DIGITAL MAPPING TECHNIQUES 2013

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USGS National Map of Surficial Mineralogy: A New Interactive Web Resource for the Detection, Mapping, and Mineralogical Characterization of Hydrothermal Alteration and Mine Waste

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Extended Abstract

Ongoing U.S. Geological Survey (USGS) national-scale mineral resource and geo-environmental assessments require an efficient and accurate means of mapping and characterizing the surficial mineralogy of exposed hydrothermally-altered rocks and mine waste. The presence and mineralogy of altered rocks are important factors in determining the potential for concealed mineral deposits. Mineral-environmental investigations at deposit and watershed scales have shown the importance of sulfide-bearing altered rocks and mine waste as diffuse sources of acidic solutions that can transport metals into the hydrologic system. These rocks and waste materials derived from these rocks contain minerals that can be identified using spectral analysis of satellite remote sensing data. Automated analyses of multispectral data acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Landsat 7 ETM+ sensors are currently being used by the USGS to rapidly generate mineral group maps at 30-meter ground resolution over large areas of the United States in support of USGS research and assessment projects (Rockwell, 2012; 2013).

The GIS-ready image maps shown here have been designed primarily for the regional mapping and characterization of exposed surface mineralogy, including that related to hydrothermal alteration and weathering of sulfide-bearing rocks. As hydrolytic alteration commonly occurs along faults and fractures that serve as conduits for potentially metal-bearing fluids, the presence and type of alteration can provide important information for mineral resource investigations. Hydrothermal base and precious metals deposits, such as those of the porphyry copper and epithermal types, have characteristic hydrothermal alteration styles. Mapping of areas of alteration can therefore be used to identify prospective areas for such deposits as well as aid in determining the deposit type, orientation of the deposit with regard to the ground surface, and degree of deposit exhumation.

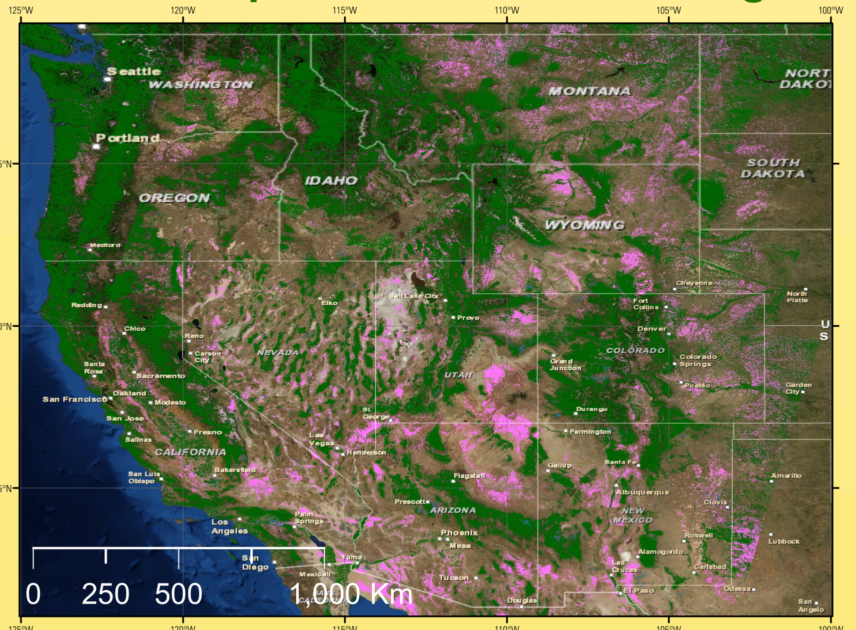
Pyrite is a common sulfide gangue mineral associated with metal-bearing sulfide assemblages and with hydrothermal alteration in many types of mineral deposits. Upon exposure to atmospheric oxygen and water, the weathering of pyrite produces sulfuric acid that can leach and transport potentially toxic metals into the surface and groundwater systems. Knowledge of the presence of pyrite and the extent and type of hydrothermal alteration is vital to geo-environmental studies which develop predictive models of surface water geochemistry in catchments containing mineral deposits and mines as a means to evaluate pre- and post-mining effects of altered areas on local hydrology. Ferric iron minerals including jarosite, copiapite, melanterite, and goethite are also produced during the pyrite weathering process, and hematite can be produced by hypogene alteration processes. Concentrations of undifferentiated ferric iron-bearing minerals can be identified by the automated analysis of ASTER and Landsat TM data. Many of these minerals can be directly detected using spectroscopic analysis of ASTER and (or) imaging spectrometer data. Acid-neutralizing carbonate rocks and propylitic alteration can also be detected using ASTER data.

