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Origin of dolomites in the phosphatic Upper Cretaceous Duwi Formation, Eastern Desert, Egypt

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The Upper Cretaceous phosphatic Duwi Formation in the Eastern Desert, Egypt is characterized by a hemipelagic facies at its base followed by reefal sediments. Detailed petrographic and geochemical investigations (trace elements and C and O stable isotopes) reveal the presence of six dolomite petrotypes. These include: 1) authigenic dolomite within phosphorites (type A), 2) dolomitized reefs, which involve selective dolomitization (type B), pervasive mimic and non-mimic dolomite replacement (type C) and void-filling dolomite (type D), 3) dolomite lenses (type E), and 4) phosphatic marly dolomite (type F). Although each of the recorded dolomite petrotypes possesses a distinct and characteristic crystal-size distribution, crystal boundary shape, zoning, and luminescence, they are all ordered and near-stoichiometric.

The absence of evidence for hypersaline or freshwater conditions during deposition, the marine $\delta^{18}O$ values (+2.0 to -4.7 ‰ PDB) of the dolomites, and the $\delta^{13}C$values (-2.5 to -6.8 ‰ PDB) and high organic carbon content (0.3 to 2.1%) supports the formation of dolomite types A,B,C,E, and F from marine-derived pore waters within the sulphate-reduction zone. The clear limpid euhederal form and limited distribution of dolomite type D suggest formation from mixed meteoric-marine water derived as a consequence of uplift during post-Eocene time.

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Lu-Hf geochronology of phosphates in ancient sediments

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Life on Earth was restricted to single cell organisms for almost 3 Byr before the first signs of multicellular animal life appeared in the fossil record towards the end of the Precambrian era (~ 700-550 Ma). The earliest animals occur close to glacial deposits believed by some to reflect periods when the entire globe was covered in ice (the so-called “Snowball Earth model”; Hoffman et al., 1998). Much research over the past decade has focused on 1) evaluating models such as “Snowball Earth”, 2) the possible link between the glaciations and early animal evolution, 3) the repeated radiations and extinctions that followed during the Cambrian “explosion of life” (~ 545 to 500 Ma). Yet, a better understanding of these important climatic and biological processes is hampered by lack of geochronological data. Phosphates are abundant in the sediments that record the critical intervals; some of the richest phosphate accumulations on Earth occur above the Precambrian glacial horizons and the Cambrian “explosion of life” left a fossil record rich in phosphatic brachiopods among others. Precambrian glacial deposits in West Africa are among the hardest to constrain stratigraphically. Lu-Hf dating of phosphorites located above glacial deposits in the Kodjari basin, West Africa, yields 576±13 Ma (MSWD=0.21, n=6). This excludes a Cambrian age for the tillites (Bertrand-Sarfati et al., 1995) and instead supports a “Marinoan” origin for these as recently concluded by Porter & Knoll (2003). For Cambrian rocks, brachiopods from the ca. 500 Ma old Riley Fm, Texas, yield a Lu-Hf age around 505 Ma. This area only experienced minor tectonic activity in contrast to the Great Basin where dating of time-equivalent specimens resulted in a range of post-Cambrian ages. The difference is presumably related to the higher degree of post-depositional disturbance within the Great Basin.

Lu-Hf dating of phosphatic material represents a way to date sediments that do not contain ash layers and therefore cannot be constrained by precise U-Pb dating of igneous zircons.

References

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