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Geochemical Sampling of Selected Playas in Nevada: Alkali Lake (Esmeralda County), Columbus Salt Marsh (Esmeralda County), Rhodes Salt Marsh (Mineral County), and Winnemucca Dry Lake (Washoe County)

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This report, which is available as an online document at www.nbmg.unr.edu, documents the results of chemical and mineralogical analyses of samples collected from the surfaces of four playas (flat, closed basins that are normally dry) in Nevada. Samples were analyzed for gold, silver, and several other elements at different laboratories. No economically significant amounts of these elements were found in the samples.

[1]Nevada Bureau of Mines and Geology
[2]Nevada Division of Minerals
[3]Nevada Bureau of Mining Regulation and Reclamation

The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada, Reno and is the State geological survey. Established by the Nevada Legislature as a department within the public service division of the Nevada System of Higher Education, NBMG is part of the Mackay School of Earth Sciences and Engineering within the College of Science and one of the Statewide Programs at the University of Nevada, Reno. NBMG's mission, to provide the State's needs for geological and mineral-resource information and research, is defined in its enabling legislation. NBMG scientists conduct research and publish reports that focus on the economic development, public safety, and quality of life in urban and rural areas of Nevada.

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This report documents the results of chemical and mineralogical analyses of samples collected from the surfaces of four playas (flat, closed basins that are normally dry) in Nevada. Samples were analyzed for gold, silver, platinum, palladium, and several other elements at three different laboratories: the Nevada Bureau of Mines and Geology (NBMG) analytical lab, Actlabs, and ALS Chemex. No economically significant amounts of these elements were found in the samples.

Sample Collection

Samples were collected on November 16, 2009 at Alkali Lake and Columbus Salt Marsh in Esmeralda County and at Rhodes Salt Marsh in Mineral County, and on November 17, 2009 at the southern end of Winnemucca Dry Lake in Washoe County. Sample locations are listed in Table 1 and plotted on Figures 1 through 4.

Table 1. Sample locations[1].

Sample number	Latitude N (degrees)	(minutes)	Longitude W (degrees)	(minutes)	Depth of hole (cm)
AL-1	37	51.731	117	22.708	31
AL-2	37	52.002	117	23.122	30
AL-3	37	51.713	117	23.325	44
CSM-1	38	04.387	118	00.377	46
CSM-2	38	04.381	117	59.818	41
CSM-3	38	04.386	117	59.271	41
CSM-4	38	04.390	117	58.728	52
CSM-5	38	03.195	118	00.491	49
RSM-1	38	16.794	118	05.710	39
RSM-2	38	16.824	118	05.654	40
RSM-3	38	16.857	118	05.582	44
WDL-1	39	58.333	119	22.661	32
WDL-2	39	58.449	119	22.649	36
WDL-3	39	59.569	119	22.465	45

[1]Longitude and latitude are given using the WGS-84 datum.

Channel samples of playa sediments were collected from the walls of holes dug with a shovel to depths of 30 to 52 cm. A trowel was used to carve a 2- to 5-cm deep channel into the walls of the hole. After sampling, the holes were refilled. White salts occurred at the surface at many of the sample locations, and a thin (approximately 1-cm thick) layer of white salts was present approximately 10 cm from the surface in the holes at Columbus Salt Marsh. The samples for

geochemical analyses were taken below these visible white salts. Samples, which at many locations were moist, were placed into labeled, clear plastic bags, which were then placed in cloth bags. Chain of custody was maintained by Paul Lechler throughout the sampling process. Figures 5 through 18 illustrate the sampling technique and the individual sample locations.

Sample Preparation and Analytical Techniques

Samples were dried overnight at 90°C, and pulverized in a ring and puck pulverizer to a fine powder (nominally greater than 95% minus 200 mesh) in the laboratory of the Nevada Bureau of Mines and Geology (NBMG). Sample powders were blended by rolling repeatedly on Kraft paper and were separated into four splits by coning and quartering. Three splits were sent to three analytical laboratories for analysis and the fourth was retained for archiving. Samples were characterized mineralogically using NBMG's X-ray powder diffractometer.

Samples were analyzed by three separate laboratories (NBMG's analytical lab, Actlabs, and ALS Chemex) using several different techniques. We included two blind standard reference materials, also in a fine powder form, with each set of samples. One is a weakly mineralized rock (sample NBM-2a, carbonate rock from the Jerritt Canyon mine area in Elko County, Nevada) and the other is a low-grade gold-silver-mineralized rock (sample NBM-4b, metasedimentary rock from the Mesquite mine in Imperial County, California).

