2015 GSA Annual Meeting

Tracing Basaltic Sedimentation From Deposition to Lithification

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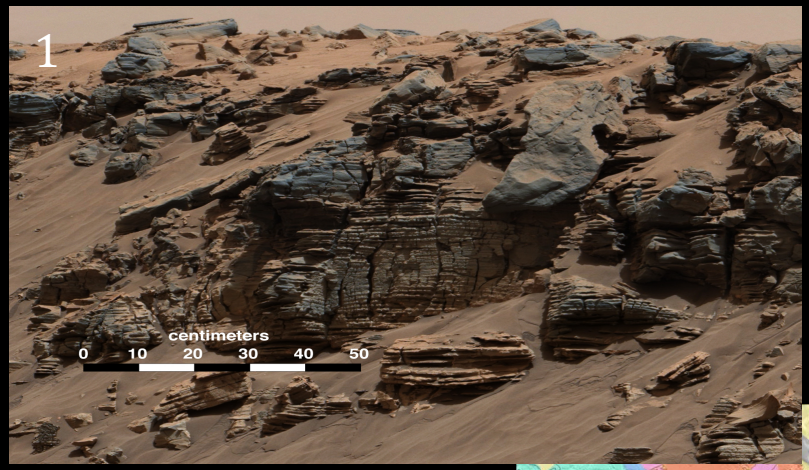
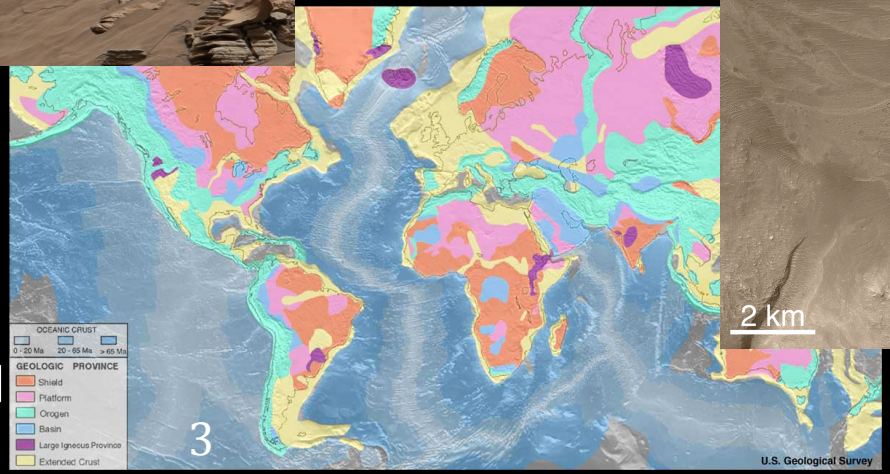
Introduction

1. Rich repository of clastic sedimentary rocks
2. Sedimentary record linked to fluvial processes
3. Gap in terrestrial reference frame



NASA/JPL-Caltech/MSSS



Exposed LIP

USGS

Terrestrial Analogs

- No perfect analog for Mars
  - Chemically or Physically
- Seek to understand the most basic fluvial driven process in **basaltic terrains**

