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GEOTHERMAL INVESTIGATIONS IN IDAHO

PART 11

Geological, Hydrological, Geophysical and Geochemical Investigations of the Nampa-Caldwell and Adjacent Areas Southwestern, Idaho

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GEOCHEMISTRY

by

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STABLE ISOTOPE STUDY

Isotopes are two forms of the same element which differ only in the number of neutrons (uncharged atomic particles) in the nucleus of an atom. This means that different isotopes of the same element will differ only in their relative masses. It is this mass difference that governs their kinetic behavior and allows isotopes to fractionate during the course of certain chemical and physical processes occurring in nature.

The four stable isotopes that have proven most useful in water resource evaluation are hydrogen (^1H or H), deuterium (^2H or D), oxygen 16 (^{16}O) and oxygen 18 (^{18}O). These isotopes make up 99.9 percent of all water molecules.

Isotopic compositions are reported in "δ" notation in parts per thousand (per mil = $^0/oo$) relative to Standard Mean Ocean Water (SMOW) as defined by Craig (1961b), where $\delta i = [(R_i/R_{std} -1] \times 1000$. R_i equals either $^{18}0/^{16}0$ or D/H and i and std represent the sample and standard, respectively.

The result of isotopic fractionation during evaporation of ocean water and subsequent condensation of vapor in clouds is that fresh (meteoric) water is generally depleted in ^{18}O and D (enriched in ^{16}O and H) compared to seawater. The isotopic variations of water in rain, snow, glacier ice, streams, lakes, rivers, and most nonthermal groundwaters are extremely systematic; the higher the latitude or elevation, the lower the δD and $\delta^{18}O$ values of the waters. On the basis of a large number of analyses of meteoric waters collected at different latitudes, Craig (1961b) showed that the $\delta^{18}O$ and δD values relative to SMOW are linearly related and can be represented by the equation:

$$\delta D = 8\delta^{18}O + 10$$

which is plotted in figure 3. Groundwater sampled in an area whose isotopic composition plots on the trend (meteoric water line) are generally considered to be meteoric waters. Gat (1971) reported that incongruous results in isotope hydrology studies have generally been interpreted to mean: (1) geographic displacement of groundwaters by flow, (2) recharge from partially evaporated surface waters, (3) recharge under different climatic conditions, (4) mixing with nonmeteoric water bodies--brines, sea-water, connate, metamorphic, or juvenile waters, (5) differential water movements through soils or aquifers which result in fractionation processes (membrane effects), (6) isotopic exchange or fractionation between water and aquifer materials. Several of these processes tend to be distinctive, either in enriching or depleting the waters in heavier isotopes and can be recognized. Others tend to be similar in results; therefore, ambiguous interpretations may result.

Sites for isotope sampling in the Nampa-Caldwell area and adjacent areas were carefully chosen on the basis of well log data on file at Idaho Department of Water Resources. Casing records, well depths, lithologies penetrated, measured surface temperature, and structural geology considerations, so far as known, were considered. Landsat images of the western Snake River Plain were studied to locate sample sites on or near lineaments passing through the Nampa-Caldwell area based on the hypotheses that the lineaments might be migration channels through which recharge waters moved into the Nampa-Caldwell area. Rivers (except the Boise, inadvertently omitted), lakes and canals in and adjacent areas outside the area of study were also sampled. A total of 41 samples were analyzed by mass spectrometry by Kruger Enterprises, Inc., Geochron Laboratories Division, Cambridge, MA. On the basis of duplicate samples and analyses the data appear to be precise within 1 ^{o}/oo unit for δD and 0.2 ^{o}/oo unit for $\delta^{18}O$. These data are given in Table 1 and sample locations are shown on figure 1 and figure 2 (in pocket). The data are shown plotted as δD and $\delta^{18}O$ in per mil units on figures 3 and 4.

The range of δD values for thermal waters sampled in the Nampa-Caldwell area is from -136 to -151 ^{o}/oo. The range of

TABLE 1

Isotope Sample Locations, Measured Surface Temperature, D, ^{18}O, Cl and F Values from Sampled Water in the Nampa-Caldwell and Adjacent Areas of Southwest Idaho

Sample or Well No. (Location)		Measured Surface Temperature (°C)	$\delta^{18}O$ SMOW °/oo	δD SMOW °/oo	Cl mg/l	F mg/l
7N-4W-22aca	Payette R., Gem Co.	12+	-14.4	-125	-	-
7N-2E-15daa	Payette R., Boise Co.	-	-14.6	-124	-	-
6N-1W-25bbd1	Willow Cr., Gem Co.	23	-14.2	-124*	6.3	-
5N-1E-35aca1	Dry Cr., Ada Co.	40	-16.9*	-143	4.9	11.0
5N-1E-36bdb1	Dry Cr., Ada Co.	24	-15.4	-128	-	-
4N-4W-04dcc1		21	-17.7	-147	5.9	-
4N-4W-05dbd1		24	-17.3	-145	6.2	-
4N-3W-19adc1	Richardson #1	40	-17.2*	-142*	5.8	1.5
3N-2E-10acc1	Capitol Mall #1, Ada Co.	65	-17.0	-141	6.9	16.9
3N-3W-03bbc1		19	-15.6	-128	21.0	0.57
3N-3W-30ddd1		16	-16.5	-137	98.0	0.60
3N-2W-14ada1		22	-17.4	-138	14.0	0.50
3N-2W-17bcb1		24	-16.3	-136	6.1	1.00
3N-2W-23bcd1		31	-17.1	-151	4.1	1.9
3N-2W-26ddb1		18	-16.6	-135	38.0	0.68
3N-2W-31bbb1		15	-15.9*	-132	104.0	0.43
3N-2W-31dcb1		15	-16.7	-138	-	-
2N-3W-08cdd1		22	-16.8	-141	24.0	0.61
2N-3W-22acd1		26	-17.4	-143	26.0	0.69
2N-3W-22bdc1		28	-17.6	-147	16.0	0.50
2N-3W-25bda1		26	-16.5	-146	7.1	1.6
2N-3W-27bba1		30	-18.0	-150	11.6	0.85
2N-3W-35caa1		28	-17.6	-147	8.1	1.3
2N-2W-04dca1		23	-15.9	-144	20.0	2.3
2N-2W-06aba1		15	-15.9	-131	-	6.3
2N-2W-16daa1		26	-17.1*	-139	16.0	1.0
2N-2W-16dba	Lake Lowell Inlet	13+	-16.5	-132	21.0	0.4
2N-2W-18bab1		14	-16.1	-138	7.1	0.55
2N-2W-34aac1		29	-16.3	-140*	28.0	3.6
2N-2W-34bda1		51	-17.0	-142*	11.0	4.3
2N-2W-34daa1		31	-17.0	-142	11.0	2.4
1N-2W-03cab1		20	-16.5	-138	9.9	-
1N-2W-03cbb1		20	-16.3	-138*	-	-
1N-2W-08acb1		21	-16.7	-139	74.0	0.36
1N-2W-09bba1		22	-15.8	-141	24.0	0.34
1N-2W-09ccb1		24	-17.0	-142	38.0	0.75
1N-2W-17dcc1		21	-16.2	-139	165.0	0.38
1S-2W-17abb1		21	-17.3	-142	14.0	4.7
1S-2W-17bad	Snake River near Walters Ferry Bridge	12+	-16.5	-133	21.	.4
2S-3W-36daa1	Reynolds, Owyhee Co.	8	-15.0	-123	25.x	-

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* Average of two analyses or samples.
\+ Average water temperature over one year period from 12 monthly averages.
\- Data not available.
x Average chloride of 4 analyses each from six wells.

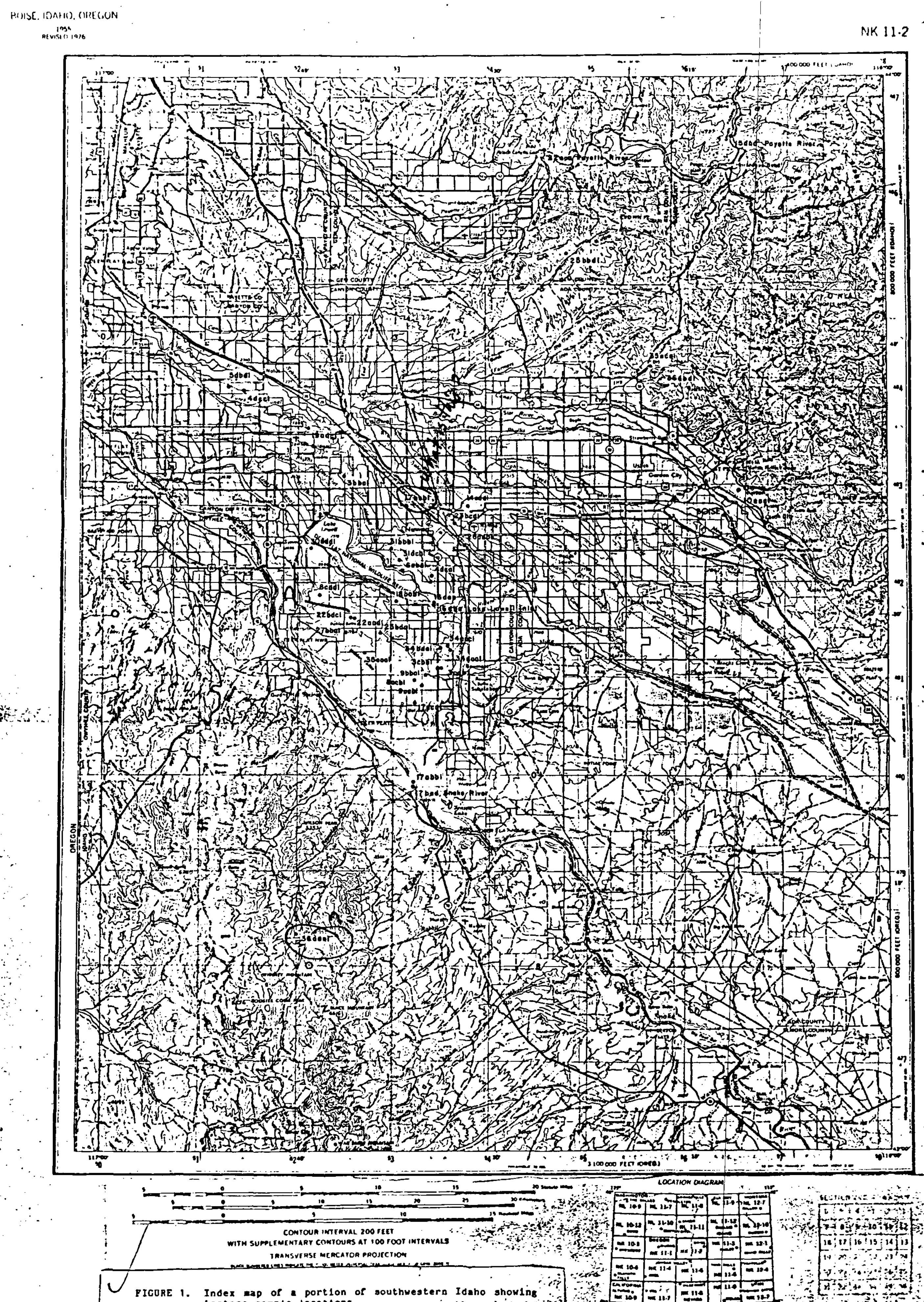

FIGURE 1. Index map of a portion of southwestern Idaho showing isotope sample locations.

This is very hard to read

?

$\delta^{18}O$ values is from -15.5 to -18.0 °/oo. For "cold" waters sampled in and around the Nampa-Caldwell area, the range of δD value is from -123 to -135 °/oo and for $\delta^{18}O$ for cold waters the range of values is from -15.0 to -16.7 °/oo. The ? "thermal" waters are therefore depleted by about 12 °/oo in δD and by about 2.3 °/oo in $\delta^{18}O$ relative to cold water from in and around the Nampa-Caldwell area.

should this be ranges, not differences?

As shown by figure 3, the Nampa-Caldwell waters are somewhat similar to other geothermal waters in Idaho, in that they plot to the right of the meteoric water line. They most closely resemble waters studied by Rightmire, Young, and Whitehead (1976) and Young and Lewis (1980) in the Bruneau-Grand View area (see figure 3 and 7b) but are displaced still further to the right of the meteoric water line and exhibit a somewhat greater spread between thermal and nonthermal water. This heavy isotope enrichment (displacement to right of meteoric water line) is typical of arid and semiarid localities. The relatively isotopically lighter thermal waters (displaced downslope? from cold waters) are, however, distinctive.

references

Rightmire, Young and Whitehead (1976) interpret light thermal waters, or displacement downslope? for thermal water in the Bruneau-Grandview and Weiser areas, to represent (1) ~~mean~~ precipitation at higher elevations where climatic temperatures ~~conditions~~ are cooler, or (2) precipitation during a period of time when the

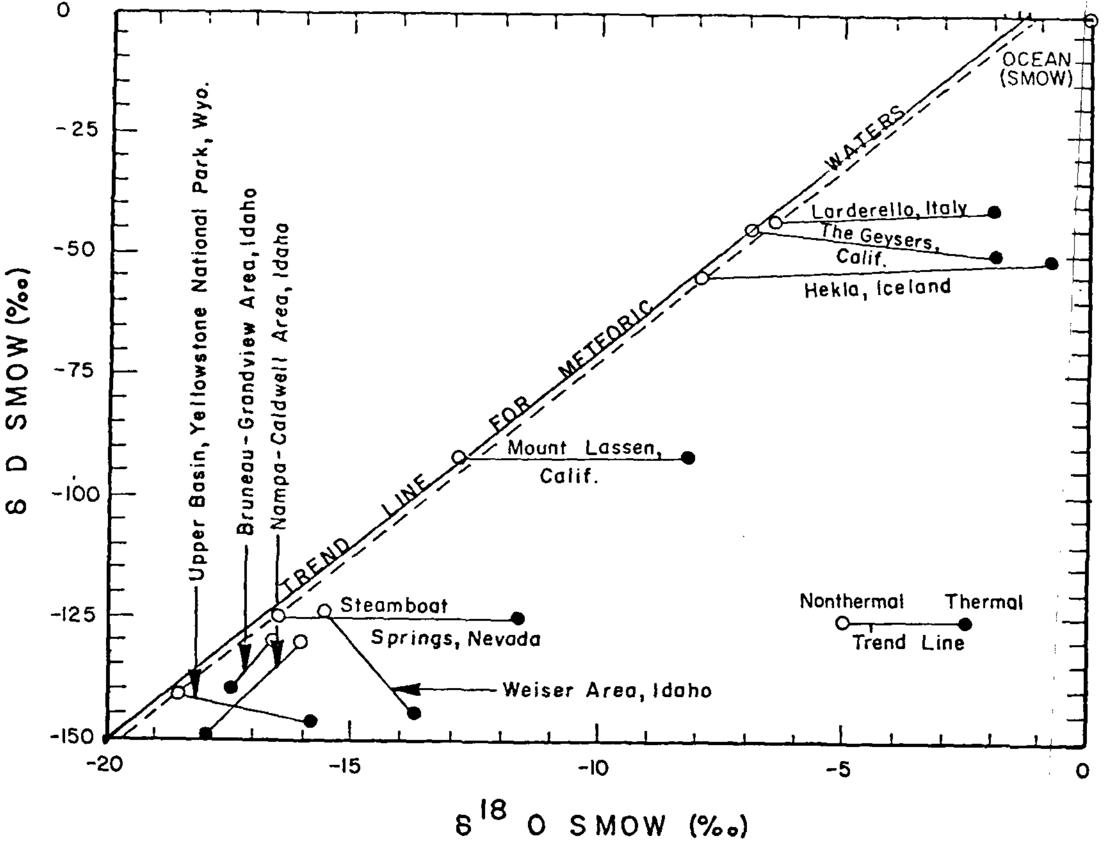

FIGURE 3. Isotopic composition of thermal and nonthermal waters of the Nampa-Caldwell area, Canyon County, Idaho compaired with meteoric waters and waters of selected geothermal systems of Idaho and the world. [Modified from Rightmire, Young and Whitehead (1976) after White, Barnes, and ONiel (1973).]

$\delta D = -150$, $\delta^{18}O = -20$

$\delta D = 0$, $\delta^{18}O = -1.25$

climate was cooler than that prevailing today. Cooler temperatures at higher elevations will result in depleted isotope values, but these should be reflected in cold water in the sampled area also, unless the cold water is recharged at lower elevations. A time period which may have been cooler than the Holocene (present) geologic Epoch was the Pleistocene Epoch or ice age that ended approximately 11,000 years ago. Mayo (1981, personal communication) reported that thermal waters in the Blackfoot Reservoir area of southeastern Idaho have been successfully age dated at 14,000 to 36,000 years old. If Pleistocene precipitation is the source water, then circulation times for recharge of the thermal aquifers may be relatively long (11,000 years or greater if old water is being displaced by new recharge), or there may be relatively little present day recharge for the system. Relatively little present day recharge could mean the waters are being mined.

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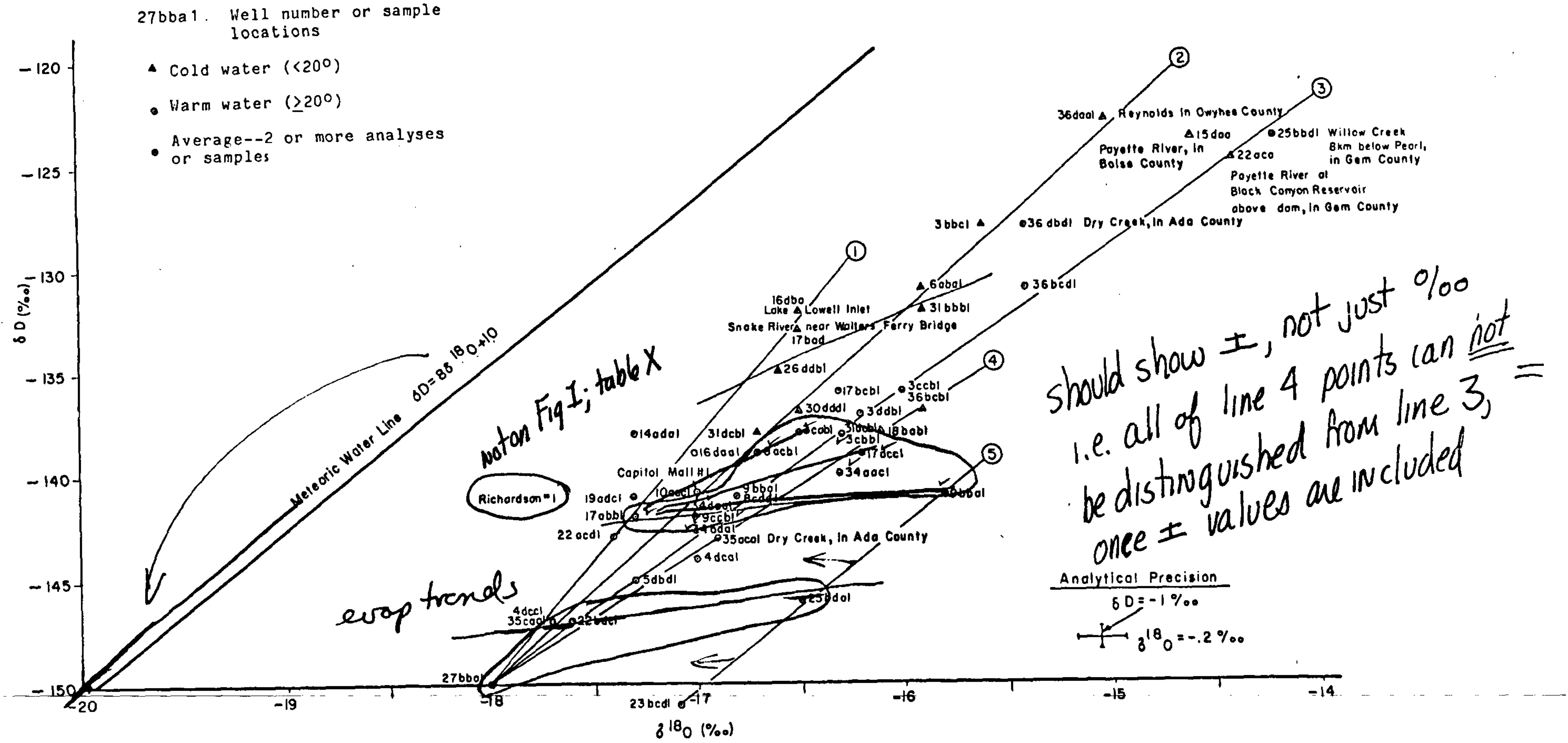
Water levels in wells in the Bruneau-Grand View area were reported by Young and Whitehead (1973) to have declined, which suggests mining or recharge insufficient for present withdrawal (recharge over long periods). Stevens (1962) noted rising water levels in wells in the Dry Lake area south of Lake Lowell, which he attributed to increased irrigation. Recently, however, water levels were noted to drop sharply, as much as 15 meters in one year (Norman Svaty, personal communication, 1979). This could reflect the drought conditions of 1976, which would indicate recharge times of about 3 years, but perhaps only for the aquifers above the "blue clay" (see Anderson, this report, for a discussion of the "blue clay"). ~~Data are insufficient to tell.~~

Alternate hypotheses which could explain the isotopically light thermal waters in the Nampa-Caldwell area are: (1) exchange of hydrogen and oxygen isotopes between water and other hydrogen and oxygen containing sources within aquifers. Methane gas is suspected in some wells in the area and organic debris was accumulated within the sediments as they were deposited. Methane gas and organic accumulations could be a source of hydrogen. (2) Fractionation of isotopes by semipermeable membrane processes in clays may also occur. (3) The thermal water may be isotopically lighter because of subsurface boiling and steam separation in a deep aquifer with the separated steam phase recondensing and reequilibrating chemically in aquifers above those where steam separation occurs. However, the isotope data do not show the characteristic oxygen shift of high temperature systems (figure 3). (4) The trend line could represent a meteoric water line for the Nampa-Caldwell and adjacent areas; however, this does not explain the temperature-isotope ratio relationship found in the data (see below). These processes have received very little study to date and definite conclusions regarding their effects on the isotope ratios in the Nampa-Caldwell area cannot be drawn at present.