The NBMG determined gold, silver, platinum, and palladium by conventional fire assay (FA) with 2 mg silver inquartation and lead collection, with a gravimetric finish for silver, with a lower detection limit of 3 g silver per metric ton (ppm). After digestion of the fire assay beads with aqua regia, gold, platinum, and palladium were determined by graphite furnace atomic absorption spectroscopy (GFAA), with lower detection limits of 0.001 ppm (1 ppb) for gold and 0.005 ppm (5 ppb) for platinum and palladium. Gold and silver were also determined separately by aqua regia digestion of sample powders followed by extraction of the gold into MIBK (methyl isobutyl ketone). Silver was quantified in the aqua regia solution by flame atomic absorption spectroscopy (FAA), and gold was quantified in the MIBK by GFAA. The aqua regia digestion will not necessarily recover gold that is in solid solution in minerals that do not dissolve. In contrast, fire assay generally recovers more than 99% of the precious metals contained in the sample, because all the minerals are melted during the assaying process.

Actlabs determined gold by fire assay fusion followed by instrumental neutron activation finish (FA-INAA), with a lower detection limit of 0.001 g gold per metric ton (1 ppb), and silver by conventional fire assay (FA), with lower detection limit of 3 g silver per metric ton (3 ppm).

ALS Chemex determined gold by fire assay and inductively coupled plasma atomic emission spectroscopy (FA-ICPAES), with a lower detection limit of 0.001 g gold per metric ton (1 ppb). ALS Chemex also analyzed the samples for a suite of trace elements typically examined in exploration for mineral deposits using a four-acid near-total digestion followed by quantification with inductively coupled plasma mass spectrometry (ICP-MS) or ICPAES. The lower detection limit for silver with this technique is 0.01 g silver per metric ton (10 ppb). Although the four-acid digestion typically dissolves most minerals in the sample, some gold may remain undissolved (locked in solid solution in the minerals that did not dissolve) with this technique.

Results

The results of mineralogical characterization by X-ray diffraction are listed in Table 2. The results of the chemical analyses are listed in Tables 3 (gold), 4 (silver), 5 (trace elements commonly associated with gold mineralization in Nevada), 6 (selected major elements), and 7 (platinum and palladium).

Table 2. Mineralogy of playa samples[1].

Sample number	Mineralogy from X-ray diffraction ha	gyp	cal	bas	qz	fs	pyr	ill	kao	mon	phy
AL-1	maj		maj		maj	maj		maj			
AL-2	pos		maj		maj	pos		maj			
AL-3			maj		maj			min			
CSM-1	maj		maj		maj	maj		min			
CSM-2	maj		maj		maj	maj		min	tr		
CSM-3	maj		maj		maj	maj		min			
CSM-4	maj		maj		maj	maj		tr	tr		
CSM-5	maj		maj		maj	min		min			
RSM-1	maj	tr		maj	maj	maj		tr			
RSM-2	maj				min	min					min
RSM-3	maj		maj		maj	maj		min			
WDL-1	maj		maj		maj	maj		min		pos	
WDL-2	maj		maj		maj	maj	maj	min		pos	
WDL-3	maj		maj		maj	maj		min		pos	

[1]ha = halite; gyp = gypsum; cal = calcite; bas = bassanite; qz = quartz; fs = feldspar; pyr = pyroxene; ill = illite or other 10-A clay; kao = kaolinite or other 7-A clay; mon = montmorillonite; phy = pyrophyllite.
maj = major quantities; min = minor quantities; tr = trace quantities, barely detectable by X-ray diffraction; pos = possible trace quantities.

Table 3. Gold analyses of playa samples and standard reference materials by different techniques and laboratories (values in grams per metric ton or parts per million by weight).

Sample number	NBMG FA	ALS FA-ICPAES	Actlabs FA-INAA	NBMG AA	Accepted Value
AL-1	0.010	0.012	0.018	0.006	
AL-2	0.013	0.017	0.023	0.007	
AL-3	0.013	0.013	0.020	0.006	
CSM-1	0.007	0.001	0.004	0.002	
CSM-2	0.006	0.008	0.012	0.004	
CSM-3	0.005	0.005	0.008	0.002	
CSM-4	0.003	0.003	0.004	0.002	
CSM-5	0.003	0.002	0.004	0.002	
RSM-1	0.004	0.004	0.008	0.004	
RSM-2	0.010	0.007	0.009	0.004	
RSM-3	0.004	0.006	0.011	0.005	
WDL-1	0.003	0.001	0.005	0.001	
WDL-2	0.001	0.002	0.004	0.001	
WDL-3	0.002	0.001	0.004	0.004	
NBM-2a	0.007	0.006	0.010	--	0.007 ± 0.004
NBM-4b	0.406	0.427	0.381	0.379	0.41 ± 0.07

Table 4. Silver analyses of playa samples and standard reference materials by different techniques and laboratories (values in grams per metric ton or parts per million by weight).

