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PRELIMINARY RESULTS OF WATER-QUALITY INVESTIGATIONS IN THE MENDENHALL PENINSULA AND AUKE BAY AREA, JUNEAU, ALASKA

by
Roman J. Motyka

STATE OF ALASKA
Department of Natural Resources
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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PRELIMINARY RESULTS OF WATER-QUALITY INVESTIGATIONS IN THE MENDENHALL PENINSULA AND AUKE BAY AREA, JUNEAU, ALASKA

by
Roman J. Motyka[1]

INTRODUCTION

Background

This water-quality study, initiated in the winter of 1984, is part of a DGGS investigation of ground water in the Mendenhall Peninsula-Auke Bay (MHP-AB) area and covers sec. 23 and 35, T. 40 S., R. 65 E., Copper River Meridian. The impetus for the investigation was a request from the Alaska Division of Land and Water Management for data on suspected saltwater contamination of ground water in the MHP-AB area.

The study was also required to help adjudicate ground-water use applications for two proposed major developments in the area: a housing complex on Fritz Cove Road, and an expansion of the Auke Bay small boat harbor facility. Both developments have the potential for drawing relatively large volumes of ground water from fractured bedrock aquifers and increasing the risk of saltwater intrusion. Property owners in the vicinity of the proposed developments have voiced concern over the potential impact of increased ground water use on the yield and water quality of nearby wells.

Aquifers in the MHP-AB area are entirely within bedrock, mainly fractured greenstones, greenschists, and pelitic rocks. Well depths are commonly about 200 ft, and yields are low, typically l-4 gpm. Ground water tends to be relatively high in dissolved solids (up to 4,000 ppm). Several homeowners, particularly those near beachfronts, have reported deterioration of water quality over the past several years, apparently from saltwater intrusion of the aquifers.

This water geochemistry study was designed as a reconnaissance effort with four goals: 1) to distinguish and classify ground water from various aquifers; 2) to determine sources of waters that recharge those aquifers; 3) to identify areas of greatest contamination; and (4) to establish baseline data from which any contamination from future development of the area may be defined and monitored,

Previous Studies

A study of water resources by Barnwell and Boning (1968) concentrated primarily on the Mendenhall Valley but also included some data on the MHP-AB area. Barnwell and Boning (1968) reported salt or brackish water occurrences in deep wells in the central part of the valley and suggested that some of the saltwater may be connate or may have been trapped during deposition of valley-filling sediments. The single water analysis they reported for the

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MHP-AB area is from a well near the University of Alaska, Juneau (UAJ). Water from the 120-ft well was Na-Ca-Mg bicarbonate with no apparent sulfate or chloride contamination. Barnwell and Boning (1968) also reported yields from <1 gpm to 20 gpm, at an average of 3 gpm, based on samples of 46 wells which tap bedrock aquifers.

A more recent study of water quality in the MHP-AB area was undertaken by G. Balding (1978) of the U.S. Geological Survey. Balding's results are based on area residents' responses to a questionnaire and on specific conductance measurements from waters in selected wells. The data indicated that saltwater intrusion was prevalent in 1979.

The Alaska Department of Environmental Conservation has measured water quality and arsenic concentrations in some well waters in the MHP-AB area. These data have not been published but are on public file.

GEOLOGIC SETTING

Bedrock

Bedrock in the MHP-AB area consists of Tertiary and Cretaceous greenstones, greenschists, metaconglomerates, pelitic rocks, metasandstones, and metasiltstones (Ford and Brew, 1973) (fig. 1). The units are part of a southwest-trending belt of metamorphic rocks in which metamorphic grade increases to the northwest. The boundary between the greenschist and prehnite-pumpellyite metagraywacke facies is located just northwest of the MHP-AB area.

Bedrock west of Mendenhall Peninsula is chiefly augite-rich metatuff (originally basaltic and andesitic), sometimes mixed with either metagraywacke, argillite, or slate. To the east, bedrock is dark volcanic-derived metasedimentary rock (Ford and Brew, 1973). Bedrock exposed in the Auke Bay area is mostly argillite and slate.

Two sets of joint patterns occur in the MHP-AB area. The first set trends about 45" NE with dips ranging from 72° SW to near vertical. The second set trends north-south with near vertical dip. Major faults in the area--the Gastineau Channel, Fish Creek, and Peterson Creek faults--all trend northwest (fig. 2).

Surficial Deposits

Surficial deposits in the MHP-AB area consist primarily of the Gastineau Channel Formation, a composite glacial-marine deposit (Miller, 1973; 1975) that occurs throughout the Gastineau Channel region. Exposures in the MHP-AB area (fig. 2) are predominately the youngest of Miller's three facies: a light-gray to greenish-gray, massive to soft, sandy diamicton that contains unbroken and articulated mollusk shells and foraminifera. Miller reported radiocarbon ages ranging from 9,700 to 10,700 yr BP and thicknesses ranging from 4 to 12 ft for the youngest facies. Deposits in the Gastineau Channel region locally overlie bedrock and normally overlie deposits of the oldest facies.

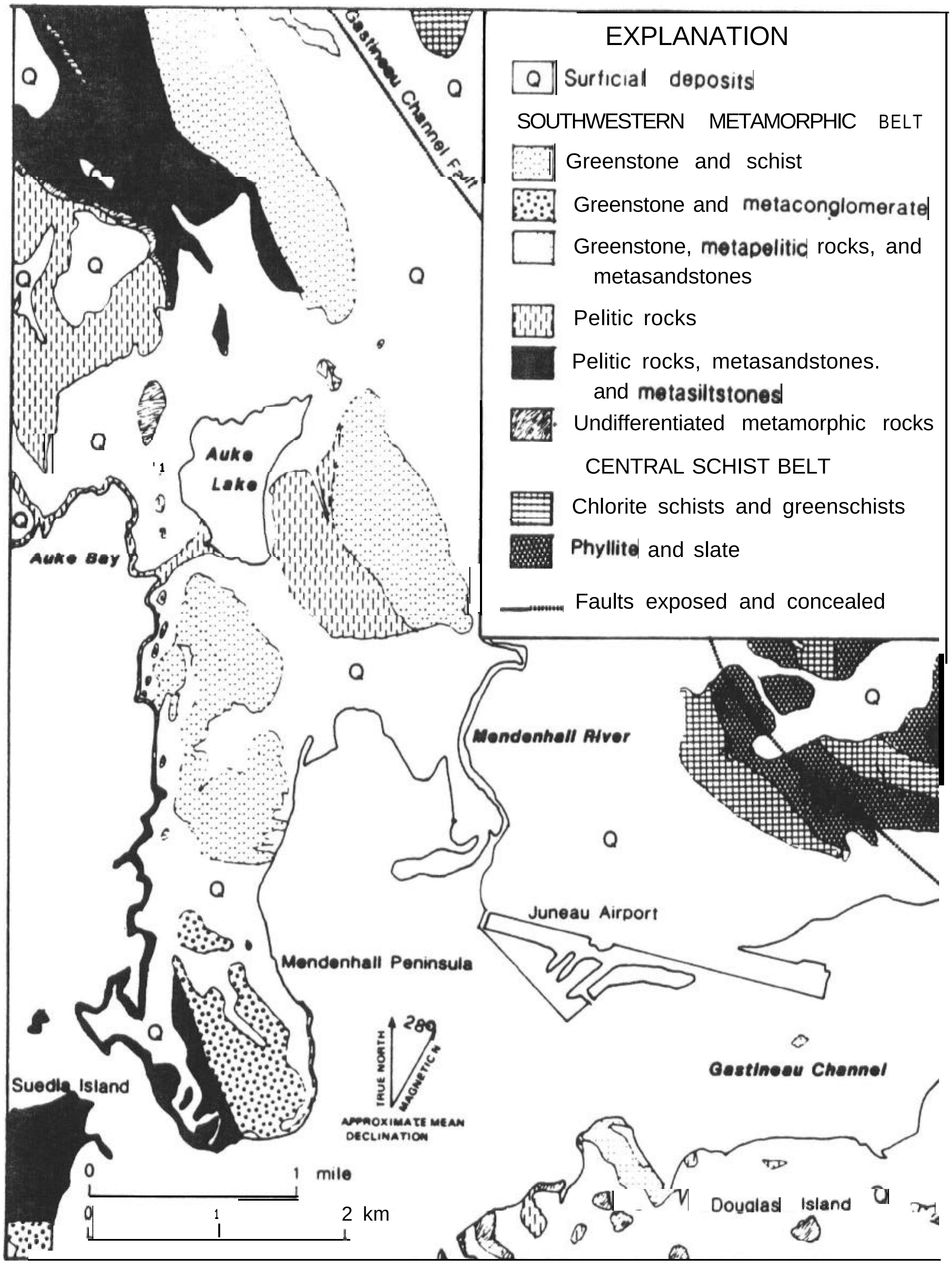

Figure 1. Bedrock geology of the Mendenhall Peninsula and Auke Bay area, Alaska. From Ford and Brew, 1973.