Figure 4, which is an enlarged version of a portion of figure 3, shows that most of the data fall on, or near, one of a group of straight lines that converge to intersect well 2N-3W-27bbal. White, Barnes and O'Neil (1973), and ~~also~~ Truesdell and Hulston (1980), interpreted data of a similar nature from the California coast ranges, and Long Valley, California, respectively, to represent fluid mixtures in various proportions with end member waters plotting at the extremities of the lines. ? ? ¶ Water from well 2N-3W-27bbal probably represents unmixed geothermal water from the Glenns Ferry Formation derived from an aquifer within or below the "blue clay". ~~as~~ Records for this well show unperforated casing extending from within the "blue clay" layers to the surface. Most other wells in the Nampa-Caldwell area are perforated, either continuously, or in various zones, or have large sections of hole uncased. The drillers logs show that many wells take water from several zones. Consequently, well 2N-3W-27bbal water may ~~therefore~~ represent one parent water from which most other well waters of the Nampa-Caldwell area are derived. The other ? parent water(s) may be represented by either Lake Lowell or Snake River water, (line 1) Reynolds, or similar elevations (line 2), or Payette River and/or Willow Creek water (line 3). Data points falling on or near the lines could represent mixtures of the parent waters in

FIGURE 4. Isotopic composition of thermal and nonthermal water from selected wells and surface waters in the Nampa-Caldwell area, Canyon County, Idaho, *and adjacent areas.*



should show ±, not just ‰
i.e. all of line 4 points can not be distinguished from line 3, once ± values are included

various proportions. ¶ Well 1S-2W-17abbl, which plots on the Snake River mixing line (line 1), was drilled within a few hundred meters of the Snake River. Well 4N-3W-19adcl (Richardson #1, line 1) may be a mixture of water represented by 2N-3W-27bbal water, Lake Lowell and/or Snake River, or perhaps Boise River water. The temperature depth profile (figure ?.) indicates water from well 4N-3W-19adcl is a mixture from at least three zones. On line 2, well 2N-2W-34bdal may represent water which is a mixture of 2N-3W-27bbal type water with a water represented by well 2S-3W-36daal near Reynolds in Owyhee County, 50 air kilometers due south of Caldwell in the Owyhee Mountains, or similar elevations. The ratio of the length of the line segment connecting data points 2N-3W-27bbal and 2N-2W-34bdal, to the length of the segment connecting 2N-2W-34bdal and 2S-3W-36daal (line 2, figure 4) represents the fraction of the hot water end member. These data indicate that a significant proportion of the recharge for the shallow groundwater (above the "blue clay") may come from the aquifer within or below the "blue clay," and also from several other sources, including perhaps Reynolds Creek Basin, or similar elevations, Lake Lowell and the Snake River through applied irrigation, and possibly leakage from Lake Lowell and its canal systems. Data points not falling on lines 1, 2, and 3, i.e. line 5 could represent sampling, analytical errors, multiple mixing or water from unknown

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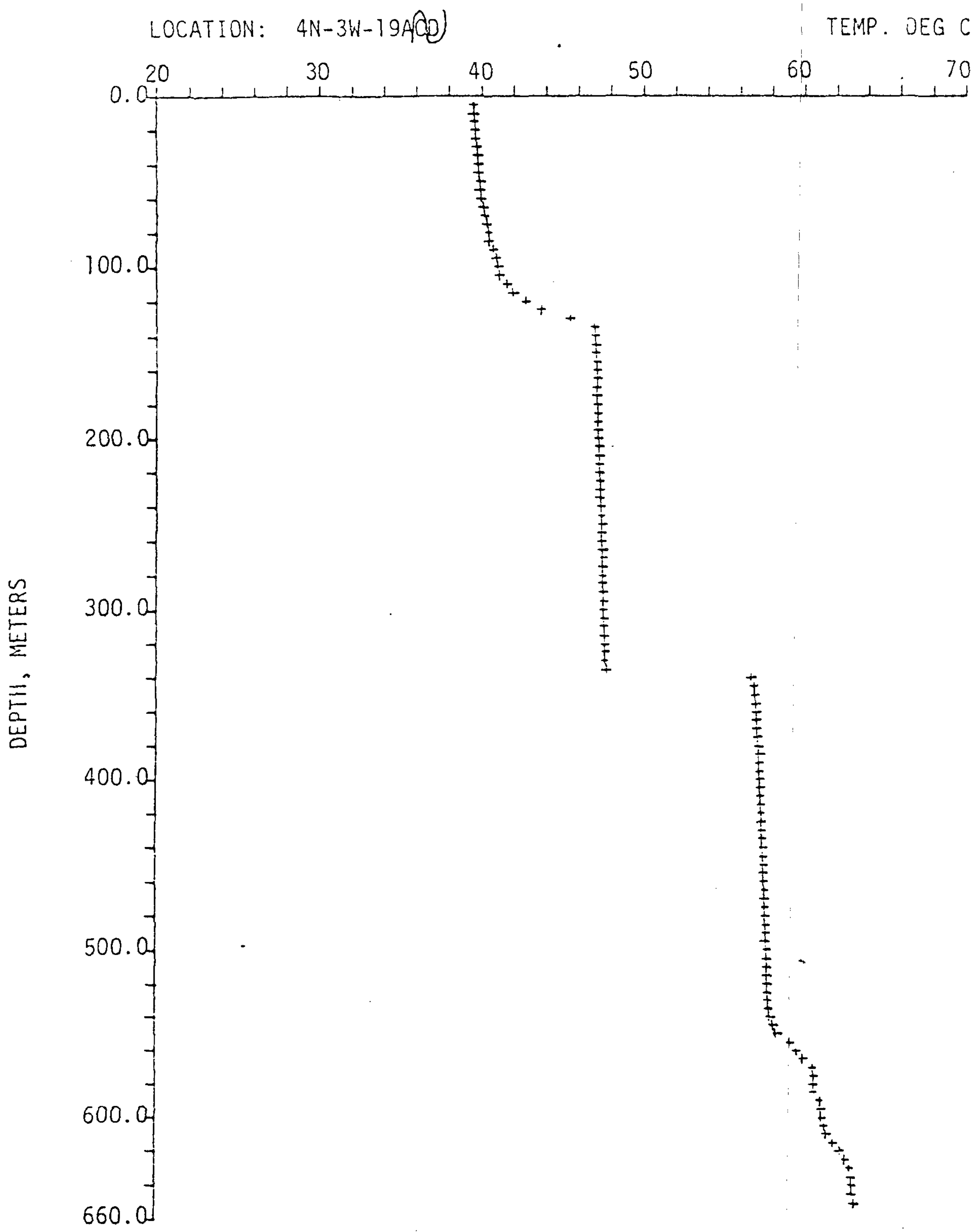


Fig. '.--Temperature-depth profile of Well #14 near Caldwell, Idaho.

From Smith (1980)

sources. The sample from well 3N-2W-23bcdl (line 5) was taken from a 200 meter long, 15 cm diameter discharge pipe only partially full of water. This may have allowed atmospheric gasses to mix with the water, or more importantly, allowed evaporation of thermal water to take place before sample 3N-2W-23bcdl was collected.

what was flow rate
evap. @ 31°C may not
have been important

It should be noted that other straight lines can be drawn through other data points (i.e., from 6N-1W-25bbdl to 4N-3W-19adcl). Other straight line data do not include all data points, do not correlate with temperature data (see below), nor do they have cold waters as one end member and thermal water as the other. They lead to ambiguous interpretations.

Figures 5 and 6 are plots of measured surface temperatures of wells verses δD and $\delta^{18}O$, respectively. Straight line plots are obtained for certain data points. A comparison of figures 4 with 5 and 6 reveals a 67% correlation of data points for line 1 for the figures. If deep water data is not included, the percent correlation is 75. This indicates a direct temperature-isotope dependence for these data points, a result that would be expected if the waters are mixtures of warm and cold water from two sources. In simple mixing of warm and cold water (no other processes taking place) the resultant temperature of the mixture would depend only on the initial temperatures of the warm and cold

I don't follow

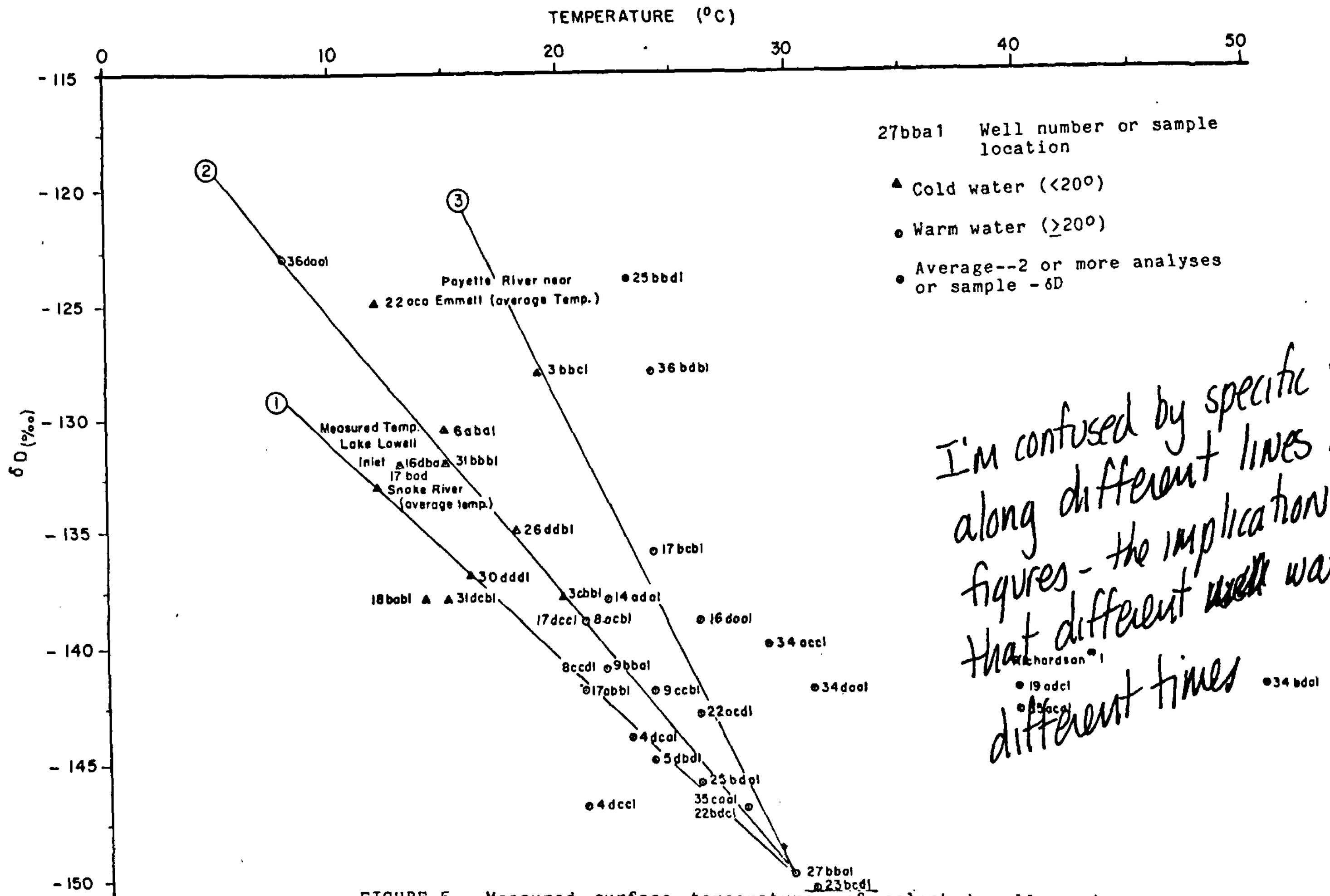


FIGURE 5. Measured surface temperatures of selected wells and ~~surface waters verses δD in the Nampa-Caldwell and~~ adjacent areas of southwestern Idaho.

I'm confused by specific wells falling along different lines in various figures - the implication seems to be that different ~~well~~ waters mix at different times

5

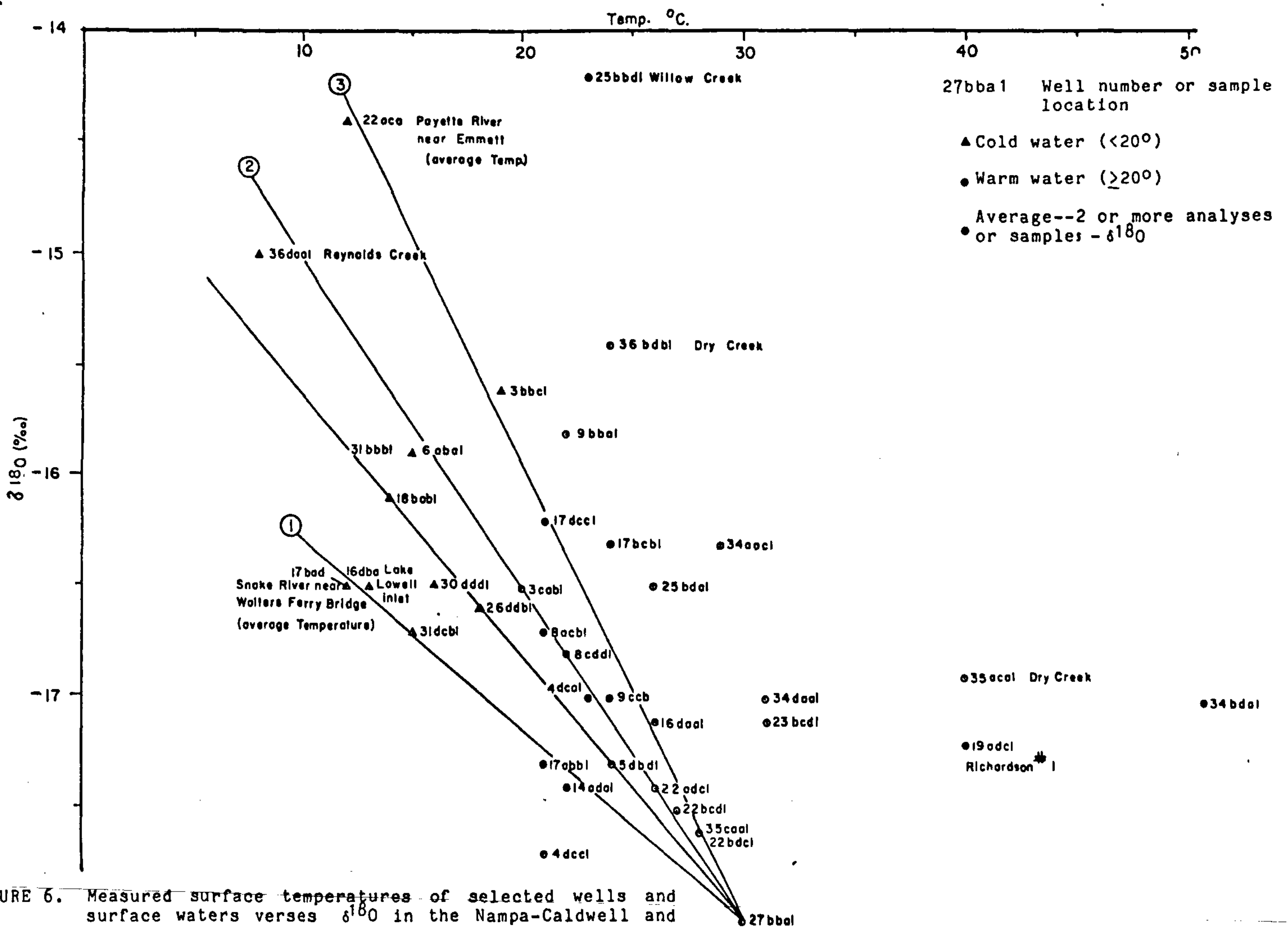


FIGURE 6. Measured surface temperatures of selected wells and surface waters verses $\delta^{18}O$ in the Nampa-Caldwell and adjacent areas of southwestern Idaho.

waters and their volumes involved in mixing. A comparison of figures 4 with 5 and 6 for line 2 reveals a 60% correlation of data points for line 2 data between figures 4 and 5 and also a 60% correlation for line 2 data between figures 4 and 6. If deep water data is ignored, the percent correlation is 69. Table X summarizes the common data points of lines 1 and 2 for figures 4, 5 and 6.

The temperature-isotope dependence is not interpreted as being caused by depletion or enrichment due to kinetic responses of the isotopes, but rather to simple mixing of two parent waters; one warm, the other cold, in various proportions, with little conductive cooling, either within aquifers, or within well bores as the result of man-made aquifer unions.

but, the rest of this report defines a complex setting, so why should this case be simple?

Various points of figures 4, 5 and 6 do not fall on any lines and this could be due to one or several processes including isotope exchange reactions with aquifer constituents, further evaporative enrichment in heavy isotopes from already enriched surface irrigation water as a result of sprinkler and corrugate irrigation practices, multiple mixing, conductive and/or convective cooling of end members or mixed waters, or waters from deeper and hotter aquifers with the same or different isotope ratios, or analytical or sampling errors. An example of conductive cooling might be represented by well 4N-4W-4dcc1 which plots on line 2 of

TABLE X

Correlation of data points for line 1 and 2 between figures 4, 5, and 6

Line 1 Data			Line 2 Data		
δD vs. $\delta^{18}O$ figure 4	δD vs. t figure 5	$\delta^{18}O$ vs. t figure 6	δD vs. $\delta^{18}O$ figure 4	δD vs. t figure 5	$\delta^{18}O$ vs. t figure 6
16dba	16dba	16dba	36daa1	36daa1	36daa1
17bad	17bad	17bad	3bbc1		
14ada1*	14ada1	14ada1	6aba1	6aba1	6aba1
16daa1			31bbb1	31bba1	31bbb1
19adc1**			26ddb1*	26ddb1	26ddb1
17abb1	17abb1	17abb1	30ddd1		
22acd1			31dcb1		
4dcc1***	4dcc1	4dcc1	8acb1	8acb1	8acb1
27bba1	27bba1	27bba1	34daa1		
			9ccb1	9ccb1	9ccb1
			34bda1**		
			35cca1	35caa1	35caa1
			22bdc1****	22bdc1	22bdc1
			27bba1	27bba1	27bba1
			10acc1**		

* Probably analytical error, see text.