Sample number	NBMG FA	ALS Four-acid	Actlabs FA	NBMG AA	Accepted Value
AL-1	<3	0.28	<3	<1	
AL-2	<3	0.31	<3	<1	
AL-3	<3	0.39	<3	<1	
CSM-1	<3	0.02	<3	<1	
CSM-2	<3	0.08	<3	<1	
CSM-3	<3	0.05	<3	<1	
CSM-4	<3	0.03	<3	<1	
CSM-5	<3	0.01	<3	<1	
RSM-1	<3	0.13	<3	<1	
RSM-2	<3	2.42	<3	<1	
RSM-3	<3	0.27	<3	<1	
WDL-1	<3	0.12	<3	<1	
WDL-2	<3	0.07	<3	<1	
WDL-3	<3	0.07	<3	<1	
NBM-2a	<3	0.27	<3	<1	0.248 ± 0.087
NBM-4b	<3	0.86	<3	<1	1.0 ± 1.4

Table 5. Concentrations of selected trace elements typically found associated with some Nevada gold deposits (values in grams per metric ton or parts per million by weight) [1].

Sample number	As	Ba	Bi	Cu	Pb	S	Sb	Se	Te	Tl	Zn
AL-1	25.5	620	0.48	35.9	25.5	2,400	3.00	1	0.16	0.80	125
AL-2	26.8	670	0.45	44.7	26.5	9,900	3.51	2	0.22	0.80	118
AL-3	26.7	650	0.48	37.8	26.2	10,600	3.12	2	0.20	0.84	125
CSM-1	26.7	710	0.23	30.4	22.3	800	2.74	1	0.09	0.67	75
CSM-2	28.2	530	0.37	32.5	19.2	2,200	3.79	1	0.07	0.68	82
CSM-3	27.3	520	0.35	29.0	17.2	2,100	2.94	1	0.06	0.55	79
CSM-4	21.8	560	0.24	42.8	19.8	1,500	3.41	1	0.11	0.66	71
CSM-5	41.6	570	0.24	23.6	24	1,600	3.95	1	0.06	0.72	77
RSM-1	20.2	240	0.27	49.6	28.4	47,600	4.03	1	0.09	0.56	78
RSM-2	32.3	490	0.24	43.7	87.7	32,600	28.1	1	0.10	0.48	98
RSM-3	75.4	710	0.31	53.5	67.9	2,800	17.2	1	0.15	0.63	113
WDL-1	21.1	1020	0.21	51.8	14.1	1,900	3.21	1	0.05	0.43	97
WDL-2	24.2	900	0.11	30.8	10.5	2,400	2.53	3	<0.05	0.34	68
WDL-3	16.2	790	0.09	29.9	11.9	1,400	1.96	1	0.06	0.31	78
NBM-2a	6.7	840	0.09	70.8	10.8	6,000	1.81	2	<0.05	0.35	96
NBM-4a	129.5	820	0.16	36.5	12.6	100	10.35	1	0.1	0.87	26

[1]Analyses by ALS-Chemex using a four-acid digestion and ICP-MS or ICPAES. As = arsenic; Ba = barium; Bi = bismuth; Cu = copper; Pb = lead; S = sulfur; Sb = antimony; Se = selenium; Te = tellurium; Tl = thallium; Zn = zinc.

Table 6. Concentrations of selected major elements (values in percent by weight) [1].

Sample number	Al	Ca	Fe	K	Mg	Na
AL-1	7.88	3.90	3.36	2.87	1.75	2.15
AL-2	7.79	4.63	3.25	2.77	1.67	1.91
AL-3	8.24	4.68	3.51	2.94	1.81	1.75
CSM-1	6.97	2.83	2.21	3.35	1.16	3.08
CSM-2	6.45	5.67	2.85	2.74	2.10	6.66
CSM-3	6.16	6.25	2.76	2.66	2.15	6.28
CSM-4	6.29	3.45	2.06	3.04	1.23	4.91
CSM-5	6.96	2.95	2.43	3.15	1.14	3.60
RSM-1	6.40	5.76	2.33	2.16	1.07	4.32
RSM-2	5.41	2.55	2.32	1.84	0.91	>10.0
RSM-3	7.25	2.26	3.07	2.44	1.19	4.32
WDL-1	7.18	5.37	3.78	1.92	2.44	4.24
WDL-2	6.37	9.20	3.09	1.56	2.17	4.82
WDL-3	7.37	4.96	3.39	1.71	1.57	4.70
NBM-2a	3.69	6.06	3.02	1.66	3.24	0.03
NBM-4b	7.62	0.93	2.26	3.47	0.25	2.70

[1]Analyses by ALS-Chemex using a four-acid digestion and ICP-MS or ICPAES. Al = aluminum; Ca = calcium; Fe = iron; K = potassium; Mg = magnesium; Na = sodium.

Table 7. Concentrations of platinum (Pt) and palladium (Pd); values in grams per metric ton or parts per million by weight[1].

