China University of Geosciences

Center for Global Tectonics

Third Annual Summer Field Meeting and Excursion

SECOND CIRCULAR

Archean Mélanges and Superimposed Tectonomagmatic Events in the Zanhuang Complex, North China Craton: Structural Geology of a Late Archean Suture

Wuhan – Zanhuang (Xingtai) - Wuhan, August 27-Sept. 2, 2017

preceeded by (Aug. 26-27):

Short Course on Crustal Evolution by Walter Mooney and Alfred Kroner

and 1 day Symposium (Aug. 28) on:

Constraints on Archean Tectonic Style: mélanges, metamorphism, geochronology, seismology, geochemistry and numerical modeling

Conference Organizers

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Preliminary Itinerary

pre-conference (Aug. 26-27) pre-conference short course in CUGW, "Crustal Evolution", led by Walter Mooney and Alfred Kroner

Day 1 (Aug 27): arrive at CUGW, register and check in, open icebreaker at 7PM in CUGW

Day 2 (Aug 28): whole day conference in CUGW

Day 3 (Aug 29): travel to Zanhuang, stay in Xingtai City, evening meeting after dinner on field trip preparations and 'what we hope to show you"

Day 5 (Aug 30): full day on late Archean melanges of the Zanhuang Complex (led by Wang Junpeng, Deng Hao, T. Kusky)

Day 6 (Aug. 31): full day on mafic dikes cross-cuts melange fabrics, and late mafic dikes (led by Deng Hao, Wang Junpeng, T. Kusky); half day on 2.1 Ga sill complexes in Northern Zanhuang (lead by Peng Peng). Return to Xingtai around dinner time. Dinner. Some participants may take night train back to Beijing and skip the Xingtai-Wuhan-Beijing route.

Sept. 1. full day on 2.1 Ga sill complexes in Northern Zanhuang (lead by Peng Peng). Return to Xingtai around dinner time. Dinner. Some participants may take night train back to Beijing and skip the Xingtai-Wuhan-Beijing route.

Day 7 (Sept 2): participants leave Xingtai and go home.

Fees:

conference registration (includes icebreaker, conference materials, and meals on Day 1 conference)

Field excursion (travel costs, hotel, and meals)

*Fees will be announced in the third circular, but we will do our best to keep them to a minimum, based on the number of people who express interest.

Archean Mélanges and Superimposed Tectonomagmatic Events in the Zanhuang Complex, North China Craton: Structural Geology of a Late Archean Suture

dates: August 29- Sept. 2, 2017

Organizers: Center for Global Tectonics, China University of Geosciences

(Timothy Kusky, Junpeng Wang, Hao Deng, Xiawen Li

Co-sponsors: Institute of Geology and Geophysics, Chinese Academy of Sciences

(Mingguo Zhai, Peng Peng)

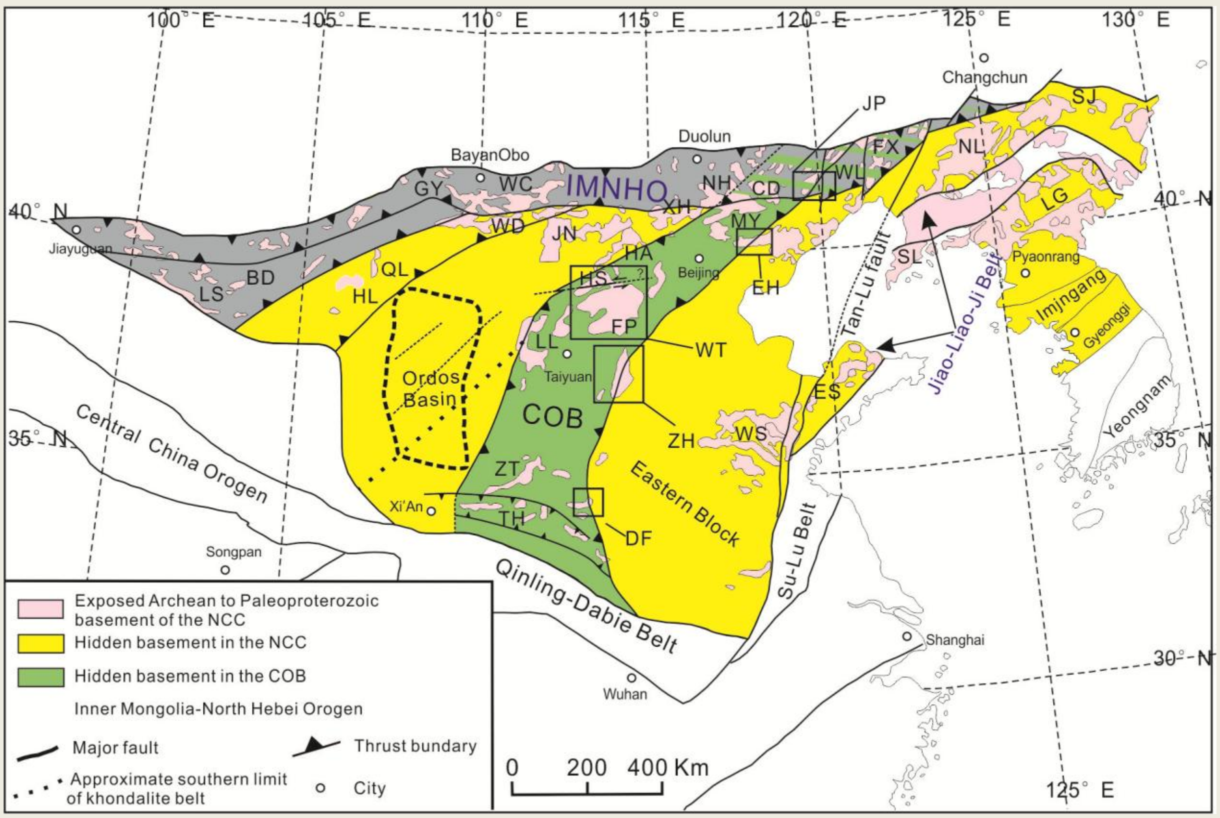

Fig. 1. Map of the NCC showing Archean division into the Eastern Block, Central Orogenic Belt (COB), Western Block (from Kusky et al., 2016) and Inner Mongolia-Northern Hebei Orogen (which includes the Yinshan Block and the northern part of the khondalite belt). Note that the northern part of the COB is strongly overprinted by tectonism related to events in the IMNHO, thus two colors are uses to express this multi-phase part of the orogens. Dashed line outlines the Ordos Basin. Abbreviations as follows: AL – Alashan (Alxa); BD – Beidashan; CD – Chengde; DF – Denfeng; EH – Eastern Hebei; ES – Eastern Shandong; : FP – Fuping; FX – Fuxin; GY – Guyang; HA- Huai'an; HL – Helenshan; HS – Hengshan; JN – Jining; LG – Langrim; LL – Luliang; LS – Longshoushan; MY – Miyun; NH – Northern Hebei; NL – Northern Liaoning; QL – Qianlishan; SJ – Southern Jilin; SL-Southern Liaoning; TH – Taihua; WC – Wuchuan; WD –

Wulushan-Daqingshan; WL – Western Liaoning; WS Western Shandong; WT – Wutai; XH – Xuanhua; ZH – Zanhuang; ZT – Zhongtiao.

Purpose

The Center for Global Tectonics, CUG Wuhan will hold its third annual summer field meeting and field excursion in China, Aug. 27-Sept. 2, 2017. The meeting will start in Wuhan with a day-long scientific conference (preceded by a two-day short course), followed by a field trip to the Zanhuang Complex, which has been proposed to lie along a late Archean suture between the Eastern Block of the Craton, and an accreted Late Archean arc in the Central Orogenic Belt. On the field trip we will examine mélanges related to this suture, as well as younger magmatic rocks possibly related to Proterozoic Andean arc magmatic events. Because this will be a field meeting, the number of participants on the field trip will be limited to 30 so please let us know as soon as possible if you plan to attend.