** Thermal water from sources deeper and hotter than the aquifer from within the "blue clay."

*** Conductively cooled (?) water, see text.

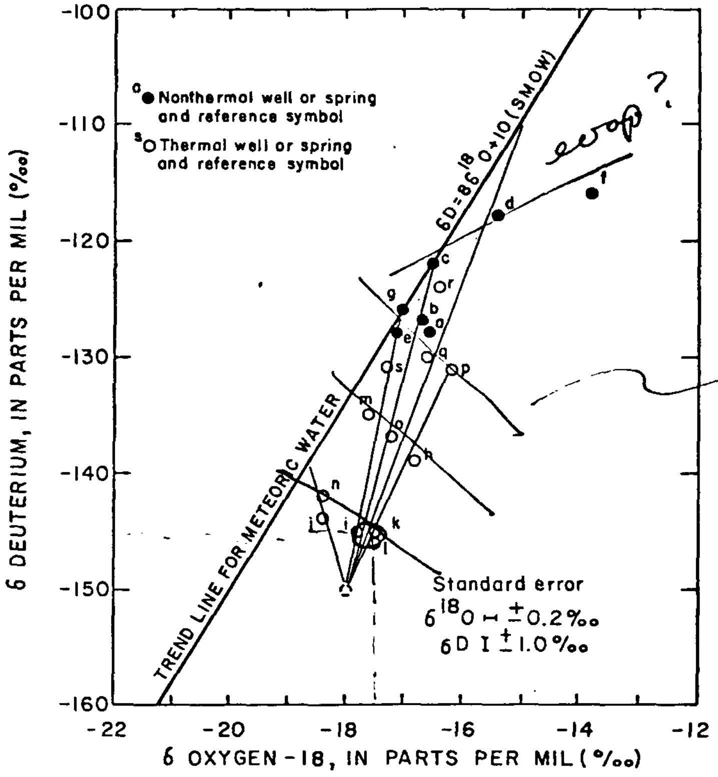
**** In this region of the graphs, lines are so close together as to lie within each others "window" of analytical precision. It is difficult to assign a given value to a given line. Sample 22bdc1 has been assigned to line 2, as temperature verses δD and $\delta^{18}O$ graphs of figures 5 and 6 indicate that this is a more reasonable location.

figure 4, but plots 6.5-7°C to the left of line 2 on both figures 5 and 6. If 6.5°C is added to the temperature of this well, it will also plot on line 2 of both figures 5 and 6. Perhaps, after mixing, the water cools by 6.5°C by conductive heat transfer as the water flows through the aquifer and up the well bore. An example of sample or analytical error might be well 3N-2W-14adal which plots on line 1 of figure 5 only. If a δD value of -4 °/oo is added to the δD value of -137 °/oo reported in the analyses, well 3N-2W-14adal water would plot on line 1 of all three figures. Likewise, if a $\delta^{18}O$ value of -.3 °/oo is subtracted from the $\delta^{18}O$ value of -16.6 °/oo reported in the analyses for well 3N-2W-26ddbl, this data will plot on line 2 of figures 4, 5, and 6. There is considerable scatter in the data related to line 3 of figure 4 when compared to line 3 of figures 5 and 6, and making definite interpretations from this data is difficult.

If this can't be demonstrate

This looks like a random correction; if it is going to be applied, it should be justified better (is this forcing the data to fit the model?).

Figure 7a is a modified plot of isotope data obtained by Young and Lewis (1980) from the Bruneau-Grandview area in southwest Idaho. Convergence of these data points to a water of identical composition as that of the parent geothermal water in the Nampa-Caldwell area (δD = -150, $\delta^{18}O$ = -18) is indicated by the diagram. If the parent water is real in the Bruneau-Grandview area it would indicate (1) considerable mixing of thermal waters in the Bruneau-Grandview area, more so than previously realized, and (2)

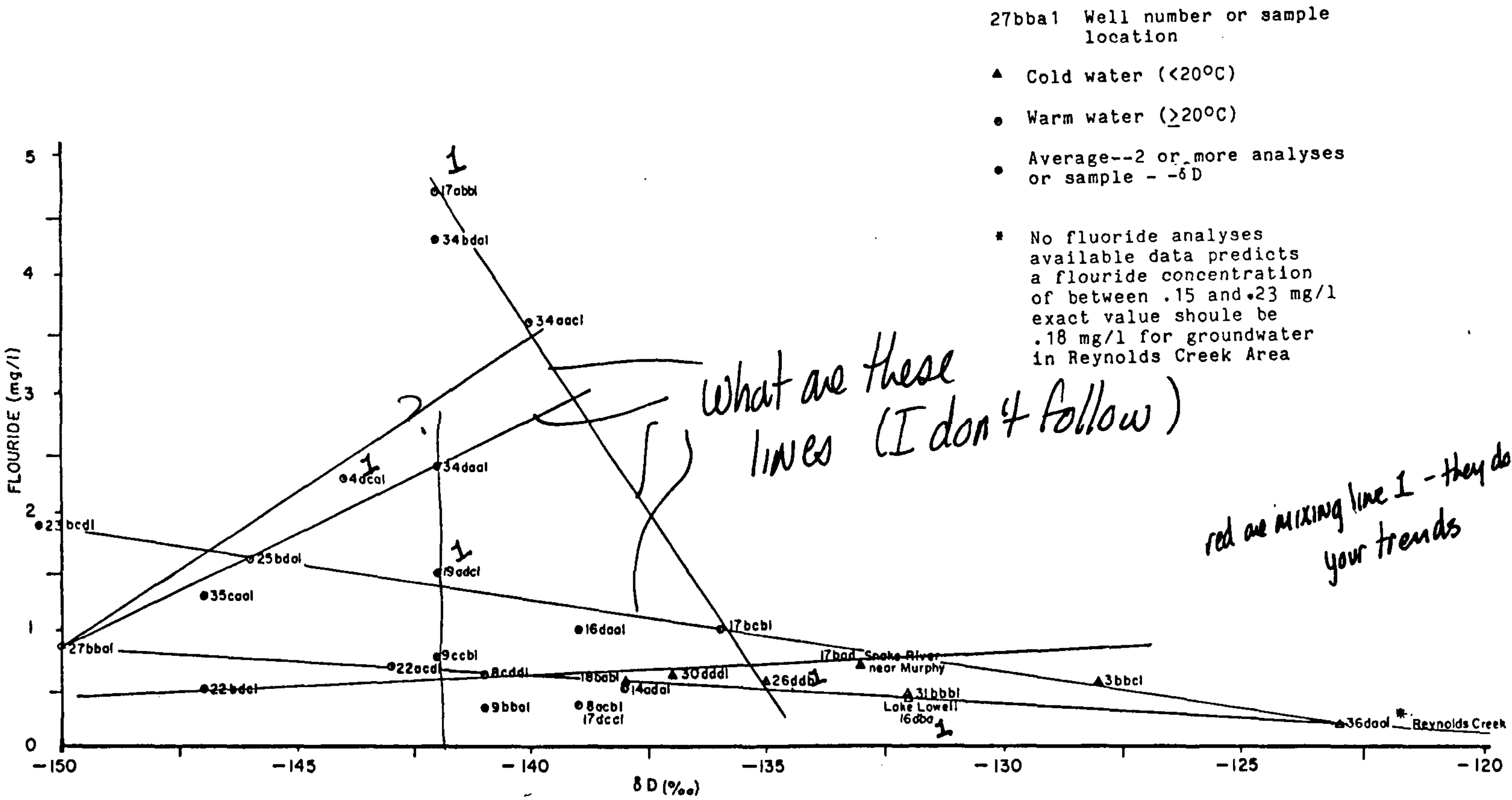


could also draw these trends?

Figure 7a. Isotopic compositions of thermal and nonthermal waters from selected wells and springs in the Bruneau-Grand View and adjacent areas, Owyhee County, Idaho. Modified from Young and Lewis(1980, P.19).

parent geothermal waters in both areas are from the same source and/or time or the systems are interconnected. Also, isotope ratios from geothermal waters found in Ada County near Boise plot on lines 2 and 4. This could indicate that in the Boise area geothermal waters might be mixtures of geothermal water of near identical isotopic composition with water from well 2N-3W-27bbal and waters of isotopic composition similar to Payette River and/or Reynolds Creek water. However, more data from the Boise area are badly needed to confirm this assumption.

Figures 7 and 8 are δD and $\delta^{18}O$ verses fluoride concentrations respectively for waters in the Nampa-Caldwell and adjacent areas. Again, the straight line plots converging to well 2N-3W-27bbal are noted, a result which would be expected if simple mixing of waters is occurring. In addition, the sequence of data points along any line should be consistent on the figures provided the plotted constituent is predominantly supplied by the parent waters and all analyses are correct. As observed on the diagrams, Reynolds stands out as an end member of line 2 provided the average fluoride concentration is between .15 and .23 mg/l for ground waters in the Reynolds Creek basin. A specific value of .18 mg/l is predicted for both plots. No data on flouride concentration in Reynolds Creek basin groundwaters are ~~is~~ available at present. The sequence of data points is consistent between figures 4, 7 and 8 for the data points

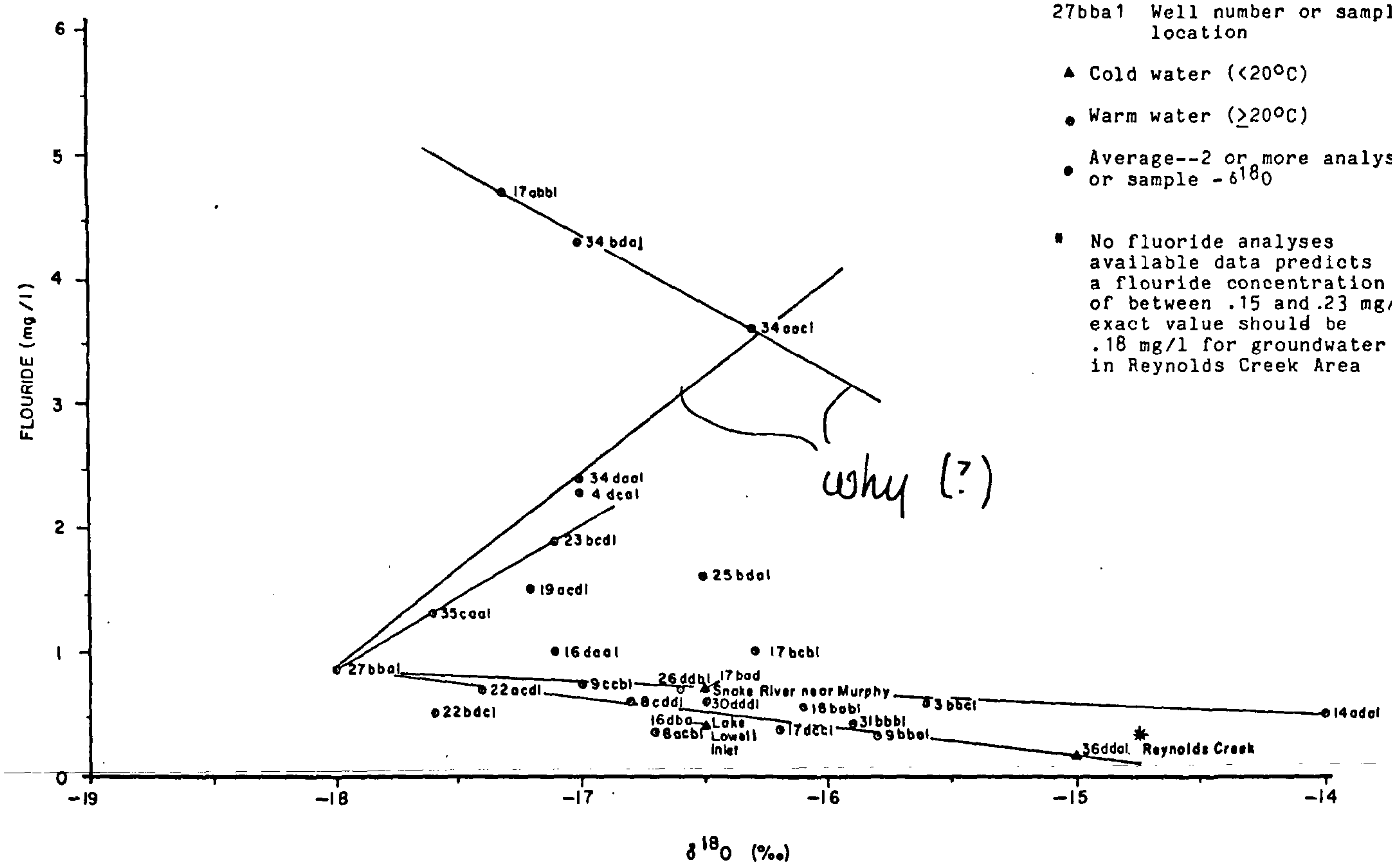


What are these lines (I don't follow)

red are mixing line 1 - they don't fit your trends

FIGURE 7. δD verses fluoride concentrations from selected wells and surface waters in the Nampa-Caldwell and adjacent areas of southwestern Idaho.

FIGURE 8. $\delta^{18}O$ verses fluoride concentrations of water from selected wells and surface waters in the Nampa-Caldwell and adjacent areas of southwestern Idaho.



27bba1 Well number or sample location

▲ Cold water (<20°C)

● Warm water (≥20°C)

● Average--2 or more analyses or sample - $\delta^{18}O$

* No fluoride analyses available data predicts a flouride concentration of between .15 and .23 mg/l exact value should be .18 mg/l for groundwater in Reynolds Creek Area

which fall on line 2 of the diagrams, and suggests that most fluoride in the waters is coming from water represented by well 2N-3W-27bba1.

Again, scatter on the diagrams may be explained by factors previously mentioned, and possibly by ion exchange of fluoride with aquifer minerals and/or solution or precipitation of fluorides in fluoride and other minerals. Also noted, if a δD value of -7 ^{o}/oo is added to sample 3N-2W-14ada1, this sample is merely moved into its proper sequential position on line 2 of figure 7. It still falls close enough to line 2 of figure 7 to be within analytical error.

See Dave's notes / this should be in the geology section

LINEAMENT DATA

Figure 11 shows locations of major lineaments in the western Snake River Plain and isotope sample locations. The linear features were drawn from Landsat false color infrared images obtained from satellite data at 1:1,000,000, 1:500,000 and 1:250,000 scale, enhanced by the EROS Data Center.

Lineament features are noted that cross the Snake River Plain as well as those that nearly parallel the Plain axis as the majority of them do. The lineaments are apparent as faint cultural features and patterns, and, in the case of the Plain axis parallel lineaments (northwest trending),

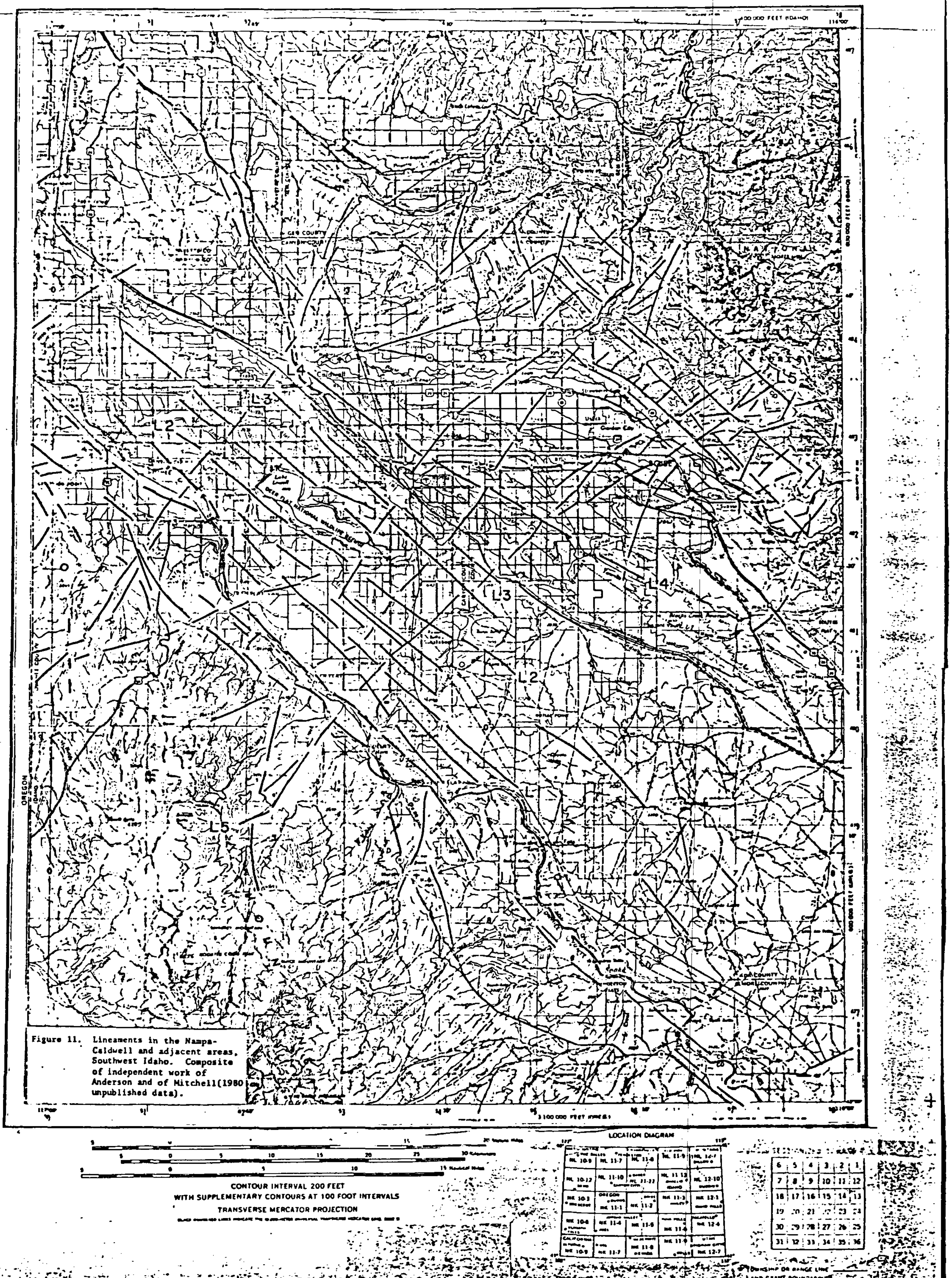


Figure 11. Lineaments in the Nampa-Caldwell and adjacent areas, Southwest Idaho. Composite of independent work of Anderson and of Mitchell(1980 unpublished data).

they are associated with some parts of minor drainages which are also Plain axis parallel. Outside the culturally disturbed area, several of the Plain axis parallel lineaments coincide with volcanic cones, buttes, and domal structures, which also line up Plain axis parallel. Some of the northeast trending lineaments (perpendicular to the Plain axis, or nearly so) can be traced into the mountain ranges flanking both sides of the Plain. In the culturally disturbed portion of the Plain, the lineaments represent edges of topographic features (hills, valleys, and drainages) which force cultivation patterns that become apparent as linear features. These hills, valleys and drainages are thought, in some cases, to be fault bounded. Because of the huge scale at which ground observations or air photo reconnaissance are made, these patterns are not apparent on the ground or on air photos. The correlation of Plain axis parallel lineaments with volcanic features (L_1 and L_2, figure 11) indicates that some of these lineaments may represent some type of fault, fissure, or perhaps a large scale deep seated joint system. Several correlate well with faults found on reflective seismic data (L_3 and L_4) and in the shallow well log data (L_1 and L_4). The fact that several lineaments are seen to cross the Plain and extend into the mountain ranges on either flank of the Plain, indicates that minor recurrent crustal instability may have occurred along the lineament after formation of the

not scientific

major features of the western Snake River Plain. The lineament (L_2) corresponds approximately with Stevens (1962 p. 20) groundwater divide. This lineament passes through Powers Butte, Initial Point and Little Joe Butte in southern Ada County. Other volcanic domes, cones, and buttes are found in similar alignment along both sides of this lineament. The lineament could explain the groundwater divide. Isotope data (figure 4) seem to ignore this divide as data from wells plotting on mixing lines 1, 2, and 3 are found on both sides of the divide. Perhaps the divide leaks, allowing substantial amounts of water to flow through it along faults or through confined aquifers.

The warm water isotope data (line 2, figure 4) generally are found in wells near the Reynolds Creek-Freestone Creek lineament (L_5). Most cold water samples, except near Reynolds, were taken from wells north of Lake Lowell. The position of the cold water wells form a linear relation parallel to the Plain axis. However, well construction, zones perforated, and aquifers penetrated, may have more bearing on which line of figure 4 the isotope data from a particular well plots than does its location with respect to other geologic features.

This doesn't fit here

The isotope data is considered remarkably consistent for an area as large as encompassed by this study and as complex as the water regime in the area appears to be. The i$\overset{o}{s}$tope data furnish constraints within which interpretations of other geochemical data must lie in order to be considered valid.

CHEMICAL DATA

Water quality samples from 48 locations (figure 9a in pocket) in the Nampa-Caldwell area were collected for chemical analyses during the summer of 1979. Water quality data ~~from analyses~~ from various sources (mostly Stevens, 1962) are also included and shown in Table 2. Data from Table 2 show that ground water in the Nampa-Caldwell area is not homogeneous ~~consistent~~ in chemical composition for ~~in~~ any area sampled. The pH values ranges from 7.7 to 8.8. Total dissolved solids ranges from 157 to 1571, (obvious) ~~an order of magnitude difference~~. Calcium ranges from 1.6 to 175 mg/l and sodium from 16 to 726 mg/l. Fluoride ranges from 0.29 to 4.3 mg/l, while chloride ranges from 5.8 to 240 mg/l. These are not considered extremely large fluctuations, but are variable enough and sufficiently inconsistent areally to make interpretations based on water chemistry alone extremely difficult and uncertain.

Available water chemistry suggest that significant environmental problems would probably not result from direct use of the thermal water for space heating purposes, provided sufficient recharge for the aquifers exists. However, users of thermal water are cautioned to obtain more data,

TABLE 2.