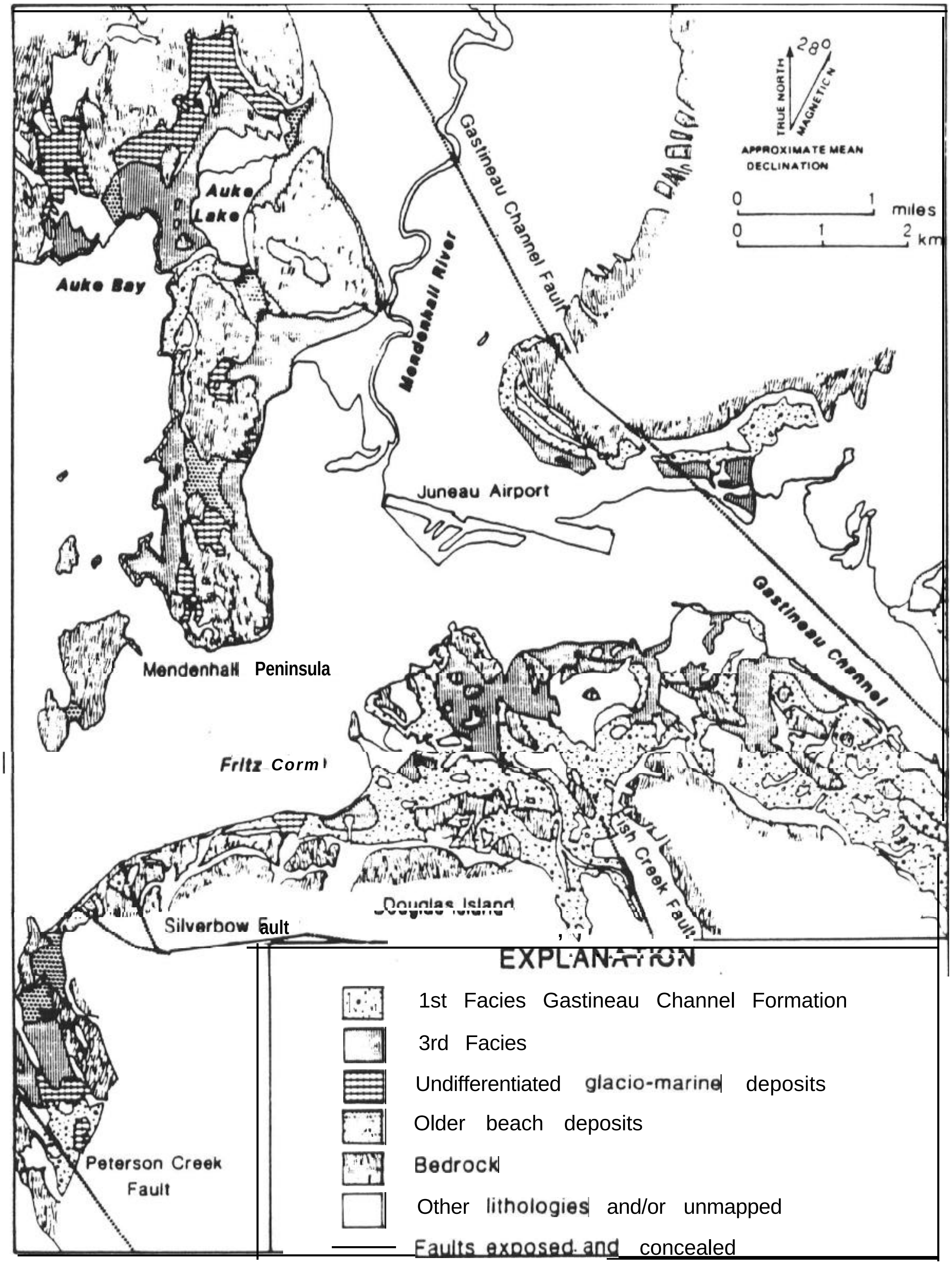

Figure 2. Surficial deposits of the Mendenhall Peninsula and Auke Bay area, Alaska. From Miller, 1975.

The oldest facies, which is exposed at the northwest end of the Mendenhall Peninsula, consists of gray to light-gray to greenish-gray generally hard, dense, till-like, stony diamicton rich in mollusks and foraminifera (Miller, 1975). This facies overlies bedrock in most places in the Gastineau Channel region and ranges in thickness from 20 to >60 ft.

Other surficial deposits in the MBP-AB area include raised-beach deposits, rubble, and fan deposits.

METHODS OF STUDY

Field Sampling

Locations of wells in the MHP-AB area and of sites for which chloride concentrations were measured during this study are shown on sheet 1. Time and funding limitations restricted the geochemical studies to sections 23 and 35, sections deemed most critical because of proposed developments. Whenever possible, static water level measurements accompany geochemical data. Some wells with static water level measurements were not sampled.

Waters from 18 well sites were sampled, filtered, and treated for full cation and anion geochemical analysis (table 1). Alkalinity and pH on these waters were measured in the field or shortly thereafter. Raw, unfiltered samples were obtained from 10 additional well sites. Alkalinity and pH values were not measured on these 10 samples, but five were analyzed for major cations and anions (except HCO_3). The remaining five were analyzed for SO_4, Cl, F, and Br only. One site was checked for Cl only.

A cold-water stream located on the southeast part of Mendenhall Peninsula was sampled, and a complete cation-anion analysis was performed to provide a comparison with ground water.

Waters from 25 different sites, including five streams and springs, were sampled and analyzed for deuterium. Analyses of $\delta^{18}O$ were made for 13 of these sites.

Wells were normally sampled after water was first run for about 5-10 min at a rate of about 0.5-l gpm. The sample was normally taken as close to wellhead as possible and always before any treatment or water softening system.

Methods of Analyses

Alkalinity as bicarbonate, pH, specific conductance, and ammonia were determined in the field using methods described in Presser and Barnes (1974). The remaining constituents were analyzed at the DGGS water laboratory in Fairbanks. Major and minor cation concentrations were determined using a Perkin-Elmer atomic absorption spectrometer. Sulfate and bromide were determined on a Dionex ion chromatograph. Fluoride was determined using the specific ion electrode method. Chlorides were analyzed by Mohr titration and boron, by carminic acid method. Aluminum, arsenic, and iron were determined by atomic absorption spectroscopy. A graphite furnace was used for arsenic

