Geochemistry of Rock Samples Collected from the Iron Hill Carbonatite Complex, Gunnison County, Colorado

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Data Files that Comprise this Report

Three data files comprise this report:

Readme.pdf	Copy of this text in Portable Document Format.
sample_site_info.xls	A spreadsheet in Excel format, listing the sample-site information.
rock_sample_chem.xls	A spreadsheet in Excel format, listing the analytical results.

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Mass	
ounce, avoirdupois (oz)	28.35	gram (g)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton, long (2,240 lb)	1.016	megagram (Mg)

Abstract

A study conducted in 2006 by the U.S. Geological Survey collected 57 surface rock samples from nine types of intrusive rock in the Iron Hill carbonatite complex. This intrusive complex, located in Gunnison County of southwestern Colorado, is known for its classic carbonatite-alkaline igneous geology and petrology. The Iron Hill complex is also noteworthy for its diverse mineral resources, including enrichments in titanium, rare earth elements, thorium, niobium (columbium), and vanadium. This study was performed to reexamine the chemistry and metallic content of the major rock units of the Iron Hill complex by using modern analytical techniques, while providing a broader suite of elements than the earlier published studies. The report contains the geochemical analyses of the samples in tabular and digital spreadsheet format, providing the analytical results for 55 major and trace elements.

Introduction

This report provides the geochemical analyses of 57 rock samples (table 1) collected in 2006 from surface exposures of the Iron Hill carbonatite complex in Gunnison County of southwestern Colorado. These data—the analyses of 55 major and trace elements—supplement a recent paper that summarizes the geology and significant mineral resource potential of this carbonatite-alkalic intrusive complex (Van Gosen and Lowers, 2007).

The Iron Hill Carbonatite Complex

The Iron Hill carbonatite complex outcrops over a 12-square-mile (31 km^2) area near the small settlement of Powderhorn, about 22 miles (35 km) south-southwest of Gunnison, Colorado (fig. 1). A large carbonatite stock forms the core of the complex, surrounded by a series of related alkalic igneous rock units. This intrusive complex was described by Olson and Hedlund (1981, p. 5) as “the best example of the carbonatite-alkalic rock association in the United States and is one of the outstanding occurrences in the world, comparable to many of the classic areas in Africa and other continents.”

From oldest to youngest, the primary rock types of the complex are pyroxenite, uncompahgrite, ijolite, nepheline syenite, and carbonatite (fig. 1; Temple and Grogan, 1965; Nash, 1972; Olson, 1974; Hedlund and Olson, 1975; Olson and Hedlund, 1981; Armbrustmacher, 1983). These igneous bodies formed about 570 m.y. ago (Olson and others, 1977; Olson and Hedlund, 1981), intruding into Early Proterozoic granite and syenite and older Proterozoic metamorphic rocks (Olson, 1974; Hedlund and Olson, 1975). Fluid reactions caused by the alkalic intrusion into the preexisting granitic country rocks formed zones of fenite (Armbrustmacher, 1994; Olson and Hedlund, 1981; White-Pinilla, 1996). Intrusion of the carbonatite stock into the pyroxenite and uncompahgrite units formed a mixed rock zone that contains a transition in textures and compositions between pyroxenite and carbonatite (Lowers, 2005). More than 200 carbonatite dikes, apparently genetically related to the carbonatite stock, cut through the all of the earlier formed igneous rock units of the complex (pyroxenite, uncompahgrite, ijolite, and nepheline syenite) as well as the surrounding Precambrian country rocks; but the carbonatite dikes apparently do not occur in the carbonatite stock. Scattered, thin jasper veins are found in the carbonatite stock. “Thorium veins,” usually less than 1 ft thick,

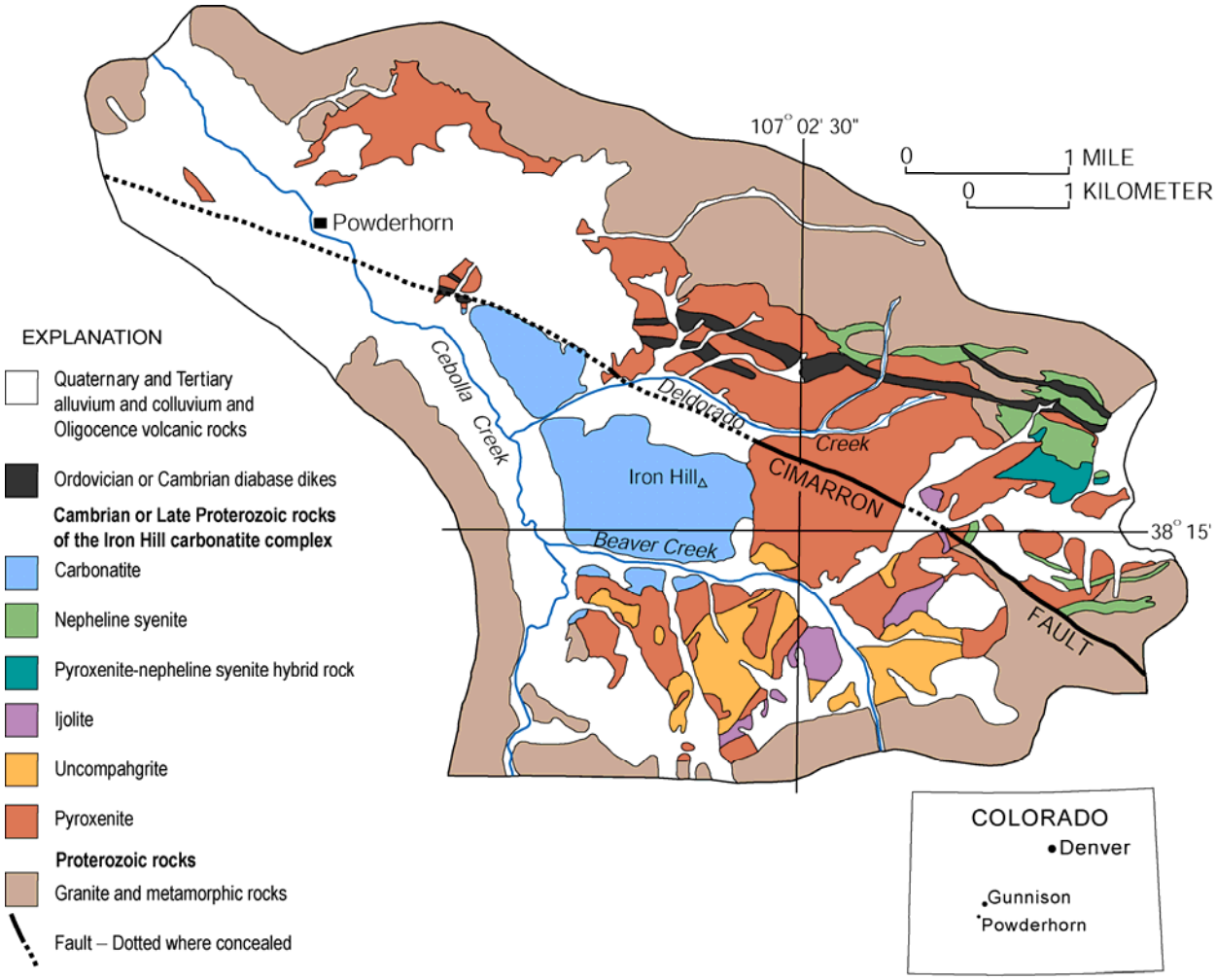

Figure 1. Geologic map of the Iron Hill carbonatite complex, simplified from Olson (1974) and Hedlund and Olson (1975).

Table 1. List showing the number of samples of each major rock type analyzed by this study.

Rock type	*Samples analyzed*
Pyroxenite	24
Uncomphagrite	5
Ijolite	2
Nepheline syenite	1
Mixed zone rocks	3
Carbonatite of the stock	13
Jasper vein	1
Carbonatite dike	7
Thorium vein	1

occur in shear zones within the same rock units in which the carbonatite dikes are found. The thorium veins are orthoclase- and quartz-rich veins with accessory thorite.

The geology of the Iron Hill carbonatite-intrusive complex was mapped at 1:24,000 scale by Olson (1974) and Hedlund and Olson (1975). Detailed descriptions of the rock units and their mineralogy are provided by Olson and Hedlund (1981).

In addition to its classic petrology and geology, the Iron Hill intrusive complex is noteworthy for its diverse mineral resources, including enrichments in titanium, rare earth elements, thorium, niobium (columbium), and vanadium. In particular, the titanium deposits in the pyroxenite unit and the niobium concentrations in the carbonatite stock are thought to represent the largest known resources of titanium and niobium in the United States, respectively. The rock unit and mineralogical residences of these mineral resources are summarized by Van Gosen and Lowers (2007).

