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A REVIEW OF THE
GEOCHEMISTY
OF
THERMAL WATERS
IN THE
BRUNEAU-GRAND VIEW AREA,
IDAHO

for

AMAX EXPLORATION, INC.
DENVER, COLORADO

by

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SUMMARY AND CONCLUSIONS

1. Previous studies of groundwater geochemistry of the Bruneau-Grand View area have been evaluated. Over 100 complete chemical analyses of well and spring waters exist, plus 15 analyses of associated gases, and 19 deuterium-oxygen isotope analyses.

2. Studies have documented the quartz and cation geothermometers and have correlated chemical parameters with aquifer rock type, showing that waters produced from sedimentary rocks of the Idaho Group have higher chemical temperatures than waters from underlying volcanic units (Banbury basalt, Idavada volcanics), due to effects of rock composition.

3. The regional hydrologic model predicts flow at depth from south to north. Recharge occurs in the Owyhee uplands to the south, into volcanic rocks and underlying granites. The volcanic rocks dip northwards toward the Snake River. Overlying sedimentary rocks act as a hydrologic barrier, creating artesian conditions. The sedimentary section thickens northwards, and the depth of wells drilled into the volcanic rocks generally increases in that direction.

4. Surface temperatures of artesian and pumped well waters are generally higher in the north. The hottest wells (83°-84°C), near Grand View, are generally the deepest. Their flow rates are high enough for minimal conductive cooling during ascent from depth. There is no evidence that the higher well temperatures in the north indicate regionally higher heat flow.

5. The area is divided into five parts: Castle Creek, Grand View, Little Valley, the south end of Bruneau Valley, and the Owyhee uplands. Little Valley is closest to the AMAX leaseholds, and has been given the most attention. Chemical analyses have been plotted on trilinear composition diagrams, and Na graphed versus K, by geographic area, aquifer type, sample temperature, and chemical geothermometry.

6. Water composition is different in aquifers of different rocks and from area to area. The most common volcanic water is Na-HCO_3, with minor Ca and SO_4. Sedimentary waters divide into a high salinity Na-HCO_3 type found in Grand View and Castle Creek, and a lower-salinity mixed-cation HCO_3-SO_4 type from scattered localities in all areas.

7. On trilinear composition diagrams, volcanic-aquifer waters of Little Valley and the south end of Bruneau Valley occupy separate elongated fields which in part overlap. Volcanic-aquifer waters from Castle Creek and Grand View are similar and almost always distinct from those of Little and Bruneau Valleys. Several deep wells at the N end of Little Valley are distinct from those to the south and very similar to the deepest, highest-temperature waters in the Grand View area.

8. A composition trend in some Little Valley waters may be due to mixing of waters from volcanic and sedimentary rocks, or may illustrate evolution of the volcanic to the sedimentary type as the deeper volcanic waters circulate upwards into and react with overlying sedimentary rocks.

9. Many waters intuitively seem likely to be mixtures of components of different temperature and composition. This is suggested by the high permeability of many volcanic rocks, the high flow rates of wells and springs, artesian conditions, shallow temperature anomalies, evidence for substantial recharge into fractured volcanic rocks in the Owyhee uplands, and production of many wells from more than one zone at depth. Despite this, however, graphical treatment of data does not illustrate mixing trends other than that of point 8.

10. The hottest waters of the region tend to have the lowest Ca and Mg relative to Na and K, and higher SO_4 relative to HCO_3. The hottest waters also have the highest Na/K ratio, which is opposite of what would be expected if temperature alone were controlling water composition. It seems more likely that the correlation of temperature and composition is due in part to a correlation with rock composition.

11. Ca and Mg probably are controlled by temperature, whereas Na/K may be mostly influenced by rock composition. Compositional data of thermal waters do not indicate mixing. In particular, there is no evidence for a deep, high-temperature component of anomalous chemical character.

12. U.S.G.S. Circular 790 lists an estimated mean reservoir temperature of $107\underline{+}6$°C for the entire Bruneau-Grand View area, in light of the chemical and sulfate-water oxygen-isotope geothermometers and artesian well temperatures. Individual subareas may be significantly hotter at depth.

13. Silica geothermometry indicates 130°-140°C by conductive quartz and 100°-110°C by chalcedony for Little Valley. In Grand View, Castle Creek and northern Little Valley, silica yields 137°-157°C (conductive quartz) and 110°-133°C (chalcedony). Chalcedony temperatures generally are preferred herein, because of abundant glassy SiO_2 in Idavada volcanic rocks, and because of similarity with cation temperatures in volcanic-rock aquifers.

14. Cation temperatures of waters from volcanic-rock aquifers exceed 100°C only in Little Valley and Bruneau Valley. Little Valley shows a bimodal distribution of 78°-92°C and 174°-198°C. This split is spurious, due to the peculiar way in which the cation geothermometer is calculated. A more reasonable cation temperature estimate is 80°C-110°C, which corresponds well with chalcedony temperatures 100°-110°C for the same waters.

15. Estimated temperatures for most deep volcanic waters of the Grand View and Castle Creek areas correspond well with the maximum observed well temperature (84°C), whereas the estimated temperatures for Little Valley are notably higher than the maximum observed well temperature (43°C). This may indicate conductive cooling, mixing of deep and shallow waters, or anomalously high geothermometry. Evidence is moot.

16. Deep waters from volcanic rocks at the north end of the Little Valley area (points 7 and 13) have believable chemical temperatures higher than elsewhere regionally. Minimum temperature estimates are 120°-130°C; temperatures of 150°-170°C are indicated, but less certain. More work may be advised here.

17. All of these waters come from outside the AMAX leasehold. No wells or deep springs are known in the leasehold which might be sampled. Because the hydrologic model suggests that waters have moved northward horizontally beneath the AMAX leasehold, the conclusions herein probably provide a fairly reliable estimate of conditions beneath the leasehold as well. However, local, undetected anomalies may be present.

18. The Bruneau-Grand View data base probably is representative of water chemistries at depth. Little new information would likely arise from additional sampling elsewhere than in northern Little Valley, given the relatively low temperatures indicated by chemical geothermometers.

INTRODUCTION

In October 1980, Dr. Harry J. Olson of AMAX requested a review of existing geochemical work in the Bruneau-Grand View area of Idaho, to determine whether further geochemical exploration or data processing would be valuable in evaluating AMAX's leaseholds in the area. A preliminary review of existing data led me to recommend further processing and interpretative studies. Results of this work are presented in this report.

Thermal waters of the Bruneau-Grand View area are only at moderate temperatures. Generally, the highest temperatures are in the north. The hottest well issues 83°C to 84°C water at the surface from 2,970 feet depth, near Grand View. The hottest spring issues 45°C water in the southern end of Bruneau Valley. Despite this, the region as a whole is of interest because of the large area (about 11 townships) within which thermal waters are known to exist in abundance. For the purposes of this report, the Bruneau-Grand View area is considered to encompass the entire region from Bruneau Valley in the east and southeast, through Grand View, to and including Castle Creek KGRA in the northwest (plate 1).

REVIEW OF EXISTING DATA AND INFORMATION

Data Base

A large number of chemical analyses of well and spring waters are available for the Bruneau-Grand View area. Data reviewed for this report are reproduced in Appendix 1. Sample locations appear on plate 1, which shows the locations of all waters for which there are analyses of Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl, F and SiO_2, plus pH. Also shown are the locations of some additional wells from which no chemical data or only partial data are available; representation of these is not complete.

The U. S. Geological Survey collected and analyzed about 20 samples in the early 1950's (Littleton and Crosthwaite, 1957), a dozen samples in 1972 (Young and Mitchell, 1973) and 94 samples in 1973 (Young and Whitehead, 1975). Several partial analyses have been published by the Idaho Department of Reclamation (Ralston and Chapman, 1969).

The references above include hydrogeologic data such as water levels, well logs, stratigraphic correlations and discussions of the major aquifers, flow patterns and recharge.

Analyses of gases from wells are included in Young and Whitehead (1975), and 14 deuterium-oxygen isotope analyses are reported by Rightmire and others (1975). Several sulfate-water oxygen-isotope temperatures have been reported by Nehring and others (1979).

Groundwater in a missile silo well at T9S-R5E-4dad in the Owyhee uplift has been sampled repeatedly by the U. S. Geological Survey. Resulting analyses are available from survey files in Boise and the computer file WATSTOR, and representative examples are in Appendix I.

AMAX analyses of waters from the area comprise a set numbered W10220 through W10228, collected in 1976 in the vicinity of Castle Creek KGRA, west and north of Grand View. These exist as original and field report forms and analyses, and are not listed in the computer-based geothermal file. In contrast, the geothermal file does include 92 of the 94 chemical analyses reported by Young and Whitehead (1975), listed under file name Granview Idaho Recon 1977. The samples have been assigned numbers W11461 through W11553, which duplicates part of a sequence in the file named Nevada California Recon 1978.

Data include thermal waters from both deep (to over 3,000 feet) and shallow wells. Many of the wells are artesian. Thermal springs and cool, shallow well waters also are represented, plus a few examples of mountain spring waters in the Owyhee uplift, which are believed to represent part of the recharge into the area's artesian aquifer(s).

Nearly all data are from areas to the north of the AMAX leasholds along the base of the Owyhee uplift. There are no waters from within the leaseholds (as shown on lease maps dated 2/12/79). Topographic maps show no springs in the leaseholds, and judging from topography there may be few or no wells. H. L. Whitehead, U. S. Geological Survey, Boise, reports that the upland areas of T8S, R4 and 5E, are unpopulated, with no wells that he is aware of (telephone conversation, November 1980). He also indicated that the samples reported in Young and Whitehead (1975) represent a high percentage of the deep wells in the region.

Several wells are as close as 1-1/2 miles north of the eastern AMAX leaseholds in T7 and 8S, R4 and 5E, and 30 to 40 analyzed waters are from the area within about 6 miles to the north and northeast. The chemistry of groundwaters beneath the leaseholds can be inferred fairly reliably from these data, because regional groundwater flow is believed to be from south to north. The leaseholds are traversed by several of the major north-dipping northwest-striking normal faults along the edge of the Owyhee uplift, and they overlie several heat-flow anomalies. It is probable that the faults are conduits for upwelling thermal waters, which migrate northwards in volcanic rock units from beneath the leasehold areas and are then tapped by the sampled wells.

The westernmost leaseholds, in T6 and 7S, R2 and 3E, are more distant from water sample points, with virtually no samples within 3 miles, and very few within 6 miles. No closer springs are apparent on topographic maps.

Interpretive Studies

AMAX in-house reports have included IOM's by Frank Dellechaie dated April 2, 1976, March 3, 1978 and April 6, 1978, and a section on geochemistry in an IOM by John Deymonaz, February 7, 1978, which is basically a summary of Young and Whitehead (1975).

The April 2, 1976 memo considered 6 hot artesian well waters sampled by Young and Whitehead (1975) from T4S, R1E, T4S, R2E and T5S, R1E, in the vicinity of Castle Creek KGRA. It was concluded that 4 of these were at equilibration below 100°C, but that two waters indicated maximum temperatures of 150°-160°C or slightly higher. Thermal water compositions were similar to those elsewhere in the Bruneau-Grand View area, as well as to waters in the Idaho batholith. Circulation with granitic rocks at depth was inferred. In summary, the Castle Creek KGRA was not considered to be a prime prospect worthy of large capital expenditure.

The March 3, 1978 memo illustrated that waters from certain shallow wells in the Bruneau-Grand View area have chemical temperatures higher than those of deeper, hotter wells. This is due to effects of aquifer rock composition, and is discussed below. Dellechaie felt that chemical temperatures between 75° and 143°C provided by the deepest, hottest wells are realistic.

The April 6, 1978 memo included silica-enthalpy mixing calculations which are said to reflect equilibrium with chalcedony for 4 Grand View area waters. Minimum hot component temperatures are 203 to 238°C and the fraction cold water is about 90% in each case. It was correctly pointed out that the quantitative significance of the mixing calculations decreases rapidly as the cold water fraction increases, but no other interpretation of the calculations was presented.

Other reports have reached conclusions essentially equivalent to Dellechaie's. Young and Whitehead (1975), for example, stated that aquifer temperatures at depth, as estimated by silica and sodium-potassium-calcium geochemical thermometers, probably do not exceed 150°C, but that a mixed-water silica thermometer indicates that temperatures at depth may exceed 180°C.

Isotope studies by Rightmire and others (1975) have established that recharge to the thermal aquifers is not entirely from within the local surface-drainage area, but may come from higher elevations near the Bruneau River to the southeast; and/or that the recharge occurred at a time in the past when regional climate was cooler than at present.

U.S.G.S. Circular 790 tabulatedan estimated mean reservoir temperature of 107±6°C for the Bruneau-Grand View area, in light of the chemical and isotope geothermometers and artesian well temperatures. Data used include sulfate-water oxygen isotope temperatures of

95°C to 130°C for several samples (Nehring and others, 1979). The estimate is for the area as a whole, however, and for waters in the aquifers feeding the deeper (to 3,000 feet) artesian wells. It remains possible that these aquifers are fed by a deeper, hotter source, and that individual localities may have significantly greater upflow and therefore higher temperatures.

NEW TREATMENT OF DATA

Objectives and Methods

In reviewing the existing data it became apparent that graphical treatment would be helpful in resolving uncertainties of water origin and circulation.

The basic hydrologic model of the Bruneau-Grand View area holds that water in the deep volcanic aquifers originates as recharge in the Oywhee uplift and flows down-gradient in north-dipping volcanic units towards the Snake River. If this is true, then it is of interest to know whether there are gradations in water composition from south to north, and whether there are distinct relationships between water temperature and composition. For example, do the moderate temperature thermal waters of the Grand View area resemble the lower temperature thermal waters of Little Valley?

The AMAX leaseholds overlie a set of parallel normal faults along the northern margin of the Owyhee uplift; heat-flow data indicate that thermal upwelling occurs in association with these zones (AMAX heat flow map, 2/7/78). Is there evidence to suggest that the low-temperature thermal waters near the uplift are actually mixtures of a high temperature component and cooler waters? Could the same thermal component be related to the hot water tapped by wells near Grand View? Finally, existing reviews of chemical geothermometry have been limited to tabulation of calculated temperatures, and to silica mixing models applied without consideration of other chemical parameters. Would insight into the geothermometry be aided by consideration of bulk composition, ionic ratios, and geographic and geologic patterns?

The Bruneau-Grand View area herein is divided into four principal subareas, although the boundaries between them are not well defined. These are Castle Creek, Grand View, Little Valley, and the south end of Bruneau Valley (plate 1). The principal area of interest is Little Valley, given its proximity to both the easternmost AMAX leaseholds and the northern edge of the Owyhee uplift.

The south end of Bruneau Valley also is close to the eastern leaseholds, but the northern half of Bruneau Valley is not included because of its greater distance and because of a desire to limit the size of the study. The Grand View and Castle Creek areas are the closest to the westernmost leaseholds. Waters in these areas have temperatures higher than in Little Valley or Bruneau Valley. A fifth, smaller group of samples comprises scattered localities in the Owyhee uplift.

All complete chemical analyses from each geographic area were processed to check for errors, using cation-anion balance, and to calculate equivalent ratios between principal ions. Ionic imbalances greater than ±10% were found to be rare, and only one analyses was discarded because of a large apparent error, probably in reported Na (Young and Whitehead, 1975, sample 7S-4E-25adc1). The analyses were then plotted on trilinear composition diagrams by geographic group, aquifer type and water temperature. Selected waters have been shown on the dual basis of cation temperature in volcanic rock aquifers and sulfate-water oxygen isotope temperature (figure 1, parts A-H).

Geographic Sub-Areas

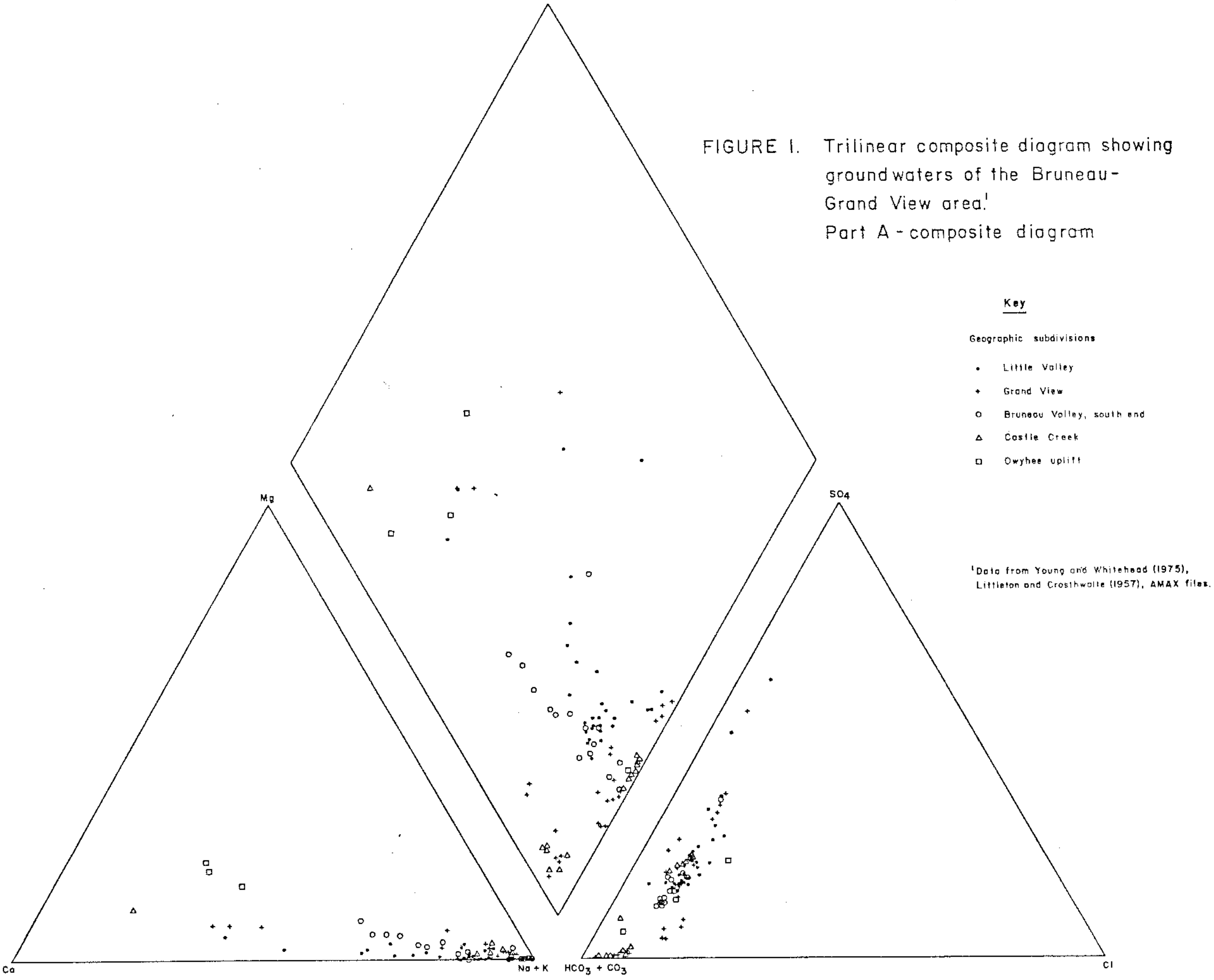
Figures 1 and 2 show that there are distinctions in groundwater composition from area to area on the basis of temperature and aquifer type. The waters of most areas cluster into well-defined groups and are generally of Na-HCO_3 type with minor but notable Ca and SO_4. Scattered examples with high and dominant Ca amongst the cations and sometimes also high SO_4 amongst the anions always prove to be waters from Idaho Group sedimentary rocks or from these and the underlying Banbury basalt.

Total salinity usually is 5 to 10 milliequivalents per liter, but there is a group of much more saline Na-HCO_3 waters from Castle Creek and Grand View areas in the Idaho Group sediments. These are notably lacking in SO_4. SO_4 probably comes from sulfides in the underlying volcanic rocks.

