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Origin and serpentinization of ultramafic rocks of Manipur Ophiolite Complex in the Indo-Myanmar subduction zone, Northeast India

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ABSTRACT

The Manipur Ophiolite Complex (MOC) is part of the Manipur-Nagaland ophiolite belt (MNOB). The belt is exposed in the eastern margin of the Indo-Myanmar Ranges (IMRs), which formed by the collision between the India and Myanmar continental plates. Several contrasting views were put forward concerning the origin of the MNOB. The complex represents a dismembered ophiolite sequence with serpentinite as the largest litho-unit formed. Petrography and Raman spectroscopy of the serpentinite suggest that they are serpentinized ultramafic cumulate and peridotite. The serpentinization may have occurred at a condition of low pressure and low temperature metamorphism. Geochemical signatures of the rocks and spinel grains revealed that the protolith be an abyssal peridotite, derived from a less depleted fertile mantle melt at a MORB setting after low degree (10–15%) partial melting. The study concluded that the serpentinite may have been created at a slow-spreading ridge, rather than a supra-subduction-zone setting. These rocks were later obducted and incorporated into the IMR of Indo-Myanmar suture zone.

1. Introduction

The closure of the Tethyan oceanic realm during the Late Cretaceous and Early Tertiary preserved many ophiolite complexes within the Indo-Myanmar-Australia suture zones (Mitchell, 1981), including the MNOB in the Indo-Myanmar suture zone (Acharyya, 2007; Singh, 2008). The ophiolites, including serpentinite of the belt were derived from tectonic activities developed in the Tethyan oceanic lithosphere due to subduction of Indian plate below the Eurasian plate (Nandy, 1981; Oldham, 1883; Brunnschweiler, 1966).

The MOC is confined within the eastern sector of the IMRS (Vidyadharan et al., 1989; Singh, 2008). The complex is a dismembered ophiolite sequence with development of a mélange zone and an olistostromal plate margin (Evans, 1964; Vidyadharan et al., 1989). Well-preserved mantle sequences occur in the ophiolite belt (Acharyya, 1986; Ghose et al., 1986; Vidyadharan et al., 1989). However, the occurrence of serpentinite is observed as the most voluminous litho-tectonic unit in the complex. Pelagic sediments, pillow basalts, volcanic rocks, mafic dyke rocks and podiform chromitites are also exposed in minor in the complex. Rare occurrences of gabbros are observed in the study area.

Several contrasting views were put forward concerning the origin of the MNOB. One school of thought believed that the belt originated from multiple subduction processes of the Indian plate beneath the Eurasian Plate (Mitchell, 1993; Acharyya, 2007). Another school believed that the MNOB is rootless sub-horizontal bodies, which are westward-propagated nappes from the Eastern Belt Ophiolite of Myanmar (Sengupta et al., 1990; Acharyya et al., 1990). Another theory also believed that the belt originated in an Island Arc developed in the Tethyn Ocean (Bhattacharjee, 1991; Nandy, 2001). Furthermore, due to remote and inaccessible nature of the terrain, very less research work has been done in the area. An understanding of the origin of the MOC serpentinite is significant in evaluating the tectonic evolution of the subduction zone. A combination of petrological and geochemical studies of serpentinite can assist in determining the origin and geodynamic settings of serpentinization (Auzende et al., 2002; Hattori and Guillot, 2007; Saumur et al., 2010; Monsef et al., 2010). Raman spectroscopy can be used to study serpentine and the serpentinization processes (Kloprogge et al., 1999; Rinaudo et al., 2003; Auzende et al., 2004; Groppo et al., 2006). This paper details the origin and serpentinization of ultramafic rocks of the MOC through a combined effort of petrology and geochemical analysis. Origin and evolution of the MOC serpentinites, and in consequence, model of subduction of the Indian Plate and Myanmar Plate is discussed.

