RADIOELEMENT GEOCHEMISTRY WITH GAMMA-RAY SPECTROSCOPY: ANALOG STUDIES.

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Summary: The natural radioelements (K, Th, and U) provide constraints on mineralogy useful for mapping and characterization of materials in a variety of geologic settings. These elements are found in low concentrations in most planetary materials. Because they have large atomic radii, they are incorporated into accessory minerals, which are concentrated in late stage magmas and evolved rocks, providing clues to the nature and timing and igneous processes. Potassium is also common in clays formed by chemical weathering and aqueous alteration of silicate minerals.

Gamma rays emitted by the decay of ^{40}K and the daughter products in the Th- and U-decay series can be measured using a gamma-ray spectrometer (GRS, Fig. 1A). The concentration of a radioelement is proportional to the intensity of its gamma rays. This measurement principle has found use in terrestrial and planetary geochemical studies [e.g. 1]. The attenuation of gamma rays limits depth of sensitivity to a few decimeters. Lateral scales depend on standoff, with contact measurements sampling ~meter scale regions. Deployment of a GRS on a rover could find use in rapid, bulk chemical analyses of surface geologic units.

We have developed compact, ruggedized gamma-ray spectrometers for use in analog studies, including upcoming field work planned by the Toolbox for Research and Exploration (TREX) project. This work involves the acquisition of geospatial data using a rover, supported by laboratory analyses of samples (XRD & low background counting). We present preliminary results of a field study designed to test and evaluate the instrumentation, mapping, and analysis methods.

Example application. Initial testing was carried out using cart-mounted and hand-held scintillators, which were used to characterize pyroclastic ash deposits found in the Española Basin in New Mexico. These middle Miocene deposits [2] originated from distant silicic volcanic eruptions and are important for stratigraphic correlations [3]. The data reveal variations in the radioelement content, including within the ash deposits themselves, reflecting differences in the volcanic source and surface alteration processes (Fig. 1B-1D).

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References: [1] Prettyman, T. H. et al. (2019), Ch. 9 & 30, doi:10.1017/9781316888872. [2] Izett, G. A. and Naeser C. W. (1981) USGS OFR 91-161. [3] T. Galusha & J. C. Blick (1971) Bulletin Am. Museum Nat. Hist. vol. 144).

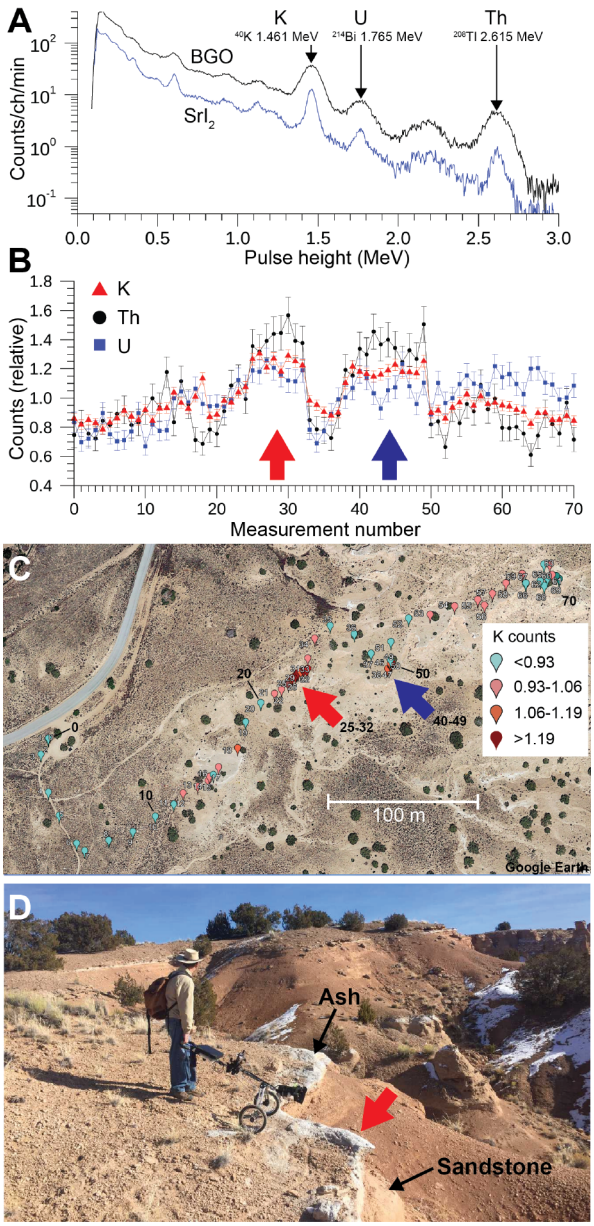

Figure 1. **A**) Gamma-ray pulse height spectra acquired using large-volume BGO and SrI_2 scintillators include distinct peaks for radioelements K, Th, and U. **B**) A time series of net peak areas (BGO, 30s accumulation intervals) acquired along a traverse through silicic ash deposits and Santa Fe Group sandstones in New Mexico's Espanola Basin is shown. Counts vary in proportion to concentration. **C**) The measurement locations, indicated by map markers, were determined using a hand-held GPS. The marker color code gives the relative intensity of the K-peak. **D**) The photo shows ash units interbedded with sandstone. The cart mounted BGO/GRS is positioned over exposed ash along a ridge for which relatively high counts were observed.