Waters in volcanic rocks of the Grand View and Castle Creek areas generally have Na + K higher relative to Ca than waters of Little Valley and Bruneau Valley south, and this correlates with the higher observed water temperatures in the two northern areas. Many of the Little Valley waters are distinguished from those of Bruneau Valley by higher relative SO_4 and frequently by lower relative Mg. These are probably effects of rock composition and are not caused by temperature differences, in spite of the fact that observed temperatures of the Bruneau Valley waters generally are higher than those of Little Valley.

Na/K ratios vary with aquifer type and geographic ara. Young and Mitchell (1975) and Dellechaie (1976) noted higher concentrations of Na in waters from Idaho Group sedimentary rocks than in those from the underlying volcanic rocks, and also stated that Na/K ratios are lower in the sedimentary aquifers. This is only partially true. The

FIGURE I. Trilinear composite diagram showing groundwaters of the Bruneau-Grand View area.[1]
Part A - composite diagram



[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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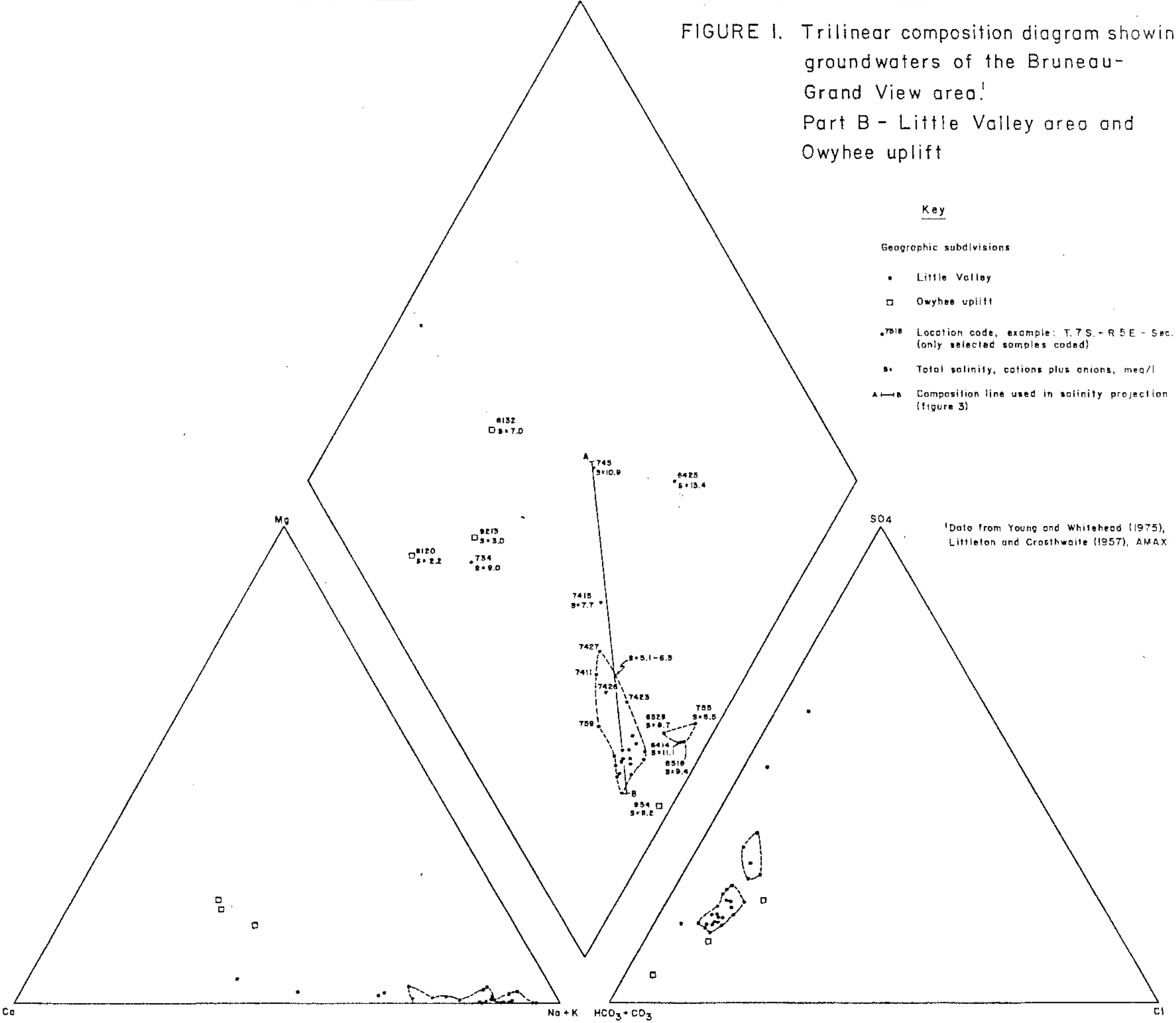
FIGURE I. Trilinear composition diagram showing groundwaters of the Bruneau-Grand View area.[1]
Part B - Little Valley area and Owyhee uplift



Key

Geographic subdivisions

- ● Little Valley
- □ Owyhee uplift
- ●7518 Location code, example: T. 7 S. - R 5 E - Sec. 18 (only selected samples coded)
- S= Total salinity, cations plus anions, meq/l
- A⊢⊣B Composition line used in salinity projection (figure 3)

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[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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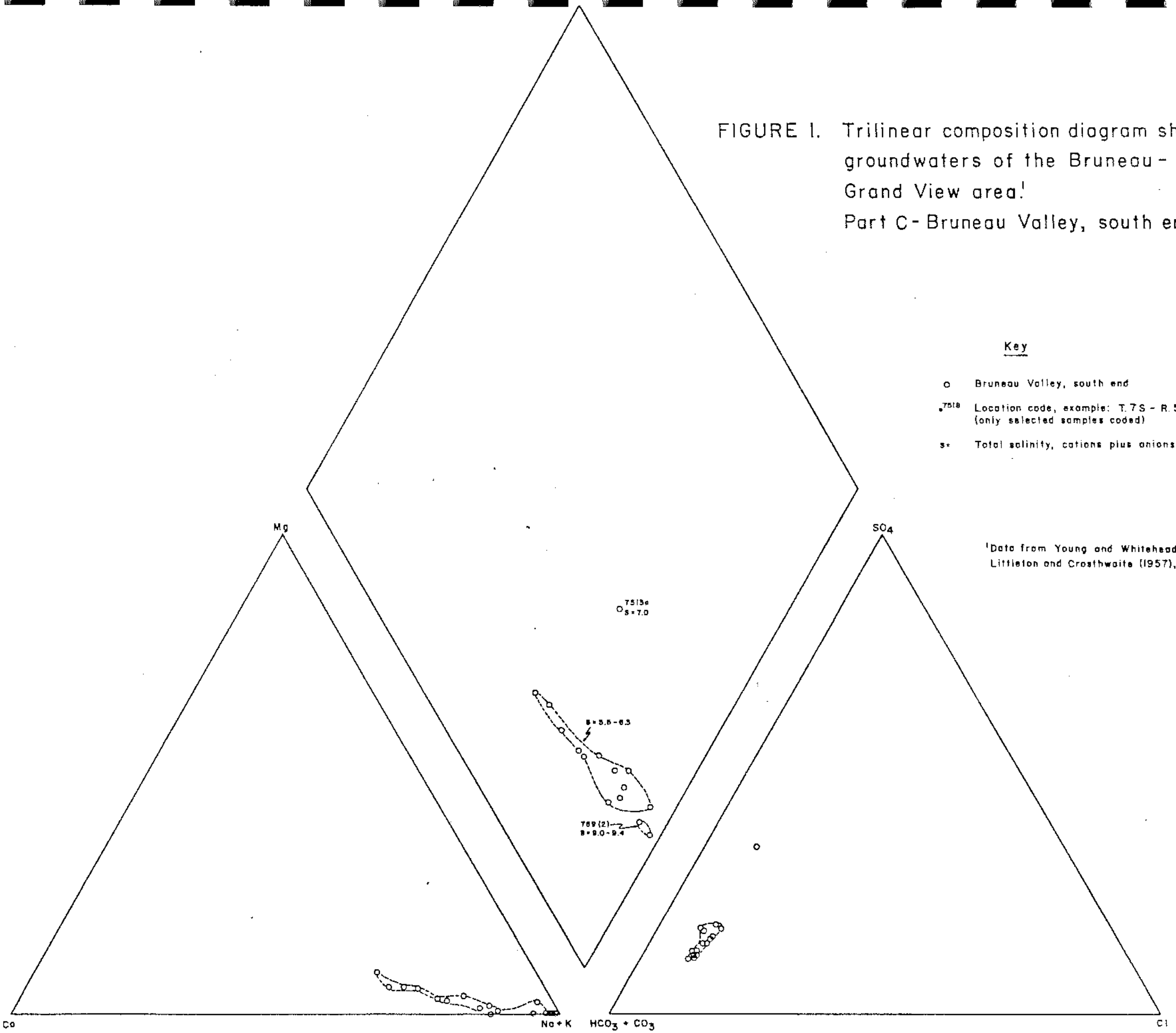
FIGURE 1. Trilinear composition diagram showing groundwaters of the Bruneau-Grand View area.[1]
Part C - Bruneau Valley, south end

Key

○ Bruneau Valley, south end

•7518 Location code, example: T. 7 S - R. 5 E. - Sec. 18 (only selected samples coded)

s= Total salinity, cations plus anions, meq/l



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[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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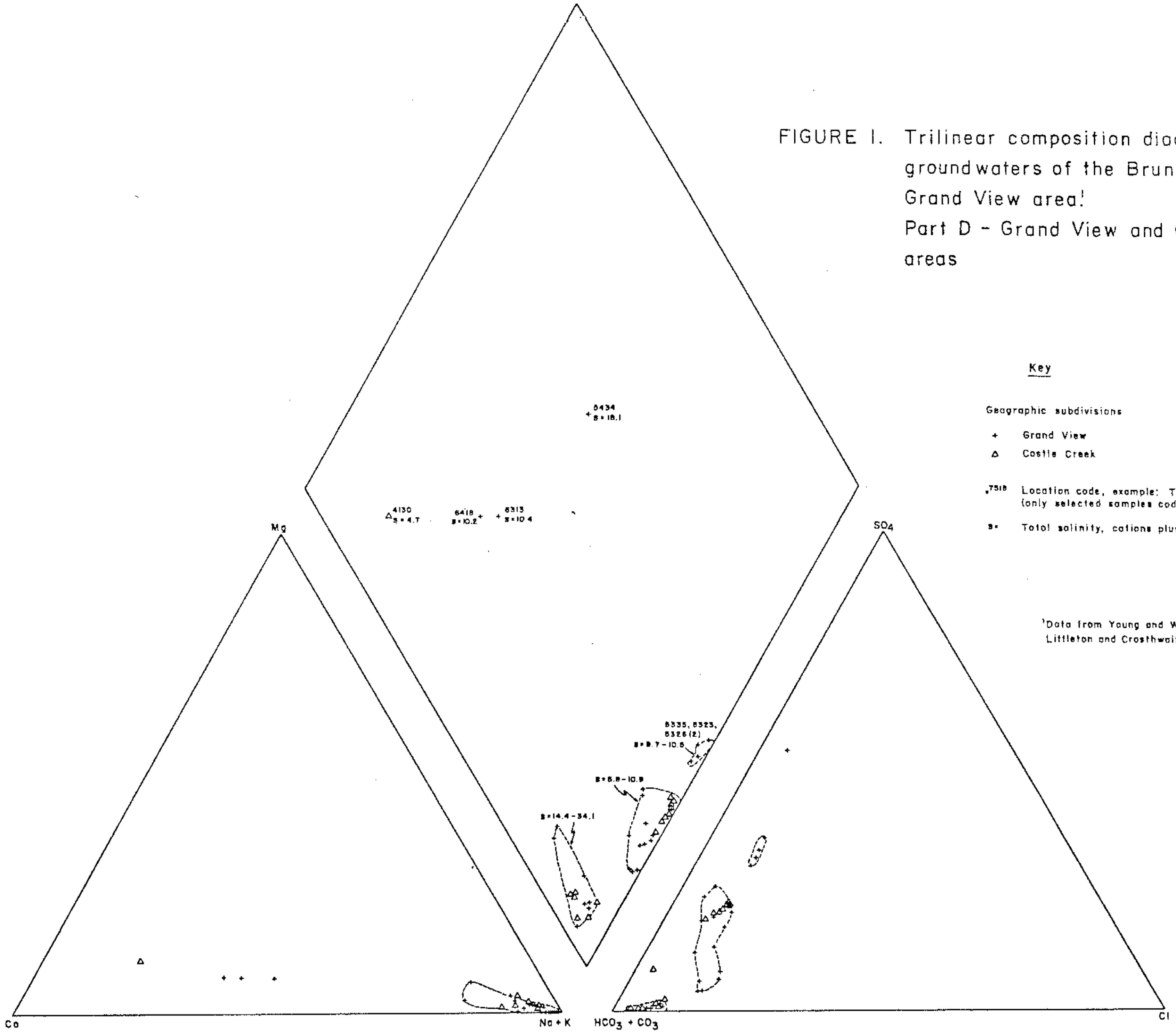

FIGURE 1. Trilinear composition diagram showing groundwaters of the Bruneau-Grand View area![1]
Part D - Grand View and Castle Creek areas

Key

Geographic subdivisions

- \+ Grand View
- △ Castle Creek

.7518 Location code, example: T. 7 S. - R. 5 E. - Sec. 18 (only selected samples coded)

s = Total salinity, cations plus anions, meq/l

[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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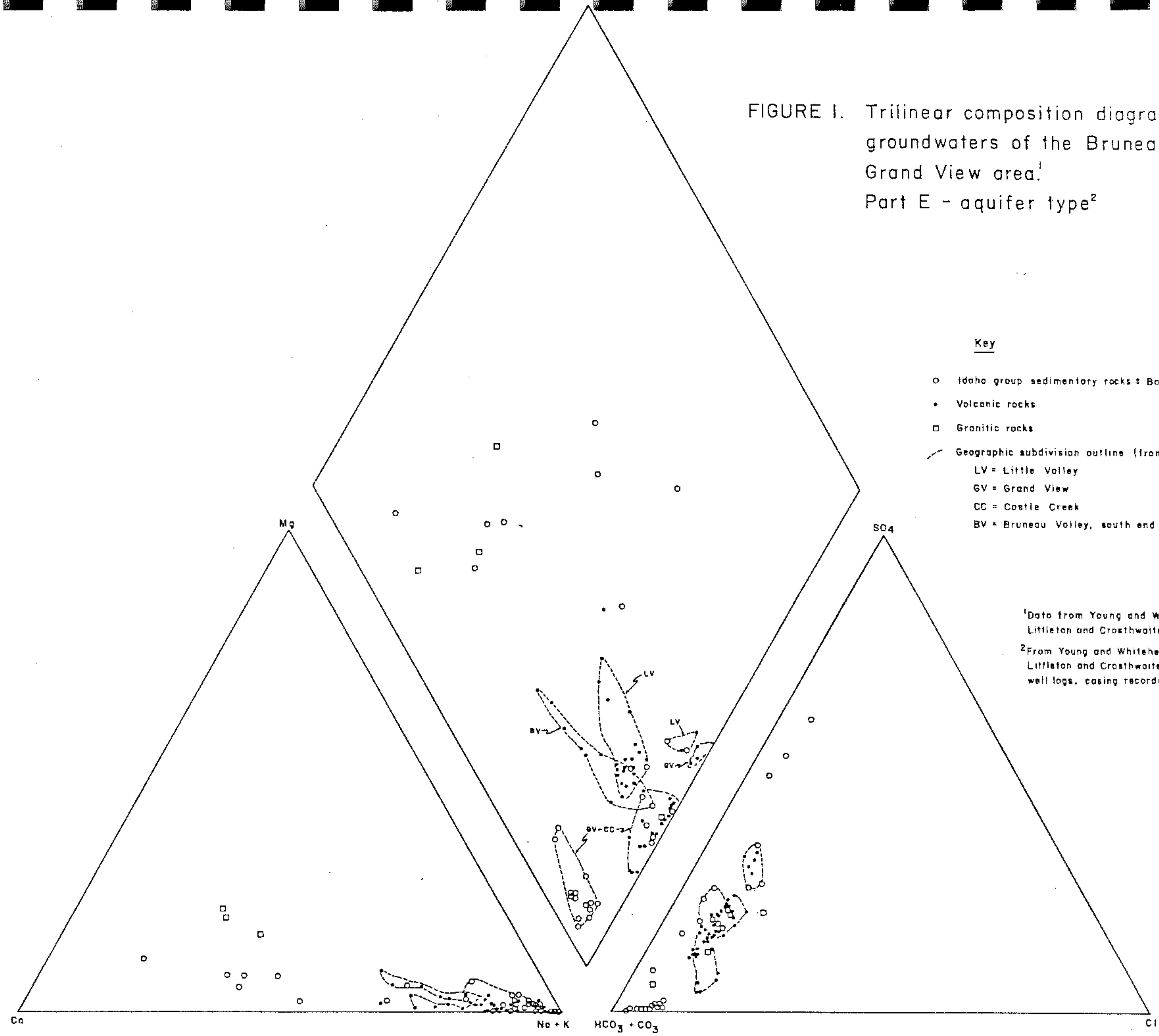
FIGURE I. Trilinear composition diagram showing groundwaters of the Bruneau-Grand View area.[1] Part E - aquifer type[2]



Key

- ○ Idaho group sedimentary rocks ± Banbury Basalt
- • Volcanic rocks
- □ Granitic rocks
- ⌒ Geographic subdivision outline (from parts B-D)
  - LV = Little Valley
  - GV = Grand View
  - CC = Castle Creek
  - BV = Bruneau Valley, south end

[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files

[2] From Young and Whitehead (1975) and Littleton and Crosthwaite (1957) based on well logs, casing records and geology.

