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Discovery of an Entrapped Early Permian (ca. 299 Ma) Peri-Gondwanic Sliver in the Cretaceous Shyok Suture of Northern Ladakh, India: Diverse Implications

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ABSTRACT

In a significant breakthrough, we report the first discovery of twenty-six genera and thirty-five species of Early Permian (Asselian–Sakmarian and Artinskian; 299 Ma to 276 Ma) Gondwanic palynomorphs from a tectonically emplaced metasedimentary sliver of Shyok Ophiolitic Mélange of the India-Asia Collision zone of Northern Ladakh, India. These palynofloral assemblages are of peri-Gondwanian (Cimmerian) origin and have a strong affinity with the Gondwana assemblage of peninsular India. Similar palynofloral assemblages are also known from Extra-Peninsular India, Salt Range, Karakoram, Antarctica, Australia, South Africa, and South America. The occurrence of Gondwanic sliver within the Shyok Suture is interpreted as a thin flake of active continental margin of peri-Gondwanic microcontinent/Kshiroda plate, which was sliced off during the subduction/collision process, between Ladakh block and Karakoram–Qiangtang-Lhasa terrane and amalgamated with obducted remnants of the accretionary prism of the nascent Shyok Suture. The Shyok Suture closed during the mid- to Late Cretaceous period. Subsequent syn- and post-collision syn-kinematic episodes tectonically juxtaposed the peri-Gondwanic sliver in the tectonized zone of Shyok Ophiolitic Mélange. The India-Asia collision, which took place ca. 60–50 Ma with the demise of Neo-Tethys Ocean, along the Indus Tsangpo Suture Zone, modified the geometry of accreted ophiolitic stack of the Shyok Suture.

INTRODUCTION

The supercontinent Pangaea began to break apart during the late Carboniferous–early Permian period (ca. 300 Ma–272 Ma). This break-up is followed by the seafloor spreading, which produced new oceanic crust and several smaller oceans and larger plates. The erstwhile Tethys Ocean, juxtaposed between the Eurasian continent in the north and Gondwana in the south, ruptured, and culminated into the subsequent opening and closing of nascent Neo-Tethys and Paleo-Tethys oceans, respectively. Several smaller continental fragments existed between the two continental masses (Smith et al., 1981; Nie et al., 1990; Scotese and Langford, 1995; Upadhyay et al., 1999b).

Paleogeographic reconstructions of Pangaea during the late Paleozoic (Smith et al., 1981; Nie et al., 1990; Scotese and Langford, 1995) show that a southern belt of these continental fragments stretching from Iran and Afghanistan, through Tibet to western Thailand, Malaysia, and Sumatra has been accreted to Asia since the mid-Paleozoic (Şengör, 1987; Metcalfe, 2006). The Karakoram-Hindukush microplate in the west and the Qiangtang-Lhasa block in central and southeastern Asia are among these blocks, which were welded/sutured to Asia, probably around 130–120 Ma (Şengör, 1987; Dewey et al., 1988, and references therein) (Fig. 1). The origin, migration path, timing of accretion, and assembly of all of these blocks in their present tectonic position are little known. The paleogeography during the break-up of Gondwana is poorly constrained, and scant geological information is available from Pamir, Northern Ladakh, Karakoram, and western Tibet. However, based on temperate fauna, flora, and even glacial and glaciomarine deposits (tillites or diamictites) from the Permian sequences, the Central Iran, Helmand, Western Qiangtang, Lhasa, and Sibumasu blocks are interpreted as having rifted off the northern margin of Gondwana in post-Early Permian times (Smith et al., 1981; Nie et al., 1990; Scotese and McKerrow, 1990; Scotese and Langford, 1995; Upadhyay et al., 1999b; Muttoni et al., 2009). These blocks belong to a poorly defined continent named peri-Gondwana or Cimmeria (Şengör, 1987). Based on the occurrence of Early Permian marine Gondwanan sediments, the Karakoram terrane is now (Fig. 1) identified as a peri-Gondwanan microcontinent at a latitude ~35 S, somewhere between the Indian plate and the Qiangtang-Lhasa blocks (Upadhyay et al., 1999b). Paleogeographic reconstruction of the Early Permian shows that these peri-Gondwanian microcontinents were situated between ~20° and 40° southern latitudes (Nie et al., 1990; Scotese and Langford, 1995; Muttoni et al., 2009).

Thus, the origin and evolution of the Ladakh-Kohistan block and Karakoram terrane of northwest India and Lhasa and Qiangtang blocks of western Tibet have now been widely accepted to have resulted from multiple subduction/collisional events between Gondwana-derived terranes or continents and Eurasia since the late Paleozoic (Gansser, 1977; Allégre et al., 1984; Şengör, 1987; Dewey et al., 1988; Scotese and McKerrow, 1990; Nie et al., 1990; Beck et al., 1995; Burg et al., 1996; Upadhyay et al., 1999b; Metcalfe, 2006; Muttoni et al., 2009; Bouilhol et al., 2013; Upadhyay, 2002, 2014; Borneman et al., 2015).

In northwest India, the Ladakh block lies between the Indian Plate in the south and the Eurasian Plate in the north. To the west, this block is separated from the Kohistan Complex by the Nanga Parbat–Haramosh syntaxis, and to the east, it is separated from the Lhasa and Quiangtang blocks by the Karakoram fault (Upadhyay, 2002, 2014) (Figs. 1 and 2). The Ladakh block is bounded by two suture zones—the Indus Suture in the south and the Shyok Suture in

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