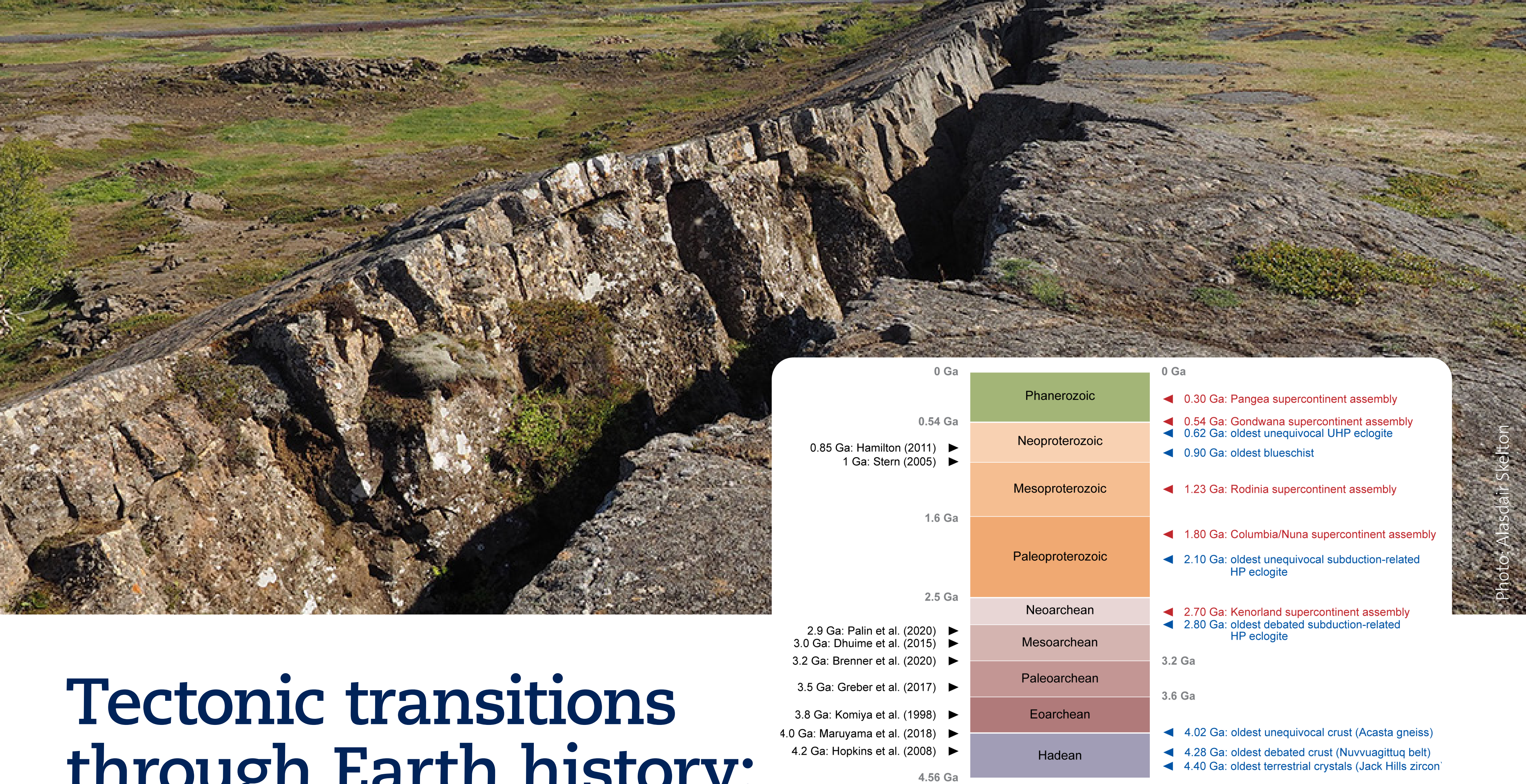

Photo: Alasdair Skelton

Tectonic transitions through Earth history: a current synthesis and future directions

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Time & place: March 7, 2024 at 15h00. William-Olsson lecture hall, Geohuset

The theory of plate tectonics provides a robust framework with which to describe and predict the behavior of Earth's rigid outer shell – the lithosphere – in space and time. Expressions of plate tectonic interactions at the Earth's surface also provide critical insight into the workings of our planet's inaccessible interior, and allow predictions to be made about the geological characteristics of other rocky bodies in our solar system and beyond. Formalization of this paradigm occurred at a landmark Penrose conference in 1969, representing the culmination of centuries of study, and geologists recently celebrated the 50-year anniversary of this meeting. However, despite five decades of focused study, there remains strong – and sometimes intensely heated – debate in the community about some fundamental questions regarding key tectonic transitions throughout Earth history, in particular related to the onset of plate tectonics and the form of geodynamic regime that existed beforehand. Here, I will summarize my understanding of some of these major questions and present a modern-day holistic model for the geodynamic evolution of the Earth that best accommodates key lines of evidence for its changes over time. Plate tectonics, as identified by formation of a global network of subduction zones, finally established itself during the Mesoarchean (c. 2.9–3.0 Ga), with firm evidence for subduction documented in older geological terranes accounted for by isolated plate tectonic 'microcells' that initiated at the heads of mantle plumes. Such early subduction likely operated at shallow angles and was short-lived, owing to the buoyancy and low rigidity of hotter oceanic lithosphere. A transitional period during the Neoarchean and Paleoproterozoic/Mesoproterozoic was characterized by continued secular cooling of the Earth's mantle, which reduced the buoyancy of oceanic lithosphere and increased its strength, allowing the angle of subduction at convergent plate margins to gradually steepen. The appearance of rocks during the Neoproterozoic (c. 0.8–0.9 Ga) diagnostic of subduction do not mark the onset of plate tectonics, but simply record the beginning of modern-style cold, deep, and steep subduction that is an end-member state of an earlier, hotter, mobile lid regime. Following this synthesis, I will present future lines of investigation that are required to make advances in this field.

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