Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22866

Establishment of modern plate tectonic regime and modern Earth system during Gondwana assembly

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Plate tectonic regime drives the recycle and exchange of elements and energy between solid Earth and surficial environs, therefore sustaining a habitable Planet Earth, but Earth was not born with Plate tectonics. The evolution of plate tectonics initiated at some time in the Archean and evolved from warm subduction to possible stagnant in the Earth's middle age, and finally to cold and deep type subduction. In particular, during the Rodinia breakup and Gondwana assembly, extensive low thermobaric ratio (T/P) ultra-high pressure metamorphic rocks occurred, along with a global tectonic re-organization at ca. 530~520 Ma. These geological evidences indicate widespread cold and deep subduction occured at this age range. Moreover, numbers of passive margins, thermobaric ratios, mean zircon Hf-O values also reached the highest or lowest values at the same time, suggesting a peak of subduction flux. Therefore, lithosphere evolution proxies indicate that modern type plate tectonic regime likely established during Gondwana assembly. Moreover, establishment of modern plate tectonic regime led to the formation of unprecedently high super-mountains during Gondwana assembly, and thus increased surface erosion rates that supplied massive nutrition to the oceans and enhanced organic carbon sequestration, improving ocean photosynthesis productivity and thus responsible for the Neoproterozoic Oxidation Event (NOE). In addition, high subduction flux also increased tectonic degassing rate, which facilitated productivity and the NOE as well. Therefore, both orogeny related erosion and carbon cycle contributed to the NOE and a more habitable Earth, eventually leading to the Ediacaran and early Cambrian life explosion events. Therefore, the Earth's climate and environment at this time became gradually analogues to modern Earth, with almost all branches of animals occurred, building a multiple cycle closely coupled and life flourished modern Earth system. This research is funded by the NSFC grants (42322208 and 42072264), National Key R&D Program of China (2022YFF0802700 and 2023YFF0803604), Hong Kong RGC GRF (17307918 and 17308023) and Internal Grants for HKU Faculty Start-up Fund (000250348).

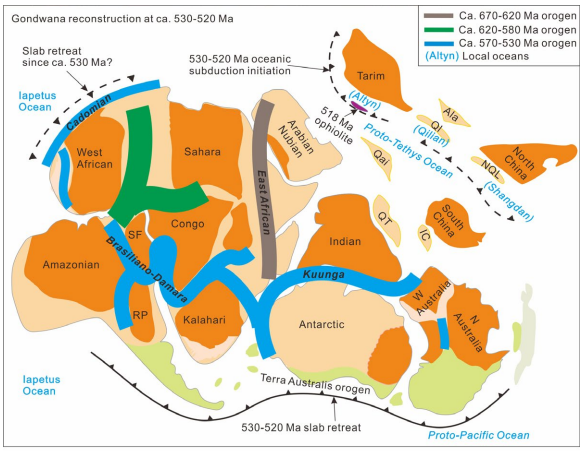

Fig. 1 Reconstruction of Gondwana and subduction zones in its margins

References:

[1] Yao JL, Cawood PA & Zhao GC et al. Mariana-type ophiolites constrain the establishment of modern plate tectonic regime during Gondwana assembly (2021), Nature Communications 12, 1489.