EARTH

MARS

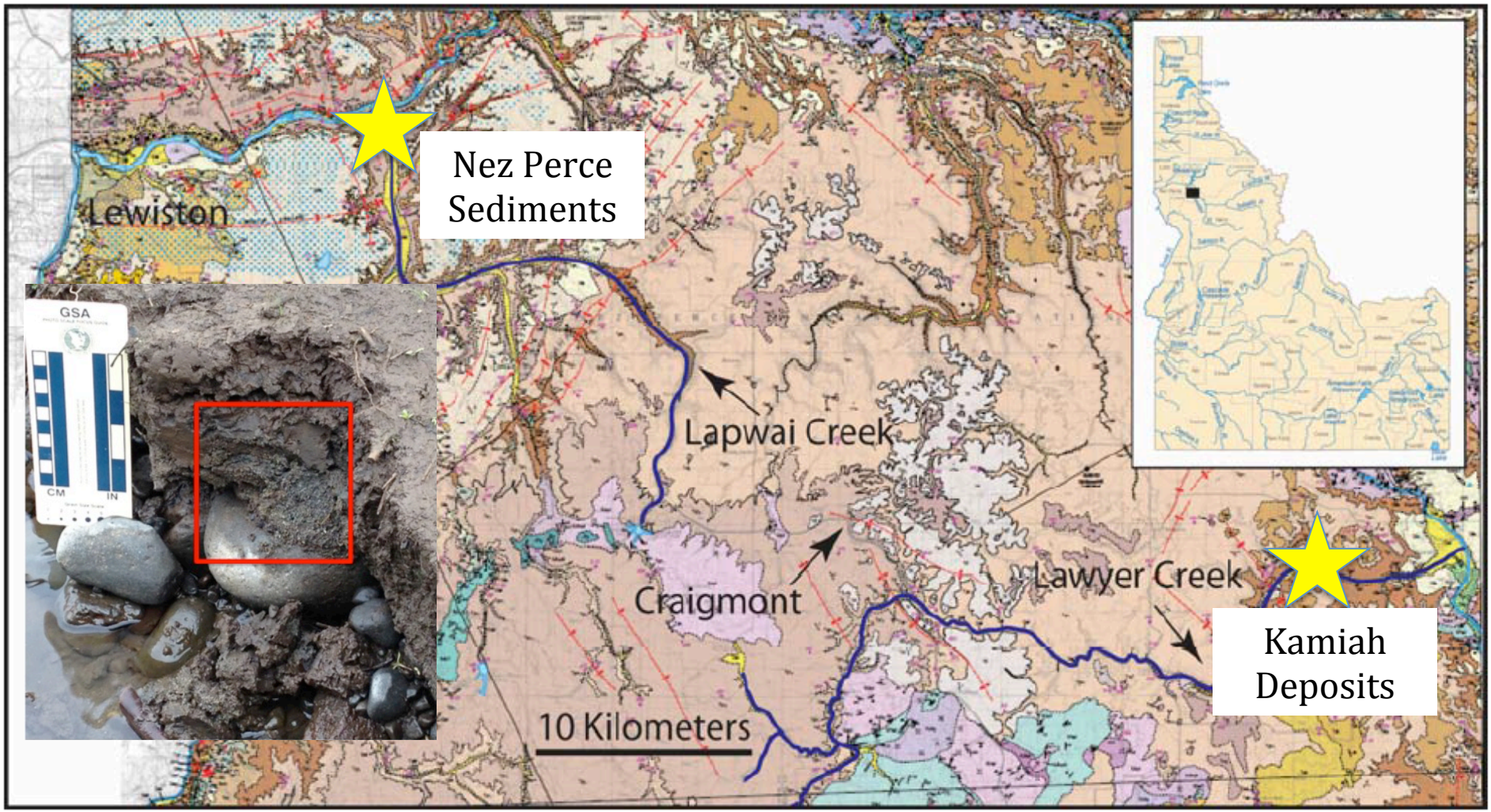
Williams et al., 2013

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?