In the past decades, based on plate tectonic theory, many scientists proposed that the Precambrian basement of the NCC is a product of collsion and amalgamation of the Eastern Block and Western Block through the intervening Central Orogenic Belt (also called the Trans-North China Orogen) (Fig. 1; Zhao et al., 2001; Kusky and Li, 2003), or amalgamation by several smaller microblocks (Zhai and Santosh, 2011). However, the ages and boundaries of the COB and the subduction polarity between the Eastern Block and the Western Block have been controversial issues. The COB is defined as an Archean orogen based on the presence of ca. 2.5 Ga ophiolitic arc-forearc assemblages and mélange belt, and Neoarchean foreland basin to passive margin sequences with Archean boundaries and structural styles reminiscent of younger orogens (Fig. 1; Deng et al., 2013; Kusky, 2011; Kusky and Li, 2003; Kusky et al., 2007; Li and Kusky, 2007; Polat et al., 2005, 2006; Wang et al., 2013). Recently, Faure et al. (2007) and Trap et al. (2009, 2012) proposed two Paleoproterozoic sutures named the Zanhuang Suture and the Taihang Suture (Fig. 1), along which the NCC was amalgamated and cratonized. Kusky et al. (2016) proposed that the craton formed through the progressive accretion of different arcs, microcontinents, and plateaus, and was strongly influnced by different episodes of arc-magmatism.

Determining the structural and tectonic attributes, metamorphic evolution and geochronology of the COB are essential to fully understand the formation history of the basement of the North China Craton. The Zanhuang metamorphic complex located on the eastern margin of the central and southern section of the COB is one of the important areas to study the collisional orogenesis between the Eastern and Western Blocks (Figs. 1, 2A). Recently, an Archean mélange belt has been documented in the Zanhuang complex (Fig. 2B; Wang et al., 2013, 2015; 2017a, b; Deng et al., 2013, 2014) which provides good constraints on tectonic evolution of the COB and the NCC.

1. Archean Zanhuang Ophiolitic Melange (leaders J.P. Wang, H. Deng and T. Kusky)-Whole day

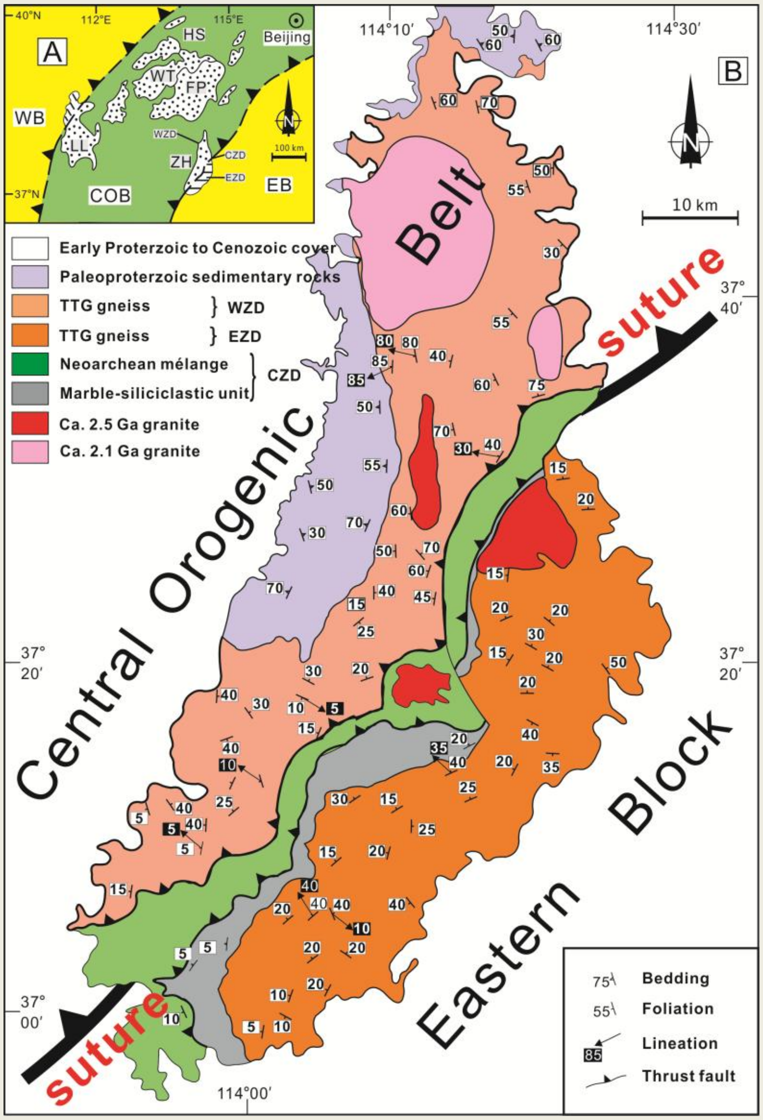

Fig 2. **(A):** Simplified map showing the location of the Zanhuang Complex in the Central Orogenic Belt, North China Craton (modified from Trap et al., 2009), EB: Eastern Block, WB: Western Block, COB: Central Orogenic Belt, HS: Hengshan Complex,WT: Wutaishan Complex, FP: Fuping Complex, LL: Lüliang Complex, ZH: Zanhuang Complex, WZD: Western Zanhuang Domain, CZD: Central Zanhuang Domain, ZMB: Zanhuang Mélange Belt, EZD: Eastern Zanhuang Domain, the western margin of the CZD is interpreted to be a suture zone between Eastern Block and Fuping Complex (Trap et al., 2009); **(B)** Geological map of the Zanhuang Complex (From Wang et al., 2015), showing tectonically juxtaposed units from west to east: the TTG gneiss of the WZD, the mélange belt of the CZD, the metacarbonate–siliciclastic unit of the CZD, and the TTG gneiss of the WZD.

