

Does monsoon rainfall drive arsenic mobilization and organic carbon release in Bangladesh aquifers?

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Organic carbon (DOC) is believed to be the main driver for arsenic (As) release during reductive dissolution of iron hydroxides from sediments in the Bengal Delta. However, the source of the organic carbon remains controversial. Recharge from man-made ponds has recently been claimed as the main source and installation of 'As-safe' wells away from ponds beneath rice fields has been suggested. Our study questions the validity of this approach throughout Bangladesh. Based on a one-year weekly sampling of wells at different depths in the Titas district, 60 km SE of Dhaka, we propose a model of natural organic carbon and As mobilization from clay and peat layers following monsoonal changes in specific storativity. During the dry season a natural decline in hydraulic heads boosted by intensive pumping for irrigation causes release of porewaters with high DOC concentrations from clay and peat layers. Flushing, diffusion, and water re-storage decrease initially released DOC concentrations in the rainy season. Maximum As concentrations and an increase in the share of arsenite follow DOC peak concentrations with a time lag which we interpret as delayed response in microbially catalyzed arsenate reduction and release of arsenite previously sorbed to sediment. Over time, aqueous As concentrations will decrease in most parts of the Holocene unconfined aquifer as organic matter is consumed. Based on our model, organic carbon and As from clay and peat layers will continue to pose a problem for underlying aquifers as they are seasonally released by changes in specific storativity. Though sorption capacities are higher in the Pleistocene sediments, long-term continuous As input from overlying clay and peat layers as in our study area eventually also leads to increased aqueous As concentrations. Before exploiting deeper aquifers the overlying clay and peat layers should thus be studied for their history of fresh-water flushing, their current pore water biogeochemistry and hydraulic properties.

Why do mafic arc magmas contain 4 wt% water on average?

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Over the last fifteen years there has been an explosion in data on the volatile contents of magmas parental to arc volcanoes. This has occurred due to the intense study of melt inclusions, trapped primarily within olivine, as aliquots of magma that have escaped degassing during eruption. The surprising first-order result is the narrow range in H₂O concentrations of the least degassed melt inclusions when averaged by volcano (based on 7 arcs for which such data exist for > 5 volcanoes: Central America, Mexico, Kamchatka, Marianas, Cascades, Tonga and the Aleutians). Nearly all arc volcanoes are sourced with mafic magmas that contain 2-6 wt% H₂O. Moreover, the average for each arc varies even less, from 3.2 (for the Cascades) to 4.5 (for the Marianas), with an average for all seven arcs of 3.8 ± 0.5 wt% H₂O. The narrow range and common average value for H₂O is in stark contrast to that for most other subduction tracers, such as Nb or Ba, which vary by orders of magnitude.

A modulating process, either in the crust or mantle, is likely responsible for the restricted range in the H₂O contents of melt inclusions. One possibility is that melt inclusions reflect vapor saturation at the last storage depth prior to eruption. Magmas rise from the mantle with variable H₂O contents (> 4 wt%), start degassing at the depth of H₂O-saturation, and continue to degas up until the depth at which they stall. If the stalling depths were ~6 km, not atypical for storage depths beneath volcanoes, magmas would be saturated at ~4 wt% H₂O, and melt inclusions, which become sealed during ascent, would thus record ≤ 4 wt% H₂O. Another possibility is that the melting process modulates water content in the melt such that magmas rise out of the mantle with ~4 wt% H₂O. A strong relationship between the water content of the source (H₂O₀) and the degree of melting (F) maintains nearly constant water contents in the melt for a restricted range in mantle temperature. Magmas with 3-4 wt% H₂O can be generated at 1230-1280°C and 1.5 GPa for a wide range in F and H₂O₀. Crust and mantle controls may dominate in different regions and may be distinguished from coupled trace element or CO₂ variations.