12. INORGANIC GEOCHEMISTRY SUMMARY[1]

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INTRODUCTION

We collected a total of 129 interstitial water samples from Sites 803–807, which were drilled on the Ontong-Java Plateau during Ocean Drilling Program (ODP) Leg 130, and analyzed them on board for various dissolved constituents (see "Inorganic Geochemistry" sections in each site chapter, this volume, for detailed descriptions of the results). The sites range in water depths from 2520 to 3861 m and in latitude from 0°19.1'N to 3°36.4'N. Sediment lithology at all sites, with the exception of the deeper sections at Sites 803 and 807, is dominated by nannofossil ooze and chalk with varying abundances of foraminifers. Sedimentation rates vary systematically from site to site, with higher rates for sites at shallower water depths.

The interstitial water gradients at these sites primarily reflect the dominance of biogenic sediment, the paucity of organic carbon supply to the sediments, and the diffusive influence of basalt alteration reactions in the underlying basement. The consistent lithology from site to site with different water depths, distances from the equator, and sedimentation rates makes a comparison of interstitial water chemical gradients from site to site instructive. For the purposes of this comparison, ages were assigned to each interstitial water sample based on its depth and a linear interpolation of age from age-depth control points given in the sedimentation rate sections of the various site reports. In the following, interstitial water chemical profiles are discussed as they reflect three categories of influence on interstitial water chemistry: organic carbon oxidation reactions, biogenic sediment diagenetic reactions, and diffusive influence of basalt alteration reactions.

ORGANIC CARBON OXIDATION REACTIONS

Decreases in sulfate concentration and increases in alkalinity and ammonia concentrations with increasing sub-bottom depths at Sites 803–807 should primarily reflect organic carbon oxidation by sulfate reduction (Fig. 1). The total extent of sulfate depletion ranges over a factor of 2, with the largest total decrease at Site 806, the shallowest site (2520 m) and the closest to the equator. Sulfate depletion is similar in total extent at Sites 803, 805, and 807 (with water depths of 3410, 3188, and 2805 m, respectively), and the lowest at Site 804, the deepest site (3861 m). Sulfate reduction continues to greater sub-bottom depths at sites high on the Ontong Java Plateau, but the age at which the sulfate profile flattens is consistent from site to site because of the inverse correlation between water depth and sedimentation rate. The limited extent of sulfate depletion at all these sites indicates that the supply of organic matter reactive on these time scales limits organic carbon oxidation, not the availability of oxidant.

As is the case for sulfate depletion, the alkalinity gradient is greatest at Site 806 (Fig. 1). The site-to-site differences for alkalinity increases are more complex than the sulfate depletion patterns, however. Controls on alkalinity other than sulfate depletion, such as calcium carbonate precipitation, are important also. The ammonia maximum likewise is greatest at Site 806, intermediate in magnitude at Sites 805 and 807, and smallest at Sites 803 and 804 (Fig. 1). The ammonia increase at each site is much lower than would be predicted based solely on the stoichiometry of organic carbon oxidation, indicating the importance of exchange reactions with clays as a sink for ammonia (Gieskes, 1981).

BIOGENIC SEDIMENT DIAGENETIC REACTIONS

Dissolved silica profiles show similar increases with depth at all five sites. Apparently, these profiles are dominated by biogenic opal dissolution. The increases with age are not consistent from site to site (Fig. 2), suggesting that the controls on the dissolved silica gradients are biogenic opal solubility coupled with diffusion through the sediment-water interface, rather than varying rates of opal dissolution. The deepest samples at Site 803 and 807 show decreases in dissolved silica near or within zones of extensive silicification, superimposed on the general increase with depth.

Increases in dissolved strontium with depth and age reflect biogenic calcite recrystallization to inorganic calcite, which releases Sr to solution (Gieskes, 1981). The dissolved Sr maximum is greatest at Site 806, the shallowest site with the highest sedimentation rates; it is intermediate at Sites 803, 805, and 807, and substantially smaller at Site 804, the deepest site with the lowest sedimentation rates (Fig. 2). Generally, the Sr maximum shallows and occurs in younger sediments if sedimentation rates increase and Sr concentrations are at or near their highest values near the ooze-chalk boundary. This has been previously observed in carbonate-rich sites and ascribed to maximal recrystallization rates there (e.g., Gieskes, 1981).