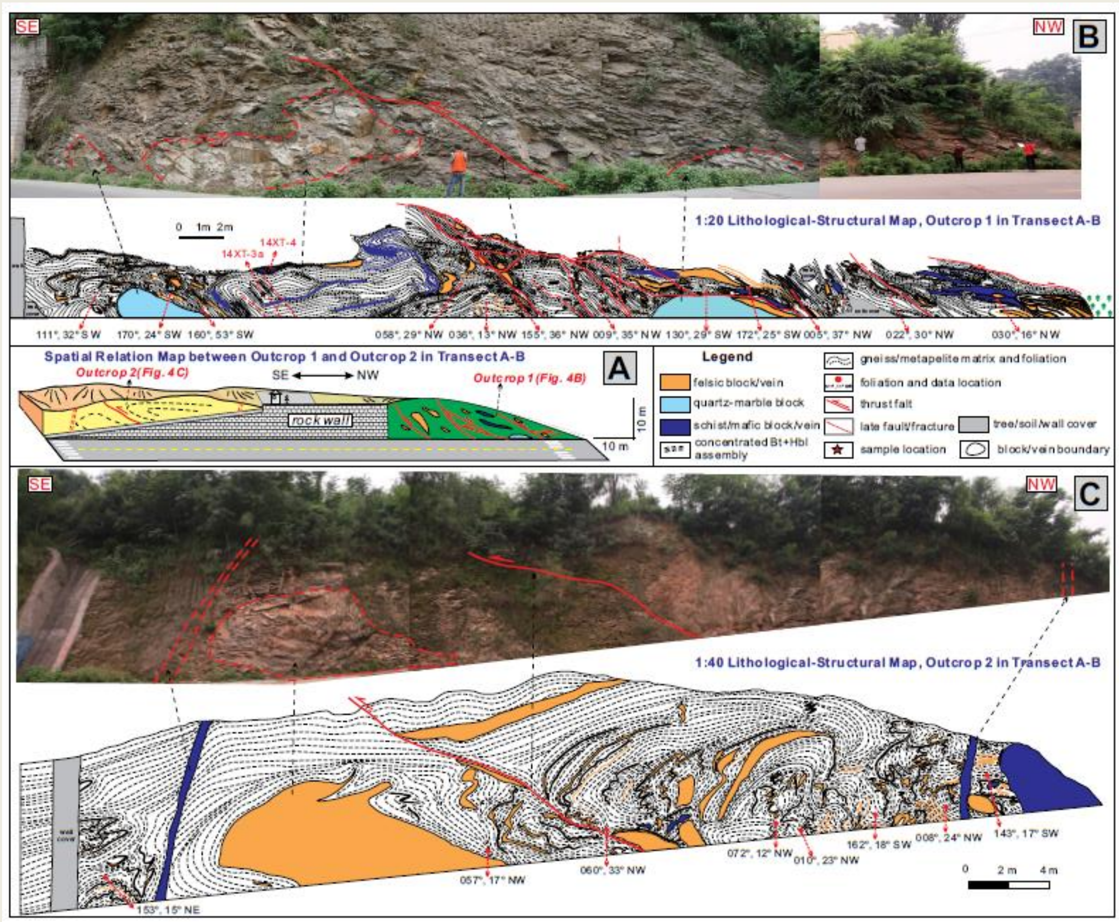

Fig 3. (above). Spatial relation map between outcrop 1 and outcrop 2 in transect A-B. Note that outcrop 1, outcrop 2, and the vertical concrete wall in between constitute a continuous profile. Bt—biotite; Hbl—hornblende. (B) Photo and 1:20 lithological and structural map of outcrop 1 in transect A-B. Location of outcrop 1 is shown in Figures 1C and 2A. (C) Photo and 1:40 lithological and structural map of outcrop 2 in transect A-B. Location of outcrop 2 is shown in Figures 1C and 2A. Note that outcrop 1 is dominated by thrusting, and outcrop 2 is dominated by folding quartzofeldspathic veins with generally northwest-dipping axial surfaces. The various blocks and matrices are thrusted and folded together composing the typical fold-and-thrust structures in an accretionary wedge. From Wang et al., 2017b.

We plan to spend one whole day on investigating an Archean mélange belt that is located in the Central Zanhuang Complex (Fig. 2) of the Central Orogenic Belt (COB) of the North China Craton (NCC). This Archean mélange belt is interpreted to represent an Archean suture zone between an arc terrane in the COB and the Eastern Block (Fig. 3). Located on the eastern side of the mélange belt is a metacarbonate-siliciclastic unit that was deposited upon the TTG gneiss on the Eastern Block and interpreted to represent a passive continent margin sequence (Wang et al., 2013; Deng et al., 2013). Located on the western side of the melange belt are TTG gneisses that are interpreted to represent part of an intra-oceanic arc terrane in the COB (Figs. 2B and 3; Wang et al., 2013; Deng et al., 2013). We will drive along a cross-section that cuts across the TTG gneiss of Eastern Zanhuang, the mélange unit and the metacarbonate-siliciclastic unit of Central Zanhuang Domain, to the TTG gneisses of the Western Zanhuang Domain, in order to observe different rock units with their tectonic affinities and regional structural signatures of the whole Zanhuang complex. We will be focused on detailed investigation on features and structures of the mélange belt, in order to know how to identify the mélange belt and its formation age, as well as how to constrain its tectonic significance for the Zanhuang Complex and the NCC as a whole. The late Archean Zanhuang mélange has been interpreted as an ophiolitic mélange with circa 2.5 Ga pillow lavas which were altered into epidosites (Fig. 4).

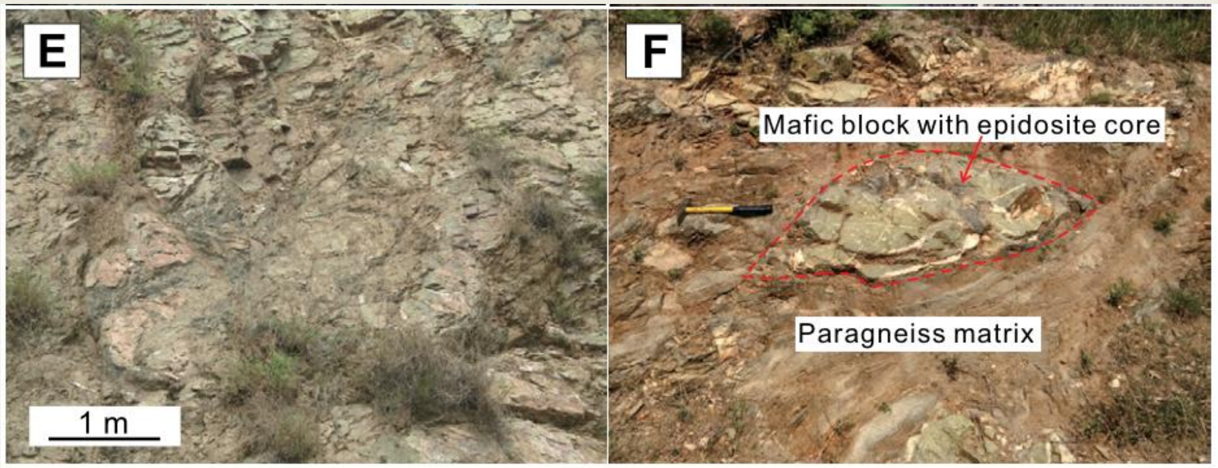

Fig 4. (E) Relict pillow basalts with altered epidosite cores within a metapelitic matrix. (F) Mafic blocks with epidosite cores within a paragneiss matrix. (Photos from Wang et al., 2017b).

