South China in the assembled Gondwana

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South China is one of the major East Asian continental blocks that shaped the northern Gondwana margin. The geodynamic interactions of South China with Gondwana and other Asian neighbours are thus important for understanding how the northern Gondwana margin was collaged and how it impacted the South China tectonics during the late-Neoproterozoic to early-Paleozoic. This comprehensive study started from the Ordovician–Silurian Wuyi-Yunkai orogeny in South China, investigating its magmatism, metamorphism and orogenic denudation history, further looked into the sedimentary records in the adjacent Ediacaran–Silurian Nanhua foreland basin, and finally correlated the late-Neoproterozoic to early-Paleozoic magmatic, metamorphic, sedimentary histories and orogenic events from both South China and Indian Gondwana.

The intraplate Wuyi-Yunkai orogeny in South China experienced high-grade metamorphism and felsic magmatism during 460-440 Ma, mafic magmatism at 435 Ma, and massive felsic magmatism but no metamorphism during 440-400 Ma. Geochemical and geological studies suggest that the orogeny featured a late-orogenic lithospheric delamination no late than the early-Silurian, which led to an orogenic collapse, melting of subcontinental lithospheric mantle and widespread late-orogenic granitic intrusions in the orogen.

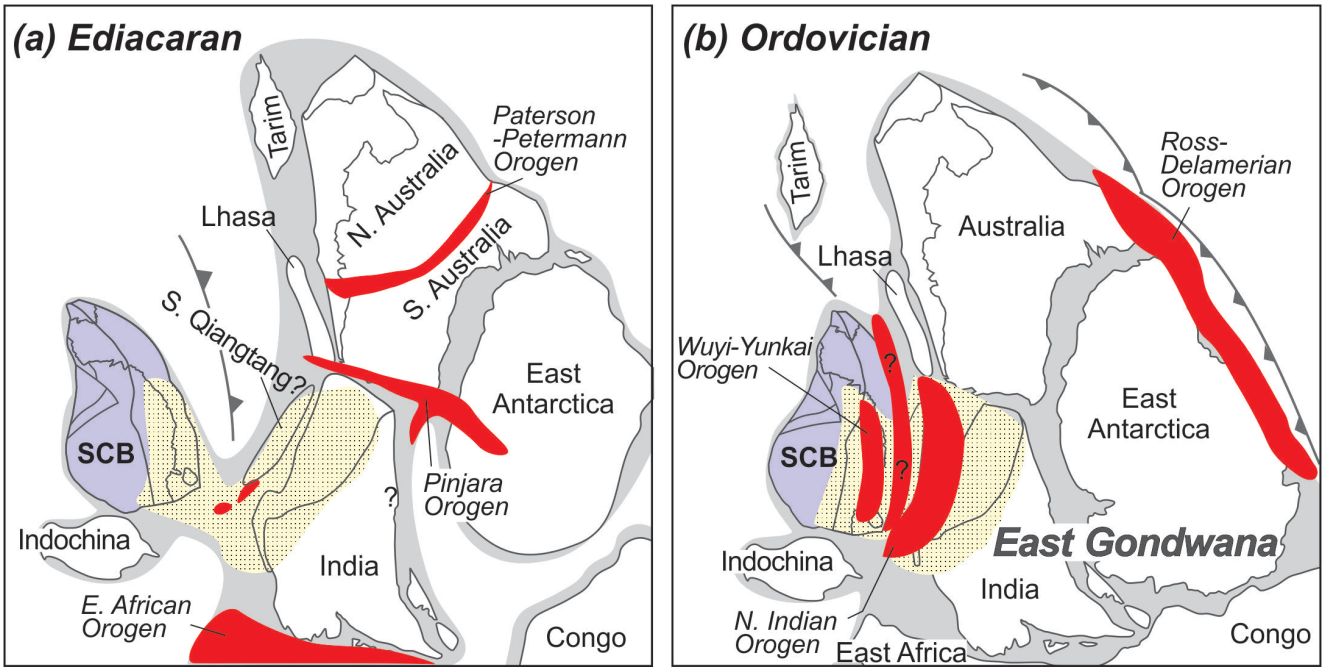
The adjacent Nanhua foreland basin started as early as the Ediacaran, and experienced a three-stage basin evolution. Stage 1: the Ediacaran–Cambrian stage, recording the start of tectonic subsidence in the basin with turbiditic siliciclastic deposition, fed by exotic orogens outboard South China; Stage 2: the Ordovician to earliest-Silurian stage, characterized by a migrating depocenter with dominant shallow marine and deltaic siliciclastic deposition, fed by the local Wuyi–Yunkai orogen; Stage 3: the Silurian stage, showing the arrival of depocenter into the Yangtze during the orogeny waning stage with deltaic deposition in the remanent foreland basin.

