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Using Spectral Data in Exploration for Geothermal Resources

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Since 2002, faculty and students at the University of Nevada, Reno have used a combination of satellite and aerial surveys at varying spatial resolutions to obtain regional information on hydrothermal alteration patterns and to target more expensive, but also more detailed, airborne spectral data collects. We have performed numerous site assessments to characterize mineral, vegetation, and thermal properties as surface identifiers of geothermal resources [1]. Our work has included the satellite sensors Landsat, ASTER, and ALI and airborne sensors MASTER, HyMap, ProSpecTIR, AVIRIS and SEBASS. As part of our validation process we collect data in the field to confirm remote identifications and we also collect samples for later laboratory analysis. These field and lab measurements corroborate our detections and help to define confidence limits in refining regions where alteration minerals are found. Validation work includes the use of an ASD field spectrometer for measurement from 0.4 to 2.5 µm in both field and lab configurations. Past work has identified sinter, tufa, various argillic and propyllitic alteration zones, vegetation concentration near small surface seeps or springs, and thermal anomalies as indicative of resource potential and structural controls on fluid pathways. Playa evaporites have also been used as diagnostic indicators of geothermal systems, where thermal springs discharge into closed basins. Mapped imagery is geo-rectified to standard projections and integrated into GIS databases so that mineral maps can be readily included in regional and site specific assessments.

We have applied these hyperspectral techniques using our field spectrometer to collect point spectra in several pilot studies of geothermal drill core and chips [2]. These studies have established reliable methods for core/chip surveys that can rapidly measure samples with high depth resolution and show the efficiency of the technique to sample continuously and provide alteration logs similar to geophysical logs. We have successfully identified layered silicates, zeolites, opal, calcite, and iron oxides and hydroxides in drill cuttings from geothermal wells. In high vertical resolution measurements (every 10') we note depth-associated changes in alteration minerals, patterns or zones. Temperature dependent mineral assemblages are found, both gradational with depth and as narrow zones associated with vein or fracture fill. Silica-opal geothermometer minerals are clearly resolved and seen only in the highest temperature wells. We can readily identify montmorillonite/illite transitions that may be associated with Na/Ca/K variation and may eventually be used for geothermometry. Many alteration minerals are similar in all wells, yet unique signatures related to lithology and alteration temperature are also seen. Depth surveys up to several kilometers were completed in a short time frame and can provide an initial assessment and point to sections of interest for more detailed or time consuming analysis such as SEM/TEM/XRD.

The presentation will provide an overview of our methods and results from two recent summary papers [1,2], highlighting successes and lessons learned.

References:

[1] Calvin, W. M. et al. (2015) Geothermics: 53: 517-526
[2] Calvin, W. M. et al. (2016) Geothermics: 61: 12-23