frontiers | Frontiers in Earth Science

TYPE Editorial
PUBLISHED 20 September 2022
DOI 10.3389/feart.2022.1033217

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Derek Keir,
University of Southampton,
United Kingdom

*CORRESPONDENCE
Xiubin Lin,
linxiubin1984@163.com

SPECIALTY SECTION
This article was submitted to Structural Geology and Tectonics, a section of the journal Frontiers in Earth Science

RECEIVED 31 August 2022
ACCEPTED 05 September 2022
PUBLISHED 20 September 2022

CITATION
Chen H, Lin X, Zuza AV, Wu L, Wei S and Sternai P (2022), Editorial: Continental basin and orogenic processes: Deep structure, tectonic deformation, and dynamics.
Front. Earth Sci. 10:1033217.
doi: 10.3389/feart.2022.1033217

Editorial: Continental basin and orogenic processes: Deep structure, tectonic deformation, and dynamics

Hanlin Chen[1], Xiubin Lin[1]*, Andrew V. Zuza[2], Lei Wu[1], Shengji Wei[3] and Pietro Sternai[4]

[1]Key Laboratory of Geoscience Big Data and Deep Resource of Zhejiang Province, School of Earth Sciences, Zhejiang University, Hangzhou, China, [2]Nevada Bureau of Mines and Geology, University of Nevada, Reno, NV, United States, [3]Earth Observatory of Singapore, Nanyang Technological University, Singapore, Singapore, [4]Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milan, Italy

KEYWORDS

continental basin and orogenic processes, stratigraphy, structural deformation and tectonic evolution, geophysical architecture and geodynamics, physical and numerical modeling

Editorial on the Research Topic
Continental basin and orogenic processes: Deep structure, tectonic deformation, and dynamics

Continental basin and orogen systems result from interactions among active (or previously active) plate boundaries, relatively stable and usually rigid continental interiors, and deep mantle tectonics, with deformation sometimes distributed far into the plate interior. These systems are rich in mineral and hydrocarbon resources, and their structure, tectonic evolution and dynamic processes provide important information to understand how plate tectonics along plate margins exerts an influence in continental interiors. To better understand continental basin and orogen systems, we have gathered 23 papers in this Research Topic that report on recent advances in 1) stratigraphy, 2) structural deformation and tectonic evolution, 3) geophysical architecture and geodynamics, and 4) physical and numerical modeling.

Stratigraphy

Guan et al. investigated the petrography, heavy mineral content, conglomerate component, and detrital zircon U-Pb geochronology of late Mesozoic sediments in the southern Junggar Basin, northwest China, to establish its tectonic and climatic evolution. They observed a significant change from a paludal deltaic and fluvial deposition to an alluvial and aeolian setting in Late Jurassic, which was interpreted as a result of aridification. Detrital zircon U-Pb geochronology analysis showed that the Tian Shan and Bogda orogenic belts shed sediments to southern Junggar Basin during Late Jurassic to Early Cretaceous, suggesting uplift of the orogenic belts at this time, which likely resulted from far field effect of accretion of Lhasa terrane onto the Eurasia Continent. Based on existing seismic, gravity, radar, and magnetic data, in combination with the subglacial bedrock relief from the BEDMACHINE project, Baranov et al. established an updated map of the sediment thickness in Antarctica. Their results showed that West Antarctica has wide sedimentary basins with depositional thicknesses of ~2–12 km, whereas East Antarctica develops shallow basins with merely ~2–7-km thick sedimentary deposits. They proposed that the sedimentary thickness depends on the degree of crustal extension, which is larger in West Antarctica than East Antarctica. These results shed new light on the basin stratigraphic evolution and its governing mechanisms in Antarctica.

Structural deformation and tectonic evolution

Li et al., using the area balancing technique and geometrical relationships, developed a 2D model to calculate the pore space of fractures associated with fault development. They proposed that the development and distribution of fault detachment voids or fault fracture pore space are controlled by the physical properties of the deforming medium, mechanics of deformation, and geometry of a fault-ramp structure. Their theoretical model gain supports from natural cases in the Daba Shan foreland fold-and-thrust belt in the Southern Qinling Orogen, China. Based on interpretations of seismic reflection profiles, Neng et al. analyzed an intraplate strike-slip fault system in the Tarim basin, northwest China. They showed the structural characteristics of the strike-slip fault system in both cross-section and planar views, and further analyzed its evolution and forcing mechanisms. These two papers show significant progresses in the quantitative prediction of fractures, particularly valuable for hydrocarbon exploration and development.