Sample number	Pt	Pd
AL-1	<0.005	<0.005
AL-2	<0.005	<0.005
AL-3	<0.005	<0.005
CSM-1	<0.005	<0.005
CSM-2	<0.005	<0.005
CSM-3	<0.005	<0.005
CSM-4	<0.005	<0.005
CSM-5	<0.005	<0.005
RSM-1	<0.005	<0.005
RSM-2	<0.005	<0.005
RSM-3	<0.005	<0.005
WDL-1	<0.005	<0.005
WDL-2	<0.005	<0.005
WDL-3	<0.005	<0.005

[1]Analyses by NBMG by FA-GFAA.

Discussion

Gold analyses in Table 3 are listed in concentrations of grams of gold per metric ton of rock (parts per million by weight or ppm). The concentration of economic metals, such as gold, in rock is commonly referred to as grade. Conversion factors are listed below. For gold to be economically extractable, mines in Nevada typically need large quantities of ore with grades that exceed 0.343 grams of gold per metric ton of rock (0.01 troy ounces of gold per short ton of rock) or, if the quantities are not large, higher grades are required. None of the samples collected from these four playas in Nevada exceeds 0.03 grams of gold per metric ton of rock.

In recent years, the price of gold has typically been 50 to 70 times more than the price of silver. In other words, concentrations of silver would have to be at least 50 times higher than the minimum concentrations of gold to have an economically viable silver deposit. That is, silver concentrations would need to be higher than 17 grams of silver per metric ton of rock (0.5 troy ounces of silver per short ton of rock) for a deposit to be considered even marginally economic. None of the samples collected from these four playas in Nevada exceeds 3.0 grams of silver per metric ton of rock.

Platinum and palladium prices vary significantly based on global supply and demand factors. Generally, recent prices have ranged from $500 to $2,000 per troy ounce for platinum and from

$100 to $1,000 per troy ounce for palladium. In other words, when evaluating the economics of platinum and palladium deposits, they can be thought of like gold deposits. Platinum and palladium deposits are rare, and there is only one operating platinum-palladium property in the United States. These deposits are commonly associated with copper and nickel and generally contain only trace amounts of gold. Minerals exploration geologists are generally only interested in occurrences with greater than 1 gram each of platinum and palladium per metric ton of rock. Thus, none of the playa samples analyzed for this report contain platinum or palladium concentrations close to economic levels.

The Alkali Lake playa was previously sampled by the Nevada Bureau of Mines and Geology. Tingley and others (1998) evaluated the lithium potential in and around the Nellis Air Force Range and analyzed samples collected from shallow holes on the surfaces of several playas in the area. They found slightly anomalous gold concentrations (0.021 and 0.024 grams of Au per metric ton) in two samples from Alkali Lake. Other playa samples in that study had concentrations from 0.002 to 0.009 grams of gold per metric ton, values that are more typical of average rocks (Table 8). The two samples from Alkali Lake also contained concentrations of some pathfinder elements for gold deposits (Ag, Bi, Sb, and Te) in concentrations that are slightly higher than those in other playa deposits, but none of the values approaches economic concentrations. Similarly, the three samples collected from Alkali Lake in this study contain higher gold concentrations than the samples from other playas, but the concentrations are not economically significant.

Table 8. Concentrations of gold and silver in typical rocks that are not mineralized[1].

Rock type	Au	Ag
Ultramafic igneous rocks	0.0032	0.06
Mafic igneous rocks	0.0032	0.1
Granitic igneous rocks	0.0023	0.037
Limestone	0.005	0.1
Sandstone	0.005	0.25
Shale	0.004	0.19

[1] Data from Rose and others (1979).

Conversion Factors

1 gram per metric ton = 1,000 parts per billion by weight (1,000 ppb) = 1 part per million by weight (1 ppm) = 0.029167 troy ounces per short ton.

1 troy ounce per short ton = 34.2857 grams per metric ton = 34.2857 ppm.

1 troy ounce = 31.103486 grams.

1 metric ton = 1.1023 short tons = 2,204.6 pounds = 32,150.737 troy ounces.

References

Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979, Geochemistry in mineral exploration, Second Edition: Academic Press, New York, 657 p.

Tingley, J.V., Castor, S.B., Weiss, S.I., Garside, L.J., Price, J.G., LaPointe, D.D., Bonham, H.F., Jr., and Lugaski, T.P., 1998, Mineral and energy resource assessment of the Nellis Air Force Range: Nevada Bureau of Mines and Geology Open-File Report 98-1, 735 p.

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Disclaimer

The information in this report should be considered preliminary. It has not been thoroughly edited or peer reviewed.