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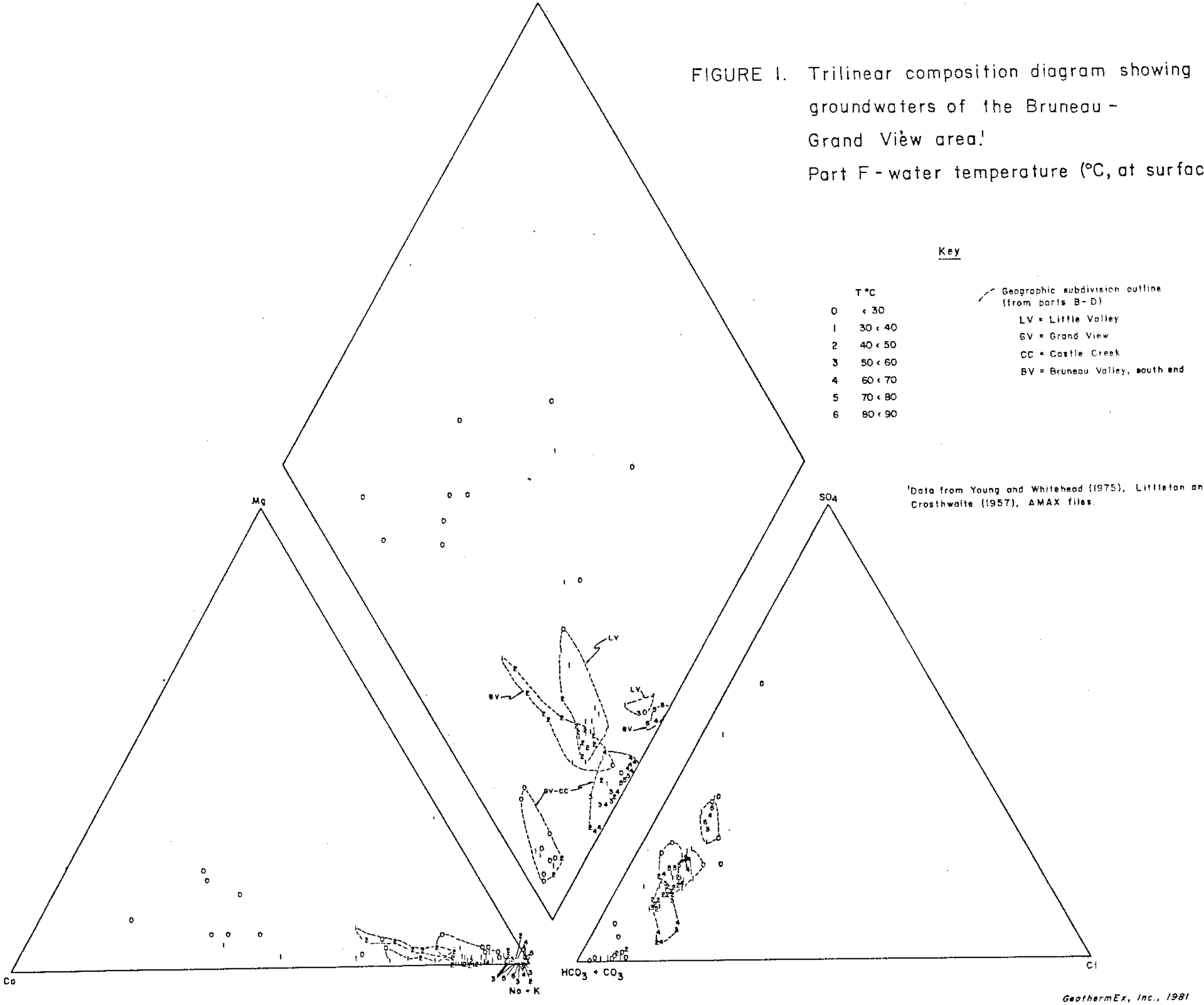
FIGURE 1. Trilinear composition diagram showing groundwaters of the Bruneau – Grand View area.[1]
Part F – water temperature (°C, at surface)



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[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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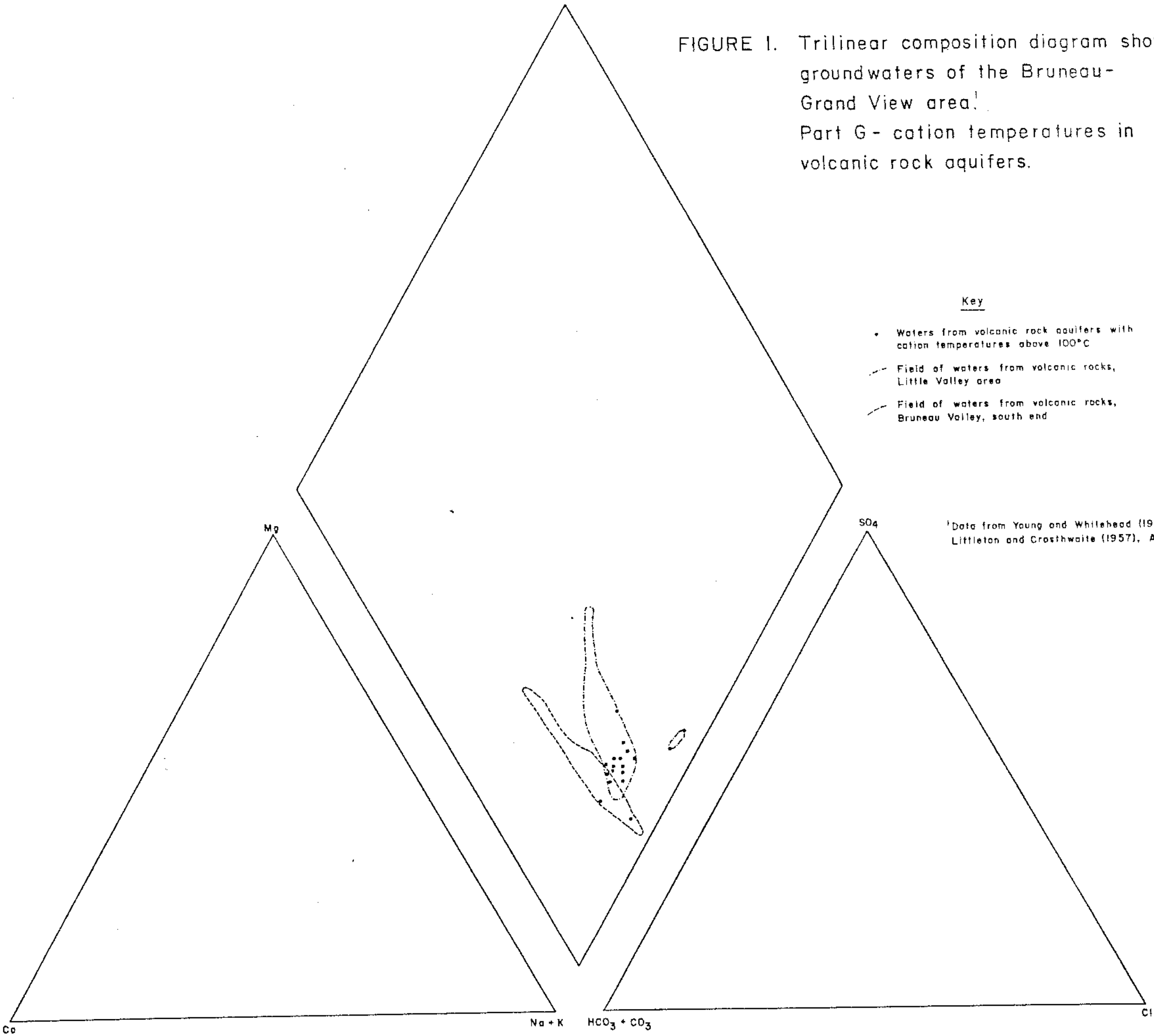

FIGURE 1. Trilinear composition diagram showing groundwaters of the Bruneau-Grand View area.[1]
Part G - cation temperatures in volcanic rock aquifers.

Key

- • Waters from volcanic rock aquifers with cation temperatures above 100°C
- Field of waters from volcanic rocks, Little Valley area
- Field of waters from volcanic rocks, Bruneau Valley, south end

[1] Data from Young and Whitehead (1975), Littleton and Crosthwaite (1957), AMAX files.

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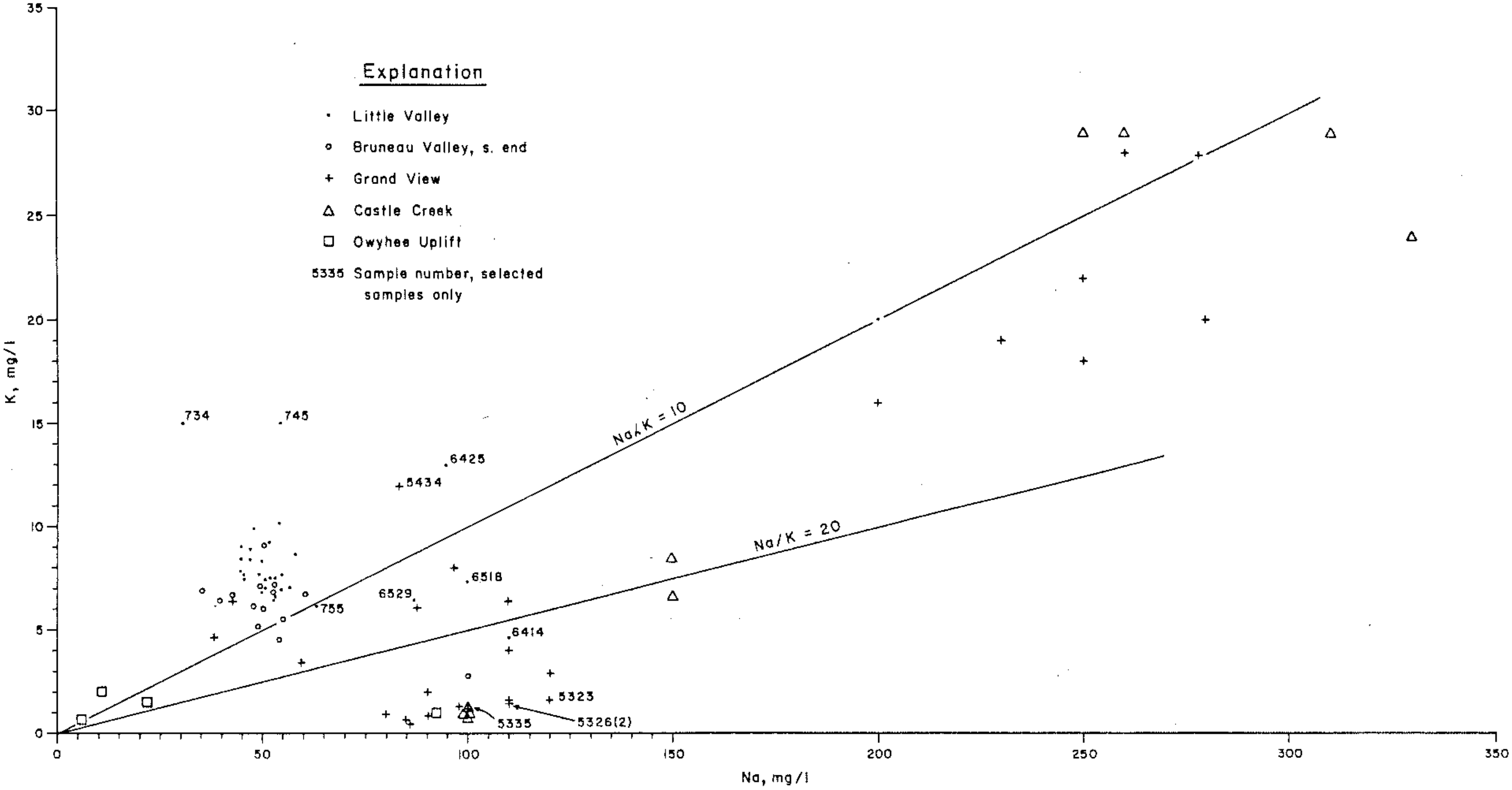

FIGURE 2. Na versus K in groundwaters of the Bruneau-Grand View area.
PART A - Geographic distribution

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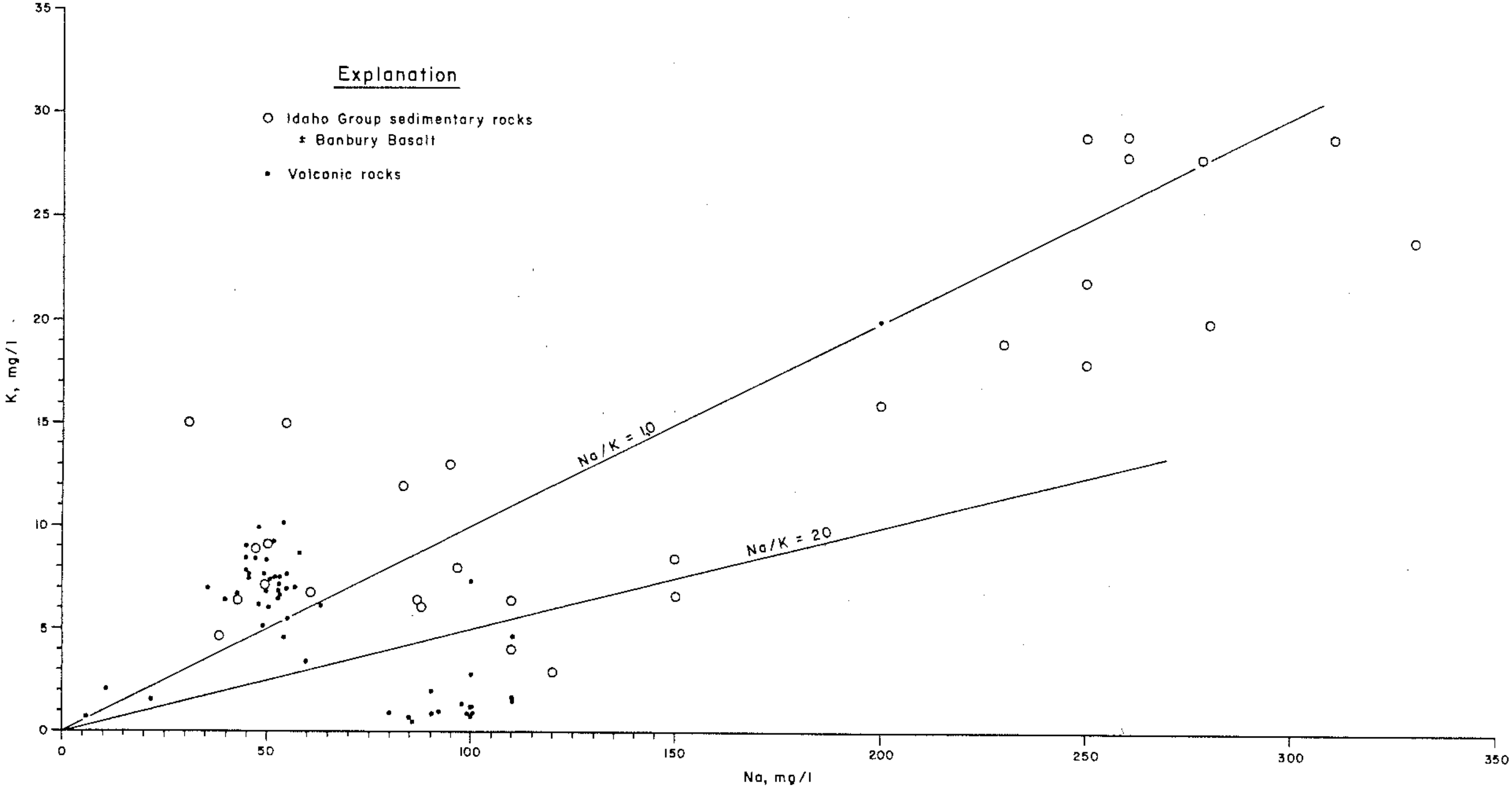

FIGURE 2. Na versus K in groundwaters of the Bruneau-Grand View area.
PART B - Aquifer type
(from Young and Whitehead (1975) and Littleton and Crosthwaite (1957) based on well logs, casing records and geology)

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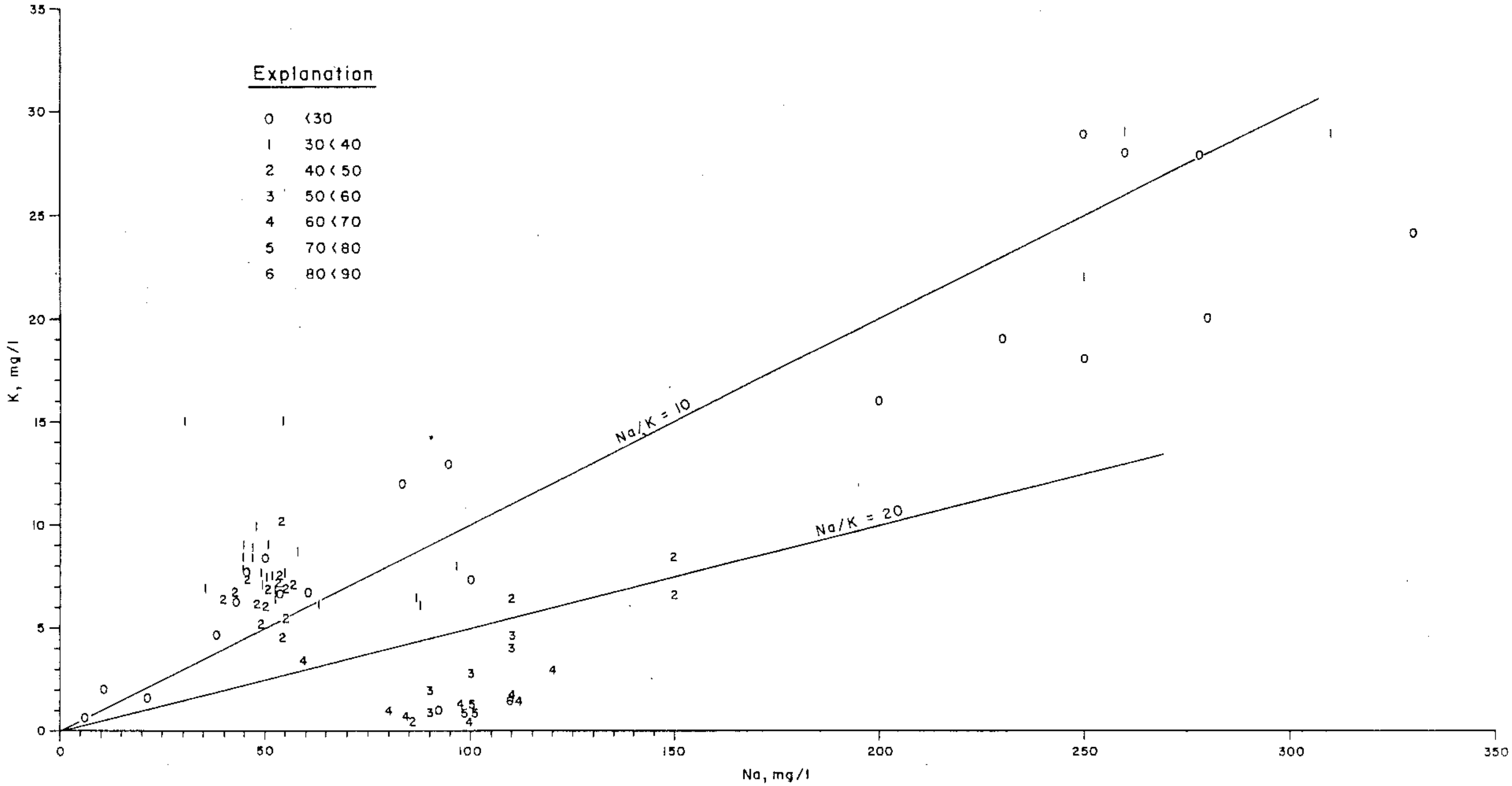

FIGURE 2. Na versus K in groundwaters of the Bruneau-Grand View area.
PART C - Water temperatures ($T^{O}C$, at surface).

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lowest Na/K are indeed in sedimentary aquifers, but volcanic aquifer ratios fall into two groups, with lower ratios in Little Valley and Bruneau Valley than in Grand View and Castle Creek. Na/K in Little and Bruneau Valleys are equivalent to Na/K in sedimentary aquifers, whereas Na/K the Grand View-Castle Creek waters are consistently higher.

Waters of Little Valley fall into three principal groups: (1) scattered waters from Idaho Group sediments which have highly variable compositions and salinities, (2) a trend of compositions from volcanic aquifers in the southern end of the Valley (figure 1, line A-B), and (3) a group in the northern end of the Valley area which resembles several waters from Grand View.

Figure 3 shows a graphical treatment of the waters from volcanic aquifers in the southern part of the Valley. Waters adjacent to line A-B have been projected first onto the line, then into a plane in which salinity is plotted against composition. Triangle A-B-C defines a plane which includes composition line A-B of the trilinear composition diagram and point C, which is defined as zero salinity above the plane of the trilinear diagram. In a projection such as this, any set of waters of varying salinity and composition which are mixtures of two end members will define a straight line in the plane A-B-C.

Relationships between points in this projection are only approximate, given that most of the waters do not lie exactly in plane A-B-C, but instead have been projected onto it from either side (above and below the page). Samples projected onto A-B-C from particularly far off are shown with the sample number in parentheses. These are included to illustrate relative salinity, but cannot reliably indicate mixing trends in this section.

Samples 745, 7415, 7427 and 7426* roughly define a line which connects 745 near side A-C of the triangle with the main group of Little Valley volcanic aquifer waters near side B-C. Water 745 is reportedly from a sedimentary aquifer, and it appears that 7425, 7427, 7411 and 7426 may be mixtures of such a water with deeper water from volcanic rocks. Surface temperatures of the well waters are roughly consistent with this. The main group of Little Valley volcanic waters is 32°-43°C, whereas the "mixed" waters are slightly cooler (27°-38°C). This may also be explained as an evolution of the volcanic waters towards a sedimentary type, as the deeper, hotter water circulates

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*All sample number are abbreviations of the T-R-S location: 745 is a water from T7S-R4E-Sec. 5.

