U.S. Department of the Interior
U.S. Geological Survey

MAPPING ARGILLIC AND ADVANCED ARGILLIC ALTERATION IN VOLCANIC ROCKS, QUARTZITES, AND QUARTZ ARENITES IN THE WESTERN RICHFIELD 1° X 2° QUADRANGLE, SOUTHWESTERN UTAH, USING ASTER SATELLITE DATA

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Pamphlet accompanies plate

EXTENDED ABSTRACT

To provide a synoptic overview of exposed lithology and hydrothermal alteration in support of a regional mineral resource assessment and ongoing deposit research in southwestern Utah, mineral and vegetation maps covering 9,541 square kilometers were produced from remotely-sensed imagery acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor.

The Richfield quadrangle in southwestern Utah is known to contain a variety of porphyry, skarn, polymetallic replacement and vein, alunite, and kaolin resources associated with 27 - 32 Ma calc-alkaline or 12 - 23 Ma bimodal volcano-plutonic centers in Neoproterozoic to Mesozoic carbonate and siliciclastic rocks.

Exposed volcanic rocks associated with the calc-alkaline suite are dominated by the Needles Range Group (32 - 28 Ma) that was extruded from the White Rock (Lund Fm.) and co-genetic Indian Peak (Wah Wah Springs Fm.) calderas located in the extreme southwest of the Richfield map, and the Hornsilver Andesite (~31 Ma) exposed in the eastern San Francisco Mountains, Beaver Lake Mountains, Rocky Range, and southern Shauntie Hills. Widespread volcanic units associated with bimodal magmatism include the Horse Valley Formation (rhyodacites and dacites, 22 - 19 Ma) exposed in the Black Mountains; the Quartz latite of Squaw Peak (22.4 Ma) exposed in the Shauntie Hills; rhyolitic flows and tuffs of the Blawn Formation (23 - 18 Ma, see simplified gray-scale map from Christiansen and others, 2007); and the Steamboat Mountain Formation (rhyolites and rhyodacites, 13 - 12 Ma) in the Broken Ridge area at the intersection of the Wah Wah Mountains and Indian Peak Range south of Pine Valley.

Advanced argillic alteration minerals (alunite, pyrophyllite, dickite and/or kaolinite) were identified in both undocumented (U) and known (K) areas, including in the southern Paradise Mtns. northwest of Mount Elenore (U) and 2 km west of the town of Modena (K); in calc-alkaline volcanic rocks in the Wah Wah Mtns. between Broken Ridge and the NG area (U/K); at Wah Wah Summit in a small zone adjacent to a 33.1 Ma diorite intrusion and marbleized Cambrian carbonates (U); in fractures cutting quartzites surrounding the 20 - 22 Ma Pine Grove Mo deposit (U); in volcanic rocks in the Shauntie Hills, both at the large steam-heated system developed in Needles Group and Squaw Peak latite near White Mountain (22.5 Ma) and in a smaller area of latite south of Squaw Peak to the north (U/K); in Proterozoic quartzites in the west-central San Francisco Mtns. (U); in volcanic rocks in the Black Mtns. (K); and in mainly 12 - 13 Ma rhyolitic rocks along a 20 km E-W belt, which includes the Bible Spring fault zone west of Broken Ridge and several small centers in the Escalante Desert to the south (U/K). Argillized Navajo Sandstone (Lower Jurassic) with kaolinite and(or) dickite ± alunite was mapped adjacent to calc-alkaline intrusions in the Star Range (U). Prominent quartz-sericite alteration with local kaolinite was identified in Hornsilver Andesite adjacent to calc-alkaline intrusions in the Beaver Lake Mountains (K). Mo-bearing phyllic alteration was identified in 22.2 Ma rhyolite plugs at the center of the NG alunite area. Limestones, dolomites, and marbles were differentiated, and quartz and sericite were identified in most unaltered quartzites.