The mineral group maps can be used to assess the acid rock drainage potential of mine waste and tailings, and to prioritize sites for remediation. For example, mine waste and tailings in which no ferric iron-bearing mineral groups are mapped are less likely to represent exposed, nonpoint sources of acidic solutions, or are too small in size to be mapped using the satellite data. The maps can also be used to evaluate mineral exposure at mine and mill sites that have undergone remediation prior to the acquisition of the image data.

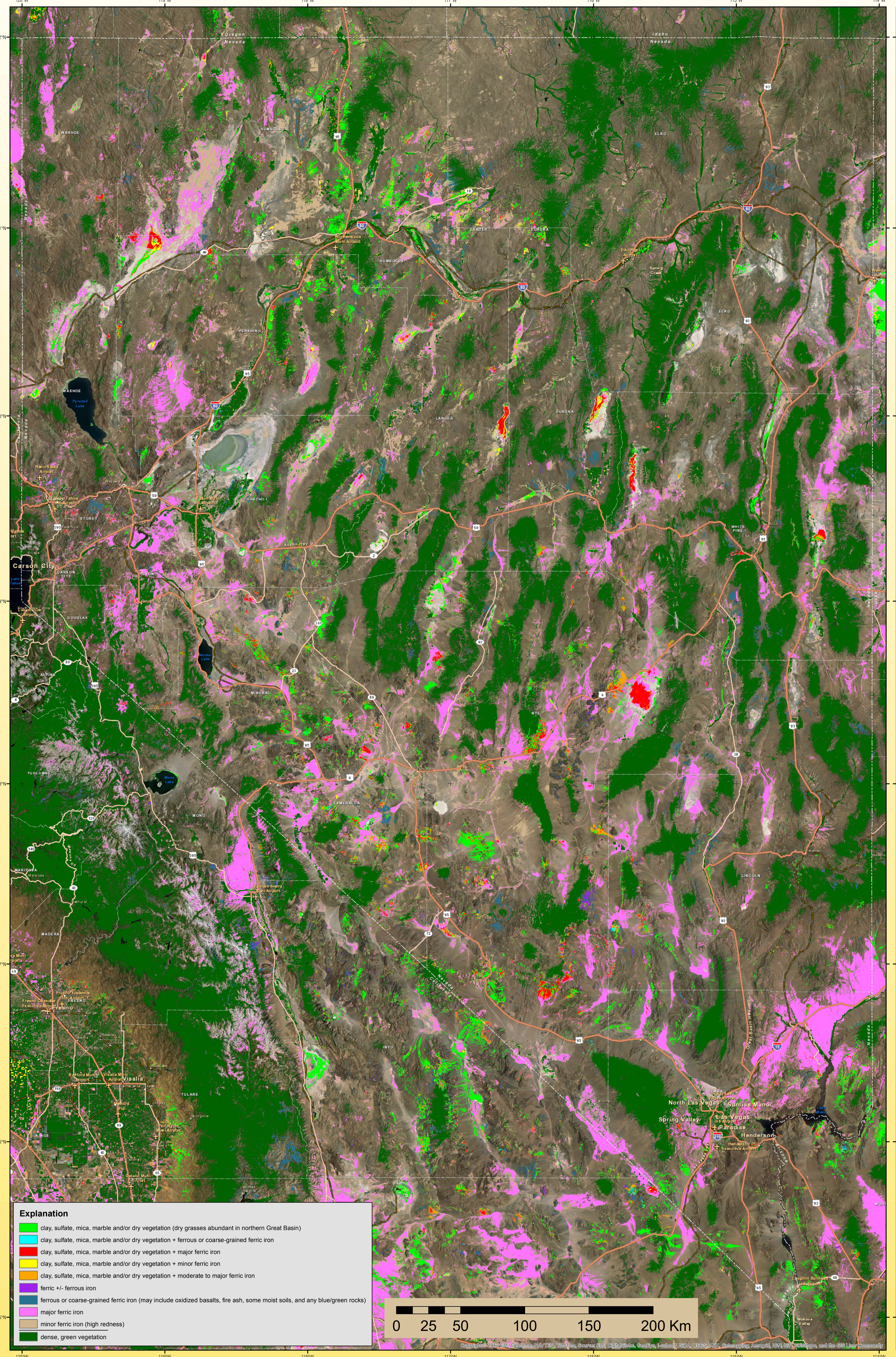
The mineral group maps have been made available to the public as an interactive, browser-based application using ArcGIS Server and theArcGIS Viewer for Flex (http://cmerwebmap.cr.usgs.gov/usminmap.html). The Flex viewer and the .NET Web Application Developer Framework viewer for ArcGIS are used to serve the data internally at the USGS. The underlying ArcGIS services upon which the web applications are based are available to USGS personnel for integration with other geospatial data in ArcMap, and may also be made publically available. Previously-published, detailed maps of surface mineralogy generated from spectroscopic analysis of ASTER and airborne imaging spectrometer data (including NASA Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and HyVista HyMap) over important active and abandoned mining districts are included in the web services where available. New mineral maps are continually being added. The multi-layer, interactive configuration of the web services allows for the easy comparison of mineral maps generated from different remote sensing data types and analysis methodologies. It is hoped that the web-based mapping resources will serve as a reference base for future geologic remote sensing research.