Sample Collection

The samples were collected from outcrops and rocks exposed in roadcuts. Sampling site locations and descriptions are listed in table 2 and ***sample_site_info.xls***. Each sample was a composite of several small pieces of rock hand-picked across an area of about 15 ft^2 (~1.4 m^2), with each sample totaling about 1 pound (~0.5 kg).

At a few sampling sites, two or more samples of the same rock type were collected in order to examine the geochemical variability across a single outcrop; these include sampling sites 1, 11, 18, 34, and 43 (table 2).

Sample Analyses

Chemical analyses of the rock samples were performed by SGS Minerals Services (SGSMS) of Toronto, Ontario, Canada, under a contract with the U.S. Geological Survey (USGS). Splits of the rock samples were analyzed for 55 major (except silicon and sodium), rare earth, and trace elements (table 3, at back of report) using inductively coupled plasma–atomic emission spectrometry (ICP–AES) and inductively coupled plasma–mass spectrometry (ICP–MS). A 0.10-g split of the sample is decomposed using a sodium peroxide sinter at 450°C. The resultant cake is leached with water and acidified with nitric acid. After an addition of tartaric acid, aliquots of the digested sample are aspirated into the ICP–AES and the ICP–MS. The concentrations of the optimal elements from the ICP–AES and ICP–MS are determined. Calibration on the ICP–AES is performed by standardizing with digested rock reference materials and a series of multielement solution standards. The ICP–MS is calibrated with aqueous standards, and internal standards are used to compensate for matrix effects and internal drifts. The analytical method used in this study is a modification of a U.S. Geological Survey method described by Meier and Slowik (2002).

Analytical results obtained from SGSMS passed two levels of validation for precision and accuracy. The laboratory's quality-control protocol is to insert a reagent blank and reference material with every batch of 20 samples to measure the analytical accuracy. Duplicate samples were analyzed at the end of the sample set to measure analytical variance as well as sample variance. Data that passed the quality-control criteria from SGSMS are sent to the USGS.

The second level of data validation was performed at the USGS. All samples submitted to SGSMS are accompanied by a set of blind, in-house reference samples. The data for the reference samples are evaluated for accuracy. The values must fall within the range of

Table 2. Sample-site information for 57 rock samples collected from 45 sites in the Iron Hill carbonatite complex, Gunnison County, southwestern Colorado. This information is provided in spreadsheet format in ***sample_site_info.xls***. Latitude and longitude values were measured at each site by a global positioning satellite (GPS) device, using the North American datum of 1927.

Lab no.	*Field no.*	*Site no.*	*Rock type*	*Latitude*	*Longitude*	*Site description*
C-290364	01A-IH06	1	uncompahgrite	38.24736	-107.04511	Outcrop exposed on hillside on north side of Beaver Creek
C-290365	01B-IH06	1	uncompahgrite	38.24736	-107.04511	Outcrop exposed on hillside on north side of Beaver Creek
C-290366	02A-IH06	2	pyroxenite	38.24728	-107.04178	Roadcut on 4-wheel drive road north of Beaver Creek
C-290367	02B-IH06	2	carbonatite dike	38.24728	-107.04178	Roadcut on 4-wheel drive road north of Beaver Creek
C-290368	03A-IH06	3	pyroxenite	38.24811	-107.04050	Roadcut on 4-wheel drive road north of Beaver Creek
C-290369	03B-IH06	3	carbonatite dike	38.24811	-107.04050	Roadcut on 4-wheel drive road north of Beaver Creek
C-290370	04-IH06	4	pyroxenite	38.24517	-107.03553	Roadcut on 4-wheel drive road along North Beaver Creek
C-290371	05-IH06	5	ijolite	38.23947	-107.03458	Roadcut on 4-wheel drive road along Beaver Creek
C-290372	06-IH06	6	uncompahgrite	38.23822	-107.03425	Roadcut on 4-wheel drive road along Beaver Creek
C-290373	07-IH06	7	uncompahgrite	38.23592	-107.03333	Outcrop on west-facing slope just east of Beaver Creek
C-290374	08-IH06	8	pyroxenite	38.25508	-107.02750	Outcrop along 4-wheel drive road
C-290375	09-IH06	9	pyroxenite	38.25733	-107.02528	Outcrop along 4-wheel drive road
C-290376	10A-IH06	10	pyroxenite	38.25575	-107.02039	Outcrop along 4-wheel drive road
C-290377	10B-IH06	10	thorite vein	38.25575	-107.02039	Outcrop along 4-wheel drive road
C-290378	11A-IH06	11	pyroxenite	38.25953	-107.02425	Rock exposed by bulldozed prospecting trenches
C-290379	11B-IH06	11	pyroxenite	38.25953	-107.02425	Rock exposed by bulldozed prospecting trenches
C-290380	11D-IH06	11	pyroxenite	38.25953	-107.02425	Rock exposed by bulldozed prospecting trenches
C-290381	12-IH06	12	nepheline syenite	38.25939	-107.01714	Prominent outcrops on southeast-facing slope of hillside
C-290382	13-IH06	13	pyroxenite	38.25700	-107.02894	Outcrop exposed in gully
C-290383	14-IH06	14	pyroxenite	38.25914	-107.04025	Roadcut on 4-wheel drive road along Deldorado Creek
C-290384	15-IH06	15	ijolite	38.25917	-107.04686	Outcrop on north side of Deldorado Creek
C-290385	16-IH06	16	pyroxenite	38.25856	-107.04125	Roadcut on 4-wheel drive road along Deldorado Creek
C-290386	17-IH06	17	pyroxenite	38.26453	-107.04444	Roadcut on 4-wheel drive road
C-290387	18A-IH06	18	pyroxenite	38.26514	-107.04661	Rock exposed on hillside by bulldozed prospect trench
C-290388	18B-IH06	18	pyroxenite	38.26514	-107.04661	Rock exposed on hillside by bulldozed prospect trench
C-290389	21-IH06	21	pyroxenite	38.26703	-107.04433	Rock exposed in small prospect pit
C-290390	22-IH06	22	pyroxenite	38.26567	-107.04183	Rock exposed in small prospect pit
C-290391	23A-IH06	23	carbonatite dike	38.26300	-107.06222	Rock exposed in bulldozed area just north of Deldorado Creek
C-290392	23B-IH06	23	pyroxenite	38.26300	-107.06222	Rock exposed in bulldozed area just north of Deldorado Creek

Table 2. Sample-site information for 57 rock samples collected from 45 sites in the Iron Hill carbonatite complex, Gunnison County, southwestern Colorado. This information is provided in spreadsheet format in ***sample_site_info.xls***. Latitude and longitude values were measured at each site by a global positioning satellite (GPS) device, using the North American datum of 1927.—Continued.

Lab no.	Field no.	Site no.	Rock type	Latitude	Longitude	Site description
C-290393	24-IH06	24	pyroxenite	38.27222	-107.05892	Rock exposed in small prospect pit
C-290331	25-IH06	25	pyroxenite	38.28506	-107.07831	Rock exposed in bulldozed prospect near head of Stone Gulch
C-290332	26-IH06	26	pyroxenite	38.28989	-107.08650	Rock exposed in shallow, bulldozed prospect trench
C-290333	27-IH06	27	pyroxenite	38.28583	-107.08631	Small outcrop exposed in gulch
C-290337	30-IH06	30	carbonatite of the stock	38.26322	-107.07525	Outcrop low on southwest slope of Little Iron Hill
C-290338	31-IH06	31	carbonatite of the stock	38.26100	-107.06872	Outcrop on southeast slope of Little Iron Hill
C-290339	32-IH06	32	jasper vein in the carbonatite stock	38.26169	-107.06889	Outcrop on southeast slope of Little Iron Hill
C-290340	33-IH06	33	carbonatite of the stock	38.26056	-107.06508	Outcrop beneath veneer of colluvium, northwest flank of Iron Hill
C-290341	34A-IHO6	34	carbonatite of the stock	38.25933	-107.06647	Pieces of crushed ore material in waste pile at the Du Pont adit
C-290342	34B-IH06	34	carbonatite of the stock	38.25933	-107.06647	Outcrop above the entrance of the Du Pont adit
C-290343	35-IH06	35	carbonatite of the stock	38.25631	-107.06697	Outcrop on the western crest of Iron Hill
C-290344	36-IH06	36	carbonatite of the stock	38.25711	-107.06331	Roadcut on 4-wheel drive road on Iron Hill
C-290345	37-IH06	37	carbonatite of the stock	38.25711	-107.06081	Rock exposed in small prospect pit on Iron Hill
C-290346	38-IH06	38	carbonatite of the stock	38.25617	-107.05681	Roadcut on 4-wheel drive road on Iron Hill
C-290347	40-IH06	40	carbonatite of the stock	38.25300	-107.05283	Rock exposed in small prospect pit near high point of Iron Hill
C-290348	41-IH06	41	carbonatite of the stock	38.25747	-107.05572	Roadcut on 4-wheel drive road on north flank of Iron Hill
C-290349	42-IH06	42	mixed zone rock	38.25419	-107.04828	Outcrop along 4-wheel drive road on east flank of Iron Hill
C-290350	43A-IH06	43	mixed zone rock	38.24889	-107.05042	Outcrop along 4-wheel drive road on east flank of Iron Hill
C-290351	43B-IH06	43	mixed zone rock	38.24889	-107.05042	Outcrop along 4-wheel drive road on east flank of Iron Hill
C-290352	44A-IH06	44	pyroxenite	38.25261	-107.04611	Rock exposed in small bulldozed prospect trench
C-290353	44C-IH06	44	carbonatite dike	38.25261	-107.04611	Rock exposed in small bulldozed prospect trench
C-290354	45-IH06	45	carbonatite of the stock	38.24722	-107.05594	Outcrop low on south flank of Iron Hill, near Beaver Creek Road
C-290355	46-IH06	46	carbonatite dike	38.24489	-107.05319	Small roadcut on 4-wheel drive road south of Beaver Creek
C-290356	47-IH06	47	carbonatite dike	38.23844	-107.05164	Rock exposed in small prospect pit
C-290357	48-IH06	48	uncompahgrite	38.23769	-107.05147	Rock exposed in small bulldozed prospect trench
C-290358	49-IH06	49	carbonatite of the stock	38.24603	-107.06619	Roadcut on east side of Cebolla Creek Road
C-290359	50A-IH06	50	pyroxenite	38.24486	-107.06628	Roadcut on east side of Cebolla Creek Road
C-290360	50B-IH06	50	carbonatite dike	38.24486	-107.06628	Roadcut on east side of Cebolla Creek Road

