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.

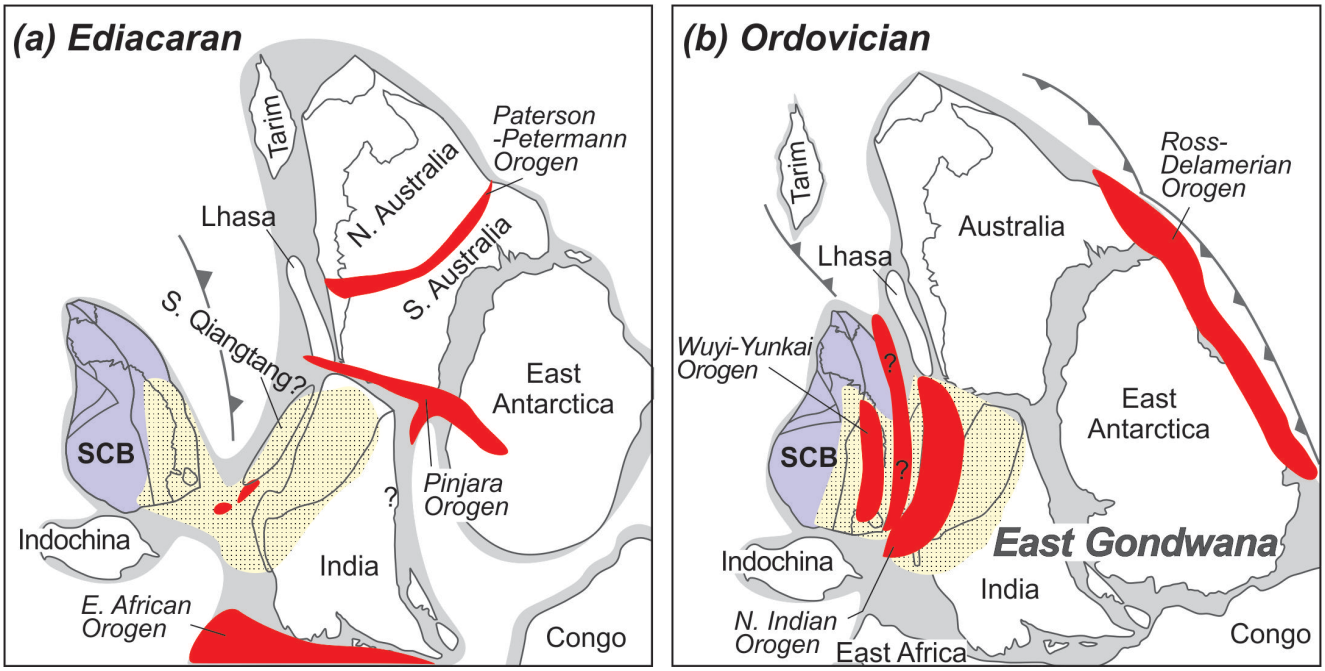
The adjacent Nanhua foreland basin started as early as the Ediacaran, and experienced a three-stage basin evolution. Stage 1: the Ediacaran–Cambrian stage, recording the start of tectonic subsidence in the basin with turbiditic siliciclastic deposition, fed by exotic orogens outboard South China; Stage 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

東京都西部、黒瀬川帯蛇紋岩からの太古代前期（35億年前）ジルコンの産出

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

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東京都日の出町の秩父帯に産する蛇紋岩より, 太古代ジルコン18粒を発見した. 同町坂本地域に狭小に露出する蛇紋岩は中期古生代の圧砕花崗岩類や青色片岩などを伴い, 四国や紀伊半島の黒瀬川帯の延長部最東端にあたる. 分離したジルコンはいずれも径60 μm以下で, 黒色不透明鉱物を包有するものが多い. 18粒のジルコンを学習院大学のLA-ICPMS によりU-Pb年代測定とREE分析を行った. 1 粒のみのU-Pb年代がコンコーディア線上にプロットされ, 3,561 ±16 Ma (太古代前期)という日本列島に産する岩石の年齢と比べて極めて古い^{207}Pb-^{206}Pb年代を持つ. その他17粒はディスコーディアな年代を示すが、^{207}Pb-^{206}Pb年代は35-38億年前という狭い範囲に集中する. コンコーダント年代を持つ粒のREEパタン(重希土類に富む, Ce正異常, Eu負異常)は典型的な花崗岩類中のジルコンのそれに類似する一方, 他の粒は1桁高いREE濃度を持ち, かつ明瞭なEu負異常を持たない. ジルコンの起源は以下のように考察される.