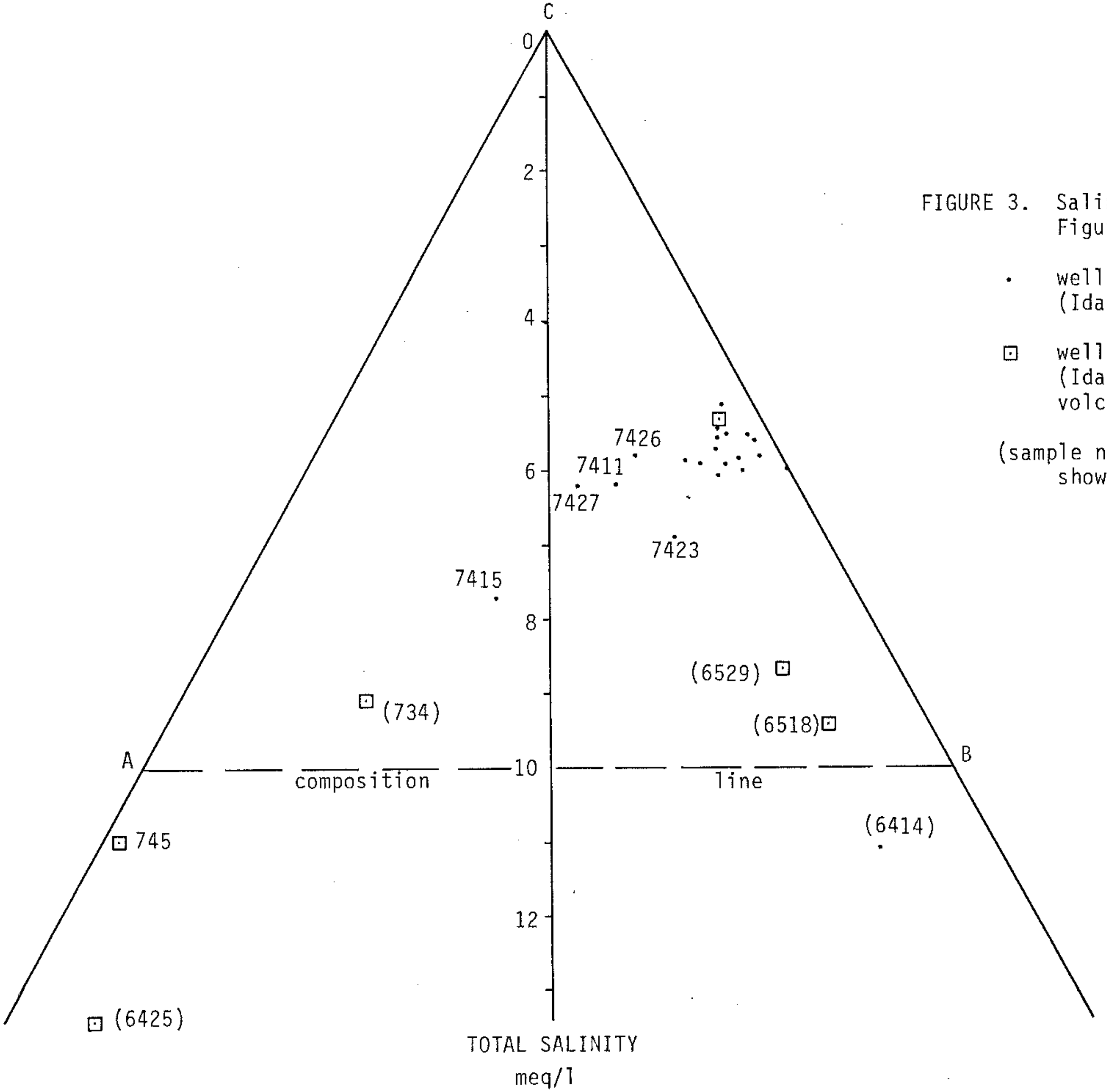

FIGURE 3. Salinity-composition projection from Figure 1, Part B.

- · wells producing from volcanic rocks (Idavada volcanics, Banbury basalt)
- ⊡ wells producing from sediemntary rocks (Idaho Group) or sedimentary rocks and volcanic rocks.

(sample no.) - not on composition line, shown to illustrate salinity only.

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upwards into and reacts with sedimentary rocks under artesian conditions.

The mild temperatures of the Little Valley volcanic waters may reflect either (a) mixing of a deep, high-temperature component with a cool component of recharge, or (b) heating of recharge during rapid circulation to only moderate depths. If mixing were occurring, this would probably show up on figure 3, assuming that the high-temperature component were anomalous in either composition or salinity with respect to the recharge. There is no evidence for such mixing or for the presence of such a component, although there is one anomalous group of waters (6414, 6518, 6529) which will be discussed below.

The absence of evidence for mixing, coupled with the overall dilute Na-HCO_3 character of the Little Valley thermal waters, suggests that their temperatures at depth are not greatly above those observed at the surface. This applies to the main group of waters, from the south end of the valley in T7S, R4E.

Some thermal waters from the south end of Bruneau Valley have compositions identical to those of Little Valley, whereas others fall on a trend towards slightly higher levels of Mg and lower SO_4. There is no trend in salinity or temperature which can be taken to indicate mixing, and the observed range of compositions appears more likely controlled by rock composition and reactions at low temperature than thermal effects. As in Little Valley, evidence for a high-temperature thermal component is lacking.

In the north of the Little Valley area there are four waters which are anomalous with respect to those in the rest of the Valley, and which are very similar to several waters from the Grand View area. These are 6414, 6518, 6529 and 755 (compare figure 1, parts B and D). Water 6414 has the highest observed temperature (54°C) in the Little Valley area. Table 1 lists these waters along with the similar set from Grand View, which is notable as including the highest temperature wells of the entire Bruneau-Grand View region.

The aquifers are those indicated by Young and Whitehead (1975), tabulated from well logs, casing history and geology. However, the compositions of waters 6518 and 6529 strongly suggest that they are actually from volcanic rocks. Data suggesting this include concentrations of Ca, F and Cl and the ratio Cl/F as well as relationships shown on figure 1.

Whereas the ionic ratios expressed by figure 1 are quite similar for all of these waters, figure 2 shows that their Na/K ratios are

Table 1. Comparison of selected Grand View and Little Valley thermal well waters.

Sample	Surface Temperature, °C	Total Salinity meq/1	Well Depth, feet	Producing aquifer(s) major/minor
Grand View				
5326bcb1	83	9.9	2,970	Idavada volcanics/Banbury basalt
5326bcb2	67	9.8	2,970	Idavada volcanics(?)/ Banbury basalt(?)
5335ccc1	71.5	9.7	2,570	Idavada volcanics(?)/ Banbury basalt(?)
5323cc	84	10.5	?	unknown
Little Valley				
6414abc	54	11.1	1,905	Idavada volcanics/Banbury basalt
6518ccb	27	9.4	2,960	Banbury basalt/Idaho Group
6529dcc	32.5	8.7	1,560	Idaho Group(?)
755dbc	32	6.5	2,405	Banbury basalt

somewhat variable, primarily due to variations in K. The waters probably all come from the same or similar rock units, and they constitute a coherent chemical anomaly; but it is uncertain if they represent a significant thermal anomaly, given the fact that they are produced from some of the deepest wells in the area.

Using surface temperature based on an estimated mean annual air temperature of 10°C, and well depth in the hottest wells, apparent gradients are calculated to be about 4.3°-4.5°F/100 feet in the hotter, deeper wells (5326, 5335, 6414). Discharge and production rates are high enough to suggest minimal conductive cooling during ascent of the well waters to the surface (c. 100 to over 1,000 gpm). However, there is no certainty that waters enter only at well bottom. These apparent gradients project to temperatures of over 450°F by 10,000 feet. There is no assurance that conductive conditions continue to such depth.

Geothermometers

Chemical geothermometry herein is limited mostly to data from the volcanic rock aquifers of the area. Young and Mitchell (1975) and Dellechaie (1976) previously pointed out that waters in the sedimentary aquifers tend to have higher silica and cation temperatures than the deeper volcanic waters and that this is an effect of rock composition and low-temperature reactions rather than equilibration at high temperatures.

Figure 1, part G illustrates that cation temperatures of waters from the volcanic rock aquifers exceed 100°C only in the Little Valley and Bruneau Valley areas.

Cation temperatures of the Little Valley volcanic waters have a bimodal distribution, with one group at about 78°-92°C and another at about 174°-198°C, and with very few exceptions in between. However, there is no corresponding bimodal distribution of water compositions. The split in cation temperatures is spurious, created by a shift to 1/3 for the value of factor beta, made when temperatures calculated with beta = 4/3 exceed 100°C. The 100°C limit for use of beta = 4/3 is conventionally stated as a fixed rule, but it is actually an approximation. Table 2 shows that temperatures of the higher temperature group could as well be only 100°C to 110°C.

Given that most Little Valley volcanic waters have cation temperatures of about 80°-110°C, is this a reliable estimate of temperatures at depth?

Table 2. Groundwaters from aquifers in volcanic rocks(1) having cation temperatures above 100°C.

Area(2)	Sample No.	Surface Temperature, °C	T°C NaKCa(4) $\sqrt{Ca}/Na$	Beta= 1/3	Beta= 4/3	Flow, gpm(3)
GV	5328	65	1.06	105	103	F
LV	6414	54	2.34	142	107	1350(P)
LV	741	40	5.69	182	103	409-688
LV	743	42	6.01	194	110	NF
LV	7410	37.5	6.56	198	109	NF
LV	7412	43	5.96	185	104	1400
LV	7413b	39	6.33	193	107	1300
LV	7413d	40	6.39	186	102	812-1000
LV	7414	39	6.85	196	106	1470(P)
LV	7423	38.5	6.86	188	100	3360-342(P)
LV	755	32	3.82	175	113	F
LV	757	39	6.57	199	110	2990-4000
LV	758	40	5.07	183	109	400
LV	7516	39.5	5.61	180	103	200
LV	7519	36.5	5.80	186	106	1170(P)
LV	7528	34	6.36	199	110	1300-1540(P)
BS	769	50	1.45	131	115	120
BS	863	39	5.53	182	105	130-160 (spring)
LV	6518	27	2.27	169	130	NF
LV	6529	32.5	3.52	161	106	F

---

(1) All samples represent wells, except for 863. Aquifers are in Idavada volcanic rocks and/or Banbury basalt. Data from Young and Whitehead (1975) and Young and others (1979).

(2) GV = Grand View; LV = Little Valley; BS = Bruneau Valley, south end

(3) NF = not flowing, pump rate not available; F = flowing, rate not available; P = pumped.

(4) Conductive quartz temperature = 122°-157°C, with all but 4 values in range 132°-137°C.

The answer to this is uncertain. Figure 4 shows that dissolved silica in Little Valley waters corresponds to chalcedony temperatures of about 100°-110°C and to quartz temperatures of about 130°-140°C. In this temperature range the chalcedony temperature is as likely as quartz to be meaningful. Both the silica and cation temperatures may be biased by rock composition or by a lack of chemical equilibration due to very rapid circulation or low-temperature conditions. Silicic volcanics in the section may be sources of anomalously high K and SiO_2 which can produce anomalously high temperature estimates.

Silica-temperature relationships among Little Valley waters do not indicate mixing. As discussed above, there is limited evidence in bulk composition data for mixing of volcanic and sedimentary aquifer waters, but none for mixing of thermal and non-thermal volcanic waters. These facts effectively discount application of silica mixing models to the Little Valley waters.

The absence of evidence for mixing in the volcanic aquifers is a bit surprising, given their high permeabilities and the abundant evidence for recharge into volcanic rocks of the Owyhee uplift close to the south end of Little Valley. It has been stated that the entire normal flow of Big Jacks Creek is absorbed by volcanic rocks in the faulted zone along the north edge of the uplift (Littleton and Crosthwaite, 1957). The effect of this recharge on heat flow in the area has been well-defined by gradient drilling (AMAX heat flow map, 2/7/78). If this recharge is mixing with warmer waters deeper in the volcanics, homogenization must be complete before the waters are tapped by valley wells.

Even if the highest temperatures are accepted (130°-140°C), there is no clear evidence of significantly higher temperatures.

In the case of deep waters at the north end of Little Valley, and at Grand View and Castle Creek, it is probable that the chemical geothermometers are meaningful. Surface temperaturs are higher and residence time at depths probably is longer.

Figure 4 shows that silica levels in the northern Little Valley waters (6414, 6518, 6529, 755) tend to be higher than in the south. Table 3 shows silica, cation and isotope geothermometers as applied to the set of northern Little Valley and similar Grand View waters. In northern Little Valley, minimum temperatures of at least 120°C and possibly 130°C appear reasonable. The higher quartz and cation temperatures of 150°-170°C are possible but less certain, particularly in light of the sulfate-water oxygen-isotope temperature. Note that the cation temperatures are subject to interpretation as being either about 140°-175°C or about 110°C, according to the choice of beta (see above).

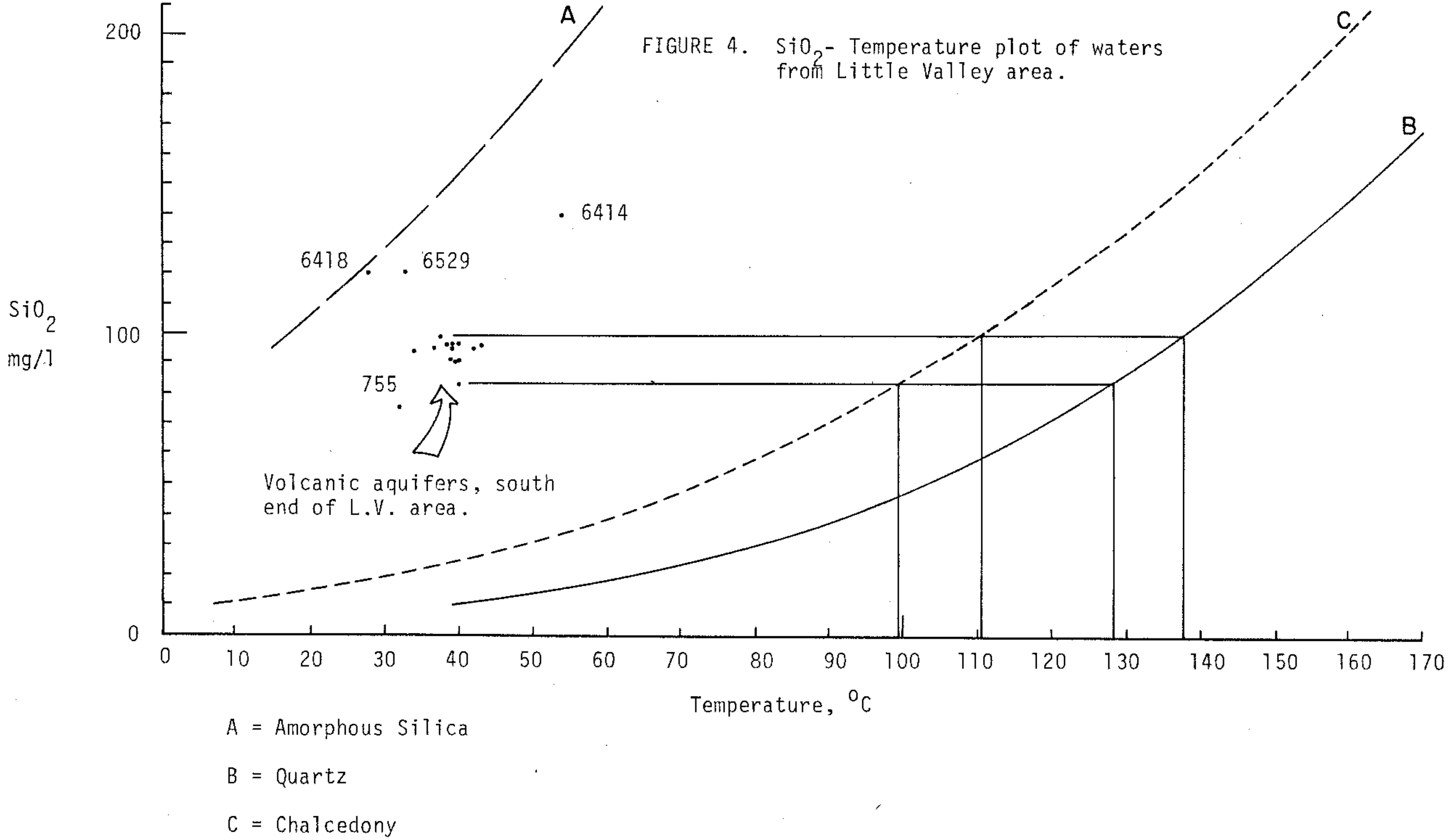


FIGURE 4. SiO_2- Temperature plot of waters from Little Valley area.

GeothermEx, Inc., 1981

Table 3. Chemical geothermometers of waters from the north end of the Little Valley area and related Grand View waters.

Sample No.	T°C	T°C SiO_2			T°C NaKCa			Sulfate-water oxygen isotope T°C
		QTZ	CHAL	AMOR	$\sqrt{Ca}/Na$	$\beta=1/3$	$\beta=4/3$	
<u>Grand View</u>								
5326bcb1	83	143	116	22	1.51	106	91	95
5326bcb2	67	137	110	17	1.28	104	95	--
5335ccc1	71.5	137	110	17	1.70	74	92	--
5323cc	84	143	116	22	1.09	105	101	--
<u>Little Valley</u>								
6414abc	54	157	133	35	2.34	142	107	103
6518ccb	27	148	122	26	2.27	169	130	--
6529dcc	32.5	148	122	26	3.52	161	106	--
755dbc	32	122	93	3	3.82	175	113	--

QTZ = quartz, conductive
CHAL = chalcedony
AMOR = amorphous silica

For the purposes of this discussion, a maximum of 150°-175°C is selected as possibly realistic.

Gases

In their study of the Bruneau-Grand View area, Young and Whitehead (1975) encountered 15 wells which issue gases in addition to water. Samples of these were collected; analyses are reproduced in Appendix 1. The gases are uniformly N_2 and O_2, with 0% to 50% methane (CH_4). No CO_2 or H_2 which would be of thermal origin have been detected. Those wells that produce principally from Idaho Group sediments have 16% to 50% methane, whereas at most 5% issues from wells which produce principally from the underlying volcanic units. The N_2 and O_2 are doubtlessly atmospheric and, based on their solubilities in water at 10°-20°C, probably were present in meteoric recharge at a ratio of about $N_2/O_2 = 2$.

Figure 5 shows N_2/O_2 in the Bruneau-Grand View gases plotted against the surface temperature of each well. There is a strong positive correlation, which can fully be evaluated only using data for the change in solubility of each gas with temperature. These data are not immediately available. To the extent that the correlation is not due to solubility, it may be due to a loss of O_2 in rock-water reactions during increased residence time, or with rising temperature.

These gases were compared with analyses of similar gases from hot springs in Nevada and Oregon sampled by Mariner and others (1975) (figure 6). In Bruneau-Grand View, $N_2 + O_2$ is at least 50% by volume of the total gases present, the rest being methane. In 16 Nevada-Oregon gases $N_2 + O_2$ is also at least 50%, the rest being methane and CO_2. N_2/O_2 in the Nevada-Oregon gases is generally higher than at Bruneau-Grand View, ranging from 3.3 to 98. Only 2 samples fall within the lower range of the Bruneau-Grand View gases. This suggests that the Bruneau-Grand View waters on the average either are less hot at depth or have shorter residence times than the typical Nevada-Oregon thermal waters. However, to qualify this statement it should be noted that the lowest N_2/O_2 of column A, figure 6 is Mickey Spring, Oregon, which is boiling and has chemical temperatures of 170°-200°C.