Halos of argillically-altered rock ~12 km in diameter surround the Pine Grove deposit, the central rhyolites at NG, and the North Peaks just south of the Bible Spring fault zone. Alunite ages shift southward from 22 - 23 Ma at NG in the northeast to the 12 - 13 Ma near Broken Ridge in the southwest. This age shift mirrors a changing locus of bimodal magmatism and is similar to the southward shift of activity from the Antelope Range to Alunite Ridge (porphyry Mo potential) in the Marysvale volcanic field farther east.

ASTER Data and Mineral Mapping

The ASTER sensor is carried aboard the Earth Observing System Terra satellite orbiting the Earth at 705 km altitude. The ASTER sensor has nine bands in the visible to shortwave infrared (SWIR) spectral region with ground pixel sizes of 15 and 30 m, and 5 bands in the thermal infrared (TIR) region with 90 m pixels.

The map of clay, sulfate, mica, carbonate, and hydrous quartz minerals shown at center was derived from spectral analysis of mainly the SWIR data, and the map of quartz and carbonate minerals at right was derived from analysis of the TIR data. The SWIR data analysis involved a quantitative, least-squares comparison of laboratory reference spectra with image reflectance spectra (Rockwell, 2009). The TIR data analysis was based on compound band ratios of surface emissivity data (Rockwell and Hofstra, 2008).

