Geophysical Research Abstracts
Vol. 17, EGU2015-8569-2, 2015
EGU General Assembly 2015

Approaches for the accurate definition of geological time boundaries

Urs Schaltegger (1), Björn Baresel (1), Maria Ovtcharova (1), Nicolas Goudemand (2), and Hugo Bucher (2)
(1) University of Geneva, Earth and Environmental Sciences, Geneva, Switzerland (urs.schaltegger@unige.ch), (2) University of Zürich, Institute and Museum of Paleontology, Karl Schmid-Strasse 4, Zürich, Switzerland

Which strategies lead to the most precise and accurate date of a given geological boundary? Geological units are usually defined by the occurrence of characteristic taxa and hence boundaries between these geological units correspond to dramatic faunal and/or floral turnovers and they are primarily defined using first or last occurrences of index species, or ideally by the separation interval between two consecutive, characteristic associations of fossil taxa. These boundaries need to be defined in a way that enables their worldwide recognition and correlation across different stratigraphic successions, using tools as different as bio-, magneto-, and chemo-stratigraphy, and astrochronology. Sedimentary sequences can be dated in numerical terms by applying high-precision chemical-abrasion, isotope-dilution, thermal-ionization mass spectrometry (CA-ID-TIMS) U-Pb age determination to zircon (ZrSiO4) in intercalated volcanic ashes. But, though volcanic activity is common in geological history, ashes are not necessarily close to the boundary we would like to date precisely and accurately. In addition, U-Pb zircon data sets may be very complex and difficult to interpret in terms of the age of ash deposition.
To overcome these difficulties we use a multi-proxy approach we applied to the precise and accurate dating of the Permo-Triassic and Early-Middle Triassic boundaries in South China.

a) Dense sampling of ashes across the critical time interval and a sufficiently large number of analysed zircons per ash sample can guarantee the recognition of all system complexities. Geochronological datasets from U-Pb dating of volcanic zircon may indeed combine effects of i) post-crystallization Pb loss from percolation of hydrothermal fluids (even using chemical abrasion), with ii) age dispersion from prolonged residence of earlier crystallized zircon in the magmatic system. As a result, U-Pb dates of individual zircons are both apparently younger and older than the depositional age of the ash, therefore masking the true age of deposition. Trace element ratios such as Th/U, Yb/Gd, as well as Hf isotope analysis of dated zircon can be used to decipher the temporal evolution of the magmatic system before the eruption and deposition of the studied ashes, and resolve the complex system behaviour of the zircons.

b) Changes in the source of the magma may happen between the deposition of two stratigraphically consecutive ash beds. They result in the modification of the trace element signature of zircon, but also of apatite (Ca5 (F, Cl, OH) (PO4)3). Trace element characteristics in apatite (e.g. Mg, Mn, Fe, F, Cl, Ce, and Y) are a reliable tool for distinguishing chemically similar groups of apatite crystals to unravel the geochemical fingerprint of one single ash bed. By establishing this fingerprint, ash beds of geographically separated geologic sections can be correlated even if they have not all been dated by U-Pb techniques.

c) The ultimate goal of quantitative stratigraphy is to establish an age model that predicts the age of a synchronous time line with an associated 95% confidence interval for any such line within a stratigraphic sequence. We show how a Bayesian, non-parametric interpolation approach can be applied to very complex data sets and leads to a well-defined age solution, possibly identifying changes in sedimentation rate. The age of a geological time boundary bracketed by dated samples in such an age model can be defined with an associated uncertainty.