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INTRODUCTION

Geologists from the Alaska Division of Geological & Geophysical Surveys (DGGS) Mineral Resources Section conducted four weeks of helicopter-supported mapping and fieldwork from June 26 through July 24, 2013. The Styx River project in the Lime Hills C-1 Quadrangle was part of the State-funded Airborne Geophysical/Geological Mineral Inventory (AGGMI) program as part of the State's Strategic Minerals Assessment Project, an initiative designed to evaluate Alaska's potential for rare-earth elements, PGEs, and other similarly supply-challenged resources. The objectives of this assessment were to improve the publicly-available geological, geophysical, and geochemical data in the area of known occurrences in the Lime Hills C-1 Quadrangle. This work included refining contacts, subdividing major units, and identifying new dikes and faults to shed new light on the structural history and metallogenesis of the area. The resulting 1:63,360-scale geologic map and supporting geochemical, petrologic, and geochronologic data will foster a better understanding of the geology and mineral potential of the area.

The Styx River and Farewell geophysical survey tracts (Burns and others, 2008) are about 100 miles northwest of Anchorage in the Lime Hills, Tyonek, Talkeetna Mountains, and McGrath quadrangles. The corresponding DGGS map area has active and ongoing mineral exploration for deposit types including porphyry copper ± molybdenum ± gold, reduced intrusion-related gold, and polymetallic veins. Lead–zinc skarns, molybdenum-bearing quartz veins, sediment-hosted base-metal, platinum-group-element, and rare-earth-element deposit types are also present. The majority of these mineral occurrences are related to numerous Cretaceous and Tertiary age plutonic complexes, dike swarms, and volcanic fields. Previously unmapped mafic dikes trend generally northwest, while major fault sets trend northwest, north–south, and north–northeast.

The major plutons in the area that intruded into the Late Jurassic to Early Cretaceous Kahiltna flysch assemblage are the Tertiary Merrill Pass, Mount Estelle, and Crystal Creek plutons, as well as the Tertiary McKinley sequence granites and the Cretaceous South Fork gabbro. Most plutons northwest of the field area are reduced to oxidized, metaluminous, and calc-alkaline (Bundtzen and others, 1997); however, peraluminous and alkaline Windy Fork granite and Middle Fork plutonic complex rocks (Solie, 1983; 1988) imply highly differentiated, shallow magma chambers. Tertiary volcanic rocks cover a significant portion of the area (Gamble and others, 2013). A preliminary analysis of major-oxide and trace-element data showed distinct compositions of plutonic complexes that help differentiate separate plutons and refine contacts on the new geologic map.

The analytical data tables associated with this report are being released in digital format as comma-delimited text (CSV) files. A complete explanation of the data file structure and contents as well as full details

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about the sampling project can be found in the metadata file associated with the digital version of this report, which is available from the DGGS website (http://www.dggs.alaska.gov/pubs/id/27181) at no charge.

DOCUMENTATION OF METHODS

SAMPLE COLLECTION

Rock samples were collected for two different purposes. Samples of visibly mineralized or altered rock were preferentially collected and analyzed for trace-element geochemistry. Most samples are "grab" samples, which were randomly collected at a location; however, a few samples are "select" samples, which were deliberately collected from a specific feature, as noted in the sample field description. Igneous and meta-igneous rocks showing little alteration or weathering were collected for whole-rock major-oxide, minor-oxide, and trace-element analyses to aid in classification and study of petrogenesis and tectonic setting. For fine-grained rocks, whole-rock analyses were performed by direct XRF of rock slabs.

Location data were collected using Trimble Juno T41/5 WAAS-enabled GPS devices running ArcGIS for Windows Mobile. Data were merged into an ArcGIS geodatabase. WAAS-enabled GPS devices have a reported error of about 1 m. Latitude and longitude are reported in the WGS84 datum.

SAMPLE PREPARATION

Rock samples were processed by ALS Minerals using their PREP-31 package. The samples were crushed to better than 70 percent passing 2 mm, and a 250 g split was pulverized to better than 85 percent passing 75 microns. Prior to crushing, samples for whole-rock analysis were trimmed by DGGS staff to remove weathering, and cut surfaces were sanded to remove any saw metal.