CHEMICAL ANALYSES OF THERMAL AND NONTHERMAL WATERS FROM THE NAMPA-CALDWELL AREA

CANYON COUNTY, IDAHO

(Chemical Constituents in Mg/l)

→ lowercase mg/l

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l or 1

Spring or Well Identification Number and Name	Sample Collection Date	Measured Surface Temperature °C	Reported Well Depth below Land Surface (meters)	Discharge est (l/min)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Boron (B)	Ammonia (NH_3)	Specific Conductance (umhos) (field)	pH (field)	Total Dissolved Solids (TDS)	Hardness		Alkalinity as $CaCO_3$	Percent Sodium (%Na)	Sodium Absorption Ratio (SAR)	Cation-Anion Balance (milliequivalence)	Data Reference*
																						Carbonate	Non-Carbonate					
GEORGE ASH WELL 4N 4W 4DCC1	9/14/78	21	128.	295.	82	19.0	1.70	56	7.30	268.	0.0	1.70	0.06	6.2	1.80	0.06	-	-	350	7.6	307	54.	0.	220.	65.6	3.3	-12.628	10
GEORGE WRIGHT JR WELL 4N 4W 5DBD1	9/19/78	24	-	227.	95	17.0	1.20	70	7.30	256.	0.0	2.50	0.04	5.9	1.60	4.40	-	-	355	7.7	330	47.	0.	210.	72.9	4.4	-4.697	10
SIMPLOT FEEDLOT RICHARDSON #1 WELL 4N 3W 19ADC1	9/11/78	40	-	189.	94	6.0	0.90	160	8.30	468.	0.0	3.20	0.02	5.8	1.50	0.07	-	-	680	7.8	509	19.	0.	384.	92.2	16.1	-3.341	10
PIONEER IRRIGATION DIST 3N 3W 3BBC1	6/29/79	13	34.	1514.	48	53.0	20.00	97	3.10	368.	0.0	78.00	0.11	21.0	0.57	7.10	-	-	826	7.3	508	214.	0.	302.	49.1	2.9	1.124	10
J M HOUSE WELL 3N 3W 6DCD1	6/29/79	17	78.	757.	38	63.0	16.00	59	6.20	233.	0.0	124.00	0.01	41.0	0.49	2.60	-	-	733	7.2	464	223.	32.	191.	35.7	1.7	-2.956	10
LLOYD KADEL WELL 3N 3W 16BDD1	6/29/79	11	30.	378.	41	41.0	11.00	83	4.20	234.	0.0	114.00	0.06	21.0	0.75	2.30	-	-	648	7.4	433	148.	0.	192.	54.1	3.0	-1.571	10
LAKE LOWELL OUTLET 3N 3W 19DCB	6/29/79	23	-	-	2	21.0	4.30	16	2.10	111.	12.00	17.00	0.01	5.1	0.45	0.34	-	-	205	8.2	134	70.	0.	111.	32.4	0.8	-12.683	10
HARRY FOGILATTI WELL 3N 3W 23CCC1	6/29/79	12	-	757.	45	36.0	11.00	39	3.30	190.	0.0	50.00	0.04	21.0	0.52	0.98	-	-	452	7.2	300	135.	0.	156.	37.9	1.5	-3.268	10
O W GRIFFIN WELL 3N 3W 26BCA1	6/29/79	17	93.	757.	36	35.0	9.00	57	5.10	183.	0.0	74.00	0.03	25.0	0.58	0.72	-	-	486	7.2	332	124.	0.	150.	48.6	2.2	-1.770	10
LESTER WALKER WELL 3N 3W 30DDD1	6/14/79	16	-	757.	61	120.0	37.00	87	7.70	287.	0.0	265.00	0.04	98.0	0.60	0.27	-	-	1239	7.4	817	452.	216.	235.	29.1	1.8	-0.105	10
A H BRUCK WELL 3N 3W 36ADC1	6/14/79	12	-	378.	38	53.0	13.00	75	2.30	238.	0.0	123.00	0.06	22.0	0.72	2.00	-	-	663	7.5	446	186.	0.	195.	46.4	2.4	-0.905	10
~~PIONEER IRRIGATION DIST~~ 3N 2W 10ABA1	7/16/79	38	16.	114.	33	1.6	~~0.0~~	~~68~~	~~0.50~~	~~109.~~	~~17.00~~	~~19.00~~	~~0.08~~	9.0	14.00	0.07	-	-	314	8.6	215	4.	0.	118.	97.0	14.8	-10.387	10
STATE HOSPITAL WELL 3N 2W 14ADA1	9/12/78	22	213.	3406.	35	24.0	3.40	26	1.40	104.	0.0	36.00	0.02	14.0	0.50	0.74	-	-	225	7.7	192	74.	0.	85.	42.8	1.3	-5.028	10
CITY OF NAMPA WELL #1 3N 2W 17BCB1	9/12/78	24	23.	2271.	42	15.0	3.20	35	2.50	195.	0.0	6.40	0.02	6.1	1.00	0.53	-	-	230	7.6	207	51.	0.	160.	58.6	2.1	-16.096	10
CITY OF NAMPA WELL #2 3N 2W 23BCD1	9/12/78	31	57.	1703.	36	7.8	0.60	66	0.90	199.	0.0	1.90	0.03	4.1	1.90	0.17	-	-	300	7.7	217	22.	0.	163.	86.1	6.1	-3.798	10
CLIFF WALLER WELL 3N 2W 26DDB1	6/ 4/79	18	34.	378.	37	83.0	20.00	87	5.40	298.	0.0	174.00	0.01	38.0	0.68	4.30	-	-	878	7.5	595	289.	45.	244.	39.0	2.2	0.090	10

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*DATA REFERENCE:

1 = ROSS, 1971	9 = SWANSON, 1977
2 = CATER, ET AL., 1973	10 = MITCHELL, UNPUBLISHED, 1978
3 = YOUNG AND MITCHELL, 1973	11 = TSCHANG, ET AL., 1974
4 = YOUNG AND WHITEHEAD, 1975A	12 = USGS WRD FILE
5 = YOUNG AND WHITEHEAD, 1975B	13 = STOKER, UNPUBLISHED, 1977
6 = MITCHELL, 1976A	14 = YOUNG, 1977
7 = MITCHELL, 1976B	- = DATA NOT AVAILABLE FOR CALCULATION
8 = MITCHELL, 1976C	

Table 1. Chemical Analyses of Thermal and Nonthermal Waters from the Nampa-Caldwell Area (continued)

Spring or Well Identification Number and Name	Sample Collection Date	Measured Surface Temperature °C	Reported Well Depth below Land Surface (meters)*	Discharge (l/min)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Boron (B)	Ammonia (NH_3)	Specific Conductance (μmhos) (field)	pH (field)	Total Dissolved Solids (TDS)	Hardness		Alkalinity as $CaCO_3$	Percent Sodium (%Na)	Sodium Absorption Ratio (SAR)	Cation-Anion Balance (milliequivalence)	Data Reference*
																						Carbonate	Non-Carbonate					
DEMOND DEPPE WELL 3N 2W 31BBB1	6/14/79	15	49.	378.	42	140.0	34.00	121	7.10	257.	0.0	360.00	0.06	104.0	0.43	4.50	-	-	1389	7.4	939	489.	278.	211.	34.6	2.4	1.635	10
NAFSINGER FARMS WELL 2N 3W 5BB 1	8/27/65	17	-	-	0	72.0	26.00	65	6.00	261.	0.0	126.00	0.0	51.0	0.0	22.00	-	0.52	8449	7.3	496	287.	73.	214.	32.5	1.7	0.091	15
FALLON WELL 2N 3W 7AA 1	8/27/65	18	58.	-	0	67.0	19.00	52	4.00	413.	0.0	21.00	0.0	3.0	0.0	4.00	-	0.33	6649	7.4	373	245.	0.	338.	31.1	1.4	-0.581	15
FRANK RAWLINGS WELL 2N 3W 8CDD1	6/14/79	22	149.	3406.	60	65.0	15.00	48	8.00	226.	0.0	120.00	0.04	24.0	0.61	0.36	-	-	667	7.4	452	224.	39.	185.	30.8	1.4	-1.056	10
GLENN KNAPP WELL #1 2N 3W 8DA 1	8/28/56	18	85.	-	0	37.0	13.00	36	6.00	147.	0.0	61.00	0.0	24.0	0.0	6.00	-	0.32	4709	7.7	255	146.	25.	120.	33.8	1.3	1.992	15
GLENN KNAPP WELL #2 2N 3W 9BC 1	8/27/56	16	68.	-	0	35.0	10.00	33	3.00	125.	0.0	56.00	0.0	20.0	0.0	3.00	-	0.14	4189	8.2	221	128.	26.	102.	35.2	1.3	3.202	15
LEROY NIELSON WELL 2N 3W 11CBA1	6/29/79	21	-	1135.	47	23.0	4.50	36	3.60	117.	0.0	29.00	0.02	10.0	0.87	0.65	-	-	326	6.7	212	76.	0.	96.	49.3	1.8	4.510	10
BRYCE MILLAR WELL 2N 3W 15DCD1	6/15/79	26	221.	30.	61	53.0	9.20	74	6.30	238.	0.0	120.00	0.04	21.0	0.93	457.00	-	-	675	7.9	919	170.	0.	195.	47.5	2.5	-36.177	10
BARLOW INC WELL 2N 3W 22ACD1	6/15/79	27	186.	3406.	54	45.0	10.00	62	5.80	206.	0.0	112.00	0.03	26.0	0.69	0.38	-	-	587	7.8	417	153.	0.	169.	45.6	2.2	-4.747	10
SPENCER FARMS WELL 2N 3W 22CB 1	5/ 6/54	27	-	-	0	40.0	11.00	55	6.50	242.	0.0	62.00	0.0	8.0	0.60	0.0	-	0.28	5089	8.0	302	145.	0.	198.	43.8	2.0	-0.624	15
CANNON FARMS WELL #5 2N 3W 22DDC1	8/27/75	27	56.	-	50	39.0	11.00	55	4.90	183.	0.0	88.00	0.0	16.0	0.50	0.0	-	-	513	7.9	354	143.	0.	150.	44.6	2.0	0.332	9
BARLOW INC WELL 2N 3W 22DDC1	6/15/79	28	-	757.	51	43.0	9.5	53	6.00	177.	0.0	109.00	0.04	20.0	0.51	0.83	-	-	549	7.9	379	146.	1.	145.	42.8	1.9	-3.773	10
ELMER TIEGS WELL #1 2N 3W 23ACD1	6/28/79	28	-	757.	54	18.0	1.70	83	4.80	242.	0.0	29.00	0.04	10.0	2.20	0.05	-	-	484	7.5	321	52.	0.	198.	75.7	5.0	-2.859	10
R E BALLEY WELL 2N 3W 23CC 1	8/28/56	23	-	-	0	24.0	10.00	61	6.00	194.	0.0	44.00	0.0	22.0	0.0	1.00	-	0.33	4759	7.8	263	101.	0.	159.	55.0	2.6	0.984	15
NAITO BROTHERS WELL #1 2N 3W 25BDA1	6/28/79	26	178.	1135.	44	13.0	2.00	67	2.70	206.	5.00	8.00	0.01	7.1	1.60	0.03	-	-	386	7.2	251	41.	0.	177.	76.8	4.6	-2.771	10
NAITO BROTHERS WELL #2 2N 3W 26AAC1	6/28/79	25	229.	1135.	35	19.0	6.20	53	4.70	157.	0.0	47.00	0.05	15.0	0.70	0.33	-	-	388	6.7	258	73.	0.	129.	59.4	2.7	-2.092	10
BARLOW INC WELL #1 2N 3W 27BBA1	6/15/79	30	-	757.	77	50.0	13.00	72	15.00	201.	0.0	200.00	0.06	11.0	0.85	0.15	-	-	763	7.8	537	178.	13.	165.	44.2	2.3	-4.955	10
D W FROST WELL 2N 3W 34DB 1	8/27/56	27	111.	-	0	29.0	16.00	126	13.00	164.	0.0	268.00	0.0	8.0	0.0	1.00	-	0.26	8589	8.4	541	138.	4.	134.	63.9	4.7	0.370	15
CHARLES PINTLER WELL #1 2N 3W 35CAA1	6/28/79	28	155.	1135.	44	9.0	1.40	77	5.10	178.	7.00	61.00	0.02	8.1	1.30	0.06	-	-	449	7.5	301	28.	0.	158.	82.8	6.3	-8.138	10

Table 1. Chemical Analyses of Thermal and Nonthermal Waters from the Nampa-Caldwell Area (continued)

Spring or Well Identification Number and Name	Sample Collection Date	Measured Surface Temperature °C	Reported Well Depth below Land Surface (meters)	Discharge (l/min)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Boron (B)	Ammonia (NH_3)	Specific Conductance (µmhos) (field)	pH (field)	Total Dissolved Solids (TDS)	Hardness Carbonate	Hardness Non-Carbonate	Alkalinity as $CaCO_3$	Percent Sodium (%Na)	Sodium Absorption Ratio (SAR)	Cation-Anion Balance (milliequivalence)	Data Reference*
CHARLES PINTLER WELL #2 2N 3W 35CA 1	8/27/56	27	155.	-	0	6.0	1.00	77	4.00	198.	5.00	17.00	0.0	6.0	0.0	0.0	-	0.27	3879	8.6	213	19.	0.	171.	87.4	7.7	-1.308	15
ORVAL PEALEY WELL 2N 2W 2ACC1	6/13/79	15	24.	30.	40	73.0	16.00	82	6.70	265.	0.0	155.00	0.04	36.0	0.34	3.70	-	-	801	7.5	543	248.	31.	217.	41.0	2.3	0.136	10
ROGER HUNGERFORD WELL 2N 2W 4DCA1	6/ 4/79	23	96.	1514.	23	12.0	1.70	75	1.30	206.	2.00	17.00	0.01	20.0	2.30	0.24	-	-	409	8.4	255	37.	0.	172.	80.9	5.4	-6.075	10
ALLEN BROTHERS INC WELL 2N 2W 16DAA1	6/14/79	26	-	2649.	62	30.0	4.40	66	5.90	222.	0.0	69.00	0.05	16.0	1.00	0.14	-	-	506	0.0	363	93.	0.	182.	58.8	3.0	-7.271	10
STEPHEN HENNIS WELL 2N 2W 18BAB1	6/28/79	14	15.	378.	39	34.0	13.00	44	2.80	251.	0.0	64.00	0.08	7.1	0.55	4.40	-	-	451	7.2	332	138.	0.	206.	40.3	1.6	-9.665	10
R BOEHLKE WELL 2N 2W 21CBC1	8/26/75	20	-	3028.	6	37.0	5.10	43	11.00	212.	0.0	42.00	0.0	22.0	0.70	0.01	-	-	485	8.0	271	113.	0.	174.	42.3	1.8	-6.346	12
BRIAN M HOWARD WELL 2N 2W 27AAA1	6/ 7/79	22	87.	30.	28	40.0	4.40	79	2.10	166.	0.0	138.00	0.0	38.0	0.92	2.40	-	-	639	7.6	414	118.	0.	136.	58.8	3.2	-7.449	10
CARL AGENBROAD WELL #1 2N 2W 27ABB1	6/ 7/79	23	-	1798.	22	27.0	4.30	112	1.80	237.	0.0	112.00	0.0	28.0	2.50	1.10	-	-	645	8.1	427	85.	0.	194.	73.6	5.3	-4.235	10
CARL AGENBROAD WELL #2 2N 2W 27DAB1	6/ 7/79	22	147.	3028.	20	16.0	2.30	138	1.40	233.	0.0	145.00	0.0	32.0	2.50	0.25	-	-	721	8.1	472	49.	0.	191.	85.4	8.5	-5.937	10
HAROLD TIEGS WELL #1 2N 2W 31CDD1	6/13/79	24	244.	1514.	31	53.0	6.80	47	3.20	156.	0.0	107.00	0.07	21.0	0.55	0.03	-	-	513	7.5	346	160.	32.	128.	38.4	1.6	-1.406	10
C R DAVENPORT WELL 2N 2W 31DAD1	6/11/79	22	160.	757.	27	29.0	4.00	34	3.00	127.	0.0	48.00	0.03	16.0	0.46	0.28	-	-	233	8.0	224	89.	0.	104.	44.4	1.6	-3.282	10
LEWIS CASSIDY WELL 2N 2W 33CCC1	10/ 7/75	15	-	11.	64	33.0	6.60	68	18.00	268.	0.0	52.00	0.0	29.0	0.80	0.05	-	-	554	7.8	403	109.	0.	220.	52.7	2.8	-6.535	12
DALE GROSS WELL 2N 2W 34AAC1	6/ 4/79	29	103.	568.	32	2.4	0.50	130	0.90	268.	22.00	80.00	0.02	38.0	3.60	0.05	-	-	673	8.8	441	8.	0.	256.	96.9	19.9	-16.484	10
JAY C NEIDER WELL #1 2N 2W 34BDA1	9/13/78	48	196.	1892.	38	9.0	0.20	140	1.00	278.	8.40	61.00	0.02	20.0	4.30	10.00	-	-	600	8.4	432	23.	0.	242.	92.5	12.6	-3.632	10
JAY C NEIDER WELL #2 2N 2W 34CDA1	6/ 7/79	30	85.	378.	24	19.0	3.60	90	2.80	249.	0.0	43.00	0.0	30.0	2.80	0.10	-	-	576	8.1	337	62.	0.	204.	74.8	5.0	-7.272	10
~~JAY C NEIDER WELL #3~~ 2N 2W 34DAA1	9/13/78	31	98.	378.	31	100.0	0.30	190	1.10	238.	0.0	180.00	0.0	68.0	2.40	0.04	-	-	930	8.6	689	251.	56.	195.	62.1	5.2	15.605	10
FRANK BLICK WELL 1N 3W 18BC1	6/15/79	21	-	30.	67	130.0	45.00	94	19.00	332.	0.0	350.00	0.02	62.0	0.51	3.30	-	-	1349	7.3	934	509.	237.	272.	27.7	1.8	0.699	10
ELMER TIEGS WELL #2 1N 3W 12BAB1	6/28/79	29	392.	757.	79	22.0	7.00	83	20.00	256.	0.0	107.00	0.08	8.1	1.40	0.09	-	-	640	7.3	453	84.	0.	210.	62.3	3.9	-7.457	10

Table 1. Chemical Analyses of Thermal and Nonthermal Waters from the Nampa-Caldwell Area (continued)

Spring or Well Identification Number and Name	Sample Collection Date	Measured Surface Temperature °C	Reported Well Depth below Land Surface (meters)	Discharge (l/min)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Boron (B)	Ammonia (NH_3)	Specific Conductance (µmhos) (field)	pH (field)	Total Dissolved Solids (TDS)	Hardness: Carbonate	Hardness: Non-Carbonate	Alkalinity as $CaCO_3$	Percent Sodium (%Na)	Sodium Absorption Ratio (SAR)	Cation-Anion Balance (milliequivalence)	Data Reference*
RON CASSIDY WELL 1N 2W 9AAA1	6/ 7/79	22	174.	30.	25	13.0	1.20	39	2.00	120.	0.0	11.00	0.0	16.0	0.38	0.0	-	-	250	8.1	166	37.	0.	98.	68.0	2.8	-3.665	10
NORMAN R COLE WELL #1 1N 2W 9BBA1	6/ 8/79	22	200.	1514.	28	26.0	4.30	36	2.80	113.	0.0	56.00	0.0	24.0	0.34	0.02	-	-	320	7.9	233	83.	0.	93.	47.6	1.7	-6.756	10
NORMAN R COLE WELL #2 1N 2W 9CCB1	6/ 8/79	24	157.	757.	35	37.0	6.00	67	5.10	161.	0.0	85.00	0.0	38.0	0.75	0.59	-	-	554	7.6	353	117.	0.	132.	54.1	2.7	-1.273	10
HYRUM MOON WELL 1N 2W 9DDD1	9/12/75	16	-	38.	57	69.0	28.00	59	30.00	451.	0.0	33.00	0.70	6.6	0.60	5.00	-	-	766	7.5	510	287.	0.	370.	28.3	1.5	3.892	12
ROBERT PORTER WELL 1N 2W 10BA 1	8/27/56	21	135.	-	0	19.0	8.00	20	2.00	112.	0.0	15.00	0.0	7.0	0.0	3.00	-	0.10	2479	7.7	129	80.	0.	92.	34.4	1.0	2.708	15
C RICHARD GUNWING WELL 1N 2W 11AAA1	6/13/79	18	213.	568.	47	18.0	7.70	28	4.30	123.	0.0	25.00	0.06	11.0	0.33	0.95	-	-	283	7.6	202	77.	0.	101.	42.6	1.4	-1.273	10
DONALD TIEGS WELL #3 1N 2W 16CBA1	6/ 8/79	18	-	2649.	34	73.0	20.00	68	6.10	209.	0.0	170.00	0.0	42.0	1.30	7.10	-	-	80999	7.6	524	264.	93.	171.	35.2	1.8	0.393	10
OPAL TIEGS WELL #1 1N 2W 16CB 1	8/28/56	26	-	-	0	92.0	34.00	69	7.00	134.	0.0	225.00	0.0	96.0	0.0	26.00	-	0.34	10699	8.1	614	369.	260.	110.	28.4	1.6	2.702	15
OPAL TIEGS WELL 1N 2W 16CB 1	5/ 6/54	20	-	-	0	83.0	29.00	72	6.30	136.	0.0	217.00	0.0	89.0	0.60	23.00	-	0.20	9499	7.8	586	326.	215.	111.	31.9	1.7	0.765	15
KENNETH TIEGS WELL #1 1N 2W 17DA 1	8/28/56	22	136.	-	0	39.0	15.00	69	6.00	181.	0.0	93.00	0.0	59.0	0.0	11.00	-	0.19	6689	7.7	380	159.	11.	148.	47.4	2.4	-3.143	15
KENNETH TIEGS WELL #2 1N 2W 17DCC1	6/ 8/79	21	206.	946.	39	145.0	72.00	86	12.00	185.	0.0	448.00	0.0	165.0	0.38	13.00	-	-	1659	7.4	1071	658.	506.	152.	21.7	1.5	-0.131	10
KENNETH TIEGS WELL #3 1N 2W 17DC 1	8/28/56	23	207.	-	0	50.0	29.00	60	9.00	193.	0.0	138.00	0.0	50.0	0.0	12.00	-	0.08	7869	7.7	442	244.	86.	158.	33.8	1.7	0.507	15

??

particularly on contaminants such as hydrogeon sulfide, boron, arsenic, mercury, and radiological contaminants as a precaution against water born chemical pollutants.