Provenance analysis were conducted on the Ediacaran–Silurian siliciclastic rocks in the Nanhua foreland basin. It reveals that, the Ediacaran–Cambrian rocks exhibit a prominent age population of 1100–900 Ma, moderate populations of 850–700 Ma and 650–490 Ma, and minor populations of 2500 Ma and 2000–1300 Ma, grossly matching that of crystalline and sedimentary rocks in northern India. Zircon Hf isotopes further reveal four episodes of juvenile crustal growth in the source regions. The provenance as defined by the Ediacaran–Cambrian sedimentary rocks is distinctly different from the known tectonomagmatic record of South China, or that of western Australia or western Laurentia, but matches well with that of the coeval sedimentary rocks and granites in northern India. The Ediacaran–Cambrian sediments in South China were thus mainly sourced from northern India and adjacent orogens, and the Ordovician–Silurian sediments were derived from both locally recycled Ediacaran–Cambrian rocks and eroded Cathaysian basement within South China. The Wuyi–Yunkai late-orogenic magmatic rocks also contributed to the Silurian sedimentation in the basin.

We speculate that there was an Ediacaran–Cambrian collisional orogen (probably the “Pan-African” Bhimphedian orogen) between South China and northern India during the Gondwana assembly, shedding

sediments to the early Nanhua foreland basin. Far-field stress during the late stage of this collisional orogeny triggered the Wuyi–Yunkai orogeny in South China, and erosion of the local Wuyi–Yunkai orogen further provided detritus to the late Nanhua foreland basin. The southern Qiangtang terrane was likely located between South China and northwestern India during this collision, and received similar detritus from the Bhimphedian orogen. The Lhasa terrane, however, was attached to western Australia during the Gondwana assembly, and received sediments from the Pinjarra orogen and vast Yilgarn basement rocks.

Keywords: South China, Gondwana, Ediacaran-Cambrian, Ordovician-Silurian, Orogenic events, Sedimentary basins



Decomposition of an arc-trench system: Cretaceous-Paleogene Japan case

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The Japanese Islands still preserved the overall orogenic framework of Cetaceous arc-trench system; e.g. the Shimanto accretionary complexes (trench), Sanbagawa high-P/T blueschists (deeper Wadati-benioff zone), and Ryoke batholith belt (magamatic arc). We analyzed U-Pb ages of detrital zircon from coeval shallow marine sandstones in SW Japan deposited in fore-arc, intra-arc, and back-arc settings, in order to check the pattern of terrigenous flux within a matured arc and their later modification. Most of the Cretaceous shallow marine sandstones contain abundant detrital zircons from the Jurassic to Early Cretaceous ages, with minor amounts of Permo-Triassic and mid-Paleozoic ones. These common age spectra record that the provenance of the Cretaceous arc had the same compositions of crustal rocks for nearly 1,000 km along the arc; i.e., dominant Jurassic to Early Cretaceous granitoids with minor amounts of pre-Jurassic orogenic elements. The most peculiar age spectra was detected in western Shikoku and Kanto Mtn. near Tokyo; e.g., Cretaceous sandstones of the Atogura and Maana formations contain abundant Paleoproterozoic (2400-1600 Ma) zircons. The field occurrence of these two units as klippen on the blueschists suggests their allochthonous origin and post-depositional tectonic transport. The unique age spectra are correlative solely with those from the Tetori/Jinzu groups in the Hida belt on the Japan Sea side, which were deposited on the back-arc domain of the Cretaceous arc with provenance featuring Precambrian basements. These suggest that the Cretaceous sandstones in klippen were primarily deposited in the back-arc, and later transported to the fore-arc for nearly 100-200 km across the Cretaceous arc crust, by the Cenozoic tectonics. The Miocene Japan Sea opening represents a typical case of extensional tectonics in the back-arc domain; nonetheless compressional tectonics operated on the Pacific side at the same time by oceanic subduction. Probably sometime in the Paleogene and/or Miocene, a large-scale contraction of pre-existing arc crusts occurred to destruct the Creataceous or older orogenic frameworks along the eastern margin of Asia. The direct justaposition of coebval blueschists and arc granitoids by the low-angle Median Tectonic Line is smoking gun evidence for such crustal shortning/destruction of arc crust.