2. Geology and field setting

The MOC is located in the MNOB, which is confined within the eastern sector of the IMRs (Fig. 1). The belt constitutes a part of the

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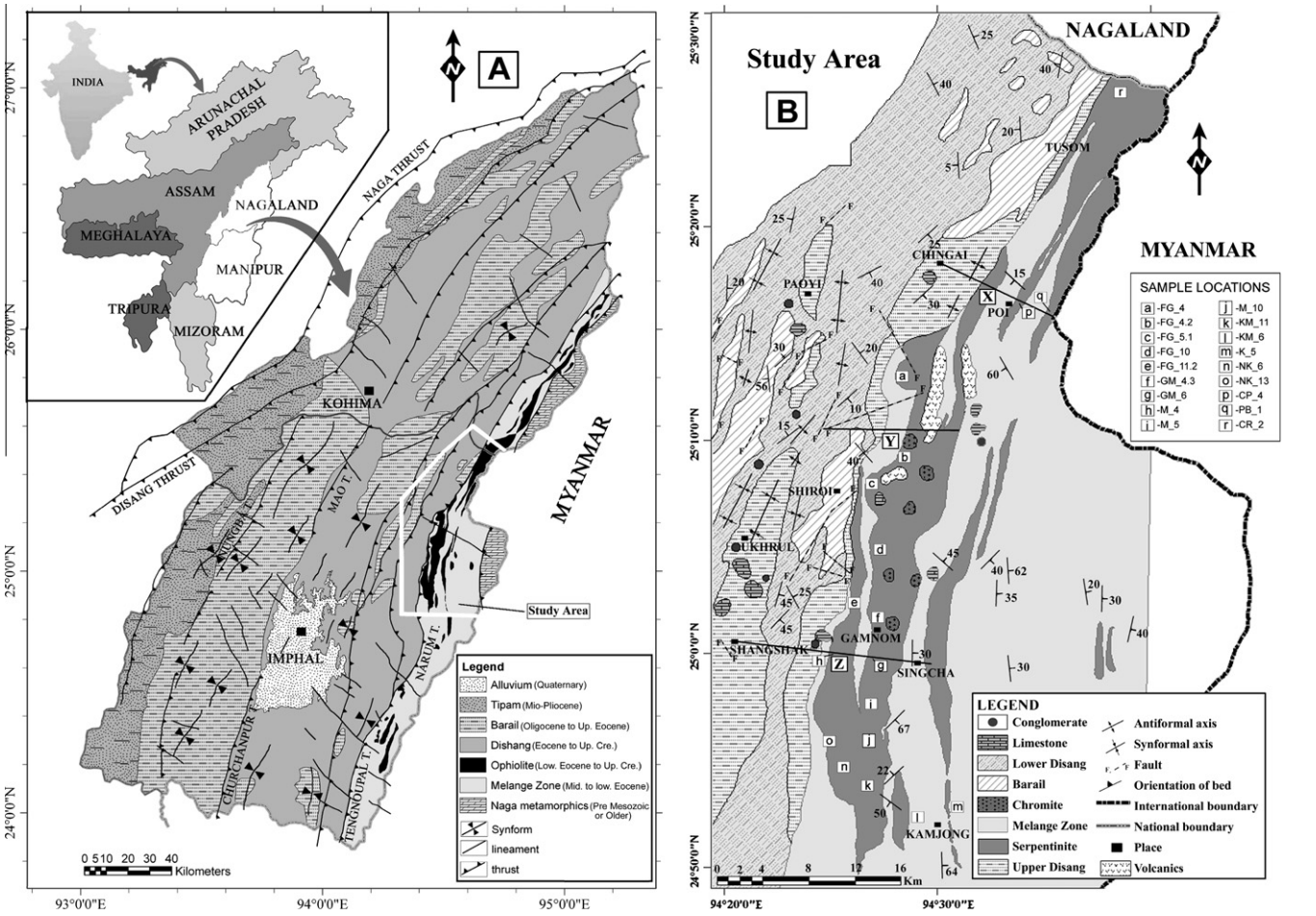

Fig. 1. (A) Geological map of the Manipur and Nagaland areas; White box show the location of the study area (Modified from GSI, M.N.C. DRG. No. 42/87; Soibam, 2006). (B) Geological map of the study area (Modified after Mitra et al., 1986; Vidyadharan et al., 1989).