Figure 9 is a trilinear plot of the Nampa-Caldwell water chemistry data. It shows the variability in chemical constituents of groundwaters in the area. The linear relations among certain wells on the plot might be interpreted as mixing, and, on the cation field the plots seem to merge toward well 2N-3W-27bbal as does the isotope data. The scatter of data, however, on the diagram makes simple mixing, except for a few wells in scattered locations, uncertain based on the trilinear diagram alone.

If the waters aren't chemically simple mixing, how can they be isotopically simple mixing?

Stevens (1962) reviewed the water chemistry available to him in southern Canyon County and was able to separate water from wells in the area into five groups according to source or aquifer from which the water was obtained. According to Stevens, native Idaho Formation water, or Glenns Ferry water using present terminology, was distinguished as being high in sodium and bicarbonate, with appreciable amounts of carbonate. This type of water is represented by water from wells 2N-3W-35cal, 1N-3W-12bal, 1N-2W-6adl and 1S-2W-17abl. Mixtures of Glenns Ferry and canal seepage was distinguished by relatively low dissolved solids from wells 1N-2W-3cbl, 4dal, 5cbl, 8abl and 10bal. Mixed Glenns Ferry and applied irrigation water was characterized by high dissolved solids roughly 27bbal

27bbal

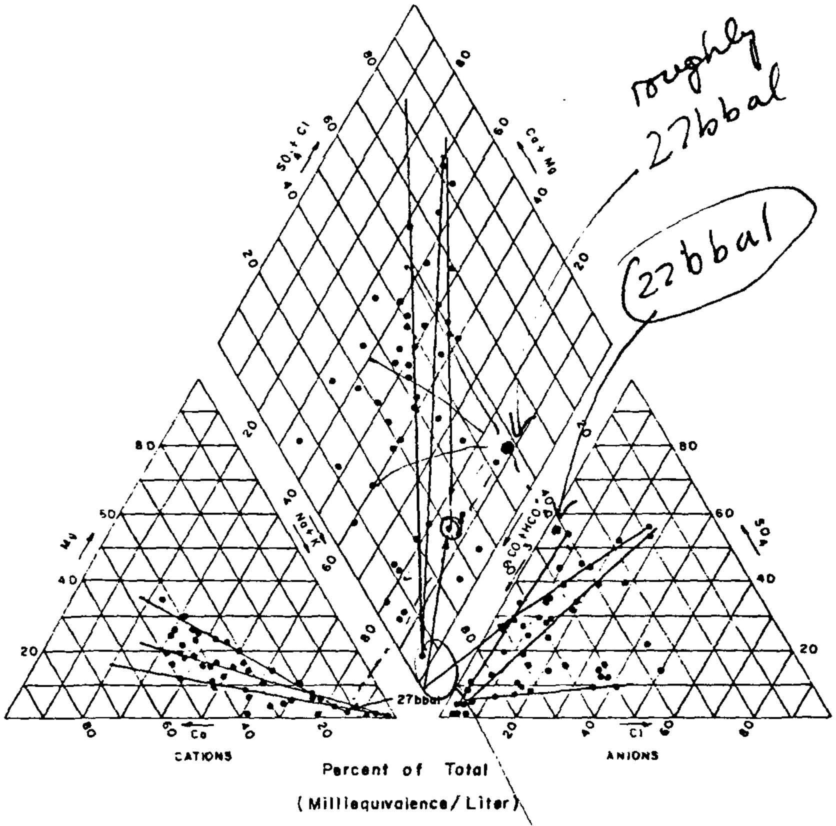


FIGURE 9. Trilinear diagram showing variations of chemical constituents in water sampled in the Nampa-Caldwell area, Canyon County, Idaho.

Why is this out of the diamond field?

most confusing

and higher proportions of calcium, sulfate, chloride and nitrate than native Glenns Ferry Formation water, Stevens (1962). This water was represented by wells 2N-3W-5bbl, 7aal, 8dal, 9bcl, 22bcl and 23ccl; 1N-2W-16cbl, 17adl and 17dcl. Stevens recycled water was represented by well 2N-3W-34dbl, and distinguished by high dissolved solids and a chemical composition classed as a sodium sulfate type water.

A Snake River Basalt water was identified by Stevens south of the present study area that is a calcium magnesium bicarbonate water, but contaminated with irrigation water. In addition to the above possibilities, Snake River water is now pumped to the farmland above the river in the southern part of Canyon County and is thought to contribute to the groundwater supply in some parts of the area. Its effects on the water chemistry of the area are not known, but may be similar to canal seepage water by contributing to the dilution of native Glenns Ferry Formation water. This relationship is, however, not clearly understood.

The isotope data tend to support Stevens contention of extended areas of mixing of waters from various sources in the Nampa-Caldwell area. Well 2N-3W-35cal is dominated by Glenns Ferry Formation water with only minor amounts of water from other sources involved. Certain waters, notably well 2N-2W-4dcl, (Stevens mixed canal seepage-Glenns Ferry water) does not fit the isotope data. It should plot on line 1 of figure 2 but plots instead on line 4. Isotopic data from wells 1N-2W-3cb1 and 1N-2W-17ad1, Stevens mixed Glenns Ferry-applied irrigation waters, fall on line 3 and 4 of figure 4. These data should fall on line one. The scatter in data and ~~enrichment~~ depletion in δD on these lines compared to other lines may be due to evaporation process during application of the irrigation water via either sprinkler or corrugate irrigation practices.

Obviously, the groundwater system in the Nampa-Caldwell area and chemical changes involved are more complex than previously realized, and are still not completely understood.

I agree.

CHEMICAL GEOTHERMOMETERS

Preliminary evaluations of geothermal systems are being successfully conducted using chemical geothermometers. In the Raft River Valley of southeastern Idaho, the reliability of these geothermometers has been tested by deep drilling. The silica, sodium-potassium-calcium (Na-K-Ca) predicted aquifer temperatures, (Young and Mitchell, 1973) and mixing model calculations (Young and Mitchell, 1973, unpublished data) agreed very closely (within 10°C) with temperatures found at depth (Kunze, 1975). This proven reliability in the Raft River Valley gives some measure of confidence in applying the same methods to other areas of the state.

but - in lower Temp systems ?.

The degree of reliability to be placed on a chemical geothermometer depends on many factors. A detailed description of the basic assumptions, cautions and limitations for these chemical geothermometers is included in the references in the bibliography. cite them! The basic assumption is that the chemical character of the water obtained by temperature dependent equilibrium reactions in the thermal aquifer is conserved from the time the water leaves the aquifer until it reaches the surface. The concentration of certain chemical constituents dissolved in the thermal waters can, therefore, be used to estimate aquifer temperatures.

It is probably worth listing the assumptions

Aquifer temperatures calculated from the chemical geothermometers, mixing models, atomic and molecular ratios of selected elements found in groundwater of the Nampa-Caldwell area are given in Table 3. These were calculated from values of concentration found in Table 2.

Figures 12, 13, and 14 are plots of quartz, chalcedony and ∝ christobalite calculated aquifer temperatures vs. Na-K-Ca calculated temperatures, respectively, obtained from Table 3. Fournier and others (1979) used plots of this nature to determine probability of mixing or chemical disequilibrium conditions. Provided that cation ratios remain unchanged, waters that plot on or near the equal temperature line are generally considered to be unmixed waters in chemical equilibrium with aquifer constituents. Substantial departure from the line (above) may represent waters which have either: (1) undergone evaporation, or (2) have dissolved excess silica from aquifer constituents. Waters that plot below the equal temperature line may be mixed waters, or waters that have lost dissolved silica or calcium by precipitation.

Cite references on unmixed water

As shown by figure 12 (quartz calculated aquifer, ach. temperatures) most waters plotted fall a considerable distance above the equal temperature line indicating considerably more reported silica in solution than can be explained by assuming quartz equilibrium. Exceptions might be well 2N-3W-35ccal, which plots close to the equal temperature line. Isotopic data for well 2N-2W-34bdal, which plots near

which is expected in basalt terrain

ESTIMATED AQUIFER TEMPERATURES, ATOMIC AND MOLAR RATIOS OF SELECTED CHEMICAL CONSTITUENTS, FREE ENERGIES OF FORMATION OF SELECTED MINERALS, PARTIAL PRESSURES OF CO_2 GAS AND R VALUES FROM SELECTED THERMAL SPRINGS AND WELLS IN THE NAMPA-CALDWELL AREA

CANYON COUNTY, IDAHO

Spring/Well Identification Number & Name	Discharge (l/min.)	Measured Surface Temperature (°C)	Aquifer Temperatures and Percentage of Cold Water Estimated from Chemical Geothermometers (see footnotes)													Atomic Ratios							Molar Ratios						Free Energies of Formation of			Partial Pressure of CO_2 Gas (atmospheres)	R= Magnesium / Magnesium + Calcium + Potassium
																Sodium / Potassium	Sodium / Calcium	Magnesium / Calcium	Calcium / Fluoride	Chloride / Boron	Chloride / Fluoride	Calcium / Sodium	Calcium / Bicarbonate	Chloride / Carbonate & Bicarbonate	Ammonia / Chloride	Ammonia / Fluoride	Chloride / Sulfate	$\sqrt{\text{Calcium}}$ / Sodium	Quartz	Chalcedony	Amorphous Silica		
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	$\%_9$	$\%_{11}$	$\frac{Na}{K}$	$\frac{Na}{Ca}$	$\frac{Mg}{Ca}$	$\frac{Ca}{F}$	$\frac{Cl}{B}$	$\frac{Cl}{F}$	$\frac{Ca}{Na}$	$\frac{Ca}{HCO_3}$	$\frac{Cl}{CO_3 + HCO_3}$	$\frac{NH_4}{Cl}$	$\frac{NH_4}{F}$	$\frac{Cl}{SO_4}$	$\frac{\sqrt{Ca}}{Na}$	$\frac{\Delta G}{\text{Quartz}}$	$\frac{\Delta G}{\text{Chalcedony}}$	$\frac{\Delta G}{\text{Amorphous}}$	PCO_2	$\frac{Mg}{Mg+Ca+K}$
GEORGE ASH WELL 4N 4W 4DCC1	295.	21	126	123	75	98	83	83	217	135	999	251	999	-	-	13.0	5.14	0.15	1.85	-	5.00	0.19	0.11	0.04	-	[illegible]	9.88	8.94	1.58	[illegible]	0.27	0.00651	11.0
GEORGE WRIGHT JR WELL 4N 4W 5DBD1	227.	24	134	130	83	107	88	88	188	132	999	239	999	-	-	16.3	7.18	0.12	1.98	-	5.04	0.14	0.10	0.04	-	-	6.39	6.76	1.62	1.03	0.31	0.00517	8.7
SIMPLOT FEEDLOT - RICHARDSON WELL #1 4N 3W 19ADC1	189.	40	133	129	83	106	156	151	118	115	999	177	291	-	91	32.8	46.49	0.25	2.07	-	1.90	0.02	0.02	0.02	-	-	4.91	1.76	1.37	0.82	0.06	0.00955	12.6
PIONEER IRRIGATION DIST 3N 3W 3BBC1	1514.	13	99	100	49	69	43	43	80	75	999	999	999	-	-	53.2	3.19	0.62	19.75	-	44.08	0.31	0.22	0.10	-	-	0:73	8.62	1.40	0.78	0.08	0.01509	-
J M HOUSE WELL 3N 3W 6DCD1	757.	17	89	91	39	58	54	54	189	111	999	178	999	-	-	16.2	1.63	0.42	44.85	-	60.95	0.61	0.41	0.30	-	-	0.90	15.45	1.20	0.59	-0.12	0.01286	-
LLOYD KADEL WELL 3N 3W 16BDD1	378.	11	92	94	42	62	54	54	116	96	999	999	999	-	-	33.6	3.53	0.44	15.01	-	25.91	0.28	0.27	0.15	-	-	0.50	8.86	1.34	0.72	0.02	0.00743	-
LAKE LOWELL OUTLET 3N 3W 19DCB	-	23	-4	7	-48	-36	33	33	218	34	999	999	999	-	-	13.0	1.33	0.34	6.07	-	22.12	0.75	0.29	0.07	-	-	0.81	32.89	-0.63	-1.22	-1.94	0.00069	-
HARRY FOGILATTI WELL 3N 3W 23CCC1	757.	12	96	98	46	66	43	43	165	104	999	999	999	-	-	20.1	1.89	0.50	21.64	-	32.82	0.53	0.29	0.19	-	-	1.14	17.67	1.38	0.76	0.06	0.00987	-
O W GRIFFIN WELL 3N 3W 26BCA1	757.	17	87	89	37	56	59	59	171	111	222	155	218	99	99	19.0	2.84	0.42	23.10	-	28.61	0.35	0.29	0.23	-	-	0.91	11.92	1.17	0.56	-0.15	0.00995	-
LESTER WALKER WELL 3N 3W 30DDD1	757.	16	111	110	60	82	51	51	170	109	999	366	999	-	-	19.2	1.26	0.51	87.54	-	94.81	0.79	0.64	0.58	-	-	1.00	14.46	1.49	0.88	0.17	0.00948	-
A H BRUCK WELL 3N 3W 36ADC1	378.	12	89	91	39	58	33	33	77	78	999	999	999	-	-	55.5	2.47	0.40	16.38	-	34.90	0.41	0.34	0.16	-	-	0.48	11.15	1.28	0.66	-0.04	0.00608	-
PIONEER IRRIGATION DIST 3N 2W 10ABA1	114.	38	83	86	33	52	53	53	1	54	999	86	999	-	-	231.3	74.09	0.0	0.34	-	0.05	0.01	0.02	0.12	-	-	1.28	2.14	0.68	0.12	-0.63	0.00032	-
STATE HOSPITAL WELL 3N 2W 14ADA1	3406.	22	85	88	35	54	25	25	121	99	117	107	999	93	-	31.6	1.89	0.23	15.01	-	22.75	0.53	0.35	0.23	-	-	1.05	21.64	1.06	0.47	-0.25	0.00204	-
CITY OF NAMPA WELL #1 3N 2W 17BCB1	2271.	24	93	95	43	63	50	50	147	108	182	139	132	94	92	23.8	4.07	0.35	3.27	-	7.11	0.25	0.12	0.05	-	-	2.58	12.71	1.14	0.55	-0.17	0.00502	-
CITY OF NAMPA WELL #2 3N 2W 23BCD1	1703.	31	87	89	37	56	40	40	29	64	103	101	999	81	-	124.7	14.75	0.13	1.16	-	1.95	0.07	0.06	0.03	-	-	5.84	4.86	0.93	0.35	-0.38	0.00457	-
CLIFF WALLER WELL 3N 2W 26DDB1	378.	18	88	90	38	57	48	48	134	99	210	150	197	98	98	27.4	1.83	0.40	29.95	-	57.86	0.55	0.42	0.22	-	-	0.59	12.03	1.16	0.56	-0.15	0.00823	-
DEMOND DEPPE WELL 3N 2W 31BBB1	378.	15	93	95	43	63	49	49	129	98	999	999	999	-	-	29.0	1.51	0.40	129.63	-	154.34	0.66	0.83	0.69	-	-	0.78	11.23	1.29	0.68	-0.03	0.00827	-
NAFSINGER FARMS WELL 2N 3W 5BB 1	-	17	-	-	-	-	51	51	174	52	999	999	999	-	-	18.4	1.57	0.60	-	29.88	-	0.64	0.42	0.33	-	-	1.10	14.99	-	-	-	-	-

maybe a blank would be better - I'd hate to see a promoter use a 999°C temperature to sell a project (& I'll bet a 6 pack it would happen)

T_1 = SILICA TEMP ASSUMING QUARTZ EQUILIBRIUM AND CONDUCTIVE COOLING (NO STEAM LOSS)

T_2 = SILICA TEMP ASSUMING QUARTZ EQUILIBRIUM AND ADIABATIC EXPANSION AT CONSTANT ENTHALPY (MAX STEAM LOSS)

T_9 = FOURNIER-TRUESDELL MIXING MODEL 1 TEMP (QUARTZ-NO STEAM LOSS)

T_{10} = FOURNIER-TRUESDELL MIXING MODEL 2 TEMP (QUARTZ-STEAM LOSS)

over for footnotes ↘

T_1 = SILICA TEMP ASSUMING QUARTZ EQUILIBRIUM AND CONDUCTIVE COOLING (NO STEAM LOSS)
T_2 = SILICA TEMP ASSUMING QUARTZ EQUILIBRIUM AND ADIABATIC EXPANSION AT CONSTANT ENTHALPY (MAX STEAM LOSS)
T_3 = SILICA TEMP ASSUMING EQUILIBRIUM WITH CHRISTOBALITE
T_4 = SILICA TEMPERATURE ASSUMING EQUILIBRIUM WITH CHALCEDONY AND CONDUCTIVE COOLING (NO STEAM LOSS)
T_5 = NA-K-CA TEMP
T_6 = NA-K-CA TEMP CORRECTED FOR MG
T_7 = NA-K TEMP
T_8 = NA-K-CA TEMP CORRECTED FOR PCO_2
T_9 = FOURNIER-TRUESDELL MIXING MODEL 1 TEMP (QUARTZ-NO STEAM LOSS)
T_{10} = FOURNIER-TRUESDELL MIXING MODEL 2 TEMP (QUARTZ-STEAM LOSS)
T_{11} = FOURNIER-TRUESDELL MIXING MODEL 1 TEMP (CHALCEDONY-NO STEAM LOSS)
%9 = PERCENT COLD WATER IN T9 CALCULATION
%11 = PERCENT COLD WATER IN T11 CALCULATION
999 = AQUIFER TEMPERATURE AND PERCENTAGE OF COLD WATER CALCULATION NOT POSSIBLE
* = R NOT CALCULATED IF $T_5 = <70^{\circ}$
- = DATA NOT AVAILABLE FOR CALCULATION.