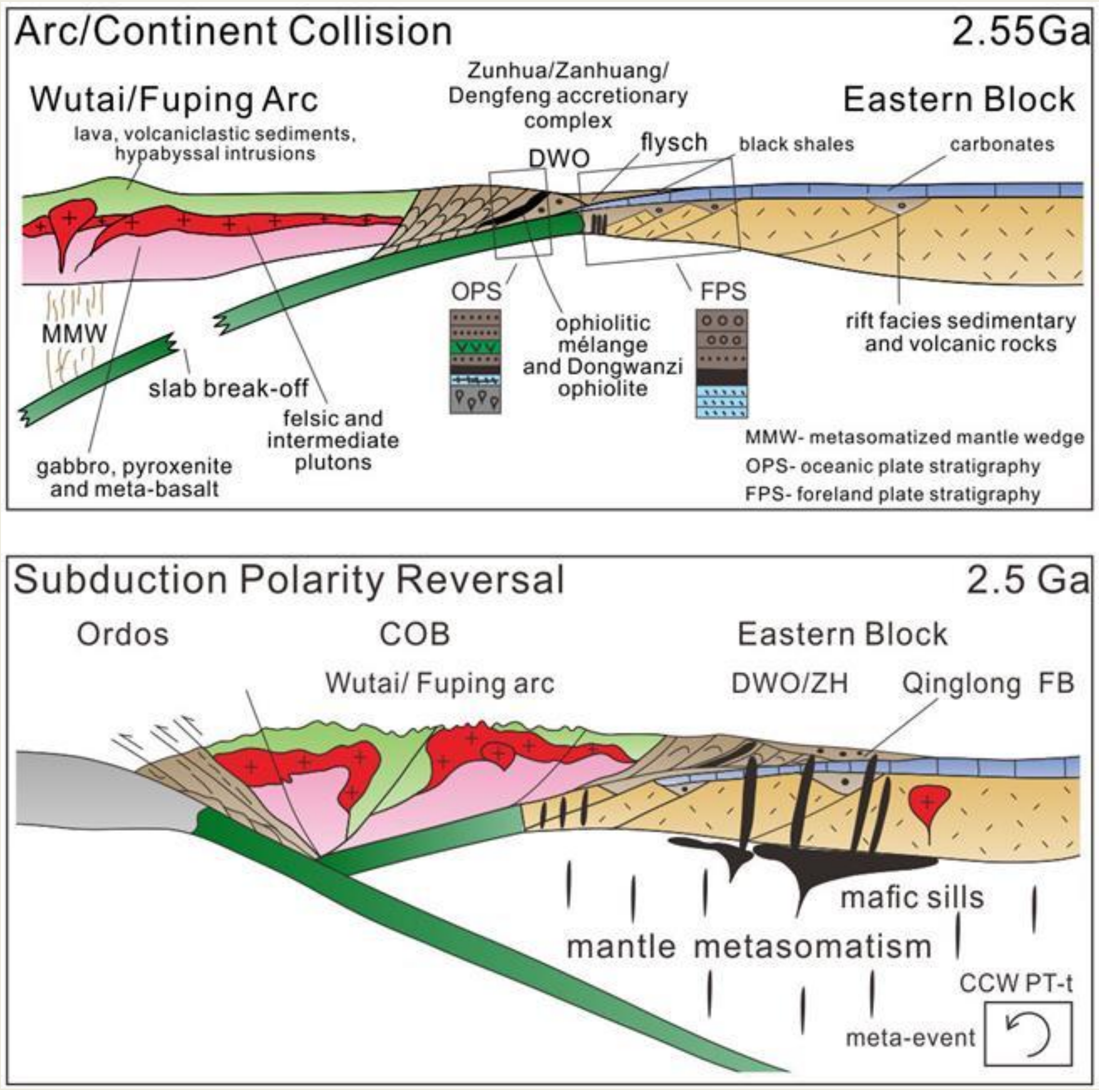

Fig. 5 (from Kusky et al., 2016). Cross-sections showing stages in the tectonic development of the NCC at 2.55 and 2.5 Ga. Panel a shows the early stages of the collision between the Wutai/Fuping intraoceanic arc with the Eastern Block of the NCC. This collision at circa 2.55 Ga caused the obduction of the Dongwanzi (DWO), Shangyin and other Archean ophiolite fragments, the formation of the ophiolitic melanges of the Zunhua-Zanhuang suture belt, led to the deposition of flysch in the Qinglong foreland basin, and imbrication of the underlying shelf sequence in foreland fold-thrust belts. Panel b shows later stages of this collision at 2.50 Ga in which the arc polarity has been reversed with a new slab dipping beneath the Eastern Block, bringing in the Ordos oceanic plateau to the collision zone. The slab is releasing fluids and metasomatizing the overlying mantle wedge, generating melts, which led to the intrusion of mafic dikes and plutons across the Eastern Block at this time (Wang et al., 2015, Deng et al., 2014) and is postulated to be the cause of the widespread CCW metamorphism of rocks in the Eastern Block at circa 2.5 Ga.

2. Circa 2.5 Ga mafic dikes cutting mélange (leaders H. Deng, J.P. Wang and T. Kusky)-Whole Day

We plan to spend thisday on investigating circa 2.54 Ga mafic dikes cutting the melange and the 2.5 Ga granitic pegmatites that cut the melange and the mafic dikes. Both the mélange belt and the Eastern Zanhuang Domain were intruded by ca. 2.50 Ga mafic dikes, which are preserved as boudins in the felsic gneisses with metamorphism up to amphibolite to granulite facies (Fig. 6, Deng et al., 2013; Xiao et al., 2011). Their length ranges from several meters to hundreds of meters and are tens of centimeters to several meters in width (Fig. 6a-b, 6e). The mafic boudins display consistent foliation with their host rocks with the long axis generally parallel to gneissic layering. The foliations developed in the boudins dip to the NW with lineations plunging toward to the NNW. Some mafic boudins form elongate trains within the felsic gneisses (Fig. 6a, e), indicating the breakup of the dikes into boudins during deformation, supplying evidence that the mafic boudins were originally dikes. Furthermore, in low strain areas, some original dikes are also preserved and cut across the fabrics of the gneisses (Fig. 6c). The mafic boudins were in turn cut across by late granitic pegmatites (Fig. 6d), demonstrating that the mafic dikes formed before the intrusion of the pegmatitic melt.

Igneous zircons from an undefomed mafic dike yield a $^{207}Pb/^{206}Pb$ age of 2535 ± 30 Ma, which is interpreted as the crystallization age. In addition, pegmatites cutting across the mafic dikes in the field also yield an igneous zircon $^{207}Pb/^{206}Pb$ age of 2504 ± 16 Ma, providing evidence that the mafic dikes in the NCC intruded during the Neoarchean. Trace element systematics of the mafic dikes are consistent with an arc-related lithospheric mantle source region, rather than an ocean island basalt (OIB)-like source region. The new whole rock Nd isotopic composition ($\varepsilon_{Nd}(t)$= +0.71 to +3.70) is relatively more evolved compared to that of the depleted mantle at 2.5 Ga, indicating an enriched lithospheric mantle source. Accordingly, the mafic dikes are proposed to have formed in a subduction-related environment and their enriched mantle source was metasomatized by the melts and fluids derived from the subducted slab (Deng et al., 2014).

The Archean mélange belt is interpreted to represent an Archean suture zone that was formed by a ~2.55 Ga arc-continent collision event between an arc terrane in the COB and the Eastern Block. After the arc-continent collision, the newly accreted arc/Eastern Block was intruded by a large volume of the 2.5 Ga mafic dikes, which are well preserved as boudins in the felsic gneisses in the COB and the Eastern Block. Considering the 2.5 Ga mafic dikes possessing arc-related signatures, we propose a subduction zone reversal event is proposed to explain the origin of the 2.5 Ga mafic dikes. We suggest that a new east-dipping subduction zone developed below the western side of the newly sutured active island arc/Eastern Block. The new subduction dehydrated the newly east-dipping slab, metasomatizing and partially melting the overlying mantle wedge, which melted the lithospheric mantle enriched by the new subduction slab-derived melts and fluids, and gave rise to formation of 2.5 Ga mafic dikes. Meanwhile, the uplifted magma ponded and underplated the suture zone and the arc crust (TTG), and induced partial melting of the over-thickened arc/continent crust generating the ca. 2.5 Ga contemporary potassic granites and related plutons, including the 2.5 Ga pegmatitic melts (Fig. 7; Wang et al., 2013, 2015).

