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Conodont succession and reassessment of major events around the Permian-Triassic boundary at the Selong Xishan section, southern Tibet, China

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ABSTRACT

A major discrepancy for the age of the Selong Group from middle Cisuralian (Early Permian) to Changhsingian resulted from previous reports of Sakmarian, Kungurian and Guadalupian (Middle Permian) conodonts and Lopingian (Late Permian) brachiopods. Recently, Cisuralian and Guadalupian conodonts were reported again from the Selong Group and the basal part of the Kangshare Formation at the Selong section, but the age discrepancy remains. We present our conodont materials based on large samples collected from the Selong Group and our interpretation based on identifications using a sample population approach. Three conodont zones are recognized in our re-investigation of the upper part of the Selong Group. They include the *Vjalovognathus* sp., the *Mesogondolella hendersoni*, and the *M. sheni* zones, in ascending order. These zones are overlain by the basal Triassic *Hindeodus parvus* Zone and the *Otoceras woodwardi* Zone. Our reassessment of conodonts reported by previous studies from Selong and nearby sections suggest that all specimens consistently point to a Lopingian age; the upper part of the Selong Group is latest Changhsingian in age based on the presence of *Clarkina orchardi* and *Mesogondolella sheni*. Previously reported early Cisuralian and Guadalupian conodonts are misidentified using a form species concept. A hiatus may be present at the erosional surface between the Selong Group and the *Waagenites* Bed of the basal part of the Kangshare Formation. However, the hiatus is minimal because conodont and brachiopod assemblages above and below this surface are very similar, and it results from a latest Changhsingian transgression just before the extinction that follows a global latest Changhsingian regression. There is a distinct rapid end-Permian mass extinction at Selong within the *Waagenites* Bed, as indicated by the disappearances of all benthic brachiopods, rugose corals and Permian bryozoans. The burst of *Clarkina* species in the *Waagenites* Bed and throughout the entire Lower Triassic at Selong is interpreted as a southward migration of equatorial conodont animals associated with the rapid global warming beginning at the end of the Permian. The cool- or cold-water species of *Mesogondolella*, in the upper part of the Selong Group and the basal part of the Kangshare Formation, are representative of the uppermost Permian in the bipolar/bi-temperate cold-water province and are not reworked from the underlying Selong Group or any other unknown Cisuralian or Guadalupian deposits.

1. Introduction

One of the most important Permian-Triassic boundary (PTB) sections is the Selong Xishan (or Selong) section in Nyalam County of southern Tibet (Fig. 1). It was proposed previously as a GSSP (Global Stratotype Section and Point) candidate for the PTB because it contains both index species for the base of the Triassic, the conodont *Hindeodus parvus* and the ammonoid *Otoceras woodwardi* (Wang et al., 1989; Orchard et al., 1994; Wang and Wang, 1995; Jin et al., 1996; Mei, 1996). The section also provides an excellent case study for the end-Permian mass extinction pattern and its associated environmental changes in the southern high-latitude region (Shen et al., 2006). However, a major controversy existed as to whether the PTB interval at the Selong section is continuous or not. The Selong Group at the Selong section contains extremely abundant brachiopods. Nine species were described by Zhang and Jin (1976) from the Selong Group at Selong and they were considered to be correlative with the Chishian (largely Kungurian) and Maokouan (roughly equals to Guadalupian) faunas of South China. The Kangshare Formation overlies the Selong Group and contains numerous ammonoids, including the lowest Triassic *Otoceras latilobatum* and *O. woodwardi* in the basal part. *Otoceras latilobatum* has been regarded as a synonym of *O. woodwardi* recently and