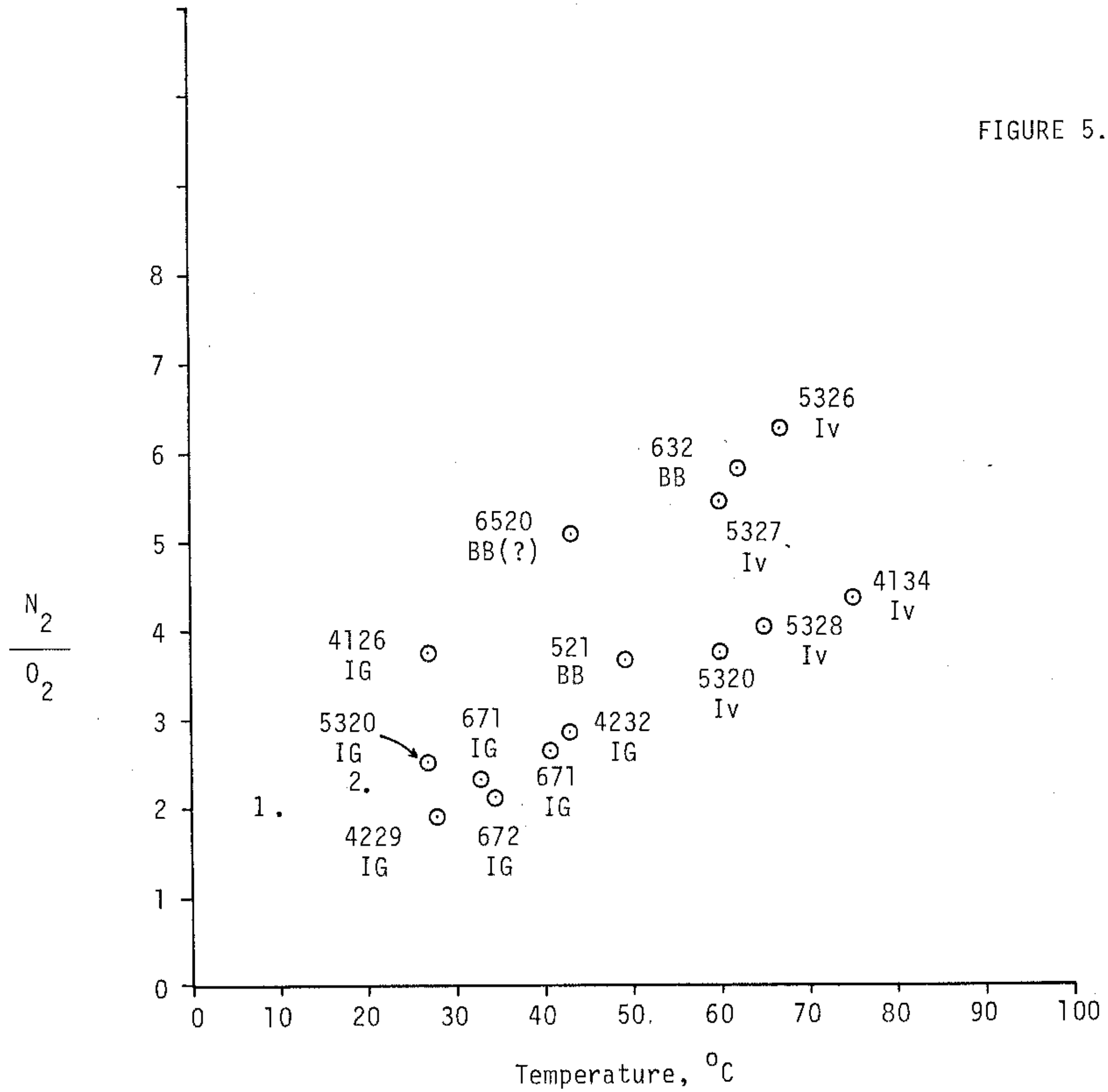


FIGURE 5. N_2/O_2 versus temperature in gases from the Bruneau-Guard View area wells.**

Sample numbering:

5328 = T. 5 S. - R. 3 E. - Sec. 28

Major aquifer:

IG = Idaho Group sedimentary rocks

BB = Banbury Basalt

Iv = Idavada volcanics

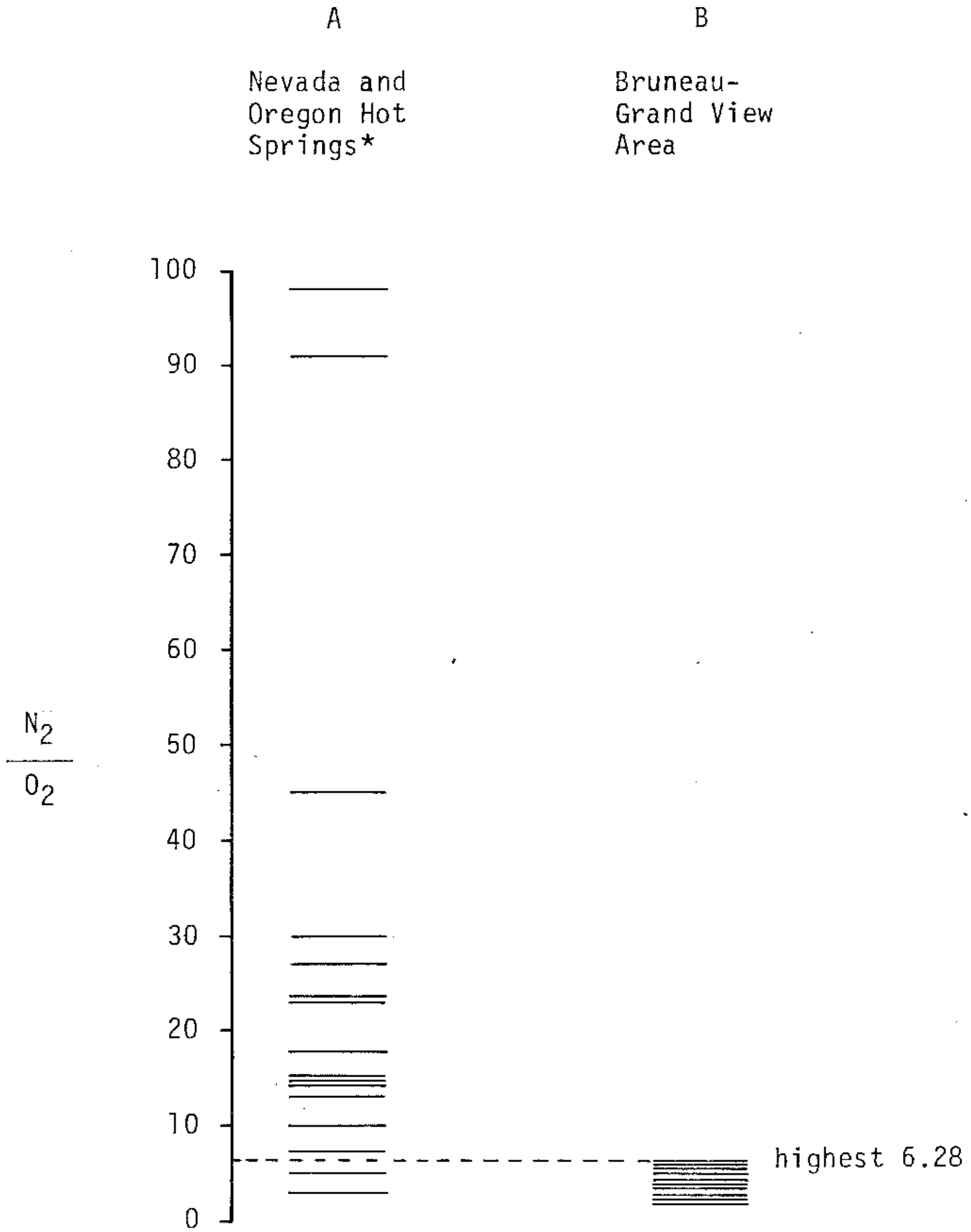
*Volume percent ratio.

[1] N_2/O_2 in pure water at 10°C = 1.96
[2] N_2/O_2 in pure water at 20°C ≃ 2.22

**Data from Young and Whitehead (1975)

GeothermEx, Inc., 1981

FIGURE 6. Frequency distribution of N_2/O_2 in gases associated with thermal waters of Nevada, Oregon and the Bruneau-Grand View area.



*Data from Mariner and others, 1975, gases with $N_2 + O_2 \geq$ 50% only.

DISCUSSION

Only in northern Little Valley can temperatures of 150°-170°C be supported by critical analysis of geothermometry, aquifer composition and other factors.

Elsehwere, maximum temperatures of 110°-120°C are suggested by geothermometry, rock-water interactions and mixing considerations. In some parts of the region, temperature at depth may not exceed the maximum found to date in deep wells (84°C at Grand View; 43°C in southern Little Valley). No significant mixing trend is observed in any of these areas.

Despite the lack of samples from the AMAX leasehold, there is no reason to suspect significantly higher temperature at depth than elsewhere. This is based on the regional hydrologic model, which predicts northward flow of recharge water across the leasehold at depth. The sample localities of Bruneau and Little Valley apparently intercept water that in the past has traversed the AMAX leasehold at depth. No evidence of conductive cooling during transit is seen.

Therefore, if additional geochemical surveys are to be considered, only the northern Little Valley area is recommended. Work might include systemmatic resampling of known wells for major cation-anion analysis; sampling for gases; sulfate-water oxygen-isotope analyses; and possibly trace element or other isotope surveys. At such time it would be useful to perform a rapid reconnaissance of the AMAX property in search of sample-collection points.

Although very little evidence was seen of deeper, hotter systems, it remains possible that such systems exist either locally or regionally, isolated and insulated by impermeable overburden. Such systems, if they exist, might be at several thousand feet in depth, not only beneath the Idavada volcanics (which are quite permeable) but beneath the underlying rock unit. As such, temperature gradient data would be of little value in evaluating it, unless gradients were obtained in units beneath the Idavada volcanics. Similarly, the layered sequence of electrically conductive and non-conductive rocks might prove impenetrable to all geoelectrical techniques.

Thus, geochemistry casts a generally negative shadow over the Bruneau-Grand View province, with the possible exception of northern Little Valley. The permissive interpretation of a hotter, deeper system at depth does not lend itself easily to definitive exploration.

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APPENDIX I

Chemical, Gas and Isotope Analyses
from the Bruneau-Grand View Area

CONTENTS:

Littleton and Crosthwaite (1957)

(Table 1)

TABLE 1.—*Chemical analyses of artesian water in the Bruneau–Grand View area, Idaho*

[Chemical constituents in parts per million. Analyses by U. S. Geological Survey]

Well No.	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids		Hardness as $CaCO_3$	Percent sodium	Specific conductance (in micromhos at 25°C)	pH
																Parts per million	Tons per acre-ft				
5S-2E-2aa1	Nov. 24, 1953	126	81	0.02	2.4	0.5	91	1.0	104	37	22	12	14.0	0.4	0.85	291	0.395	8	95	395	9.4
-13ad1	do	80	98	.22	13	2.7	278	28	710	39	1.9	12	1.2	.8	.76	825	1.121	44	88	1,260	8.8
6S-3E-11cc2	do	94	110	------	3.2	1.2	98		128	24	19	16	14	1.6	------	329	.447	13	94	419	9.0
-13ac1	do	64	40	.00	56	4.7	42	6.3	215	------	65	10	.9	1.3	.05	334	.454	159	35	485	7.5
6S-5E-24db1	Nov. 23, 1953	77	90	------	4.4	.9	104		185	------	35	13	12	3.6	------	356	.484	15	94	505	8.3
	Aug. 15, 1922	92	87	.10	6.0	1.6	105		185	0	32	12	------	------	------	379	.515	22	91	------	---
-24dd1	Nov. 23, 1953	94	77	.00	3.6	.5	100	3.1	141	------	38	12	24	2.9	.28	321	.436	11	94	455	7.9
-29dc1	Nov. 24, 1953	94	103	------	4.8	.2	97		118	------	52	17	18	.6	------	336	.457	13	94	425	7.8
	Aug. 1, 1922	90	84	.10	13	.9	91		149	0	73	15	------	------	------	375	.510	36	85	------	---
-36dd1	Nov. 24, 1953	71	82	------	19	.5	87		160	------	69	13	6.0	2.2	------	341	.463	49	79	460	8.2
	Aug. 15, 1922	71	71	.05	26	.9	75		161	0	63	13	------	------	------	343	.466	69	70	------	---
7S-4E-12bd1	Nov. 23, 1953	92	94	.01	6.0	.2	54	10	106	------	30	9.0	7.0	.6	.15	264	.359	16	80	289	7.5
-24dc1	Nov. 23, 1953	99	84	------	6.7	.3	60		102	------	22	11	10	.8	------	222	.302	18	88	271	8.0
	Aug. 7, 1922	99	92	.16	8.8	1.6	52		102	0	16	8.0	------	------	------	245	.333	29	80	------	---
7S-5E-5ba2	Nov. 24, 1953	59	59	------	16	1.8	75		123	------	68	12	7.0	4.0	------	282	.383	47	78	402	7.2
	Aug. 1, 1922	60	63	.20	21	2.0	75		132	0	82	11	------	------	------	328	.446	61	73	------	---
-7ab1	Nov. 23, 1953	102	88	.06	6.7	1.2	52	7.5	100	------	20	9.0	10	.7	.01	240	.326	22	78	286	7.0
-7ab2	Nov. 24, 1953	73	78	------	7.1	4.8	53		100	------	39	10	6.0	.8	------	228	.310	37	75	290	7.8
	Aug. 2, 1922	73	80	.60	7.6	.4	52		100	0	31	10	------	------	------	244	.332	21	85	------	---
-8bb1	Nov. 24, 1953	73	70	------	7.9	.3	58		105	------	23	10	8.0	1.2	------	216	.294	21	86	274	7.3
-9dd1	do	92	82	.02	5.2	.7	57	7.0	115	------	20	7.0	10	1.0	.12	279	.379	16	83	290	7.8
-18bc1	do	92	90	.32	6.4	.4	50	8.3	108	------	18	8.0	9.0	.8	.08	294	.400	18	79	271	8.2
7S-6E-7aa1	Nov. 24, 1953	90	116	------	5.6	2.1	78		59	41	26	12	12	.1	------	299	.406	23	88	337	9.4
	Aug. 15, 1922	91	96	.08	7.4	1.0	69		56	34	22	11	------	------	------	282	.383	23	87	------	---
-9ba1	Nov. 23, 1953	120	118	------	4.0	1.4	100		127	25	31	12	22	.2	------	370	.503	16	94	461	9.1
	Aug. 9, 1922	122	94	------	5.4	1.6	91		154	0	29	10	------	------	------	352	.478	20	91	------	---
-9ba2	Nov. 23, 1953	120	99	.04	2.4	1.4	100	2.9	111	24	30	10	24	.5	.10	271	.368	12	93	449	9.2
-16cd1	Nov. 23, 1953	100	80	------	10	.9	55		117	------	20	9.0	7.0	1.6	------	222	.302	29	81	282	7.6
	Aug. 11, 1922	100	74	.05	10	1.0	51		112	0	23	9.0	------	.5	------	245	.333	29	79	------	---
-21db1	Nov. 23, 1953	104	86	------	7.9	1.4	63		114	------	21	10	12	.8	------	236	.321	25	84	302	8.2
	Aug. 11, 1922	106	74	.04	7.2	1.0	64		100	0	20	13	------	------	------	238	.323	22	84	------	---
-23ca1	Nov. 23, 1953	115	94	------	14	2.1	58		122	8	21	11	7.0	1.6	------	261	.355	44	74	311	8.6
	Aug. 11, 1922	115	88	.22	15	2.2	48		120	7.2	21	8.0	------	------	------	256	.348	47	69	------	---
-23dc1	Nov. 23, 1953	105	86	------	17	3.1	47		137	------	19	9.0	4.0	1.9	------	234	.318	55	65	286	8.2
	Aug. 11, 1922	110	92	------	16	2.6	48		132	0	15	9.0	------	.95	------	254	.345	51	67	------	---
-27aa1	Nov. 23, 1953	117	75	.00	9.1	1.2	51	6.1	110	------	17	9.0	10	1.3	.21	237	.322	28	76	287	7.2

Ralston and Chapman (1969)

(Table 2)

TABLE 2

WATER QUALITY ANALYSES

No.	Locations	Date	pH	Temp.	Total Dissolved Solids	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$	Ions in Parts Per Million											SAR
								Calcium Ca	Magnes. Mg	Iron Fe	Mangan. Mn	Sodium Na	Chloride Cl	Sulfate SO_4	Nitrate NO_3	Phosphate PO_4	Fluoride F	CO_3 & HCO_3	
1	1N 4W 12ac1	1-24-68	8.4	104	280	152	52	8	8	0.02	0.05	10	4	14	2.4	0.08	1.90	189	0.6
2	1S 3W 10bc1	4-25-68	8.0L	69	258	120	188	56	12	0.05	0.30	32	4	58	0.1	0.04	0.72	146	3.2
3	1S 2W 7cc1	3-19-68	8.6L	114	330	156	-	-	-	.19	-	110	15	50	-	0.01	22.20	190	-
4	1S 2W 18dcc1	3-19-68	8.4L	83	200	104	12	4	2	.23	-	66	5	43	.5	0.11	20.00	127	6.7
5	2S 2W 3ba1	2-28-68	8.9	82	220	140	20	5	2	.08	0.05	75	3	35	.7	1.04	1.50	170	7.2
6	2S 2W 26ccc	11- 7-50	-	-	525	-	198	64	9	.04	-	-	16	230	-	-	0.5	-	-
7	2S 2W 27dcd	11- 7-50	-	-	314	-	102	30	7	.04	-	-	13	51	-	-	1.1	-	-
8	2S 2W 36ba1	4-28-68	7.1	90	222	50	40	16	-	0.05	0.07	12	10	92	0.05	0.32	0.72	61	0.8
9	3S 2W 36dd1	4-25-68	7.2L	55	148	58	82	19	3	0.05	0.06	66	7	38	0.4	0.06	0.46	70	3.7
10	3S 1W 4dc1	2- 6-68	7.2	80	444	154	170	54	8	0.05	0.20	69	4	102	6.5	0.30	0.65	88	7.3
11	3S 1W 36dda1	4-25-68	7.4	70	174	64	86	33	1	0.05	0.09	62	10	37	1.6	0.04	0.01	78	2.9
12	4S 1W 36aac1	4-26-68	7.6	60	168	72	116	45	1	0.30	0.07	22	21	17	1.8	0.08	0.06	88	2.8
13	4S 1E 28bd1	3-19-68	7.6L	64	250	176	64	16	6	.23	-	63	5	115	10	0.10	.85	215	3.4
14	4S 1E 30bb1	3-13-68	7.1	59	132	106	124	40	6	0.03	0.08	8	2	14	1.0	0.56	0.39	129	1.0
15	4S 1E 34ab1	3- 1-68	8.6L	170	235	160	100	15	10	0.09	0.05	85	6	47	.8	0.56	2.30	195	4.2
16	4S 2E	4-26-68	7.6	58	398	108	244	69	17	0.20	0.20	110	15	152	1.0	0.14	1.65	131	9.7
17	4S 2E 19ac	4- 8-63	10.0	178	320	-	3	1.0	.2	.05	-	84	5.0	25	.2	-	9.2	-	20.0
18	5S 1E 21cb1	4-30-68	9.2	146	252	84	40	14	1	0.09	0.06	36	5	24	0.9	0.06	1.70	102	2.5
19	5S 1E 24ac1	4-25-68	8.8	150	250	82	40	3	8	0.05	0.02	14	15	39	1.2	0.04	1.60	155	1.0
20	5S 2E 2aa1	11-24-53	9.4	126	291	-	8	2.4	0.5	0.02	-	91	12	22	0.4	-	14.0	141	-
21	5S 2E 13ad1	11-24-53	8.8	80	825	-	44	13	2.7	.22	-	278	12	1.9	.8	-	1.2	749	-
22	5S 3E 28bc1	3-19-68	8.0	149	190	120	172	32	23	0.80	-	75	5	8	-	0.09	20.60	146	7.8
23	6S 3E 11cc2	11-24-53	9.0	94	329	-	13	3.2	1.2	-	-	98(a)	16	19	1.6	-	14	152	11.8
24	6S 3E 13ac1	11-24-53	7.5	64	334	-	159	56	4.7	-	-	42	10	65	1.3	-	.9	215	-
25	6S 3E 34cd	10- 2-68	7.0	86	298	212	102	29	7	0.08	0.20	32	5	47	0.5	0.11	0.69	258	4.4
26	6S 5E 24db1	11-23-53	8.3	77	356	-	15	4.4	.9	-	-	104(a)	13	35	3.6	-	12	185	11.8
27	6S 5E 24dd1	11-23-53	7.9	94	321	-	11	3.6	.5	-	-	100	12	38	2.9	-	24	141	13.1
28	6S 5E 29dc1	11-23-53	7.8	94	336	-	13	4.8	.2	-	-	97(a)	17	52	.6	-	18	118	11.8
29	6S 5E 36dd1	11-24-53	8.2	71	341	-	49	19	.5	-	-	87(a)	13	69	2.2	-	6.0	160	5.4
30	6S 6E 13abc	10-11-68	8.3	105	920	-	40	16	1	2.70	-	182	2	49	4.4	-	5.95	-	11.9
31	7S 4E 3ac	11-28-67	-	-	219	-	146	40	11	-	-	80	6	90	.4	-	-	-	9.1
32	7S 4E 12bd1	11-23-53	7.5	92	264	-	16	6.0	.2	.01	-	54	9.0	30	.6	-	7.0	-	5.9
33	7S 4E 24dc1	11-23-53	8.0	99	222	-	18	6.7	.3	-	-	60(a)	11	22	.8	-	10	106	6.2
34	7S 5E 5ba2	11-24-53	7.2	59	282	-	47	16	1.8	-	-	75(a)	12	68	4.0	-	7.0	102	4.7
35	7S 5E 7ab1	11-23-53	7.0	102	240	-	22	6.7	1.2	.06	-	52	9.0	20	.7	-	10	100	4.8
36	7S 5E 7ab2	11-24-53	7.8	73	228	-	37	7.1	4.8	-	-	53(a)	10	39	.8	-	6.0	100	3.7
37	7S 5E 8bb1	11-24-53	7.3	73	216	-	21	7.9	.3	-	-	58(a)	10	23	1.2	-	8.0	105	5.5
38	7S 5E 9dd1	11-24-53	7.8	92	279	-	16	5.2	.7	.03	-	57	7.0	20	1.0	-	10	115	6.2
39	7S 5E 18bc1	11-24-53	8.2	92	294	-	18	6.4	.4	.32	-	50	8.0	18	.8	-	9.0	108	5.2
40	7S 6E 7aa1	11-24-53	9.4	90	299	-	23	5.6	2.1	-	-	78(a)	12	26	.1	-	12	100	7.1
41	7S 6E 9ba1	11-23-53	9.1	120	370	-	16	4.0	1.4	-	-	109(a)	12	31	.2	-	22	152	11.9
42	7S 6E 9ba2	11-23-53	9.2	120	271	-	12	2.4	1.4	.04	-	100	10	30	.5	-	24	135	12.9
43	7S 6E 16cd1	11-23-53	7.6	100	222	-	29	10	.9	-	-	55(a)	9.0	20	1.6	-	7.0	117	4.5
44	7S 6E 21db1	11-23-53	8.2	104	236	-	25	7.9	1.4	-	-	63(a)	10	21	.8	-	12	114	5.4
45	7S 6E 23ca1	11-23-53	8.6	115	261	-	44	14	2.1	-	-	-	11	21	1.6	-	7.0	130	3.8
46	7S 6E 23dc1	11-23-53	8.2	105	234	-	55	17	3.1	-	-	48(a)	9.0	19	1.9	-	4.0	137	2.8
47	7S 6E 27aa1	11-23-53	7.2	117	237	-	28	9.1	1.2	-	-	51	9.0	17	1.3	-	10	110	4.2
48	9S 5E 4	4- 8-63	9.4	-	303	-	2	1.0	-	1.9	-	92	13	26	.2	-	20	-	25.3