TABLE I. PRELIMINARY GEOCHEMICAL ANALYSES GROUPED BY LOCATION, AUKE BAY-MENDENHALL PENINSULA, ALASKA,

Location (Site no.)	Date sampled	Area	Well depth (ft)	T (°C)	pH[a]	Cations (ppm) Na	K	Ca	Mg	Li	Sr	Anions (ppm) CO_3	HCO_3[a]	SO_4	Cl	F	Br	Other (ppm) SiO_2	Fe	B	NH_4	NO_3	As (ppb)	TDS[d]	SC[e]	Stable isotopes (per mil) $\delta^{18}O$	δD
Olson (23-24)	b-16-84	1	275	7	1.1	352	1.7	26.8	9.2	0.00	3.5	••	143	788	90	2.7	bd[b]	6.6	0.00	--	--	tr	4	1,364	1,600	••	-98
UAJ (23-14)	b-lb-84	1	227	11	0.4	299	9.1	20.4	19.3	0.06	1.4	1.5	269	396	166	0.3	tr[c]	15.0	0.20	--	--	bd	9	1,070	1,450	••	-96
Bay View (23-01A)	b-14-84	1	so	10	7.3	440	20.1	147.0	103.0	0.11	7.2	--	241	292	944	0.3	tr	12.5	0.22	<0.50	--	0.5	1	2,086	2,boo	••	-94
UREA (23-28)	b-14-84	2	73	7	0.4	139	a.5	5.2	2.9	0.02	0.3	2.5	345	15	8	a.7	bd	8.2	0.10	<0.50	--	0.3	2	362	460	••	-97
Jones (23-05)	b-19-84	2	145	7	7.7	93	6.5	29.3	11.8	0.01	0.5	••	286	39	53	0.1	bd	14.0	1.06	<0.50	--	bd	4	390	450	••	-100
Dehardt (23-08)	b-14-04	2	290	12	7.5	179	6.1	29.3	15.5	0.05	2.2	••	277	235	78	1.9	bd	9.0	0.12	<0.50	--	0.1	3	696	790	••	-98
Auke Bay (23-23)	6-19-84	2	202	10	0.0	230	4.9	29.3	9.7	0.07	2.4	••	328	262	80	2.8	bd	7.8	0.04	0.60	--	tr	1	792	1,000	••	-90
Trambitas (23-31)	b-19-84	3	109	9	7.7	18	2.6	31.5	10.5	0.01	0.6	—	204	10	2	<0.1	bd	10.8	0.23	0.60	--	bd	263	449	220	••	-93
Coates (23-41)	b-20-84	3	••	8	7.5	29	4.1	37.5	19.2	0.02	0.8	—	260	35	10	<0.1	bd	15.0	0.69	<0.50	--	tr	76	357	310	••	-9s
Auke Creek (23-44)	6-15-84	4	—	14	--	--	--	••	--	--	••	--	••	••	—	--	••	—	--	—	--	--	••	••	21	••	-96
Bay Creek (23-45)	6-15-84	4	--	9	--	--	--	--	••	••	••	••	••	--	--	--	--	••	—	—	--	--	--	••	44	••	-96
Lake Creek (23-46)	b-15-04	4	—	9	--	--	••	--	--	--	••	—	••	--	••	--	--	--	--	••	--	--	••	••	21	••	-99
Karenin (35-13)	3-13-84	1	85	5	9.3	199	3.0	1.4	1.2	0.01	0.1	28.0	506	35	4	1.2	td	6.2	0.18	0.83	--	bd	2	504	600	-13.4	-96
Thomason (35-24)	1-13-85	1	216	5	8.7	154	0.4	1.5	1.1	0.02	0.2	6.0	346	57	4	0.7	bd	7.5	0.12	co.50	--	bd	1	403	410	-13.3	-95
Houlihan (35-15)	3-22-84	1	260	5	--	276	0.0	2.7	2.5	0.02	••	--	••	345	24	1.0	bd	7.3	--	.80	--	bd	2	662	775	••	--
Hursch (35-10)	3-14-84	2	200	7	7.0	40	0.9	31.5	1.2	0.01	0.3	••	210	19	2	<0.1	bd	10.5	0.23	Co.50	--	bd	14	223	215	-13.0	-95
Watts (35-28)	2-02-84	2	200	7	••	04	1.6	19.0	6.5	0.01	••	••	••	22	2	0.1	bd	12.7	--	Co.50	--	bd	4	153	320	••	--
Glasby (35-05)	3-04-84	2	150	14	0.9	105	0.4	2.11	1.7	0.02	0.5	6.0	283	109	40	0.0	bd	7.7	0.1s	co.50	--	bd	1	495	590	-12.6	-93
Lamonica (35-53)	5-02-84	2	200	9	7.3	17	4.6	166.0	17.0	0.04	1.3	••	334	62	153	<0.1	bd	16.0	1.02	<0.50	--	bd	<1	601	760	-12.7	-95
Meilke (35-38)	2-01-84	2	220	9	••	277	2.5	4.2	2.6	0.03	--	••	••	214	157	0.6	bd	10.0	--	0.50	--	tr	2	671	900	--	••
Nash (35-48)	S-03-84	3	80	6	--	—	••	--	--	--	••	••	••	12	2	0.0	bd	••	--	••	--	tr	--	14	450	-13.3	-96
Buckley (35-12)	S-20-84	3	87	6	--	••	••	--	—	••	••	••	--	73	4	0.3	bd	••	--	••	--	bd	••	77	420	--	••
Mc Vey (35-39)	3-22-84	3	89	12	7.2	40	7.1	140.0	33.4	0.06	1.5	--	410	295	9	0.4	bd	26.0	1.28	co.50	0.4	bd	3	754	790	-13.0	-98
Cummings (35-09)	2-07-84	3	212	6	--	171	1.2	16.2	0.5	0.02	••	—	--	9	13	0.4	bd	19.0	--	co.50	--	bd	46	284	470	--	••
Johnson (35-52)	S-02-84	3	475	9	--	—	--	--	—	--	••	—	--	34	17	0.1	bd	—	••	<0.50	--	tr	--	--	420	--	--
Bradley (35-03)	3-14-84	3	95	8	7.9	90	5.0	24.0	14.0	0.03	1.3	••	334	57	22	0.2	bd	13.3	0.00	<0.50	--	bd	24	400	430	-12.6	-95
Argetsinger (35-02)	2-01-84	3	115	,	--	132	24.0	211.0	92.0	0.09	--	••	--	85	632	a.2	tr	10.0	0.09	<0.50	--	tr	7	1.201	1,650	--	••
Keithahn (35-32)	2-01-84	3	92	9	--	••	--	••	—	—	--	••	--	••	1,000	••	--	••	--	••	--	••	--	..	2,500	••	••
Hagerup (35-08)	S-02-84	3	129	8	--	••	--	--	••	--	--	••	--	21s	1.720	0.2	tr	••	••	—	--	tr	--	1,935	4,500	-12.5	-90
Ramsey (35-20)	3-22-84	4	202	7	6.7	13	0.5	35.8	6.5	0.01	0.3	••	lb7	2	2	<0.1	bd	13.7	1.12	<0.50	--	bd	7	155	175	-12.4	-91
Lundstrom (35-33)	S-02-84	4	••	10	--	••	--	--	—	••	••	—	--	3	9	0.1	bd	••	--	—	--	tr	--	12	320	--	--
Palmer (35-43)	S-03-84	4	93	7	7.5	44	2.7	47.0	25.8	0.02	0.0	--	324	9	44	<0.1	bd	24.0	0.62	--	--	tr	9	366	400	-13.5	-96
Beaver Spring* (35-55)	5-03-84	5	—	4	--	••	••	--	--	••	—	••	--	••	••	--	--	—	••	••	--	--	--	--	32	-12.3	-92
Mendenhall 1390 (35-54)	5-03-84	5	••	5	5.4	1	Q.5	3.5	<1.0	< 0.01	<0.01		7		1	<0.1	bd	5.6	1.14	<0.50		bd	<1	17	15	-13.1	-94

[a]Measured at well-water temperature.
[b]bd = below detection.
[c]tr = trace.
[d]TDS = total disolved solids.
= no data.

determinations to enhance low-level detection. Silica concentrations were determined by the molybdate blue method. Stable isotopes were analyzed at the Stable Isotope Laboratory at Southern Methodist University, Dallas, Texas.

RESULTS

Geochemical analyses results are grouped by location in table 1, and by proposed water types in table 2. Major cation and anion composition percentages of waters for which full analyses were run are plotted on a Piper diagram (fig. 3). The milliequivalent concentrations for all major constituents except HCO_3 are also plotted. HCO_3 concentrations were estimated by comparing cation-anion milliequivalent balances. The additional milliequivalent anions required to balance cation totals were assumed to be HCO_3. For comparison, the percentage composition of seawater is plotted on the Piper diagram.

Based on relative and absolute cation-anion composition, three water types were distinguished (fig. 3, table 2). Type 1 waters are high pH, sodium-bicarbonate-rich waters, with relatively low concentrations of Ca and Mg and varying amounts of Cl. The increases in Cl, and possibly some SO_4, are presumably caused by varying degrees of saltwater contamination. The waters tended to have comparatively low concentrations of As, Fe, and Sr. Type 1 waters were located exclusively in section 35 and approximately southwest of a line running through sites 35-38 and 35-13.

Type 2 waters were found in section 23 and have concentrations of Na and HCO_3 similar to type 1 waters, with significantly greater concentrations of K, Ca, and Mg. Type 2 waters also tend to have lower pH and greater concentrations of Sr, and sometimes Fe, than type 1 waters. The higher Cl concentrations of all type 2 waters sampled (except sites 23-28 and perhaps 23-05) suggest some degree of saltwater contamination. The most contaminated well, site 23-01A (Cl = 950 ppm), lies close to the Auke Bay beachfront and is the primary water supply for an apartment complex. Two sites with slightly elevated levels of Cl, 23-14 and 23-05, are located 1,500 ft from the beachfront. This suggests that saltwater intrusion from Auke Bay may not be the source of Cl contamination in the aquifers supplying these wells. Site 23-24 had an SO_4 concentration (790 ppm) significantly higher than any other site in the MHP-AB area. Type 2 waters were low in As and, except for site 23-05, low in Fe.

