. 3. Location map of the Mineoka and Setogawa areas.
Compiled from Renard et al.(1984) and Arai and Okada(1991).

Eocene to Quaternary strata occur in Bangladesh. In this study, the Middle Eocene to Quaternary strata were investigated in two areas in Bangladesh. Sandstone and sand samples were collected and studied to establish the uplift history of the Himalayas. Morever, piston core samples obtained by the Hakuho-maru of the Oceanic Research Institute, the University of Tokyo from the Bengal Fan (Fig. 2) were also studied.

The analyses of chemical composition of detrital chromian spinel, garnet and clinopyroxene, and measurements of modal composition of sandstone were adapted in this study.