Zircon U-Pb SHRIMP Ages from the Late Paleozoic Turpan-Hami Basin, NW China

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ABSTRACT: Permian volcanic rocks are widely distributed in the Turpan-Hami Basin, which is part of the Central Asian orogenic belt. Here we present SHRIMP zircon data for the rhyolite in Well Baocan 1, one of the deepest wells in the basin. The 283.9±2.7 Ma reported in our study provides the best precise age determination for the Yierxitu Formation, the oldest Permian layer of Hami Depression, one of the three substructural units of the Turpan-Hami Basin, and a potential hydrocarbon reservoir in this basin. Our data refines earlier imprecise 39Ar-40Ar ages and shows that the volcanic rocks both inside the Turpan-Hami Basin and along its margin are almost coeval. We delineate a collisional orogenesis, and the new age of 283.9±2.7 Ma may limit the latest time of the collision orogenesis.

KEY WORDS: SHRIMP U-Pb zircon geochronology, Turpan-Hami Basin, Permian, Yierxitu Formation, Central Asian orogenic belt.

0 INTRODUCTION

During Late Paleozoic, the Central Asian orogenic belt (CAOB) was in a transitional period with complex crust-mantle material exchange and formation of transitional crust as evidenced from the Xinjiang region (Xiao et al., 2006). As a result, large scale Paleozoic volcanic activity occurred throughout the Junggar and Turpan-Hami basins. However, compared with the large database accumulated in recent studies from the Junggar Basin, there are only limited studies on the Paleozoic volcanic rocks from the Turpan-Hami Basin primarily because the surface of the basin is covered mostly by desert, and the only exposures are limited to the margin of the basin. For instance, Li et al. (2006) studied the Permian mafic-ultramafic complexes on the southern margin of the Turpan-Hami Basin; Ren et al. (2006) dated the east Caixiashan quartz diorite stock in the southern margin of the basin, and Li et al. (2011) investigated the petrology, isotope chronology, and geochemical features of Carboniferous volcanic rocks in eastern Tianshan, bounded to the south of the Turpan-Hami Basin. There are also some reports on 39Ar-40Ar dating of the volcanic rocks from the core samples from inside the basin (Liu et al., 2006; Zhou et al., 2006), but the imprecise age range is much wider than the range of the volcanic rocks in the margin. In addition, the characteristics of Paleozoic volcanic rocks buried inside the basin are still poorly understood.

The Turpan-Hami Basin has been intensively studied since the 1980s, with a number of reports on the sedimentological and tectonic evolution (Wu et al., 2009; Greene et al., 2001; Shao et al., 1999; Shao, 1996; Zhao et al., 1992; Allen et al., 1991; Windley et al., 1990; Zhu and Yang, 1988; Zhu and Chen, 1980). In addition, as one of the three biggest basins in Xinjiang, the Turpan-Hami Basin is currently a focus for mineral and energy resource exploration. Several literatures about the oil, natural gas, coal, porphyry copper, and the large-scale regional uranium anomalies has been published recently (Wang et al., 2011; Wu et al., 2009; Tang et al., 2007; Han et al., 2006; Chen et al., 2001). Since exploration in the volcanic reservoirs in the adjacent Junggar and Santanghu basins has been successfully carried out, the prospects for hydrocarbon exploration in the volcanic reservoirs in the Turpan-Hami Basin are also fairly good.

In this study, we report a zircon U-Pb SHRIMP age of the rhyolite from the core of Well Baocan 1, one of the deepest wells in the Turpan-Hami Basin, in the eastern part of the basin. Our study provides important new constraints on the timing of the Paleozoic volcanic activity in the Turpan-Hami Basin and shows the contrasting evolution between the margin and the basin.

1 GEOLOGICAL SETTING AND SAMPLING

The Turpan-Hami Basin (also called Tuha Basin, Fig. 1), is located in the eastern side of the Xinjiang Uygur Autonomous region in Northwest China. It covers an area of approximately 5.35×10^4 km^2, and most of the basin consists of desert or regolith sediments (Wang et al., 2011; Chen et al., 2001). Aiding Lake, located in the southwestern part of the basin, is the lowest land surface in China, lying 154 m below sea level; it is also the second lowest continental point in the world (Wang et al., 2011; Wu et al., 2009; Pirajno et al., 2008;
Min et al., 2005; Shao et al., 1999). Bounded by the Bogda Mountains to the north, Jueluotage Mountains to the south, Haerlike Mountain to the east, and Kalawucheng Mountain to the west (Wu et al., 2009; Chen et al., 2001; Shao et al., 1999; Fig. 1), the Turpan-Hami Basin is positioned between the Junggar Basin to the northwest and the Tarim Basin to the southwest, being surrounded on all sides by the Tian Shan fold belts (Pirajno et al., 2008; Ge et al., 1997; Fig. 1). The basin can be subdivided into three sub-basins: the Turpan Depression in the west, the Liaodun Uplift in the mid-section, and the Hami Depression in the east (Chen et al., 2001; Fig. 1).

Windley et al. (1990) and Allen et al. (1991) proposed that the Turpan-Hami Basin was formed as a foreland basin during the Palaeozoic collisions that formed the Tian Shan orogenic belts, and Hou (1995) proposed that the collision occurred during the Late Carboniferous–Early Permian. However, there are also alternate views on its tectonic evolution, such as Ge et al. (1997) who held that the Turpan-Hami Basin is a piggyback on the Bogda nappe.

The basement rocks of the Turpan-Hami Basin are Proterozoic metasedimentary units and Carboniferous intermediate-acidic volcanic and volcanioclastic rocks (Min et al., 2005). The Permo-Carboniferous strata in the Turpan-Hami Basin consist primarily of marine carbonate rocks, volcanic rocks, and pyroclastic rock assemblages. The Upper Permian is a lacustrine sequence whereas the Triassic rocks are composed of moderately deep to shallow lake and fluvial deposits. Above the Triassic, the dominant rocks are Jurassic conglomerate, sandstone, shale and coal, Cretaceous red conglomerate and sandstone, Tertiary red conglomerate, sandstone and shale, and Quaternary gravel, sand and clays (Min et al., 2005; Chen et al., 2001). In the Hami Depression, the Yierxitu Formation is the first cap rock with an angular unconformity above the Carboniferous basement (Gao et al., 2004; Zhang et al., 1997). It is comprised of volcanic rocks (mainly andesite, tuff and volcanic breccia) and clastic rocks, with a total thickness ranging from 355 to 1 215 m.

In this work, samples were collected from Well Baocan 1 in the Hami Depression. Well Baocan 1 was drilled on September 8th, 2009 and was the deepest well in the Turpan-Hami Basin (with a designed depth of 5 600 m) at that time. Volcanic rocks of the Yierxitu Formation (mainly brownish red andesite) were obtained below 4 240 m. From the rhyolite (Fig. 2; red, with obvious fluxion structure in hand specimen and highly directional quartz in microsection) from the 1/2 of the fourth core barrel (4 854.4 m), Sample T79 was selected for SHRIMP U-Pb zircon analyses.

2 ANALYTICAL METHOD AND RESULT

Sample T79 was processed by crushing and initial heavy liquid and subsequent magnetic separation. Together with several grains of standard zircon TEMORA, the zircons extracted from the sample were handpicked and mounted in epoxy, which was then polished to section the crystals for analysis. All zircons were then studied under transmitted and reflected light as well as cathodoluminescence (CL) to identify their internal structures and to ensure that analytical sites did not transgress internal boundaries. The mount was vacuum-coated with high-purity gold.

U-Th-Pb analyses of the zircons were performed on the SHRIMP II in the Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences. Analytical