(a) Sodium and Potassium

Young and Mitchell (1973)

(Table 2)

Spring or Well Identification Number	Reported Well Depth Below Land Surface (feet)	Sample Collection Date	Discharge (gpm)	Temperature (°C)	Silica (Si)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (P)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids (Calculated)	Dissolved Solids (tons per ac-ft)	Hardness		Specific Conductance	pH (field)	Alkalinity as $CaCO_3$	Percent Sodium	Sodium Absorption Ratio	Area No. Fig. 6
																			as $CaCO_3$	Non-carbonate						
OWYHEE COUNTY																										
4S 2E 32bcc1	2,704	6- 6-72	30	42.0	94	4.1	.7	150	8.8	390	0	7.1	.08	15	7.7	.05	479	.65	13	0	689	8.2	320	93	18	20
5S 3E 26bcb1	3,000	6-12-72	a280	84.5	110	1.8	0	90	1.5	74	38	74	.02	14	30	.06	416	.57	4	0	522	7.6	124	98	24	20
6S 3E 2ccc1	1,940	6-12-72	489	55.0	92	1.3	0	90	3.9	149	29	25	.02	17	17	.05	369	.05	3	0	506	8.1	171	97	28	20
6S 5E 10ddd1	1,667	6-14-72	4	38.5	70	2.5	.1	120	4.5	165	21	24	.04	15	28	.12	366	.50	6	0	549	8.6	170	96	22	20
6S 5E 29dcc1	1,560	6-14-72	3	34.0	100	6.8	0	92	7	140	0	56	.07	15	15	.03	361	.49	17	0	459	8.0	115	89	9.7	20
6S 6E 12ccd1	990	6-15-72	-	37.0	100	10	.5	170	14	460	0	3.6	.06	18	5.6	.06	548	.75	27	0	833	7.3	377	89	14	20
7S 5E 7abb1	1,625	6-14-72	-	39.0	81	6.3	.1	50	7.2	96	1	18	.04	8.3	9.7	.33	230	.31	16	0	278	8.1	80	81	5.4	20
Indian Bathtub Hot Springs																										
8S 6E 3bdd1S		7- 3-72	458	39.0	76	5.9	.4	54	7.3	124	2	15	.04	8	8.8	.79	242	.33	16	0	287	8.2	105	82	5.8	20
Murphy Hot Springs																										
16S 9E 24bb1S		5-23-72	a70	51.0	83	.6	0	30	2.0	67	1	4.7	.1	2.3	3.6	.64	163	.22	2	0	137	7.1	57	94	11	21
1N 4W 12dbb1	640	6-13-72	410	35.5	40	2.2	0	110	.3	214	0	8.6	.01	28	7.9	.04	302	.41	5	0	483	7.2	176	98	20	
1S 2W 7ccb1	1,700	6- 5-72	169	45.5	32	1.9	0	120	1.2	187	12	45	.01	19	11	.04	334	.45	5	0	545	8.7	173	98	24	
4S 1E 34bad1	2,960	6- 6-72	-	75.0	83	1.1	.2	98	.7	108	33	40	.03	12	12	.05	333	.45	4	0	454	7.9	144	98	23	
5S 1E 24ad1	3,120	7-24-72	1,060	66.0	82	1.2	.1	100	.8	105	31	45	.23	13	14	.04	339	.46	3	0	459	7.9	138	98	24	
5S 2E 1bbc1	1,800	6- 7-72	30	49.5	68	1.5	0	87	.6	60	54	20	.02	11	5.8	.04	277	.38	4	0	394	8.2	139	98	20	
7S 6E 9bad1	910	6-15-72	153	50.0	93	1.6	0	99	2.8	72	40	27	.06	9.7	22	.05	331	.45	4	0	446	8.2	126	97	22	
Indian Hot Springs																										
12S 7E 33c1S		6- 2-72	1,730	69.0	75	1.5	0	75	.6	67	30	24	.04	8.4	14	.06	262	.36	4	0	360	8.0	105	97	17	

Young and Whitehead (1973)

(Table 3)

TABLE 3

CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS AND SPRINGS

(Chemical constituents in milligrams per litre except where noted.)

Well or spring identification number	Reported well depth below land surface (feet)	Date of collection	Discharge (cubic feet per second)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite plus Nitrate ($NO_2 + NO_3$)	Phosphorus (P)	Dissolved Solids (calculated)	Dissolved Solids (tons per ac-ft)	Hardness		Percent sodium	Sodium-absorption ratio	Specific conductance (field)	pH (field)	Water temperature (°C)	Chemical constituents in micrograms per litre			
																			as $CaCO_3$	Noncarbonate						Arsenic (As)	Boron (B)	Lithium (Li)	Mercury (Hg)
3S-1E-35dac1	300	73/7/24	–	55.0	43.0	9.9	35.0	6.0	246	0	202	25.0	7.7	2.1	0.01	0.07	305	0.41	150	0	33	1.3	440	7.8	20.0	4	60	30	0
4S-1E-25ccd1	–	73/7/24	0.01	120	25	2.9	310	29	952	0	781	5.5	25	.6	.02	.25	989	1.35	74	0	86	16	1,420	7.3	30.0	4	1,000	810	0
26abc1	1,700	73/6/8	.01	96	13	2.8	250	29	763	0	626	3.6	13	.6	.01	.16	786	1.07	44	0	87	16	1,160	7.3	27.0	14	780	710	0.6
29ccd1	3,040	73/6/5	3.3	83	1.2	0	100	.8	69	51	142	39	12	12	0	.01	333	.45	3	0	98	25	476	9.2	70.0	22	150	10	.2
30bdb1	350	73/7/23	–	57	33	3.2	7.9	3.1	129	0	106	10	2.7	.3	.01	.10	181	.25	96	0	15	.4	220	8.9	16.5	20	20	10	0
34bad1	2,960	73/7/9	–	91	1.0	0	99	.8	72	46	136	40	13	13	0	0	339	.46	3	0	98	27	453	9.2	75.5	29	150	10	0
4S-2E-29dbc1	1,000+	73/7/27	.02	100	21	6.9	330	24	1,010	0	828	4.5	31	.3	0	–	1,020	1.39	81	0	87	16	1,390	7.4	28.0	0	620	630	0
32bcc1	2,704	73/7/9	.05	110	5.8	.7	150	8.5	383	0	314	5.2	17	8.7	.70	.07	499	.68	17	0	92	16	699	8.8	43.0	5	1,000	260	.3
5S-1E- 3aab1	1,900	73/7/24	–	120	27	1.3	260	29	787	0	645	7.2	18	.5	0	.22	853	1.16	73	0	84	13	1,230	7.8	32.0	10	800	700	0
10bdd1	2,960	73/6/5	2.7	83	2.2	0	100	.7	63	49	133	42	13	15	0	.01	336	.46	6	0	97	19	514	9.3	64.0	44	160	10	.3
21cbc1	660	73/6/6	.81	77	1.3	0	100	.7	57	50	130	42	13	15	.05	.02	317	.43	3	0	98	24	468	9.2	65.0	30	170	10	.2
24acd1	3,120	73/7/9	4.5	89	1.1	0	100	1.3	82	39	132	41	14	15	.78	.01	344	.47	3	0	98	26	463	9.3	64.5	29	150	20	.3
5S-2E- 1bbc1	1,800	73/7/9	.06	77	1.7	0	86	.6	46	59	136	7.1	16	15	.36	0	288	.39	4	0	86	18	423	9.8	49.5	1	1,100	10	0
2cda1	2,460	73/6/7	.02	89	9.9	2.0	250	22	675	0	554	3.4	25	6.4	.01	.06	742	1.01	33	0	90	19	1,100	–	36.5	4	1,200	740	.3
5bcd1	2,009	73/6/5	.17	110	5.2	1.1	150	6.7	223	75	308	8.1	20	8.6	0	.04	496	.67	18	0	93	16	648	9.3	42.5	3	990	250	.3
13ada1	1,748	73/6/22	.01	110	13	2.6	260	28	767	0	629	3.2	30	1.5	0	.10	828	1.13	43	0	88	17	1,260	7.6	23.0	5	1,200	830	0
5S-3E-14cbb1	2,300	73/7/23	.14	81	2.4	0	91	.8	66	42	124	10	18	23	0	.05	302	.41	6	0	97	16	419	9.6	58.5	2	1,100	10	0
15cba1	1,620	73/6/21	.01	130	22	5.7	280	20	886	0	727	5.4	36	1.3	0	.17	950	1.29	80	0	86	14	1,260	7.3	15.0	5	1,100	1,100	.7
20ada1	2,420	73/7/13	–	110	1.1	.1	85	.7	27	61	124	6.4	15	19	.09	.01	313	.43	3	0	98	21	396	9.6	60.0	1	780	0	0
20bbb1	–	73/7/23	.01	110	42	3.9	230	19	703	0	577	6.7	30	.5	3.6	.13	806	1.10	120	0	78	9.1	1,330	7.2	27.0	2	790	730	0
22aad1	1,300	73/6/22	.01	140	19	3.4	250	18	683	0	560	4.0	38	.7	.02	.04	812	1.10	61	0	87	14	1,280	7.3	25.0	6	1,200	950	0
25bbb1	1,320	73/6/28	.01	98	30	8.7	200	16	528	0	572	5.5	28	.2	0	.12	733	1.00	110	0	77	8.2	1,120	7.2	18.0	2	800	940	0
5S-3E-26bcb1	2,970	73/6/7	–	110	2.1	0	110	1.7	22	64	125	62	15	15	.01	.02	391	0.53	5	0	97	21	530	9.3	83.0	4	570	40	.3
26bcb2	2,970	73/6/8	–	100	1.5	.1	110	1.5	35	55	120	64	15	14	.03	.01	380	.52	4	0	98	23	529	9.3	67.0	4	550	30	.5
27bdd1	2,900	73/7/13	–		1.4	.1	81	.9	63	39	124	12	17	20	.25	0	279	.38	4	0	97	18	403	9.4	60.0	4	830	0	.2
28bcc1	2,540	73/5/31	–	98	.8	0	97	1.3	27	67	134	9.8	15	21	0	.02	324	.44	2	0	98	30	437	9.4	65.0	5	620	20	.1
35ccc1	2,570	73/5/31	–	100	2.2	0	100	1.1	54	49	126	72	16	15	.01	.03	391	.53	3	0	98	30	551	9.3	71.5	7	560	40	2.7
5S-4E-34ccb1	356	73/7/20	–	94	85	7.8	83	12	227	0	186	240	18	1.7	0	.03	654	.89	240	58	41	2.3	845	8.3	27.0	5	130	140	0
5S-5E-33bbd1	250	73/7/31	–	40	86	66	170	6.9	425	0	349	450	50	.6	5.3	–	1,100	1.50	490	140	43	3.4	1,650	7.2	22.0	28	300	230	0
34ddd1	885	73/7/31	–	87	29	12	190	26	625	0	513	12	24	.6	.33	–	691	.94	120	0	73	7.5	1,100	7.5	25.0	10	700	440	0
6S-2W-14cba1S		73/7/3	0.06	30	5.6	1.4	8.2	2.0	28	0	23	8.5	6.3	.1	2.3	.06	86	.12	20	0	44	.8	91	7.1	11.0	1	30	0	.2

TABLE 3. Chemical analyses of water from selected wells and springs. (continued)

Well or spring identification number	Reported well depth below land surface (feet)	Date of collection	Discharge (cubic feet per second)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite plus Nitrate ($NO_2 + NO_3$)	Phosphorus (P)	Dissolved Solids (calculated)	Dissolved Solids (tons per ac-ft)	Hardness		Percent sodium	Sodium-absorption ratio	Specific conductance (field)	pH (field)	Water temperature (°C)	Chemical constituents in micrograms per litre			
																			as $CaCO_3$	Noncarbonate						Arsenic (As)	Boron (B)	Lithium (Li)	Mercury (Hg)
6S-1E-32bba1S		73/7/12	–	45	37	8.5	22	1.6	126	0	103	35	21	0.5	0.56	0.01	235	0.32	130	24	27	0.8	344	7.2	25.0	5	30	0	0.1
6S-3E- 2cbc1	3,050	73/5/31	–	99	1.2	0	120	2.8	86	52	157	45	19	17	.01	.02	399	.54	3	0	98	30	599	9.1	62.0	2	850	40	0
2ccc1	1,940	73/7/6	1.6	100	1.2	.1	110	4.0	120	37	160	27	18	17	.03	.01	374	.51	3	0	97	26	504	9.2	53.0	3	760	40	.1
4bcc1	1,680	73/6/4	–	110	1.6	0	110	6.4	58	74	171	42	11	12	0	.02	396	.54	4	0	95	24	534	9.4	48.0	2	440	20	.2
5cac1	3,600	73/6/4	–	94	4.6	0	59	3.4	78	12	84	20	9.7	11	.08	.01	253	.34	11	0	89	7.6	320	8.6	61.0	23	150	10	.2
9acc1	1,425	73/6/4	3.7	130	3.6	.1	97	8.1	157	25	170	42	11	9.1	0	.06	404	.55	9	0	91	14	516	8.8	39.0	2	420	80	.2
11dad1	1,400	73/7/25	–	120	5.6	.3	86	6.1	155	0	127	33	11	11	.03	.12	350	.48	15	0	89	9.6	433	8.9	34.0	0	400	50	0
6S-4E-14abc1	1,905	73/5/30	3.3	140	5.0	.1	110	4.7	20	74	140	65	19	24	.02	.06	452	.61	13	0	93	13	583	9.4	54.0	30	540	0	.4
18bcc1	455	73/6/27	2.3	44	58	4.6	38	4.7	220	0	180	58	9.2	.7	1.3	.01	332	.45	160	0	33	1.3	462	7.3	18.0	22	80	30	0
25bcc1	1,750	73/6/26	.20	73	41	2.3	95	13	129	0	106	190	14	3.9	.23	.03	497	.68	110	6	62	3.9	702	7.8	20.0	3	130	90	0
35cda1	955	73/6/26	–	96	4.6	.1	47	8.9	96	0	79	24	9.0	8.0	0	.04	245	.33	12	0	81	5.9	273	8.5	32.5	24	100	20	0
6S-5E-10ddd1	1,667	73/7/5	.01	78	2.6	.3	120	4.3	159	19	162	24	15	29	.04	.02	371	.50	8	0	95	19	508	8.4	39.0	2	690	10	0
18ccb1	2,960	73/6/26	–	120	3.9	.1	100	7.3	93	25	118	52	20	13	.13	.03	388	.53	10	0	92	14	520	7.6	27.0	20	540	40	0
6S-5E-20aab1	–	73/5/30	0.01	59	4.7	0.1	110	5.6	198	18	192	3.7	17	24	0	0.04	341	0.46	12	0	93	14	562	8.8	43.5	8	950	50	0
24bca1	1,095	73/6/25	.01	89	3.6	0	120	4.6	149	21	157	28	13	27	0	.02	380	.52	9	0	95	17	509	9.1	33.5	6	570	10	0
24ddb1	1,938	73/7/25	–	79	2.8	0	99	2.3	127	10	121	35	11	25	0	.05	327	.44	7	0	96	16	418	9.0	32.5	20	380	10	0
29dcc1	1,560	73/7/5	.01	120	7.1	.3	87	6.3	117	4	103	42	15	19	.05	.04	359	.49	19	0	88	8.7	435	8.8	32.5	1	400	70	0
35cca1	460	73/7/19	–	73	38	3.3	54	8.6	166	0	136	66	11	6.9	.17	.02	344	.47	110	0	50	2.3	462	9.1	22.0	18	100	40	0
6S-6E-12ccd1	990	73/7/6	–	120	10	.6	180	15	493	0	404	3.6	19	5.9	3.0	.07	612	.83	27	0	89	15	843	8.2	37.0	1	1,100	220	.3
19ccd1	913	73/5/22	.01	88	3.0	0	93	3.1	94	19	109	38	10	26	.01	.01	327	.44	8	0	95	15	457	9.0	38.0	15	340	0	.2
19dbd1	1,092	73/7/18	–	84	2.3	0	94	1.9	87	24	111	28	10	26	.02	–	314	.43	6	0	96	17	421	9.2	42.0	25	340	10	0
32bdd1	1,402	73/6/25	.06	87	3.1	.1	94	3.1	132	8	122	28	11	27	.01	.02	327	.44	8	0	94	14	413	9.3	34.5	45	350	10	0
6S-7E- 1acb1	1,000+	73/8/1	.01	73	7.0	.6	260	8.0	614	0	504	3.4	62	4.4	0	–	723	.98	20	0	95	25	1,240	8.0	41.0	0	1,500	230	0
1dbd1	1,050+	73/8/1	.02	72	8.1	1.2	250	8.2	585	0	480	3.6	79	3.2	.02	–	716	.97	25	0	94	22	1,170	8.0	33.0	0	1,900	220	0
2cdd1	1,350	73/6/25	.01	75	5.8	.5	210	7.6	524	0	431	2.8	56	7.6	.30	.01	628	.85	17	0	94	22	951	8.0	34.5	1	1,700	20	0
8bba1	365	73/7/26	–	87	26	17	240	31	530	0	435	250	17	.7	.01	.04	931	1.27	140	0	75	9.0	1,210	7.0	23.0	40	280	240	0
7S-3E- 4acd1	804	73/6/8	1.6	94	51	2.8	31	15	214	0	176	36	7.2	1.7	.02	.02	346	.47	140	0	29	1.1	437	7.4	34.0	24	80	50	.3

