

The role of temperature in the genesis of “calcite” and “aragonite” seas

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The “aragonite” and “calcite” seas concept in the Phanerozoic [1] is linked to oscillations in seawater composition and carbonate mineral polymorphism. In this context, the stabilization of aragonite has been demonstrated to be affected by the seawater Mg/Ca ratio, and lately, SO₄ [2]. Recently temperature has also been suggested as an important factor controlling CaCO₃ mineralogy [3], yet the link between temperature and seawater composition in modern and past oceans is still poorly constrained. Here we experimentally investigated CaCO₃ precipitation in seawater at 5-35°C in constant addition experiments and at variable Mg/Ca and SO₄ contents spanning Phanerozoic ocean chemical conditions. Our results show that: (a) temperature has only a minor effect on the primary calcium carbonate mineralogy, since calcite, aragonite and vaterite predominance (>50%) fields were equivalent at all temperatures; (b) temperature does however, have a major effect on size and morphology of the crystals formed (c) the calcite-aragonite coexistence field is much narrower than recently proposed [3]. We also observe that the relative proportion of aragonite in the calcite-aragonite coexistence field increases with temperature, likely a consequence of the elevated temperature dependent precipitation rate of aragonite relative to calcite. Combining literature data [e.g., 2] with our new results revealed that in the Phanerozoic, the time periods where calcite precipitation predominated are far shorter than previously predicted from the rock record. Most likely inter-transformations between primary aragonite and more stable calcite lead to the observations in Phanerozoic samples. Our results clearly suggest that throughout Earth’s history an additional parameter other than temperature, Mg/Ca and SO₄ (e.g., pCO₂, or dissolved organics) must have played a more dominant role in regulating the secular oscillations in seawater compositions and thus prevalent CaCO₃ polymorphs mineralogy.

[1] Holt *et al.*, 2014 *GCA* **134**: 317-334; [2] Bots *et al.*, 2011 *Geology* **39**:331-334; [3] Balthasar & Cusack 2015. *Geology* **43**:99-102.