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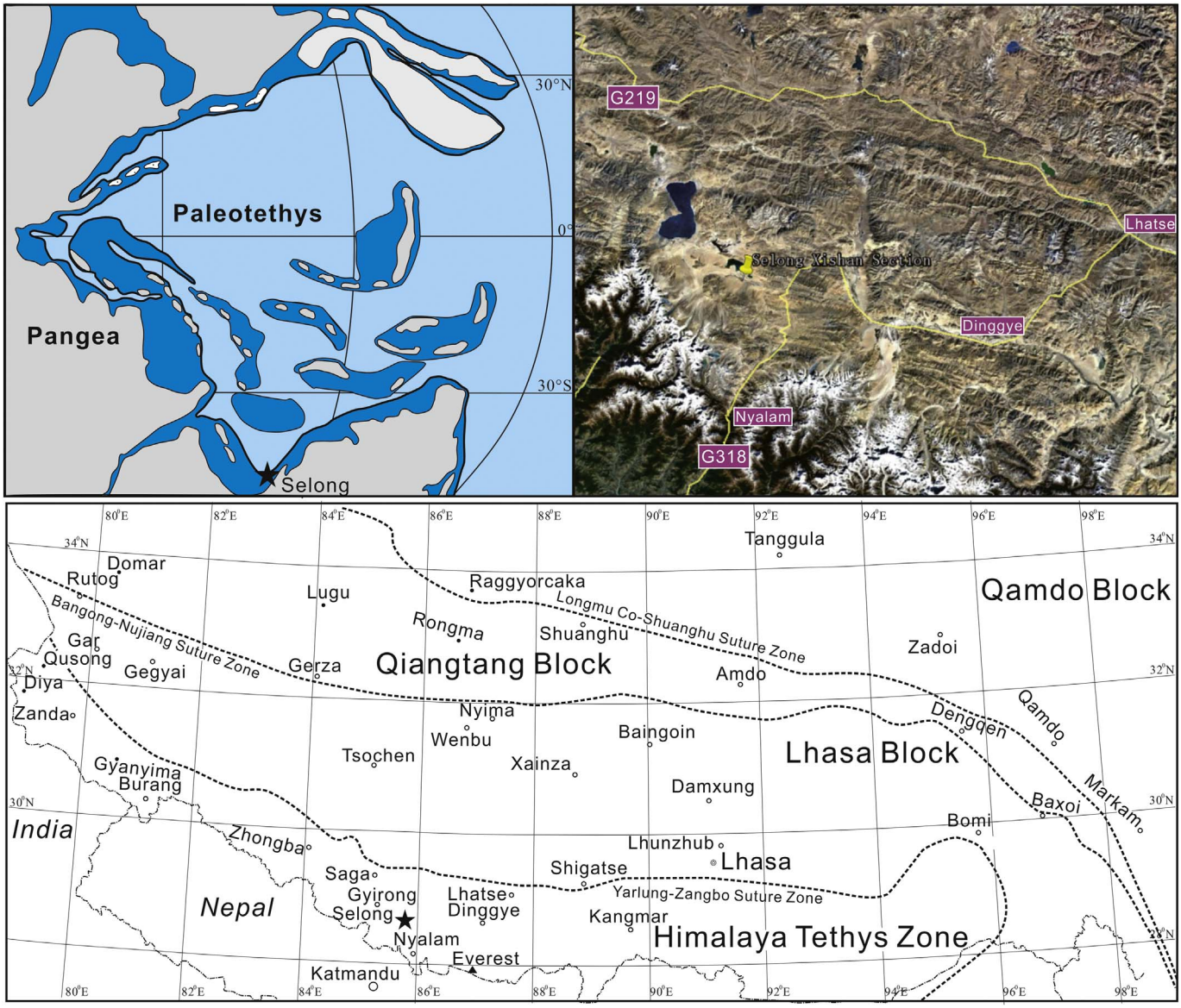

Fig. 1. Maps showing the location of the Selong section in Tibet, China.

stratigraphically it does not overlap with Permian fossils (Zhang et al., 2017). Yao and Li (1987) reported abundant conodonts from the Kangshare Formation including the *Gondolella* (= *Clarkina* in this paper) *subcarinata changxingensis-G. deflecta* Zone from the basal part of the formation; their study documented the existence of Changhsingian strata at the Selong section for the first time. However, the age of the Selong Group below the Kangshare Formation was not discussed because Yao and Li (1987) did not recover conodonts. Wang et al. (1988, 1989) described more detailed ammonoid and conodont zones around the PTB for the purpose of establishing the PTB GSSP at Selong. The Permian succession was subdivided into two parts, including the pre-latest Changhsingian and latest Changhsingian parts and separated by the Caliche Bed (or clay bed). The latest Changhsingian part (= *Waagenites* Bed of Jin et al., 1996) is only 5–17 cm thick and contains extremely abundant conodonts including *Clarkina* cf. *changxingensis* and many Permian-type brachiopods (Shen and Jin, 1999). A distinct irregular erosional surface, which may include a hiatus, occurs in outcrop between the pre-latest Changhsingian and latest Changhsingian units (Fig. 2). Twelve Triassic ammonoid zones including the *Otoceras woodwardi* Zone in the basal part of the Triassic were established (Wang et al., 1989). The PTB was considered continuous and the brachiopod *Chonetella nasuta* assemblage from the Selong Group is comparable with those in the Zewan Formation in Kashmir and the Chhidru Formation in the Salt Range, Pakistan. Therefore, the Selong section was proposed for defining the GSSP of the PTB (Wang et al., 1988, 1989). In contrast, Xia and Zhang (1992) studied the conodonts from the uppermost part of the Selong Group (within the pre-latest Changhsingian part or the Coral Bed of Jin et al., 1996) and reported Cisuralian (Early Permian) conodonts *Neogondolella* (= *Mesogondolella* in this paper) *bisselli* and *N. intermedia*. These two species are considered to be of Sakmarian and Artinskian age. Wang and Wang (1995) restudied the conodonts from Selong and reported *Mesogondolella idahoensis*, *M. phosphoriensis* and *M.* spp. from the topmost part of the Selong Group. They assigned the Selong Group to the Kungurian and Guadalupian. Although very different conodont species (Sakmarian, Artinskian, Kungurian or Guadalupian) were identified by Xia and Zhang (1992) and Wang and Wang (1995), both studies suggested a huge hiatus between the Selong Group and the Kangshare Formation. They suggested that at least most of the Lopingian Series and a large part of Guadalupian are missing. The section cannot be used therefore for defining the GSSP of the PTB (Xia and Zhang, 1992), not for study of the end-Permian mass extinction if these conodonts are correctly identified.