Keywords: Japan, Cretaceous, arc-trench system, detrital zircon, sandstone

Early Archean (3.5 Ga) zircons from serpentinite mélange of the Kurosegawa belt in western Tokyo

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Archean zircons were found for the first time from Tokyo in central Japan. Eighteen grains of them occurred from a serpentinite mélange zone of the Kurosegawa belt of SW Japan. Zircons in the serpentinite are smaller than 60 μm in diameter with black opaque mineral. Their U-Pb ages and REE pattern were analyzed by using LA-ICPMS at Gakushuin University. One grain attains ^{207}Pb-^{206}Pb age of 3,561 ±16 Ma (Early Archean), which is plotted on the Concordia Line. Other 17 grains have discordant U-Pb ages; however, their ^{207}Pb-^{206}Pb ages concentrate in a narrow range of 3.5-3.8 Ga. The grain with concordant ages has enrichment in HREE, positive Ce anomaly, and negative Eu anomaly, that are common in zircons from granitoid, whereas other grains have an order of magnitude higher REE concentration without clear Eu anomaly. These results suggest the following possible origin of the Archean zircons in serpentinite.

These zircons were likely crystallized primarily in felsic magma but not in mantle periodtite, as the grain with concordant ages preserved isotopic information of Archean felsic rocks. Other grains probably have the same origin but secondarily metamorphosed, as suggested by the loss of Pb and addition of U and REE. Two processes are possible to explain the occurrence of such extremely old zircons in serpentinite: 1) Archean meta-granitoid was tectonically mixed into serpentinite within Phanerozoic orogenic belts in shallow crust, and 2) Archean granitoid subducted into the mantle during the Archean to be mixed with mantle peridotite. The South China block, from which Japan was originated, has dominant Proterozoic crust with extremely minor Archean one. The North China Craton has both Archean and Proterozoic crusts. The studied serpentinite with Archean zircon totally lacks Proterozoic and Phanerozoic zircons, even though the serpentinite mélange in the same area contains blocks of mid-Paleozoic granitoid. This supports the second explanation. Serpentinite in subduction-related orogens represents hydrated peridotite primarily from subducted oceanic lithosphere or from the wedge mantle beneath an arc. Archean granitoid probably once subducted into the mantle and its fragments returned to crustal surface through orogenic belt for the first time in the last three billion years. More discussion is needed to explain how to mix solely older Archean continental zircons with mantle periodtite without involving much younger grains.

Keywords: zircon U-Pb age, serpentinite, Archean, Kurosegawa belt

Igneous activities of the Paleo-Kuril forearc induced by Izanagi-Pacific ridge

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The Late Cretaceous to Paleogene Nemuro Group, located in the easternmost of Hokkaido (Japan) is interpreted as a forearc basin deposit of the Paleo-Kuril Arc due to their W-E elongated shape and characteristic volcaniclastic sediments. The Nemuro Group contains different volcanic levels of adakitic and shoshonitic composition.. Shoshonitic magma generally erupts at active back-arcs and rarely at volcanic front, however and to our knowledge this is the first appearance of shoshonites in a forearc region. Because of the inconsistency between such geological setting and the petrological aspect, tectonics of the Paleo-Kuril arc-trench system are enigmatic. Here, we present the petrogenesis of those and a tectonic reconstruction of Paleo-Kuril arc based on the igneous rocks in Nemuro Group.

The shoshonitic associations occur as sills and pillow lavas. They can be divided into two groups in petrography and geochemistry. The Group 1 has higher Mg# (Mg/[Mg+Fe]) than the Group 2, which is in contrast relatively differentiated. The Group 1 mainly occurs as sills intruded into lower part of the Nemuro Group whereas the Group 2 occurs as pillow lavas and sills mainly into mid- to upper sequences of the Nemuro Group (70-54 Ma), some of which are erupted over unconsolidated sediments (i.e. interpillow sediments). It is possible to consider the Group 2 shoshonites are formed by fractional crystallization of phenocrysts in the Group 1. The adakitic association can be seen in the lowermost part of the Nemuro Group.

