Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.22876

Machine learning reveals sediment-derived granite in Hadean: implications for early Earth tectonics and habitability

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Due to the scarcity of rock samples before 4 billion years ago (Ga), Jack Hills zircon, Earth's oldest material, is the key materials to uncover the mystery of the provenance of Hadean magma. By searching for the first occurrence of "S-type" detrital zircon sourced from sediment-derived (S-type) granite, closely related to continental collision, orogeny, and crustal thickening critical insights into the operation of Hadean plate subduction could be gained. However, traditional use of trace elements and isotopes to fingerprint the source of the Jack Hills zircon has reached contentious conclusions. Here, we thus developed a machine learning classifier to recognize S-type zircon, especially low-P S-type zircon, because low-P zircon accounts for >95% of Hadean–Archean detrital zircon. With a high accuracy of 96%, we demonstrate not only the abundant existence of Jack Hills S-type zircon, but also supercontinent-like cycles of global S-type zircon proportion since Hadean. Our observations imply that a considerable amount of sediments are reworked into the magma sources of the Jack Hills zircons through the early operation of both subaerial weathering and plate subduction. This implication suggests that early Earth was strikingly akin to modern Earth in terms of active tectonics and habitable surface conditions.