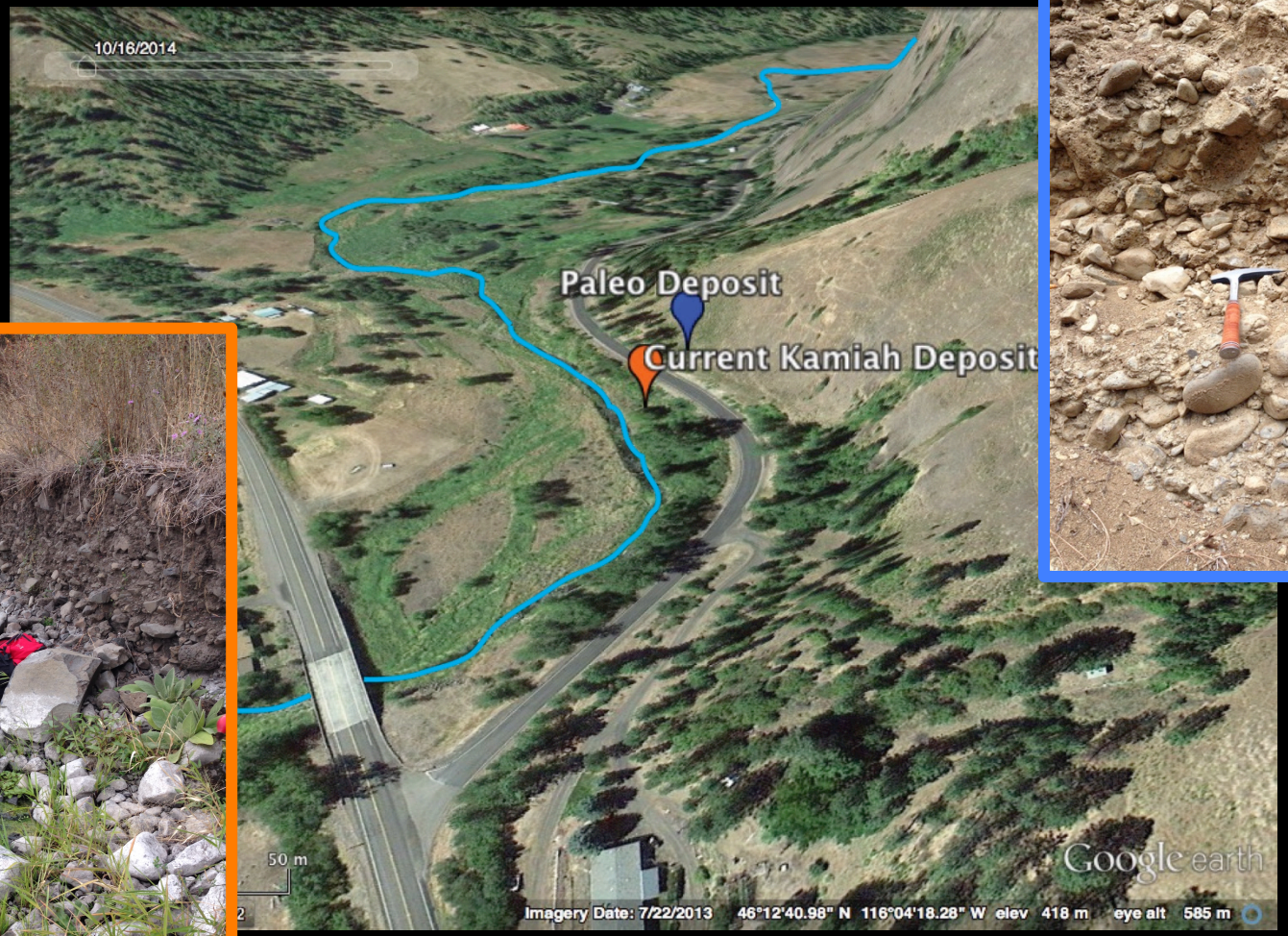
Field Site # 1 Columbia River Basalts



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

From Deposition to Lithification

Lithified Basaltic Fluvial Deposit



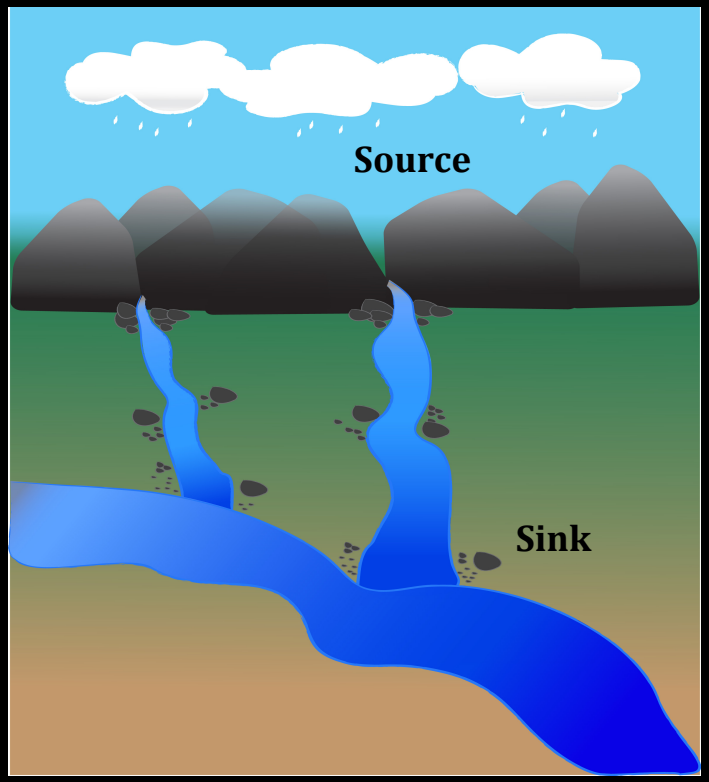
Modern Unconsolidated Equivalent

Field work/ Geochemistry/Mineralogy

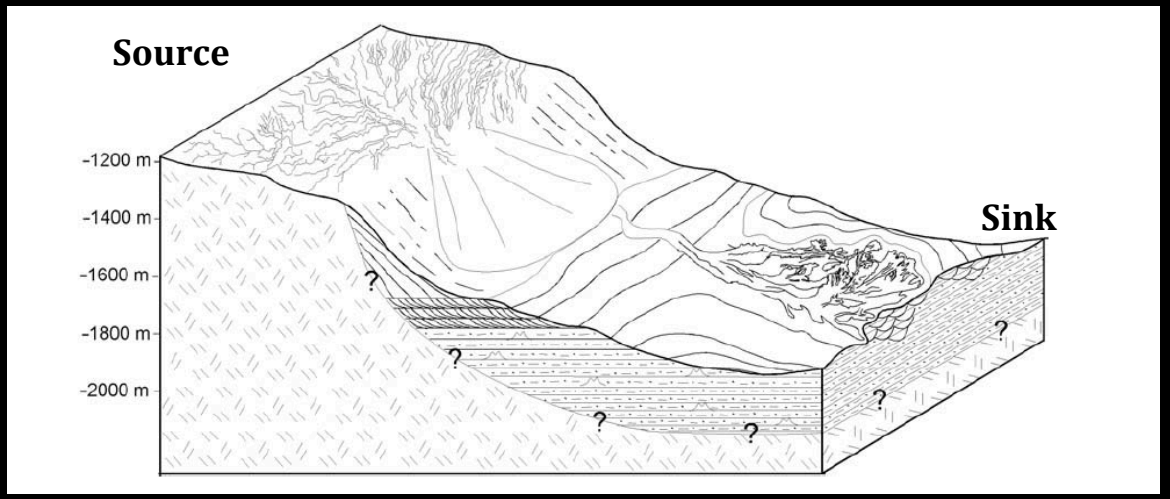
Goal: Sedimentary Processes *(source-to-sink)*

