Geophysical Research Abstracts
Vol. 17, EGU2015-15930, 2015
EGU General Assembly 2015

A Voyage through Scales - Archives of the Continental Crust

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Geology and the Earth Sciences have distinctive positions in the sciences. They draw widely on the hard sciences, but for the most part the evidence is already present in the geological records of the history of the Earth. That record is far from complete, and critically it is also biased in what has been preserved and what has been lost. Scale is fundamental as even on outcrop discussions may range from the identification of minerals and fabrics to their implications, to inferred regional conditions of pressure and temperature, and the movement of plates many million years ago. Recent technological developments now make it possible to analyse very small amounts of material. This has highlighted that many rock samples are mixtures of materials of different provenance, and allowed us to be increasingly sure about what is being analysed. U/Pb dating of zircon is the basis for establishing geological time scales, and the combination of imaging techniques and high precision dating of small spots has highlighted the complexity of many grains and the importance of imaging each portion that is dated. Magmatic zircons crystallise from relatively high silica magmas, and so notwithstanding how widely they are used, magmatic zircons only yield ages for certain rock types in the geological record.

There are links between the length- and time-scales of natural phenomena. This lecture seeks to explore how material analysed on a wide range of scales influences the models developed and how they may be tested. High-resolution 3-D mapping has illuminated the debate over the oldest preserved fossils. The position-specific isotopic anatomies of organic molecules are now being investigated. The compositions of detrital sediments are widely used as a way to sample the bulk composition of portions of crust. Yet the sedimentary record is biased by preferential sampling of relatively young material in their source terrains. There are now large numbers of radiometric ages, often obtained in regional studies, and globally the continental crust is characterised by distinctive peaks and troughs in the distribution of ages of magmatic activity, metamorphism, continental margins and mineralisation. This is unexpected in the context of steady state plate tectonics, and it is thought to reflect the different preservation potential of rocks generated in different tectonic settings. In contrast there are other signals, such as the Sr isotope ratios of seawater, mantle temperatures, and redox conditions on the Earth, which appear to retain primary records because they are less sensitive to the numbers of samples of different ages that have been analysed. Bias does appear to be significant for signals that rely on distributions of ages.