KUSKY T.M., LI J.H., PLOAT A., WANG Junpeng, DENG Hao and WANG Lu, 2015. The Zunhua-Zanhuang Ophiolitic Mélange: Traces of an Archean Suture in the North China Craton. *Acta Geologica Sinica* (English Edition), 89(supp. 2): 37-38.

The Zunhua-Zanhuang Ophiolitic Mélange: Traces of an Archean Suture in the North China Craton

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Sutures mark places where oceans have closed and two once widely separated terranes have collided. Sutures are defined on the basis of geological relationships, and differences in the geologic, structural, magmatic, sedimentary, and metamorphic histories of the terranes on either side of the suture. Sutures are characterized by complex structures and rock units such as mélanges and ophioltes that were scraped off the intervening oceanic substratum during convergence and collision of the two terranes. The North China craton (NCC) is divided into two major blocks and several minor terranes, yet positions and ages of sutures between the Eastern and Western blocks within the Central orogenic belt (COB) have been controversial. The Zanhuang massif is located in the south-central COB along its border with the eastern block of the NCC. The Eastern Domain of the massif consists of TTG gneiss and migmatite of the Eastern Block of the NCC, overlain by a sequence of metasandstones, marbles, and metapelites, grading up into a matagraywacke-pelite unit. This zone is interpreted as the older continental crust of the Eastern Block overlain by a passive margin sequence then a foreland basin flysch sequence (Wang et al., 2013). The Western Domain of the Zanhuang massif consists of tonalitic gneiss with ages of 2692±12 Ma (Yang et al., 2013), as well as a suite of undated plutons. The Western Domain is considered to be an island arc terrane, with ages of circa 2.7–2.5 Ga. The Central Domain of the Zanhuang Domain consists of a complex mixture of metapelitic rocks, metapsammites, metabasalts, metagabbros, and rare ultramafic rocks, forming a structurally complex mélange (Wang et al., 2013). The mélange belt preserves NW to SE kinematic indicators. We interpret this zone to be a subduction/accretion mélange, related to the collision of the Western Zanhuang Domain (Fuping arc) with the passive continental margin of the Eastern Block, representing the suture between the Eastern Block and a NeoArchean island arc. Wang et al. (2013) and Deng et al. (2013) report ages of circa 2.5 Ga on granitic plutons and pegmatites that cut the fabrics in the mélange, showing clearly that the accretion and collision happened before 2.5 Ga. The Zanhuang (or Taihangshan) suture is thus circa 2.5 Ga old. Eastern Hebei contains a well-exposed cross section from a fore-arc accretionary complex, containing ophiolitic mélanges and slivers, through a foreland fold-thrust belt, into a little deformed foreland basin that is cut by 2.4 Ga granitoids. The late Archean suture is preserved in the Zunhua mélange belt that separates the fore-arc accretionary complex from gneisses of the late Archean Taipingzai enderbitic-charnockitic gneiss complex. The late Archean rocks of this belt are referred to as the Zunhua Structural Belt (ZSB), comprised of highly-strained metasedimentary gneiss, numerous tectonic slices of 2.6–2.5 Ga greenstones (mostly amphibolite facies metabasalts, gabbros, and ultramafic rocks), banded iron formations, and ophiolitic mélanges with metamorphosed blocks of basalt, gabbro, ultramafic rocks including harzburgite tectonite, dunite, and podiform chromite bearing serpentinites (Li et al., 2002; Huang et al., 2004; Kusky et al., 2007, Kusky, 2011). The ZSB exhibits east-vergent folds with west-dipping axial surfaces, sliced by numerous NE-striking shear zones. The ZSB is intruded by 2.6–2.5 Ga tonalite-trondhjemite-granodiorite rocks that are now gneisses, and 2.5 Ga granites. The whole complex is thrust over the Taipingzhai gneiss complex, and linear structural patterns in the ZSB are clearly discordant with the more domal structural style of the Taipingzhai complex, and the early Archean granulite-gneiss dome. The Paleoproterozoic Chengde-Hengshan high-pressure granulite belt overprints the northwestern part of the belt, and circa 300 Ma plutons cut most rocks of the area. The ZSB is noteworthy for two

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remarkable features, specifically the 2.5 Ga Dongwanzi ophiolite (DWO), and the 2.5–2.6 Ga Zunhua podiform chromite deposits in an ophiolitic mélange (Kusky et al., 2001; Li and Kusky, 2002; Huang et al., 2004). The DWO was initially proposed as a full ophiolite sequence, including basal thrust, harzburgite tectonite, cumulate ultramafics, cumulate and layered gabbros, a sheeted dike complex, and overlying volcanic section including remnants of pillow lavas interbedded with chert and BIF. Subsequent analyses showed that some of the units originally included in the DWO were much younger intrusions (Kusky et al., 2004; Zhao et al., 2008), but most of the units originally described as the DWO remain, and it still represents one of the best-preserved, dismembered and metamorphosed late Archean ophiolites in the world (Kusky and Zhai, 2011). Ages of the Dongwanzi ophiolite and associated Zunhua podiform chromites are well-constrained. U-Pb ages from gabbros from the DWO yield ages for the gabbro section of 2504±2.2 Ma (Kusky et al., 2001), and Re-Os ages on the chromites from the Zunhua podiform deposits yield ages of 2.5–2.6 Ga (Kusky et al, 2006). Peridotites from the base of the DWO and Zunhua also yield Lu-Hf ages of 2528±130 Ma (Polat et al, 2006), showing that the mantle and crustal sections of the DWO and Zunhua podiform chromitities are contemporaneous. We correlate the circa 2.5 Ga Zanhuang and Zunhua ophiolitic mélanges, and suggest that they represent the late Archean >600 km long suture between the Eastern block of the NCC and a late Archean island arc.