Here, we provide the new tectonic model for elucidating the forearc volcanism in the Paleo-Kuril Arc. Our model suggest that the adakitic igneous activity was caused by approaching of Izanagi-Pacific ridge to the Paleo-Kuril trench.

Early Paleozoic high-Mg andesites in NE China: a tectonic resemblance to SW Japan?

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A suite of high-Mg volcanic rocks (MgO=7.05-10.73%, Mg#=65-73) with silica compositions ranging from 50% to 68% was discovered in Duobaoshan area, NE China. No parental relationships existed between the basalts and andesites as andesites displayed the highest Mg# (68-73) of all and may represent the near-primary magma. The magma differentiation cannot be explained by the simple fractional crystallization process as normally thought. Detailed geochronological and geochemical studies were conducted for this suite of volcanic rocks to discuss their ages, petrogenesis and tectonic settings, which may shed new light on the geological evolution of the whole region.

NE China is the major component of the eastern segment of the Central Asian Orogenic Belt (CAOB) and recorded the long-lasting accretionary orogeny during the Paleozoic amalgamation of the Central Asia. Numerous island arcs, subduction complexes, continental margins, sea mounts and ophiolites have been discovered and reported along this belt, particularly in its western and central segment, which marks its complex and protracted accretionary history. However, in the studied area, the tectonic model remains debatable. The sampling location is at the southern border of the Xing'an block, one of the several micro-blocks composing the easternmost CAOB (others include the Erguna and Songliao blocks), and the samples are generally considered to relate with the subduction and accretion processes of the Paleo-Asian Ocean (PAO, the paleo-ocean once existed between the North China Craton and Siberia).

Two samples were selected to conduct the accurate LA-ICP-MS U-Pb zircon dating and 30 analyses were carried out for each of them. The CL imaging and measured Th/U ratios indicated the heterogeneity of the zircon sources, with both co-magmatic zircons and inherited ones. The co-magmatic zircons with euhedral morphology and relatively clear concentric zonings clustered tightly to define the approximate eruption age, which is in upper Ordovician (460 Ma and 444 Ma). The xenocrystic zircons were basically subhedral to rounded in shape without clear zonings or with metamorphic core-rim structure, and they yielded a complex profile including ages similar to 550 Ma, 0.8 Ga, 1.2 Ga, 1.8-1.9 Ga, and 2.3-2.5 Ga, which may deliver critical information from the continental crust of the Xing'an block.

All samples were plotted as calc-alkaline series in the Co-Th diagram, which was used to avoid the influence from secondary process given the relatively high L.O.I. Apart from the high Mg abundance, samples also displayed high Al compositions (Al_2O_3=15-20%). The total REE abundance was low (ΣREE=120-164ppm) and typical arc-affinity geochemical features were shown, including the slightly enriched LREE ($(La/Yb)_N$=6.8-9.3) and a lack of Eu anomaly (Eu/Eu*=0.9-1.0). The LILE and highly incompatible elements were also enriched such as Cs, Ba, Th, U, Pb and Sr, compared with the HFS (Sr/Y=18-37). The twin elements of Nb-Ta and Zr-Hf were not severely depleted, indicating the enrichment from the metasomatized upper mantle. Other characters include the highly fractionated Cs and Rb (Rb/Cs<20), subtly decoupled Th and U (Th/U=3.3-3.6), supra-chondritic ratio of Zr/Sm (31-41), which all have been experimentally proved related with the partial melting of the subducted oceanic slab with recycled sediments. This featured subduction-derived high-Mg volcanic rocks, particularly high-Mg andesites (HMAs), were also discovered in the Setouchi Volcanic Belt, SW Japan (Tatsumi, 2006). With the synthesized age and geochemical data, we suggest that the arc magmatism by the subduction of the PAO

was happening during the upper Ordovician along the southern border of the Xing'an block, and the tectonic environment probably resembled the SW Japan.

Reference:
Tatsumi, Y. (2006). High-Mg andesites in the Setouchi volcanic belt, southwestern Japan: analogy to Archean magmatism and continental crust formation?. *Annu. Rev. Earth. Planet. Sci.*, *34*, 467-499.