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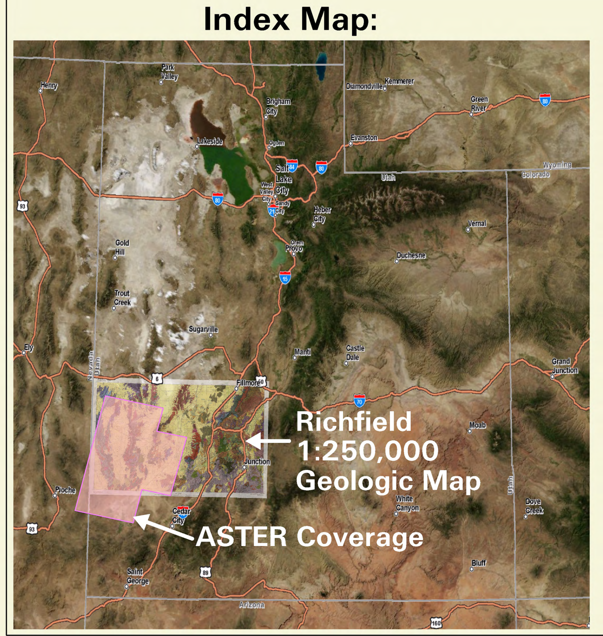
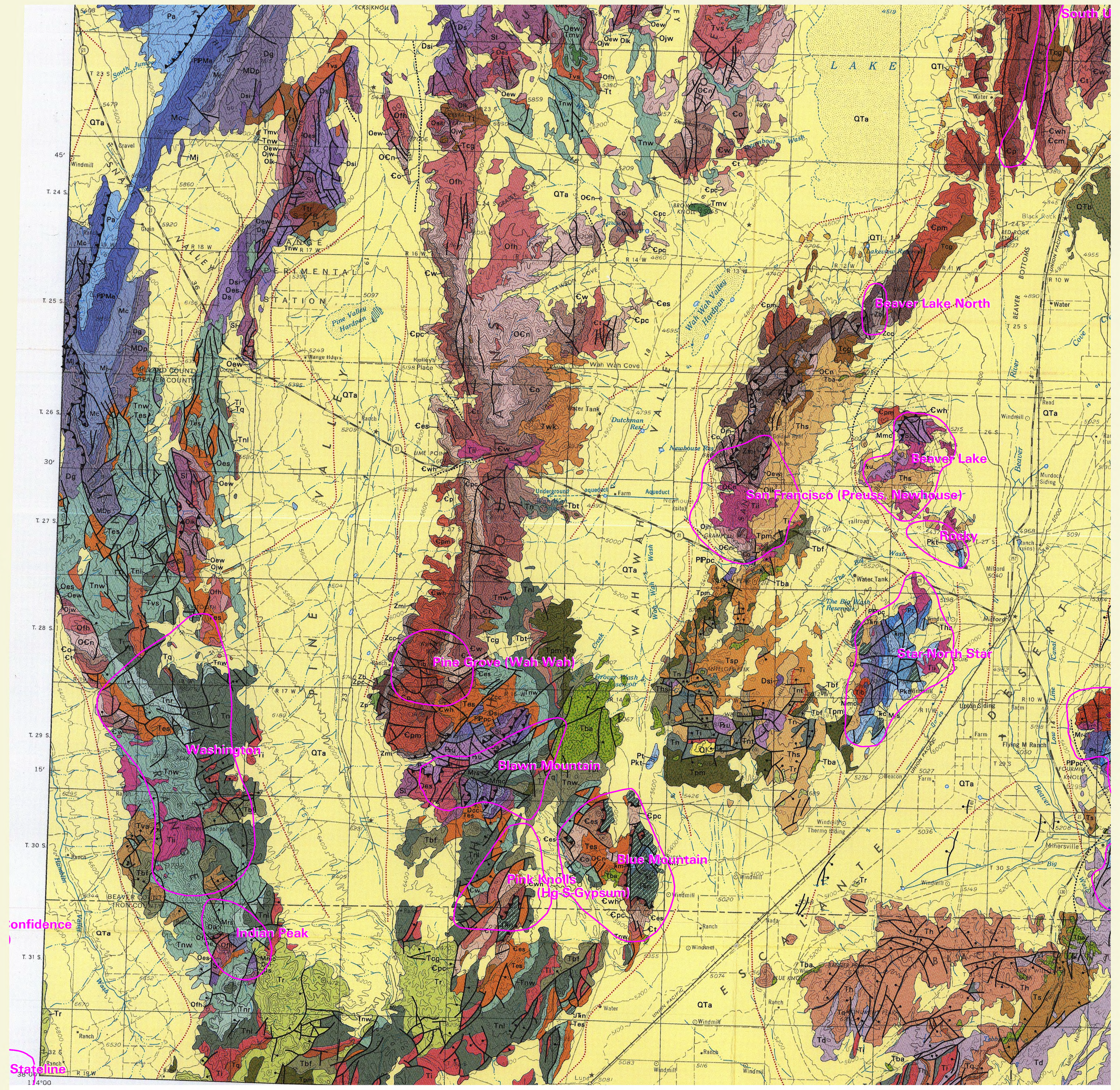
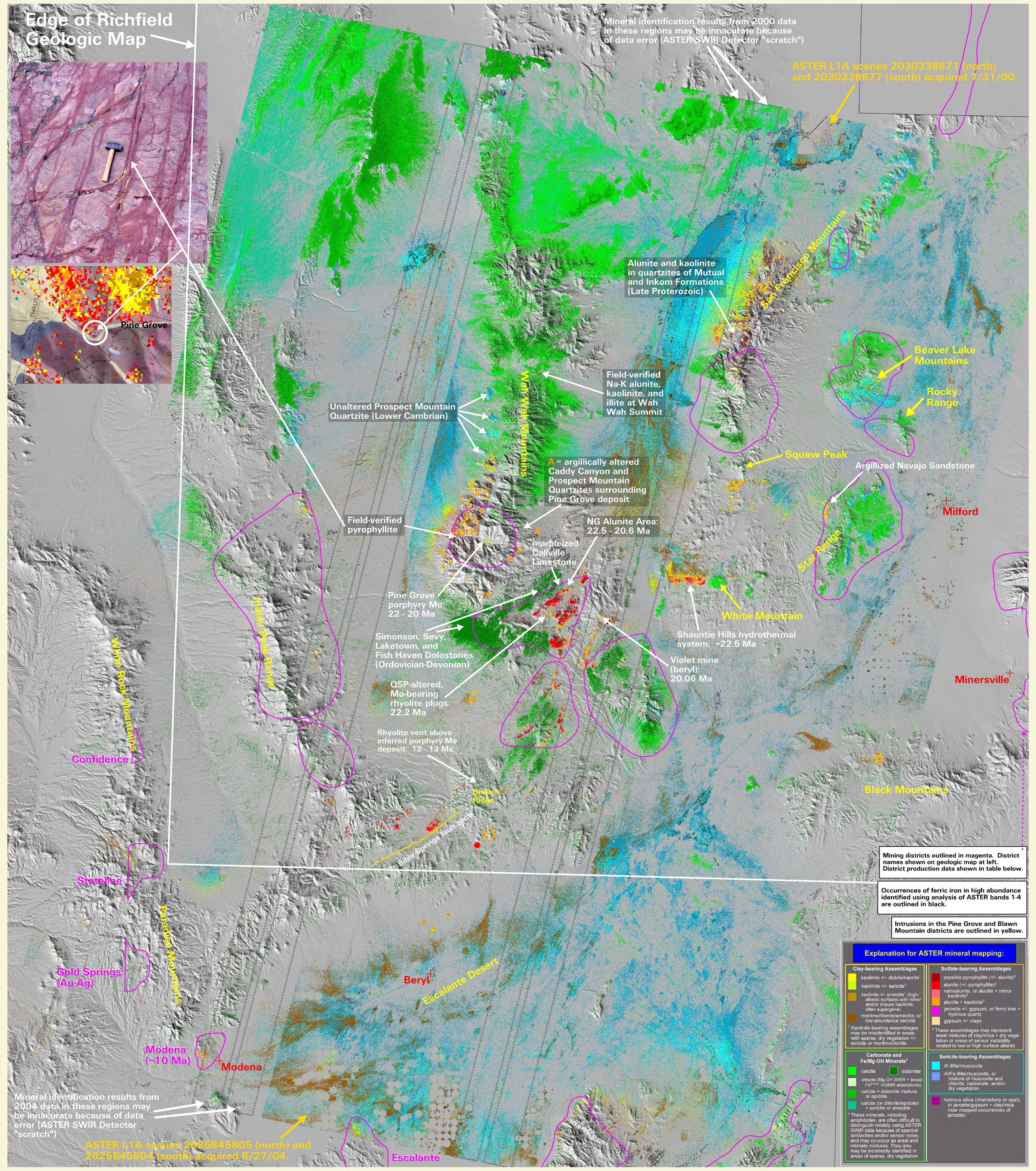
Index Map:



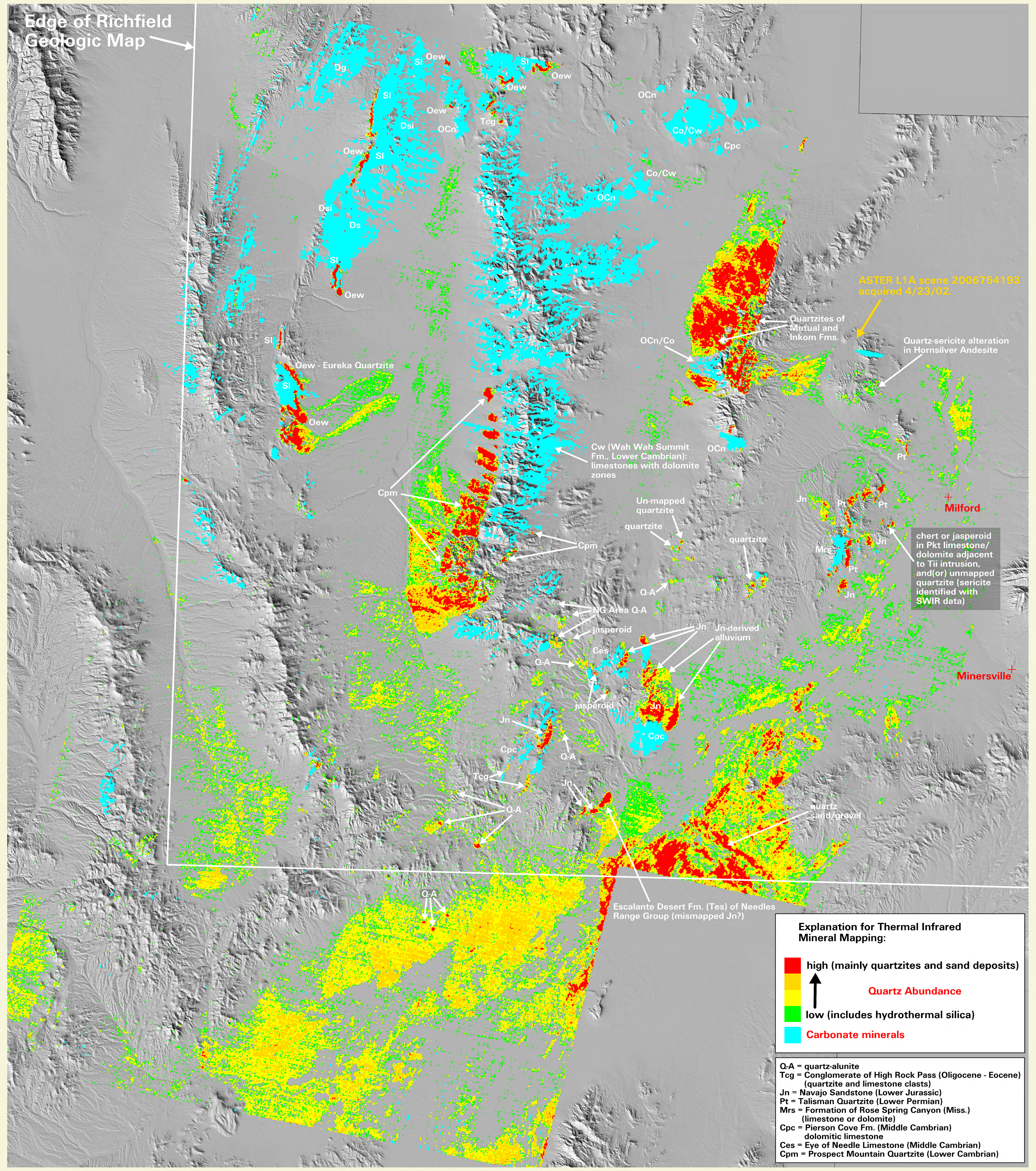
Richfield 1:250,000 Geologic Map (Steven and others, 1990)