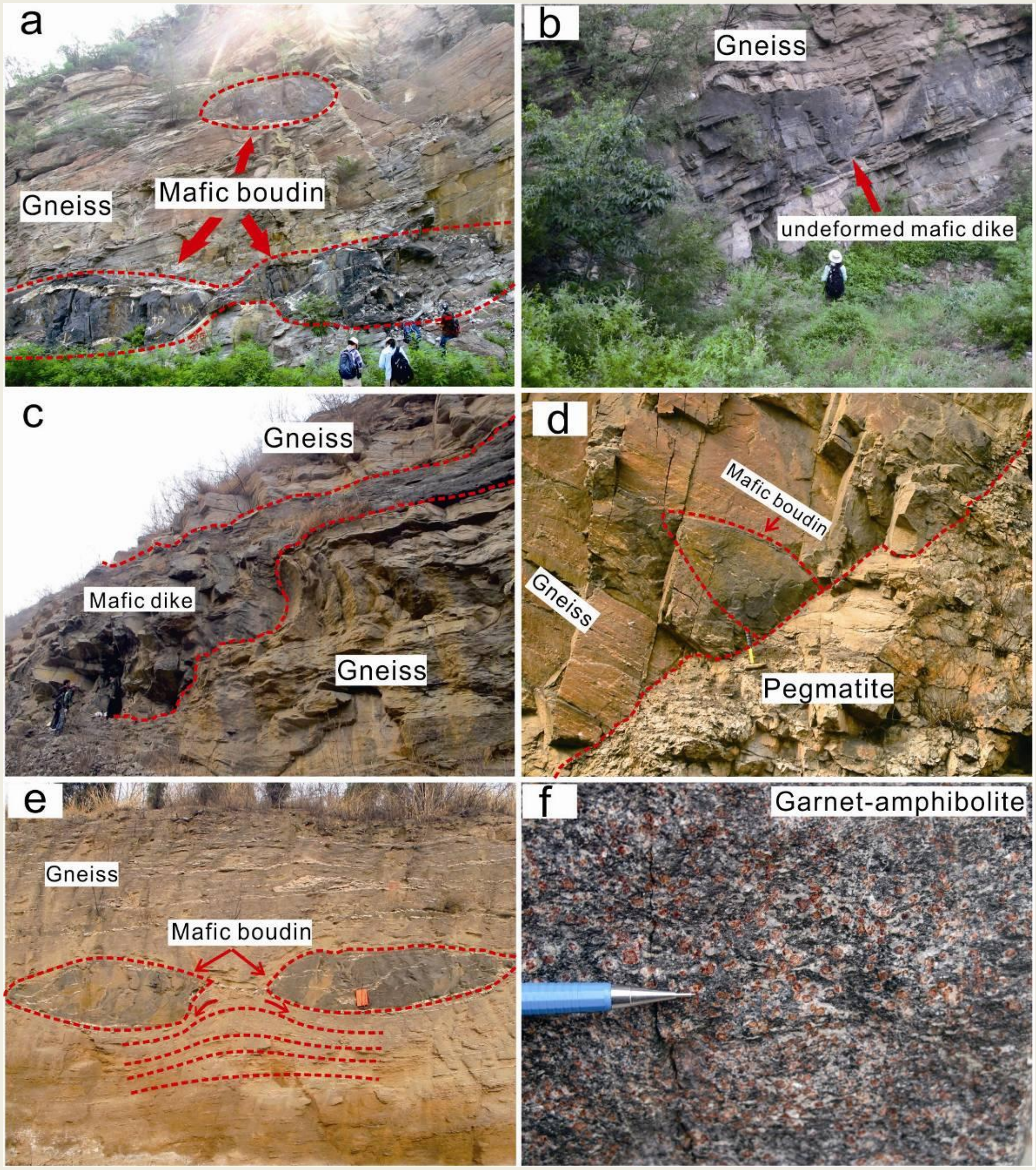

Fig. 6. Field photographs showing relationships and lithological characteristics of 2.5 Ga mafic dikes in the Zanhuang Complex. (a) large boudins of mafic dikes within grey gneisses; (b) relatively undeformed mafic dikes within gneiss; (c) undeformed mafic dike cutting across the fabrics of the gneiss; (d) pegmatite veins cutting across the mafic boudin and the surrounding gneiss; (e) mafic boudins closely dispersed in the gneiss, showing the boudinage of the mafic dikes during deformation; (f) close-up of garnet-amphibolite boudins of mafic dikes, showing conspicuous garnet porphyroblasts with plagioclase corona around them. From Deng et al., (2014).

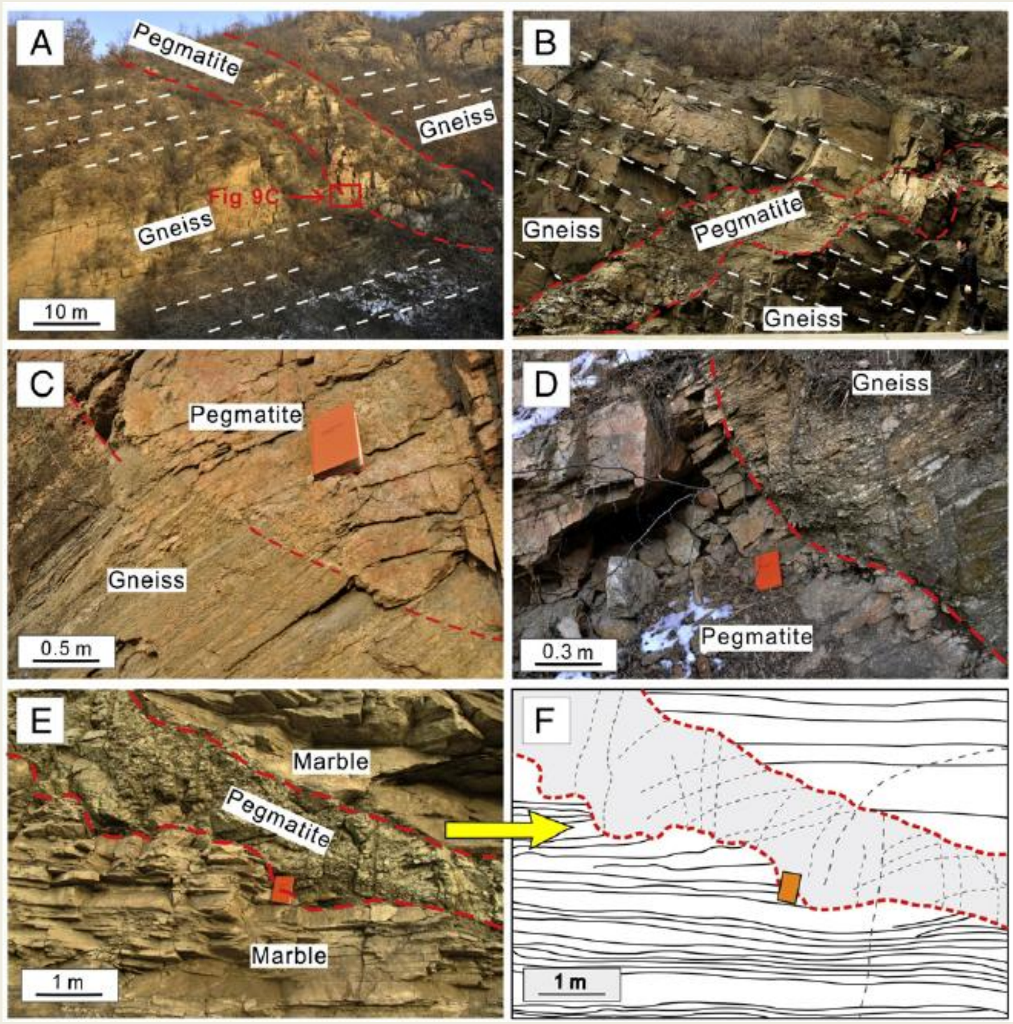

Fig. 7. Field photographs of pegmatite cross-cutting early fabrics. A and B: Undeformed circa 2.5 Ga pegmatite cross-cutting the foliation of the TTG gneisses in the Eastern Block, panel A and panel B near Lujiazhuang village. The white dashed lines in panels A-B represent the foliations in the gneiss. C and D: Pegmatite cross-cutting the foliation of the gneisses with late joint subparallel to the foliation. Location of panel C shown in panel A, panel D nearby panel A. E: Pegmatite cross-cutting marble layer, near Baihuzhuang village. F: Sketch of panel E. The black dashed lines in panel F represent the joints. The red dashed lines represent the contacts between the pegmatite and the country rocks. From Wang et al., (2013).