Type 3 waters are distinguished by proportionately greater concentrations of Ca and Mg and lower pH than either type 1 or type 2 waters, and also tend to have higher concentrations of Fe or As, or both. Type 3 waters were rich in HCO_3 and, with the exception of site 35-39, were comparatively low in SO_4. Two type 3 samples on which full analyses were performed showed significant Cl contamination. Two other samples, probably type 3, on which only partial analyses were made (sites 35-32 and 35-08) also had high concentrations of Cl. All four sites are located near shorelines along the west side of the Mendenhall Peninsula.

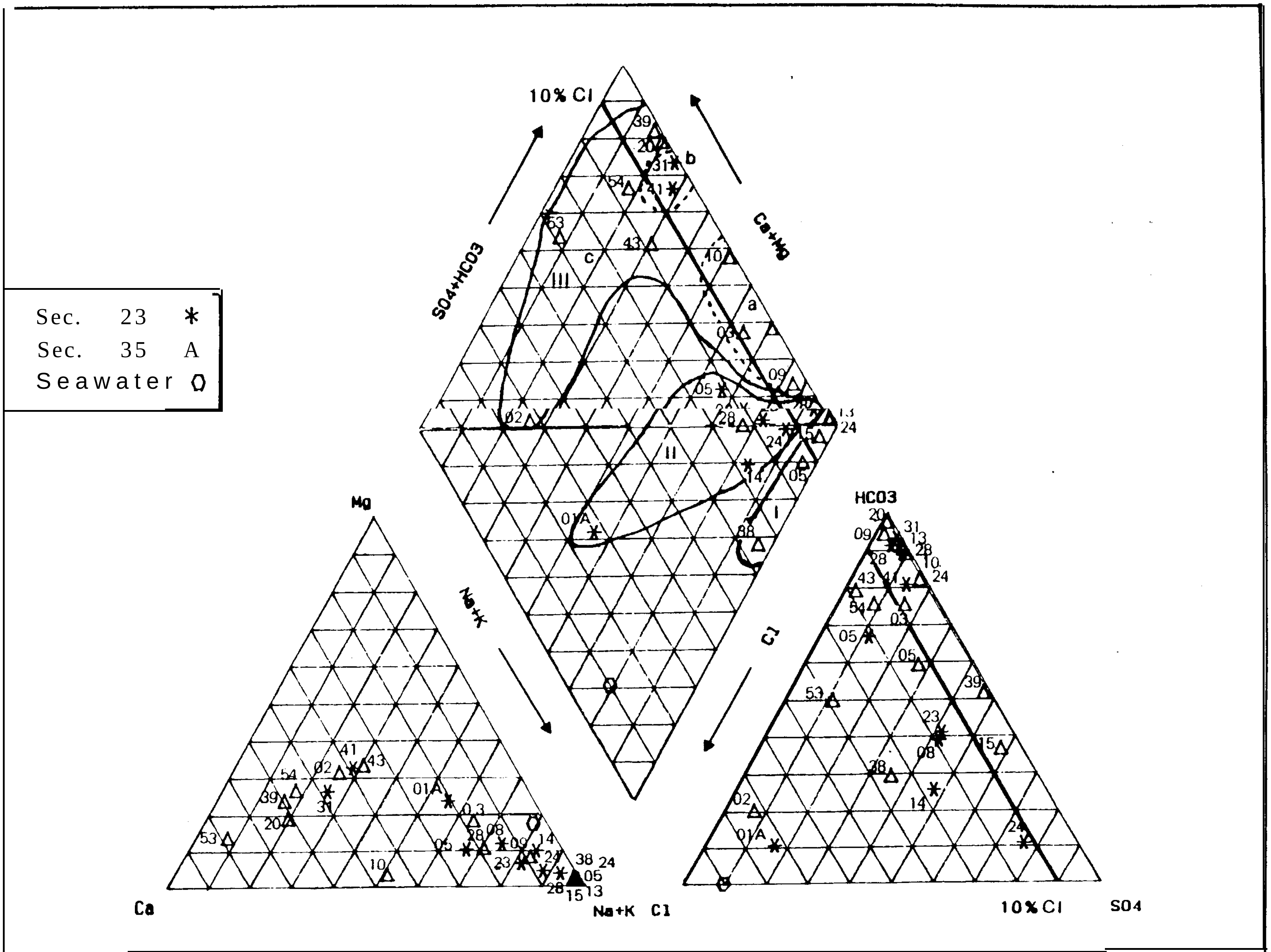

Figure 3. Piper diagram for water samples from Auke Bay (section 23) and Mendenhall Peninsula (section 35).

TABLE 2. PRELIMINARY GEOCHEMICAL ANALYSES GROUPED BY WATER TYPE, AUKE BAY-MENDENHALL PENINSULA, ALASKA.

Location (Site no.)	Data sampled	Water Type	Well depth (ft)	T (°C)	pH[a]	Cations (ppm)						Anions (ppm)						Other (ppm)					As (ppb)	TDS[d]	SC[a]	Stable isotopes (per mil)	
						Na	K	Ca	Mg	Li	Sr	CO_3	HCO_3[a]	SO_4	Cl	F	Br	SiO_2	Fe	B	NH_4	NO_3				$\delta^{18}O$	δD
Thomason (35-24)	3-13-84	1	216	5	a.7	154	0.4	1.5	1.1	0.02	0.2	6.0	346	57	4	0.7	bd[b]	7.5	0.12	<0.50	--	bd	1	403	410	-13.3	-95
Karenin (35-13)	3-13-84	1	85	5	9.3	199	3.8	1.4	1.2	0.01	0.1	28.0	506	35	4	1.2	bd	6.2	0.11	0.83	--	bd	2	504	600	-13.4	-96
Houlihan (35-15)	3-22-84	1	260	5	--	276	0.8	2.7	2.5	0.02	--	--	--	345	24	1.0	bd	7.3	--	0.80	--	bd	2	662	775	--	--
Clasby (35-05)	3-04-84	1	150	14	8.9	185	0.4	2.1	1.7	0.02	0.5	6.0	283	109	40	0.8	bd	7.7	0.15	<0.50	--	bd	1	495	590	-12.6	-93
Meilke (35-38)	2-01-84	1	220	9	--	277	2.5	4.2	2.6	0.03	--	--	--	214	157	0.6	bd	10.8	--	0.50	--	tr	2	671	S W	--	--
CHEA (23-28)	6-14-84	2	73	7	8.4	139	6.5	5.2	2.9	0.02	0.3	2.5	345	15	8	0.7	td	8.2	0.10	co.50	--	0.3	2	362	460	--	-97
Olson (23-24)	6-16-84	2	275	7	8.1	352	2.7	26.8	9.2	0.08	3.5	--	143	788	98	2.1	bd	6.6	0.01	--	--	tr	4	1,364	1,600	--	-98
Dehardt (23-08)	S-14-84	2	290	12	7.5	179	6.1	29.3	15.5	0.05	2.2	--	277	235	78	1.3	bd	9.0	0.12	<0.50	--	0.1	3	696	790	--	-98
Auke Bay (23-23)	h-19-84	2	202	10	8.0	230	4.9	29.3	9.7	0.07	2.4	--	238	262	80	2.8	bd	7.1	0.04	0.60	--	tr	1	792	1,000	--	-98
UAJ (23-14)	6-16-84	2	227	11	8.4	299	9.1	20.4	19.3	0.06	1.4	1.5	269	3 %	166	0.3	tr[c]	15.0	0.20	--	--	bd	9	1.070	1,450	--	-96
Jones (23-05)	6-19-84	2	145	7	7.7	93	6.5	29.3	8.0	0.01	0.5	--	286	39	53	0.1	bd	14.0	1.08	41.50	--	bd	4	390	450	--	-100
Bay View (23-01A)	6-14-84	2	90	10	7.3	440	20.1	147.0	103.0	0.11	7.2	--	241	292	944	0.3	tr	12.5	0.22	<0.50	--	0.5	1	2,086	2,600	--	-94
Hursch (35-10)	3-14-84	3a	200	7	7.0	40	0.9	31.5	1.2	0.01	0.3	--	210	19	2	<0.1	bd	10.5	0.23	<0.50	--	bd	14	223	215	-13.0	-95
Bradley (35-03)	3-14-84	3a	9s	8	7.9	SE	5.0	24.0	14.1	0.03	1.3	--	334	57	22	0.2	bd	13.3	0.08	<0.50	--	bd	2,	400	430	-12.6	-95
Watts (35-28)	2-02-84	3a	200	7	--	84	1.6	19.S	6.5	0.01	--	--	--	22	2	0.1	bd	12.7	--	co.50	--	bd	,	153	320	--	--
Cummings (35-09)	2-07-84	3a	212	6	--	171	1.2	16.2	1.5	0.02	--	--	--	9	13	0.4	bd	19.0	--	<0.50	--	bd	46	284	470	--	--
Coates (23-41)	6-20-84	3b	--	8	7.5	29	4.1	37.5	19.2	0.02	0.8	--	260	35	10	<0.1	bd	15.0	0.69	<0.50	--	tr	78	357	310	--	-95
Trambitas (23-31)	6-19-84	3b	109	9	7.7	18	2.6	31.5	10.5	0.01	0.6	--	204	10	2	<0.1	bd	10.8	0.23	0.60	--	bd	163	449	220	--	-93
Ramsey (35-20)	3-22-84	3c	202	7	6.7	13	0.5	35.8	6.5	0.01	0.3	--	167	2	2	<0.1	bd	13.7	1.12	<0.50	--	td	7	155	175	-12.4	-91
Mc Vey (35-39)	3-22-84	3c	09	12	7.2	40	7.7	140.0	33.4	0.06	1.3	--	410	2 %	3	0.4	bd	26.0	1.20	<0.50	0.4	bd	3	754	790	-13.0	-98
Mendenhall 1390 (35-54)	5-03-84	3c	--	5	5.4	1	<0.5	3.5	'1.0	4.0.01	<0.01	--	7	1	1	<0.1	bd	5.6	1.14	<0.50	--	bd	<1	17	15	-13.1	-94
Lamonica (35-53)	5-02-84	3c	200	9	7.3	17	4.6	166.0	17.0	0.04	1.3	--	334	62	153	a.1	bd	16.0	1.02	<0.50	--	bd	<1	601	760	-12.7	-95
Palmer (35-43)	S-03-84	3c	93	7	7.5	44	2.7	47.0	25.8	0.02	0.1	--	324	9	44	<0.1	bd	24.0	0.82	--	--	tr	9	366	400	-13.5	-96
Argetsinger (35-02)	2-01-84	3c	115	7	--	132	24.0	211.0	32.0	0.09	--	--	--	85	632	<0.2	tr	10.0	0.09	<0.50	--	tr	7	1,201	1,650	--	--
Nash (35-48)	5-03-84	--	80	6	--	--	--	--	--	--	--	--	--	12	2	0.8	bd	--	--	--	--	tr	--	14	450	-13.3	-96
Keithahn OS-321	2-01-84	--	92	9	--	--	--	--	--	--	--	--	--	--	1.000	--	--	--	--	--	--	--	--	--	2,500	--	--
Hagerup (35-08)	S-02-k	--	129	8	--	--	--	--	--	--	--	--	--	215	1,720	0.2	tr	--	--	--	--	tr	--	1.935	4.500	-12.5	-SO
Johnson (35-52)	5-02-84	--	475	9	--	--	--	--	--	--	--	--	--	34	17	0.1	bd	--	--	<0.50	--	tr	--	--	420	--	--
Lundstrom (35-33)	S-02-84	--	--	10	--	--	--	--	--	--	--	--	--	3	3	0.1	bd	--	--	--	--	tr	--	12	320	--	--
Buckley (35-12)	5-20-84	--	87	6	--	--	--	--	--	--	--	--	--	73	4	0.3	bd	--	--	--	--	bd	--	77	420	--	--
Auke Creek (23-44)	L-15-84	--	--	14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21	--	-96
Bay 'reek (23-45)	6-15-84	--	--	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	44	--	-96
Rearer Springs (35-55)	S-03-84	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	-12.3	-92
Lake Creek (23-46)	6-15-84	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21	--	-99