acceptance, which varies between ±5 percent and ±20 percent depending on analytical method. Analytical results that meet the accepted quality control are released to the submitter. Analytical results with rejected quality control are reanalyzed by SGSMS.

Highlights of the Results

This geochemical study was conducted to reexamine the chemistry and metallic content of the major rock units of the Iron Hill complex by using modern analytical techniques. These new analyses also provide a broader suite of elements than the earlier published studies. The geochemical results obtained from this study are in general agreement with earlier published analyses of samples from the Iron Hill complex (Armbrustmacher, 1979, 1980; Armbrustmacher and Brownfield, 1979; Olson and Wallace, 1956; Rose and Shannon, 1960; and Staatz and others, 1979, 1980). Highlights of this study's analytical results are listed below.

Pyroxenite: On the basis of 24 widely scattered samples, the pyroxenite unit consistently contains enrichments in titanium (Ti) and rare earth elements (REE), in particular cerium (Ce—a light rare earth element), as well as niobium (Nb), thorium (Th), and vanadium (V), as shown below.

[%, weight percent; ppm, parts per million; 1% is equivalent to 10,000 ppm]

Element	*Median value*	*High value*	*Upper crust (Earth) abundance (Taylor and McClennan, 1985)*
Titanium	3.2 %	5.74 %	0.3 %
Total REE	1,240 ppm	3,470 ppm	168 ppm
Cerium	510 ppm	1,640 ppm	64 ppm
Niobium	250 ppm	512 ppm	12 ppm
Vanadium	255 ppm	502 ppm	107 ppm
Thorium	22 ppm	162 ppm	11 ppm

The Ti concentrations in the pyroxenites of the Iron Hill intrusive complex (fig. 2) are particularly high and may represent the largest known titanium deposit in the United States. For comparison, Best (1982, p. 615) reported that the titanium content of typical pyroxenite is approximately 0.88 percent. Also, Upton (1967, p. 283) showed the Iron Hill pyroxenite as having the highest titanium concentrations amongst his example chemistries of alkaline pyroxenites worldwide.

Carbonatite stock of Iron Hill: The Iron Hill stock (figs. 3 and 4) is enriched in REE, cerium in particular, as well as niobium and thorium (13 samples), which is not usual for carbonatites (Deans, 1966; Heinrich, 1980; Bell, 1989). As mentioned earlier, the Iron Hill stock is thought to represent the largest known niobium resource in the United States.

Element	*Median value*	*High value*
Total REE	1,630 ppm	>23,000 ppm
Cerium	680 ppm	>10,000 ppm
Niobium	416 ppm	1,820 ppm
Thorium	31 ppm	96 ppm

Carbonatite dikes: The carbonatites dikes of the complex, which are genetically related to the carbonatite stock, are also enriched in REE, particularly cerium, and also niobum and thorium (seven samples).

Element	*Median value*	*High value*
Total REE	3,070 ppm	3,900 ppm
Cerium	1,410 ppm	1,920 ppm
Niobium	265 ppm	1,690 ppm
Thorium	34 ppm	182 ppm

Also noteworthy is the chemistry of a jasper vein sample (32-IHO6) collected within the carbonatite stock, which revealed 12,600 ppm total REE; 6,370 ppm cerium; 2,420 ppm niobium; and 108 ppm thorium.

Acknowledgements

Teck Cominco Limited was generous in allowing the author to sample its properties in the Iron Hill area and to publish the resulting analytical results shown in this report.

Figure 2. Pyroxenite exposed by shallow prospect trenches at the site of samples 11A-IHO6, 11B-IH06, and 11D-IH06. These samples had concentrations of 3.47 to 4.94 percent titanium (table 3).

Figure 3. Carbonatite stock of Iron Hill (fig. 1). Pyroxenite forms most of the rock in the low hills of the foreground. View is toward the northwest.

Figure 4. Outcrops of the carbonatite stock on the eastern slope of Iron Hill. Outcrop on the left was the site of sample 45-IH06, which contained 411 parts per million cerium and 816 parts per million niobium (table 3).

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Table 3. Geochemical analyses of 57 rock samples collected in the Iron Hill carbonatite complex, southwestern Colorado. These data are provided in digital spreadsheet format in ***rock_sample_chem.xls***. Sample site information is provided in table 2 and ***sample_site_info.xls***. The analyses were conducted by inductively coupled plasma-atomic emission spectrometry (ICP–AES) and inductively coupled plasma-mass spectrometry (ICP–MS). ***%***, weight percent; ***ppm***, parts per million; <, below the specified detection limit; >, above the specified detection limit

Lab No.	***Field No.***	***Rock type***	***Al %***	***Ca %***	***Fe %***	***K %***	***Mg %***	***Mn %***	***P %***	***Ti %***	***Ag ppm***	***As ppm***	***Ba ppm***
C-290364	01A-IH06	uncompahgrite	3.64	17.5	4.78	1.87	3.13	0.137	0.8	0.41	<1	<30	1120
C-290365	01B-IH06	uncompahgrite	3.41	17.5	6.06	1.44	3.3	0.168	0.53	1.03	<1	<30	1100
C-290366	02A-IH06	pyroxenite	1.99	17.5	8.19	0.28	5.89	0.101	2.13	3.16	<1	<30	289
C-290367	02B-IH06	carbonatite dike	0.46	28.7	4.09	0.58	0.61	0.481	0.11	0.51	<1	<30	7520
C-290368	03A-IH06	pyroxenite	2.75	13.6	6.42	1.51	6.78	0.061	1.68	3.11	<1	<30	1380
C-290369	03B-IH06	carbonatite dike	1.14	26.8	5.41	1.24	1.06	0.186	0.99	1.29	<1	60	1020
C-290370	04-IH06	pyroxenite	2.4	12	10.1	0.4	4.22	0.084	1.64	2.85	<1	<30	276
C-290371	05-IH06	ijolite	4.09	17.3	5.89	0.35	4.17	0.124	0.62	1.21	<1	<30	423
C-290372	06-IH06	uncompahgrite	2.9	16.6	9.44	0.66	3.64	0.191	1.12	2.5	<1	<30	458
C-290373	07-IH06	uncompahgrite	2.34	22.3	6.26	0.31	3.49	0.126	3.14	1.29	<1	<30	296
C-290374	08-IH06	pyroxenite	1.22	15.3	8.91	0.11	4.75	0.122	1.43	3.1	<1	<30	178
C-290375	09-IH06	pyroxenite	1.7	14.3	8.28	0.26	7.45	0.108	0.18	3.72	<1	<30	231
C-290376	10A-IH06	pyroxenite	2.18	15.7	8.51	0.26	3.72	0.179	1.49	2.67	<1	<30	91.4
C-290377	10B-IH06	thorite vein	3.07	12.4	6.89	3.95	1.71	0.082	1.77	1.32	<1	<30	4400
C-290378	11A-IH06	pyroxenite	1.92	13.2	8.9	0.52	7.23	0.094	0.05	3.86	<1	<30	431
C-290379	11B-IH06	pyroxenite	1.63	9.05	7.49	0.79	5.72	0.062	<0.01	3.47	<1	<30	470
C-290380	11D-IH06	pyroxenite	1.33	13.8	8.64	0.12	6.63	0.081	0.02	4.94	1	<30	95
C-290381	12-IH06	nepheline syenite	9.84	0.21	2.88	12.2	0.05	0.02	0.03	0.19	<1	<30	2350
C-290382	13-IH06	pyroxenite	1.3	13.6	6.99	0.22	6.37	0.081	0.02	3.24	<1	<30	136
C-290383	14-IH06	pyroxenite	1.71	11.6	10	0.21	5.33	0.137	0.38	3.67	<1	<30	303
C-290384	15-IH06	ijolite	4.45	13.5	9.12	0.79	4.11	0.187	1.3	1.99	<1	<30	226
C-290385	16-IH06	pyroxenite	4.86	11.9	9.12	2.05	3.72	0.149	0.97	2.12	<1	<30	1130
C-290386	17-IH06	pyroxenite	1.35	9.85	12.1	0.36	4.93	0.097	0.02	5.63	1	<30	1020
C-290387	18A-IH06	pyroxenite	2.26	14.4	10.4	0.93	5.58	0.126	1.59	2.47	<1	<30	531
C-290388	18B-IH06	pyroxenite	1.56	13.3	7.26	0.39	6.21	0.082	0.58	2.69	<1	<30	235
C-290389	21-IH06	pyroxenite	1.49	13.4	9.03	0.51	7.13	0.069	0.04	4.67	<1	<30	317
C-290390	22-IH06	pyroxenite	1.19	11.1	6.92	0.38	5.76	0.05	0.05	3.39	<1	<30	225
C-290391	23A-IH06	carbonatite dike	0.66	26.1	3.01	0.99	3.32	0.356	1.63	0.31	<1	<30	>10000
C-290392	23B-IH06	pyroxenite	2.73	12	8.92	2.24	5.1	0.165	1.1	2.65	1	<30	1760