BASALT ALTERATION: DIFFUSIVE INFLUENCES

The signature of basalt alteration reactions in the underlying basement is present in the profiles of calcium, magnesium, potassium, and rubidium by means of diffusion (e.g., McDuff and Gieskes, 1976; Gieskes, 1981; McDuff, 1981). Typically, the low-temperature, basalt hydrolysis reactions result in the release of Ca to solution and the uptake of Mg; in addition, these reactions typically result in the uptake from solution of the alkali elements potassium and rubidium (McDuff, 1981; Gieskes, 1981). Observed gradients should reflect the integrated flux over time from these alteration reactions and the controls on diffusion in the sediment column.

The gradients of Ca and Mg with depth and the $\Delta Ca/\Delta Mg$ ratio for each site are summarized in Table 1 and are consistent with previous observations. In ocean sediments, if a Ca gradient is present, it averages 8 mM/100 m. The estimated world ocean average gradient (i.e., including areas with thin sediment cover and no Ca depth gradients) is 4 mM/100 m (Gieskes, 1981). The $\Delta Ca/\Delta Mg$ ratios typical for sites located on basaltic basement
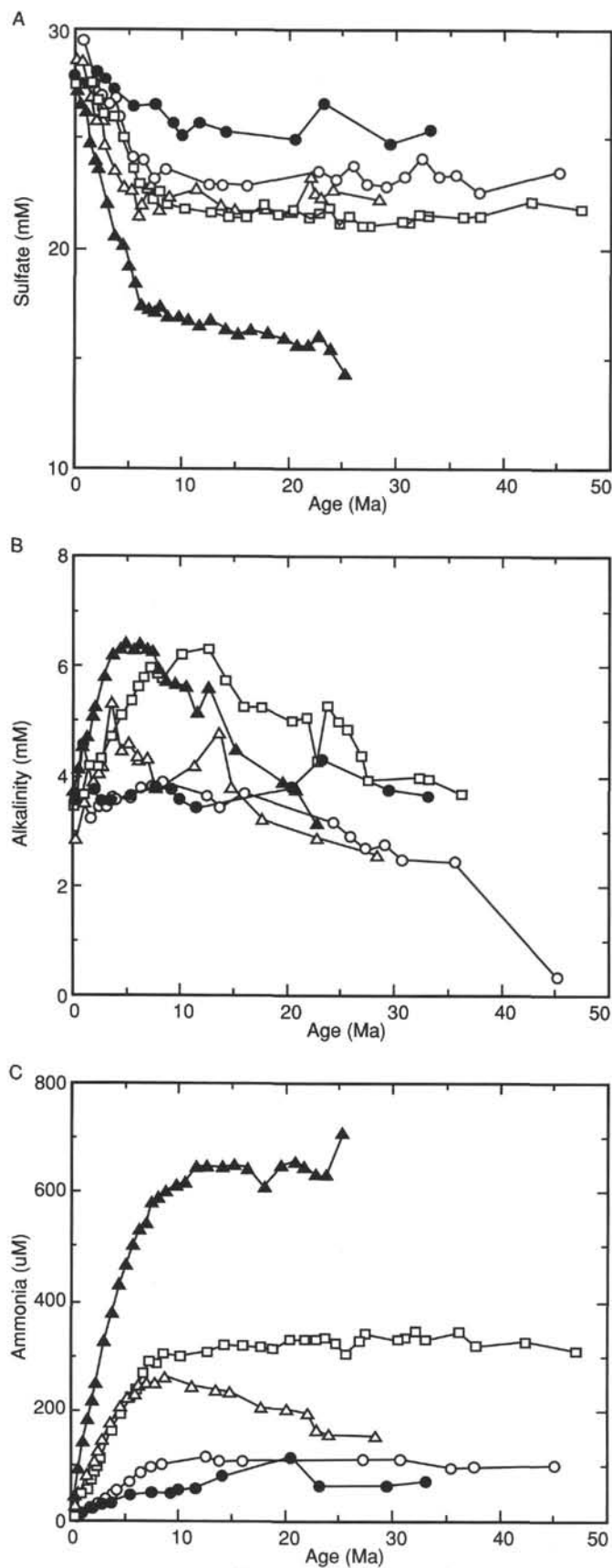
Figure 1. Interstitial water geochemical data for sulfate, alkalinity, and ammonia vs. assigned ages for Sites 803 (open circle), 804 (filled circle), 805 (open triangle), 806 (filled triangle), and 807 (square).
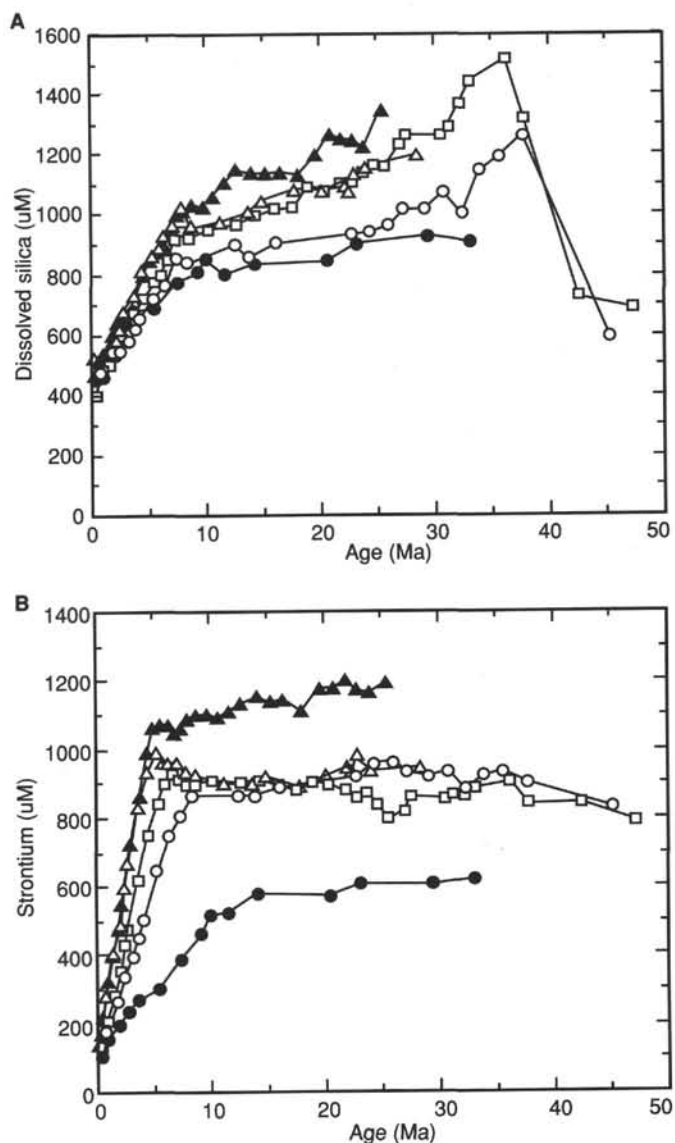