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

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



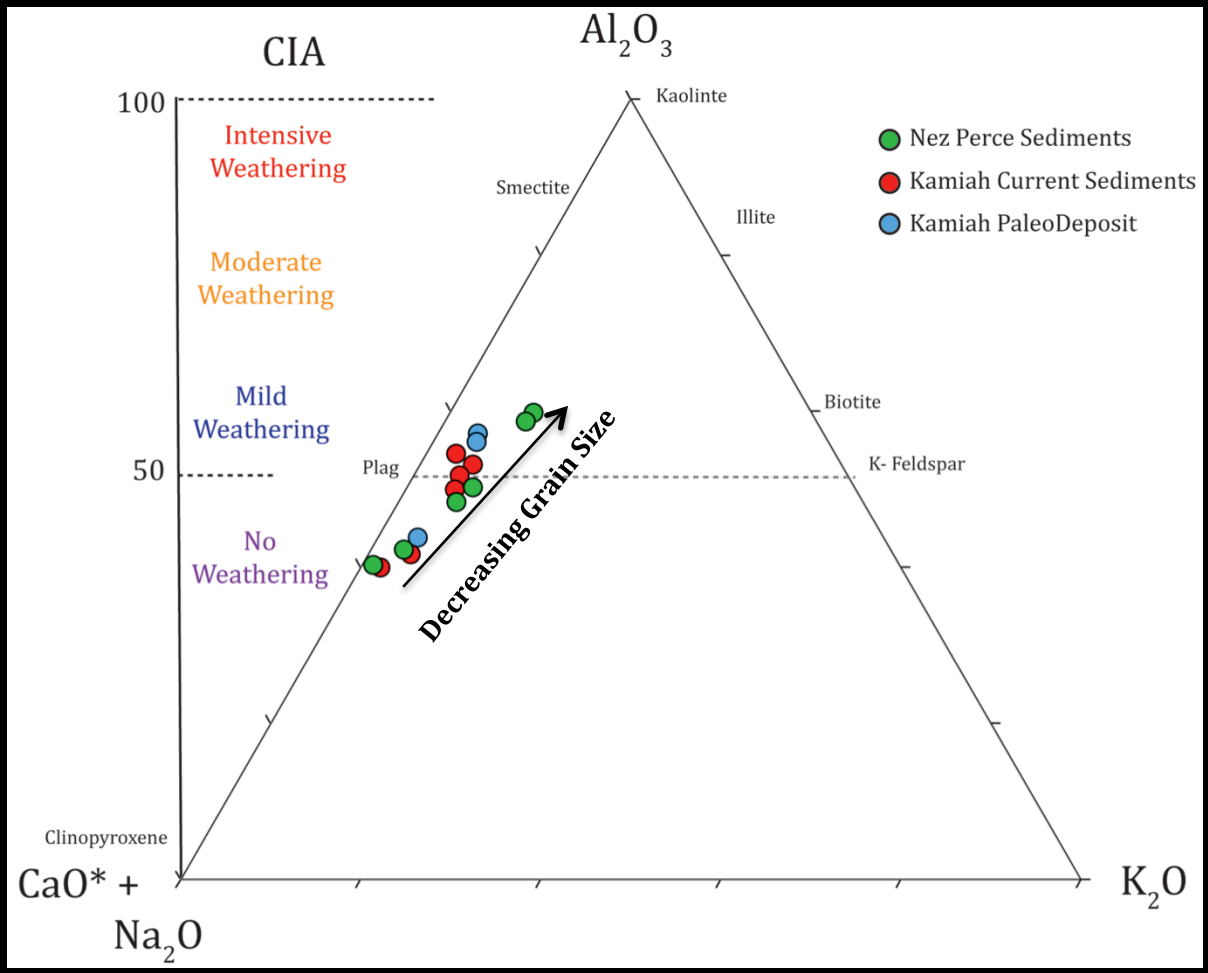
Schematic of CRB source to Sink



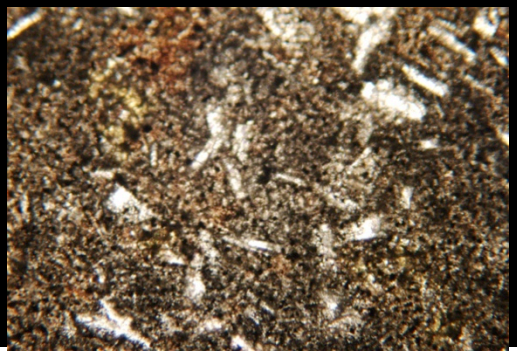
Proposed schematic from **Metz et al., (2009)** depicting potential sublacustrine depositional sites on Mars

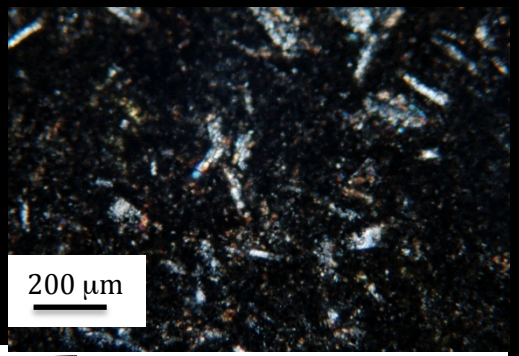
Chemical Index of Alteration (CIA)

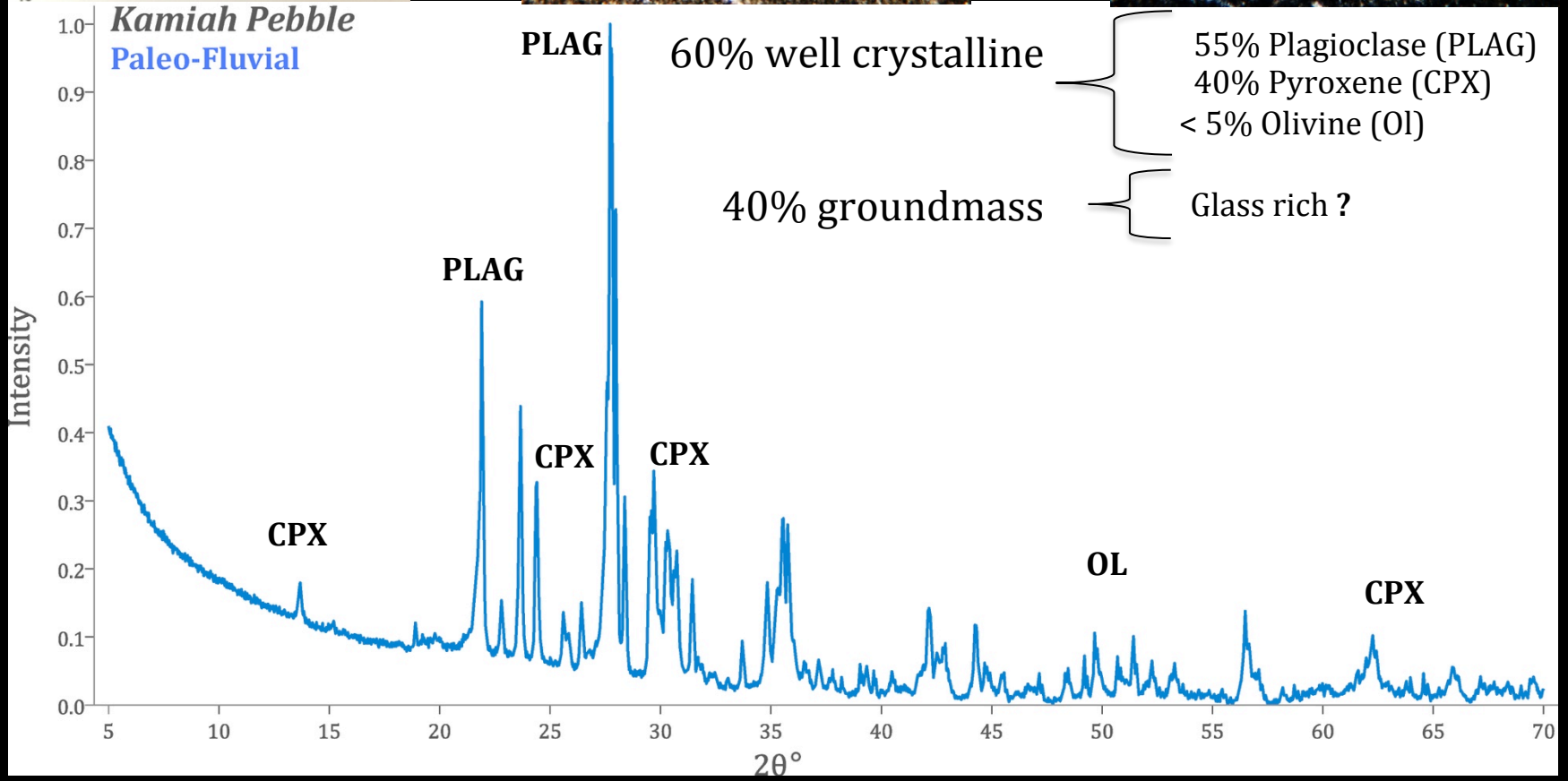
- Enrichment in Al as a function of decreasing grain size
- Clay mineral formation via weathering
- Sedimentary processes transport and segregate clay minerals into finest grain fraction at fluvial depositional sites