The USGS Mineral Deposit Database project is compiling a nationwide vector database of mine features (including open pits, shafts, adits, and tailings) from a variety of sources. These points and polygons will be used to query the maps of surficial mineralogy shown here to populate a mineralogy table in the database. These data can then be used to characterize and prioritize the mine features for potential environmental effects such as acid rock drainage. The surficial mineralogy data are also being used to support other USGS research related to geologic mapping, ore genesis, and mineral resource estimation.

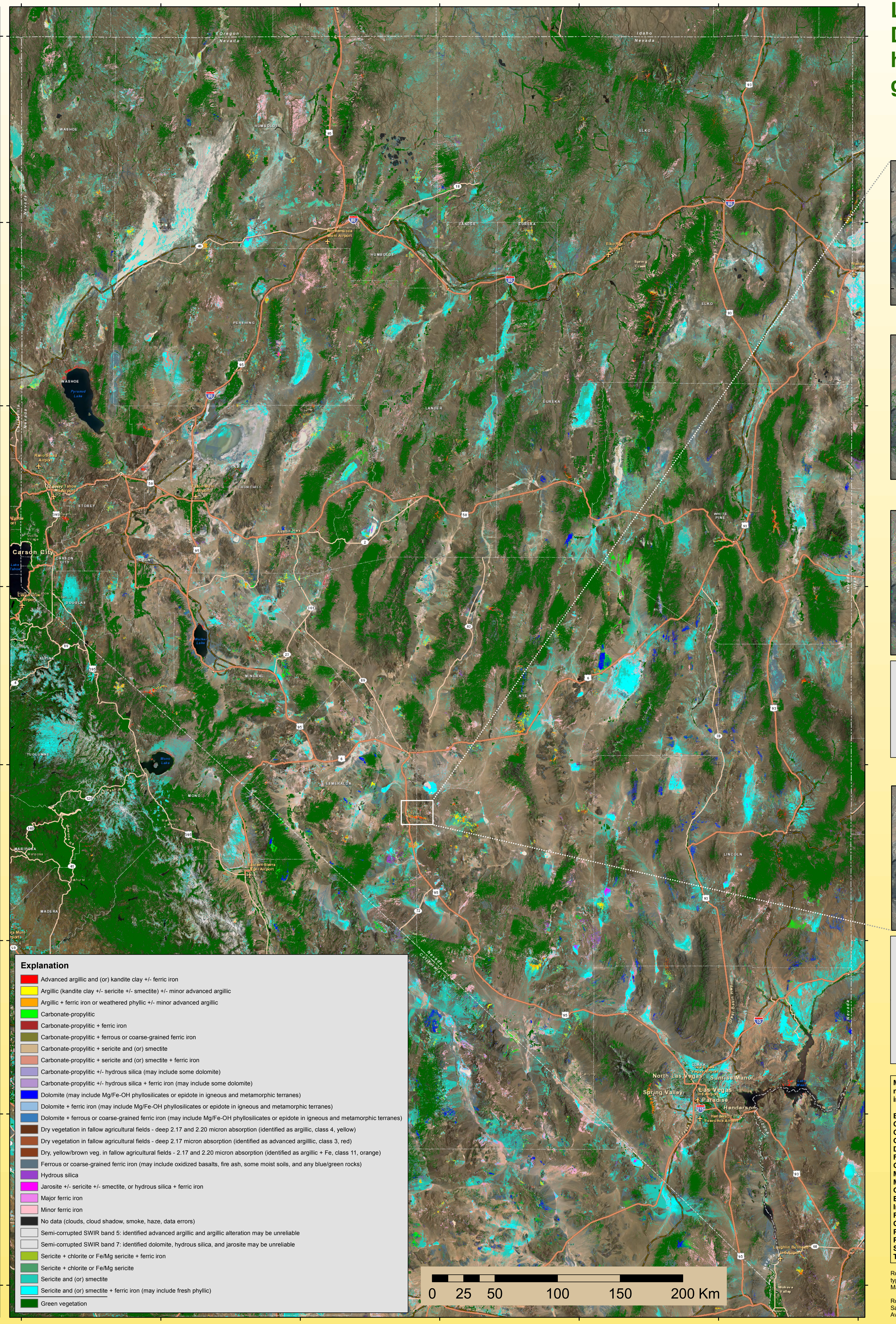
Index Map - Current Data Coverage



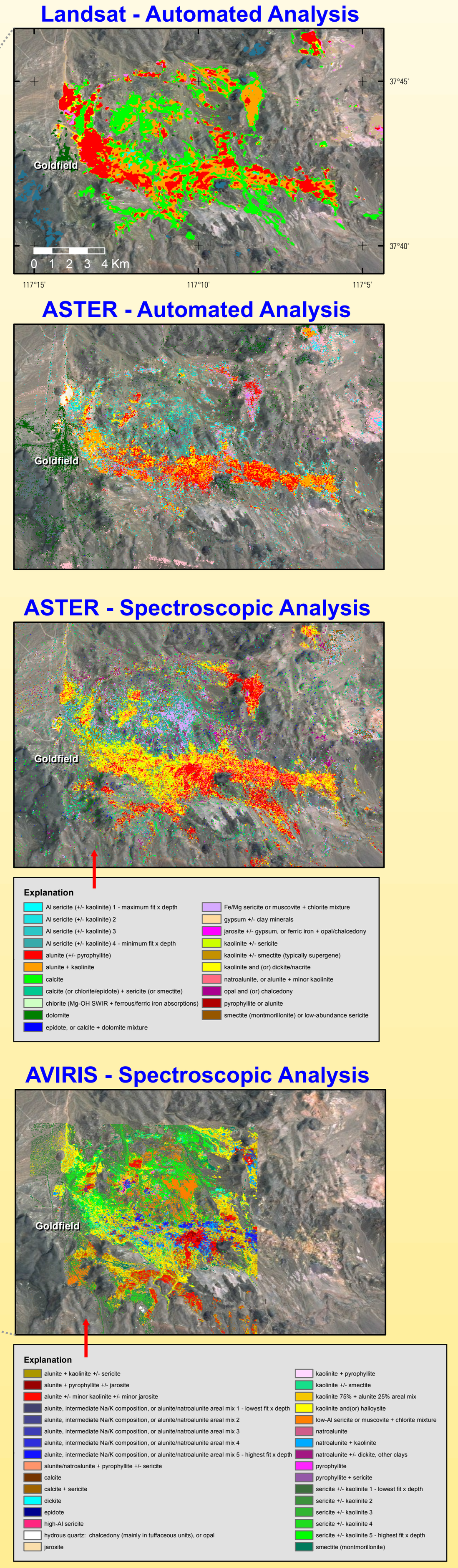
Landsat 7 ETM+ Mineral Group and Green Vegetation Mapping, Nevada



