

Rates of Processes from the Geological Record

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The importance of establishing a precise absolute chronology in the study of the Earth and other planets cannot be overstated. Chronology provides the framework for interpreting the geological record, it is critical in determining which events are coeval and which are not, and it is the basis for measuring rates that have a key role in the interpretation of natural processes. Smaller and smaller time differences can now be resolved typically by a combination of relative age dating pinned by numerical ages from radiogenic isotopes. This approach will be illustrated in selected examples from igneous, tectonic and Quaternary climate change systems, where it can also be shown that constraining the rates has resulted in new insights into the nature of those processes. In Quaternary systems relative ages are obtained from the counting of bands deposited annually, and in magmatic and metamorphic systems relative chronometers involve major, trace element and isotope profiles in crystals that may have been modified by diffusion. Thus ages can be obtained on individual crystals, and it is increasingly clear that many volcanic rocks consist of a cargo of minerals of different ages and different histories. Differentiation of the bulk rock composition may be controlled thermally, whereas the observed crystals may be younger and reflect decompression and degassing en route to the surface. This has opened up exciting new approaches to the study of igneous processes, and more widely it is increasingly possible to tackle the highly episodic nature of the geologic record as smaller and smaller time differences are resolved by different dating approaches.