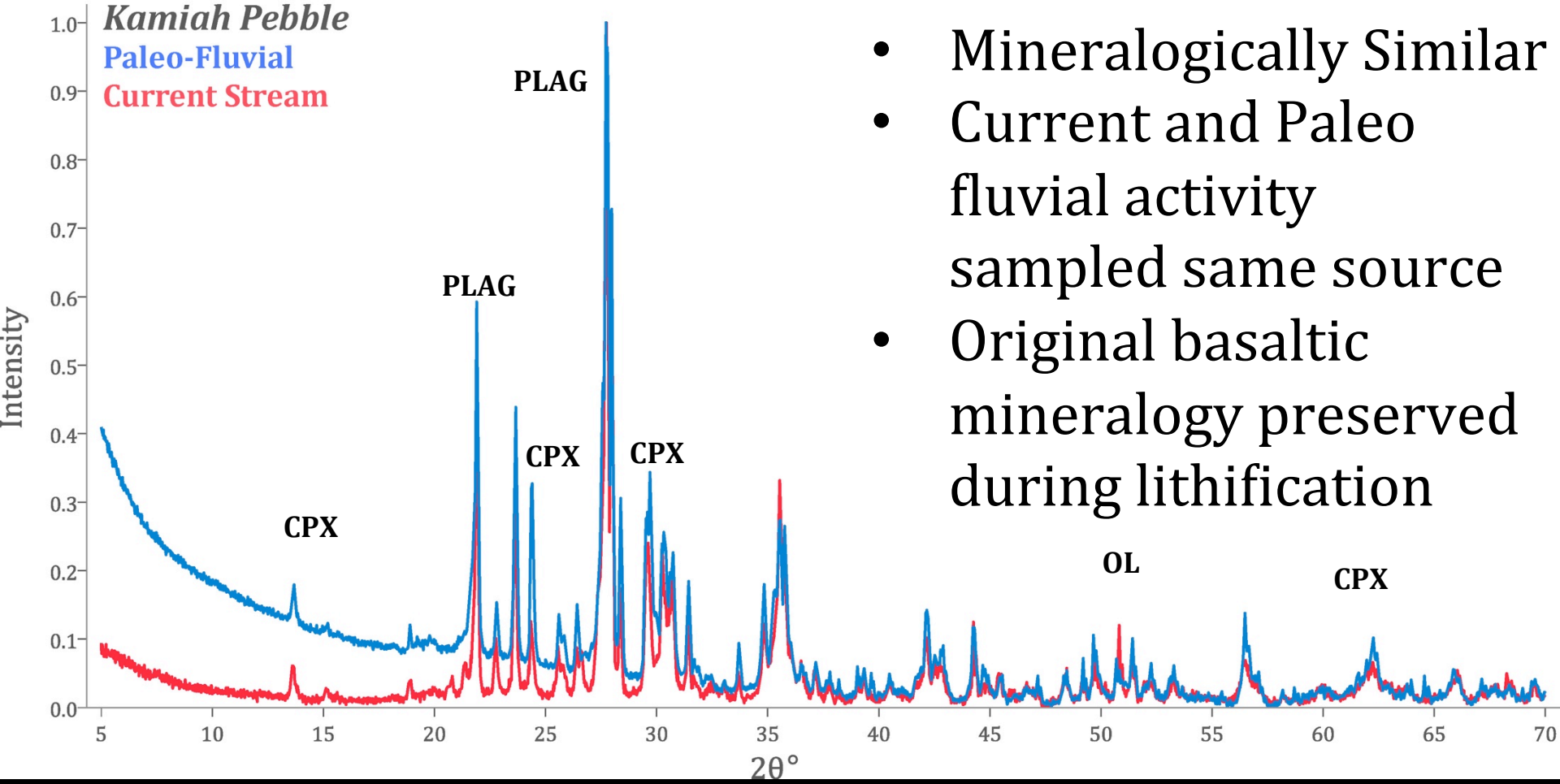
Paleo-Fluvial Deposit (cm scale pebble)





