Do Critical Zone carbon and water fluxes control chemical denudation?

JULIA N. PERDRIAL[1*], PAUL BROOKS[2], JON CHOROVER[1], KATE CONDON[2], ADRIAN HARPOLD[2], MOLLY HOLLERAN[1], DAVID HUCKLE[2], REBECCA LYBRAND[1], PETER TROCH[2], JEN MCINTOSH[2], TOM MEIXNER[2], REBECCA MINOR[3], BHASKAR MITRA[3], MICHAEL POHLMANN[1], CRAIG RASMUSSEN[1], TYSON SWETNAM[3], ANGELICA VASQUEZ-ORTEGA[1], XAVIER ZAPATA-RIOS[2]

[1]University of Arizona, Department of Soil, Water and Environmental Sciences, Tucson, AZ, USA, jnperdri@email.arizona.edu (*)

[2]University of Arizona, Department of Hydrology and Water Resources, Tucson, AZ, USA

[3]University of Arizona, School of Natural Resources, Tucson, AZ, USA

What controls the magnitude of weathering fluxes in the Critical Zone (CZ) and how vulnerable are those fluxes towards changes in climatic forcing? We believe that these fundamental questions can be uniquely addressed through an integrative approach that includes multiyear CZ water, carbon and lithogenic element flux records using a scaling approach that bridges multiple CZ sub disciplines. Based on the theoretical framework of the Santa Catalina Mountains - Jemez River Basin (SCM-JRB) CZO, we postulate that effective energy and mass transfer (EEMT, MJ m^{-2} y^{-1},[1]) is a predictive variable for chemical denudation. This parameter can be estimated from meteorological variables, as we have done previously for our CZO [2], or it can be measured directly, as we report in this presentation. Within the CZO framework, we are now testing the hypothesis that direct hydrologic and organic geochemical quantifications of EEMT in CZ fluids are correlated with fluxes of major and trace lithogenic elements for several montane forest catchments. Rare earth elements (REE) are investigated as tracers for chemical denudation mechanisms and preliminary data on REE-organic carbon interaction indicate the importance of labile organic carbon (the biomass energy flux component of EEMT) as a key controller of chemical denudation patterns. Climatic impacts on inter-annual variations in EEMT seem to exert an overarching constraint on chemical denudation.

[1] Rasmussen et al. (2010). *An open system framework for integrating critical zone structure and function*. Biogeochemistry. **102**, 15-29.

[2] Chorover et al. (2011). *Probing how water, carbon, and energy drive landscape evolution and surface water dynamics: The Jemez River Basin – Santa Catalina Mountains Critical Zone Observatory*. Vadose Zone Journal. **10**, 884-899.

Modeling the hydrothermal circulation and the hydrogen production at the Rainbow site with Cast3M

FLORIAN PEREZ[1*], CLAUDE MÜGLER[1], PHLIPPE JEAN-BAPTISTE[1] AND JEAN LUC CHARLOU[2].

[1]LSCE, CEA-CNRS-UVSQ, Gif-Sur-Yvette, France florian.perez@lsce.ipsl.fr (* presenting author)

[2] Géosciences Marines, IFREMER, Brest, France Jean.Luc.Charlou@ifremer.fr

Background and Aims

On the Mid-Atlantic Ridge, the Rainbow venting site is described as an ultramafic-hosted active hydrothermal site and releases high fluxes of methane and hydrogen [1, 2]. This behavior has first been interpreted as the result of serpentinization processes. But geochemical reactions involving olivine and plagioclase assemblages, and leading to chlorite, tremolite, talc and magnetite assemblages, could contribute to the observed characteristics of the exiting fluid [2].

Objectives and methods

The predominance of one of these geochemical reactions or their coexistence strongly depend on the hydrothermal fluid circulation. We developed and validated a 2D/3D numerical model using a Finite Volume method to simulate heat driven fluid flows in the framework of the Cast3M code [3, 4]. We also developed a numerical model for hydrogen production and transport that is based on experimental studies of the serpentinization processes [5]. This geochemical model takes into account the exothermic and water-consuming behavior of the serpentinization reaction and it can be coupled to our thermo-hydrogeological model.

Results and conclusion

Our simulations provide temperatures, mass fluxes and venting surface areas very close to those estimated in-situ [6]. We showed that a single-path model [7] was necessary to simulate high values such as the in-situ measured temperatures and estimated water mass fluxes of the Rainbow site [6].

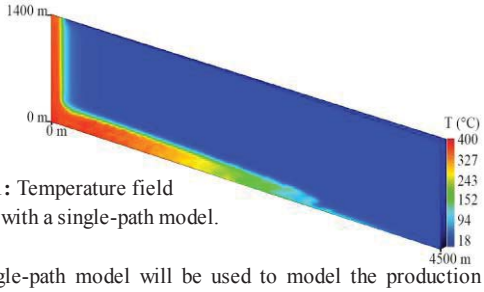

Figure 1: Temperature field obtained with a single-path model.

This single-path model will be used to model the production and transport of hydrogen at the Rainbow hydrothermal site.

[1]Charlou et al. (2010) *AGU Monograph series*. [2]Seyfried et al. (2011) *Geochim. Cosmochim. Acta 75*, 1574-1593. [3]http://www-cast3m.cea.fr. [4]Martin & Fyfe (1970) *Chem. Geol. 6*, 185-202. [5] Marcaillou et al. (2011) *Earth and Planet. Sci. Lett. 303*, 281-290. [6]Perez et al. (2012) submited to Computational Geosciences. [7]Lowell & Germanovich (2004) AGU, Washington DC, USA.