Keywords: Central Asian Orogenic Belt, High-Mg Andesites, Continental Arc

Continental construction in Central Asia: evaluation of juvenile vs. recycled crust and identification of Pacific-type orogens

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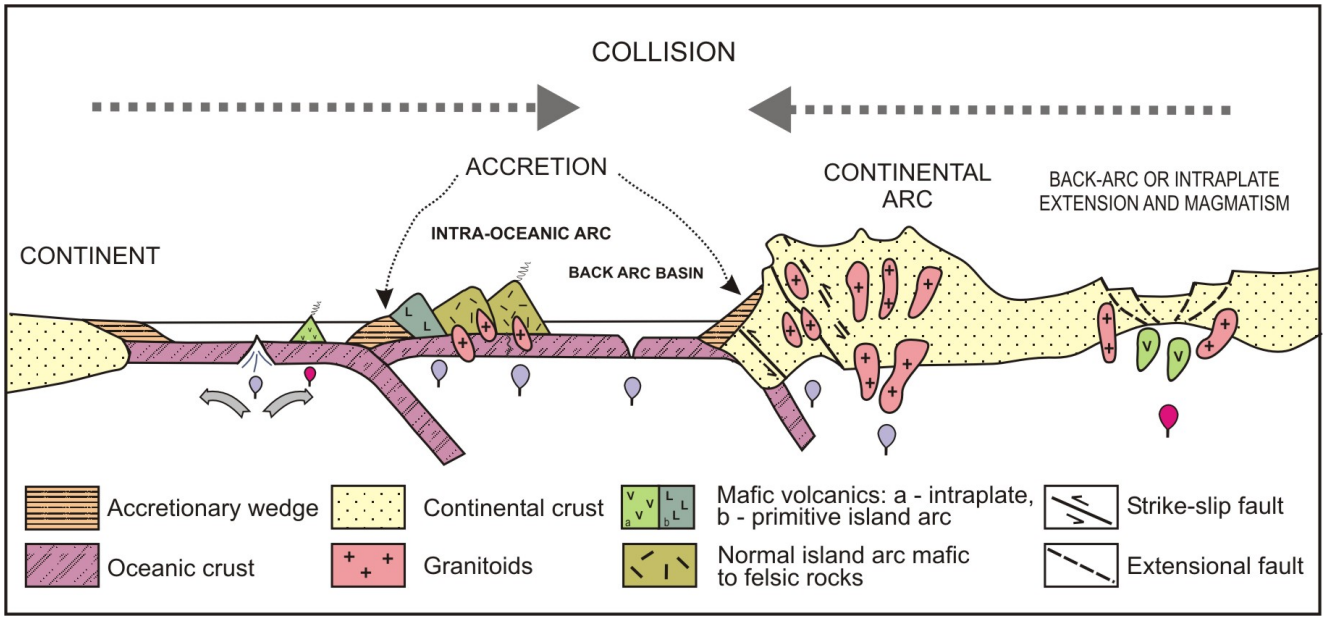
New or “juvenile” crust forms and grows mainly through mafic to andesitic magmatism at Pacific-type (P-type) or accretionary type convergent margins as well as via tectonic accretion of oceanic, island-arc and translation of continental terranes. During the last decades the juvenile or recycled nature of crust has been commonly evaluated using whole-rock isotope and Hf-in-zircon isotope methos. However, evidence for the accretionary (or P-type) nature of an orogenic belt comes from geological data, for example, from the presence of accretionary complexes (AC), intra-oceanic arcs (IOA), oceanic plate stratigraphy units (OPS), and MORB-OIB derived blueschist belts (BSB). The Central Asian Orogenic Belt (CAOB) represents the world’s largest province of Phanerozoic juvenile crustal growth during ca. 800 m.y. between the East European, Siberian, North China and Tarim cratons. From geological point of view, the CAOB is a typical P-type belt as it hosts numerous occurrences of accretionary complexes, intra-oceanic arcs, OPS units, and MORB-OIB derived blueschist belts. In spite of its accretionary nature, supported by positive whole rock Nd isotope characteristics in CAOB granitoids, the Hf-in-zircon isotope data reveal a big portion of recycled crust. Such a controversy can be explained by presence of accreted microcontinents, isotopically mixed igneous reservoirs and by the tectonic erosion of juvenile crust. The most probable localities of tectonic erosion in the CAOB are the middle and southern Tienshan and southern Transbaikalia because these regions comprise a predominantly recycled crust (based on isotope data), but the geological data show presence of intra-oceanic arcs, blueschist belts and accreted OPS with oceanic island basalts (OIB) and tectonically juxtaposed coeval arc granitoids and accretionary units. This warrants combination of detailed geological studies with isotopic results, as on their own they may not reflect such processes as tectonic erosion of juvenile crust and/or arc subduction. The works was supported by the Ministry of Education and Science, Russian Federation, grant no. 14.Y26.31.0018.