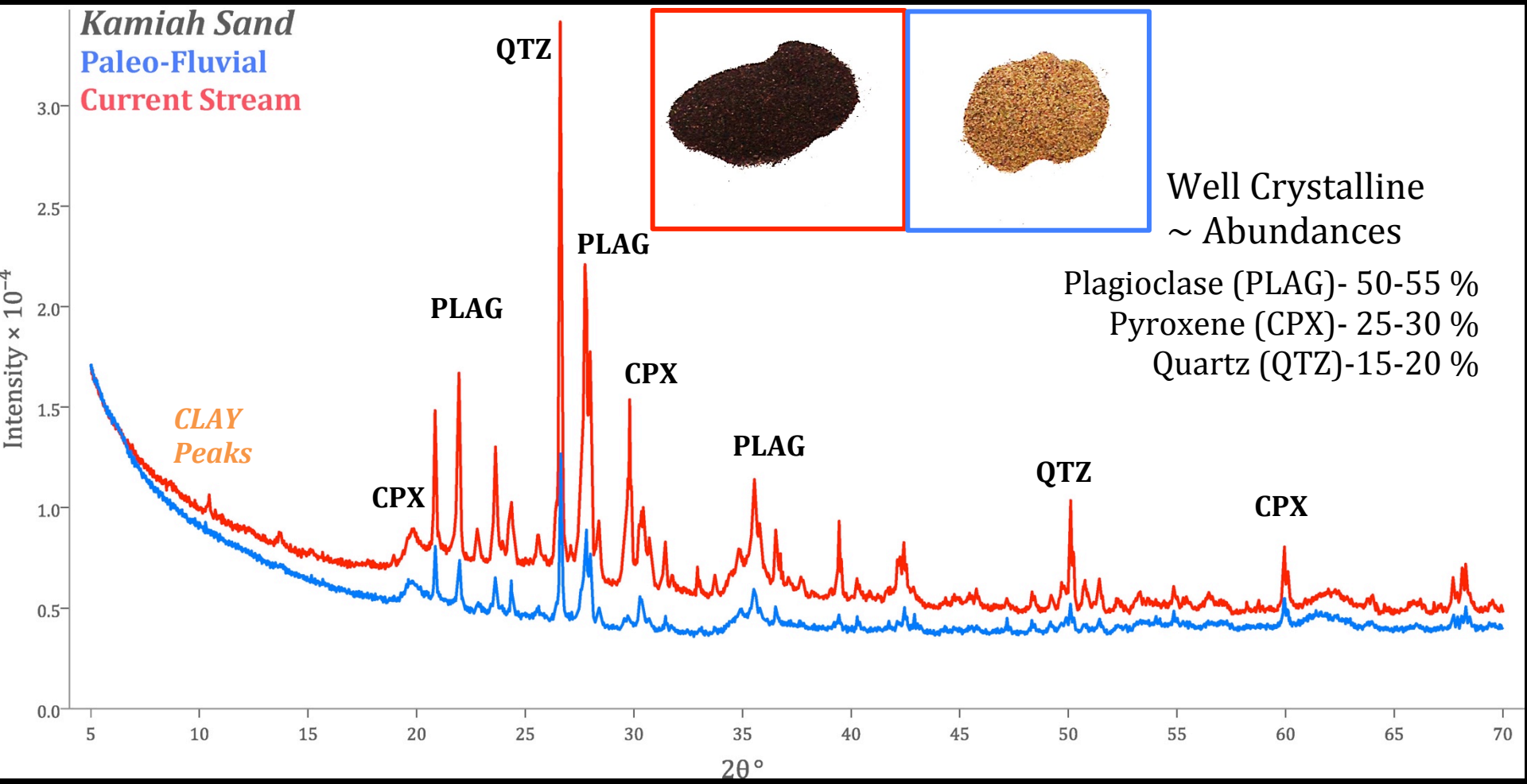


Current vs. Paleo Deposit Mineralogy



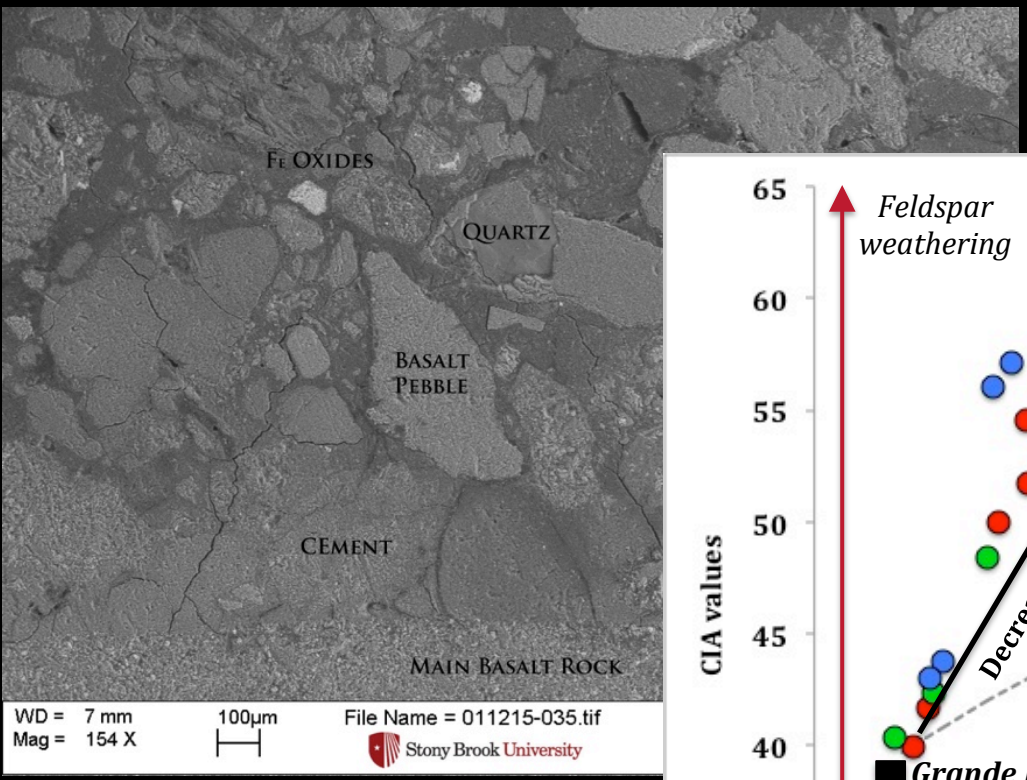
- Mineralogically Similar
- Current and Paleo fluvial activity sampled same source
- Original basaltic mineralogy preserved during lithification