Slab XRF samples were cut into rough discs 4 cm in diameter and polished on a lapidary wheel.

ANALYTICAL METHODS

Samples were analyzed for a variety of suites of major and trace elements depending on the sample type. In addition to ALS Minerals' accredited (ISO/IEC 17025–2005) internal quality-control program, DGGS monitored analysis quality with one standard reference material per batch of 20 analyses.

a. Major- and trace-element compositions for rock samples were determined by ALS Minerals method ME-MS61: Four-acid digestion followed by inductively coupled plasma–atomic emission spectroscopy (ICP-AES) and inductively coupled plasma–mass spectroscopy (ICP-MS).

b. Gold values were analyzed by 30 g fire assay with ICP-AES finish (ALS Minerals method Au-ICP21) for all the rock geochemistry samples.

c. Platinum, palladium, and gold values were analyzed by 30 g fire assay with ICP-MS finish (ALS Minerals method PGM-MS23) for select samples as shown in the data tables. One batch of rock geochemistry samples was analyzed at ALS for a suite of metals that did not include Au, Pt and Pd. The pulps of some of the samples were subsequently reanalyzed at ALS (PGM-MS23 and Au-AA25 ore grade Au 30 g fire assay with atomic absorption AA for over-limit Au values).

d. Samples that exceeded detection limits for elements of interest were reanalyzed using specific elemental tests. Over-limit values for Ag, Cu, Zn and Pb were reanalyzed using four-acid digestion and ICP-AES (ALS Minerals procedure ME-OG62). Over-limit values for Au were reanalyzed by 30 g fire assay with atomic absorption (AA) finish (ALS Minerals procedure Au-AA25).

e. Major and minor oxides for whole-rock geochemistry samples were analyzed by lithium metaborate fusion digestion and ICP-AES (ALS Minerals method ME-ICP06), loss on ignition was determined via OA-GRA05 method. Trace elements, including rare-earth elements, were determined using lithium metaborate fusion digestion, and ICP-MS (ALS Minerals method ME-MS81). Metals were determined by four-acid digestion and ICP-AES (ALS Minerals method ME-ICP61).

f. For slab XRF samples, polished sample slabs were directly analyzed using the PANalytical Axios wavelength-dispersive XRF and SuperQ™ software at the University of Alaska Fairbanks. Nb, Rb, Sr, Y, and Zr were measured using the 37mmRbSrYZr analytical routine; other elements were measured with the IQ+37mmVac analytical routine. The 37mmRbSrYZr routine uses specific predetermined peak and background positions for which X-ray intensities are measured for 2–800 seconds (depending on the element). The intensity of the Rh Compton peak is used to estimate mass-absorption coefficients (MACs) for both unknowns and well-characterized natural standards. Peak intensities are computed and converted to concentrations using calibration curves employing at least ten natural rock standards. These procedures are routinely checked by analysis of secondary natural standards that were not employed in making the calibration curves. Elemental abundances are typically within 2–5 percent of the amount present for concentrations >10 times the detection limit; within 5–10 percent of the amount present for concentrations 4–10 times the detection limit; and within 30 percent of the amount present for concentrations near the detection limit. The IQ37mmVac program scans over a series of energies corresponding to a range from Ce K-alpha to O K-alpha. Peak heights and backgrounds, and X-ray elemental interferences are picked with the software and checked manually to ensure quality control. Elemental abundances for all elements with atomic numbers between 8 and 92 are estimated from artificial standards; these estimations are used to calculate MACs for each element present above the detection limit. Revised concentrations are employed to calculate revised MACs until a stable solution is determined. Elemental abundances are then normalized to 100 percent. The software is routinely checked using pressed pellets of well-characterized natural rock standards. Elemental abundances are within 1–2 percent of the amount present for major elements, 2–5 percent of the amount present for minor elements, and 5–10 percent of the amount present for trace elements.

Detection limits for each of the reported elemental values obtained by the various methods are documented in the metadata file.

The metadata file also contains negative numbers representing coded value placeholders of non-valid analytical data, including analyses that were outside the detection limit range.

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