[a]Measured at well-water temperature.
[b]bd = below detection.
[c]tr = trace.
[d]TDS = total disolved solids.
-- = no data.

Three subcategories of type 3 waters were distinguishable based on cation composition and location. Type 3a waters had low Cl, greater proportions of Na than Ca + Mg, and tended to be located inland. Type 3b waters were distinguished by high As concentrations and were located in section 23. Type 3c waters had Ca + Mg in greater proportion than Na and, except for site 35-20, were located near shorelines.

Total dissolved solids (TDS) in samples for which full analyses were performed ranged from 155 ppm at site 35-20 to 2,086 ppm at site 23-01. However, based on the partial anion analysis available for site 35-08, TDS in waters from some beachfront wells would likely substantially exceed 2,000 ppm. For comparison, TDS in waters sampled from the stream referenced as Mendenhall 1390 (site 35-54) were 17 ppm.

Table 3 ranks sampled sites in order of decreasing chloride concentrations. Chloride concentrations ranged from 1,720 ppm at site 35-08 to as low as 1 ppm at site 35-54, the Mendenhall 1390 stream site. Except for the samples with highest chloride concentrations, the amount of Na shows little correlation with increases in Cl (fig. 4). As can be seen from figure 5, high concentrations of Na are associated with high concentrations of bicarbonate.

Table 4 ranks sampled sites in order of decreasing arsenic concentrations. The arsenic concentrations of three sites were at or near the Department of Environmental Conservation maximum allowable standard for drinking water. Site 23-31 was considerably above the standard safe level of 50 ppb.

Results of stable isotope analyses are presented in tables 1 and 2 and in figures 6, 7, and 8. Deuterium compositions (δD) of well waters ranged from -90 to -100 per mil with respect to standard mean ocean water (SMOW) and were similar to deuterium compositions of locally derived meteoric water (LDMW) (fig. 6). $\delta^{18}O$ values are plotted in figure 7, for those samples with available data. The meteoric water line of Craig (1961) and the Adak precipitation line (Motyka, 1982) are also plotted in figure 7 for comparison. Adak is the only coastal site in Alaska for which there is sufficient stable isotope data to determine a precipitation line. MHP-AB area waters tended to plot close to the Craig meteoric water line, but a few samples appeared slightly shifted towards more positive $\delta^{18}O$ values. The similarity between LDMW and the well-water stable isotope compositions indicates the MHP-AB aquifers are recharged by meteoric waters that precipitate at low elevations.

The deuterium compositions of the well waters showed a weak correlation with increases in Cl concentration. An increase in δD values would be expected if sea water were the source of increased Cl in the well waters. The isotopic composition of Gastineau Channel saltwater is not known, but would be expected to be substantially lighter than SMOW because of the large influx of freshwater runoff from coastal mountains.

Table 3. Chloride concentrations (in decreasing order) from well waters in Mendenhall Peninsula and Auke Bay, Alaska.

Site	Date sampled	Site no.	Cl (ppm)	Well depth (ft)
Hagerup	5-02-84	35-08	1,720	129
Keithahn	2-01-84	35-32	1,000	92
Bay View	6-14-84	23-01A	944	90
Argetsinger	2-01-84	35-02	632	155
UAJ	6-16-84	23-14	166	227
Meilke	2-01-84	35-38	157	220
Lamonica	5-02-84	35-53	153	200
Olson	6-16-84	23-24	98	275
Auke Bay	6-19-84	23-23	80	202
Dehardt	6-14-84	23-08	78	290
Jones	6-19-84	23-05	53	145
Palmer	5-03-84	35-43	44	93
Clasby	3-04-84	35-05	40	150
Houlihan	3-22-84	35-15	24	260
Bradley	3-14-84	35-03	22	95
Johnson	5-02-84	35-52	17	475
Cummings	2-07-84	35-09	13	212
Coates	6-20-84	23-41	10	--
Lundstrom	5-02-84	35-33	9	--
Mc Vey	3-22-84	35-39	9	89
GHEA	6-14-84	23-28	8	73
Thomason	3-13-84	35-24	4	216
Karenin	3-13-84	35-13	4	85
Buckley	5-02-84	35-12	4	87
Watts	2-02-84	35-28	2	200
Hursch	3-14-84	35-10	2	200
Ramsey	3-22-84	35-20	2	202
Trambitas	6-19-84	23-31	2	109
Nash	5-03-84	35-48	2	80
Mendenhall 1390	5-03-84	35-54	1	--
Bay Creek	6-15-84	23-45	--	--
Beaver Springs	5-03-84	35-55	--	--
Lake Creek	6-15-84	23-46	--	--
Auke Creek	6-15-84	23-44	--	--

-- = no data.

DISCUSSION

The geographic trend of ground-water types discussed above (except type 1 $Na-HCO_3$ waters, noted earlier) cuts across the trend of bedrock contacts but correlates with the primary fracture orientation of 45" NW.