Table 3. Estimated Aquifer Temperatures, Atomic and Molar Ratios of Selected Chemical Constitutents, Free Energies of Formation of Selected Minerals, Partial Pressures CO_2 Gas and R Values from Selected Thermal Springs and Wells in the Nampa-Caldwell Area (continued)

Spring/Well Identification Number & Name	Discharge (l/min.)	Measured Surface Temperature (°C)	Aquifer Temperatures and Percentage of Cold Water Estimated from Chemical Geothermometers. (see footnotes)													Atomic Ratios							Molar Ratios						Free Energies of Formation of			Partial Pressure of CO_2 Gas (atmospheres)	R= Magne Magne + Calc + Potas
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	%9	%11	Sodium/Potassium $\frac{Na}{K}$	Sodium/Calcium $\frac{Na}{Ca}$	Magnesium/Calcium $\frac{Mg}{Ca}$	Calcium/Fluoride $\frac{Ca}{F}$	Chloride/Boron $\frac{Cl}{B}$	Chloride/Fluoride $\frac{Cl}{F}$	Calcium/Sodium $\frac{Ca}{Na}$	Calcium/Bicarbonate $\frac{Ca}{HCO_3}$	Chloride/Carbonate & Bicarbonate $\frac{Cl}{CO_3 + HCO_3}$	Ammonia/Chloride $\frac{NH_4}{Cl}$	Ammonia/Fluoride $\frac{NH_4}{F}$	Chloride/Sulfate $\frac{Cl}{SO_4}$	$\sqrt{Calcium}$/Sodium $\frac{\sqrt{Ca}}{Na}$	Quartz $\frac{\Delta G}{Quartz}$	Chalcedony $\frac{\Delta G}{Chalcedony}$	Amorphous Silica $\frac{\Delta G}{Amorphous}$	PCO_2	$\frac{M}{Mg+C}$
FALLON WELL 2N 3W 7AA 1	-	18	-	-	-	-	40	40	155	40	999	999	999	-	-	22.1	1.35	0.47	0.0	2.77	0.0	0.74	0.25	0.01	-	-	0.39	18.08	-	-	-	-	-
FRANK RAWLINGS WELL 2N 3W 8CDD1	3406.	22	110	110	59	81	59	59	252	132	999	202	999	-	-	10.2	1.29	0.38	21.09	-	50.51	0.78	0.44	0.18	-	-	0.54	19.29	1.38	0.79	0.07	0.00853	-
GLENN KNAPP WELL #1 2N 3W 8DA 1	-	18	-	-	-	-	58	58	252	58	999	999	999	-	-	10.2	1.70	0.58	0.0	22.85	0.0	0.59	0.38	0.28	-	-	1.07	19.40	-	-	-	-	-
GLENN KNAPP WELL #2 2N 3W 9BC 1	-	16	-	-	-	-	40	40	173	40	999	999	999	-	-	18.7	1.64	0.47	0.0	43.52	0.0	0.61	0.43	0.27	-	-	0.97	20.59	-	-	-	-	-
LEROY NIELSON WELL 2N 3W 11CBA1	1135.	21	98	100	48	68	53	53	184	104	999	175	284	-	97	17.0	2.73	0.32	6.16	-	12.53	0.37	0.30	0.14	-	-	0.93	15.30	1.26	0.66	-0.06	0.02285	-
BRYCE MILLAR WELL 2N 3W 15DCD1	30.	26	111	110	60	82	60	60	165	122	999	179	999	-	-	20.0	2.43	0.29	12.10	-	27.02	0.41	0.34	0.15	-	-	0.47	11.30	1.32	0.74	0.01	0.00299	-
BARLOW INC WELL 2N 3W 22ACD1	3406.	27	105	105	54	75	59	59	176	123	244	161	224	94	94	18.2	2.40	0.37	20.20	-	30.92	0.42	0.33	0.21	-	-	0.63	12.42	1.23	0.65	-0.08	0.00335	-
SPENCER FARMS WELL 2N 3W 22CB 1	-	27	-	-	-	-	63	63	204	63	999	999	999	-	-	14.4	2.40	0.45	7.15	8.70	31.60	0.42	0.25	0.06	-	-	0.35	13.21	-	-	-	-	-
CANNON FARMS WELL #5 2N 3W 22DDC1	-	27	101	102	51	71	56	56	170	124	217	152	215	94	94	19.1	2.46	0.46	17.15	-	36.98	0.41	0.32	0.15	-	-	0.49	13.04	1.18	0.60	-0.12	0.00236	
BARLOW INC WELL 2N 3W 22DDC1	757.	28	102	103	52	72	59	59	199	133	214	151	202	93	93	15.0	2.15	0.36	21.02	-	39.97	0.47	0.37	0.19	-	-	0.50	14.21	1.18	0.60	-0.13	0.00232	-
ELMER TIEGS WELL #1 2N 3W 23ACD1	757.	28	105	105	54	75	75	75	127	105	233	158	221	94	93	29.4	8.04	0.16	2.44	-	3.88	0.12	0.11	0.07	-	-	0.93	5.87	1.22	0.64	-0.09	0.00827	12.1
R E BALLEY WELL 2N 3W 23CC 1	-	23	-	-	-	-	72	72	182	72	999	999	999	-	-	17.3	4.43	0.69	0.0	20.31	0.0	0.23	0.19	0.19	-	-	1.35	9.22	-	-	-	-	37.9
NAITO BROTHERS WELL #1 2N 3W 25BDA1	1135.	26	95	97	45	65	61	61	97	87	182	139	132	93	90	42.2	8.99	0.25	2.38	-	3.85	0.11	0.10	0.06	-	-	2.40	6.18	1.13	0.55	-0.17	0.01380	-
NAITO BROTHERS WELL #2 2N 3W 26AAC1	1135.	25	85	88	35	54	68	68	170	102	105	102	999	88	-	19.2	4.86	0.54	11.48	-	12.87	0.21	0.18	0.16	-	-	0.86	9.44	1.02	0.43	-0.29	0.03257	-
BARLOW INC WELL #1 2N 3W 27BBA1	757.	30	123	120	72	94	88	88	289	161	999	186	999	-	-	8.2	2.51	0.43	6.94	-	27.89	0.40	0.38	0.09	-	-	0.15	11.28	1.40	0.83	0.09	0.00337	27.1
D W FROST WELL 2N 3W 34DB 1	-	27	-	-	-	-	173	173	187	173	999	999	999	-	-	16.5	7.57	0.91	0.0	9.37	0.0	0.13	0.27	0.08	-	-	0.08	4.91	-	-	-	-	42.5
CHARLES PINTLER WELL #1 2N 3W 35CAA1	1135.	28	95	97	45	65	91	91	140	117	168	134	125	91	88	25.7	14.92	0.26	3.34	-	3.28	0.07	0.08	0.07	-	-	0.36	4.47	1.10	0.52	-0.21	0.00613	16.6
CHARLES PINTLER WELL #2 2N 3W 35CA 1	-	27	-	-	-	-	92	92	118	92	999	999	999	-	-	32.7	22.37	0.27	0.0	6.77	0.0	0.04	0.05	0.05	-	-	0.96	3.65	-	-	-	-	17.0
ORVAL PEALEY WELL 2N 2W 2ACC1	30.	15	91	93	41	61	56	56	161	111	999	999	999	-	-	20.8	1.96	0.36	56.75	-	101.78	0.51	0.42	0.23	-	-	0.63	11.97	1.26	0.65	-0.06	0.00702	-
ROGER HUNGERFORD WELL 2N 2W 4DCA1	1514.	23	68	73	19	36	43	43	42	43	999	999	999	-	-	98.1	10.90	0.23	4.66	-	2.47	0.09	0.09	0.16	-	-	3.19	5.30	0.77	0.18	-0.54	0.00065	-
ALLEN BROTHERS INC WELL 2N 2W 16DAA1	2649.	26	112	111	61	83	68	68	171	68	999	181	999	-	-	19.0	3.84	0.24	8.58	-	14.22	0.26	0.21	0.12	-	-	0.63	9.53	-	-	-	-	-

Estimated Aquifer Temperatures, Atomic and Molar Ratios of Selected Chemical Constituents, Free Energies of

Minerals, Partial Pressures CO_2 Gas and R Values from Selec Thermal Springs and Wells in the Nampa-Caldwell Area (continued)

Spring/Well Identification Number & Name	Discharge (l/min.)	Measured Surface Temperature (°C)	Aquifer Temperatures and Percentage of Cold Water Estimated from Chemical Geothermometers (see footnotes)													Atomic Ratios							Molar Ratios						Free Energies of Formation of			Partial Pressure of CO_2 Gas (atmospheres)	Magne Magn + Cal + Pota
																Sodium / Potassium	Sodium / Calcium	Magnesium / Calcium	Calcium / Fluoride	Chloride / Boron	Chloride / Fluoride	Calcium / Sodium	Calcium / Bicarbonate	Chloride / Carbonate & Bicarbonate	Ammonia / Chloride	Ammonia / Fluoride	Chloride / Sulfate	$\sqrt{\text{Calcium}}$ / Sodium	Quartz	Chalcedony	Amorphous Silica		
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	$\%_9$	$\%_{11}$	$\frac{Na}{K}$	$\frac{Na}{Ca}$	$\frac{Mg}{Ca}$	$\frac{Ca}{F}$	$\frac{Cl}{B}$	$\frac{Cl}{F}$	$\frac{Ca}{Na}$	$\frac{Ca}{HCO_3}$	$\frac{Cl}{CO_3 + HCO_3}$	$\frac{NH_4}{Cl}$	$\frac{NH_4}{F}$	$\frac{Cl}{SO_4}$	$\frac{\sqrt{Ca}}{Na}$	ΔG Quartz	ΔG Chalcedony	ΔG Amorphous	PCO_2	Mg+C
STEPHEN HENNIS WELL 2N 2W 18BAB1	378.	14	90	92	40	59	41	41	136	92	999	999	999	-	-	26.7	2.26	0.63	6.92	-	29.31	0.44	0.21	0.05	-	-	0.30	15.22	1.26	0.65	-0.06	0.01345	
R BOEHLKE WELL 2N 2W 21CBC1	3028.	20	27	36	-19	-5	79	79	328	172	999	999	999	-	-	6.6	2.03	0.23	16.84	-	25.06	0.49	0.27	0.18	-	-	1.42	16.24	0.13	-0.46	-1.18	0.00197	16
BRIAN M HOWARD WELL 2N 2W 27AAA1	30.	22	76	80	26	45	36	36	68	79	999	999	999	-	-	64.0	3.44	0.18	22.14	-	20.61	0.29	0.37	0.39	-	-	0.75	9.19	0.93	0.34	-0.38	0.00400	
CARL AGENBROAD WELL #1 2N 2W 27ABB1	1798.	23	67	72	17	35	41	41	38	75	999	999	999	-	-	105.8	7.23	0.26	6.00	-	5.12	0.14	0.17	0.20	-	-	0.68	5.33	0.76	0.17	-0.55	0.00181	
CARL AGENBROAD WELL #2 2N 2W 27DAB1	3028.	22	63	68	14	31	46	46	15	66	999	999	999	-	-	167.6	15.04	0.24	6.86	-	3.03	0.07	0.10	0.23	-	-	0.60	3.33	0.72	0.13	-0.59	0.00126	
HAROLD TIEGS WELL #1 2N 2W 31CDD1	1514.	24	80	84	30	49	37	37	143	102	999	58	999	-	-	25.0	1.55	0.21	20.46	-	45.68	0.65	0.52	0.23	-	-	0.53	17.79	0.96	0.37	-0.35	0.00489	
C R DAVENPORT WELL 2N 2W 31DAD1	757.	22	75	79	25	43	43	43	169	126	999	999	999	-	-	19.3	2.04	0.23	18.64	-	29.89	0.49	0.35	0.21	-	-	0.90	18.19	0.90	0.31	-0.41	0.00123	
LEWIS CASSIDY WELL 2N 2W 33CCC1	11.	15	113	112	63	84	215	215	335	175	999	999	999	-	-	6.4	3.59	0.33	19.43	-	19.55	0.28	0.19	0.18	-	-	1.51	9.70	1.52	0.91	0.21	0.00363	20
DALE GROSS WELL 2N 2W 34AAC1	568.	29	82	85	32	50	69	69	-1	69	77	79	999	77	-	245.7	94.43	0.34	5.66	-	0.32	0.01	0.01	0.22	-	-	1.29	1.37	0.79	0.22	-0.51	0.00034	
JAY C NEIDER WELL #1 2N 2W 34BDA1	1892.	48	89	91	39	58	57	47	0	59	95	97	999	54	-	238.1	27.12	0.04	2.49	-	0.99	0.04	0.05	0.12	-	-	0.89	2.46	0.67	0.15	-0.63	0.00152	
JAY C NEIDER WELL #2 2N 2W 34CDA1	378.	30	70	75	20	38	58	58	78	96	999	999	999	-	-	54.7	8.26	0.31	5.74	-	3.22	0.12	0.12	0.20	-	-	1.89	5.56	0.69	0.11	-0.62	0.00211	
JAY C NEIDER WELL #3 2N 2W 34DAA1	378.	31	80	84	30	49	13	13	-8	13	999	73	999	-	-	293.8	3.31	0.00	15.19	-	19.75	0.30	0.64	0.48	-	-	1.02	6.04	0.77	0.20	-0.54	0.00055	
FRANK BLICK WELL 1N 3W 1BBC1	30.	21	115	114	65	87	78	78	284	139	999	226	999	-	-	8.4	1.26	0.57	65.16	-	120.84	0.79	0.60	0.32	-	-	0.48	13.93	1.46	0.87	0.15	0.01483	34
ELMER TIEGS WELL #2 1N 3W 12BAB1	757.	29	124	121	73	96	217	217	316	160	999	193	999	-	-	7.1	6.58	0.52	3.10	-	7.45	0.15	0.13	0.05	-	-	0.21	6.49	1.44	0.86	0.13	0.01393	26
ELMER TIEGS WELL #3 ~~1N 3W 12BA 1~~	~~0.~~	~~32~~	~~-~~	~~-~~	~~-~~	~~-~~	~~193~~	~~193~~	~~227~~	~~193~~	~~999~~	~~999~~	~~999~~	-	-	12.1	13.41	0.51	0.0	6.41	-	0.07	0.06	0.04	-	-	3.61	4.14	-	-	-	-	24
M O CLEMENTS WELL 1N 3W 13AAA1	1892.	20	104	104	54	74	61	61	215	125	999	204	999	-	-	13.2	1.56	0.37	110.17	-	98.76	0.64	0.80	0.88	-	-	1.38	14.84	1.34	0.74	0.03	0.00824	
C D RUDDICK WELL 1N 2W 3CBB1	1885.	20	91	93	41	61	54	54	240	144	215	152	214	97	97	11.0	2.32	0.57	17.69	-	28.44	0.43	0.24	0.15	-	-	1.28	20.30	1.16	0.56	-0.16	0.00188	
C D RUDDICK WELL 1N 2W 3CBB1	1135.	20	90	92	40	59	50	50	212	50	198	146	157	97	96	13.5	1.69	0.55	51.75	-	58.85	0.59	0.43	0.37	-	-	0.97	19.69	1.16	0.56	-0.15	0.00067	
STEVEN HENNIS WELL #2 1N 2W 3CB 1	0.	21	-	-	-	-	16	16	163	16	999	999	999	-	-	20.4	0.58	0.18	-	182.79	-	1.72	0.98	0.18	-	-	1.30	40.60	-	-	-	-	
STEVEN HENNIS WELL #3 1N 2W 3CB 1	0.	21	-	-	-	-	55	55	244	55	999	999	999	-	-	10.7	2.32	0.58	13.40	38.08	21.33	0.43	0.24	0.15	-	-	1.29	20.30	-	-	-	-	

9 Minerals, Partial Pressures CO_2 Gas and R Values from Selected Thermal Springs and Wells in

Spring/Well Identification Number & Name	Discharge (l/min.)	Measured Surface Temperature (°C)	Aquifer Temperatures and Percentage of Cold Water Estimated from Chemical Geothermometers (see footnotes)													Atomic Ratios							Molar Ratios						Free Energies of Formation of			Partial Pressure of CO_2 Gas (atmospheres)	R = Magnesium / (Magnesium + Calcium + Potassium)
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	%9	%11	Sodium/Potassium $\frac{Na}{K}$	Sodium/Calcium $\frac{Na}{Ca}$	Magnesium/Calcium $\frac{Mg}{Ca}$	Calcium/Fluoride $\frac{Ca}{F}$	Chloride/Boron $\frac{Cl}{B}$	Chloride/Fluoride $\frac{Cl}{F}$	Calcium/Sodium $\frac{Ca}{Na}$	Calcium/Bicarbonate $\frac{Ca}{HCO_3}$	Chloride/Carbonate & Bicarbonate $\frac{Cl}{CO_3 + HCO_3}$	Ammonia/Chloride $\frac{NH_4}{Cl}$	Ammonia/Fluoride $\frac{NH_4}{F}$	Chloride/Sulfate $\frac{Cl}{SO_4}$	$\sqrt{\text{Calcium}}$/Sodium $\frac{\sqrt{Ca}}{Na}$	Quartz $\frac{\Delta G}{Quartz}$	Chalcedony $\frac{\Delta G}{Chalcedony}$	Amorphous Silica $\frac{\Delta G}{Amorphous}$	PCO_2	$\frac{Mg}{Mg+Ca+K}$ *
LAVISH WELL 1N 2W 3DBB1	568.	20	89	91	39	58	49	49	186	127	182	139	132	97	95	16.7	1.48	0.47	124.48	-	91.75	0.67	0.77	1.03	-	-	1.23	17.44	1.16	0.56	-0.15	0.00214	-
KENNETH BROWN WELL 1N 2W 4ADA1	38.	17	120	118	69	91	-	-	-	-	999	330	999	-	-	-	7.21	0.53	-	-	-	0.14	0.10	0.05	-	-	5.74	7.17	1.57	0.97	0.26	0.00627	-
EDWIN TIEGS WELL #1 1N 2W 4DA 1	2631.	22	-	-	-	-	39	39	151	39	999	999	999	-	-	23.0	2.62	0.46	-	3.39	-	0.38	0.23	0.09	-	-	1.08	18.04	-	-	-	-	-
L M HOPKINS WELL 1N 2W 5BBC1	946.	23	76	80	26	45	40	40	165	40	999	999	999	-	-	20.0	1.86	0.21	21.73	-	39.72	0.54	0.36	0.19	-	-	0.94	19.38	0.90	0.31	-0.41	0.00032	-
LEONARD TIEGS WELL #1 1N 2W 5CAB1	378.	23	91	93	41	61	56	56	161	56	170	135	127	94	92	20.8	1.96	0.36	56.75	-	101.78	0.51	0.84	0.46	-	-	0.63	11.97	1.10	0.51	-0.21	0.00059	-
LEONARD TIEGS WELL #2 1N 2W 5CB 1	-	22	-	-	-	-	34	34	137	34	999	999	999	-	-	26.4	2.16	0.59	-	4.73	-	0.46	0.30	0.12	-	-	1.06	18.52	-	-	-	-	-
HAROLD TIEGS WELL #1 1N 2W 6ADD1	378.	25	93	95	43	63	59	59	157	118	172	136	128	93	91	21.7	3.87	0.25	9.86	-	12.53	0.26	0.22	0.17	-	-	1.17	10.80	1.12	0.53	-0.19	0.00332	-
HAROLD TIEGS WELL #2 1N 2W 6AD 1	4542.	24	-	-	-	-	74	74	142	74	999	999	999	-	-	25.1	8.57	0.27	-	3.73	-	0.12	0.11	0.06	-	-	1.62	6.74	-	-	-	-	19.0
ELMER TIEGS WELL #4 1N 2W 6CAA1	1135.	24	85	88	35	54	50	50	190	124	109	103	999	90	-	16.1	2.16	0.24	18.22	-	27.50	0.46	0.34	0.22	-	-	0.90	17.18	1.03	0.44	-0.28	0.00328	-
ELMER TIEGS WELL #5 1N 2W 7ADC1	1892.	26	121	119	70	92	93	93	201	140	999	200	999	-	-	14.7	7.63	0.19	10.72	-	6.32	0.13	0.13	0.22	-	-	1.62	6.56	1.44	0.85	0.13	0.00389	12.8
DONALD TIEGS WELL #1 1N 2W 8AB 1	-	23	-	-	-	-	38	38	129	38	999	999	999	-	-	28.9	2.82	0.24	-	3.39	-	0.35	0.26	0.01	-	-	0.12	15.48	-	-	-	-	-
DONALD TIEGS WELL #2 1N 2W 8ACB1	1892.	21	84	87	34	53	43	43	188	127	99	99	999	92	-	16.4	1.03	0.22	110.17	-	115.88	0.97	1.10	1.03	-	-	1.29	20.72	1.06	0.46	-0.25	0.00176	-
DALE TIEGS WELL 1N 2W 8DDD1	1514.	18	97	99	47	67	55	55	130	102	999	209	999	-	-	28.7	1.54	0.75	356.16	-	267.61	0.65	1.07	1.40	-	-	1.05	9.80	1.29	0.69	-0.02	0.00650	-
RON CASSIDY WELL 1N 2W 9AAA1	30.	22	72	76	22	40	48	48	117	48	999	999	999	-	-	33.2	5.23	0.15	22.57	-	16.22	0.19	0.16	0.23	-	-	3.94	10.62	0.85	0.26	-0.46	0.00094	-
NORMAN R COLE WELL #1 1N 2W 9BBA1	1514.	22	76	80	26	45	44	44	156	121	999	999	999	-	-	21.9	2.41	0.27	37.83	-	36.25	0.41	0.35	0.36	-	-	1.16	16.27	0.93	0.33	-0.38	0.00138	-
NORMAN R COLE WELL #2 1N 2W 9CCB1	757.	24	85	88	35	54	60	60	154	115	109	103	999	90	-	22.3	3.16	0.27	27.16	-	23.39	0.32	0.35	0.40	-	-	1.21	10.43	1.03	0.44	-0.28	0.00402	-
HYRUM MOON WELL 1N 2W 9DDD1	38.	16	108	107	57	78	247	247	509	185	999	349	999	-	-	3.3	1.49	0.67	5.90	-	54.52	0.67	0.23	0.02	-	-	0.54	16.17	1.45	0.84	0.13	0.01212	35.4
ROBERT PORTER WELL 1N 2W 10BA 1	-	21	-	-	-	-	35	35	184	35	999	999	999	-	-	17.0	1.84	0.69	-	21.33	-	0.54	0.26	0.11	-	-	1.26	25.03	-	-	-	-	-
C RICHARD GUNWING WELL 1N 2W 11AAA1	568.	18	98	100	48	68	60	60	240	142	999	213	999	-	-	11.1	2.71	0.70	17.87	-	25.86	0.37	0.22	0.15	-	-	1.19	17.40	1.30	0.70	-0.01	0.00285	-
DONALD TIEGS WELL #3 1N 2W 16CBA1	2649.	18	84	87	34	53	52	52	171	116	120	110	75	97	94	19.0	1.62	0.45	17.32	-	26.62	0.62	0.53	0.34	-	-	0.67	14.43	1.11	0.51	-0.20	0.00460	-
OPAL TIEGS WELL #1 1N 2W 16CB 1	-	26	-	-	-	-	52	52	185	52	999	999	999	-	-	16.8	1.31	0.61	-	86.02	-	0.76	1.05	1.21	-	-	1.16	15.96	-	-	-	-	-
OPAL TIEGS WELL 1N 2W 16CB 1	-	20	-	-	-	-	51	51	168	51	999	999	999	-	-	19.4	1.51	0.58	79.50	135.57	65.58	0.66	0.93	1.11	-	-	1.11	14.53	-	-	-	-	-
KENNETH TIEGS WELL #1 [illegible]	[illegible]	[illegible]	-	-	-	-	64	64	169	64	999	999	999	-	-	19.6	3.08	0.63	-	94.60	-	0.32	0.33	0.55	-	-	1.72	10.39	-	-	-	-	-