To understand intracontinental deformation across the North China Craton in response to tectonic processes along its plate boundaries, Yang et al. performed geological investigations and fault-slip vector analysis of the Shanyi Basin, north China. They observed three phases of deformation in the basin, including Late Jurassic to earliest Cretaceous NW-SE contraction, middle-late Early Cretaceous NW-SE extension, and post-110 Ma NE-SW contraction. They suggested that the main structural architecture of the basin is dominated by the first phase, i.e., the NW-SE contraction in Late Jurassic to earliest Cretaceous. They attributed these three phases of deformation to the subduction of Paleo-Pacific plate to the east and closure of the Mongol-Okhosk Ocean to the north, destruction of the North China Craton possibly linked to roll-back of the Paleo-Pacific subducted plate and post-orogenic collapse of the Mongol-Okhotsk belt, and the collision between the Qiangtang and Lhasa terranes, respectively. Chang et al. analyzed the Meso-Cenozoic paleo-tectonic stress fields of the Kexueshan Basin along the northwestern Ordos block, north China. They observed Middle Jurassic, NE-to NNE-trending folds and thrust faults superimposed by late Cenozoic, NW- to NNW-trending folds, with the former attributed to a combined influence of southward convergence of the Siberian block and northwestward subduction of the Paleo-Pacific plate, while the latter to northeastward growth of the Tibetan Plateau.

Based on outcrop investigation and analysis of seismic reflection profiles, Zhao et al. identified five Mesozoic unconformities in eastern Heilongjiang Province, northeast China. They attributed these unconformities to the Mongol-Okhotsk suturing to the north and the subduction of the Paleo-Pacific plate to the east. Zhang et al. investigated the disruption of the Dasanjiang unified basin, northeast China, by using fission-track thermochronology. The results showed three stages of exhumation at ~100–90 Ma, ~73–40 Ma, and ~23–5 Ma, respectively. They proposed that these uplift/exhumation events disrupted the initially unified Dasanjiang basin into isolated basins. By comparing these events with the Paleo-Pacific subduction, they suggested that the varying speed, direction and subduction angle of the Paleo-Pacific plate caused the formation and destruction of the Dasanjiang unified basin. To establish the relationship between supradetachment basins and metamorphic core complexes, Sun et al. analyzed the stratigraphy and structural geology of the Fuxin basin in northeast China. They divided the stratigraphy into syn-rift volcanic sedimentary and post-rift clastic rock sequences. The basin evolution is characterized by four stages (i.e., proto-rift, fault subsidence, transition, and compression), whereas the Yiwulvshan metamorphic core complex underwent an earlier faulting-dominated stage and a later exhumation stage. They proposed that the rollback of the Paleo-Pacific plate and retreat of the subduction trench governed the evolution of this rift and metamorphic core complex system. Li et al. analyzed seismic reflection profiles and outcrops along southern Tarim Basin in northwest China, and identified Late Triassic compressional and Jurassic-Cretaceous extensional structures. They attributed the compressional structures to the collision between North Qiangtang and Tarim terranes, while the extensional ones to post-collision extension of the Paleo-Tethys evolution. These six studies demonstrate that the tectonics along plate margins exerts a decisive role in shaping the intracontinental basin structures and governing their evolution.

Besides these studies, another two papers addressed the initial formation of intracontinental orogens. To investigate the accretionary processes and continental growth of the Altaids in middle Asia, Mao et al. conducted comprehensive analyses of lithology, geochemistry, chronology and structural mapping of the Huaniushan complex in the Beishan orogen along the southern Altaids. The results revealed a prolonged subduction history of the Liuyuan Ocean from late Mesoproterozoic to late Triassic (~1,071–234 Ma), with a series of seamounts and/or oceanic plateaus emplaced onto the Liuyuan accretionary complex. Abuduxun et al. investigated the geochemistry and geochronology of A-type granitoids from South Tianshan along southern Altaids. They proposed that these ~298–272 Ma A-type granitoids resulted from a high-temperature gradient in a subduction-related extensional setting, possibly triggered by southward rollback of the South Tianshan oceanic lithosphere and upwelling of asthenospheric mantle. These results indicated a broad magmatic arc in the southern active margin of the Yili-Central Tianshan in the Permian. These two studies show these intracontinental orogens were initially formed in a plate-margin setting.

Geophysical architecture and geodynamics

To investigate the thermal structure of the Tarim craton in northwest China, Xu et al. analyzed the aeromagnetic dataset and calculated the Curie point depth (CPD). They observed a minimum magnetic CPD zone in NW Tarim craton that they attributed to the Permian Tarim plume-lithosphere interaction. They also suggested that the transition zones of the CPD surfaces play a significant role in controlling present seismic activities. To investigate the effect of reservoir water load on earthquakes, Wu et al. carried out density structure analysis in the Zigui Basin of the Three Gorges area, middle China, by using 3D gravity inversion method. The results, combined with focal mechanism solutions of earthquakes, led them to infer that the ~5–10 km depth of the basin partly comprise limestone that has a chance to be dissolved and subsequently triggers earthquakes. These two papers establish a link between the deep geophysical architectures and the seismic activities.