Arakan-Yoma Fold Belt separating Northeastern India from Myanmar (Nandy, 1981). The belt forms a NNE–SSW trending linear tract with a length of about 200 km and has an average width of about 15 km. The IMR are mainly composed of the Late Cretaceous–Paleogene marine sedimentary rocks, unconformably overlying the Upper Triassic flysch-type sedimentary rocks and associated ophiolite rocks, thought to be the southern extension of the Indus-Yarlung Tsangpo suture zone (Mitchell, 1993).

The belt is bounded on the east by the Cenozoic sedimentary rocks of central lowland of Myanmar (Chattopadhyay et al., 1983) and to the west by a tectonic pile of the Tertiary overthrust known as the 'Schuppen Belt' (Evans, 1964) and Disang Group of Eocene. The belt has overthrusted the younger flysch sediments known as the Disang and the Barail (Fig. 1A). Bhattacharjee (1991) interpreted MNOB as slices of oceanic crust and upper mantle obducted onto the Indian continental margin. The linear tract consists of a complex mixture of igneous and sedimentary rocks representing oceanic and lithospheric assemblages. The belt is composed of highly dismembered composite zone of various rocks occurring as tectonic slices (Fig. 2). Principal rock types include dunite, harzburgite, lherzolite, wehrlite, pyroxenite and mafic volcanic rocks in association with oceanic pelagic sediments (Agarwal and Kacker, 1979; Ghose et al., 1986; Acharyya, 1986).

The MOC is wider in the northern side and gradually decreases in size towards the southern side and ultimately becomes discontinuous thereby giving patches of its existence in the south (Fig. 1A). A summary of the lithologies in the study area is given in Table 1. The Naga metamorphic of the Pre Mesozoic occurs as the oldest Group in the area (Brunnschweiler, 1966). They are found to occur on the eastern and northeastern fringes of the complex (Fig. 1A). The group consists of quartzite, crystalline limestone-marble, phyllite, mica schist, gneiss, sheared granite and minor serpentinite (Brunnschweiler, 1966; Roy and Kacker, 1980; Chattopadhyay et al., 1983). These rocks are occurring as klippen thrusted westward over the younger ophiolite belt of Lower to Upper Cretaceous (Fig. 2). The narrow strip of the main ophiolitic body is found to have a stretch of about 200 km in a NNE–SSW trend from Nagaland to Manipur (Fig. 1A.) as a continuous strip, and beyond it, the strip continues towards the south as discontinuous bodies and extended further into the Myanmar territory extending up to the Andaman-Nicober Isles. The ophiolite suite predominantly consists of well-preserved mantle sequence of peridotite with podiform chromitite along with mafic rocks and pelagic sediments (Singh, 2008). Vidyadharan et al. (1989) reported the occurrence of harzburgite, lherzolite, pyroxenite, gabbro, plagiogranite, volcanic rocks, agglomerates and oceanic pelagic sediments from the complex. However, in our detailed field work serpentinite are found to occur as the largest lithounit, they constitute much more than 90% of the exposure of the igneous ophiolitic rocks. The suite has thrusted contact with oceanic pelagic sediment (OPS) of the Middle to Lower Eocene. Some sporadic exposures of mafic rocks, including the extrusive pillow lavas and dyke rocks were observed in the complex (Fig. 1B). The Ophiolite complex is located within the Disang Group of Eocene to Upper Cretaceous (Fig. 1B). The term Disang was introduced by Mallet (1876) to describe a thick dark gray to black color splintery shale, interbedded