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ANALYTICAL RESULTS AND SAMPLE LOCALITY MAP FOR ROCK, STREAM-SEDIMENT, AND SOIL SAMPLES, NORTHERN AND EASTERN COLORADO DESERT BLM RESOURCE AREA, IMPERIAL, RIVERSIDE, AND SAN BERNARDINO COUNTIES, CALIFORNIA

By

H.D. King* and M.A. Chaffee*

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*U.S. Geological Survey, Denver Federal Center, Box 25046, MS 973, Denver, CO 80225-0046

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INTRODUCTION

In 1996-1998 the U.S. Geological Survey (USGS) conducted a geochemical study of the Bureau of Land Management's (BLM) 5.5 million-acre Northern and Eastern Colorado Desert Resource Area (usually referred to as the NECD in this report), Imperial, Riverside, and San Bernardino Counties, southeastern California (figure 1). This study was done in support of the BLM's Coordinated Management Plan for the area. This report presents analytical data from this study.

To provide comprehensive coverage of the NECD, we compiled and examined all available geochemical data, in digital form, from previous studies in the area, and made sample-site plots to aid in determining where sample-site coverage and analyses were sufficient, which samples should be re-analyzed, and where additional sampling was needed. Previous investigations conducted in parts of the current study area included the National Uranium Resource Evaluation (NURE) program studies of the Needles and Salton Sea 1° x 2° quadrangles; USGS studies of 12 BLM Wilderness Study Areas (WSAs) (Big Maria Mountains, Chemehuevi Mountains, Chuckwalla Mountains, Coxcomb Mountains, Mecca Hills, Orocopia Mountains, Palen-McCoy, Picacho Peak, Riverside Mountains, Sheephole Valley (also known as Sheep Hole/Cadiz), Turtle Mountains, and Whipple Mountains); and USGS studies in the Needles and El Centro 1° x 2° quadrangles done during the early 1990s as part of a project to identify the regional geochemistry of southern California. Areas where we did new sampling of rocks and stream sediments are mainly in the Chocolate Mountain Aerial Gunnery Range and in Joshua Tree National Park, which extends into the west-central part of the NECD, as shown in figure 1 and figure 2.

This report contains analytical data for 132 rock samples and 1,245 stream-sediment samples collected by the USGS, and 362 stream-sediment samples and 189 soil samples collected during the NURE program. All samples are from the Northern and Eastern Colorado Desert BLM Resource Area and vicinity. Included in the 1,245 stream-sediment samples collected by the USGS are 284 samples collected as part of the current study, 817 samples collected as part of investigations of the12 BLM WSAs and re-analyzed for the present study, 45 samples from the Needles 1° X 2° quadrangle, and 99 samples from the El Centro 1° X 2° quadrangle. The NURE stream-sediment and soil samples were re-analyzed as part of the USGS study in the Needles quadrangle. Analytical data for samples from the Chocolate Mountain Aerial Gunnery Range, which is located within the area of the NECD, were previously reported (King and Chaffee, 1999a). For completeness, these results are also included in this report. Analytical data for samples from the area of Joshua Tree National Park that is within the NECD have also been reported (King and Chaffee, 1999b). These results are not included in this report. The analytical data presented here can be used for baseline geochemical, mineral resource, and environmental geochemical studies.

SAMPLE COLLECTION AND PREPARATION

As part of this study, we collected a total of 132 rock samples from 123 sites. The samples consisted of composited chips from several outcrops, or of a composite of several grab samples from a mine or prospect dump, that were collected from within a 30-meter radius of the site for each sample plotted on figure 2.

We also collected samples of bulk stream sediment from 284 sites. All samples were taken from dry stream beds, and most were from stream beds with gentle to moderate gradients. The bulk stream sediment at each site was composited from several localities extending across what appeared to be the most recently active stream channel and within an area of 30-meter radius of the site for each sample plotted on figure 2.

Selected stream-sediment samples previously collected for USGS reconnaissance geochemical studies of 12 BLM WSAs were obtained from USGS archives in Denver, Colorado, for re-analysis. The BLM WSAs and the reports of original geochemical data are Chemehuevi Mountains (Hopkins and others, 1984), Chuckwalla Mountains (Adrian and others, 1985), Coxcomb Mountains (Kilburn, and others, 1983), Mecca Hills (Detra and Kilburn, 1985), Orocopia Mountains (Adrian and others, 1989), Palen-McCoy (Detra and others, 1984), Picacho Peak (Adrian and others, 1984), Turtle Mountains (Detra and others, 1983), and Whipple Mountains (Erickson and others, 1987). The Big Maria Mountains, Riverside Mountains, and Sheephole Valley WSA investigations were not completed by the BLM, and analytical data reports were never released.