Kuang et al. used magnetic gradient-processing methods to map the location of basement faults in eastern Tarim Basin, northwest China. The results in combination with seismic reflection profiles revealed that the Tarim Central Highly Magnetic Anomaly Belt was mainly caused by the Archean crystalline basement; while the Northeastern Mangal Domain was equipped with a Neoproterozoic rifting-modified Archean crystalline basement that was originally the same as the Central Tadong Domain. The weakly magnetic Southeastern Domain was inferred to be sutured to the highly magnetic Central Tadong Domain along the Tadong South Fault during the Paleoproterozoic. Zheng et al. obtained the magnetic and gravitational structures of West Junggar along southwestern Central Asian Orogenic Belt (CAOB) by integrating aerial magnetic-gravity data. They observed a prominent Bouguer gravity high between the Darbut and Karamay-Urho faults that was interpreted to be a trapped oceanic slab. The Tacheng Basin, characterized by high-frequency magnetic signals and gravity highs, was interpreted to be a back-arc basin. These results provided a renewed tectonic model consisting of trench-arc-basin system related to the fossil Late Paleozoic intra-oceanic subduction. Chang et al. investigated the crustal structures of the eastern CAOB by an integrated magnetic-gravity analysis. The results revealed the upper crustal Chifeng-Baiyan Obo fault bounding the CAOB from the North China Craton to the south. This boundary extended northward to the Xar Moron fault in the middle and lower crust. They speculated unexposed Mesozoic granites extensively in the mid-lower crust along the Solonker suture zone. Lei et al. analyzed the magnetic structures of the Longmenshan fault zone and surrounding regions, southwest China. The results showed that the Longmengshan fault zone displayed as a transition zone between the positive anomalies in the Sichuan Basin to the east and the negative anomalies in the Sonpan-Ganzi fold belt to the west. Han et al. investigated the crustal structure and anisotropy of the Middle-Lower Yangtze Metallogenic Belt (MLYMB) in south China by teleseismic receiver functions in combination with previous velocity structure. The results revealed a ~2–4 km uplifted Moho and relatively high Poisson's ratio, which were consistent with predictions of underplating model. They suggested that the significant local anisotropy of the MLYMB and the Dexing porphyry copper deposit was a result of upwelling and underplating of mantle-derived materials or local lateral ductile shear in the lower crust. The consistent NE-SW fast polarization direction and the SKS splitting results indicated coupling deformation in a lithospheric scale. These four studies demonstrate that the lithospheric architectures formed by previous tectonics can last for a long time and exert a significant role in later tectonics and metallogenesis.

Another study by Zhao et al. shows the lithospheric architecture is decisive in controlling the geodynamics of the modern intracontinental tectonics. They used inversion method to obtained the magnetic and electrical structures of the Songpan-Aba terrane and surrounding areas via analyzing magnetic and magnetotelluric data. They observed a low-resistance and weakly magnetic zone below ~20 km in the West Qinling, Songpan-Aba, and Longmenshan areas, which they attributed to the molten crustal materials that extruded from the eastern edge of the Tibetan Plateau. These results are significant in understanding the mechanism of the uplift of the eastern Tibetan Plateau.

Physical and numerical modeling

Physical and numerical modeling is useful in determining the geodynamics of intracontinental tectonics. To investigate the factors that control the tectonic evolution of the Yinggehai Basin in south China, Liu et al. performed sandbox analog experiments with conditions of a preexisting basal velocity discontinuity boundary, rotation of crustal blocks, and syntectonic sedimentation. The modeling produced two-phase evolution of the Yinggehai Basin, with an early phase of deformation characterized by nucleation of the main internal faults above the velocity discontinuity boundary and segmented en echelon border fault systems, and a late phase of deformation localized along the boundary and secondary internal faults. Similarities between the modeling results and the natural case led them to propose that transrotational tectonics governs the evolution of the Yinggehai Basin. Chen et al. successfully reproduced the spatiotemporal development of the fold-and-thrust belts in Jiudong Basin northeast Tibetan Plateau by using 2D elastic-plastic numerical finite element modeling. The results demonstrated that different geometries and materials will produce different deformational sequences, such as in- or out-of-sequence deformation. These results provided geodynamic explanations for the growth of the mountain ranges along the NE margin of the Tibetan Plateau. Chen used 2D numerical models to investigate the role of the lower crust rheology in lithospheric delamination during orogeny. He observed that delamination occurs only if the lower crust rheology of the orogen is represented by the weak end-member flow law. With these results, he suggested that the subvertical high-velocity mantle structures in southern and western Tibet may exemplify localized delamination of the mantle lithosphere due to rheological weakening of the Tibetan lower crust. These three studies show how boundary conditions govern the tectonics.

Author contributions

XL wrote the manuscript. HC, AZ, LW, SW, and PS revised the manuscript.

Funding

This Research Topic is supported by the Second Tibetan Plateau Scientific Expedition and Research of China (2019QZKK0708), the National Natural Science Foundation of China (Grants 41720104003 and 41972217), and the Fundamental Research Funds for the Central Universities of China (Grants 2021XZZX005, 2019FZA3008, and 2019QNA3013).

Acknowledgments

We appreciate the efforts of the Editorial Office in facilitating the development of this Research Topic. We are grateful for all the reviewers for their comments that significantly improve these contributions.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note