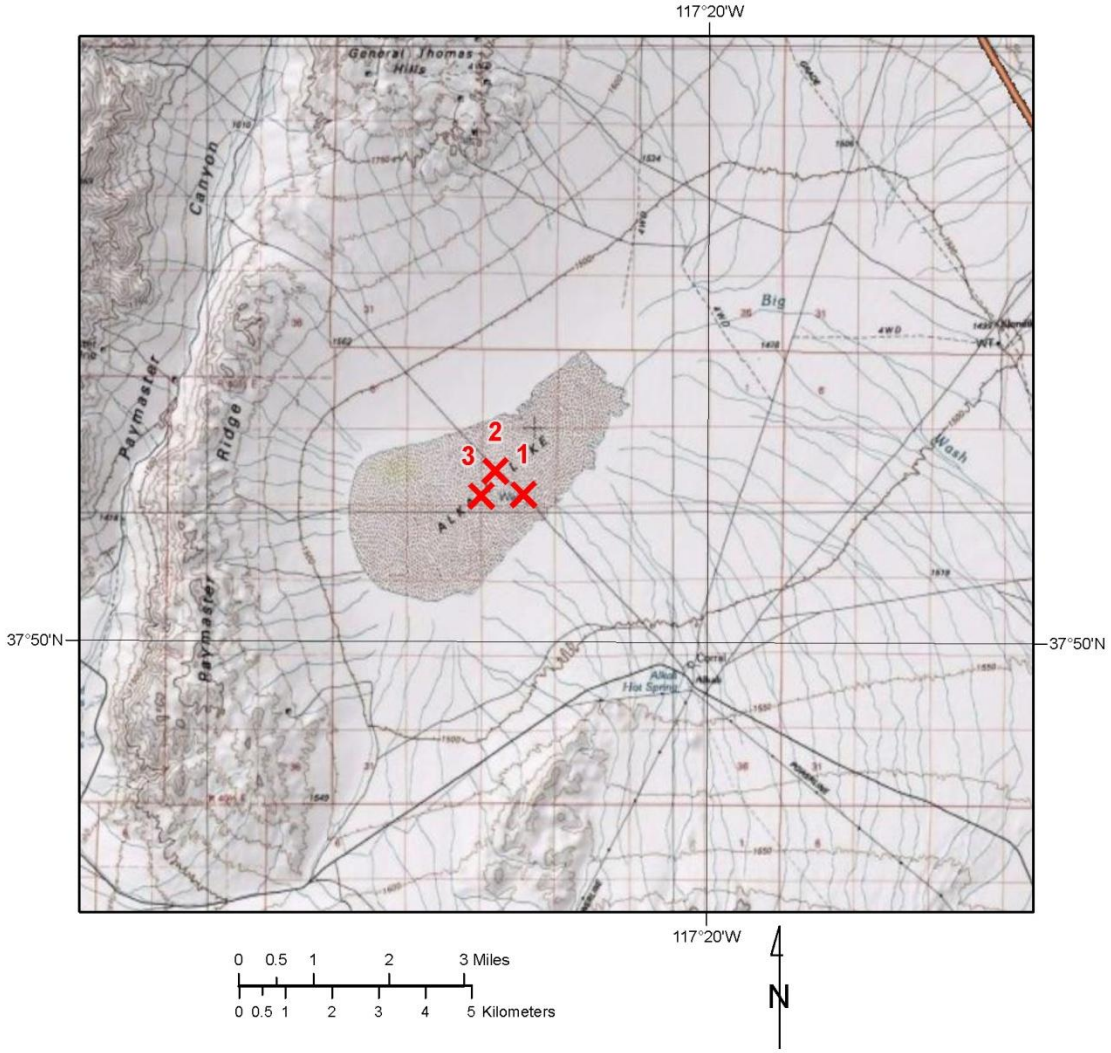

Figure 1. Sample locations at Alkali Lake, plotted on the 1:100,000-scale base map of the U.S. Geological Survey, Goldfield quadrangle.

