Tracing Basaltic Sedimentation From Deposition to Lithification

Michael T. Thorpe
Dr. Joel A. Hurowitz

2015 GSA Annual Meeting
1. Rich repository of clastic sedimentary rocks
2. Sedimentary record linked to fluvial processes
3. Gap in terrestrial reference frame
Terrestrial Analogs

• No perfect analog for Mars
  • Chemically or Physically

• Seek to understand the most basic fluvial driven process in basaltic terrains

Williams et al., 2013
Questions to be answered with Terrestrial Analogs

1. How does basaltic sediment geochemistry and mineralogy evolve during weathering, transport, deposition, and lithification?

2. How does varying climate affect these sedimentary processes in a basaltic watershed?
Field Site # 1 Columbia River Basalts

Kauffman et al., 2009  **Miocene Basalts**  Permian/Triassic Seven Devils volcanics
Jurassic/Cretaceous Diorites

Nez Perce
Sediments

Kamiah Deposits

Lapwai Creek

Craigmont

Lawyer Creek

10 Kilometers

Kamiah
Deposits
From Deposition to Lithification

Lithified Basaltic Fluvial Deposit

Modern Unconsolidated Equivalent
Field work/ Geochemistry/Mineralogy

**Goal:** Sedimentary Processes (*source-to-sink*)

**Goal:** Major and minor element abundances (*XRF and ICP-OES*)

**Goal:** Mineralogical evolution in fluvial system (*XRD*)

Schematic of CRB source to Sink

Proposed schematic from Metz et al., (2009) depicting potential sublacustrine depositional sites on Mars
Chemical Index of Alteration (CIA)

- Enrichment in Al as a function of decreasing grain size
- Clay mineral formation via weathering
- Sedimentary processes transport and segregate clay minerals into finest grain fraction at fluvial depositional sites
Paleo-Fluvial Deposit (cm scale pebble)

60% well crystalline
40% groundmass

55% Plagioclase (PLAG)
40% Pyroxene (CPX)
< 5% Olivine (Ol)
Glass rich?

Kamiah Pebble
Paleo-Fluvial
Current vs. Paleo Deposit Mineralogy

- Mineralogically Similar
- Current and Paleo fluvial activity sampled same source
- Original basaltic mineralogy preserved during lithification
Sand (90-250 µm) Mineralogy

**Kamiah Sand Paleo-Fluvial Current Stream**

- Sand fraction still preserves igneous mineralogy (plag, cpx)
- Clay Minerals begin to appear in low two-thetha degrees
  - QTZ, Aeolian contribution?
Palouse Addition

- Loess mixing but chemical weathering primary control
- Trace/Major elements similar story

(1) Wolff et al., 2008
(2) Stark, 2012
Paleo Clay Mineralogy (disaggregated cement)

- Three clay minerals present: Smectite, Illite, Kaolinite
Current Clay Mineralogy (loose 2µm)

No broad Smectite peak or shift

Current Stream Deposit clay
Air Dried
Ethylene Glycol Solvation

Deposition (2 clay phases)
Kaolinite and Illite

Sedimentary process?
Lithification (3 clay phases)
Smectite, Kaolinite, and Illite
Preliminary Interpretations

1. Source regions experience *mild to moderate weathering* producing clay minerals

   Fresh Basalt + H₂O + CO₂ → Soluble Cations + Clay⁰ + Mafic Sediments

2. Sedimentary processes (i.e., fluvial transport) segregate weathered material into the finest grain fraction
   • Preserve basaltic mineralogy in coarser grained deposits

3. Mixing with loess over transportation pathway adds Quartz but chemical weathering dominates all other major and trace elemental relationships

4. Deposition to Lithification may result in *reverse weathering reactions*

   Clay⁰ + Soluble Cations → New Clays⁰ Smectites
   Current Deposit → Paleo Deposit
Upcoming Work

Iceland September 2015

Noachian Mars: Warm and Wet? Idaho Cold and Icy? Iceland

Photo Credit: Dr. Erwin Dehouck

Michael T. Thorpe
michael.thorpe@stonybrook.edu
Department of Geosciences at Stony Brook University

Map Icelandic Institute of Natural History