ASTER Mineral Group and Green Vegetation Mapping, Nevada



An example of Multiple Levels of Mineral Mapping Detail from the Goldfield high-sulfidation, epithermal gold deposit, Nevada



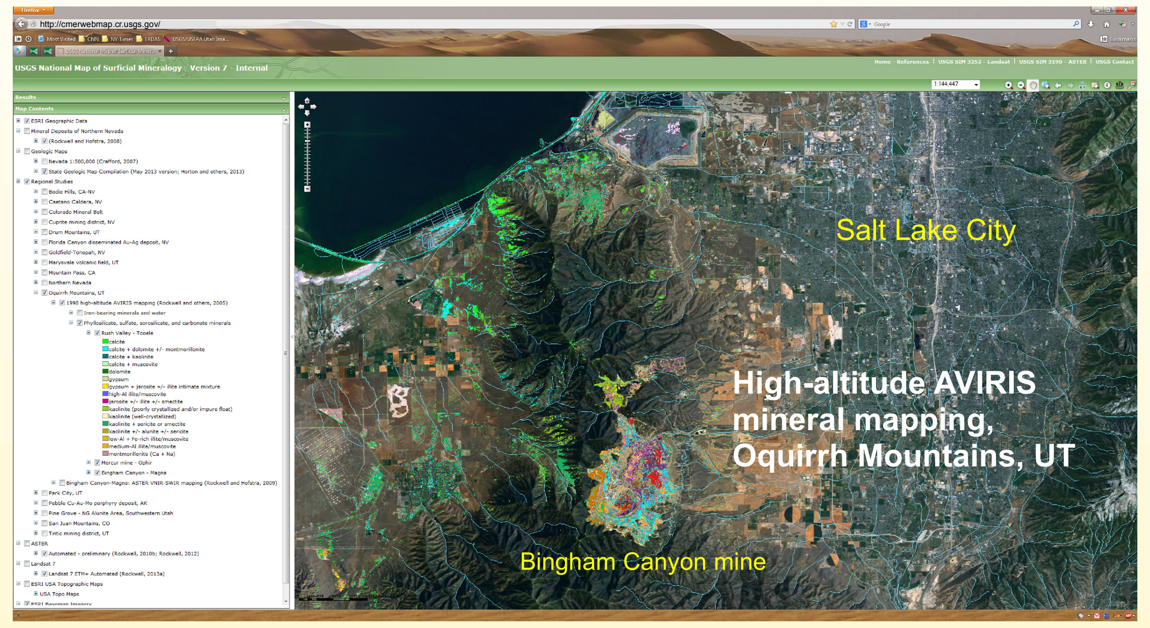
Mining districts and mineralized areas for which detailed mineral maps derived from spectroscopic analysis of ASTER and airborne imaging spectrometer ("hyperspectral") data are available:

Bodie Hills/Aurora, CA-NV (ASTER)
Caetano caldera, NV (ASTER)
Colorado Mineral Belt (AVIRIS, ASTER)
Cuprite district, NV (AVIRIS, HyMap, SpecTIR, ASTER)
Drum Mountains, UT (ASTER)
Florida Canyon disseminated Au-Ag deposit, NV (HyMap)
Goldfield/Tonopah, NV (AVIRIS, ASTER)
Marysvale volcanic field, UT (AVIRIS, ASTER)
Mountain Pass (REE), CA (AVIRIS)
Carlin Trend, NV (AVIRIS)
Battle Mountain-Eureka Trend, NV (AVIRIS)
Independence Trend, NV (AVIRIS)
Ruby Mountains - Alligator Ridge, NV (AVIRIS)
Oquirrh Mountains, UT (Bingham Canyon - Mercur), UT (AVIRIS, ASTER)
Park City, UT (AVIRIS)
Pine Grove (porphyry Mo) - NG Alunite Area, UT (ASTER)
Silverton - Summitville mine regions, San Juan Mtns., CO (AVIRIS, ASTER)
Tintic district, UT (AVIRIS, ASTER)

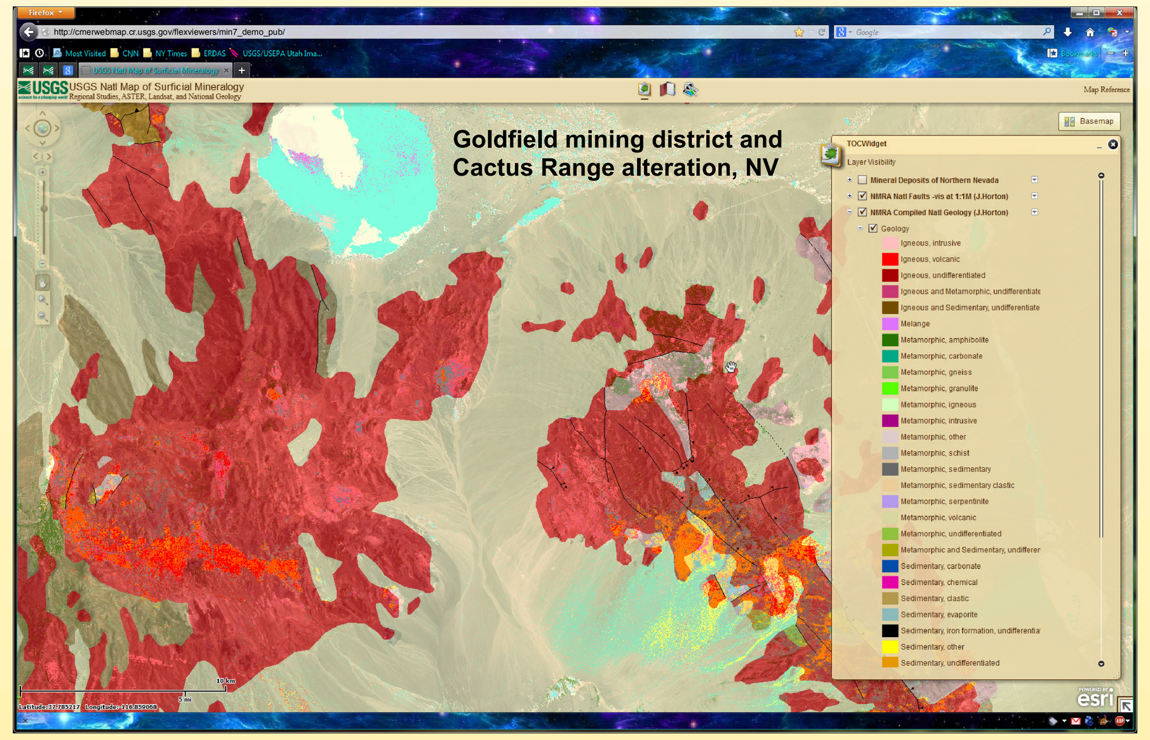
Rockwell, B.W., 2012, Description and validation of an automated methodology for mapping mineralogy, vegetation, and hydrothermal alteration type from ASTER satellite imagery with examples from the San Juan Mountains, Colorado: U.S. Geological Survey Scientific Investigations Map 3190, 35 p. pamphlet, 5 map sheets, scale 100,000. Available at http://pubs.usgs.gov/sim/3190/.

