



Activity Report 2024 – Task Forces / Coordination Committees

Project Title: Formation, character, history, and behavior of Earth's oldest lithospheres (2023-2027)

Project No.: 2023-TF1

PI(s): Chair: T. Kusky, China and T. M. Harrison, USA;

1. Highlights of recent ILP Task Force work/results

In 2024, our ILP Task Force achieved significant progress across multiple directions. Timothy Kusky published 14 papers in top journals like *Science*, *Geology*, *EPSL*, and *Earth-Science Reviews*, with 7 as first or corresponding author. T. Mark Harrison published an important philosophical look at our science in the *Journal of the Geological Society* entitled “We don't know when plate tectonics began“ (<https://doi.org/10.1144/jgs2023-212>). Many of our other members have also been active with numerous papers published in many journals. The academic exchanges of our Task Force have been very active. Timothy Kusky chaired a session at IGC 2024, delivered six keynote talks at academic conferences, and engaged in collaborative visits to institutions including Curtin University, Melbourne University, Peking University, the Chinese Academy of Geological Sciences, and so on. The summary of several important academic achievements funded by this project in 2024 is as follows:

1) *Archean Tectonics*: Our group identified the Mulgandinnah Shear Zone Complex in the Pilbara Craton as the oldest known remnant of an arc-slicing transform fault, providing key evidence for horizontal plate tectonics in the Mesoarchean Pilbara Craton, reflecting the operation of modern-style convergent plate boundary processes in the Mesoarchean. This work was published in *Geology* (Aldoud, A., **Kusky T.M.***, Wang L. 2024. *Geology* 52(11): 801–806. <https://doi.org/10.1130/G52360.1>).

2) *Archean Orogens*: Our group reported a dramatic inverted metamorphic gradient across an Archean suture zone within the Zanhuang massif of the North China Craton. This inverted metamorphic gradient were documented to be formed during emplacement of thrust sheets during an Archean arc/continent collision, accommodating horizontal transport of at least hundreds of kilometers 2.5 Ga. This finding highlights similar convergence rates and thermal structure of orogens between Archean and modern examples. This study was published in *Earth and Planetary Science Letters* (Zhong, Y.T., Stuwe, K., **Kusky, T.M.***, et al. 2024. *Earth and Planetary Science Letters* 651: 119121. <https://doi.org/10.1016/j.epsl.2024.119121>)

Proposals: Key members of the ILP 2023-TF1 team submitted one major Key Project proposal to the Chinese NSFC on the study of Hadean and Eoarchean rock and mineral records to test early Earth's habitability. The proposal passed the reviews, and we were asked to defend the proposal, but failed at that step, with encouragement to re-submit for 2025.

2. Presence at international meetings/workshops (this year)

1) **Kusky, T.M.**, Integrating field-based structural and map data with big data geochronological and geochemical datasets to aid interpretation of Archean tectonic style. The 2nd National Symposium on Data-Driven Earth Science Development, Sept. 7-9, 2024, Beijing.

2) **Kusky, T.M.**, and Şengör, A.M.C., 2024. Comparative orotomy of the Archean Superior, North China, and Phanerozoic Altaid orogenic systems architecture, DEEP 2024, International Symposium on Deep Earth Exploration and Practices, Oct. 22-24, 2024, Beijing.

3) **Kusky, T.M.**, and Şengör, A.M.C., 2024. Comparative orotomy of the Archean Superior, North China, and Phanerozoic Altaid orogenic systems, International Geological Congress, Session on Deep probing of 3D-4D lithospheric architecture and metallogenic processes, August 25-31, Busan, South Korea.

4) Wang, L. (Sub-group leader), Hu, W., Zhong, Y., Ning, W.B., **Kusky, T.M.**, Evidence for large scale horizontal movement and deep subduction recorded within an ophiolitic mélangé reveal modern-style plate tectonics operated in the late Archean. DEEP 2024, International Symposium on Deep Earth Exploration and Practices, Oct. 22-24, 2024, Beijing.