Sand (90-250 μm) Mineralogy

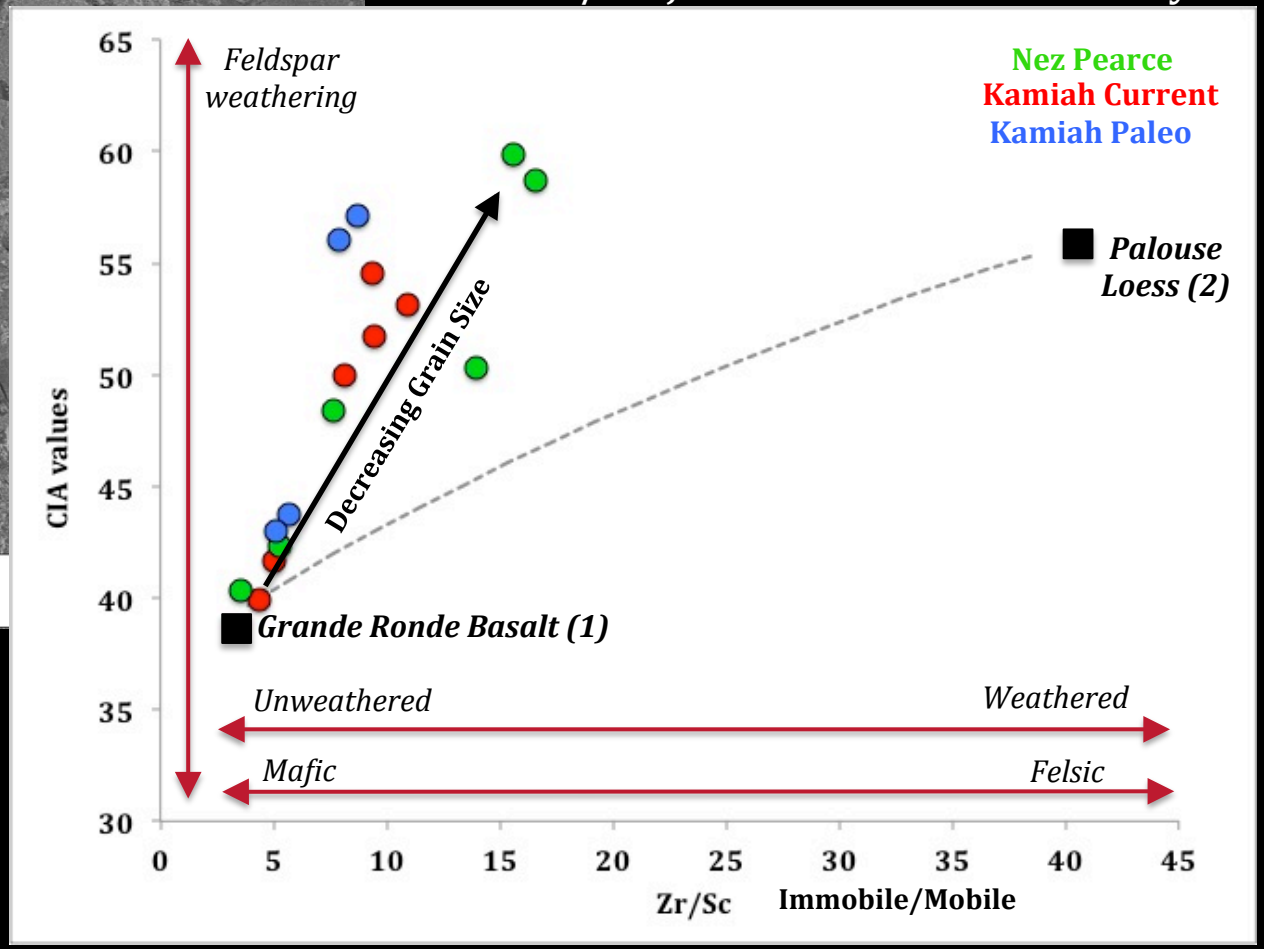


- Sand fraction still preserves igneous mineralogy (plag, cpx)
- Clay Minerals begin to appear in low two-thetha degrees
- QTZ, Aeolian contribution?

Palouse Addition



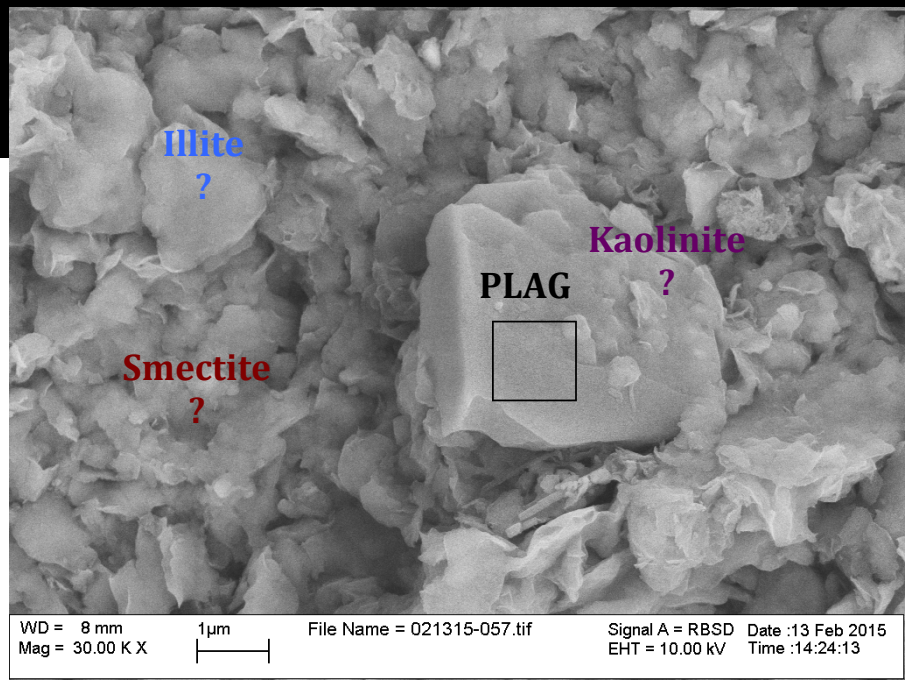
- Loess mixing but chemical weathering primary control
- Trace/Major elements similar story