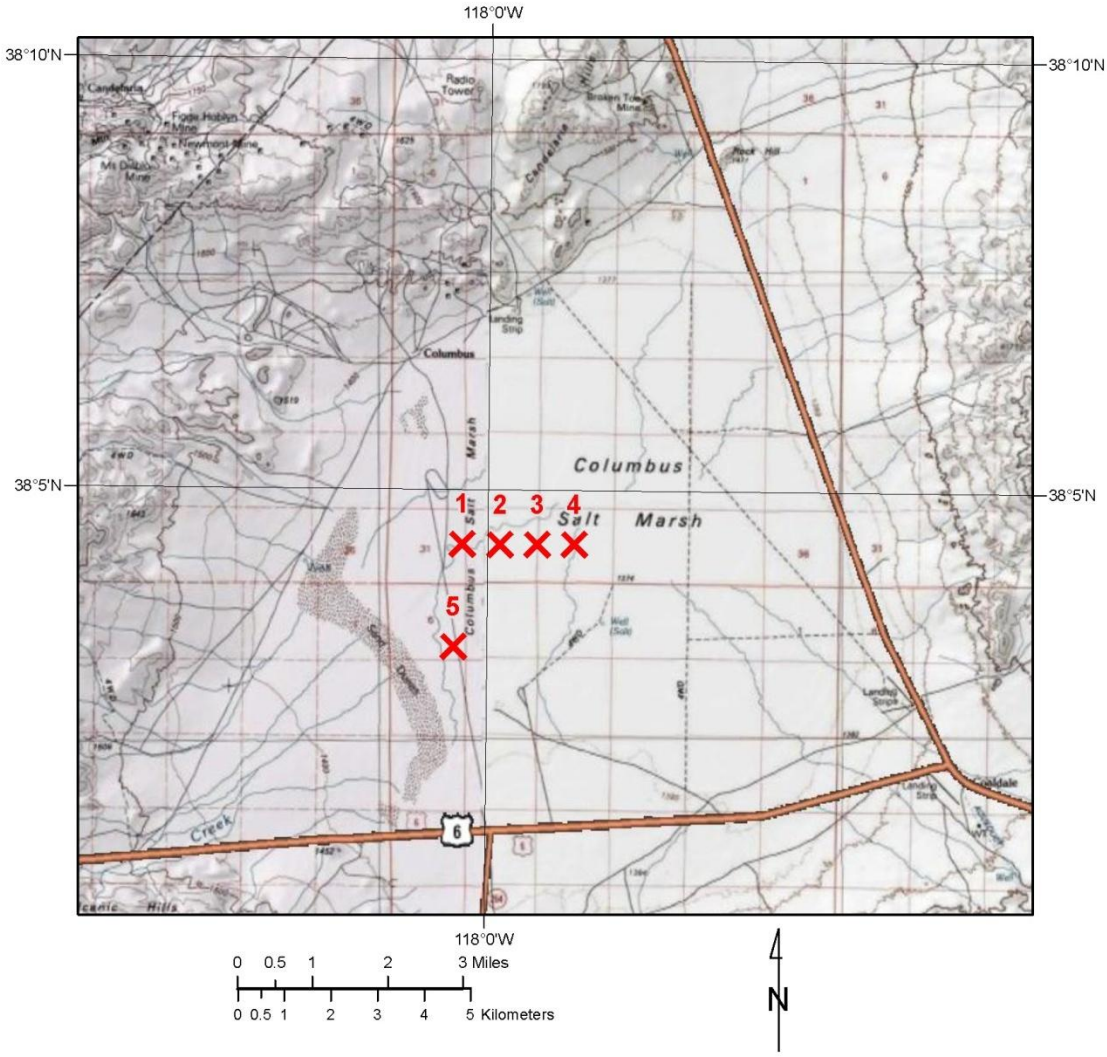

Figure 2. Sample locations at Columbus Salt Marsh, plotted on the 1:100,000-scale base map of the U.S. Geological Survey, Excelsior Mountains and Tonopah quadrangles.

