Middle–Late Triassic trench-slope basin in Central Qiangtang, Tibet: Records of subduction-accretion process of the Paleo-Tethys Ocean

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Abstract

The Middle–Late Triassic Mayer Kangri trench-slope basin in Central Qiangtang of Tibet is the first fore-arc sedimentary unit discovered in the Longmu Co–Shuanghu suture and has important implications for the tectonic evolution of the Paleo-Tethys Ocean. The strata of this basin are exposed as isolated E–W-trending ductile-fault bounding blocks that are embedded in the Carboniferous–Permian accretionary complex. Outcrop deformation analyses show an accordant structural style that can be attributed to the oceanic subduction both in these strata and in the surrounding late Paleozoic clastics with a distinct variation in metamorphism. Detailed observations of the lithostratigraphy and sedimentary facies indicate that this basin is characterized by submarine fan sediments that are composed of interbedded layers of either siltstone and fine sandstone or mudstone and siltstone embedding sandstone lenses progressively transforming into abyssal thin chert layers. Bathyal lamellar micrites containing thin chert interlayers are also observed to be embedded within the submarine fan strata. Micrite bearing conodont fossils of the Anisian–Norian Stages were identified at two adjacent locations in south Mayer Kangri. The trench-slope basin developed during the northward subduction of the Paleo-Tethys Ocean, and its conodont assemblage clearly constrains the closure time of the ocean as ~215 Ma in the Norian Stage, thus dividing the Central Qiangtang accretionary orogeny into two coherent stages such as oceanic subdcution and terrane collision.

Introduction

Trench-slope basins (accretionary basins) are located in active continental margins between magmatic arcs and subducting ocean crust and are accompanied by accretionary wedges. They preserve significant clues to the processes of oceanic subduction and arc or continental lateral accretion [Moore and Karig, 1976; Dickson and Seely, 1977]. They develop along trench inner slopes that contain turbidite and submarine fan sediments that range from a few tens of meters on the lower slope to several hundred meters on the upper slope and exhibit a complex interplay of contemporaneous sedimentation and deformation [Dickson & Seely, 1977; Stevens & Moore, 1985]. Although they have less investigated as compared with fore-arc basins in convergent tectonics, they provide important information on the tectonic frameworks and constraint the closure time of paleo-ocean.

The Longmu Co-Shuanghu suture located in Central Qiangtang of Tibet is an important Triassic collision zone that resulted from the closure of the Paleo-Tethys ocean and separates the North Qiangtang terrane of the Cathaysian affinity to the north and the Central Qiangtang accretionary complex belt of the Gondwana affinity to the south [Li, 1987; Li et al., 1995, 2009; Zhai et al., 2011; Pan et al., 2012]. Because large volumes of Late Paleozoic sediments changed gradually from typical glacier and cold-water Gondwana to subsequent warm Tethys Ocean facies [Liang et al., 1983], it has been concluded that the suture is confined to the northernmost boundary of the Gondwana-derived terranes and therefore links with the Changning–Menglian suture in west Yunnan [Liu et al., 2002]. As a result of the Triassic northward subduction of the Paleo-Tethys Ocean [Li et al., 2008; Zhai et al., 2011; Liang et al., 2012], an E–W-trending accretionary wedge developed along the Gangma Co–Gemu–Mayer Kangri–Qomo Ri–Shuanghu areas to the south that bear high-pressure rock blocks containing eclogite and blueschist.

This mélange-like accretionary wedge is chracterized by strong shear deformation, the matrix of which is mainly composed of penetratively foliated Late Paleozoic fine-grained detrital rocks enclosing massive blocks of varied lithologies, ages, tectonic backgrounds and metamorphic facies [Wang et al., 2009; Liang et al., 2012]. A Late Carboniferous–early Permian mafic dyke swarm bearing rift-type geochemical features is exposed in the east-west direction [Zhai et a., 2013]. Mafic-ultramafic magmatic rocks of ophiolitic suite are randomly distributed in the complex, with a wide age range from the Middle Ordovician–early Silurian [Li et al.,2008; Zhai et al., 2013], early Carboniferous [Zhai et al., 2013] and early-middle Permian [Zhai et al., 2006; Wu et al., 2009]. Radiolarian-bearing cherts also extend from the late Devonian to the Late Triassic [Li et al., 1997; Deng et al., 1996; Zhu et al., 2006]. The high-pressure metamorphic rocks embedded within the metamorphic complex in the shape of giant E–W-trending boudins extend discontinuously from Gangma Co in the west (33° 50′ N, 84° 33′ E), via Gemu-Pianshishan-Guoganjianian (~33° 30N, 86° E) and Lanling (33° 10′ N, 86° 45′ E) in central, to Shuanghu in the east (33° 12′ N, 89° E). Unlike other rocks of the complex, the ages of the HP metamorphic rocks, such as eclogite, blueschist and phengite schist, are mostly Triassic and gradually turn newer [Kapp et al., 2003; Li et al., 2008; Pullen et al., 2008; Zhai et al., 2011; Liang et al., 2012].