3. Circa 2.1 Ga Zanhuang Magmatic Suite (leader P. Peng)-Whole Day

Following our examination of the melanges on the first two days, we will drive to the northern Zanhuang Complex and examine a suite of circa 2.1 Ga igneous rocks that Peng Peng et al. (2017) interpret as recording a craton-wide episode of extension. In the Kusky et al. (2016) model this would most likely be caused by slab rollback and extension in the back-arc region of a large Andean arc complex built on the northern margin of the craton.

~2100 Ma igneous rocks are widespread in the Eastern North China craton, represented by volcanic-sedimentary sequences and mafic-felsic intrusions including mafic sills/ dykes/ layered intrusions and felsic plutons (Peng et al., 2012). In the Zanhuang region, the Paleoproterozoic sequences include the Gantaohe Group, the Xuting A-type granites and the Zanhuang sills and some other mafic intrusions. The mafic sills are doleritic and were intruded at ~2090 Ma (Xie et al., 2012). The A-type granites chiefly consist of the potassic and monzonitic granite with minor albite granite, which was emplaced at 2090-2070 Ma (Yang et al., 2011a, b; Du et al., 2016a). A Na-rich type and a K-rich type can be differentiated (Du et al., 2016a). There are pyroxenite-gabbro- anorthosite intrusives along the margin of the A-type granitic plutons; and both baddeleyite and zircon from the gabbro give U-Pb ages of ~2090 Ma, representing the age of crystallization (Peng et al., 2017). Peng et al. (2017) propose that the mafic intrusives and the crosscutting A-type granites comprise several ring complexes (Fig. 6). The mafic rocks of the ring complex and sills show similar chemical features: they were characterized by enriched light rare earth elements, enriched large lithosphile elements but depleted high field strength elements, and enriched Sr-Nd isotopes (εNd_t = -1.9–-0.6, Nd T_{DM}=~2.7 Ga). They most likely originated from the same magma source, with compositional variation of mafic sills resulting from the fractionation of olivine and plagioclase. A-type granites could have originated from this same source with first olivine + plagioclase-dominated fractionation in the lower magma chamber to produce intermediate compositions, and then with significant removal of clinopyroxene ± plagioclase in the upper magma chamber, which at the same time produced pyroxenite-gabbro and minor anorthosite cumulates in the ring complexes (Peng et al., 2017).

At the Huzhaikou Stop/Section, we will check a mafic sill intruding the Gantaohe Group low-grade clastic sediments; while at the Xitaicheng Stop/Section, we wll check the pyroxenite-gabbro suite, as well as the A-type granites (see Fig. 6 for locations). As a substitution or complement to the Xitaicheng Stop, we may try the Beishuiyu Stop/Section to check the gabbro-anorthoiste suite if the road condition is good then (Fig. 6).

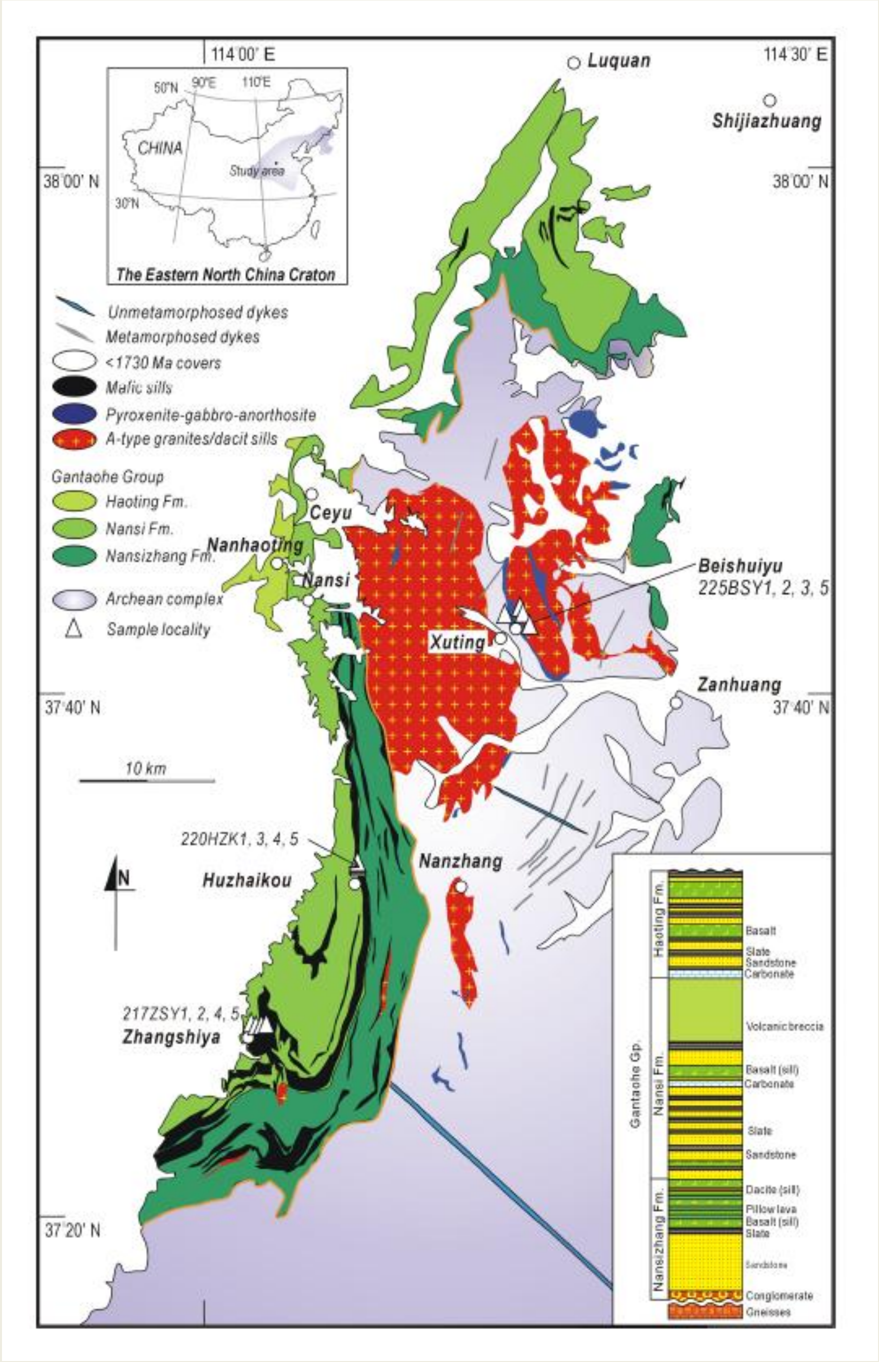

Fig. 6. Simplified geological map of Zanhuang region (South Taihang Mts.). From Peng et al., 2017.