NURE samples in the Needles 1° x 2° quadrangle were collected for the Savannah River National Laboratory in 1979. The original analyses are reported in Cook (1981) and the NURE sampling methods are described in Price and Jones (1979).

The rock and stream-sediment samples collected for the present study were prepared and analyzed by Activation Laboratories, Ltd. (ACTLABS), Ancaster, Ontario, Canada. ACTLABS routinely crushed the entire rock sample to minus-10-mesh (2 mm), mechanically split the rock sample, and pulverized one of the splits to at least minus-150-mesh for analysis. The stream-sediment and soil samples were sieved at the sample site to minus-2-mm with stainless-steel sieves. These samples were further sieved in the laboratory and the minus-80-mesh (0.18-mm) fraction was retained for analysis and pulverized as described for the rock samples.

The archived stream-sediment samples originally collected from the BLM WSAs had also been sieved to minus-80-mesh. The NURE stream-sediment and soil samples were originally sieved to minus-100-mesh. For the new analysis all these samples were pulverized to a fine powder that was approximately minus 150-mesh. The NURE samples from Needles 1° x 2° quadrangle were re-analyzed by the USGS prior to the present study but the data were never published. The stream-sediment samples from the BLM WSAs were re-analyzed by XRAL Laboratories, Toronto, Ontario, Canada.

ANALYTICAL METHODS

All samples collected during the present study and the BLM WSA samples for re-analysis were submitted to the laboratories in a random sequence and generally in groups of 40 samples. Duplicate samples and internal standards were submitted with the samples to check the accuracy and reproducibility of the analyses. ACTLABS analyzed samples for 29 elements (As, Au, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, La, Lu, Na, Nd, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Th, U, W, and Yb) by instrumental neutron activation (INAA), and for 19 elements (Ag, Al, Be, Bi, Ca, Cd, Cu, K, Mg, Mn, Mo, Ni, P, Pb, Sr, Ti, V, Y, and Zn) by inductively coupled plasma-atomic emission spectrometry (ICP-AES) after a total extraction. The elements analyzed and lower limits of determination are listed in table 1.

Two methods of ICP-AES, a partial-extraction method (Motooka, 1996), and a total-extraction method (Briggs, 1996) were used for the samples analyzed by the USGS. Similar methods were used by XRAL. Ten elements (Ag, As, Au, Bi, Cd, Cu, Mo, Pb, Sb, and Zn) were analyzed by the partial-extraction method of ICP-AES, and 40 elements (Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Ga, Ho, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Sc, Sn, Sr, Ta, Th, Ti, U, V, Y, Yb, and Zn) were analyzed by the total-extraction method. The elements analyzed and lower limits of determination are given in table 2. The USGS also analyzed samples for Au by graphite-furnace atomic absorption spectrometry (O'Leary and Meier, 1996), and for W by visible absorption spectrophotometry (O'Leary and Welsch, 1990).

The results for all elements analyzed by the three laboratories are listed in table 3, table 4, table 5, table 6, table 7, and table 8 of this report. Elements with no reported values above their respective lower limits of determination have been omitted from table 3, table 4, table 5, table 6, table 7, and table 8. As a result, of the original 48 elements determined by ACTLABS, two determined by INAA (Ir and Sn), were deleted from the rock data set (table 3), and three elements determined by INAA (Ir, Hg, and Sn) were deleted from the stream-sediment data set (table 4). Of the original 52 elements determined by the USGS with the ICP-AES total extraction method, five (Ag, Au, Sn, Ta, and U) were deleted from the NURE stream-sediment data set (table 5), seven (Ag, Au, Cd, Ho, Sn, Ta, and U) were deleted from the NURE soil data set (table 6), and eight (Ag, Au, Bi, Cd, Ho, Sn, Ta, and U) were deleted from the data set of previously collected USGS stream-sediment samples (table 7). Of the original 50 elements determined by XRAL, one (Au), determined by partial extraction method ICP-AES, and five (Ag, As, Bi, Sn, and U), determined by total extraction method ICP-AES were deleted from the stream-sediment data set of WSA samples (table 8). Analyses for the remaining elements for each sample type are listed in tables 3-8.

