Geochemistry of Fast-spreading Lower Crust: Results from IODP Expedition 345 at the Hess Deep Rift

M. GODARD[1], R. MEYER[2], A. SAHA[3], K. M. GILLIS[4], J.E. SNOW[5], A. KLAUS[6] AND IODP EXPEDITION 345 SHIPBOARD SCIENTIFIC PARTY

[1]Géosciences, CNRS-Université Montpellier 2, France; (Marguerite.Godard@um2.fr)
[2]University of Bergen, Norway
[3]Indian Institute of Science, Bangalore, India
[4]University of Victoria, B.C., Canada
[5]University of Houston, Houston TX, USA
[6]Texas A&M University, College Station TX, USA

We report preliminary results of IODP Expedition 345 (Site U1415, Dec. 2012-Feb. 2013) to the Hess Deep Rift where propagation of the Cocos Nazca Ridge into young, fast-spreading East Pacific Rise crust exposes a dismembered, but nearly complete lower crustal section, with extensive exposures of the plutonic crust. Reasonable recovery for hard rock expeditions (15%–30%) was achieved in three holes (35–110 m below seafloor), despite water depths of more than 4500 m and challenging drilling conditions.

Olivine gabbro and troctolite are the dominant plutonic rock types at Site U1415, with minor gabbro, clinopyroxene oikocryst-bearing troctolite, clinopyroxene oikocryst-bearing gabbro, and gabbronorite. All recovered gabbroic rocks have primitive compositions except for one gabbronorite sampled in the upper rubble zone at Hole U1415E, that is similar in composition to the evolved shallow gabbros previously sampled at Hess Deep. Site U1415 olivine gabbros, gabbros and gabbronorites overlap in composition : they have high Mg# (79-87), high Ni (130-570 ppm) and low TiO_2 (0.1-0.3 wt.%). Troctolites have high Mg# (81-89), Ni (260-1500 ppm) and Cr (365- 1100 ppm) and low TiO_2 (<0.1 wt.%). The main geochemical characteristics of Site U1415 gabbroic rocks are consistent with formation as a cumulate sequence from a common parental MORB melt, troctolites representing the most primitive end-member of this sequence. They overlap in composition with the most primitive of slow and fast spread crust gabbroic rocks. These primitive geochemical signatures seem however contradictory with orthopyroxene (up to 5%) in the primary mineral assemblage of the olivine gabbros. In MORB crystallization series, orthopyroxene is expected to crystallize from evolved melts. The presence of orthopyroxene in the primitive gabbroic sequence sampled at Site U1415 suggests that it was formed in a more complex magmatic system, with possible mixing with melts in equilibrium with mantle orthopyroxene.

Rates of consumption of atmospheric CO_2 through the weathering of loess during the next 100 years of climate change

YVES GODDÉRIS[1], SUSAN L. BRANTLEY[2], LOUIS M. FRANÇOIS[3], JACQUES SCHOTT[1], DAVID POLLARD[2], MICHEL DÉQUÉ[4] AND MARIE DURY[3]

[1]Géoscience Environnement Toulouse, CNRS, France
[2]Earth and Environmental Systems Institue, PennState, USA
[3]IAG, Université de Liège, Belgium
[4]Météo-France/CNRM, CNRS/GAME, Toulouse, France

We investigate how weathering of the Mississippi Valley loess will respond over the next 100 years of climate change along a North-South transect. Using a cascade of numerical models for climate (ARPEGE), vegetation (CARAIB) and weathering (WITCH), we explore the effect of an increase in CO_2 of 315 ppmv (1950) to 700 ppmv (2100 projection). Our simulations predict that temperature increasing in the next 100 years causes the weathering rates of the silicates to increase into the future. In contrast, the weathering rate of dolomite – which consumes most of the CO_2 – decreases in both end members (South and North) of the transect due to its retrograde solubility. We thus infer slower rates of advance of the dolomite reaction front into the subsurface, and faster rates of advance of the silicate reaction front. However, additional simulations for 9 pedons located along the North-South transect show that the dolomite weathering advance rate will increase in the central part of the Mississippi Valley, owing to a maximum in the response of vertical drainage to the ongoing climate change.

The carbonate reaction front can be likened to a terrestrial lysocline because it represents a depth interval over which carbonate dissolution rates increase drastically. However, in contrast to the lower pH and shallower lysocline expected in the oceans with increasing atmospheric CO_2, we predict a deeper lysocline in future soils. In the central Mississippi Valley, soil lysocline deepening accelerates but in the South and North the deepening rate slows. This result illustrates the complex behavior of carbonate weathering facing short term global climate change. Predicting the global response of terrestrial weathering to increased atmospheric CO_2 in the future will mostly depend upon our ability to make precise assessments of which areas of the globe increase or decrease in precipitation and soil drainage.

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