Figure 2. Interstitial water geochemical data for dissolved silica and strontium vs. assigned ages for Sites 803 (open circle), 804 (filled circle), 805 (open triangle), 806 (filled triangle), and 807 (square).

Table 1. Calcium and magnesium depth gradients and ΔCa/ΔMg ratios for Sites 803–807.

Site	Ca gradient (mM/100 m)	Mg gradient (mM/100 m)	ΔCa/ΔMg
803	6.2	−3.5	−1.8
804	3.7	−3.8	−0.91
805	4.1	−3.4	−1.2
806	2.7	−4.2	−0.71
807	1.1	−1.4	−0.78

average −1.5, with Mg gradients leveling off in magnitude for larger Ca gradients (McDuff, 1981).

Calcium gradients with age are the smallest at Sites 804 and 807 and are the most pronounced at Site 805 (Fig. 3). Magnesium age gradients are the largest at Sites 805 and 806 and are
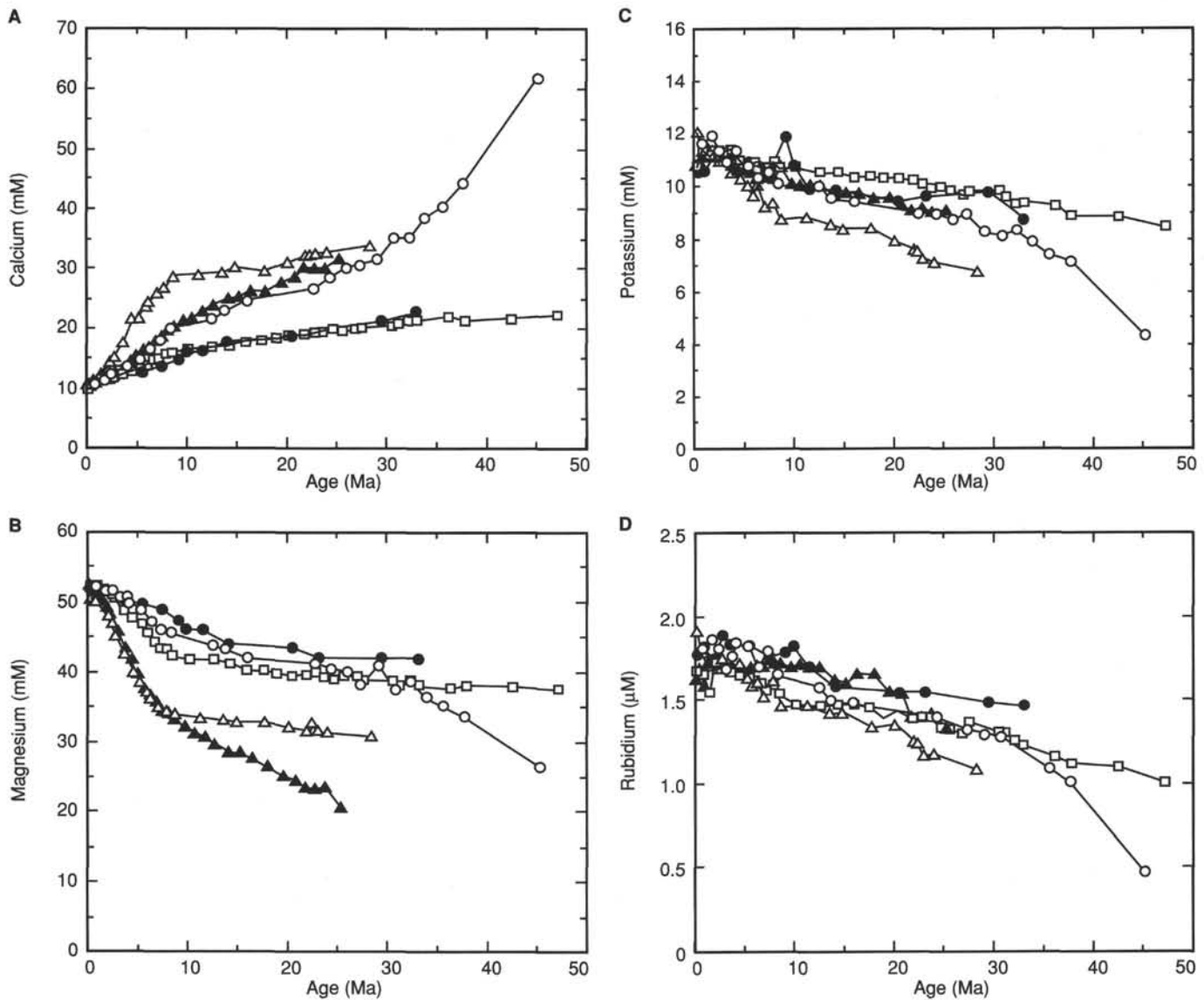
Figure 3. Interstitial water geochemical data for calcium, magnesium, potassium, and rubidium vs. assigned ages for Sites 803 (open circle), 804 (filled circle), 805 (open triangle), 806 (filled triangle), and 807 (square).

smaller and similar to each other at Sites 803, 804, and 807 (Fig. 3). As with Ca and Mg, K age gradients are the largest at Site 805 (Fig. 3). Rubidium age gradients demonstrate approximately the same pattern as K, with age gradients for Site 805 the largest and gradients for the other sites smaller and quite similar (Fig. 3). There is no simple correlation between the chemical gradients that reflect basalt alteration and such site characteristics as sedimentation rate or latitude. Thus, the differences in these gradients from site to site may reflect local variations in the intensity of basalt alteration on the plateau.

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