Map of Clay, Sulfate, Mica, Carbonate, Sorosilicate, and Hydrous Silica Minerals

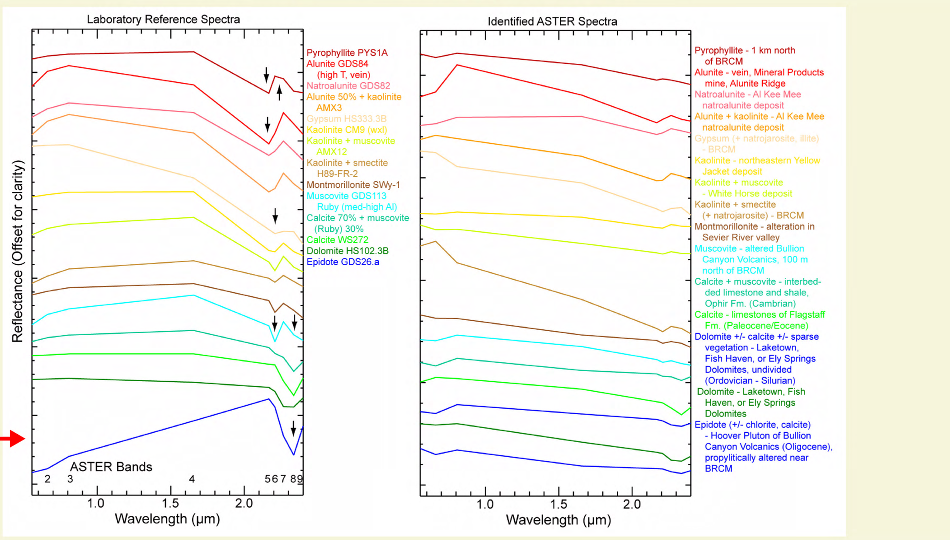


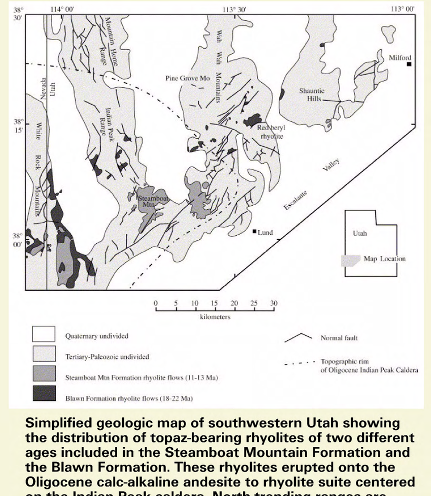
Map of Quartz and Carbonate Minerals



Mining District	Productive	Cu	Pb	Zn	Au	Ag	Other	Age (Ma)
		Percent Total Production						
·San Francisco	1870-1976	15%	40%	6%	5%	33%	0%	32
·Washington/ Indian Peak	1916-1946	0%	12%	10%	0%	1%	77%	21
·Beaver Lake	1870-1976	99%	0%	0%	0%	0%	0%	31
·Blawn Mountain (alunite)		0%	0%	0%	0%	0%	100%	23
·Pine Grove	1911-1945	1%	25%	38%	9%	28%	0%	23
·Blue Mountain (iron ore)		0%	0%	0%	3%	0%	97%	20
·Star/North Star	1870-1976	67%	49%	8%	4%	32%	0%	22
·Rocky	1870-1975	89%	0%	0%	0%	1%	10%	30
·Stateline	1902-1932	0%	2%	0%	62%	36%	0%	17
·Escalante	1966-1988	0%	0%	0%	1%	99%	0%	12

Plot of selected laboratory spectra of clay, sulfate, mica, carbonate, and other minerals and mineral mixtures having diagnostic SWIR absorption features (on left) used as references for analysis of ASTER data. Representative ASTER image spectra of pixels from the Marysvale volcanic field identified as specific materials based on spectral similarity with the reference spectra are shown at right. Black arrows indicate selected diagnostic absorption features used in analysis (Rockwell, 2009).





Simplified geologic map of southwestern Utah showing the distribution of topaz-bearing rhyolites of two different ages included in the Steamboat Mountain Formation and the Blawn Formation. These rhyolites erupted onto the Oligocene calc-alkaline andesite to rhyolite suite centered on the Indian Peak caldera. North-trending ranges are bounded by buried Miocene and younger normal faults. From Christiansen and others (2007).

UTM Projection
Zone 12 North
Clarke 1866 Spheroid
NAD27 Horizontal Datum

Scale
10 0 10 Kilometers
5 0 5 10 Miles
1 : 175,000

Suggested citation:
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Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Or visit the Central Mineral and Environmental Resources Science Center Web site at:
http://minerals.cr.usgs.gov/

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Christiansen, E.H., Haapala, Ilmari, and Hart, G.L., 2007, Are Cenozoic topaz rhyolites the erupted equivalents of Proterozoic rapakivi granites? Examples from the Western United States and Finland: Lithos, v. 97, no. 1-2, p. 219-246.

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Acknowledgments:

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