

Earth's habitability regulated by deep processes

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Earth is the only habitable planet in the solar system with life, and investigating its development processes, driving factors, and mechanisms of Earth's habitability is crucial for predicting the future of our planet. The earth has two major characteristics that distinct itself from all the inhabitable planets: one is that it has an active interior, and the other is that it has plate tectonics, where the former is a prerequisite for the latter. The energy related to the convection, cooling and exothermic processes of the core and mantle is about 34-66TW, which supports the operation of the entire plate tectonic system. Once the energy inside the earth is exhausted, the plate tectonics will cease accordingly. From the perspective of material composition, more than 90% of elements such as carbon, hydrogen, and oxygen that have a decisive impact on the habitable environment on the surface are essentially stored in the deep earth. Therefore, a slight "turbulence" in the deep earth will profoundly affect the earth's surface system, resulting in deformation and metamorphism, resource enrichment, and dramatic changes in climate and environment on the geological time scale. The dynamism of Earth's interior not only directly leads to the development of deep megastructures such as the large low shear velocity provinces of the core-mantle boundary and the core engine, but also gives rise to a series of major events in geological history as the primary driving force, such as the growth of continental crust, the initiation of plate tectonics, continental aggregation and breakup, Great Oxidation Event, Snowball Earth, large igneous provinces, life explosions, and mass extinctions. Therefore, the deep earth is the operation engine of the entire earth system. Only by grasping this crucial earth's engine can we effectively reveal the nature of the interaction of different layers in the earth system and promote the development of earth system science.