5) Tao Wang, **Kusky, T.M.** (conveners), Lithospheric architecture, deep Earth material probing, and metallogenesis, Session 8, International Symposium on Deep Earth Exploration and Practices, Oct. 22-24, 2024, Beijing.

3. Important publications of ILP Task Force members (max. five)

The following papers was authored by our ILP Task Force members and acknowledge support by this project:

- 1) Aldoud, A., **Kusky T.M.***, Wang L. 2024. Is the Mesoarchean Mulgandinnah shear zone, Pilbara Craton, the world's oldest arc-slicing transform fault? *Geology* 52(11): 801–806. <https://doi.org/10.1130/G52360.1>
- 2) Zhong, Y. T., Stuwe, K., **Kusky, T.M.***, Hauzenberger, C.A., Schorn, S., Wang, L. 2024. Inverted metamorphic gradient in the Zhanhuang nappe/thrust system, north China indicates large-scale thrust stacking in an Archean Orogen. *Earth and Planetary Science Letters* 651: 119121. <https://doi.org/10.1016/j.epsl.2024.119121>
- 3) Sotiriou, P., Polat, A., **Kusky, T.M.**, Windley, B.F., Frei, R., and Yang, X.M., Geochemistry of Archean anorthosite-bearing layered intrusions, *Earth Science Reviews*, 249. 104654. <https://doi.org/10.1016/j.earscirev.2023.104654>
- 4) Dong, Z.Y., Deng, H., **Kusky, T.M.**, Polat, A., Peng, G.L., Zhang, H., Wang, L., and Wang, J.P., Growth of the Central Orogenic Belt, North China Craton through accretion of different Neoproterozoic arc terranes, *Precambrian Research*, 412, 107555. <https://doi.org/10.1016/j.precamres.2024.107555>
- 5) Jiang, K., Wang, J.P., **Kusky, T.M.**, Polat, A., Huang, B., Wang, L., Deng, H., and Peng, Y.Y., 2024. Genesis of Archean to Paleoproterozoic banded iron formations in the North China Craton: Geological and paleoenvironmental implications, *Earth-Science Reviews* 250, 104710 <https://doi.org/10.1016/j.earscirev.2024.104710>

4. New contacts (this year)

Gideon Rosenbaum, University of Queensland, Australia

Sandra Piazzola, University of Leeds, UK

Craig O'Neill, Queensland University of Technology, Australia

5. Usage of ILP funding (this year)

This year, our program partly funded our ILP team members collaboration visits to Curtin University and University of Melbourne, establishing new research collaboration plans and proposals, with a the field investigation in Pilbara Craton, Australia. In addition, the taskforce leaders (T.M. Kusky, T.M. Harrison, Lu Wang) took a group of students and young professors for field work and sampling of key outcrops in the Muzidian gneiss complex of the Dabie Shan of southern China, which has been recently reported to have the potential existence of Eoarchean rocks. Work is underway to test this hypothesis and its significance.

Our program has funded 6 articles, all of which have been published in top geological journals such as *Geology*, *EPSL*, *Earth-Science Reviews*, and all of which acknowledged this program. Remaining funds will be carried over to 2025.

6. Activities planned for 2025

Our ILP Task Force is organizing an international meeting on Early Earth dynamics and early lithospheres, and a field excursion in North China for May of 2025, in conjunction with several other organizations. We are currently planning to have an ILP 2023-TF1 get together at the EGU meeting in Vienna. We will re-submit our proposal on Hadean and Eoarchean Earth habitability to NNSFC.

Field work is planned for collecting detrital Hadean/Eoarchean zircons from Brazil (Harrison) and continued work on the Mesoarchean Pilbara craton, with the ILP 2023-TF1 organizing a field trip to be attended by many of the world's experts on the Pilbara, all with different interpretations of the geological relations. The trip will be followed or preceded by presentations by the participants. Participants will pay their own expenses.