- analytic uncertainty suggests that this sample can't be distinguished as type 2 or 3 water, ∴ mixing of types cont may be invalid

the center of the cluster of plots, suggests this well is a mixed water with 53% being cold water of Reynolds Creek type (figure 4). A chemical mixing model for this well (Table 3, column T_9) indicates 95°C maximum temperature of the hot water component and 54% of the water being cold, in agreement with isotopic data for mixing and, temperature wise with conductivity cooled water from well 2N-3W-27bbal (see below).

archaic usage

The discordance between the isotope data (which suggests mixing) for well 2N-2W-34bdal and the equal temperature plot of figure 12 (which suggests excess silica or changes in cation ratios) can most easily be explained by assuming an increased sodium/potassium ratio brought about by decreased potassium. For these waters, a general rule of thumb is an increased sodium or calcium or decreased potassium content, effectively lowers the calculated Na-K-Ca aquifer temperature causing the data point to plot to the left of the equal temperature line. Water from well 2N-2W-34bdal has the lowest dissolved potassium content of any well sampled in the Nampa-Caldwell area, and has higher sodium/potassium ratios than all but two wells (see tables 2 and 3). Lower sodium/potassium ratios and higher potassium content appears normal for the geothermal waters in this area, therefore, adjusted cation ratios from mixing or precipitation probably are not the cause of most of the other high quartz predicted temperatures shown on figure 12 (also see below). Figure 15

?

quantify this "appearance"

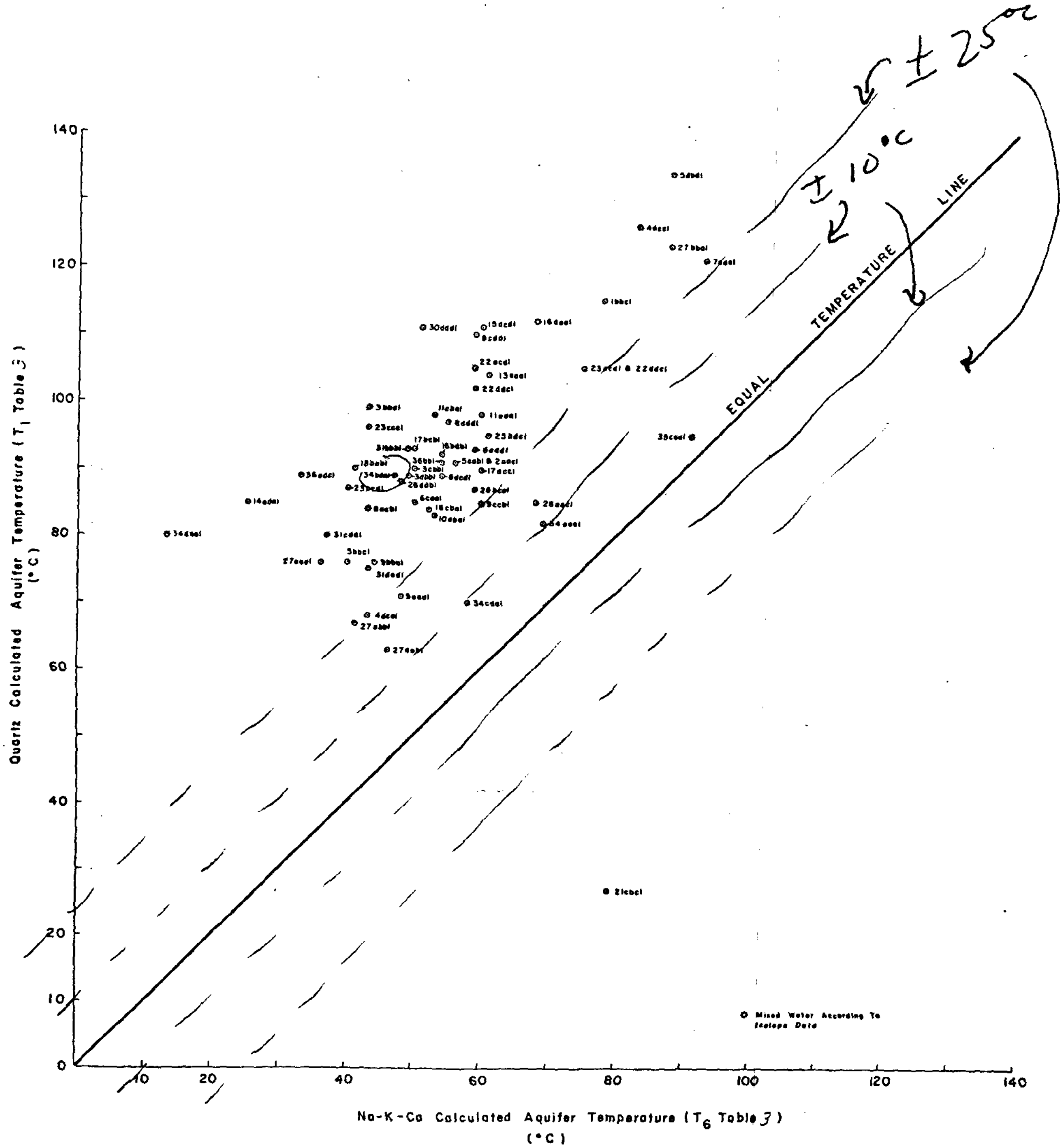


FIGURE 12. Na-K-Ca calculated aquifer temperatures compared to Silica (quartz) calculated aquifer temperatures in the Nampa-Caldwell area, Canyon County, Idaho.

Seems out of place ?!

shows the generalized effects of changes in cations on the Na-K-Ca chemical geothermometer in this area.

Figure 13 (chalcedony calculated aquifer temperatures) is a considerable improvement over figure 12. Most agreement or close agreement in chalcedony and Na-K-Ca chemical geothermometers occurrs between 42 and 55°C and could indicate these waters are in equilibrium and from an aquifer of that temperature (see figure 16 for a schematic conceptual model of the aquifer systems in this area). However, wells falling on lines 1 and 2 (mixed waters according to the isotope - isotope temperature plots) of figures 4, 5 and 6 are found mostly above the equal temperature line instead of below the line as would be expected for mixed waters. This indicates that many of these wells have more reported silica than can be explained by chalcedony equilibrium. Those falling on or near the equal temperature line of figure 12 might be in equilibrium with chalcedony and unmixed, ie., well water 2N-3W-27bba1.

awkward

I'm confused about arguments earlier, in favor of mixing, breaking down to arguments for no mixing.

or not in equilib., & ∴ mixed

Figure 14 (α christobalite calculated aquifer temperatures) indicates most of the waters found on lines 1 and 2 of figures 4 through 6 now fall below the equal temperature line as a mixed water should. The isotope ratio data and geothermometry can, therefore, be brought into closest agreement by making a generalization that mixed thermal waters (according to isotope data) have reequilibrated after

? poor terminology

?

wow

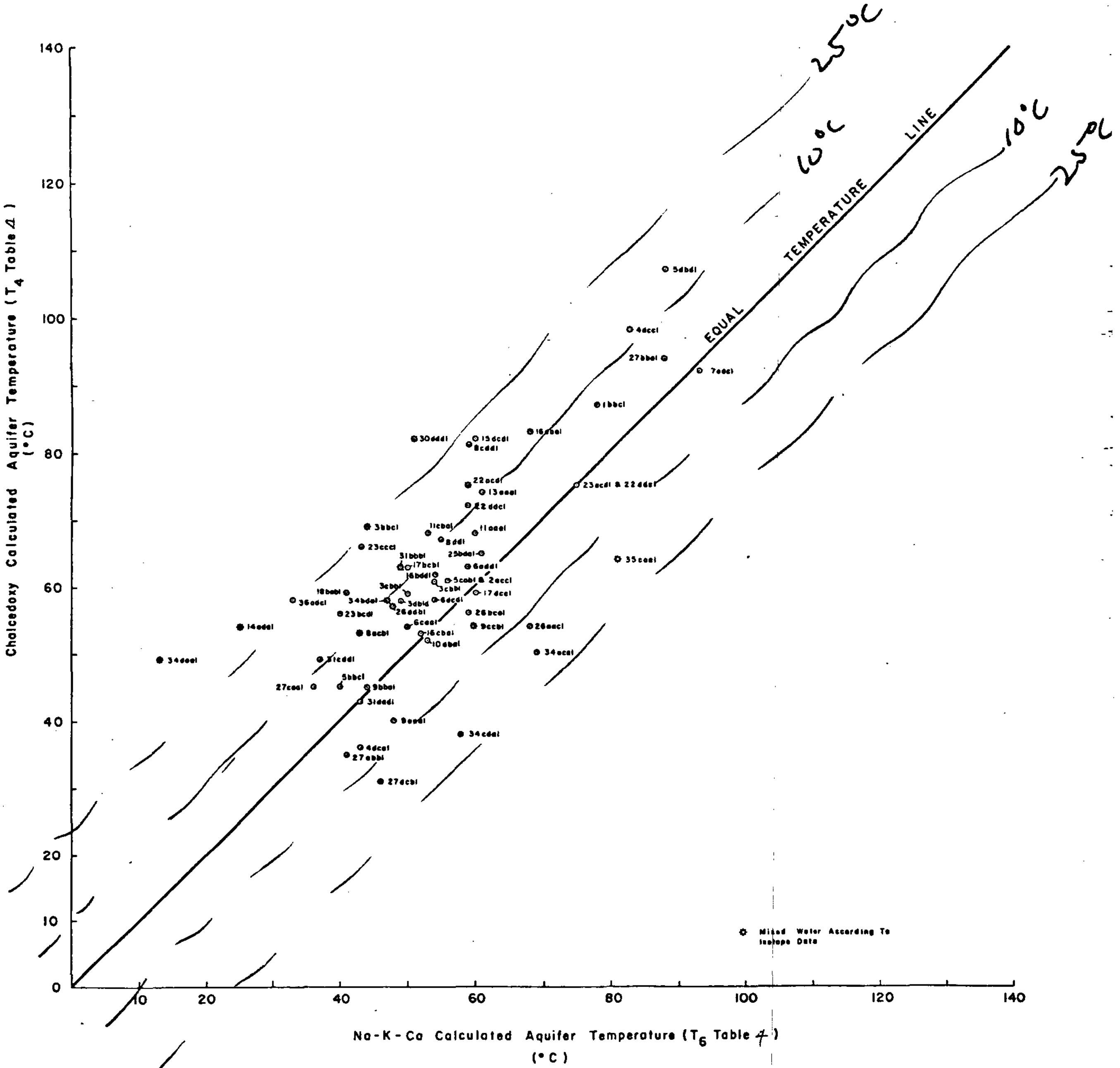


FIGURE 13. Na-K-Ca calculated aquifer temperatures compared to Silica (chalcedony) calculated aquifer temperatures in the Nampa-Caldwell area, Canyon County, Idaho.

New paragraph needed somewhere

mixing. Dissolved silica in these thermal waters may now be in equilibrium with α christobalite. This may explain the total failure, in most instances, of the mixing models to predict aquifer temperatures as mixing models do not work if the waters have reequilibrated after mixing. Unmixed thermal waters are, for the most part, still in equilibrium with chalcedony or quartz but represent waters that have cooled conductively during ascent from deeper, warmer, thermal aquifers (see figure 16). Support for this hypotheses is seen in the temperature-depth log from well 4N-3W-19adcl obtained by Smith (figure , this report) and the cross sections of Wood and Anderson (figure , this report). A thermal water temperature of 63.19°C was recorded at a depth of 650 m in well 4N-3W-19adcl. The temperature was still rising with depth when the end of the cable for the down hole temperature probe was reached. Consequently, deeper penetration into the well bore could not be achieved. The fact that isotopic data from wells 4N-3W-19adcl and 2N-2W-34bdal (surface temperature 51°C) plot~~s~~ on lines 1 and 2, respectively, of figure 4, indicates that the deep water is isotopically identical to water from the aquifer within the "blue clay" represented by water from well 2N-3W-27bbal. ~~This~~ These data indicate~~s~~ that thermal aquifers of the required temperatures to explain the higher temperatures plotted on figure 13 exists beneath the Nampa-Caldwell area. Amorphous silica temperatures (not shown in table 2) in nearly all

one well on thin ice

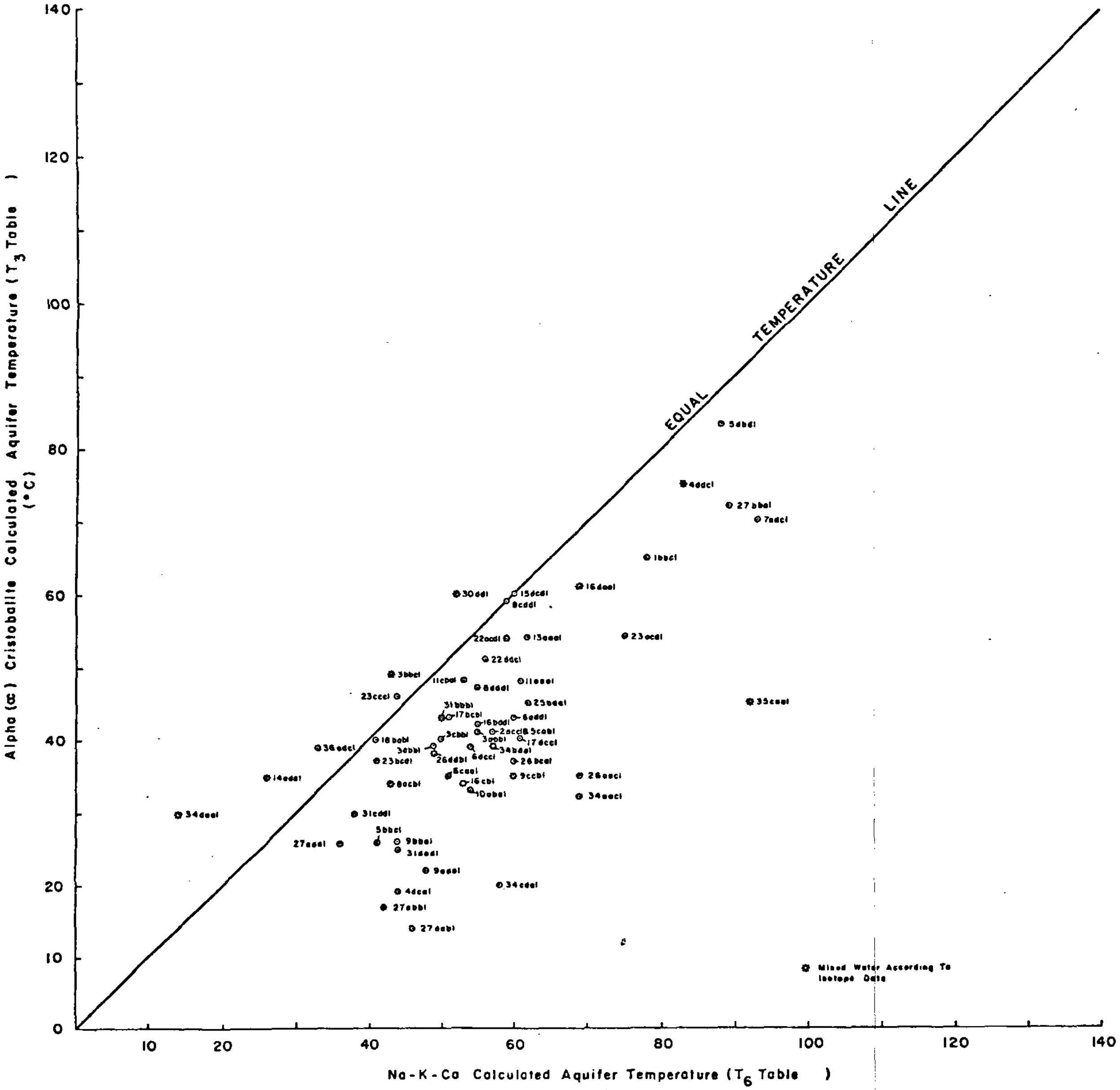


FIGURE 14. Na-K-Ca calculated aquifer temperatures compared to Silica (∝ christobalite) calculated aquifer temperatures in the Nampa-Caldwell area, Canyon County, Idaho.

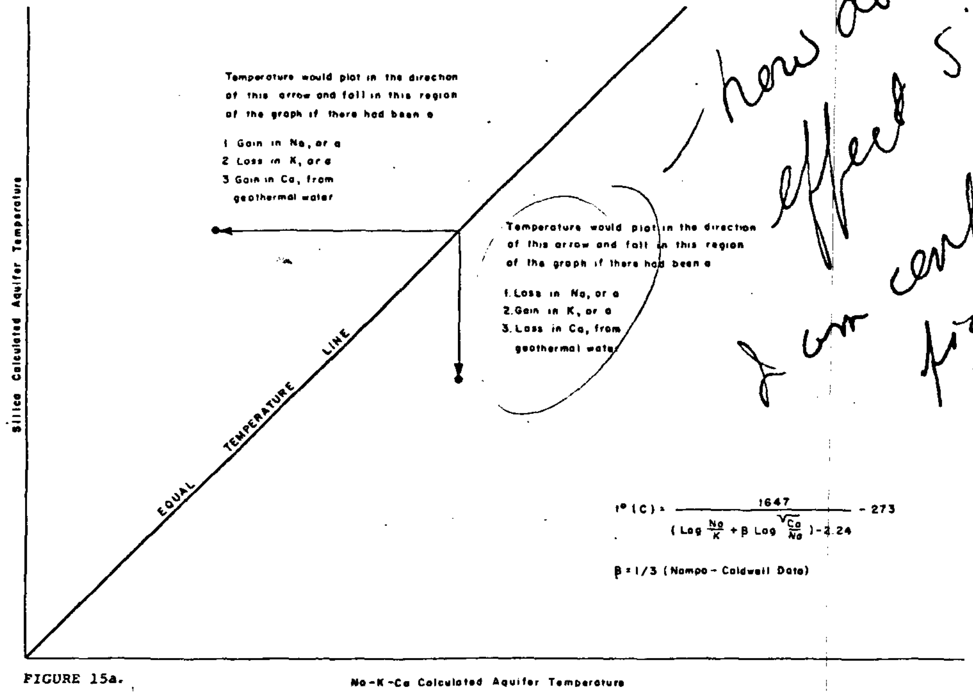


FIGURE 15a.

— how does this effect SiO_2 Temp.

I am confused by this figure

Why 2 diagrams?