The majority of wells showing chloride contamination are located near shorelines, which indicates that the contamination is primarily due to the

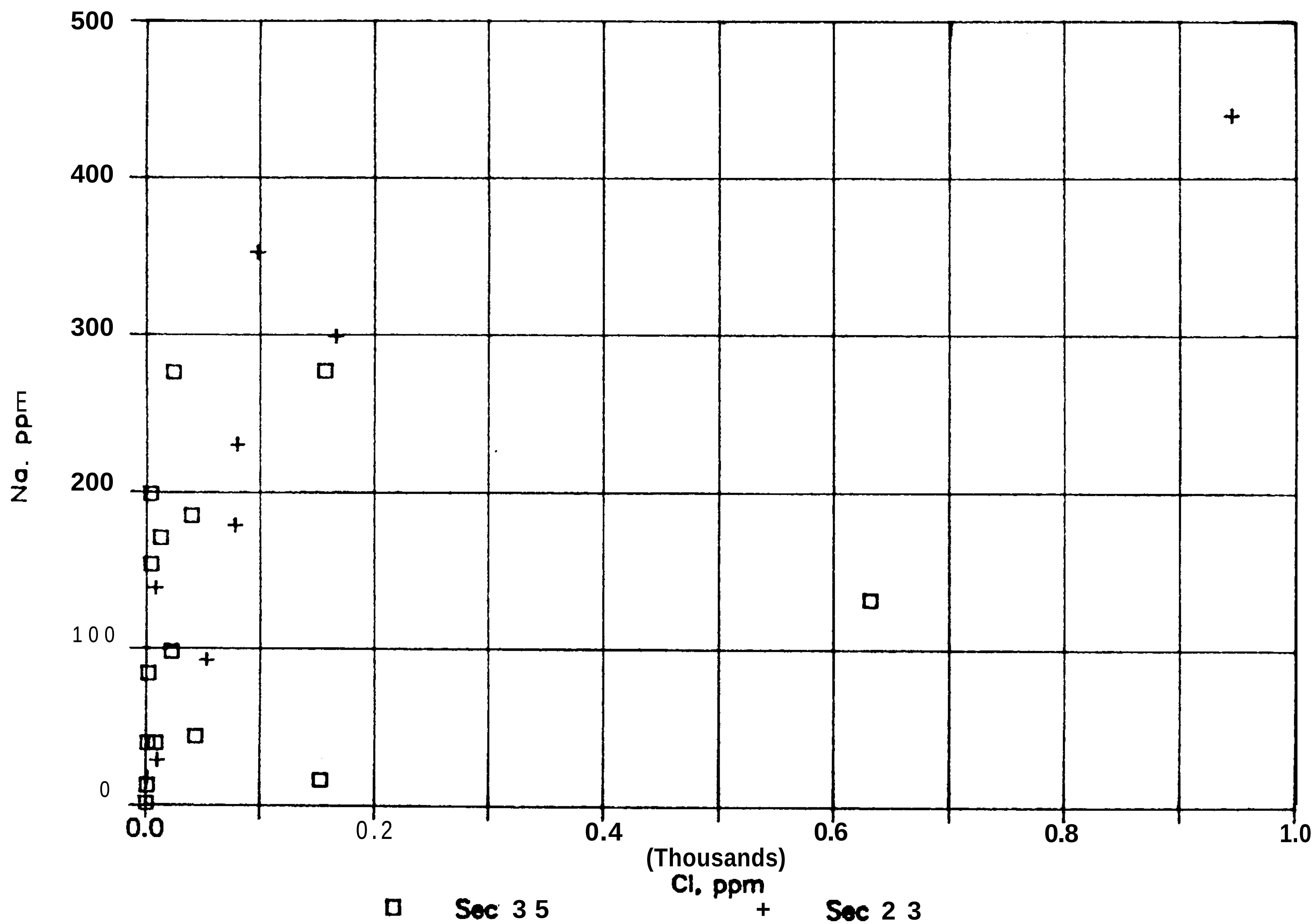

Figure 4. Diagram of chloride concentration vs. sodium concentrations for water samples from the Mendenhall Peninsula-Auke Bay area, Alaska.

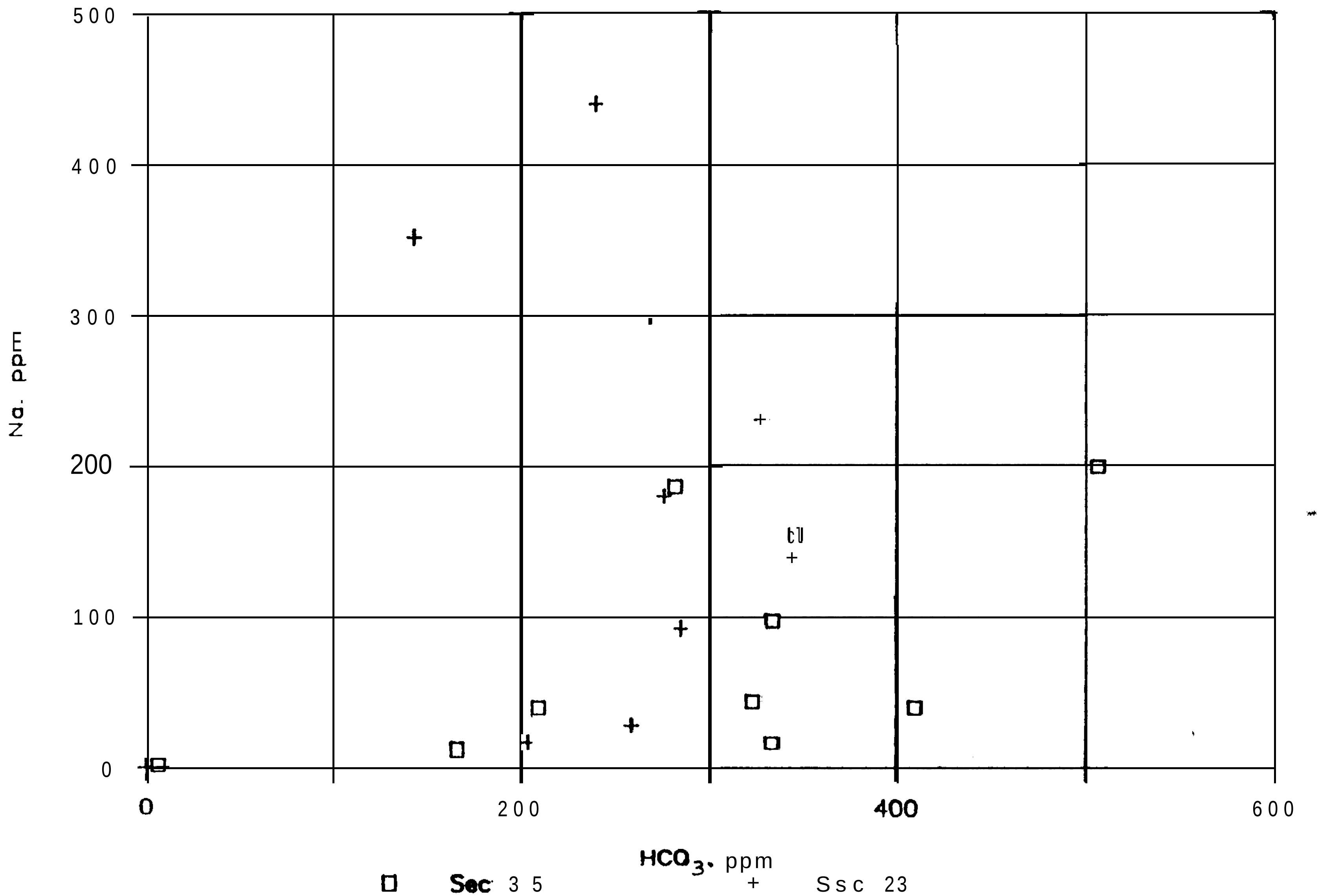

Figure 5. Diagram of sodium concentration vs. bicarbonate concentrations for water samples from the Mendenhall Peninsula-Auke Bay area, Alaska.

Table 4. Arsenic concentrations (in decreasing order) from well waters in Mendenhall Peninsula and Auke Bay, Alaska.

