Monazite anamnesis – providing a quantitative timeframe for metamorphic petrogenetic processes

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Monazite is a privileged phase in metamorphic assemblages, as it has a wide p-T stability field, a complex chemical composition, incorporates high concentrations of radioactive elements and is remarkably refractory to diffusion. Its chemical substitutions represent a very sensitive response to mineral reactions triggered by changing conditions, being recorded and preserved in grain zonations, as well as in regular chemical variations in the monazite populations. Connecting age data with chemical features allows not only dating monazite growth, but also a sometimes surprisingly accurate insight in the concurrent mineral reactions.

We performed several hundred microprobe analyses on monazite in pelitic and gneissic rocks from the South Carpathian basement units, for both chemical characterization and dating. The chemical characterization included structural formulae, ternary plots, normalized plots and elemental ratios therefrom. Relating age point data to compositional trends reveals homogeneous compositional and age domains, as well as regular chemical shifts, having a counterpart in mineral reactions involving monazite, and in variations in the crystallization versus resorption rates of monazite itself.

Monazite acts as a LREE and Th scavenger from decomposing REE-bearing phosphates, carbonates and silicates, and Th (U)-bearing silicates, phosphates and oxides, recording high Th (+Ca, U) and LREE contents in the initial growth stages. Oppositely, monazite resorption is typically indicated by its Nd and Sm enrichment. LREE correlations are variable, reversing differently in different samples with increasing atomic number, whereas the corresponding ratios indicate changes in modal abundance. Y content is buffered by coexisting xenotime and melt, being also markedly fractioned in coexisting garnet, as Y variation strongly and inversely reflects changes in modal garnet abundance. Eu is fractioned in plagioclase (metamorphic or crystallizing from melts) and U in coexisting melts. Heavier MREE are partitioned in xenotime. Monazite chemistry holda thus valuable keys for both identifying and dating thermometamorphic processes, especially those involving melting episodes and garnet growth and decomposition.

Towards Quantitative Paleohydrology: Reconstructing changes in relative humidity from lipid biomarker δD values

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The stable isotopic composition of meteoric waters, recorded through the hydrogen isotopic composition of lipid biomarkers is an integral of a number of hydrological parameters, such as condensation temperature, precipitation amount, evaporation, moisture pathway. It is often difficult to disentangle these parameters for a true quantitative reconstruction of hydrological variables, such as precipitation amount and relative humidity. Here we review the current state of knowledge of the factors driving leaf wax δD values and evaluate how terrestrial plant lipid biomarker δD values in combination with plant physiological modelling can be used to quantitatively reconstruct changes in relative humidity (rH).

We present a proof-of-concept for this approach by estimating relative humidity changes during the Younger Dryas cold period in Western Europe from the analysis of lipid biomarker δD values from the annually varved sediments of Lake Meerfelder Maar. We use the isotopic difference between aquatic and terrestrial lipid biomarkers as a measure of mean leaf water isotope enrichment. We parameterized a Craig-Gordon leaf water isotope model with plant physiological parameters estimated from available vegetation cover information from palynological records and climate proxy data (such as temperature) and solved this model for rH. Our reconstruction of Younger Dryas rH changes documents profound hydrological changes - likely as a consequence of changes in atmospheric circulation due to the position of North Atlantic Sea Ice - which were the ultimate trigger for the observed environmental changes. While supporting previous suggestions of a dry Younger Dryas in Western Europe our new biomarker and modelling approach delivers for the first time quantitative estimates of hydrological changes (i.e. relative humidity changes), which can be directly compared to the output from climate models.

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