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Lab no.	***Field no.***	***Rock type***	***Al %***	***Ca %***	***Fe %***	***K %***	***Mg %***	***Mn %***	***P %***	***Ti %***	***Ag ppm***	***As ppm***	***Ba ppm***
C-290393	24-IH06	pyroxenite	0.88	16.8	6.28	0.1	5.11	0.107	1.35	4.09	<1	<30	148
C-290331	25-IH06	pyroxenite	1.34	15.4	12.3	0.08	5.01	0.135	1.57	5.74	1	<30	354
C-290332	26-IH06	pyroxenite	1.7	13.8	11.8	0.32	5.94	0.111	1.32	3.73	<1	<30	365
C-290333	27-IH06	pyroxenite	1.46	14.6	8.91	0.06	4.88	0.083	1.39	3.05	<1	<30	1170
C-290337	30-IH06	carbonatite of the stock	6.07	5.42	2.15	4.8	2.16	0.162	0.17	0.18	<1	<30	1540
C-290338	31-IH06	carbonatite of the stock	0.15	1.53	19.3	0.09	0.11	0.332	1.29	0.02	1	640	>10000
C-290339	32-IH06	jasper vein in the carbonatite stock	0.14	1.58	16.4	0.07	0.1	1.5416	0.56	0.12	<1	620	>10000
C-290340	33-IH06	carbonatite of the stock	0.25	15.1	5.85	0.76	8.46	0.752	1.01	0.24	<1	<30	>10000
C-290341	34A-IHO6	carbonatite of the stock	0.04	13.7	7.86	0.05	4.81	0.927	0.61	0.02	<1	480	>10000
C-290342	34B-IH06	carbonatite of the stock	0.07	2.55	20.6	0.07	0.14	2.2451	1.26	0.01	<1	1750	>10000
C-290343	35-IH06	carbonatite of the stock	0.2	20.6	5.94	0.27	5.88	0.285	2.87	0.13	2	1110	1080
C-290344	36-IH06	carbonatite of the stock	0.07	18.1	4.19	0.08	8.09	0.47	0.98	0.03	<1	100	>10000
C-290345	37-IH06	carbonatite of the stock	2.55	3.58	6.35	3.27	0.21	0.161	1.12	0.88	3	300	>10000
C-290346	38-IH06	carbonatite of the stock	0.65	16.1	5.3	1.29	7.87	0.424	1.99	0.64	<1	30	>10000
C-290347	40-IH06	carbonatite of the stock	0.6	20.8	5.42	1.11	1.22	9.3125	1.6	0.78	<1	340	>10000
C-290348	41-IH06	carbonatite of the stock	0.39	16.9	7.27	0.39	6.16	0.529	1.93	0.25	2	100	>10000
C-290349	42-IH06	mixed zone rock	1.65	18.3	6.92	1.8	4.72	0.25	1.09	1.73	2	<30	1870
C-290350	43A-IH06	mixed zone rock	1.6	17.3	8.9	2.41	4.75	0.494	1.04	1.53	2	<30	2680
C-290351	43B-IH06	mixed zone rock	4.52	4.15	8.88	4.84	7.62	0.132	1.57	2.77	<1	50	1250
C-290352	44A-IH06	pyroxenite	3.37	15.1	6.35	1.98	4.06	0.178	1.41	1.16	<1	<30	2450
C-290353	44C-IH06	carbonatite dike	3.96	17.2	6.17	5.18	0.73	0.325	0.48	0.82	<1	40	4730
C-290354	45-IH06	carbonatite of the stock	0.22	17.1	3.06	0.43	7.23	0.446	0.86	0.06	3	30	>10000
C-290355	46-IH06	carbonatite dike	1.5	17.8	6.32	2.14	4.76	0.279	1.52	0.92	6	30	3800
C-290356	47-IH06	carbonatite dike	2.43	9.13	12.9	3.74	0.44	0.253	1.17	2.47	<1	30	3640
C-290357	48-IH06	uncompahgrite	3.13	17.3	3.22	0.19	4.4	0.093	0.24	0.23	<1	<30	89.6
C-290358	49-IH06	carbonatite of the stock	2.08	17.1	5.65	2.48	6.76	0.269	1.63	1.02	<1	<30	2160
C-290359	50A-IH06	pyroxenite	2.48	16	7.64	2.36	3.99	0.139	1.05	2.37	<1	<30	861
C-290360	50B-IH06	carbonatite dike	1.6	11.9	9.91	2.93	5.39	0.424	0.92	2.48	1	<30	5010

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Lab no.	***Field no.***	***Rock type***	***Be ppm***	***Bi ppm***	***Cd ppm***	***Ce ppm***	***Co ppm***	***Cr ppm***	***Cs ppm***	***Cu ppm***	***Dy ppm***	***Er ppm***
C-290364	01A-IH06	uncompahgrite	18	<0.1	<0.2	307	20.5	20	51.8	17	8.56	3.19
C-290365	01B-IH06	uncompahgrite	23	0.2	<0.2	194	18.4	<10	33.1	77	15.7	7.49
C-290366	02A-IH06	pyroxenite	9	<0.1	<0.2	519	33.4	10	1.2	132	20.3	6.02
C-290367	02B-IH06	carbonatite dike	<5	<0.1	0.9	1760	26.9	10	0.9	91	26.7	9.74
C-290368	03A-IH06	pyroxenite	8	0.1	0.5	361	38.6	<10	1.2	365	12	3.44
C-290369	03B-IH06	carbonatite dike	9	<0.1	0.2	244	31.5	50	4.5	55	9.87	3.34
C-290370	04-IH06	pyroxenite	9	<0.1	<0.2	823	43.3	80	0.5	136	19.5	5.44
C-290371	05-IH06	ijolite	24	<0.1	<0.2	435	23.5	<10	3.4	16	13.6	4.15
C-290372	06-IH06	uncompahgrite	22	<0.1	<0.2	1400	33.3	20	0.8	64	36.7	12.4
C-290373	07-IH06	uncompahgrite	15	0.4	0.5	1070	26.7	10	0.2	441	49.2	17.9
C-290374	08-IH06	pyroxenite	9	<0.1	<0.2	230	31.8	<10	0.9	109	12.8	4.78
C-290375	09-IH06	pyroxenite	10	<0.1	<0.2	496	43.1	<10	0.5	26	10.8	2.97
C-290376	10A-IH06	pyroxenite	8	<0.1	<0.2	397	34.5	<10	2.8	135	30.5	15.3
C-290377	10B-IH06	thorite vein	7	0.2	<0.2	613	20.9	<10	0.5	98	27	7.19
C-290378	11A-IH06	pyroxenite	12	0.1	<0.2	635	46.2	<10	0.7	181	14.3	3.67
C-290379	11B-IH06	pyroxenite	10	0.1	<0.2	558	43.3	<10	0.5	192	12.9	3.25
C-290380	11D-IH06	pyroxenite	15	<0.1	<0.2	1640	45.2	<10	0.1	115	22.7	5.79
C-290381	12-IH06	nepheline syenite	<5	<0.1	<0.2	38.9	1.8	10	0.6	<5	2.35	0.82
C-290382	13-IH06	pyroxenite	10	<0.1	<0.2	577	40.1	<10	0.8	52	12	2.94
C-290383	14-IH06	pyroxenite	<5	<0.1	<0.2	558	47.8	<10	0.5	288	15.2	4.6
C-290384	15-IH06	ijolite	9	<0.1	0.2	196	34	20	4.7	59	24.3	12
C-290385	16-IH06	pyroxenite	9	<0.1	<0.2	224	38.6	<10	8.2	237	12.3	4.83
C-290386	17-IH06	pyroxenite	17	0.2	<0.2	1630	60.2	10	1.3	<5	23.1	5.73
C-290387	18A-IH06	pyroxenite	9	<0.1	<0.2	222	63.6	<10	2.5	342	10.4	3.56
C-290388	18B-IH06	pyroxenite	9	<0.1	<0.2	433	42.4	20	0.6	72	10.5	3.16
C-290389	21-IH06	pyroxenite	15	<0.1	<0.2	684	43.9	<10	0.6	<5	16.1	4.29
C-290390	22-IH06	pyroxenite	10	<0.1	<0.2	533	37.2	<10	1.1	371	13.4	3.44
C-290391	23A-IH06	carbonatite dike	<5	<0.1	0.8	1130	17.1	20	0.7	69	34.8	11.3
C-290392	23B-IH06	pyroxenite	14	<0.1	0.4	454	40	10	55.3	205	13.8	4.36

