The Onset Of Plate Tectonics

CHRIS HAWKESWORTH[1*], PETER CAWOOD[2], BRUNO DHUIME[1,3]

[1] University of Bristol, School of Earth Sciences, UK; *email: c.j.hawkesworth@bristol.ac.uk

[2] School of Earth, Atmosphere and Environment, Monash University, Melbourne, VIC 3800, Australia

[3] CNRS-UMR 5243, Géosciences Montpellier, Université de Montpellier, France.

Plate tectonics is a globally linked system of lateral motion of rigid surface plates. Estimates of its onset range from the Hadean to the Neoproterozoic; over three-quarters of Earth history. This contribution considers the spatial and temporal distribution of a range of geological constraints as to when plate tectonics began. It explores ways in which the results of detailed case studies carried out in different locations can be put into a more global context.

Tectonic styles, and the degree of seismic anisotropy, are different in different Archaean terranes. Those with dome and basin geometries, associated with vertical tectonics, characterise the Australian Pilbara and southern Africa cratons. They tend to be associated with within-plate magmatism. Linear Archaean orogenic systems with pronounced regional deformation fabrics appear to be characterised by lithosphere of greater seismic anisotropy, as in North America. These in turn tend to be characterised by fluid flux melting in the mantle, as in subduction zones at the present day, and in some areas terrains with stronger regional fabrics are younger than those in which such fabrics are less well developed. Magma types similar to those from recent within-plate and subduction-related settings were generated in different areas at broadly similar times in the period 3.8-2.7 Ga. It may be that subduction took place locally, but that is not necessarily evidence that plate tectonics was active globally.

The end of the Archaean is marked by the development of passive margins and of supercontinents, the preservation of major dyke swarms, an increase in the degree of crustal reworking, and a shift in the composition of both juvenile and upper crust from mafic to more intermediate compositions accompanied by an increase in the thickness of the crust at the sites of crust generation. Critically it marks a ~70% reduction in the rates of crustal growth which is attributed to an increase in the rates of crustal recycling. It is argued that these global signals reflect the transition to plate tectonics as a sustainable global tectonic system on Earth.