Project ESPRESSO: Exploration Roles of Handheld LIBS for Field Geology on Earth and Planetary Surfaces at the Palisades Sill

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Overview:

In order to characterize the role, utility, and development requirements for hLIBS for planetary exploration we analyzed the Palisades Sill in New Jersey (Figure 1). The Palisades Sill is a Triassic diabase sill along the lower stretches of the Hudson River in New York and New Jersey. The sill is composed of primarily plagioclase feldspars and clinopyroxene and intrudes into the Triassic Lockatong Formation which consists primarily of lacustrine sand and siltstones.

The composition is strongly dependent on vertical location within the sill. In-situ measurements of the elemental and mineralogical differentiation across the Palisades Sill, from rapidly chilled margins to a highly differentiated, late stage residual melt horizon were collected using hLIBS. Samples were also analyzed in the lab using both hLIBS and benchtop LIBS.

Field Instrument:

SciAps LIBS Z-300
- Wavelength range:
  - UV: 190 – 300nm
  - Visible: 300 – 950nm
- Elemental analysis range:
  - Hydrogen - Uranium
- Laser spot size:
  - 50 – 100µm
  - Line, single, grid - raster
- Analysis modes:
  1) Element Pro: non-calibrated
  2) Geochem: calibrated
  3) Geochem Pro: mapping

Methods:

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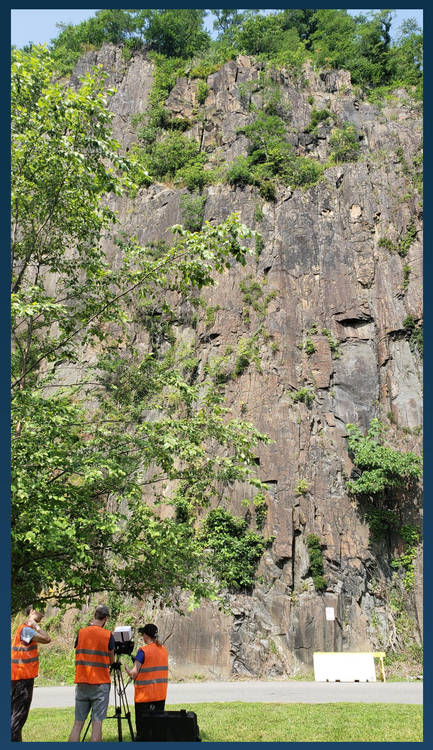
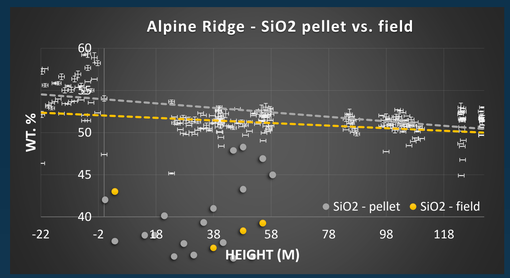
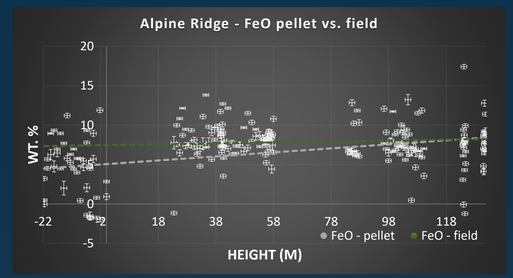
Data Collection
1) 114 samples were analyzed in-situ /collected along the Sill
   - Calibrated Geochem Mode (3 cleaning shots, 5 locations, 10 spectra)
2) The collected samples were homogenized into powders and analyzed
   - Calibrated Geochem Mode (3 cleaning shots, 5 locations, 10 spectra)
3) 16x16 raster was acquired for a relatively fine-, medium-, and coarse-grained samples
   - Geochem Pro Mode (1 cleaning, 10 spectra, 256 locations)

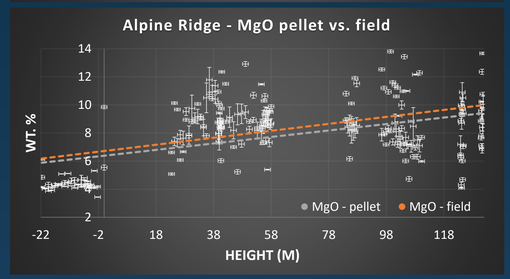
Data analysis
1) Evaluate the ability of these field portable instruments to resolve meaningful geochemical trends
   - Observe in-situ geochemical trends / locate boundaries
   - Compare field collected data with previous laboratory DCP-AES data
2) Investigate the statistical accuracy for bulk geochemical estimation
   - Compare heterogenous field data with homogenous powders
   - Calculate point-to-point variability for major element oxides
     - Oxide compositions normalized from 0-1
     - Individual Gini Indices and mean Gini Index calculated