ジルコンは蛇紋岩の原岩であるかんらん岩中で初生的に晶出したもののではなく, おそらく珪長質マグマから晶出したと判断される. コンコーダントな年代を持つ1粒は35億年前の太古代珪長質火成岩での晶出時の情報を保持するのに対して, 他の粒子は二次的な変成作用による鉛の消失と, 外部（おそらく斜長石を含まない岩石）からのウランやREEの添加を記録すると推定される. これらが二次的に日本列島の顕生代蛇紋岩に取り込まれる過程として2つの可能性が考えられる； 1)太古代珪長質岩の一部が古生代以降の弧地殻内で蛇紋岩中に構造的に混入した, あるいは2) 太古代にマントルへ沈み込んだ珪長質岩が、かんらん岩と混在化し変成作用を受けた。 日本が起源を持つ南中国地塊には太古代前期の岩石はほとんど産さず, 原生代地殻が卓越する. 北中国には太古代地殻に加えて原生代地殻も産する. 本試料は、原生代ジルコンのみならず隣接して産する古生代中期花崗岩類由来の粒子を全く含まない. 蛇紋岩が３５億年前のジルコンのみを選択的に含むことから, おそらく後者の説明が有望である. プレート沈み込み型造山帯に産する蛇紋岩は, 海洋プレートのリソスフィアあるいはくさび状マントルのかんらん岩が加水されて、地表に露出した岩石である. 東京西部に産する太古代ジルコンは、おそらく先カンブリア時代にマントルに混入したものが約30億年ぶりに蛇紋岩を介して地球表層へ戻ってきたのであろう. このような他の年代のジルコンの混入を排除する古期大陸地殻物質のマントルかんらん岩中への混入プロセスについてはさらに考察を進める.

キーワード：ジルコンウラン鉛年代、蛇紋岩、太古代、黒瀬川帯
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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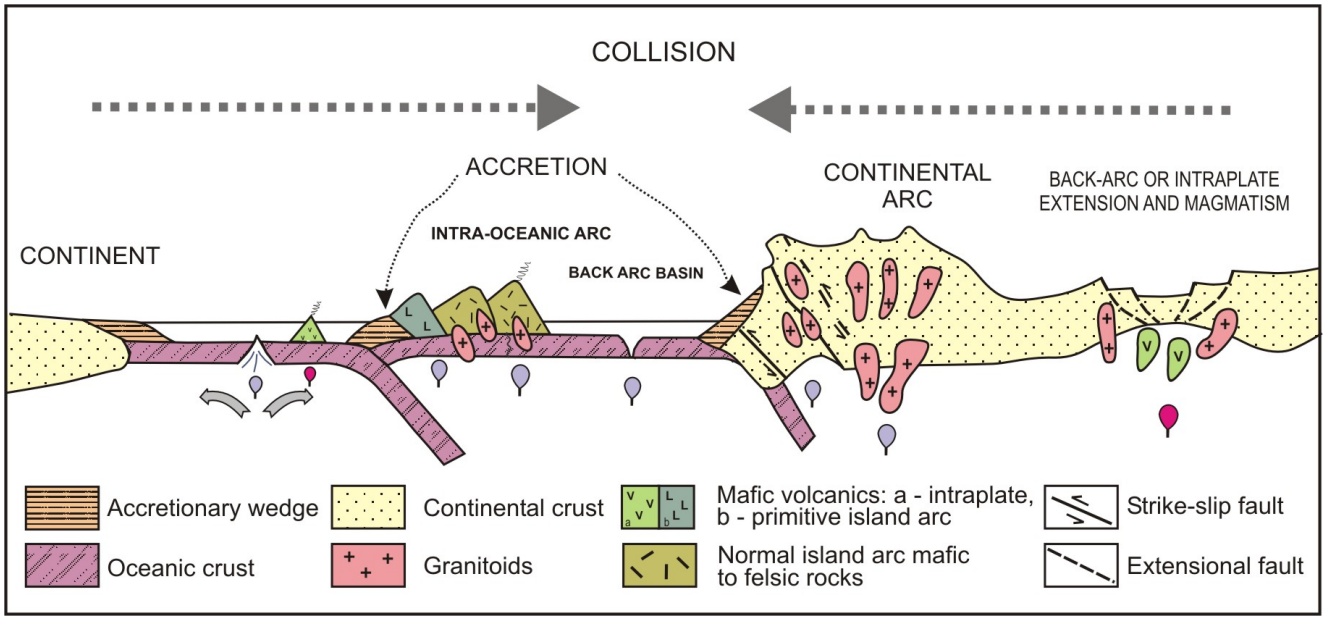
New or “juvenile” crust forms and grows mainly through mafic to andesitic magmatism at Pacific-type (P-type) or accretionary type convergent margins as well as via tectonic accretion of oceanic, island-arc and translation of continental terranes. During the last decades the juvenile or recycled nature 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

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.

キーワード：Eclogites、Iran、Paleotethys
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