Keywords: Pacific-type orogeny, Central Asian Orogenic Belt, Ocean Plate Stratigraphy



Proterozoic cratonic fragments in western and northern Mongolia: importance in the onset of formation of the Central Asian orogenic belt

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Despite extensive work on the Paleozoic Central Asian orogenic belt (CAOB), little is known about the initiation and early stages of tectonism. The Zavkhan and Tuva-Mongolia terranes are Proterozoic cratonic fragments with Neoproterozoic to Paleozoic cover sequences that constitute majority of southwestern and northern Mongolia and record the earliest stages of tectonism in the CAOB. Here we present new geochronologic data to constrain Proterozoic to Paleozoic tectonic evolution of the two regions and propose a tectonic scenario for the initiation of orogenesis in the CAOB. Available geochronologic and lithostratigraphic data of the Neoproterozoic through Terreneuvian strata of the Tuva-Mongolia and Zavkhan terranes are similar. The ~ 2 Ga Gargan basement of the Tuva-Mongolia terranes, its overlying ~ 750 Ma Sarkhoi Group volcanics and Neoproterozoic carbonate dominated strata of the Khuvsgul Group are all comparable. We suggest that the two regions have co-evolved geologically and the areal extent of the Proterozoic cratonic fragments in western and northern Mongolia is much vaster than previously estimated. Particularly, orogenesis began around these terranes with arc accretion followed by slab reversal and accretion around Proterozoic cratonic fragments and ribbon continents, which later oroclinally bent and trapped supracrustal material between larger cratons.

Keywords: Central Asian orogenic belt, Proterozoic to Paleozoic tectonic evolution

Paleotethys born or made? Keys from subduction relics from Iran

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The tectonic processes involved in Pangea birth and death resulted in the creation and destruction of oceanic lithosphere. Remnants of the involved oceans now occur along the margins of the Atlantic, Mediterranean, Black and Caspian seas, as well as in the Alpine-Himalayan and adjacent orogens. Of those oceans, three (Iapetus, Tornsquist and Rheic) were closed during the amalgamation of Pangea and another (Neo-Tethys) is the main witness of its break-up.

However, there is an ocean, the Paleotethys, whose origin is under strong debate. Allegedly it was born during the latest stages of the amalgamation (Devonian-Carboniferous) and closed when Pangea was an “stable” supercontinent (Permian). However, Is the Paleotethys a remnant of Rheic or it opened as a new ocean? If the latter, why the Paleo-Tethys developed in a collisional area? And how? The geodynamic relationship between the ocean and the tectonic and paleogeographic evolution of Pangea are crucial.

To solve those questions is capital to found remnants of this ocean. The Shanderman eclogites, in NW Iran are a potential candidate. They are metamorphosed oceanic rocks (protolith oceanic tholeiitic basalt with MORB composition). Eclogite occurs within a serpentinite matrix, accompanied by mafic rocks resembling a dismembered ophiolite. The eclogitic mafic rocks record different stages of metamorphism during subduction and exhumation. In this talk I will show the new petrological, geochemical and geochronological results from this eclogites to shed light on the Paleotethyan problem.

Keywords: Eclogites, Iran, Paleotethys

Pangea and East Asia: With or Without you

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Pangea, the latest supercontinent, amalgamated during the Paleozoic after the colisions of Gondwana, Laurentia, Baltica and several microplates. Meanwhile an intense tectonic activity accoumpaned a series of cratons and microplates that were located in the interface between the Panthalassa and Tethyan oceans as well as along the acretionary orogens of Altaids and Terra Australis. Most of research has forgotten the role of all these areas into the supercontinent tenure and evolution, however understanding them is crucial to our understanding of the supercontinent cycle and Pangean tectonics.

Keywords: Pangea, East Asian Tectonics, Supercontinents

