Volatile cycling in subduction zones: Decreasing the deficit

CRAIG E. MANNING

Dept. of Earth and Space Sci., University of California, Los Angeles, CA 90095, USA (manning@ess.ucla.edu)

Tabulations of the volatile content of subducted materials suggest that more volatiles enter subduction zones than exit at mid-ocean ridges and arcs (Ito et al., 1983; Jambon, 1994; Bebout, 1995). This challenges models for the volcanic origin of the atmosphere and oceans, and supports mediation of Earth's volatile budget by supply of extraterrestrial volatiles (Chyba, 1990; Deming, 1999). However, surveys of volatile budgets do not account for the large potential for volatile transfer from arc magmas to the crust's metamorphic-fluid system. Hydrologic and mineral-solubility data suggest that the metamorphic-fluid system can accommodate sufficient subduction-derived volatiles to erase the "deficit."

Crustal permeability during metamorphism is sufficient to transport not only fluids produced within the crust, but also the entire deficit in subducted H_2O (~$7x10^{14}$ g/yr; Ingebritsen and Manning, 2002), assuming delivery by degassing of magma ponded at the base of the crust. The volatiles may either diffusely transit the crust or be sequestered in minerals. Solubilities of volatile-bearing minerals in crustal fluids favor significant mineral storage because they are high and change little with pressure (P) between subduction depths and ~6 kbar, but decrease strongly with P decrease at lower P. For example, calcite solubility in H_2O increases by 10^3 from 1-6 kbar at 600 °C, but by <10 from 6-20 kbar (Caciagli and Manning, 2003). Anhydrite ($CaSO_4$) shows similar behavior. NaCl increases total solubility, but does not change the large P dependence (Newton and Manning, 2002). The small changes in solubility with decreasing P at high P favor transport of CO_2 and S from depth to mid-crustal levels in rising fluids. However, decompression at shallower levels yields mineral precipitation. Allowing for mediation of the terrestrial volatile budget by the metamorphic-fluid system in arc crust implies no loss of ocean volume through time and minimal extraterrestrial volatile input.

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Calcareous foraminiferal test as a proxy of Cd in coastal marine environment

N. MARÉCHAL-ABRAM [1], J.-P. DEBENAY [2] AND H. WADA [1]

[1] Geosciences Department, Shizuoka University, 836 Oya Shizuoka, 422-8529 (r5144007@ipc.shizuoka.ac.jp)
[2] Laboratoire de Géologie, Université d'Angers, 2 bld Lavoisier, 49045 Angers cedex, France (debenay@univ-angers.fr)

Anthropogenic pressures exerted on estuaries and coastal areas necessitate to develop new methods for environmental assessments. In the perspective to develop a heavy metal proxy in coastal areas based on foraminiferal calcite, we present cadmium partition coefficients D_{Cd}: $([Cd]/[Ca])_{foram} = D_{Cd}$ x $([Cd]/[Ca])_{SW}$, obtained from calcitic tests of the benthic foraminifer species Ammonia beccarii (Linné). Foraminifers were grown in sediment free cultures at 18°C and salinity of 28‰ with cadmium concentration at 4.3, 6.4 and 9.0 nmol l^{-1}. After reproduction or formation of new chambers, foraminifers or test fragments were collected, carefully decontaminated for cadmium and calcium analyses. Cadmium partition coefficients measured from culture experiments with controlled Cd concentration of 6.4 and 9.0 nmol l^{-1} are 1.0±0.1 (n=8) and 1.2±0.2 (n=19) respectively. These values are comparable with the data published by Havach et al., (2001). They report an average D_{Cd} for Ammonia beccarii of 1.0 ± 0.5 with S= 35‰ and T= 10°C. Tachikawa and Elderfield (2002) estimated D_{Cd} relative to pore water for several species. Reported values are not significantly different from 1.0, with D_{Cd} were 0.9 ± 0.2 to 1.2 ± 0.2,

Reduced sample scatters showed an equilibrium of Cd/Ca ratios between sea water and calcite. D_{Cd} values ≈ 1.0 show that Cd/Ca ratios of sea water and foraminiferal calcite are also close to equality.

For culture with Cd concentration of 4.3 nmol l^{-1}, D_{Cd} is significantly different with 1.8 ± 0.2. The increase of D_{Cd} value is probably due to intracellular bio-accumulation.

The presence of 6% of deformed tests in culture with Cd concentration of 9.0 nmol l^{-1} shows an impact of Cd on Ammonia beccarii. The comparison of D_{Cd} = 1.5 measured from abnormal foraminifers with others partition coefficients, does not seem to support the assumption of heavy metal enrichment of abnormal foraminifer test in polluted environments.

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