Denudation of the Lesser Antilles

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We report in this paper the results of a multidisciplinary project aiming at determining the rates of chemical and physical denudation in the Lesser Antilles and the carbon fluxes exported to the ocean in a volcanic arc setting (Guadeloupe, Martinique, Dominica). Chemical denudation rates, determined by using river dissolved load range from 30 to 600 t/km2/yr, are extremely variable as a result of highly variable runoff and of the variable input of groundwaters influenced by volcanic acids [1], [2]. Physical denudation was estimated using different methods. Temporal monitoring of selected watershed gives a first estimate over a relatively short observation period. Based on the chemistry of the bottom sands transported in rivers, we calculated the physical denudation rates expected for a weathering system at steady state by solving a mass budget between source rocks and erosion products. Results show that the volcanic relief of Guadeloupe is eroding both chemically and physically at rates ranging between 100 mm/kr and more than 1000 mm/yr from the northern (and older) part of the Island to the southern (and younger) part respectively. These rates are important at a global scale and show that volcanic arc islands are "hot spots" of chemical and physical denudation on Earth. The denudation of the Lesser Antilles Arc is 2-3 higher that the eruptive rate, or island construction rate, meaning that volcanic arc islands have a limited lifetime (of typically 1 to a couple of million years) at a geological time scale. In addition to be a locus of intense sediment production to the ocean, the Lesser Antilles have a significant role of carbon export to the ocean. In terms of atmospheric carbon sequestration, first results show that the sequestration of organic carbon (in both dissolved and suspended load) may be about the same order of magnitude than inorganic sequestration [3]. Hydrology, and particularly orographic precipitation are proposed to be the main drivers of the weathering and denudation of tropical volcanic islands. Progresses have to be done primarily to establish proper water budgets of volcanic island to separate the effect of surface waters from groundwaters and to monitor over long periods of time the exportation of solids and particulate carbon.

[1] Gaillardet et al., (2012) *Am. J. of Sci.* in press. [2] Rivé et al., 2012, submitted to Earth Pl. Sci. Let. [3] Lloret et al. (2010) Chem. Geol. doi: 10.1016/j.chemgeo.2010.10.016, 2901-2910.

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Non-traditional isotope variations in the Cordillera del Paine pluton

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Non-traditional isotope systems provide unique insight into magma differentiation processes. We present new Fe and U isotope analyses (along with traditional Sr and Pb isotope data) on samples from the Cordillera del Paine igneous complex to assess relationships with differentiation. The Cordillera del Paine complex consists of a 1 km vertical exposure of relatively homogenous granite overlying a nearly contemporaneous and possibly cogenetic 0.5 km mafic gabbro suite. The mafic suite includes a small zone of diorites underlain by hornblende gabbros at the base of the exposure.

Samples previously characterized by Michael (1984, 1991) [1,2] were analyzed by MCICPMS. Fe isotope data shows a hyperbolic trend of increasing δ^{56}Fe with increasing SiO_2 in the pluton. Results show a strong correlation between $^{87}Sr/^{86}Sr$ and silica. Ten mafic suite samples average $^{87}Sr/^{86}Sr$ 0.7043(±)0.0004 and eleven granites average $^{87}Sr/^{86}Sr$ 0.70527(±)0.0004. In contrast, Pb isotopes are remarkably constant hovering ~ $^{208}Pb/^{204}Pb$ 38.72, $^{207}Pb/^{204}Pb$ 15.64 and $^{206}Pb/^{204}Pb$ 18.83. Finally, preliminary U isotope data show a trend of increasing $^{238}U/^{235}U$ with increasing SiO_2 (ranging from -0.37 to -0.26) although these data are only marginally outside of analytical error.

We assess four possible processes responsible for fractionating Fe isotopes during magma differentiation: 1) thermal migration and thermal gradients [3]; 2) crustal contamination, 3) fractional crystallization and 4) late stage fluid removal [4]. Quantitative assessment of #3 & #4 awaits results of experiments in progress to measure mineral-melt fractionation factors. The correlation of $^{87}Sr/^{86}Sr$ with silica as well as δ^{56}Fe suggests crustal contamination could be important to all isotope systems. This is reinforced by the Pb isotope data which fall very close to nearby Chile trench values [5]. On the other hand, fractionation of the heavy Fe and U isotope ratios with differentiation is also consistent with thermal migration and thermal gradient laboratory experiments. Further tests of other non-traditional stable isotope systems, such as Si, will help to assess the plausibility of this mechanism.

[1] Michael (1984) *Cont. Min, Petrol.***87**, 179-195. [2] Michael (1991) *Cont. Min. Petrol.* **108**, 396-418. [3] Lundstrom (2009) *GCA* **73,** 5709-5729. [4] Heimann A. et al. (2008) *GCA* **72**, 4379-4396. [5] Kilian R. and Berhmann J.H. (2003) *JGS* **160**, 57–70.