							Na	K																					
7S-4E- 1acc1	1,800	73/5/21	1.7	83	6.9	.2	53	6.7	79	10	81	17	8.6	9.7	.29	.02	235	.32	18	0	81	5.4	278	8.6	40.0	3	100	0	.8
3abd1	1,142	73/6/28	3.7	95	5.8	.1	46	7.4	88	5	81	20	8.7	8.9	.12	.01	241	.33	15	0	80	5.2	272	8.4	42.0	17	120	10	0
5cca1	1,040	73/6/27	4.1	96	50	1.4	54	15	154	0	126	130	8.7	2.0	.01	.03	433	.59	130	4	44	2.1	497	7.7	30.0	9	120	60	0
10bdb1	1,145	73/6/11	1.1	99	7.2	.1	47	8.3	106	0	87	24	8.6	9.4	.26	.04	257	.35	19	0	78	4.7	284	8.6	37.5	17	110	10	.1
11cbc1	1,500	73/6/12	4.4	99	16	.3	45	9.0	113	0	93	30	9.3	8.2	1.3	.03	278	.38	41	0	65	3.1	312	8.3	36.0	20	100	20	.2
12bdd1	1,105	73/5/21	–	96	7.0	.1	51	7.0	97	0	80	17	8.4	8.7	.29	.02	244	.33	18	0	81	5.2	293	8.7	43.0	13	100	0	1.1
13bcc1	1,060+	73/7/26	3.3	95	7.3	.2	49	7.8	89	6	83	20	8.0	9.0	.26	.06	247	.34	19	0	79	4.9	289	9.0	39.0	19	100	10	0
13dcd1	1,000	73/5/30	2.8	97	8.7	.1	53	7.5	80	11	84	19	9.0	11	.25	.02	257	.35	22	0	78	4.9	261	8.7	40.0	14	90	10	.4
7S-4E-14abc1	1,146	73/6/12	3.7	96	7.2	0.1	45	7.8	104	0	85	18	8.1	6.0	1.2	.04	245	.33	18	0	85	4.6	275	8.6	39.0	12	110	10	0.1
15acd1	1,065	73/6/12	5.9	100	23	.8	48	9.9	123	0	101	54	9.9	14	.80	.04	323	.44	58	0	60	2.7	359	8.0	33.0	12	110	30	.1
23cbb1	810	73/6/13	7.3	96	12	.2	58	8.7	108	6	99	36	11	10	1.1	0	296	.40	31	0	75	4.5	352	8.4	38.5	–	–	–	–
25adc1	735	73/5/24	6.1	100	6.8	.1	25	6.4	108	0	89	29	11	15	.58	.04	250	.34	18	0	67	2.5	364	8.9	36.5	36	120	10	.1
26bcb1	867	73/7/10	2.9	91	13	.4	45	8.3	103	0	84	22	12	8.2	.82	.05	254	.35	34	0	69	3.4	300	8.2	31.0	15	110	10	4.3
27bcc1	1,390	73/7/10	3.1	76	16	1.3	46	7.7	109	0	89	28	14	6.6	1.9	.06	258	.35	45	0	64	3.0	292	8.0	27.0	15	110	10	2.9
7S-5E- 5dbc1	2,405	73/6/25	.05	75	4.4	.1	63	6.1	87	4	78	48	9.5	8.2	0	.02	261	.36	11	0	88	8.1	332	9.0	32.0	3	170	10	0
7abb1	1,625	73/7/6	7.8	91	8.5	.2	51	7.4	96	0	79	17	9.8	9.7	.95	.04	246	.33	22	0	78	4.7	279	8.5	39.0	21	90	10	.6
8ccc1	1,500	73/5/21	1.8	90	5.9	.1	55	6.9	81	11	85	19	9.3	11	.25	.01	249	.34	15	0	83	6.2	291	8.7	40.0	10	110	0	.1
9ddd1	2,065	73/6/14	2.0	89	12	.5	50	6.8	85	9	85	18	9.0	11	.71	0	250	.34	32	0	73	3.8	290	8.6	40.0	14	60	10	.1
13aac1	150	73/7/17	.78	93	18	2.3	51	9.2	100	0	82	50	10	10	.15	.04	294	.40	54	0	63	3.0	361	8.4	25.0	46	120	20	1
13cbb1	1,954	73/6/21	–	83	6.7	0	50	7.1	86	5	79	19	9.0	11	.13	.04	234	.32	17	0	81	5.3	284	8.7	36.0	27	130	10	.3
16acd1	1,515	73/5/30	–	90	6.7	.1	53	6.5	101	0	87	20	9.8	16	.26	.02	259	.35	17	0	83	5.9	278	8.7	39.5	17	90	10	.3
19ccc1	760	73/7/23	2.6	95	7.7	.1	55	7.6	103	0	84	24	11	12	.24	–	264	.36	20	0	80	5.4	309	8.4	36.5	19	110	10	0
28acd1	1,003	73/5/24	2.5	94	8.3	.3	52	9.2	97	0	80	24	9.5	11	.23	.01	257	.35	22	0	77	4.8	297	8.6	34.0	16	110	0	.4
7S-6E- 7aac1	1,086	73/7/19	–	100	2.8	.1	61	6.8	80	16	92	23	10	10	.01	.03	269	.37	7	0	89	9.8	310	9.2	25.0	30	140	10	0
9bad1	910	73/7/5	–	100	1.6	.3	100	2.8	59	43	120	27	10	24	.06	.04	338	.46	5	0	96	19	461	9.4	50.5	78	210	10	.1
16cdc1	513	73/6/14	–	81	7.4	.4	49	5.1	99	3	86	18	9.0	8.9	.33	0	232	.32	20	0	80	4.8	287	8.5	42.5	17	60	10	.2
21dbc1	760	73/6/14	–	82	5.9	.3	54	4.6	91	7	86	18	9.0	12	.28	0	239	.33	16	0	84	5.9	287	8.5	43.0	16	70	0	.1
22aad1	1,410	73/5/22	5.5	86	16	1.9	40	6.3	124	0	102	15	8.4	3.7	.60	.01	241	.33	48	0	61	2.5	274	8.0	45.0	4	90	20	.1
23cad1	1,300	73/5/22	–	100	12	1.1	53	7.2	126	0	103	17	8.7	8.2	.54	.01	272	.37	35	0	73	3.9	327	8.3	44.0	16	120	20	0
26ada1	1,000	73/5/22	2.3	82	16	2.8	36	6.9	134	0	110	15	8.6	3.1	.66	.02	240	.33	51	0	57	2.2	288	8.0	38.0	7	100	20	1.1
27adb1	400	73/6/19	1.2	84	12	1.1	48	6.2	129	0	106	17	8.6	5.4	.59	.03	249	.34	35	0	71	3.6	287	9.2	43.0	18	80	10	.3
34dcb1S		73/6/19	1.0	83	6.2	.3	55	5.5	103	6	94	18	8.8	8.5	.46	.03	244	.33	17	0	83	5.9	288	9.1	41.0	26	10	0	.2
35bbb1S		73/7/18	–	89	13	1.8	43	6.7	126	0	103	15	8.8	4.5	.60	.03	247	.03	40	0	66	3.0	287	8.5	40.0	19	110	10	1
8S-1E-20cca1S		73/7/2	.01	22	11	2.8	6.0	.7	62	0	51	3.2	2.0	.2	.62	.07	81	.11	39	0	25	.4	100	7.1	9.5	2	20	0	.1
8S-6E- 3bdd1S		73/7/5	1.0	87	6.5	.6	53	6.7	113	5	101	15	9.1	6.0	.66	.06	248	.34	19	0	81	5.3	300	8.3	39.0	18	80	10	0
9S-2E-13cbc1S		73/7/2	.01	39	14	2.9	11	2.1	71	0	58	9.5	6.3	.3	.04	.08	120	.16	47	0	33	.7	130	7.2	11.0	0	40	0	.3

Analyses by: U. S. Geological Survey

*analysis does not balance, error in Na suspected.

Young and Whitehead (1975)

(Table 5)

TABLE 5
GAS ANALYSES FROM SELECTED WELLS

Well or spring identification number	Water temperature[1] (°C)	Major aquifer	Percent by volume					N_2/O_2 in sample	N_2/O_2 in water at 10°C	Sum
			Nitrogen (N_2)	Oxygen (O_2)	Methane (CH_4)	Carbon Dioxide (CO_2)	Hydrogen (H_2)			
4S-1E-26abc1	27.0	Sedimentary rocks of Idaho Group	53	14.2	28.8	<1	< 0.1	3.73	1.96	96+
34bad1	75.5	Idavada Volcanics	72	16.6	0	<1	$<.1$	4.34	1.96	89±
4S-2E-29dbc1	28.0	Sedimentary rocks of Idaho Group	36	19.3	50	<1	$<.1$	1.87	1.96	105+
32bcc1	43.0	Sedimentary rocks of Idaho Group	38	13.5	40.4	<1	$<.1$	2.81	1.96	92±
5S-2E- 1bbc1	49.5	Banbury Basalt(?)	67	18.2	0	<1	$<.1$	3.68	1.96	85+
5S-3E-20ada1	60.0	Idavada Volcanics	72	19	0	<1	$<.1$	3.77	1.96	91+
20bbb1	27.0	Sedimentary rocks of Idaho Group	62	24.2	16.4	<1	$<.1$	2.56	1.96	103±
26bcb2	67.0	Idavada Volcanics(?)	76	12.1	0	<1	$<.1$	6.28	1.96	88+
27bdd1	60.0	Idavada Volcanics(?)	70	12.8	5.5	<1	$<.1$	5.47	1.96	88+
28bcc1	65.0	Idavada Volcanics	69	17.2	2	<1	$<.1$	4.01	1.96	88+
6S-3E- 2cbc1	62.0	Banbury Basalt	67	11 5	5	<1	$<.1$	5.83	1.96	84±
6S-5E-20aab1	43.5	Banbury Basalt(?)	84	16.5	0	<1	$<.1$	5.09	1.96	101±
6S-7E- 1acb1	41.0	Sedimentary rocks of Idaho Group	61	23.3	20.9	<1	$<.1$	2.62	1.96	105+
1dba1	33.0	Sedimentary rocks of Idaho Group	38	16.4	35.4	<1	$<.1$	2.32	1.96	90±
2cdd1	34.5	Sedimentary rocks of Idaho Group	38	17.6	46.3	<1	$<.1$	2.16	1.96	102±

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[1] Temperature of the water at land surface at time of sampling.

ANALYSES BY: Katherine L. Pering, U. S. Geological Survey

Rightmire and others (1975)

(Table 3)

9-230

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. Washington ______
District ______

Table 3.--Isotope analyses of water from selected wells and springs in the Bruneau-Grand View a

Analyses by U.S. Geological Survey

Well or spring location number			δD_{SMOW}	$\delta^{18}O_{SMOW}$	$\Delta^{18}O$		Reference number					
			NONTHERMAL									
6S	2W	14cbc1S	-133	-16.4	+1.45		1					
8S	1E	20cca1S	-128	-17.1	+0.20		2					
9S	2E	13cbc1S	-129	-16.5	+0.90		3					
			THERMAL									
4S	1E	26abc1	-144	-18.2	+0.95		4					
		34bad1	-145	-17.5	+1.80		5					
4S	2E	32bcc1	-146	-17.4	+2.05		6					
5S	2E	16bc1	-144	-17.0	+2.25		7					
5S	3E	14cbb1	-142	-17.6	+2.00		8					
		26bcb1	-146	-17.5	+2.00		9					
		28bcc1	-142	-17.6	+0.90		10					
6S	3E	2ccc1	-154	-17.6	+2.80		11					
6S	4E	14abc1	-144	-17.6	+1.65		12					
6S	6E	12ccd1	-144	-18.1	+1.10		13					
		19ccd1	-156	-18.1	+2.55		14					
6S	7E	2cdd1	-135	-15.0	+3.25		15					
7S	5E	7abb1	-135	-17.6	+0.55		16					
		16acd1	-135	-17.1	+1.00		17					
7S	6E	9bad1	-142	-18.2	+0.80		18					
8S	6E	3bdd1S	-150	-17.1	+2.95		19					

AMAX file data - 1976

Samples W10220-W10228

Castle Creek and Grand View areas

LAB AMAX-DENVER

PAGE 1 of 2

ANALYTICAL REPORT

DATE 4/1/76

ANALYST C.M. JENSEN, AFR

TYPE SAMPLES GEOTHERMAL WATER

REQ. NO. 6088

PROJECT 423

REQUESTED BY DELLECHAIE

	Sample	Lab No.	Na	K	Ca	Mg		Sample	Lab No.	SiO_2	B	SO_4	Li
			PPM	PPM	PPM	PPM				PPM	PPM	PPM	PPM
01	W10220		110	0.7	1.0	<0.5	31	W10220		73	0.2	34	<.1
02	21		120	1.6	1.3	<0.5	32	21		110	0.5	75	<.1
03	22		90	0.9	1.1	<0.5	33	22		76	0.8	4	<.1
04	23		120	3.8	1.2	<0.5	34	23		96	0.6	32	<.1
05	24		110	1.0	1.4	<0.5	35	24		80	<0.2	40	<.1
06	25		100	0.8	0.9	<0.5	36	25		82	0.3	38	<.1
07	26		110	1.3	1.2	<0.5	37	26		93	0.3	42	<.1
08	27		110	0.6	1.1	<0.5	38	27		80	<0.2	40	<.1
09	28		110	0.7	1.1	<0.5	39	28		81	0.2	42	<.1
10							40						
11							41						
12							42						
13							43						
14							44						
15							45						
16							46						
17							47						
18							48						
19							49						
20							50						
21							51						
22							52						
23							53						
24							54						
25							55						
26							56						
27							57						
28							58						
29							59						
30							60						

METHODS: DIGESTION-

SAMPLE WEIGHT-

DETERMINATION- SiO_2 - AA

REMARKS: Li - AA

B - CARMINIC ACID

NOTE: MAIL ORIGINAL TO
AMAX EXPLORATION, INC.,
12620 W. CEDAR DRIVE,
P.O. BOX C, DENVER, COLO., 80226

COPIES TO: 1 F. DELLECHAIE AT LAKESIDE OFFICE
2 E. J. ROWE AT DENVER LAB
3. C. JENSEN AT DENVER LAB
→ H. OLSON LAKESIDE OFFICE

LAB AMAX - DENVER

PAGE 2 of 2

ANALYTICAL REPORT

DATE 4 / 1 / 76

ANALYST C.M. JENSEN, AFR

TYPE SAMPLES GEOTHERMAL WATER

REQ. NO. 6088

PROJECT 423

REQUESTED BY DELLECHAIE

	Sample	Lab No. Loc.	F	Cl	HCO_3	CO_3		Sample	Lab No.	pH	HCO_3	CO_3	
			ppm	ppm							PPM	PPM	
✓ 01	W10220	4S-1E-28SWNE	12	10	84	41	31	W10220		9.3	69	68	
✓ 02	21	5S-3E-23SWSW	17	15	46	47	32	21		9.2	38	78	
03	22	?	28	12	13	68	33	22		9.5	11	114	
04	23	?	20	13	115	41	34	23		9.0	94	68	
05	24	5S-1E-24SW¼NE	18	14	70	43	35	24		9.2	57	72	
✓ 06	2	4S-1E-34NENW	16	13	72	46	36	25		9.2	59	76	
07	26	5S-1E-24 NENE	19	14	77	40	37	26		9.1	63	66	
08	27	5S-1E-10 center	20	14	72	41	38	27		9.1	59	68	
09	28	5S-1E-21NWSW	20	15	68	42	39	28		9.2	56	70	
10							40						
11							41						
12					as HCO_3		42						
13					and CO_3		43						
14							44						
15							45						
16							46						
17							47						
18							48						
19							49						
20							50						
21							51						
22							52						
23							53						
24							54						
25							55						
26							56						
27							57						
28							58						
29							59						
30							60						

METHODS: *DIGESTION-*

SAMPLE WEIGHT-

DETERMINATION-

F - SPECIFIC ION ELECTRODE
Cl - MERCURIMETRIC TITRATION
pH - ELECTROMETRIC

REMARKS:

$\left.\begin{matrix} HCO_3 \\ CO_3 \end{matrix}\right\}$ - PPM AS $CaCO_3$

NOTE: *MAIL ORIGINAL TO*
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3. C.M. JENSEN *AT* DENVER LAB
H. OLSON ~~LAKESIDE OFFICE~~

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ____ Sample No. X W10221 Date ____ Time 1200

Name: Sec 23 Well Location: Co. [illegible] State [illegible]

[illegible] Sec. 23 T [illegible] R: [illegible] ; ____ Km/mi. ____ of ____

Lat.: ____ Long.: ____ Sampler: B.D

Elevation: [illegible] Quad. [illegible]

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 34

Ground Temp. °C ____

Air Temp. ____

Odor [illegible]

Fluid Color clear

Fluid Taste [illegible]

Bubbling yes

Boiling no

Vegetation no

Fluid issues from [illegible] holes

____

Salt: Type [illegible]

Quantity ____

Color ____

Form ____

Sinter: Type CaCO3

Quantity minor

Color yellow-white

Form [illegible]

Discharge: 280 gpm/Lpm

Well Data: Depth ?

Bore ____

Pump Type ____

Level of water in bore ____

Type of piping ____

Artesian Head yes

Rock Data:

Type (surface) ____

Color ____

Grain size ____

Megascopic Minerals ____

Alteration: ____

Rx Type (at depth) ____

Water used for irrigation

Immediate area used for: cattle

Quality of sample: [✓ Exc], Good, Poor

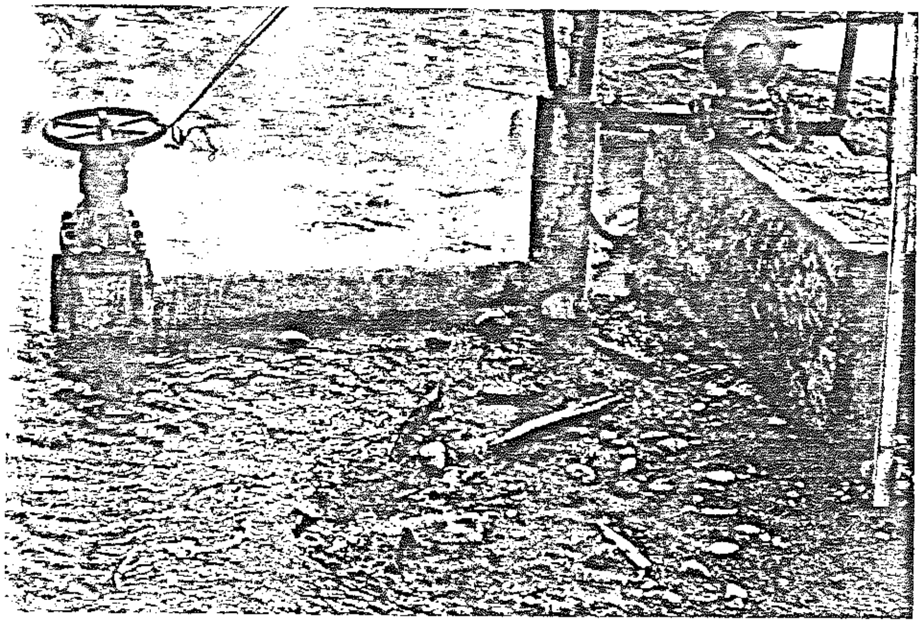
Probable cause of manifestation well

Property owned by ____

Previous and/or Current Leases ____

Comments: R, F14

SKETCHES



AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ____ Sample No. X W10227 Date 13:00 Time 3-27-76

Name: Sec 10 H AW Location: Co. Owyhee State Id

Centr, Sec. 10 T 5S R: 1E ; ____ Km/mi. ____ of ____

Lat.: ____ Long.: ____ Sampler: B Willechan

Elevation: 2650 Quad. Oreana

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 57

Ground Temp. °C ____

Air Temp. ____

Odor 0

Fluid Color 0

Fluid Taste hard HCO_3

Bubbling yes

Boiling no

Vegetation no

Fluid issues from Steel pipe

Discharge: 500 [✓ gpm]/lpm

Well Data: Depth ____

Bore ____

Pump Type ____

Level of water in bore ____

Type of piping ____

Artesian Head yes

Rock Data:

Type (surface) ____

Color ____

Grain size ____

Megascopic Minerals ____

Salt: Type 0

Quantity ____

Color ____

Form ____

Sinter: Type $CaCO_3$

Quantity minor

Color gray

Form amorph

Alteration: ____

Rx Type (at depth) ____

Water used for ____

Immediate area used for: ____

Quality of sample: [✓ Exc], Good, Poor

Probable cause of manifestation well

Property owned by ____

Previous and/or Current Leases ____

Comments: R, F 15

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ______ Sample No. X W/C233 Date 3-29-76 Time 1350

Name: Sec 21 4 NW Location: Co. Owyhee State Id

NW SW Sec. 21 T 5S R: 1E ; ______ Km/mi. ______ of ______

Lat.: ______ Long.: ______ Sampler: J.D

Elevation: ______ Quad. Mahogany (BLM)

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 64 Discharge: 50 [✓ gpm]/Lpm

Ground Temp. °C ______ Well Data: Depth ?