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Lab no.	***Field no.***	***Rock type***	***Be ppm***	***Bi ppm***	***Cd ppm***	***Ce ppm***	***Co ppm***	***Cr ppm***	***Cs ppm***	***Cu ppm***	***Dy ppm***	***Er ppm***
C-290393	24-IH06	pyroxenite	13	<0.1	<0.2	334	33.3	20	0.5	68	16.7	5.99
C-290331	25-IH06	pyroxenite	16	<0.1	<0.2	1010	50	10	0.1	101	26.6	7.81
C-290332	26-IH06	pyroxenite	10	0.1	<0.2	333	55.8	60	0.4	151	10.4	2.98
C-290333	27-IH06	pyroxenite	9	<0.1	<0.2	583	36	<10	0.4	401	15.8	4.49
C-290337	30-IH06	carbonatite of the stock	6	0.2	0.3	510	2.7	10	1.2	9	7.56	2.63
C-290338	31-IH06	carbonatite of the stock	13	0.2	1.9	>10000	20.5	40	0.5	31	8.04	1.96
C-290339	32-IH06	jasper vein in the carbonatite stock	16	0.5	1.1	6370	42.3	90	1.9	40	5.34	1.34
C-290340	33-IH06	carbonatite of the stock	<5	<0.1	1.5	1140	28.6	70	0.7	33	6.47	2.03
C-290341	34A-IHO6	carbonatite of the stock	9	0.2	0.9	2220	25.5	20	0.5	23	4.34	1.23
C-290342	34B-IH06	carbonatite of the stock	16	<0.1	0.7	3080	48.5	20	0.6	20	4.88	1.45
C-290343	35-IH06	carbonatite of the stock	15	<0.1	0.6	466	9.8	70	1.3	32	13.7	3.53
C-290344	36-IH06	carbonatite of the stock	<5	<0.1	1.1	2700	11.1	30	0.3	17	5.96	1.55
C-290345	37-IH06	carbonatite of the stock	13	<0.1	0.4	663	14.6	130	8.2	51	13.8	4.27
C-290346	38-IH06	carbonatite of the stock	11	<0.1	0.5	681	9.6	70	1.4	91	12.7	3.37
C-290347	40-IH06	carbonatite of the stock	23	<0.1	4.5	349	191	130	9.3	94	13	3.39
C-290348	41-IH06	carbonatite of the stock	7	0.2	1.5	3430	19.3	80	1.1	47	14.3	3.55
C-290349	42-IH06	mixed zone rock	9	<0.1	0.4	587	33.1	260	2	89	17	6.44
C-290350	43A-IH06	mixed zone rock	13	<0.1	0.5	1660	40.6	290	1.2	79	22.8	7
C-290351	43B-IH06	mixed zone rock	14	<0.1	1.8	835	58.6	280	50.7	112	19	7.09
C-290352	44A-IH06	pyroxenite	16	<0.1	0.2	432	27	<10	107	155	30.6	12.6
C-290353	44C-IH06	carbonatite dike	12	<0.1	0.5	1600	23.6	30	3.8	138	13.7	5.95
C-290354	45-IH06	carbonatite of the stock	<5	<0.1	1.7	411	15.8	30	0.9	39	5.34	1.43
C-290355	46-IH06	carbonatite dike	6	<0.1	0.5	1410	19.3	110	1.1	120	25.3	9.48
C-290356	47-IH06	carbonatite dike	12	4.8	0.4	1140	57	370	0.3	123	55.4	15.1
C-290357	48-IH06	uncompahgrite	17	<0.1	<0.2	142	26.4	<10	<0.1	68	4.88	1.46
C-290358	49-IH06	carbonatite of the stock	9	<0.1	0.4	676	24.7	30	8.5	115	20.6	6.99
C-290359	50A-IH06	pyroxenite	9	<0.1	0.2	293	40.1	20	1.9	165	12	4.46
C-290360	50B-IH06	carbonatite dike	12	0.2	1.1	1920	58.3	170	2.8	200	12.7	4.73

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Lab no.	*Field no.*	*Rock type*	*Eu ppm*	*Ga ppm*	*Gd ppm*	*Ge ppm*	*Hf ppm*	*Ho ppm*	*In ppm*	*La ppm*	*Li ppm*	*Lu ppm*
C-290364	01A-IH06	uncompahgrite	5.43	23	17	1	5	1.31	<0.2	155	60	0.21
C-290365	01B-IH06	uncompahgrite	5.23	23	18.4	1	25	2.89	<0.2	104	90	0.64
C-290366	02A-IH06	pyroxenite	12.6	18	38.8	2	30	2.92	<0.2	293	<10	0.37
C-290367	02B-IH06	carbonatite dike	19.7	11	59	2	7	4	0.3	935	<10	0.9
C-290368	03A-IH06	pyroxenite	7.99	16	25.1	2	14	1.72	<0.2	219	<10	0.2
C-290369	03B-IH06	carbonatite dike	6.5	9	18.8	3	9	1.49	<0.2	119	10	0.21
C-290370	04-IH06	pyroxenite	14.8	24	44.9	2	32	2.73	<0.2	364	<10	0.3
C-290371	05-IH06	ijolite	9.61	28	28.1	1	11	1.99	<0.2	212	10	0.25
C-290372	06-IH06	uncompahgrite	24.1	32	73.9	2	47	5.47	<0.2	627	<10	0.78
C-290373	07-IH06	uncompahgrite	24.8	23	80.3	2	69	7.8	<0.2	583	<10	1.22
C-290374	08-IH06	pyroxenite	6.08	11	19.4	2	24	2.07	0.2	130	<10	0.36
C-290375	09-IH06	pyroxenite	9.2	14	27.2	3	13	1.5	<0.2	237	<10	0.17
C-290376	10A-IH06	pyroxenite	11.7	15	37.8	3	37	5.46	0.3	207	20	1.59
C-290377	10B-IH06	thorite vein	31.6	19	79	3	7	3.61	0.3	318	20	0.44
C-290378	11A-IH06	pyroxenite	11.9	16	34.6	3	12	1.93	<0.2	298	<10	0.22
C-290379	11B-IH06	pyroxenite	10.6	14	30.9	2	12	1.72	<0.2	275	<10	0.15
C-290380	11D-IH06	pyroxenite	21.3	18	61.8	4	12	3.05	<0.2	674	<10	0.29
C-290381	12-IH06	nepheline syenite	2.53	26	6.1	2	2	0.36	<0.2	19.5	<10	0.07
C-290382	13-IH06	pyroxenite	10.6	14	31	3	10	1.54	<0.2	257	<10	0.16
C-290383	14-IH06	pyroxenite	11	17	32.3	2	14	2.1	<0.2	271	<10	0.28
C-290384	15-IH06	ijolite	7.28	21	25	3	39	4.57	0.3	118	30	1.25
C-290385	16-IH06	pyroxenite	6.19	23	19.1	2	17	1.96	<0.2	123	140	0.44
C-290386	17-IH06	pyroxenite	24.9	20	70.4	3	8	2.89	<0.2	595	<10	0.26
C-290387	18A-IH06	pyroxenite	5.2	17	17.1	2	26	1.62	<0.2	143	<10	0.23
C-290388	18B-IH06	pyroxenite	8.6	14	25.2	2	16	1.42	<0.2	201	<10	0.32
C-290389	21-IH06	pyroxenite	13.1	14	37.9	3	8	2.12	<0.2	330	10	0.2
C-290390	22-IH06	pyroxenite	10.5	12	31.1	3	11	1.76	<0.2	284	<10	0.17
C-290391	23A-IH06	carbonatite dike	23.4	11	72.3	2	3	5.14	0.3	500	20	0.79
C-290392	23B-IH06	pyroxenite	9.03	17	26.9	2	14	2	<0.2	243	30	0.35

