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Isotopic chronostratigraphy

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The use of isotopic geochronology in stratigraphy and the establishment of numerical time-scales goes back by over half a century. There are two ways in which this can occur: direct dating of the sedimentary strata, and indirect dating of basin formation by dating detrital influx.

The classical approach is dating the strata by dating freshly formed minerals. Odin (1982) had proposed glauconites as a dating tool, as glauconites form in most sedimentary environments. A problem that became apparent in later years is that glauconite maturation after digestion by burrowing organisms can post-date by 1-2 Ma the true sedimentation age. The remaining alternative is dating volcanic tephra layers, if they are primary deposits and neither reworked nor mineralogically altered. For high-precision work the most widely used analytical techniques are $^{40}Ar/^{39}Ar$ (e.g. Meyers *et al*., 2011) and U-Pb, preferably using thermal ionization mass spectrometry (Macdonald *et al*., 2010).

The link between quantitative astronomical models of the Earth's orbit and high-precision dating of cyclostratigraphic sequences (e.g. Rivera *et al*., 2011) are starting to provide a long-duration window on the 100 ka and 400 ka cyclicities, reducing the systematic uncertainties of the geological timescale.

In recent years, the use of automated laser microprobes combined with substantial improvements in mass spectrometry has greatly expanded the sedimentary data-base by dating large numbers of individual detrital mineral grains. Two approaches have been proposed in the literature. The first, applied to unfossiliferous sedimentary basins, evaluates the age of the onset of sedimentation as less or equal to the youngest age obtained on unaltered mineral grains. The second seeks tectonic information on erosion and unroofing rates by comparing the ages of fossil-dated sedimentary strata with the detrital mineral ages. This approach can sometimes lead to a conflict with sedimentology (see e.g. Malusà *et al*., 2011); the reason is twofold. Firstly, isotopic ages do not simply reflect a "cooling age" but are normally controlled by post-magmatic retrogression reactions. Further, the erosion of a vertically unzoned magmatic source results in so-called "stationary age peaks", whose age differences with the age of the basin sediments increase even if the erosion rate also increases (Malusà *et al*., 2011).

In summary, the coupled effect of an improved understanding of the petrological processes that affect any mineral geochronometer and of continuing analytical improvements will be beneficial to the whole Earth Sciences community, including the establishment of an increasingly accurate and increasingly precise geological timescale.

Keywords: Chronostratigraphy, U-Pb dating, $^{40}Ar/^{39}Ar$ dating

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