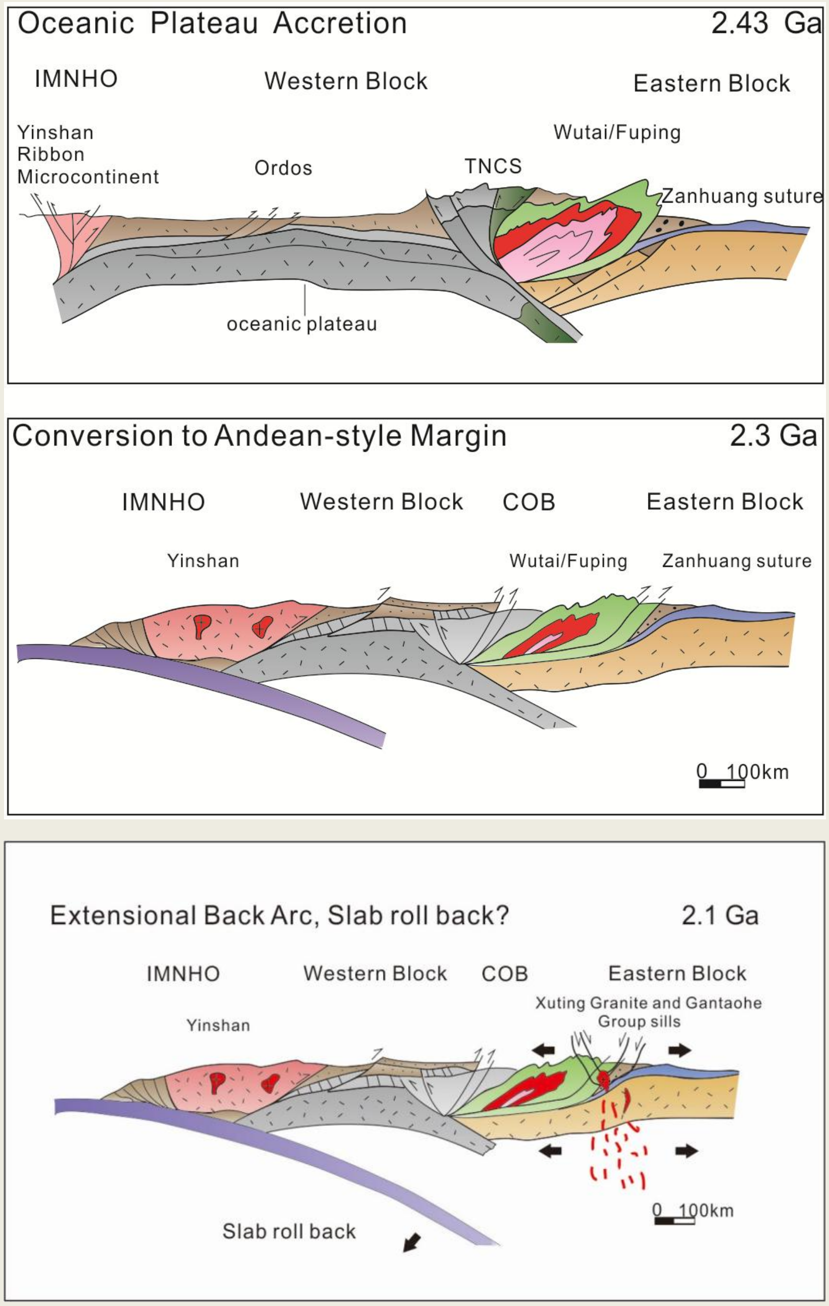

Fig. 7. (a and b from Kusky et al., 2016). Cross-sections showing stages in the tectonic development of the NCC at 2.43 and 2.3 Ga. Panel a at 2.43 Ga shows the accretion of the Ordos oceanic plateau to the collision-modified margin of the Eastern Block, and the initial impingement of the Yinshan Ribbon Microcontinent to the Ordos Block and the northern margin of the amalgamated Eastern and Western Blocks. Panel b shows later stages of the accretion of the Yinshan Block to the northern margin of the NCC, and the initial conversion of the NCC to an Andean-style plate margin with the active arc along the north margin of the continent. (c) Tectonic scenario envisioned for circa 2.1 Ga magmatism and partial melting across the northern half of the NCC. An episode of slab roll-back could induce extension in the upper plate, decompression, and partial melting.

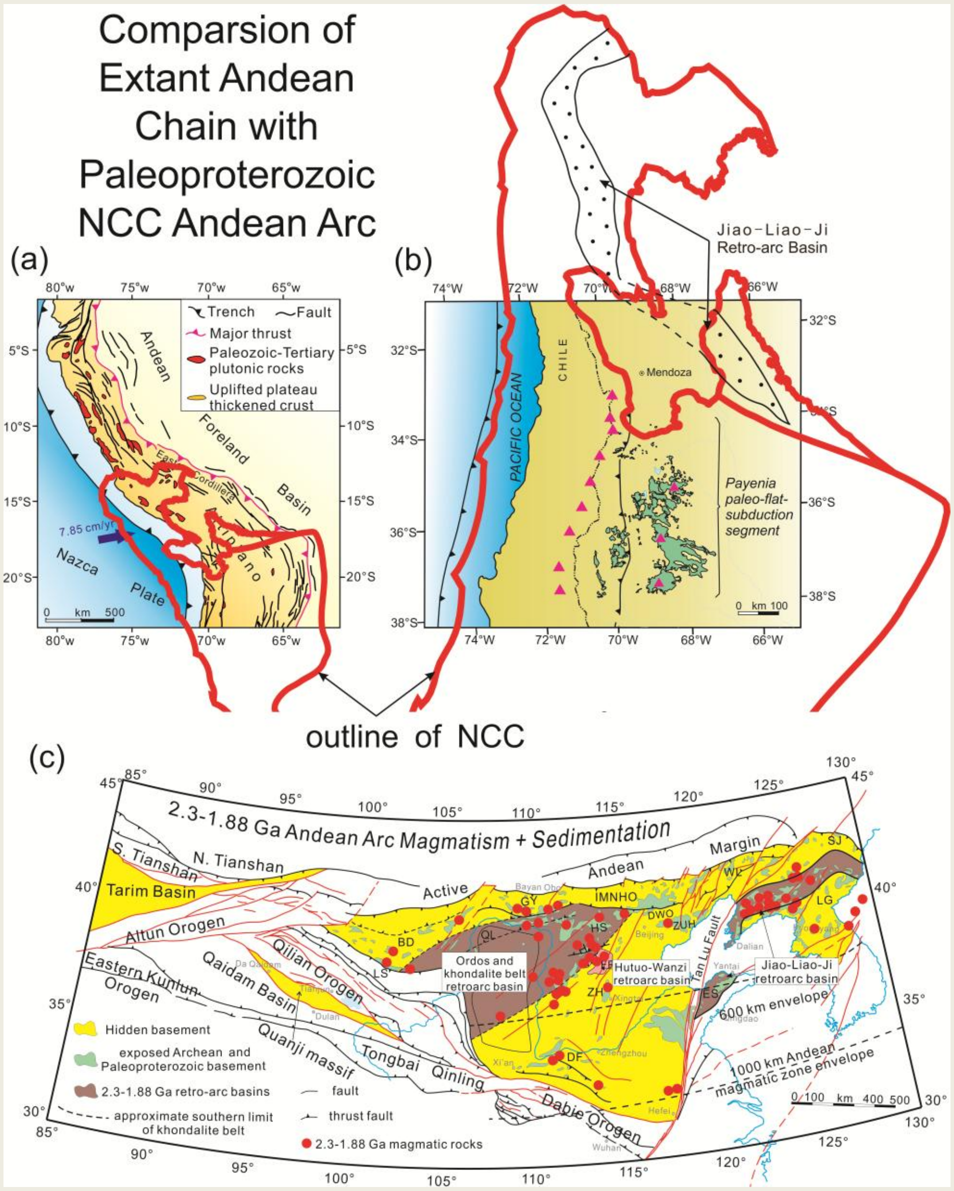

Fig. 8 (from Kusky et al., 2016). Comarison of the NCC with different segments of the Andes. Maps in A and B of the Andes are shown with an outline of the NCC at the same scale plotted over the Andean maps for comparison. Red triangles in (b) show locations of active volcanoes. Location of magmatic rocks in C compiled from (Peng et al., 2012, Li et al., 2007, Zhang et al., 2013, and Gong et al. 2011). Note that most magmatism and deformation is concentrated within 600 km of the active Andean margin (see “600 km front" line), but can extend as far as 1000 km (1000 km “Andean front” line). as in the present day Andes. Distribution of circa 2.3-1.88 sedimentary basins of this age is also located in the retro-arc region and the distribution, types of rocks, and associated with magmatic rocks are all similar to the modern day Andean system. Abbreviations as follows: AL – Alashan (Alxa); BD – Beidashan; DF – Denfeng; DWO – Dongwanzi Ophiolite; EH – Eastern Hebei; GY – Guyang; HS – Hengshan; LG – Langrim; LS – Longshoushan; QL – Qianlishan; SJ – Southern Jilin; WL – Western Liaoning; ZH – Zanhuang; ZUH - Zunhua.