DESCRIPTION OF DATA TABLES

The analyses are listed in tables 3-8. Information on the column headings and sample numbers are given below:

Sample--For samples in tables 3-8 (with the exception of samples labeled "MJA" in table 7), the first two letters identify the original project for which the samples were collected:

CD	Samples collected for the current project
NE	NURE samples from the Needles 1° x 2° quadrangle
EC	Previously collected USGS samples from the El Centro 1° x 2° quadrangle
CH	Chemehuevi Mountains WSA
TM	Turtle Mountains WSA
WM	Whipple Mountains WSA
RM	Riverside Mountains WSA
BM	Big Maria Mountains WSA
PM	Palen-McCoy WSA
CX	Coxcomb Mountains WSA
SH	Sheep Hole/Cadiz (now known as Sheephole Valley) WSA
CW	Chuckwalla Mountains WSA
OA	Orocopia Mountains WSA
MH	Mecca Hills WSA
PP	Picacho Peak WSA

Table 1. Lower limits of determination for instrumental neutron activation analysis (INAA) and inductively coupled plasma-atomic emission spectrometric analysis (ICP-AES) methods used by ACTLABS

Instrumental neutron activation analysis (INAA)

Element	Lower limit	Element	Lower limit
Antimony (Sb)	0.1 ppm	Mercury (Hg)	1 ppm
Arsenic (As)	0.5 ppm	Neodymium (Nd)	5 ppm
Barium (Ba)	50 ppm*	Rubidium (Rb)	15 ppm
Bromine (Br)	0.5 ppm	Samarium (Sm)	0.1 ppm
Cerium (Ce)	3 ppm	Scandium (Sc)	0.1 ppm
Cesium (Cs)	1 ppm	Selenium (Se)	3 ppm
Chromium (Cr)	5 ppm	Sodium (Na)	0.01 %
Cobalt (Co)	1 ppm	Tantalum (Ta)	0.5 ppm*
Europium (Eu)	0.2 ppm	Terbium (Tb)	0.5 ppm
Gold (Au)	2 ppb*	Thorium (Th)	0.2 ppm
Hafnium (Hf)	1 ppm	Tin (Sn)	100 ppm
Iridium (Ir)	5 ppb	Tungsten (W)	1 ppm*
Iron (Fe)	0.01 %	Uranium (U)	0.5 ppm
Lanthanum (La)	0.5 ppm	Ytterbium (Yb)	0.2 ppm
Lutetium (Lu)	0.05 ppm		

Inductively coupled plasma-atomic emission spectrometric analysis (ICP-AES)

Element	Lower limit	Element	Lower limit
Aluminum (Al)	0.01 %	Nickel (Ni)	1 ppm
Beryllium (Be)	2 ppm	Phosphorus (P)	0.001 %
Bismuth (Bi)	5 ppm	Potassium (K)	0.01 %
Cadmium (Cd)	0.5 ppm	Silver (Ag)	0.5 ppm*
Calcium (Ca)	0.01 %	Strontium (Sr)	1 ppm
Copper (Cu)	1 ppm	Titanium (Ti)	0.01 %
Lead (Pb)	5 ppm	Vanadium (V)	2 ppm
Magnesium (Mg)	0.01 %	Yttrium (Y)	2 ppm
Manganese (Mn)	1 ppm	Zinc (Zn)	1 ppm
Molybdenum (Mo)	2 ppm		

* Some additional lower limits were used for these elements, as shown in the “wk1" files. The most commonly used lower limits are shown in this table.

Table 2. Lower limits of determination for inductively coupled plasma-atomic emission spectrometry (ICP-AES) methods used by USGS and XRAL Laboratories

ICP-AES, partial-extraction method

Element	Lower limit	Element	Lower limit
Antimony (Sb)	1 ppm	Gold (Au)	0.1 ppm
Arsenic (As)	1 ppm	Lead (Pb)	1 ppm
Bismuth (Bi)	1 ppm	Molybdenum (Mo)	0.1 ppm
Cadmium (Cd)	0.05 ppm	Silver (Ag)	0.08 ppm
Copper (Cu)	0.05 ppm	Zinc (Zn)	0.05 ppm

