Primitive Submarine Basalts and Three Primary Magma Types from Pagan, Mariana arc

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Primitive Basalts from the Mariana Volcanic Front

Pagan is an active volcano located in the volcanic front of the central Island Province of the Mariana arc (18°07'N) and is one of the largest volcanoes in the Mariana arc; its main edifice rises from a base ~3,000 m below sea level and has a volume of 2,160 km^3 [1]. Tamura et al. (2011) demonstrate the existence of near-primitive, phenocryst-poor lavas at NW Rota-1 volcano in the Mariana arc, which is located about 40 km west of the volcanic front. These magnesiana basalts are petrographically distinct cpx-olivine basalt (COB) and plagioclase-olivine basalts (POB) [2].

The active Pagan volcano has erupted near-primitive lavas on its submarine flanks. The least fractionated compositions recovered from the NE flank (HPD1147) extend to higher MgO (7-11 wt %) and Mg# (60-70), than have ever been sampled from Pagan island lavas.

The Fo contents of olivine (up to Fo$_{94}$) and Cr-number of spinels (up to 0.8) suggest that these magmas formed from high degrees of mantle melting. There are three geochemical groups of cpx-olivine basalt (COB1, COB2 and COB3). TiO_2, Na_2O, K_2O, Rb, Nb are lowest in COB1 and highest in COB3. COB3 have steeper LREE-enriched patterns but the REE patterns of COB1 show contrasting LREE-depleted patterns, suggesting that COB1 formed from higher degrees of mantle melting. On the other hand, COB1 have the highest Ba/Th ratios and COB3 have the lowest, suggesting that a shallow subduction component is more important for COB1 than COB3, with COB2 intermediate. COB1, COB2 and COB3 show a negative trend on the Ba/Nb-Nb/Yb diagram (Fig. 1), suggesting that greater subduction components resulted in larger degrees of melting.

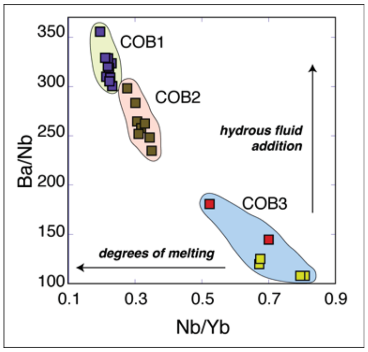

Figure 1: Ba/Nb vs Nb/Yb. The higher Ba/Nb of the COB1 indicate that the COB1 contain greater abundances of slab-derived subduction components than the COB2 and COB3. Nb/Yb suggests that the degree of melting of the COB1 source is higher than for the COB2 and COB3.

[1] Bloomer *et al.* (1989) *Bulletin of Volcanology* **51,** 210-224.
[2] Tamura *et al.* (2011) *Journal of Petrology* **52**, 1143-1183.

Modeling U(VI) reduction in a field test with Emusified Vegetable Oil (EVO) as the electron donor

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A one-time 2-hour EVO injection in a fast flowing aquifer resulted in decreased U(VI) flux to an surface stream for over a year. A model was developed to couple EVO hydrolysis, production and oxidation of long-chain fatty acids (LCFA), glycerol, acetate and H_2, reduction of nitrate, Fe(III), U(VI) and sulfate, and methanogenesis with growth and decay of microbial functional groups. Literature values were used for U(VI) sorption and microbially-mediated reduction reactions with acetate and H_2. Microcosm test data were used to estimate hydrolysis, glycerol fermentation, and LCFA oxidation parameters. The model was implemented in PHT3D to model coupled processes in the field test.

The model approximately matched the observed aqueous acetate, nitrate, Fe, U (Figure 1), and sulfate concentrations, and decribed the trends of growth and decay of microbial functional groups. While the lab-determined parameters were generally applicable for the field-scale simulation, the hydrolysis rate constant was estimated to be an order of magnitude faster in the field than in the microcosms. Sulfate reducer biomass was predicted to accumulate near the injection wells and along the side boundaries of the treatment zone where electron donors (LCFA) and electron acceptors (sulfate) from the surrounding environment met. Consequently, biogenic U(IV) accumulation in these locations was predicted (Figure 2).

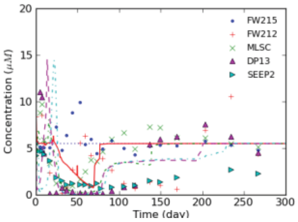

Figure 1 Observed (points) vs. calculated (curves) aqueous U(VI) concentrations

Figure 2. Predicted U(IV) distribution at 50 days

While EVO retention and hydrolysis characteristics were expected to control the treatment longevity, these modeling results indicated that electron acceptors such as sulfate not only compete for electrons but also may play a conducive role in degrading LCFA and enhancing U(VI) reduction and immobilization. The models could be useful for further research and bioremediation design.