

## Fluid inclusion size, depth and shape: aspects of re-equilibration

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### Introduction

In recent decades of fluid inclusion research potential evidences of post-entrapment changes of fluid inclusions have been increasingly noticed. Several studies of re-equilibration experiments have already been published with complex multi-component fluid mixtures. This series lacks experiments with relative simple one-component fluid systems, where the result of alteration processes, such as diffusion, can be directly related to the activity of one fluid component. Specific re-equilibration experiments are currently performed by using pure H<sub>2</sub>O and pure D<sub>2</sub>O. The interaction of distinct fluid inclusions attributes such as the inclusion depth below the crystal surface, the inclusion size and the inclusion shape appear to be essential for post-entrapment compositional changes.

### Performing re-equilibration experiments

For this study pure H<sub>2</sub>O fluid inclusions are synthesized in Brazilian quartz crystals which are then exposed to pure D<sub>2</sub>O during the re-equilibration process. Fluid properties of D<sub>2</sub>O and H<sub>2</sub>O are approximately similar, as evidenced with specific equations of state at our experimental conditions. However, diffusion coefficients through quartz will be slightly higher for H<sub>2</sub>O than D<sub>2</sub>O. Both, synthesis and re-equilibration are carried out under hydrothermal conditions without a pressure gradient. The initial synthesis and the subsequent re-equilibration are performed each at the same experimental conditions.

To clarify the emphases of the above mentioned fluid inclusions attributes two different series of re-equilibration experiments are performed, as examined: **1)** time-dependent series, i.e. different experimental running-times; **2)** temperature-dependent series, i.e. different formation and re-equilibration temperatures.

### Results

The gradient in the chemical potential of the entrapped H<sub>2</sub>O and the external D<sub>2</sub>O is a driving force for diffusion of these species through the quartz crystal at constant *P-T* conditions. Fluid inclusion size and depth play an important role in relative short experiments. Fluid inclusion shapes change from irregular to regular and equant in all experiments. The diffusion of H<sub>2</sub>O and D<sub>2</sub>O increases rapidly between 400 and 500 °C at 337 MPa. At a geological time scale, fluid inclusions in deep rock should re-equilibrate instantaneously to new pore-fluid conditions, if the grain that contains these inclusions is completely enclosed by the pore-fluid.

## High resolution reservoir age reconstructions from cold-water corals in the North-eastern Atlantic during the Holocene (~ 1700 – 4800 cal yr BP)

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Coupled U-series and radiocarbon dating were performed on cold-water corals (*Lophelia pertusa*) from the North-eastern Atlantic. The coral fragments come from 2 sediment cores (+56-08/929VE and +56-08/930VE with 3.61 m and 5.25 m recovery, respectively) retrieved from shallow inshore coral reefs from the Mingulay Reef Complex (~56°N, 7°W and 120-190 m water depth).

The 40 U-series dates show that coral fragments within the cores are in chronological order and span the mid-late Holocene (1700 - 4800 yr BP). The sediment cores show exceptionally high accumulation rates around 5 - 6 mm yr<sup>-1</sup> which is higher than those estimated for reefs along the Norwegian shelf (2 - 3 mm yr<sup>-1</sup>) and an order of magnitude greater than from the coral carbonate mounds of the European continental margin (~0.2 mm yr<sup>-1</sup> for the Holocene).

Reservoir ages were reconstructed from 18 paired U-series and <sup>14</sup>C dates measured on the same coral fragments. This high resolution dating, about one analysis every 150 yrs, allows reconstructions of high frequency changes in ventilation and ocean circulation patterns in this region. The reservoir ages estimated range from 240 yrs to 700 yrs with a mean value around 400 years. Our results also suggest cyclic circulation changes in the North-eastern Atlantic: 3 periods, around 2800, 3300 and 3700 yr BP, are characterized by lower values 240, 260 and 290 yr, respectively. One prominent increase of reservoir age is observed at about 3250 yr BP with values reaching 700 yr. The lower reservoir ages are relatively well correlated with lower δ<sup>18</sup>O values recorded by planktonic foraminifer *G. bulloides* and reduced coral reef accumulation rates within the Mingulay Reef Complex.

This study suggests that cyclic circulation changes occurred in the North-eastern Atlantic during the mid-late Holocene every 400 - 500 yrs. Further studies with records of similar resolutions would be needed to determine if these changes in reservoir ages are related to local and/or global environmental changes. This study demonstrates that cold-water corals constitute a powerful alternative to provide accurate reservoir ages with unprecedented temporal resolutions.