Rockwell, B.W., 2013, Automated mapping of mineral groups and green vegetation from Landsat Thematic Mapper imagery with an example from the San Juan Mountains, Colorado: U.S. Geological Survey Scientific Investigations Map 3252, 25 p. pamphlet, 1 map sheet, scale 1:325,000. Available at http://pubs.usgs.gov/sim/3252/.

.Net Web Interface

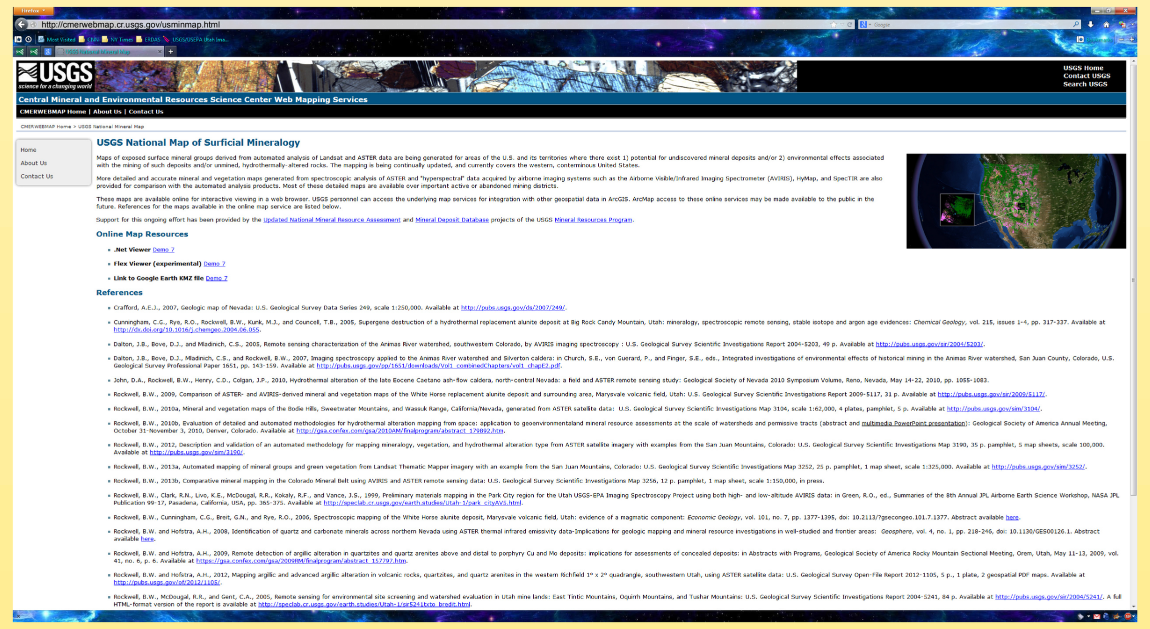


Flex Web Interface



ASTER-derived mineral group map overlain by preliminary USGS State Geologic Map Compilation of the Conterminous United States (Horton, J.D., San Juan, C.A., and Stoeser, D.B., in prep.)

Web Site Portal



Landsat mineral group map of the Goldfield District, NV overlain by mine point and polygon features. Queries of the mineral group maps using the polygon data will be used to populate a mineralogy field in a mine database.