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Editorial: Tectono-magmatism, metallogenesis, and sedimentation at convergent margins

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Editorial on the Research Topic
Tectono-magmatism, metallogenesis, and sedimentation at convergent margins

Convergent plate margins are key regions for material and energy recycling between surface and interior Earth reservoirs, and are major sites for continental growth, reworking, and destruction. The type, geometry, and thermal structure of subduction zones have critical impacts on subduction processes and the nature of magmatic products that formed in the overlying arc, which produces a wide range lithologies and associated ore deposits at convergent margins. Identification and characterization of the physical and chemical processes that occur at convergent margins, alongside correlating these effects with specific subduction types and stages, are crucial to understand spatiotemporal interactions between the crust, lithosphere, and asthenosphere in orogenic belts.

The geodynamic evolution of crustal and mantle components at convergent margins involves multiple processes that operate over discrete time and length scales. Recent advances in computational and analytical capability have allowed a growing body of new techniques to emerge that can unveil these geological processes in new and unprecedented detail. This Research Topic aims to bring together multi-disciplinary and state-of-the-art studies on the applications of geochronology, geochemistry, isotopic analysis, numerical modeling, machine learning, and big data to scrutinize the dynamics and effects of all stages of the Wilson Cycle, including subduction initiation, subduction zone processes, and continental collision.

Subduction initiation at continental margins

The geological mechanism that promote subduction initiation remain uncertain, despite decades of study. Numerical modelling is fast-becoming a critical tool that can be used to study this process. Candioti et al. focused on horizontally forced subduction zone initiation at passive margins and quantify the horizontal force required for subduction zone initiation with two-dimensional petrological-thermomechanical numerical models. Interestingly, the modelling shows a causal link between subduction zone initiation and slab detachment. If forces required for subduction zone initiation are smaller, then the lithosphere is weaker and then slab detachment occurs at shallower levels and corresponding slabs are shorter.

In a separate study, Li et al. evaluated the influence of strike-slip motion on the effective strength of incipient margins and the ease of subduction initiation using computational models. Models suggest that subduction initiation can be triggered when margins become progressively weakened to the point that the resisting forces become smaller than the driving forces. Despite not being a governing factor, strike-slip velocity can still dramatically lower the force required to induce formation of a new plate margin, thereby providing a favorable condition for subduction initiation.

Magmatism at convergent margins

Teng et al. investigated a series of plutonic rocks that formed in Huatugou, situated in the inner part of the Qaidam Block. These intrusions were formed in two stages: early granodiorites formed at 451 Ma and display geochemical features of adakitic rocks, and thus were likely generated by partial melting of the thickened lower mafic crust, and were followed by later S-type muscovite granites (410 Ma) and A_2-type monzogranites (400 Ma). These authors infer that the Qaidam Block was composed of thickened continental crust during subduction, until the detachment of subducted crust during the continental collision.

Tian et al. presented a comprehensive analysis of the geochronology, whole-rock geochemistry, clinopyroxene mineral geochemistry, zircon Ti crystallization temperature, and gabbro magma temperature and pressure in the Yushigou ophiolite of the North Qilian orogenic belt. New data shows that the gabbro in the Yushigou ophiolites has zircon U-Pb ages of 519 to 495 Ma, and exhibits dual characteristics of MORB and IAT, suggesting that it may have formed in a back-arc basin environment.

Yogibekov et al. reports the petrography, geochronology, and geochemistry of Cretaceous granites and diabase dikes that intrude into the Pshart complex. The granites are highly fractionated, strongly peraluminous S-type granites with zircon U-Pb ages of 124–118 Ma. The diabase dikes contain low SiO_2, high MgO, and negative Nb and Ta anomalies, which were interpreted to record partial melting in an extensional environment. These units formed in a post-collisional environment after the final closure of the Rushan–Pshart Meso-Tethys Ocean.

Sedimentation at convergent margins

Mao et al. conducted structural mapping, geochemistry and geochronology on various lithologies within the Kanguer subduction complex, Haluo, eastern Tianshan. New analytical data from Upper Permian (257 Ma) basaltic blocks emplaced in a sandstone matrix in the northern Haluo area show N-MORB signatures, and geochronological results indicate that the sandstone matrices display two different provenance. All mélanges and coherent units in the north of the study area belong to an accretionary complex of the Dananhu intraoceanic arc, and those in the south belong to an accretionary complex of the Yamansu-central Tianshan arc.

Yang et al. performed stratigraphic and geochronologic studies to establish a chronostratigraphic framework of the western Junggar Basin, in order to better understand the evolution of the Juggar Ocean. The southern West Junggar region experienced three stages of an extended tectonic-sedimentary evolution: oceanic subduction, slab roll-back and intra-continental setting. This new model constrains closure of the Junggar Ocean during the Late Carboniferous.

Wakabayashi performed restoration of post-subduction dextral faulting to evaluate the spatial distribution of units of the Franciscan subduction complex of California. The Franciscan subduction complex exhibits significant along-strike variation, reflecting along-strike differences in the history of accretion, non-accretion, and subduction erosion, and likely slab dip. Two segments 830 km apart record subduction erosion associated with low-angle subduction events that took place at ca. 120 Ma and ca. 80–70 Ma in the north and south. Between these segments the subduction complex records net accretion from ca.175–12 Ma, but includes horizons recording non-accretion. These new results demonstrate the strong variations that may occur along strike in a single subduction zone.

Wang et al. propose a biomarker method using C_{20}-C_{21}-C_{23} tricyclic terpanes (TTs) as a tracer, and developed a discrimination diagram for environmental identification. Based on the analysis of 271 C_{20}-C_{21}-C_{23}TT data from 32 basins in 18 countries, a relationship between C_{20}-C_{21}-C_{23}TT abundance patterns and depositional environments were observed. This relationship was attributed to the control of depositional environments on the input proportions of plankton and terrigenous plants. The validity of this C_{20}-C_{21}-C_{23}TT biomarker method is well demonstrated by the rock samples with typical environmental indicators.

Deformation at subduction margins

Ninis et al. investigated tectonic uplift across the southern Hikurangi subduction margin, Aotearoa New Zealand, during the past ~200 ka, in order to understand the mechanisms driving permanent vertical displacement. Using shore platform elevation data and corresponding attitudes, together with the formation age of these shore platforms, uplift rates have been calculated across the southern Hikurangi subduction margin–since the Late Pleistocene. These results highlight the complex processes that drive uplift in subduction settings, and demonstrate the important contribution that upper-plate faults can make to such uplift.

Other papers in this Research Topic

Domel et al. examined the short-duration events (SDEs) over a 10-month period at an active seepage site on Vestnesa Ridge, a continental margin located in West Svalbard. The results indicate that both tremors and SDEs in such geological settings show a periodic behavior. Signal periodograms show that SDEs have periodic patterns related to solar and lunar cycles, while the periodicity analysis of tremors shows a different pattern, likely caused by the effect of tidally controlled underwater currents on the instrumentation.

Yang et al. provided a method with combined use of in-reservoir geological records to rapidly identify oil-reservoir destruction, using the Yanchang Formation in the Ordos Basin as an example. Petrological and geochemical of sandstones from the Yanchang Formation were studied. They proposed that the oil-reservoir destruction was likely caused by the uplift-induced erosion and the fault activities after oil accumulation during the Late Early Cretaceous.

Author contributions

MW: Writing–original draft. RP: Writing–review and editing. DL: Writing–review and editing. JY: Writing–review and editing. PW: Writing–review and editing.

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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.

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