Although some aspects of the suture have been well studied, such as the ophiolites and HP metamorphism, detailed research on the sedimentary layers, especially the sedimentation in the fore-arc region, is lacking. Such research, however, is helpful to investigate the oceanic subduction process and collision zone tectonic framework. The newly discovered Middle–Late Triassic trench-slope basin in Mayer Kangri of Central Qiangtang, which is typically characterized by submarine fans, hemipelagic limestones and deep sea cherts, provide further insights into the closure time of the Paleo-Tethys Ocean and accretionary tectonics along the North Qiangtang active continental margin.

Method

Geological mapping with an emphasis of lithology & deformation was acquired to determine the constitution and arechitecture of the Central Qiangtang accretionary complex. The Middle-Late Triassic strata with different rock assemblage and deformation feature was then extracted from the Late Carboniferous-Middle Permian mélange. We then use multiple stratigraphic division and sedimentary facies analyses to specify the geological chacateristics of the strata. The thin limestones layers, embedded within the fine grained clastic rocks were chosen to ascertain the timing of the strata. To pick and identify the conodonts, we collected over ten fresh limestone samples and only two samples (PM040-10-WH1 and PM011-1-WT2) were discovered to contain conodonts with the processing procedure mianly including rock crushing, steeping in acetic acid and residue separation.

Results

The Middle–Late Triassic trench-slop basin sediments were broken up into remnants and sandwiched into the matrix of the late Paleozoic accretionary complex, emerged in the shape of E–W-trending giant ductile-fault bounded tectonic blocks and have concordant structural geometries to the surrounding intensively foliated clastic rocks. The stratigraphic sequence was destroyed such as the removal of the bottom and top boundaries, internal parallel ductile shear zones and penetrative contractional crenulation cleavage. The Triassic strata, however, underwent metamorphism below greenschist facies shallower than that observed in the surrounding Paleozoic strata.

The strata is characterized by the sedimentary facies of submarine fans, which is mainly composed of clastic turbidites, dark thin-layered limestones and lesser thin chert layers. Bioclastic limestone lenses that are 10–30 cm wide are locally sandwiched into the clastic layers, which indicate that their origin was related to the collapse of the carbonate platform margin. Those rock layers can be classified into three major categories that separately represent the middle fan subfacies, outer fan subfacies and deep-sea facies.

Limestones bearing Middle–Late Triassic conodonts were found at two locations on the south slope of Mayer Kangri. For the limestone layers in the west block, it exhibit little ductile shear deformation. Conodonts of 4 species were discovered in sample PM040-10-WH1: *Paragondolella* inclinata (Kovacs, 1983), *Paragondolella* sp. (undefined species), *Gladigondolella* sp. (undefined species) and *Neogondolella* sp. (undefined species) (Table 1 and Figure 9). Basically, *Paragondolella* inclinata (Kovacs, 1983) is a common species which indicates a boundary between the Ladinian Stage of the Middle Triassic and the Carnian Stage of the Upper Triassic [Kozur, 1993; Orchard and Tozer, 1997; Orchard, 2007; Hornung, 2006]. *Gladigondolella* is also an indicator of the boundary between the upper Early Triassic and the middle Carnian Stage of the Upper Triassic [Wang et al., 1990]. The age of the limestone can be classified from the top of the Ladinian to the lower Carnian Stage.

For the east block, limestone experienced intense simple shear deformation and incorporated a small basalt mass to become mylonitic zones in the E–W direction. Sample PM011-1-WT2 contains fossil *Neogondolella* navicula, which is spread widely in the Upper Yangtze Platform and the Tibetan region. The age can be confined to the range of the *N. regale* zone of the bottom Anisian Stage to the *Epigondolella* primitia zone of the bottom Norian Stage.

Conclusions

This study reveals a Middle–Late Triassic trench-slop basin in Central Qiangtang characterized by submarine fan clastic-carbonate layers with chert interlayers, which was drawn into the accretionary wedge in the northward subduction process of the Paleo-Tethys Ocean. This sediment emerged as E–W-trending tectonic blocks enclosed by Carboniferous–middle Permian penetratively foliated clastic layers.

The primary sedimentary sequence can be divided into three subfacies: the forepart of the middle-fan, outer-fan and deep-sea. Thin dark limestone layers that represent carbonate turbidites were well interbedded in the clastic layers. Conodont fossils were found in limestones indicate the top of the Ladinian Stage to the lower Carnian Stage and the bottom of Anisian Stage to the bottom of the Norian Stage, which reveals that the Paleo-Tethys Ocean was closed at the Norian Stage.

The Triassic active continental margin of North Qiangtang exhibits a two-stage evolution separated at ~215 Ma. The first stage is reflected by the Andean-type trench-arc system that includes the Raggyorcaka fore-arc basin with a complete Triassic sedimentary sequence of transgression and regression, Mayer Kangri trench-slope basin submarine fan, Qomo Ri accretionary complex, and the Xueshuihe trench-fill radiolarian cherts. After ~215 Ma, the accretionary complex belt uplifted in a compressional background and was unconformably overlain by the residual sea sediments of the Wanghuling Formation.

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