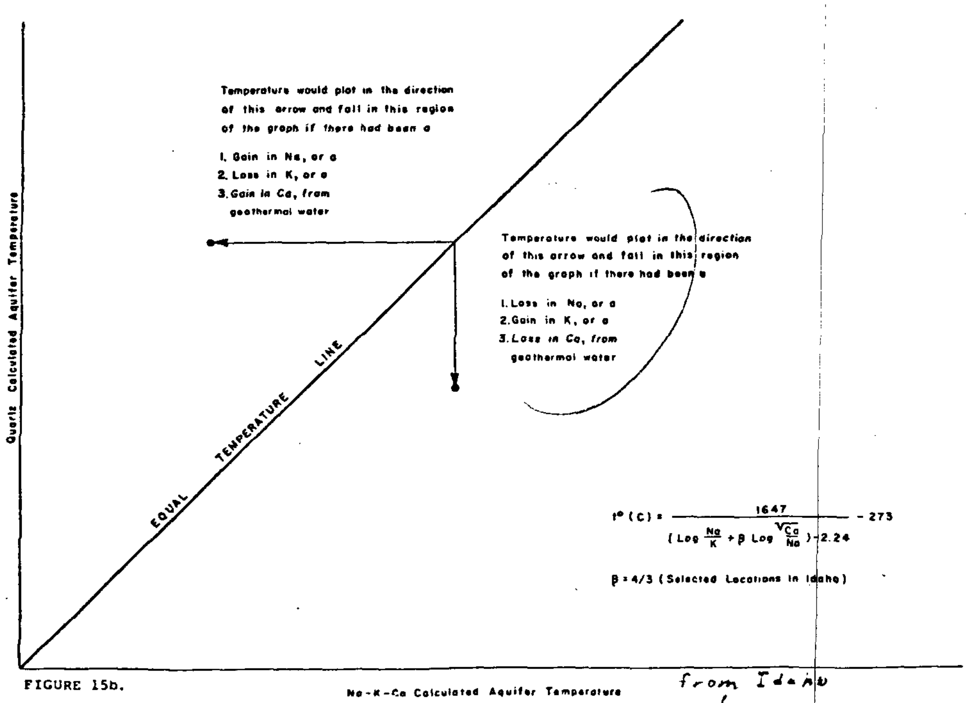


FIGURE 15b.

from Idaho

FIGURE 15. Generalized effects of cation changes in geothermal water on the Na-K-Ca chemical geothermometer. Concomitant changes in cations were not considered in making diagrams.

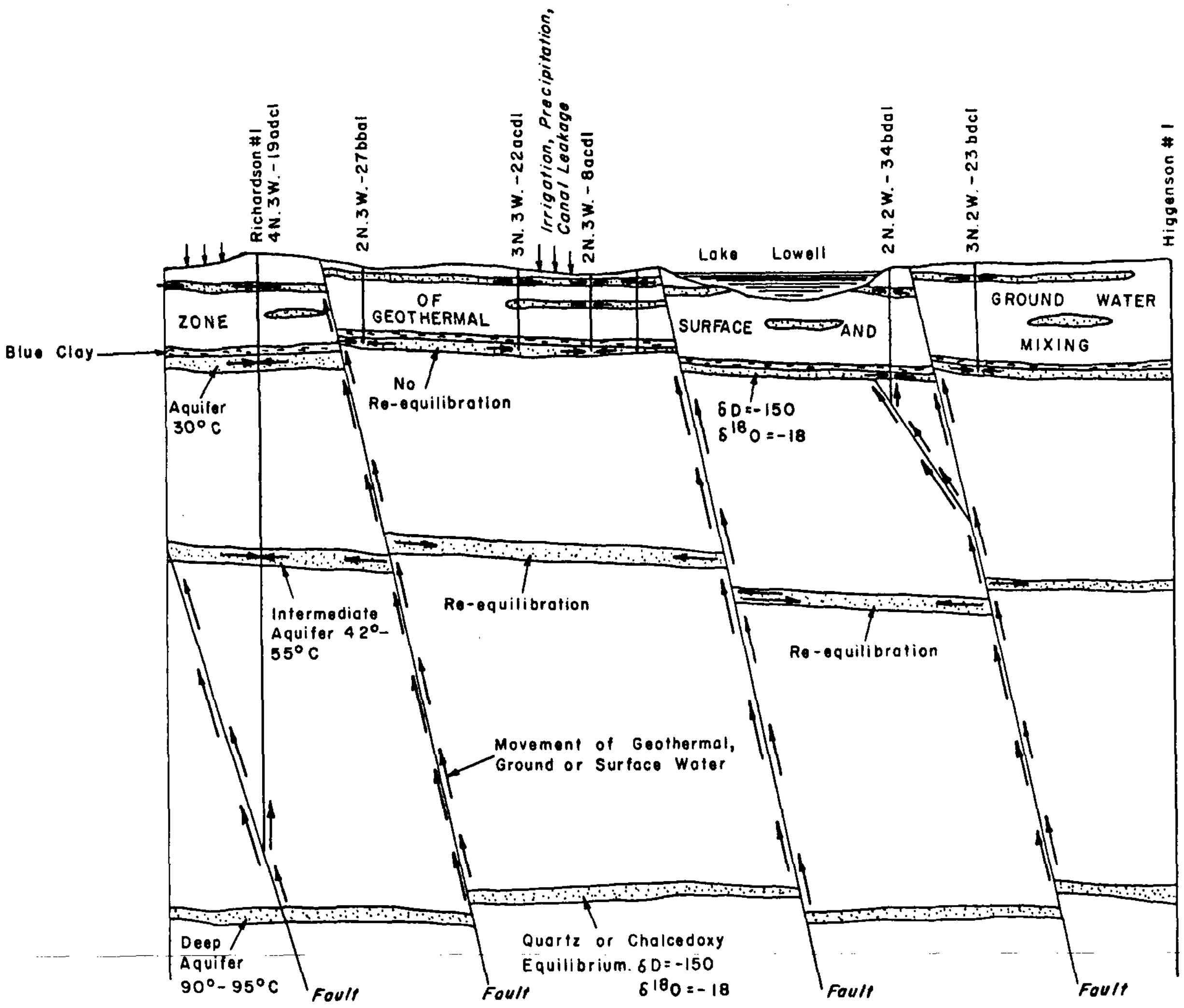


FIGURE 16. Idealized cross section across the Nampa-Caldwell area (west to east) depicting conceptual model of a highly complex, compartmentalized, interconnected hydrologic system (not to scale).

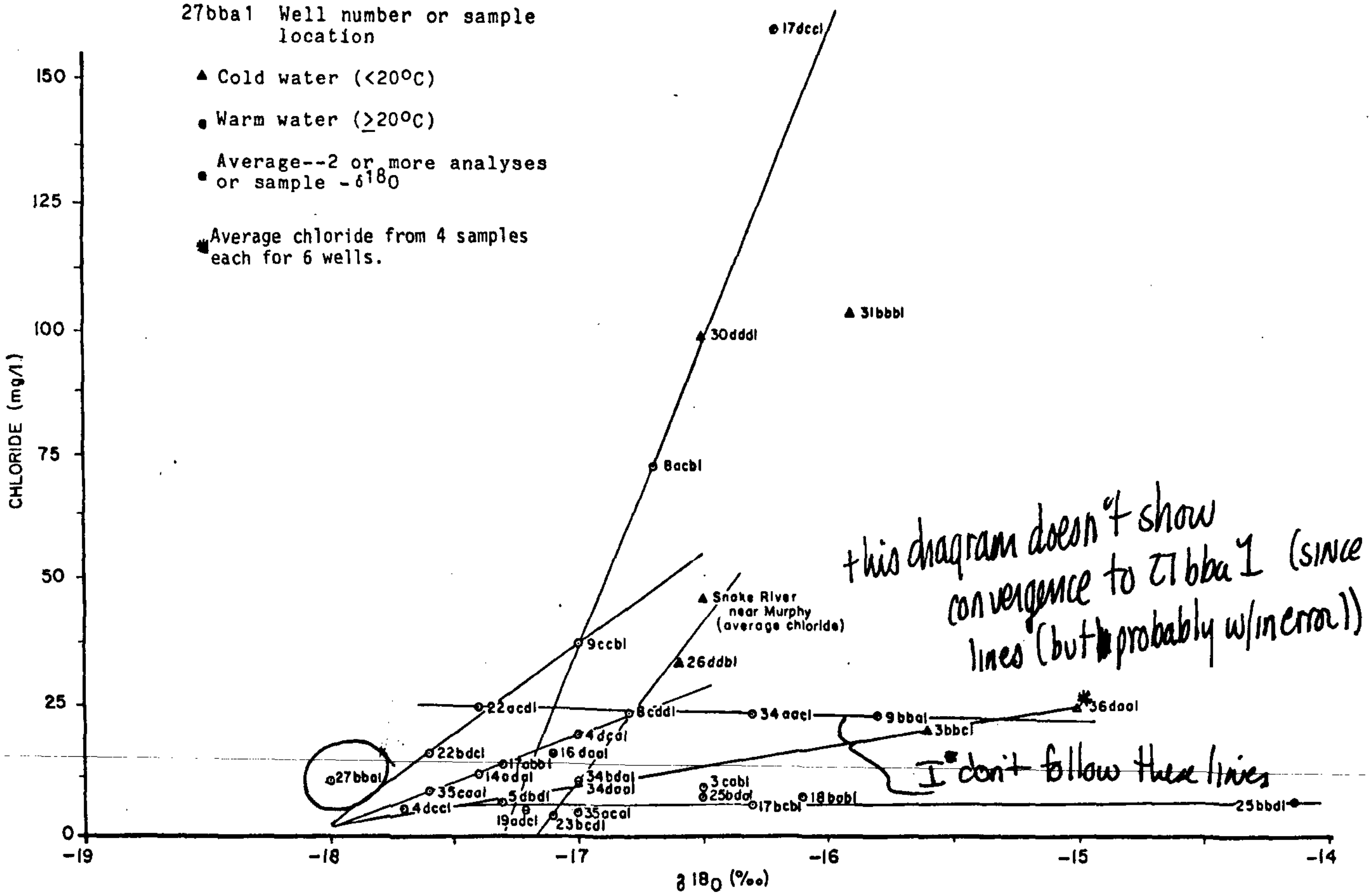
cases calculate out to be below the freezing point of water as do many β christobalite calculated temperatures and therefore are probably invalid. ✓

Well 2N-3W-27bbal would appear to be most appropriate to obtain reliable information on aquifer temperatures in the Nampa-Caldwell area since the isotope data indicate that water from this well is unmixed. However, the isotope data suggests some changes in dissolved chemical constituents in water from this well may have occurred. Figure 10 is a plot of chloride vs. $\delta^{18}O$. This plot shows convergence again toward well 2N-3W-27bbal, but to a point of chloride concentration below that actually found in well 2N-3W-27bbal water by chemical analysis. The diagram indicates either the reported chloride concentration in the analysis is too high by 10 mg/l (cation-anion balance about 5, within acceptable limits) or changes in chloride concentration have occurred.

Shakey

Dissolved flouride in water from well 2N-3W-27bbal (figures 7 and 8) appears normal. The apparent convergence of data in the cation field in the trilinear diagram (figure 9), and relatively good agreement between chalcedony (94°C) and Na-K-Ca (cation) geothermometer (89°C) (a 5°C temperature difference, columns T_4 and T_5, Table 2) indicate little change in cations in the chemical analyses for well 2N-3W-27bbal, and that these might be within acceptable

FIGURE 10. $\delta^{18}O$ verses chloride concentration from selected wells and surface waters in the Nampa-Caldwell and adjacent areas of southwestern Idaho.



this diagram doesn't show convergence to 27bba1 (since it is off the lines (but probably w/in error))

I don't follow these lines

limits. But a discharge of 757 l/min from this well, and a moderate depth of 195 m indicate water being pumped to the surface rapidly enough that there could be very little (1° or 2°C at most) change in temperature of the water in the well bore (no conductive cooling). Consequently, the measured surface temperature of the well water (30°C) should be a good indicator of actual aquifer temperatures from the aquifer within the "blue clay." In addition, the uniformity of isotope verses temperature data suggests relatively uniform temperature for this aquifer over fairly large areas. Consequently, aquifer temperatures probably are not much greater than 30°C for this aquifer. Thermal water may be migrating upward along faults or joints from a deeper aquifer and cooling by conduction to about 30°C from 90° to 95°C as it ascends into the aquifer within the "blue clay." Heat flow data of Smith (1980) indicates 90° to 95°C temperatures would be reached at depth only below about 1500 m. The correlation of the above chemical and isotope data indicate that essential chemical equilibrium may be conserved in the deeper water during its ascent to and residence in the aquifer within the "blue clay," provided mixing has not taken place, at least for several wells in the Nampa-Caldwell area.

RADIOACTIVITY

Forty water samples were collected and submitted to Idaho Department of Health and Welfare for analyses for gross alpha (α) and gross beta (β) radiological contaminants. Alpha particles are helium nuclei and β particles are electrons, ejected from the nucleus of certain elements during radioactive decay. The result of these analyses are shown in Table 4. Sample locations are shown IN POCKET in figure 17. Six samples were found to exceed the U.S. Environmental Protection Agencies (EPA's) drinking water standards of 15 pCi/l (pico curies per liter) maximum for α emmissions. For β emmissions the maximum radiation level allowable by law is 50 pCi/l where 1 Ci is equal to 3.7×10^{10} disintegrations per second. Water from wells 3N-3W-3bbc1, 26bca1, 3N-2W-26ddb1, 31bbb1, 2N-2W-27aaa1 and 1N-2W-8ddd1 all exceeded the standard of 15 pCi/l for α emmissions. The highest value found was from well 3N-3W-26bca1 at 59.8 pCi/l. Well 3N-3W-30ddd1 had 14.5 pCi/l, only slightly under the standard. All β radiation counts were well within the limits, the highest being 25.1 pCi/l from water from well 3N-3W-26bca1, which also gave the highest α counts. Water from well 2N-3W-27bba1 showed low radiation levels; the high radiation levels, therefore might be coming from sources above the blue clay in the cold water aquifers.

The source of the higher radioactivity in waters discharged from the six wells mentioned above is not known. "speculation" A speculation is that the source may be dissolved chemical constituents from radioactive oxidate or ? sp reduzate minerals

TABLE 4

Radiological Contaminants from Ground and Surface Waters in the Nampa Caldwell Area, Canyon County, Idaho

Well or Sample No.	Sample Collection Date	Gross	Gross
3N-3W-03bcc1	6-29-79	20.6*	1.1
06dca1	6-29-79	9.9	7.1
16bdd1	6-29-79	11.3	5.8
19dcb1	6-29-79	2.8	1.8
23ccc1	6-29-79	4.9	2.8
26bca1	6-29-79	59.8*	25.1
30ddd1	6-14-79	14.5	6.8
3N-2W-26ddb1	6-04-79	23.1*	11.0
31bbb1	6-14-79	24.7*	9.3
2N-3W-08cdd1	6-14-79	7.7	6.2
11cba1	6-29-79	.81	1.8
23acd1	6-28-79	3.6	3.7
25bda1	6-28-79	3.0	3.5
26aac1	6-28-79	3.8	3.6
27bba1	6-15-79	.44	19.1
35caa1	6-15-79	3.3	9.3
2N-2W-04dca1	6-04-79	2.7	1.1
16daa1	6-14-79	1.2	2.1
18bab1	6-28-79	2.8	2.0
27aaa1	6-07-79	16.7*	11.6
27daba	6-07-79	6.7	3.9
31cdd1	6-13-79	4.5	3.3
31dad1	6-11-79	1.5	2.2
34dba1	6-04-79	1.5	1.8
34cda1	6-07-79	4.3	1.3
34aac1	6-04-79	2.1	<1
1N-3W-12bab1	6-28-79	.42	17.9
01bbc1	6-15-79	6.4	21.1
1N-2W-03cbb1	6-07-79	5.9	3.8
05cab1	6-11-79	1.2	2.7
06caa1	6-12-79	1.9	4.3
07adc1	6-12-79	<.1	4.8
08acb1	6-11-79	4.4	6.8
08ddd1	6-08-79	21.4*	11.4
09bba1	6-08-79	1.9	1.4
09ccb1	6-08-79	2.0	5.4
11aaa1	6-13-79	2.1	2.1
16cba1	6-08-79	9.9	10.1
17dcc1	6-08-79	7.4	15.1
22dad1	6-11-79	2.9	10.2
1N-1W-07cba1	6-13-79	5.6	5.7
13aaa1	6-28-79	3.1	4.9

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* Exceeds EPA maximum permissible level for radiation in drinking water.

deposited within arcosic sands derived from weathering of the grantic rocks of the Idaho batholith which are found along both the northern and southern margins of the western Snake River Plain. A radioactive contaminant common in some geothermal systems in other areas is radon, a gaseous element dissolved in thermal water and thought to be derived from natural radioactive disintegration of uranium or radium from uranium or radium containing minerals.

what other sources of Rn might there be?

CONCLUSIONS

When observed in its entire perspective, and in view of the complicated nature of the Nampa-Caldwell groundwater systems and possible surface water sources mixing with groundwaters, the isotopic data from the Nampa-Caldwell area of southeastern Idaho ~~is~~ are remarkably consistent in ~~its~~ their interrelations to itself and other types of data. This consistency lends credence to the following conclusions.

(1) Geothermal waters are depleted in heavy isotopes which may mean precipitation in areas of higher elevation (geographic displacement) or during a time when the climate was colder than that prevailing today. If recharge were during the Pleistocene Epoch (ice age) the water is equal to or greater than 11,000 years old. Alternatively, depleted water could be the result of semipermeable membrane clay layer processes, or result from

little ice age ?

fractionation, or from exchange of isotopic species with aquifer constituents, or result from deep seated steam separation by subsurface boiling.

(from P-T elsewhere in SRP.) Isn't major boiling unlikely?

(2) Recharge may be taking place over a long period of time or, there may be relatively little present day recharge to the thermal system.

(3) Mixing of thermal and nonthermal waters is widespread in the Nampa-Caldwell area occurring within aquifers and well bores due to well construction. The total effects on the geothermal and nonthermal aquifers due to migration and mixing of thermal and nonthermal waters on the longevity of the geothermal aquifers for use as a heat source ~~is~~ are not known.

(4) Cold water recharge, for aquifers above the "blue clay," appears, from isotope data, to be from Reynolds Creek basin south of the Snake River Plain or similar elevations, the Snake River, Lake Lowell and canals due to irrigation practices, perhaps the Payette River, Boise River, and Willow Creek areas north of the Snake River Plain.

(5) The thermal water appears ultimately to be coming from aquifers deeper than the aquifer within the "blue clay."

(6) Temperatures from the aquifer within the "blue clay" appear to be only about 30°C and may be

fairly uniform over large areas.

(7) Temperatures of 90° to 95°C might be obtained nearly everywhere in the area, but only by drilling to depths greater than 1500 m, or perhaps at shallower depths in fault zones.

(8) Thermal water of isotopic composition $\delta D = -150$ ^{o}/oo and $\delta^{18}O = -18$ ^{o}/oo appears to be widespread in the western Snake River Plain region and may be the parent geothermal water in the Nampa-Caldwell area, the Boise area, and the Bruneau-Grandview area. This indicates the water in these areas may be from the same source(s) and/or times of recharge, or the geothermal system may be interconnected.

This needs more justification if it is to be included - this report doesn't gi enough, d

RECOMMENDATIONS

The isotope data suggests that thermal waters in the Nampa-Caldwell area, and indeed other areas in Idaho, including Weiser, Bruneau-Grandview and Boise areas may be old waters (11,000 years or greater). It is not known if present withdrawals of old water are being replaced with present day recharge. If not, the thermal waters are being mined and large scale withdrawals, i.e., for space heating or other purposes could eventually deplete the aquifer(s) to a point where further economic use is not feasible. To

This needs to be developed more - by presenting further data, references, & more evidence

which may be an IDWR regulatory (legal) worry, but not a concern about the resource. We do mine Cu - econom are dictated by the quality of the deposit, not that it isn't being replenished maximize the longevity of the resource until recharge can be proven or disproven, it is recommended that for any future use of the aquifers for space heating or other geothermal purposes, consideration be given to the use of down hole heat exchangers (heat exchangers located within the well bores adjacent to, or within the aquifers). These have proven practical at other localities such as Kalamath Falls, Oregon. Down hole heat exchangers have two advantages: (1) they do not deplete the water resource, (2) there is little or no chemical pollution, as little or no geothermal water is brought to the surface.

They have problems, too - requiring good aquifers

an entirely new point - on USPHS standards

Investigations of effects of widespread artificial aquifer connections by well drilling on the longevity of the thermal aquifers and their use for a heat source should be conducted.

what about natural vertic. permeability?

Investigations to delineate possible recharge of the thermal aquifers should be undertaken to determine if recharge is presently occurring. These could include further stable isotope work in suspected recharge areas in the mountains on both sides of the Snake River Plain, tritium age dating, and dating using C_{12}, C_{13} and inert gas methods to determine absolute age of thermal water from various thermal aquifers.

the aquifers are being recharged - the questi is what rate

More work is needed to determine clay layer semipermeable membrane effects on the stable isotope ratios in the Nampa-Caldwell area. This particular study would be in the realm of institutions with adequate research facilities for such studies.

Isotope data has proved to be a very valuable tool in this investigation and should be incorporated as standard water quality data in other areal investigations where deemed appropriate. Isotope studies should be integrated in any groundwater study of the Boise Front Geothermal system.

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