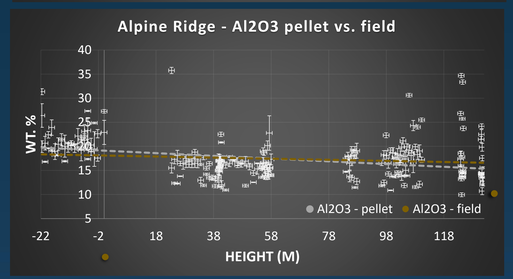
Palisades Sill – Field LIBS

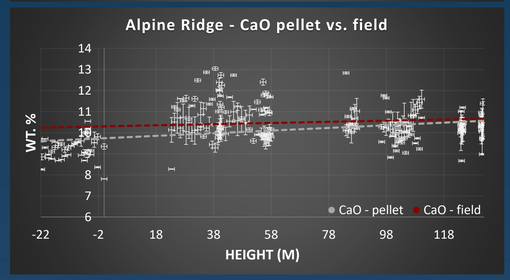


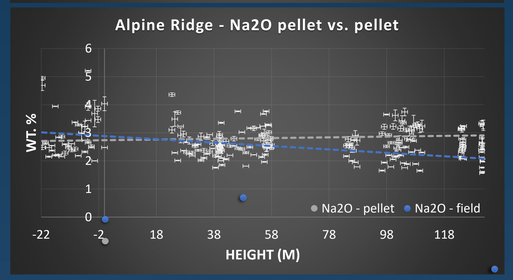




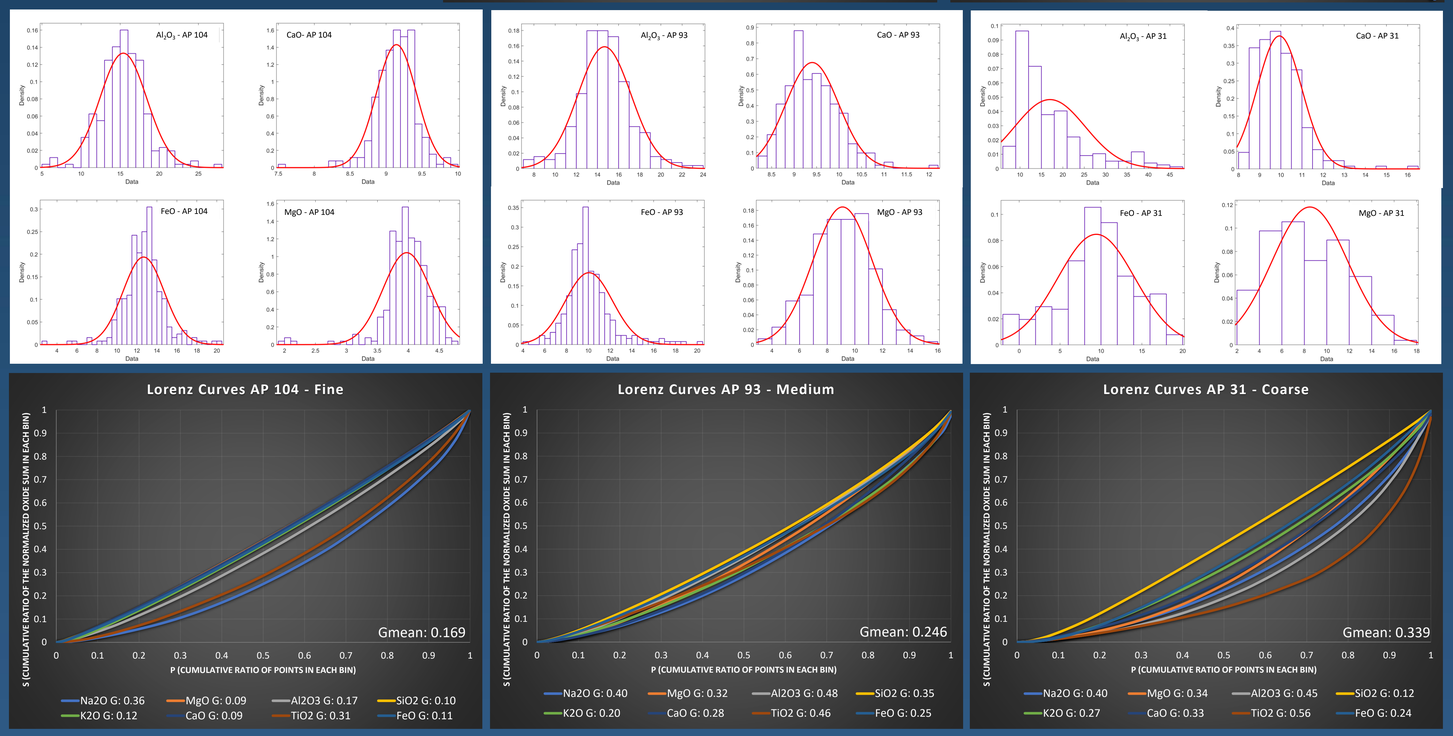








Gini Index:



Gini Index (G) - measure of statistical dispersion that here is used to quantify shot-to-shot hLIBS variability
- → G ranges from 0 to 1, where G=0 expresses complete equality or uniformity and G=1 complete inequality
- → The G value varies between individual oxides as well as for different target materials
- → Rocks with grains smaller than the laser spot size produce bulk rock compositions at each LIBS point, resulting in a lower G value
- → Rocks with grains about the size of the spot or larger contain contributions from individual grains at each point, resulting in a higher G value