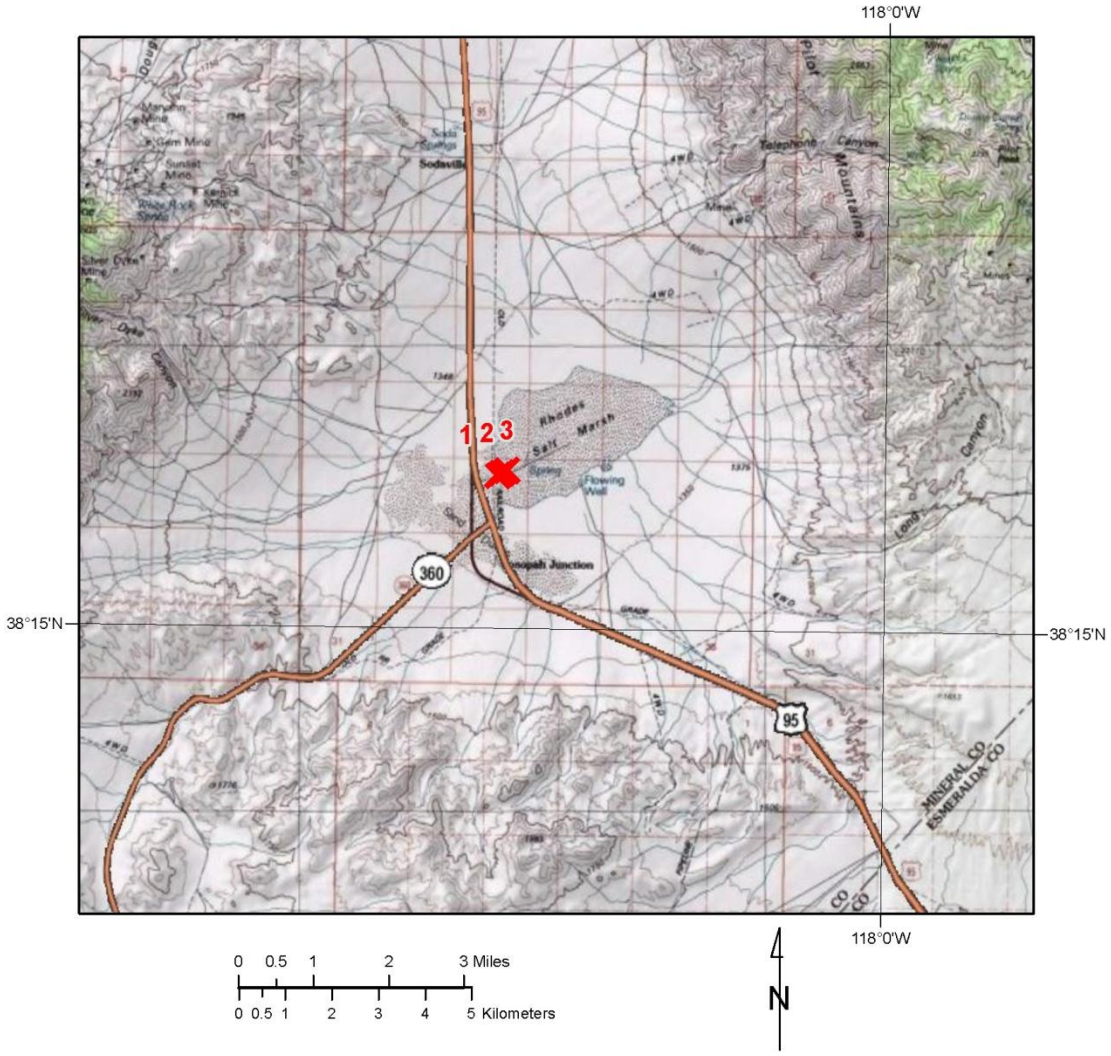

Figure 3. Sample locations at Rhodes Salt Marsh, plotted on the 1:100,000-scale base map of the U.S. Geological Survey, Excelsior Mountains quadrangle.