ICP-AES, total-extraction method

Element	Lower limit	Element	Lower limit
Aluminum (Al)	0.005 %	Manganese (Mn)	4 ppm
Arsenic (As)*	10 ppm	Molybdenum (Mo)	2 ppm
Barium (Ba)	1 ppm	Neodymium (Nd)	9 ppm
Beryllium (Be)	1 ppm	Nickel (Ni)	3 ppm
Bismuth (Bi)*	10 ppm	Niobium (Nb)*	4 ppm
Cadmium (Cd)	2 ppm	Phosphorus (P)	0.005 %
Calcium (Ca)	0.005 %	Potassium (K)	0.01%
Cerium (Ce)	5 ppm	Scandium (Sc)	2 ppm
Chromium (Cr)	2 ppm	Silver (Ag)	2 ppm
Cobalt (Co)	2 ppm	Sodium (Na)	0.005 %
Copper (Cu)	2 ppm	Strontium (Sr)	2 ppm
Europium (Eu)*	2 ppm	Tantalum (Ta)	40 ppm
Gallium (Ga)	4 ppm	Thorium (Th)	6 ppm
Gold (Au)	8 ppm	Tin (Sn)	10 ppm
Holmium (Ho)*	4 ppm	Titanium (Ti)	0.005 %
Iron (Fe)	0.02 %	Uranium (U)	100 ppm
Lanthanum (La)	2 ppm	Vanadium (V)	2 ppm
Lead (Pb)	4 ppm	Ytterbium (Yb)	1 ppm
Lithium (Li)	2 ppm	Yttrium (Y)	2 ppm
Magnesium (Mg)	0.005 %	Zinc (Zn)	2 ppm

Flameless atomic emission spectrophotometry with heated graphite atomizer	
Element: Gold (Au)	Lower limit: 0.002 ppm

Visible absorption spectrophotometry	
Element: Tungsten (W)	Lower limit: 0.5 ppm

*Some additional lower limits were used for these elements, as shown in the “wk1" files. The most commonly used lower limits are shown in this table.

Samples with the letter prefix “MJA” (table 7) are previously collected USGS samples from the Needles 1° x 2° quadrangle. For the NURE sample ID’s (table 5 and table 6), the second set of two letters identifies the 15' quadrangle from which the samples were collected (Cook, 1981, p. 11). The three digits following the letters give the site number. Letters following the site numbers, if present, indicate the sample type as follows: “RK” for rock, “SS” or “S” for stream sediment. The suffix “L” in table 7 is used for samples deemed to be soil rather than stream sediment.

In table 3, identical sample IDs followed by an “A”, “B”, “C” indicate more than one sample collected at the same site.

TAG_NO–The second column in tables 5-8 list the laboratory, or tag, identification numbers for each sample. Tag numbers were not assigned to the samples listed in table 3 and table 4.

LATITUDE and LONGITUDE–In the “wk1" files the next two columns give the latitude and longitude in decimal degrees for each sample. Values are based on 1927 datum.

LATITUDE, LAT_DEG, LAT_MIN, LAT_SEC, LONGITUDE, LON_DEG, LON_MIN, LON_SEC–In the “dbf” files latitude and longitude are given in decimal degrees and also in degrees, minutes, and seconds for each sample. Values are based on 1927 datum.

AG PPM through ZN PPM--These columns of analytical data list the element symbol, whether the concentrations are in parts per million (PPM), parts per billion (PPB), or percent (PCT), and the analytical method. A “NAA” indicates instrumental neutron activation analysis; an “ICP” indicates inductively coupled plasma-atomic emission spectrometry (ICP-AES) with total digestion (table 3 and table 4, ACTLABS analyses). For table 5, table 6, table 7, and table 8, a “P” indicates a partial-extraction ICP-AES method was used; a “T” indicates a total extraction ICP-AES method was used; “AA” indicates graphite furnace atomic absorption spectrometry; and “S” indicates visible absorption spectrophotometry.

DESCRIPTION--The rock descriptions given in table 3 are field terms based on identification with a hand lens. The list also includes locality comments, where appropriate.

OTHER INFORMATION

More than one lower limit of determination was reported for some of the elements analyzed by ACTLABS and by the USGS (table 1 and table 2). These differences in lower limits possibly resulted from the use of a smaller than standard sample aliquot for a given analysis because of insufficient available sample material, or from sample matrix differences.

The “wk1" files show the correct lower limits for each censored value reported as a negative number (i.e., -5 ppm

equals <5 ppm). The “dbf” files show lower limits for each censored value by appending a N to the limiting value.

Because of the formatting in the computer programs used to produce the data in the “dbf” and “wk1" files, the elements listed in the tables may carry one or more nonsignificant zeros to the right of the decimal point. The analysts did not determine these elements to the accuracy suggested by the extra zeros shown. In general, the elements shown in percentage, are significant to two decimal places (Phosphorus is correct to three places). For other elements values to the left of the decimal point generally do not contain more than two or three significant digits.

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