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Fluid Flow Through the Tahiti Barrier Reef Traced by Sr Isotopes and Pore Water Chemistry

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Introduction

The internal fluid circulation of the Tahiti barrier reef has been studied with Sr isotopes and pore water chemistry. The study is based on 15 sample series recovered over 2 years from a 150 m deep core drilled through the entire barrier reef down to the volcanic basement. Its aim is to trace fluid migration within the reef build up over time and to identify exchange and mixing processes between interstitial fluids, reef carbonates, and the open ocean. The present work is complementary to an earlier study of Andrié et al. (1998), who investigated pore waters from the same drilling with anthropogenic tracers (chlorofluorocarbon-CFC and tritium), oxygen isotopes, and helium isotopes.

Origin of the fluids

The presence of recent anthropogenic tracers in the pore waters demonstrates that they originate directly from the present-day open ocean and that they are not trapped palaeo-waters (Andrié et al. 1998). Density calculations based on temperature and salinity show that the interstitial fluids are systematically lighter than open ocean water at the same depth. This implies that the fluids are migrating upwards within the reef driven by buoyancy. A comparison between the temperature and salinity data of the interstitial fluids and open ocean water furthermore allows to make an estimate for the depth origin of the fluids: the data indicate that they originate from seawater which penetrated the volcanic basement at 300-350 m depth on the ocean-sided slope below the barrier reef.

Strontium isotopes

The Sr isotopic compositions have been analysed on a single sample series. The $^{87}Sr/^{86}Sr$ ratios vary in a range of 0.7088 to 0.7091. The values decrease upwards within the volcanic basement and are lowest at the limit towards the reef carbonates. Above this minimum, the ratios constantly increase and reach almost seawater values in the upper part of the young reef. The Sr mixing and the Rb-Sr isochron diagrams clearly demonstrate that the decrease of the Sr isotope ratios within the volcanics is due to growing basalt-seawater interaction, whereas the increase of the ratios within the carbonate reef is due to admixture of water from the open ocean. Mixing calculations suggest that this admixture is a continuous process and that there are no local injections of seawater at specific depth levels. However, this finding is contradictory to the temperature and salinity data of some sample series showing a clear shift towards seawater values. These shifts occur at depth levels where the reef is karstified due to emersion in the Pleistocene. The data thus indicate that admixture of open ocean water by lateral injections may occur, but only during specific time intervals.

Silica and Alkalinity

In order to resolve the above contradiction, we have been looking for parameters able to monitor seawater admixture similar to Sr isotopes. However, the parameters should be available for all 15 sample series in order to identify changing patterns of seawater admixture through time. A detailed evaluation of the data has shown that H_4SiO_4 and alkalinity fulfil these requirements. A plot of the H_4SiO_4 values of all samples series against alkalinity is shown below together with seawater composition. Silica concentrations are decreasing and alkalinity values are increasing with increasing seawater influence. The samples from the volcanics define a wide range in the upper left of the diagram (Figure 1). The samples from the lower part of the reef are most scattered and cover the whole range defined by all other sample groups. In contrast, the scatter of the data points of the two sample groups from the upper part is clearly smaller and the points approach seawater composition with decreasing depth. The large scatter of the data points from the lower part of the reef shows that changes in seawater admixture are limited to this depth interval. The different parameters able to trigger such changes are presently in evaluation and will be presented at the conference.

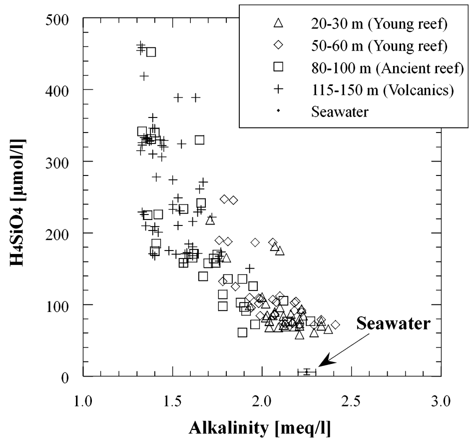

Figure 1: H_4SiO_4 concentrations and alkalinity values of the interstitial fluids from different depth levels and open ocean water

Andrié C, Jean-Baptiste P, Pierre C, Déjardin P, Fichez R, Poupeau, JJ & Rougerie F, *Geochim. Cosmochim. Acta*, **62**, 2809-2822, (1998).