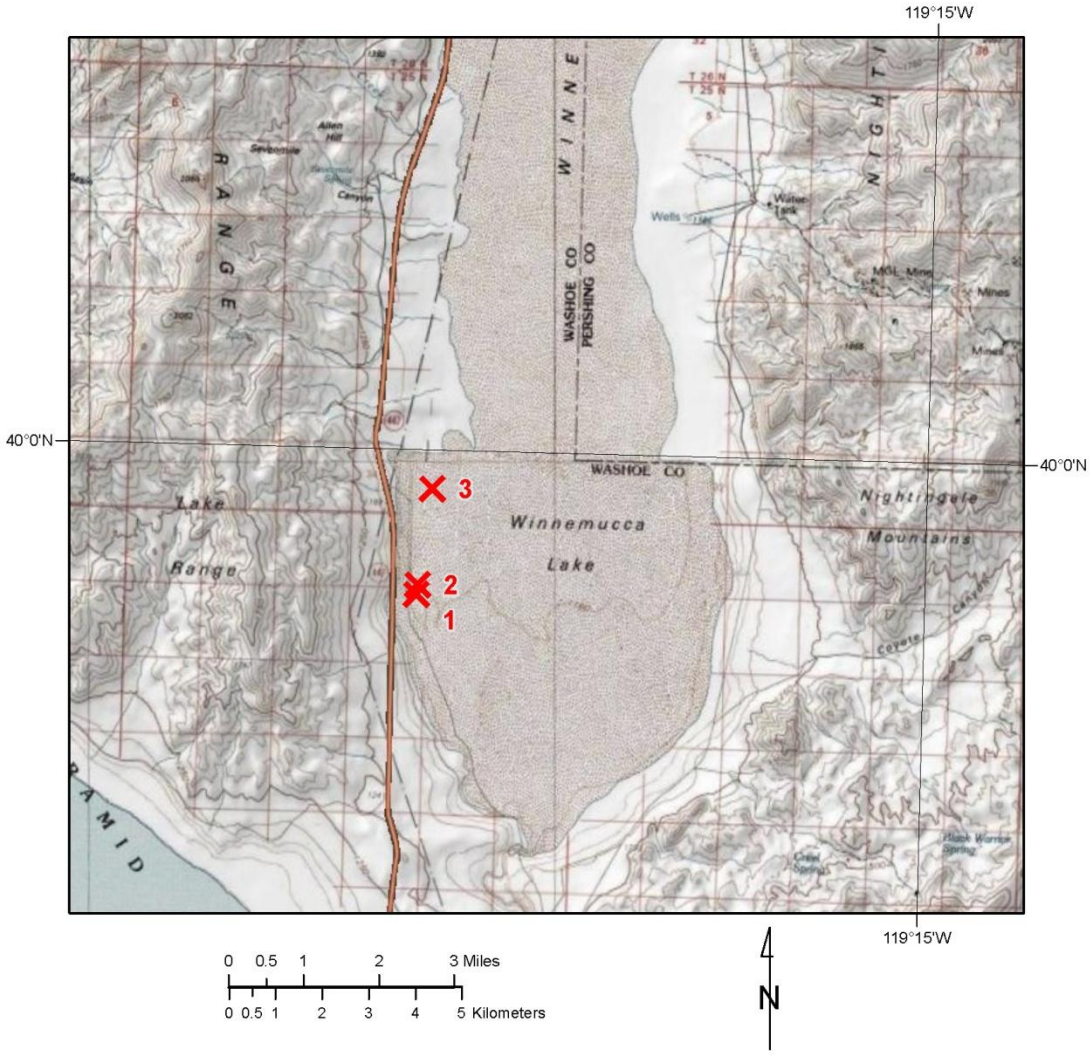

Figure 4. Sample locations at Winnemucca Dry Lake, plotted on the 1:100,000-scale base map of the U.S. Geological Survey, Reno and Kumiva Peak quadrangles.

Appendix - Photographs of Sample Sites

Sample AL-1

Figure 5a. Sample location AL-1.

Figure 5b. Looking southwest from sample location AL-1.

Figure 5c. Looking northeast from sample location AL-1, at Hasbrouck Peak left of center.

Sample AL-2

Figure 6a. Sample location AL-2.

Figure 6b. Looking south from sample location AL-2, at the Montezuma Range.

Figure 6c. Refilling the sample hole, looking northwest from sample location AL-2, at the Weepah Hills.

Sample AL-3

Figure 7a. Sample location AL-3, taking channel sample from the wall of the hole dug to a depth of 44 cm.

Figure 7b. Looking southeast from sample location AL-3.

Figure 7c. Looking north-northwest from sample location AL-3, with hole refilled.

Sample CSM-1

Figure 8a. Sample location CSM-1, showing channels on the side of the 46-cm-deep hole from which the sample was collected. The channel sample did not include the salt-encrusted upper 10 cm of sediment but did include the moist, brown sediment below the salt crust.

Figure 8b. Looking southwest from sample location CSM-1, at Boundary Peak and the White Mountains.

Figure 8c. Looking west from sample location CSM-1, at Miller Mountain, with hole refilled after sampling.

Sample CSM-2

Figure 9a. Sample location CSM-2, with channels, below salt crust, in greenish sediment.

Figure 9b. Looking north from sample location CSM-2.

Figure 9c. Looking southeast from sample location CSM-2, at the Monte Cristo Range.

Sample CSM-3

Figure 10a. Sample location CSM-3.

Figure 10b. Looking northwest from sample location CSM-3, at the Candelaria Hills.

Figure 10c. Looking east from sample location CSM-3, at the Monte Cristo Range.

Sample CSM-4

Figure 11a. Sample location CSM-4.

Figure 11b. Looking south from sample location CSM-4.

Figure 11c. Looking southwest, refilling hole at sample location CSM-4, with Boundary Peak in the background.

Sample CSM-5

Figure 12a. Sample location CSM-5.

Figure 12b. Looking north from sample location CSM-5, at the Candelaria Hills.

Figure 12c. Looking southwest from sample location CSM-5, at Boundary Peak.

Sample RSM-1

Figure 13a. Sample location RSM-1.

Figure 13b. Looking east from sample location RSM-1, at the Pilot Mountains.

Figure 13c. Looking southwest from sample location RSM-1.

Sample RSM-2

Figure 14a. Sample location RSM-2.

Figure 14b. Looking north from sample location RSM-2.

Figure 14c. Looking east from sample location RSM-2.

Sample RSM-3

Figure 15a. Sample location RSM-3.

Figure 15b. Looking northwest from sample location RSM-3.

Figure 15c. Looking east from sample location RSM-3.

Sample WDL-1

Figure 16a. Sample location WDL-1.

Figure 16b. Refilling hole for sample WDL-1.

Figure 16c. Looking west from sample location WDL-1, at the Lake Range.

Sample WDL-2

Figure 17a. Taking channel samples from wall of hole dug at sample location WDL-2.

Figure 17b. Looking northwest from sample location WDL-2, at the Lake Range.

Figure 17c. Looking southwest from sample location WDL-2, at the Lake Range.

Sample WDL-3

Figure 18a. Sample location WDL-3.

Figure 18b. Digging hole for sample WDL-3, looking southeast at the Nightingale Mountains.

Figure 18c. Sample WDL-3, with channels on the wall of the hole dug to a depth of 45 cm.