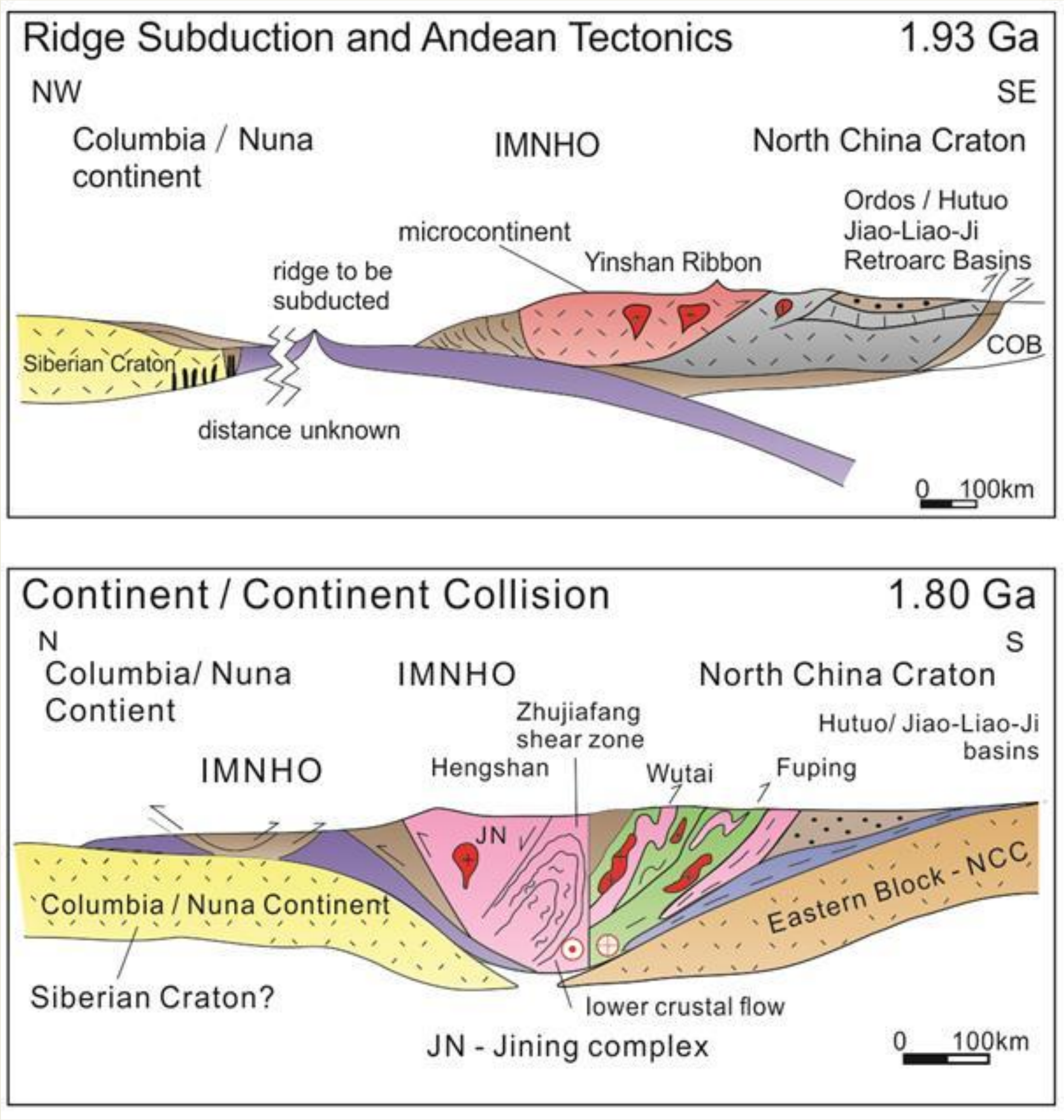

Fig. 9. Cross-sections showing the tectonic development of the NCC at 1.93 and 1.8 Ga (from Kusky et al., 2016). Panel a shows the northern Andean-arc style margin of the NCC at 1.93, when the Yinshan Ribbon Microcontinent had been accreted, and the whole craton was under the influence of Andean margin style tectonics. A wide range of magmatic rocks intruded across the craton, and sedimentation in retroarc basins in Ordos, Hutuo, and Jiao Liao Ji had begun. As the ocean between the Columbia/Nuna Continent (perhaps the Siberian segment was impinging) was closing, an oceanic ridge in the ocean was subducted, causing the UHT metamorphism on the north margin of the craton at 1.92 Ga (Santosh and Kusky, 2010). Panel b shows the ultimate continent-continent collision between the Siberian segment of the Columbia/Nuna Continent with the NCC, resulting in craton-wide high-grade metamorphism, with HP granulite facies and evidence for lower crustal flow during anatexis in the north, and medium-pressure granulite to amphibolite facies metamorphism in the center and southern parts of the craton. Widespread deformation and metamorphism during this event are the most widely recorded and preserved events from the craton.

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Call for Papers

Aug 29, 2017: Pre-Field Trip Conference, CUGW, Constraints on Archean tectonic style: melanges, metamorphism, geochronology, seismology, geochemistry and numerical modeling."

Hosted by: China University of Geosciences, Wuhan

The Pre-Conference field meeting will be held at the China University of Geosciences in Wuhan. Sessions for the one day meeting will include, but not be limited to the topics below. We are currently developing a list of keynote and invited speakers, which will be listed in the third circular. Please let us know as soon as possible if you are interested in presenting at the meeting (oral and poster), or participating in the whole trip. We anticipate publishing a special volume from talks at the meeting in a respected SCI journal.

Themes (invited key note talks to be announced in third circular)

Archean Tectonic Style: Field Based Approaches and Comparative Tectonics

Numerical Models of Archean tectonics

Seismic and Geophysical Constraints on Crustal Structure

Metamorphic and Geochronologic Constraints on Archean tectonic Style

Geochemical Constraints on Archean Tectonics with an Evolving Mantle

Overview of the Field Trip (this topic will be discussed on Aug. 30 in Xingtain City)

T. Kusky

Junpeng Wang

Deng Hao

Peng Peng

Expression of Interest Form and for Center for Global Tectonics Third Annual Summer Field Meeting and Excursion, August 27 - Sept 2, 2017, Wuhan-Zanhuang (Xingtai) – Wuhan

Name		Gender		Nationality	
Postal Code		Phone/Cell			
Fax		E-mail			
Affiliation					
Address					
Oral Presentation (Yes/No)			Field Excursions	Yes/No	
Presentation Title					
Entourage					
Accommodation Request	Single/Double				
Remarks					

Please send form to Junpeng Wang(wangjp@cug.edu.cn) **and Hao Deng (**denghao815@126.com**)**, first 30 people can be accommodated on field trip.

Expenses to be determined, but we will do our best to keep them to a minumum for participants.