Table 3. Geochemical analyses of 57 rock samples collected in the Iron Hill carbonatite complex, southwestern Colorado. These data are provided in digital spreadsheet format in ***rock_sample_chem.xls***. Sample site information is provided in table 2 and ***sample_site_info.xls***. The analyses were conducted by inductively coupled plasma-atomic emission spectrometry (ICP–AES) and inductively coupled plasma-mass spectrometry (ICP–MS). ***%***, weight percent; ***ppm***, parts per million; <, below the specified detection limit; >, above the specified detection limit.—Continued.

Lab no.	***Field no.***	***Rock type***	***Eu ppm***	***Ga ppm***	***Gd ppm***	***Ge ppm***	***Hf ppm***	***Ho ppm***	***In ppm***	***La ppm***	***Li ppm***	***Lu ppm***
C-290393	24-IH06	pyroxenite	9.69	8	28.1	2	16	2.65	<0.2	181	<10	0.39
C-290331	25-IH06	pyroxenite	19.3	17	57.8	2	12	3.69	<0.2	474	<10	0.44
C-290332	26-IH06	pyroxenite	7.11	15	21.6	2	8	1.46	<0.2	169	<10	0.21
C-290333	27-IH06	pyroxenite	11.6	15	33.8	2	12	2.23	<0.2	304	<10	0.25
C-290337	30-IH06	carbonatite of the stock	6.44	20	18.9	2	5	1.1	<0.2	310	30	0.24
C-290338	31-IH06	carbonatite of the stock	39.1	54	147	29	<1	0.74	1.5	7760	20	0.1
C-290339	32-IH06	jasper vein in the carbonatite stock	25.7	28	89.9	28	<1	0.54	1	2970	10	0.07
C-290340	33-IH06	carbonatite of the stock	6.18	7	25.3	1	<1	0.91	0.5	512	140	0.11
C-290341	34A-IHO6	carbonatite of the stock	8.95	9	32.3	10	<1	0.54	0.9	1160	<10	0.09
C-290342	34B-IH06	carbonatite of the stock	11.5	14	41.9	21	2	0.6	1	1680	10	0.15
C-290343	35-IH06	carbonatite of the stock	12.2	6	36	6	3	1.75	<0.2	183	100	0.21
C-290344	36-IH06	carbonatite of the stock	13.2	12	43	4	<1	0.73	0.2	1750	<10	0.09
C-290345	37-IH06	carbonatite of the stock	9.97	14	31.7	16	7	2.02	0.2	329	40	0.29
C-290346	38-IH06	carbonatite of the stock	10.6	10	32.3	2	6	1.67	0.3	287	140	0.17
C-290347	40-IH06	carbonatite of the stock	11	7	33.7	18	<1	1.71	<0.2	172	70	0.27
C-290348	41-IH06	carbonatite of the stock	22.4	17	71.8	5	2	1.71	0.5	1550	40	0.26
C-290349	42-IH06	mixed zone rock	9.68	15	29.9	1	9	2.75	0.3	281	50	0.45
C-290350	43A-IH06	mixed zone rock	14	18	47.4	2	7	3.33	0.5	675	90	0.39
C-290351	43B-IH06	mixed zone rock	13.6	27	39	24	27	2.95	0.5	378	80	0.6
C-290352	44A-IH06	pyroxenite	12.6	24	40.6	2	48	5	<0.2	270	20	1.07
C-290353	44C-IH06	carbonatite dike	9.44	20	31.6	10	11	2.27	0.3	972	20	0.56
C-290354	45-IH06	carbonatite of the stock	4.53	4	16.8	2	<1	0.71	<0.2	195	20	0.08
C-290355	46-IH06	carbonatite dike	14.9	16	47.7	4	17	3.99	0.3	806	<10	0.68
C-290356	47-IH06	carbonatite dike	43.4	24	120	3	9	7.36	0.8	404	10	0.65
C-290357	48-IH06	uncompahgrite	3.5	21	9.89	<1	<1	0.75	<0.2	81.1	<10	0.09
C-290358	49-IH06	carbonatite of the stock	13	16	41.3	1	17	3.04	<0.2	344	20	0.52
C-290359	50A-IH06	pyroxenite	6.92	20	20.9	2	14	1.95	<0.2	160	20	0.34
C-290360	50B-IH06	carbonatite dike	12.9	26	40.5	3	27	1.94	0.5	941	110	0.44

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Lab no.	*Field no.*	*Rock type*	*Mo ppm*	*Nb ppm*	*Nd ppm*	*Ni ppm*	*Pb ppm*	*Pr ppm*	*Rb ppm*	*Sb ppm*	*Sc ppm*	*Sm ppm*
C-290364	01A-IH06	uncompahgrite	<2	84	151	<5	6	39.8	49.8	0.2	5	22.1
C-290365	01B-IH06	uncompahgrite	<2	256	89.9	<5	11	23.5	31.5	0.3	17	16.2
C-290366	02A-IH06	pyroxenite	<2	329	232	27	7	60.7	24.2	0.1	39	44.8
C-290367	02B-IH06	carbonatite dike	6	156	596	15	23	176	34.7	1.2	18	79.5
C-290368	03A-IH06	pyroxenite	<2	209	145	27	6	39.9	62.4	0.1	53	28.3
C-290369	03B-IH06	carbonatite dike	3	149	115	78	17	28.9	57.9	4.2	25	22.9
C-290370	04-IH06	pyroxenite	<2	511	356	33	<5	94.7	12.4	<0.1	12	57
C-290371	05-IH06	ijolite	<2	265	197	8	<5	51.8	6.4	<0.1	<5	35.1
C-290372	06-IH06	uncompahgrite	<2	863	540	6	9	147	16.4	<0.1	14	90
C-290373	07-IH06	uncompahgrite	<2	314	397	<5	27	106	5.6	0.1	18	80.1
C-290374	08-IH06	pyroxenite	<2	206	101	<5	<5	26.5	3.3	0.3	25	20
C-290375	09-IH06	pyroxenite	<2	191	222	20	<5	59.6	8.7	<0.1	97	36.9
C-290376	10A-IH06	pyroxenite	3	129	191	7	<5	48.5	9.8	0.1	19	38.5
C-290377	10B-IH06	thorite vein	5	315	440	7	64	88.6	58.1	0.4	22	125
C-290378	11A-IH06	pyroxenite	<2	261	292	20	<5	77.6	19.7	<0.1	68	46
C-290379	11B-IH06	pyroxenite	<2	244	245	14	<5	65	31.5	<0.1	53	40.6
C-290380	11D-IH06	pyroxenite	<2	512	625	14	7	173	2.2	<0.1	68	89.3
C-290381	12-IH06	nepheline syenite	3	66	31.5	<5	9	5.93	185	0.6	<5	10.1
C-290382	13-IH06	pyroxenite	<2	216	283	16	<5	73.5	6.7	0.1	75	43.5
C-290383	14-IH06	pyroxenite	<2	327	246	<5	<5	66.7	13.2	<0.1	47	40.9
C-290384	15-IH06	ijolite	4	156	87.2	<5	<5	22.1	19.2	<0.1	8	20.6
C-290385	16-IH06	pyroxenite	<2	207	103	5	<5	26.5	63.2	<0.1	18	20.3
C-290386	17-IH06	pyroxenite	<2	381	757	29	8	194	11.5	0.1	51	109
C-290387	18A-IH06	pyroxenite	<2	176	84.2	8	<5	23	31.7	0.1	40	17.3
C-290388	18B-IH06	pyroxenite	<2	157	203	14	16	53.1	13	<0.1	63	32.6
C-290389	21-IH06	pyroxenite	<2	292	299	19	6	79.9	19	<0.1	83	49.8
C-290390	22-IH06	pyroxenite	<2	271	235	15	<5	62.9	18.9	0.1	56	39.3
C-290391	23A-IH06	carbonatite dike	<2	151	531	25	14	133	30.9	<0.1	10	93.4
C-290392	23B-IH06	pyroxenite	<2	354	195	12	6	52.6	69.2	0.1	31	32.6

Table 3. Geochemical analyses of 57 rock samples collected in the Iron Hill carbonatite complex, southwestern Colorado. These data are provided in digital spreadsheet format in ***rock_sample_chem.xls***. Sample site information is provided in table 2 and ***sample_site_info.xls***. The analyses were conducted by inductively coupled plasma-atomic emission spectrometry (ICP–AES) and inductively coupled plasma-mass spectrometry (ICP–MS). ***%***, weight percent; ***ppm***, parts per million; <, below the specified detection limit; >, above the specified detection limit.—Continued.