Site	Date sampled	Site no.	As (ppb)	Well depth (ft)
Trambitas	6-19-84	23-31	263	109
Coates	6-20-84	23-41	78	--
Cummings	2-07-84	35-09	46	212
Bradley	3-14-84	35-03	24	95
Hursch	3-14-84	35-10	14	200
UAJ	6-16-84	23-14	9	227
Palmer	5-03-84	35-43	9	93
Ramsey	3-22-84	35-20	7	202
Argetsinger	2-01-84	35-02	7	115
Jones	6-19-84	23-05	4	145
Watts	2-02-84	35-28	4	200
Olson	6-16-84	23-24	4	275
Dehardt	6-14-84	23-08	3	290
Mc Vey	3-22-84	35-39	3	89
Karenin	3-13-84	35-13	2	85
Houlihan	3-22-84	35-15	2	260
Meilke	2-01-84	35-38	2	220
GHEA	6-14-84	23-28	2	73
Clasby	3-04-84	35-05	1	150
Bay View	6-14-84	23-01A	1	90
Thomason	3-13-84	35-24	1	216
Auke Bay	6-19-84	23-23	1	202
Lamonica	5-02-84	35-53	<1	200
Mendenhall 1390	5-03-84	35-54	<1	--
Keithahn	2-01-84	35-32	--	92
Nash	5-03-84	35-48	--	80
Buckley	5-02-84	35-12	--	87
Lundstrom	5-02-84	35-33	--	--
Lake Creek	6-15-84	23-46	--	--
Johnson	5-02-84	35-52	--	475
Auke Creek	6-15-84	23-44	--	--
Bay Creek	6-15-84	23-45	--	--
Beaver Springs	5-03-84	35-55	--	--
Hagerup	5-02-84	35-08	--	129

-- = no data.

intrusion of Auke Bay saltwater into fractures in aquifer walls. For two well sites (23-14 and 23-05) some distance from the coast, chloride contamination may originate from a different source; Auke Lake, a remnant glacial lake, is located about 700 ft east of these two inland wells, and the aquifers that feed these two wells might be charged by waters infiltrating along northeast-oriented fractures. If so, some of the recharge waters may originate in Auke Lake.

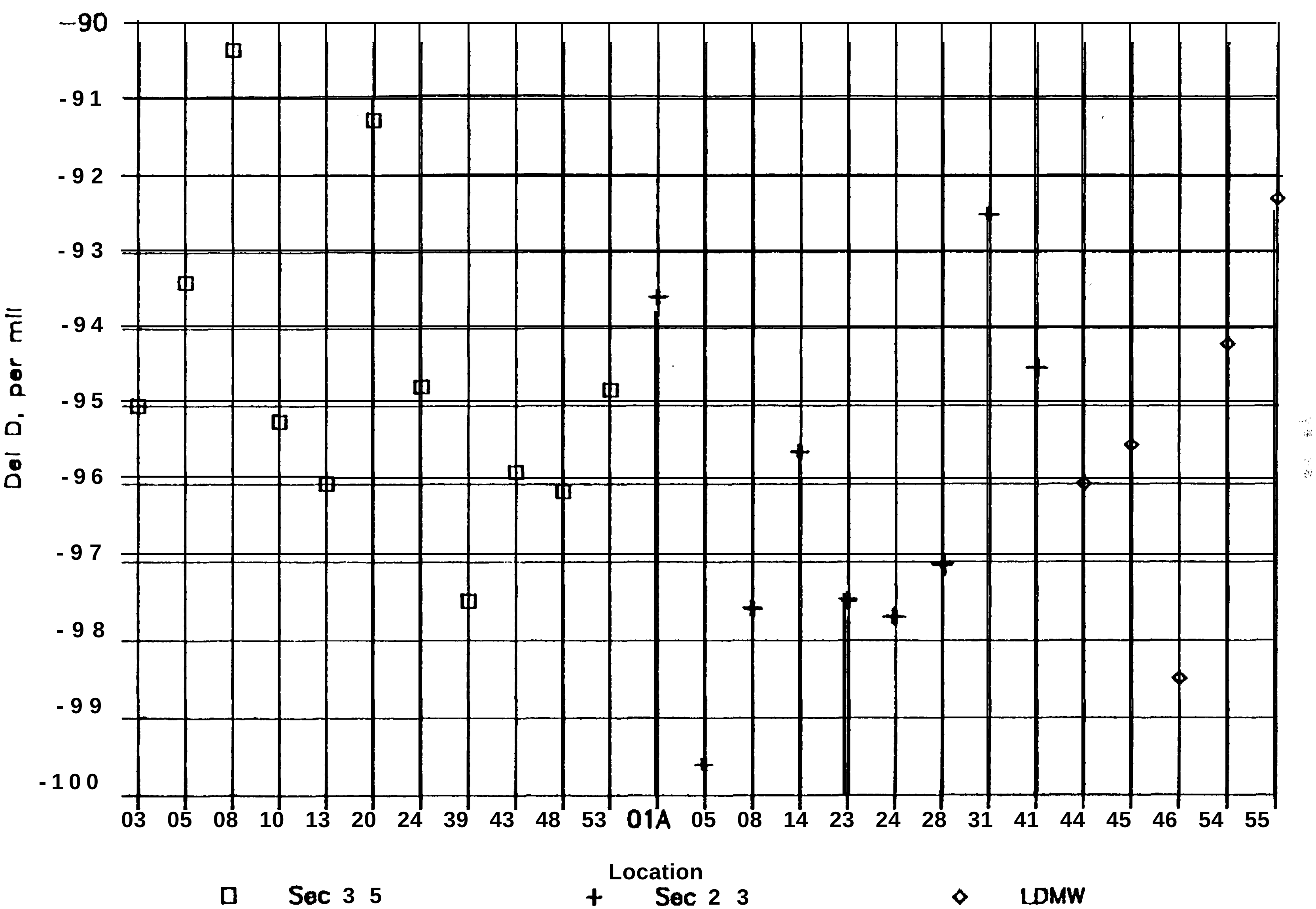

Figure 6. Plot of δD (per mil) values with respect to SMOW for meteoric and wellwater samples from the Mendenhall Peninsula-Auke Bay area, Alaska.

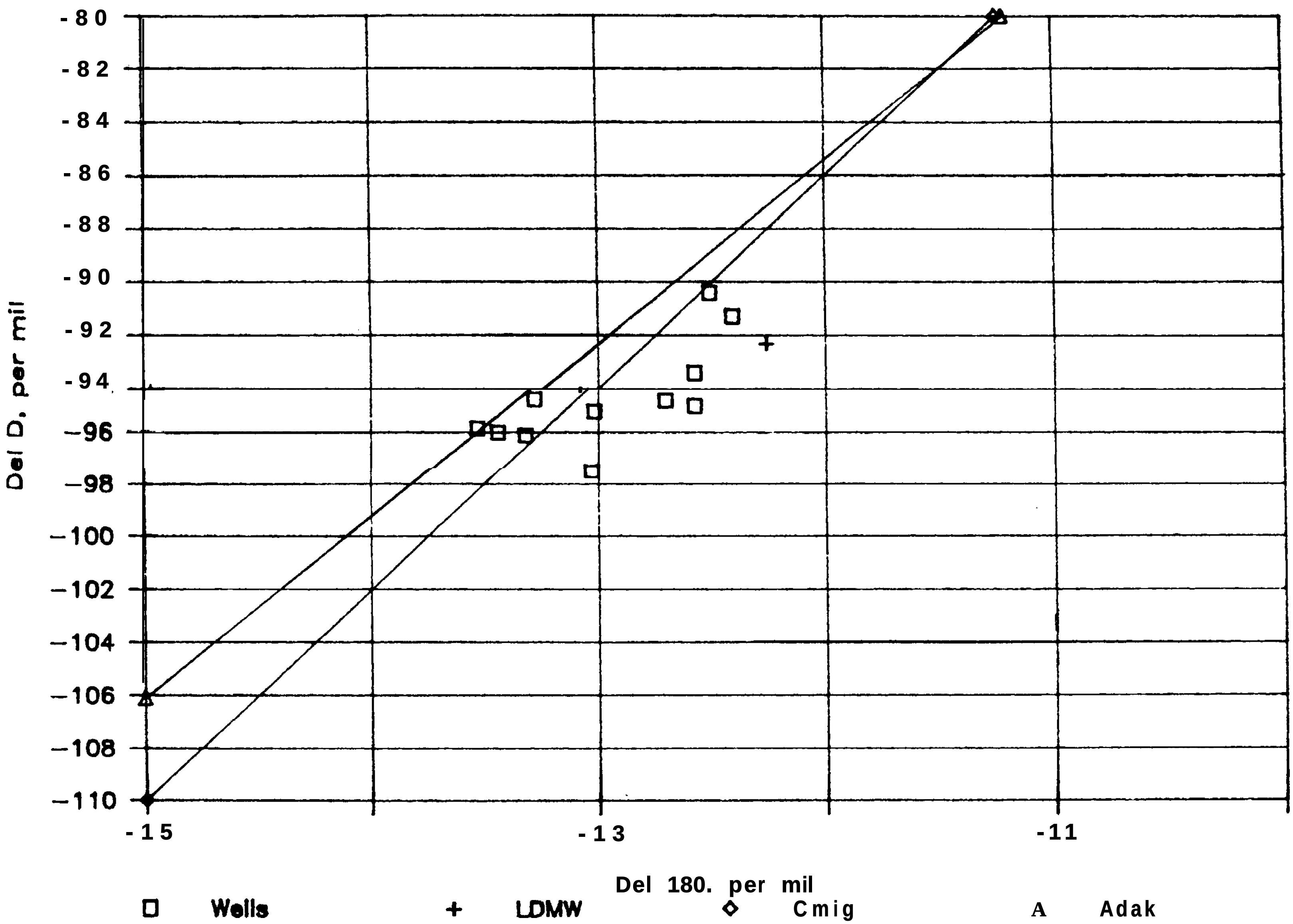

Figure 7. Plot of δD values vs. $\delta^{18}O$ values for water samples from the Mendenhall Peninsula-Auke Bay area, Alaska. Craig meteoric water line and Adak precipitation line are included for reference.

