

## Timing and Mode of Origin of Calcareous Concretions in the Lower Cretaceous Ben Nevis Formation, White Rose Field, Jeanne d'Arc Basin, offshore Newfoundland

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### Introduction

The Ben Nevis Formation of Aptian to Albian age is the primary producing interval in the White Rose Field of the Jeanne d'Arc Basin, approximately 350 km offshore from St. John's, Newfoundland. Mid- to lower shoreface reservoir sandstones are well-sorted, very fine to fine grained quartz arenites with relatively homogeneous reservoir properties, average porosity of ~ 16% and average permeability of ~ 100mD. However, calcareous concretions scattered throughout the Formation, locally constitute significant baffles to fluid flow, and it is the objective of this study to constrain the controls on the timing and depth of origin of selected concretions sampled in Well F-04 in the southern pool of the Field. Four(4) concretions ranging in thickness from 30 to 80 cm were sampled on continuous core within a 46-m interval located at subsea depths of 2765-2811 m . The database includes closely-spaced (5-10 cm) thin sections and micro-drilled geochemical samples of cement, mollusc shells and serpulid tubes for  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$  and selected major oxides.

### Theory and/or Method

The four concretions display different degrees of cementation and are interpreted as reflecting different stages in nearly concurrent growth of the concretions. The thickest concretion located at ~2810 m has the largest amount of cement (50-60%) with large 4-5 mm poikilotopic crystals; a small proportion of the calcite is of replacement origin, following dissolution of framework grains. In contrast, the thinnest concretion (30 cm) located at ~2765 m, shows the least amount of cement (30-40%) with significantly smaller 0.5-1 mm poikilotopic crystals.

### Examples

Low positive values of  $\delta^{13}\text{C}_{\text{PDB}}$  (0-4.5 ‰) are consistent with mixed-layer (aragonitic and calcitic) mollusc shells precipitated from marine waters and subsequently dissolved within marine-type pore waters. Slight depletion of  $\delta^{13}\text{C}_{\text{PDB}}$  in cements (+2.5 ‰) relative to shells (+4.5 ‰) may be from limited amounts of carbon sourced from organic matter decomposition. Oxygen isotope values of cements range from -2 to -8.5  $\delta^{18}\text{O}_{\text{PDB}}$ , typically more depleted in the highly evolved cores of concretions. Corresponding values for mollusc shells range from -1 to -2.5 ‰  $\delta^{18}\text{O}_{\text{PDB}}$ , consistent with mollusc shell layers precipitated from Cretaceous marine waters.

### Conclusions

Mollusc shell fragments may be visibly thinned, arguably having lost aragonitic layers to dissolution during shallow burial. Isotope relationships are consistent with early dissolution of aragonitic layers in mollusc shells, providing the source for the initiation of concretions prior to any significant mechanical compaction, perhaps only a few hundred meters below the sediment surface. The degree of mollusc shell dissolution

is thought to directly correlate to the amount of cement in the concretions. More highly  $\delta^{18}\text{O}$ -depleted cements likely record continuous concretion growth during burial and progressively increasing temperatures although the possible influence of fresh-water incursions cannot be rejected altogether at present.