Lab no.	***Field no.***	***Rock type***	***Mo ppm***	***Nb ppm***	***Nd ppm***	***Ni ppm***	***Pb ppm***	***Pr ppm***	***Rb ppm***	***Sb ppm***	***Sc ppm***	***Sm ppm***
C-290393	24-IH06	pyroxenite	<2	377	158	6	8	40.8	0.9	0.1	20	31.1
C-290331	25-IH06	pyroxenite	<2	447	440	14	12	115	1	<0.1	38	72.2
C-290332	26-IH06	pyroxenite	<2	151	148	17	9	38.8	13.4	0.1	56	25.9
C-290333	27-IH06	pyroxenite	<2	271	244	<5	<5	66.1	2.6	<0.1	32	41.9
C-290337	30-IH06	carbonatite of the stock	3	53	191	7	10	54.4	74.9	2.5	16	26.7
C-290338	31-IH06	carbonatite of the stock	105	59	4080	60	43	>1000	2.3	23.9	14	266
C-290339	32-IH06	jasper vein in the carbonatite stock	43	2420	2210	52	38	728	1.9	14.7	21	169
C-290340	33-IH06	carbonatite of the stock	15	416	413	38	7	122	24.7	0.2	29	39.9
C-290341	34A-IHO6	carbonatite of the stock	21	643	704	28	19	224	1	1.8	19	58
C-290342	34B-IH06	carbonatite of the stock	49	128	949	61	12	302	0.8	4.7	32	77.1
C-290343	35-IH06	carbonatite of the stock	13	1610	265	52	23	62.7	12.7	36.8	21	47.8
C-290344	36-IH06	carbonatite of the stock	7	111	807	31	18	251	2.6	6.2	15	74.1
C-290345	37-IH06	carbonatite of the stock	7	363	291	83	29	77.5	71.5	36.6	18	43.2
C-290346	38-IH06	carbonatite of the stock	4	1820	337	31	<5	89.7	58.7	0.4	29	47.5
C-290347	40-IH06	carbonatite of the stock	4	9	224	92	<5	55	60.3	17	15	42.8
C-290348	41-IH06	carbonatite of the stock	11	849	1240	65	15	371	16.6	11.9	16	120
C-290349	42-IH06	mixed zone rock	<2	291	258	101	<5	69.7	88.6	0.3	26	37.3
C-290350	43A-IH06	mixed zone rock	22	447	583	239	10	173	59.8	0.5	27	61.4
C-290351	43B-IH06	mixed zone rock	3	644	356	126	9	95	147	19.1	18	52.4
C-290352	44A-IH06	pyroxenite	<2	213	181	<5	5	48.4	70.7	0.2	15	38.8
C-290353	44C-IH06	carbonatite dike	5	425	470	37	23	152	146	17.4	12	44.1
C-290354	45-IH06	carbonatite of the stock	4	816	183	27	10	50	17.3	2.6	7	23.7
C-290355	46-IH06	carbonatite dike	4	265	446	46	32	135	54.6	7.1	17	58.7
C-290356	47-IH06	carbonatite dike	210	1690	710	65	60	158	50.7	1.8	87	158
C-290357	48-IH06	uncompahgrite	4	35	62.1	16	49	16.4	2.1	0.1	<5	11.2
C-290358	49-IH06	carbonatite of the stock	<2	791	306	39	<5	81.2	74.5	0.3	12	49.9
C-290359	50A-IH06	pyroxenite	<2	195	134	41	<5	34.9	89.4	0.1	19	24.6
C-290360	50B-IH06	carbonatite dike	2	616	653	147	30	195	78.4	0.3	30	64.7

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Lab no.	*Field no.*	*Rock type*	*Sn ppm*	*Sr ppm*	*Ta ppm*	*Tb ppm*	*Th ppm*	*Tl ppm*	*Tm ppm*	*U ppm*	*V ppm*	*W ppm*
C-290364	01A-IH06	uncompahgrite	4	3600	1.6	2.06	10.9	<0.5	0.35	1.54	93	<1
C-290365	01B-IH06	uncompahgrite	17	2880	2.7	2.83	24.1	<0.5	0.94	2.09	181	7
C-290366	02A-IH06	pyroxenite	5	906	12.5	4.85	16.7	<0.5	0.58	7.84	188	<1
C-290367	02B-IH06	carbonatite dike	2	3750	2.6	7.07	45.9	<0.5	1.08	3.62	108	4
C-290368	03A-IH06	pyroxenite	3	761	11	2.96	5.7	<0.5	0.33	3.61	156	<1
C-290369	03B-IH06	carbonatite dike	4	695	5	2.32	9.6	2	0.31	28.2	159	34
C-290370	04-IH06	pyroxenite	4	641	28.8	5.03	63.4	<0.5	0.5	9.32	223	<1
C-290371	05-IH06	ijolite	2	2340	10.9	3.45	18.3	<0.5	0.4	5.08	93	<1
C-290372	06-IH06	uncompahgrite	4	2500	29.2	9.01	39.5	<0.5	1.31	15.4	153	<1
C-290373	07-IH06	uncompahgrite	<1	3380	5.1	10.5	6.3	<0.5	1.87	8.46	125	1
C-290374	08-IH06	pyroxenite	7	828	7.8	2.58	5.5	<0.5	0.52	1.8	409	<1
C-290375	09-IH06	pyroxenite	3	392	16.2	3.04	21.3	<0.5	0.27	4.6	201	<1
C-290376	10A-IH06	pyroxenite	6	977	7.2	5.46	13.8	<0.5	2.03	2.58	502	15
C-290377	10B-IH06	thorite vein	8	1360	5.9	7.87	256	<0.5	0.67	4.24	331	7
C-290378	11A-IH06	pyroxenite	3	431	21.7	3.95	24	<0.5	0.35	7.06	203	<1
C-290379	11B-IH06	pyroxenite	2	251	19.9	3.54	37.6	<0.5	0.28	6.54	190	<1
C-290380	11D-IH06	pyroxenite	3	459	42.5	6.95	145	<0.5	0.49	15.9	211	<1
C-290381	12-IH06	nepheline syenite	1	627	1.4	0.65	28.1	1	0.09	0.78	70	4
C-290382	13-IH06	pyroxenite	3	290	22.2	3.42	49.8	<0.5	0.27	5.17	166	<1
C-290383	14-IH06	pyroxenite	5	380	19.6	3.83	26.6	<0.5	0.46	7.74	324	<1
C-290384	15-IH06	ijolite	4	929	5.9	4.15	4.8	<0.5	1.58	4.33	337	1
C-290385	16-IH06	pyroxenite	5	788	7	2.57	8.1	<0.5	0.58	4.09	440	<1
C-290386	17-IH06	pyroxenite	3	360	52.9	7.64	162	<0.5	0.43	9.78	287	<1
C-290387	18A-IH06	pyroxenite	4	689	5.4	2.18	4.8	<0.5	0.38	3.81	294	<1
C-290388	18B-IH06	pyroxenite	3	507	13.6	2.96	27.1	<0.5	0.3	3.97	188	<1
C-290389	21-IH06	pyroxenite	2	401	24.6	4.49	22.4	<0.5	0.38	7.56	212	1
C-290390	22-IH06	pyroxenite	2	326	19.6	3.59	24.2	<0.5	0.3	6.61	180	<1
C-290391	23A-IH06	carbonatite dike	<1	3240	8.1	8.65	129	<0.5	1.18	7.3	40	<1
C-290392	23B-IH06	pyroxenite	5	1390	12.6	3.39	15.4	<0.5	0.47	2.21	331	<1