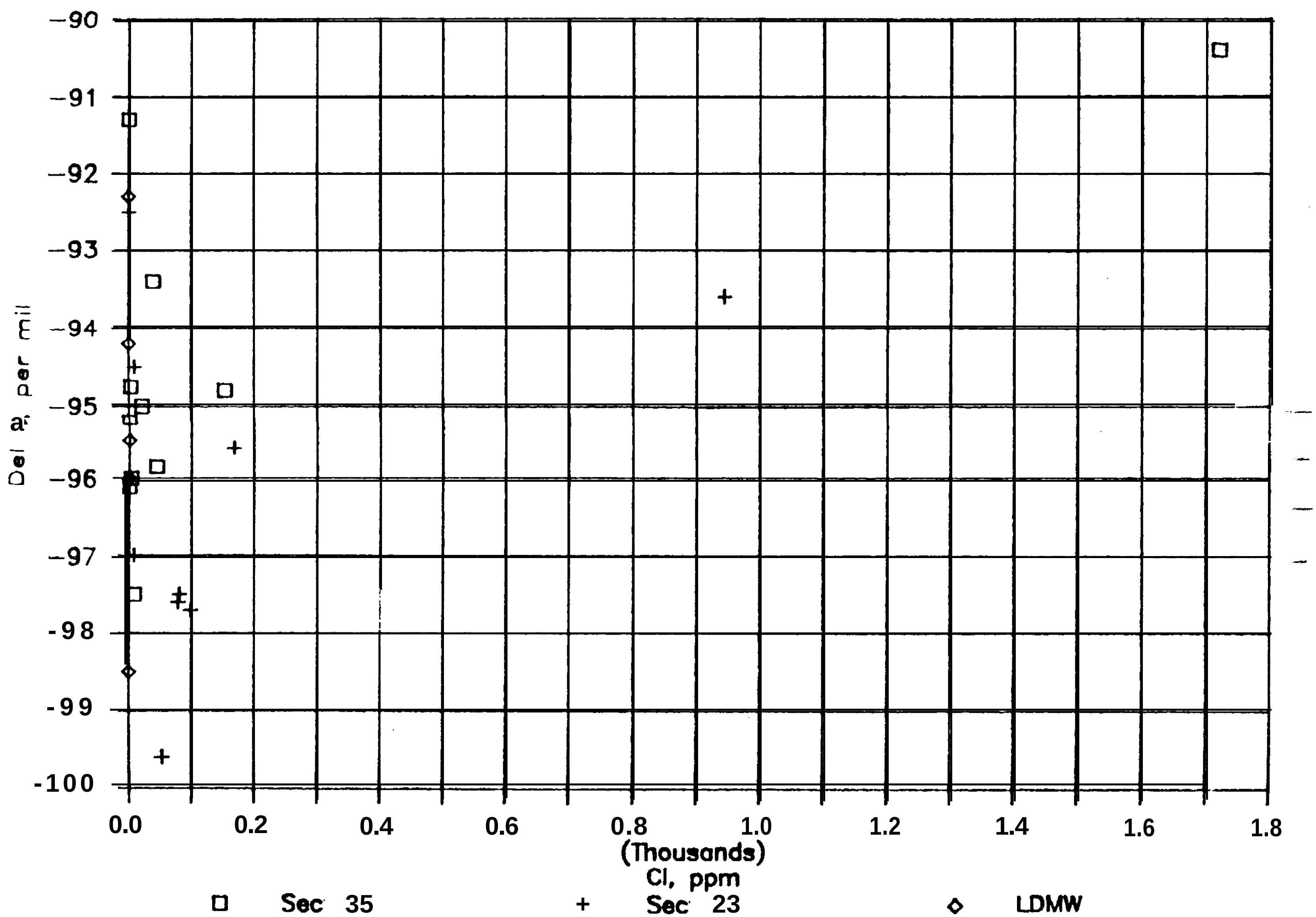

Figure 8. Plot of δD values vs. chloride concentrations for water samples from the Mendenhall Peninsula-Auke Bay area, Alaska.

Auke Lake is 110 ft deep; judging by the large scale and rapid rate of isostatic rebound throughout the Gastineau Channel region (Miller, 1973), Auke Lake may have been connected to a saltwater source in the recent past and may still be saline at depth. In addition, it is likely that Holocene glacial-marine deposition took place in Auke Lake as it did throughout the rest of the Gastineau channel region, and a relatively thick layer of glacial-marine deposits could have accumulated within this basin that would now underlie the lake. Percolation of lake waters through these sediments would leach salts and introduce them into subsurface aquifers. High Ca and Sr levels in type 2 waters could originate from decomposition of mollusk shells. These or similar marine beds could be a source of the high SO_4 levels in some MHP-AB well waters.

For sample sites plotted on sheet 1, chloride concentrations of <10 ppm indicate no saltwater contamination and those >50 ppm indicate incipient saltwater contamination. Caution should be exercised before increasing the rate of extraction from the supplying aquifer. Concentrations between 100 and 500 ppm indicate saltwater contamination has occurred and no further stress should be placed on the aquifer. Concentrations >500 ppm indicate saltwater contamination is severe.

The similarity in isotopic composition of water from wells and LDMW indicates that the primary source of water recharging the bedrock aquifers is precipitation at relatively low elevations. For sites where saltwater intrusion is severe (Cl >500 ppm), higher δD values reflect mixing of a saltwater component with the meteoric recharge waters.

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REFERENCES

Balding, Gary, 1979, An assessment of water supplies in the Mendenhall Peninsula - Auke Bay area: unpublished report to Alaska Division of Forestry, Land and Water Management, 14 p.

Barnwell, W.W., and Boning, C.W., 1968, Water resources and surficial geology of the Mendenhall Valley, Alaska: U.S. Geological Survey Hydrological Investigations Atlas HA-259, 6 p.

Craig, Harmon, 1961, Isotopic variations in meteoric waters: Science, v. 133, p. 1702.

Ford, A.B., and Brew, D.A., 1973, Preliminary geologic and metamorphic-isograd map of the Juneau B-2 Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-527, scale 1:63,360.

Miller, R.D., 1975, Surficial geologic map of the Juneau urban area and vicinity, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-885, scale 1:63,360.

Miller, R.D., 1973, Gastineau Channel Formation, a composite glaciomarine deposit near Juneau, Alaska: U.S. Geological Survey Bulletin 1394-C, 20 p.

Motyka, R.J.', 1982, High-temperature hydrothermal resources in the Aleutian arc, in Alaska Geological Society Symposium on Western Alaska Geology and Resource Potential, Anchorage, 1982, Proceedings: Journal of Alaska Geological Society, v. 3, p. 87-89.

Presser, T.S., and Barnes, Ivan, 1974, Special techniques for determining chemical properties of geothermal waters: U.S. Geological Survey Water-Resources Investigation Report 22-74, 11 p.

Appendix A. Acceptable values for selected contaminants in public drinking water supplies.[a]

Contaminant	Maximum allowable level (mg/L)
Arsenic	.05
Barium	1.0
Chloride	250.
Fluoride	2.4
Iron	0.3
Manganese	0.05
Nitrate	10.
Sodium	250.
Sulfate	250.
Total dissolved solids	500.
pH	6.5 to 8.5

[a]From State of Alaska Drinking Water Regulations, Department of Environmental Conservation.