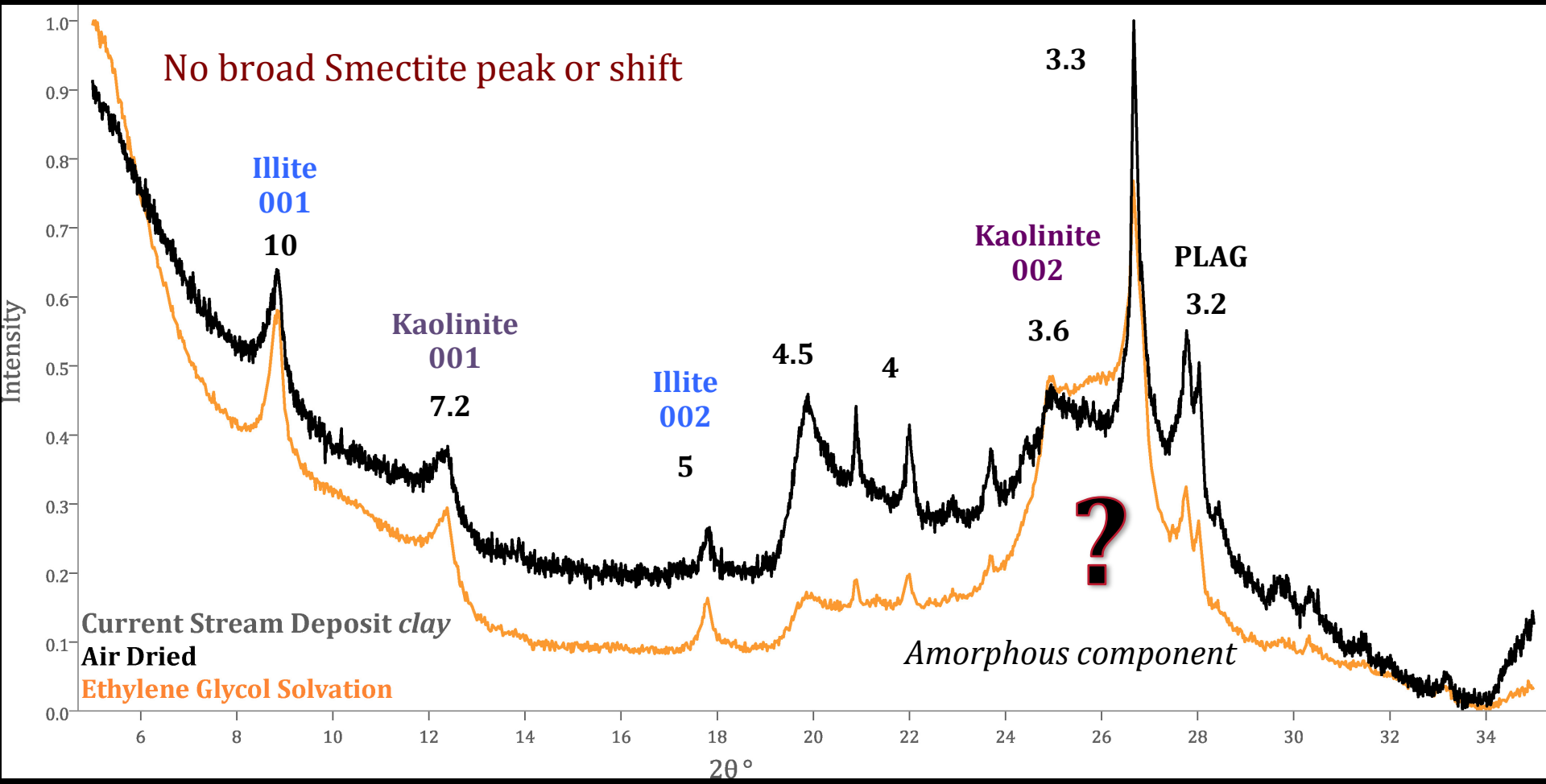
(1) Wolff et. al., 2008 (2) Stark, 2012

Paleo Clay Mineralogy (disaggregated cement)

- Three clay minerals present:
  Smectite, Illite, Kaolinite



Current Clay Mineralogy (loose 2μm)



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

$$\text{Fresh Basalt} + H_2O + CO_2 \longrightarrow \text{Soluble Cations} + \text{Clay}_{\text{Kaolinite}} + \text{Mafic Sediments}$$

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*

$$\text{Clay}_{\text{Kaolinite}} + \text{Soluble Cations} \longrightarrow \textit{New}\ \text{Clays}_{\text{Smectites}}$$

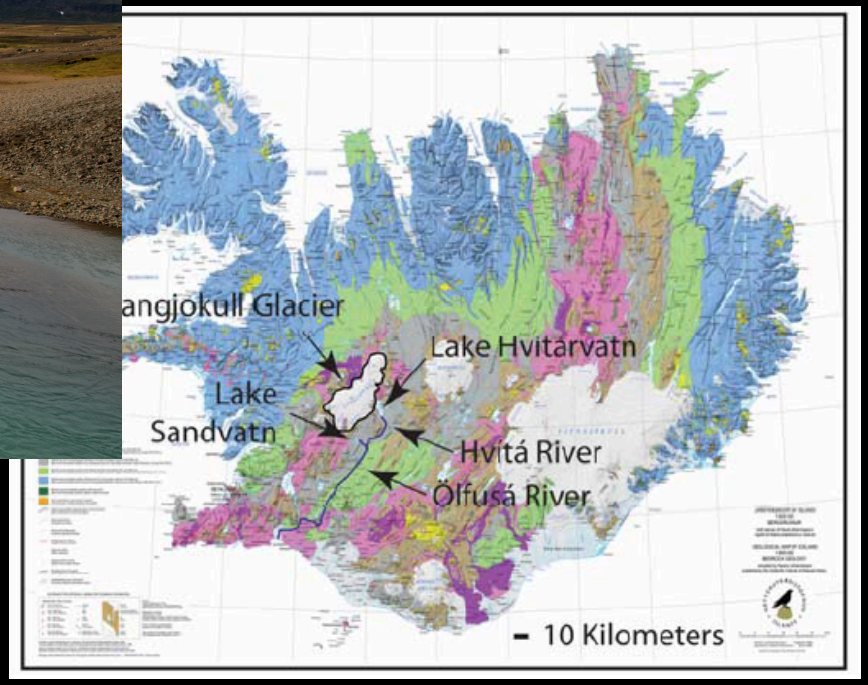
Current Deposit — Paleo Deposit

Upcoming Work

Iceland September 2015

Photo Credit: Dr. Erwin Dehouck

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



Map Icelandic Institute of Natural History

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