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Lab no.	***Field no.***	***Rock type***	***Sn ppm***	***Sr ppm***	***Ta ppm***	***Tb ppm***	***Th ppm***	***Tl ppm***	***Tm ppm***	***U ppm***	***V ppm***	***W ppm***
C-290393	24-IH06	pyroxenite	6	799	15	3.69	5.2	<0.5	0.61	2.13	378	<1
C-290331	25-IH06	pyroxenite	4	839	32.5	6.85	44.7	<0.5	0.73	9.95	390	<1
C-290332	26-IH06	pyroxenite	4	512	12.2	2.56	12.5	<0.5	0.28	3.86	365	<1
C-290333	27-IH06	pyroxenite	3	701	17.2	4.05	28.6	<0.5	0.42	8.5	319	<1
C-290337	30-IH06	carbonatite of the stock	5	516	<0.5	2.11	18.7	<0.5	0.29	0.91	74	2
C-290338	31-IH06	carbonatite of the stock	<1	4580	<0.5	14	89.3	0.9	0.1	3.39	54	59
C-290339	32-IH06	jasper vein in the carbonatite stock	56	1200	2.8	8.48	108	8.2	0.11	7.39	116	9
C-290340	33-IH06	carbonatite of the stock	2	8230	3.3	2.64	7.5	<0.5	0.17	3.42	38	<1
C-290341	34A-IHO6	carbonatite of the stock	6	4510	2.1	3.21	31.1	0.7	0.1	4.58	19	5
C-290342	34B-IH06	carbonatite of the stock	3	5330	<0.5	4.04	35.1	1.5	0.12	6.59	61	6
C-290343	35-IH06	carbonatite of the stock	7	3930	59.8	3.93	39.9	<0.5	0.34	50.3	28	32
C-290344	36-IH06	carbonatite of the stock	2	6400	0.9	4.1	41.3	<0.5	0.11	2.27	38	29
C-290345	37-IH06	carbonatite of the stock	6	871	8.6	3.72	16.8	0.8	0.42	3.17	123	84
C-290346	38-IH06	carbonatite of the stock	15	7720	33.7	3.69	44.7	<0.5	0.33	25.4	74	2
C-290347	40-IH06	carbonatite of the stock	<1	2610	<0.5	3.63	13.1	77.4	0.32	3.31	53	<1
C-290348	41-IH06	carbonatite of the stock	8	5770	7.6	7.22	95.9	<0.5	0.31	6.77	67	14
C-290349	42-IH06	mixed zone rock	7	1510	10.8	3.82	23.5	<0.5	0.75	4.61	189	<1
C-290350	43A-IH06	mixed zone rock	6	1390	8.7	6.26	69.1	<0.5	0.67	15.8	183	<1
C-290351	43B-IH06	mixed zone rock	13	725	17	4.72	26.2	0.9	0.8	9.65	380	18
C-290352	44A-IH06	pyroxenite	4	1590	5.2	5.82	7.9	<0.5	1.48	7.07	204	<1
C-290353	44C-IH06	carbonatite dike	4	670	5.3	4.01	16.6	1.4	0.7	10.5	175	88
C-290354	45-IH06	carbonatite of the stock	<1	4910	3.9	1.8	6.8	<0.5	0.12	5.02	18	2
C-290355	46-IH06	carbonatite dike	5	1380	7.1	6.06	34	0.5	1.01	6.78	214	27
C-290356	47-IH06	carbonatite dike	97	924	22.5	14	182	1	1.37	12.1	864	4
C-290357	48-IH06	uncompahgrite	<1	2260	1.2	1.19	4	<0.5	0.16	0.94	30	<1
C-290358	49-IH06	carbonatite of the stock	4	3620	10.3	5.05	21.5	<0.5	0.74	6.05	148	<1
C-290359	50A-IH06	pyroxenite	3	2450	8.5	2.64	8.5	<0.5	0.51	3.11	384	<1
C-290360	50B-IH06	carbonatite dike	8	1280	20.4	4.44	30.3	<0.5	0.54	3.26	253	1

Table 3. Geochemical analyses of 57 rock samples collected in the Iron Hill carbonatite complex, southwestern Colorado. These data are provided in digital spreadsheet format in ***rock_sample_chem.xls***. Sample site information is provided in table 2 and ***sample_site_info.xls***. The analyses were conducted by inductively coupled plasma-atomic emission spectrometry (ICP–AES) and inductively coupled plasma-mass spectrometry (ICP–MS). ***%***, weight percent; ***ppm***, parts per million; <, below the specified detection limit; >, above the specified detection limit.—Continued.

Lab no.	***Field no.***	***Rock type***	***Y ppm***	***Yb ppm***	***Zn ppm***	***Zr ppm***
C-290364	01A-IH06	uncompahgrite	36.6	1.9	501	210
C-290365	01B-IH06	uncompahgrite	75.8	5.4	333	1020
C-290366	02A-IH06	pyroxenite	65.7	3.4	84	766
C-290367	02B-IH06	carbonatite dike	102	7.2	128	276
C-290368	03A-IH06	pyroxenite	39.1	1.8	61	353
C-290369	03B-IH06	carbonatite dike	35.9	1.8	236	251
C-290370	04-IH06	pyroxenite	56.5	2.7	111	1240
C-290371	05-IH06	ijolite	44.9	2.2	581	589
C-290372	06-IH06	uncompahgrite	125	7	431	2130
C-290373	07-IH06	uncompahgrite	194	10.1	289	4110
C-290374	08-IH06	pyroxenite	53.6	3.1	75	738
C-290375	09-IH06	pyroxenite	29.4	1.5	62	302
C-290376	10A-IH06	pyroxenite	155	12.2	88	1440
C-290377	10B-IH06	thorite vein	80.2	3.8	91	258
C-290378	11A-IH06	pyroxenite	36.4	1.9	45	276
C-290379	11B-IH06	pyroxenite	30.8	1.6	42	295
C-290380	11D-IH06	pyroxenite	53.2	2.7	67	266
C-290381	12-IH06	nepheline syenite	9.2	0.6	29	86.8
C-290382	13-IH06	pyroxenite	29.8	1.5	41	223
C-290383	14-IH06	pyroxenite	45.4	2.6	98	458
C-290384	15-IH06	ijolite	120	9.9	94	2030
C-290385	16-IH06	pyroxenite	54.6	3.6	105	862
C-290386	17-IH06	pyroxenite	48.2	2.3	94	191
C-290387	18A-IH06	pyroxenite	40.2	2.1	54	702
C-290388	18B-IH06	pyroxenite	31	1.7	54	390
C-290389	21-IH06	pyroxenite	39.8	1.9	69	193
C-290390	22-IH06	pyroxenite	34.2	1.6	52	258
C-290391	23A-IH06	carbonatite dike	127	6.6	52	175
C-290392	23B-IH06	pyroxenite	48	2.9	95	489

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Lab no.	***Field no.***	***Rock type***	***Y ppm***	***Yb ppm***	***Zn ppm***	***Zr ppm***
C-290393	24-IH06	pyroxenite	68.2	3.4	59	523
C-290331	25-IH06	pyroxenite	76.1	3.9	109	336
C-290332	26-IH06	pyroxenite	33.4	1.5	88	204
C-290333	27-IH06	pyroxenite	47.6	2.4	73	343
C-290337	30-IH06	carbonatite of the stock	27.9	2	96	249
C-290338	31-IH06	carbonatite of the stock	11.6	0.9	2540	12.8
C-290339	32-IH06	jasper vein in the carbonatite stock	8.5	0.7	847	17.6
C-290340	33-IH06	carbonatite of the stock	20.9	1	392	10.1
C-290341	34A-IHO6	carbonatite of the stock	11.2	0.7	716	4.2
C-290342	34B-IH06	carbonatite of the stock	13.5	0.9	1260	11.7
C-290343	35-IH06	carbonatite of the stock	39	1.9	217	26.7
C-290344	36-IH06	carbonatite of the stock	14.4	0.9	135	6.1
C-290345	37-IH06	carbonatite of the stock	48.6	2.4	554	375
C-290346	38-IH06	carbonatite of the stock	39.3	1.6	194	93.8
C-290347	40-IH06	carbonatite of the stock	41.4	1.8	535	16.8
C-290348	41-IH06	carbonatite of the stock	37.3	2	908	49.7
C-290349	42-IH06	mixed zone rock	69.3	3.9	235	493
C-290350	43A-IH06	mixed zone rock	82.4	3.7	286	339
C-290351	43B-IH06	mixed zone rock	68.9	4.7	935	1550
C-290352	44A-IH06	pyroxenite	143	8.8	306	2070
C-290353	44C-IH06	carbonatite dike	62.5	4.6	235	686
C-290354	45-IH06	carbonatite of the stock	16.3	0.8	196	6.4
C-290355	46-IH06	carbonatite dike	96.1	5.6	208	1200
C-290356	47-IH06	carbonatite dike	171	6.6	209	182
C-290357	48-IH06	uncompahgrite	18.9	0.8	499	44.5
C-290358	49-IH06	carbonatite of the stock	78.5	4.3	202	1070
C-290359	50A-IH06	pyroxenite	51.9	2.8	154	673
C-290360	50B-IH06	carbonatite dike	48.5	3.5	575	1030