Air Temp. ______ Bore ______

Odor S= Pump Type ______

Fluid Color Clear Level of water in bore ______

Fluid Taste S= Type of piping ______

Bubbling O Artesian Head ______

Boiling no Rock Data:

Vegetation no Type (surface) ______

Fluid issues from Steel Color ______

pipe Grain size ______

Megascopic Minerals ______

Salt: Type O

Quantity ______

Color ______ Alteration: ______

Form ______ Rx Type (at depth) ______

Sinter: Type O Water used for irrigation

Quantity ______ Immediate area used for: Ranching

Color ______

Form ______ Quality of sample: [✓ Exc], Good, Poor

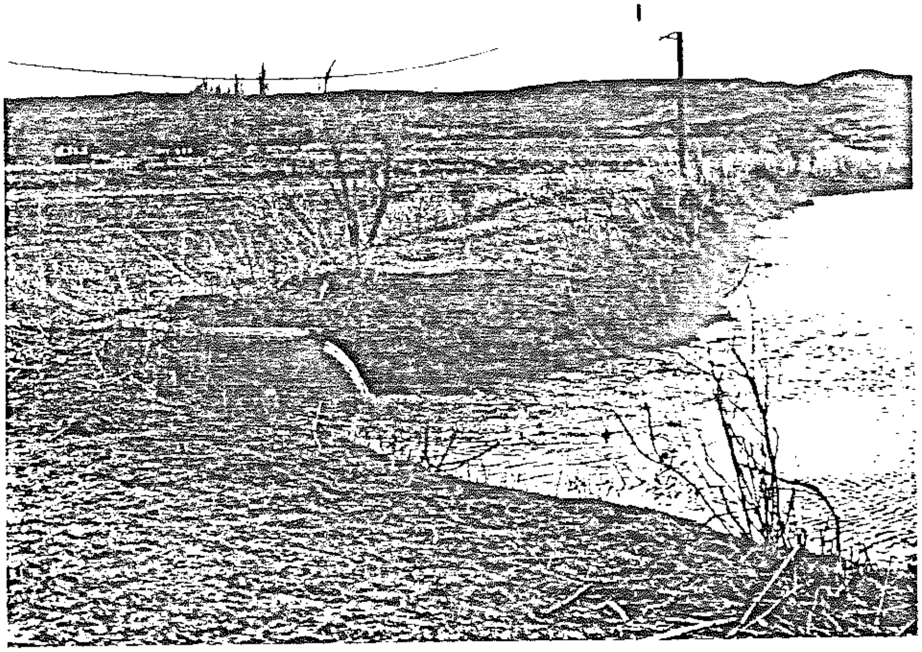
Probable cause of manifestation well

Property owned by ______

Previous and/or Current Leases ______

Comments: R1 F16

SKETCHES



AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ______ Sample No. X 10633 Date ___

Name: KITTERING HALL Location: Co. L

NE NE Sec. 24 T 5S R: 1E ; ______ Km/mi. ___

Lat.: ______ Long.: ______ Sampler: [illegible]

Elevation: ______ Quad. Mak.

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt gas, rock, snow.

Senda

Description:

Water Temp. °C 66

Ground Temp. °C ______

Air Temp. ______

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation 0

Fluid issues from Steel pipe

Salt: Type 0

Quantity ______

Color ______

Form ______

Sinter: Type $CaCO_3$

Quantity minor

Color Gray

Form amorphous

Discharge: 1000

Well Data: Depth 320

Bore 24"

Pump Type none

Level of water in bore —

Type of piping Steel

Artesian Head Artesian

Rock Data:

Type (surface) ______

Color ______

Grain size ______

Megascopic Minerals ______

Alteration: ______

Rx Type (at depth) ______

Water used for irriga

Immediate area used for: ______

Quality of sample: [✓ Exc.],

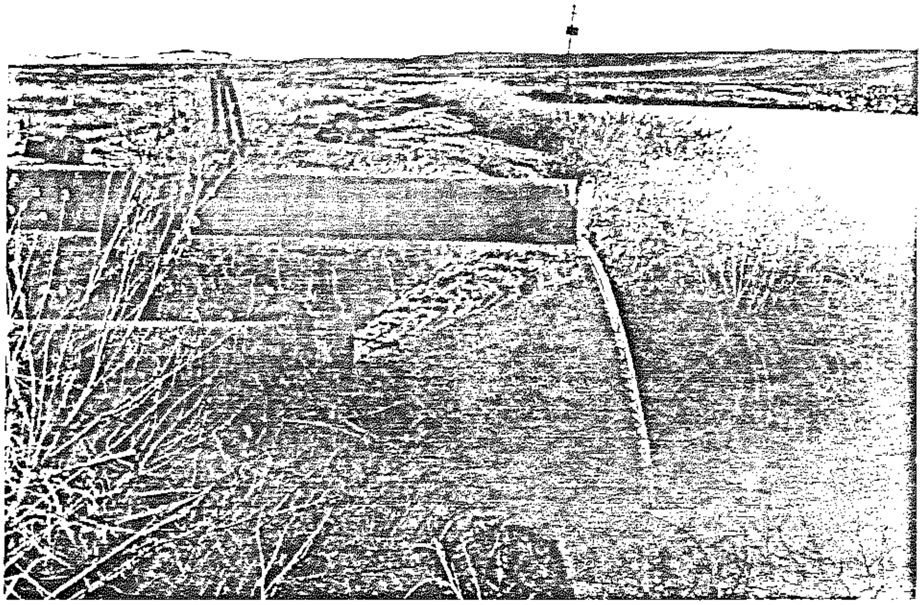
Probable cause of manifestation well

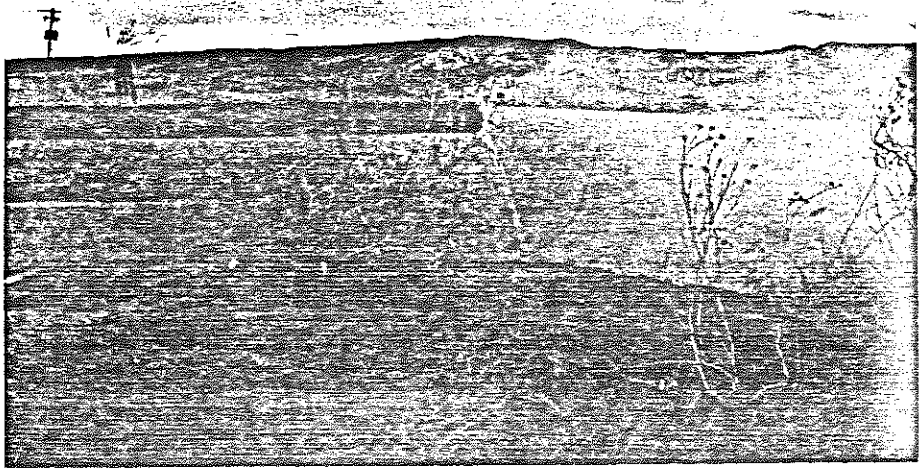
Property owned by Tony Kitterling, General Del., Cr

Previous and/or Current Leases ______

Comments: R, F 16-17

SKI





AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ______ Sample No. X CC10224 Date ______ Time ______

Name: KITTERLING H.AW #2 Location: Co. Cyhee State Id

SW1/4 NE Sec. 24 T 5S R: 1W ; ______ Km/mi. ______ of ______

Lat.: ______ Long.: ______ Sampler: S. Dellechaie

Elevation: ______ Quad. Mahogany

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 66°

Ground Temp. °C ______

Air Temp. ______

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation gray algae

Fluid issues from Steel pipe

Salt: Type 0

Quantity ______

Color ______

Form ______

Sinter: Type 0

Quantity ______

Color ______

Form ______

Discharge: 5 [✓ gpm]/Lpm

Well Data: Depth ?

Bore ______

Pump Type ______

Level of water in bore ______

Type of piping ______

Artesian Head ______

Rock Data:

Type (surface) ______

Color ______

Grain size ______

Megascopic Minerals ______

Alteration: ______

Rx Type (at depth) ______

Water used for 0

Immediate area used for: Ranching

Quality of sample: [✓ Exc.], Good, Poor

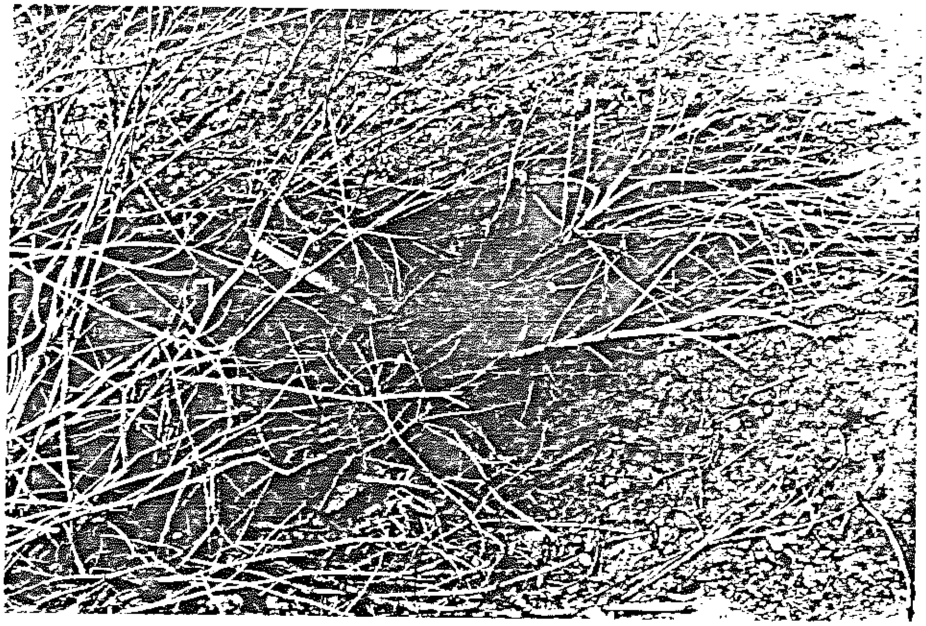
Probable cause of manifestation Well

Property owned by KITTERLING

Previous and/or Current Leases ______

Comments: ______

SKETCHES



AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ______ Sample No. X WI0225 Date ______ Time 1600

Name: King Hot ART Well Location: Co Owyhee State Id

NE NW Sec. 34 T4S R: 1E ; ______ Km/mi. ____ of ______

Lat.: ______ Long.: ______ Sampler: B. Delickaic

Elevation: ______ Quad. Bisuku

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 72

Discharge: 500 [✓ gpm]/Lpm

Ground Temp. °C ______

Well Data: Depth ?

Air Temp. ______

Bore ______

Odor 0

Pump Type ______

Fluid Color 0

Level of water in bore ______

Fluid Taste HCO_3

Type of piping ______

Bubbling minor

Artesian Head ______

Boiling no

Rock Data:

Vegetation no

Type (surface) Qal

Fluid issues from Steel pipe

Color ______

Grain size ______

Megascopic Minerals ______

Salt: Type 0

Quantity ______

Color ______

Alteration: ______

Form ______

Rx Type (at depth) ______

Sinter: Type $CaCO_3$

Water used for irrigation

Quantity minor

Immediate area used for: irrigation

Color white

Form amorp

Quality of sample: [✓ Exc.], Good, Poor

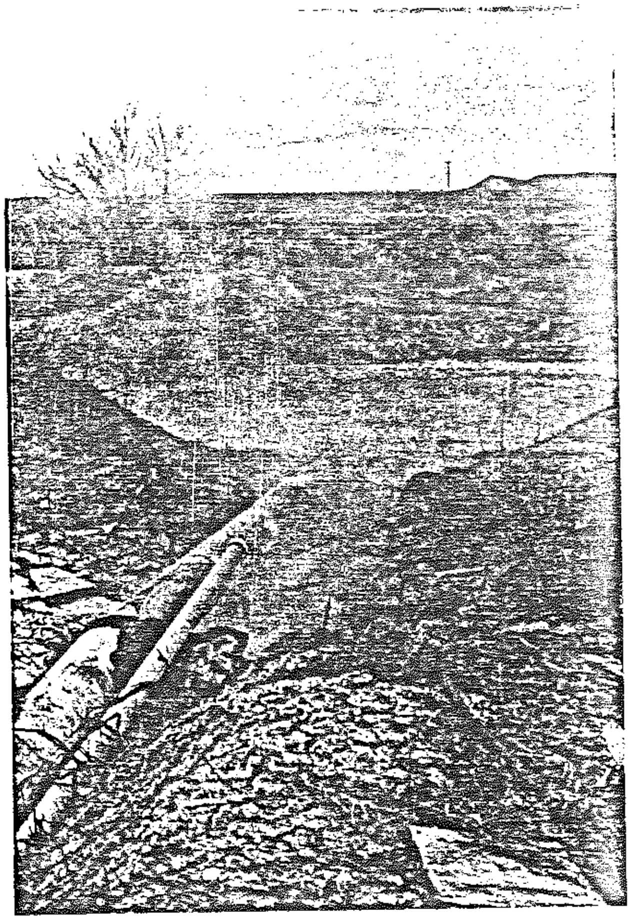
Probable cause of manifestation well

Property owned by ______

Previous and/or Current Leases ______

Comments: Rz F5

SKETCHES



AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. ______ Sample No. X W10220 Date ______ Time ______

Name: Sec 29 HAW Location: Co. Owyhee State Id

SW NE Sec. 28 T 4S R: 1E ; ______ Km/mi. of ______

Lat.: ______ Long.: ______ Sampler: S. Dellechaie

Elevation: 2644 Quad. Oreana

Sample Type: Spring (p), [✓ well (p)], creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 69

Ground Temp. °C ______

Air Temp. ______

Odor $S^=$

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation 0

Fluid issues from Steelpipe

Salt: Type 0

Quantity ______

Color ______

Form ______

Sinter: Type $CaCO_3$

Quantity minor

Color white

Form amorp

Discharge: 500 [✓ gpm]/Lpm

Well Data: Depth 0 ?

Bore 24"

Pump Type 0

Level of water in bore full

Type of piping Steel

Artesian Head yes

Rock Data:

Type (surface) Qal

Color ______

Grain size ______

Megascopic Minerals ______

Alteration: ______

Rx Type (at depth) ______

Water used for irrigation

Immediate area used for: ranching

Quality of sample: [✓ Exc], Good, Poor

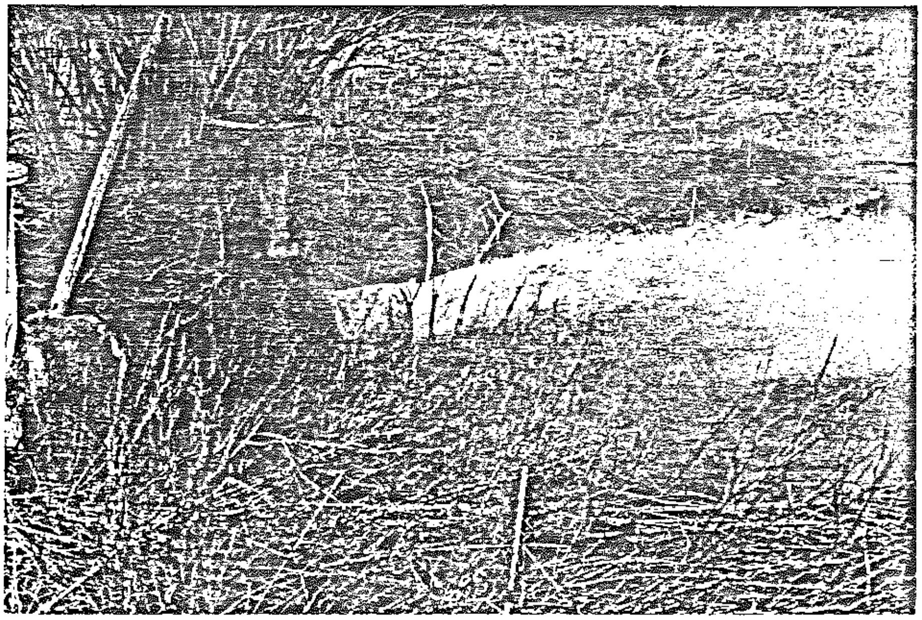
Probable cause of manifestation well

Property owned by ?

Previous and/or Current Leases ______

Comments: ?2F6

SKETCHES



U. S. Geological Survey, Boise ID

File Data

Analyses of well, 9S-5E-4dad1

FORM NO.

SITE NO. 9S-5E-4DAD1

IDAHO DISTRICT
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Recorded by ____________________

Date ____________________

SITE SCHEDULE

Check One ✓ English ___ Metric Units

GENERAL SITE DATA (0)

Site Ident No 424012115515501 (5–19)

RG Number R=0 *

Transaction T- [✓ A] D M V * (add, delete, modify, verified)

Site-Type 2- C D H I M P T [✓ W] * (collector, drain, sinkhole, connector well, multiple, pond, tunnel or shaft, well)

Data Reliability 3- [✓ C] U L M * (field checked, unchecked, location not accurate, minimal data)

Reporting Agency 4- USGS *

Project No. 5- ID-79-116 *

District 6- 16 *

State 7- 16 *

County (or town) OWYHEE 8- 077 *

Latitude 9- 424012 * (deg min sec)

Longitude 10- 1155155 * (deg min sec)

Lat-Long Accuracy 11- S F T M * (sec, 5 sec, 10 sec, Min)

Local Number 12- 09S 05E 04DAD1 *

Land Net Loc. 13- SE NE SE S 04 T 09S R 05E B * (1/4, 1/4, 1/4, section, township, range, merid)

Location Map 14- *

Scale 15- *

Altitude 16- 3633. * 2733

Method of Measurement 17- A L M * (altimeter, level, map)

Accuracy 18- *

Topo Setting 19- D C E F H K L O P S T U V W * (depression, stream channel, dunes, flat, hilltop, sink, swamp, offshore, pediment, hillside, terrace, undulating, valley flat, upland draw)

Hydrologic Unit (OWDC) 20- *

Date of First Construction/Completion 21- / / * (month day year)

Use of Site 23- A D E G H O M P R S T U W X Z * (anode, drain, geothermal, seismic, heat reserv., observation, mine, oil or gas, recharge, repress, test, unused, withdrawal, waste, destroyed)

Use of Water 24- A B C D E F H I M N P R S T U Y Z * (air cond., bottling, commercial, dewater, power, fire, domestic, irrigation, medicinal, industrial, public supply, recreation, stock, institution, unused, desal, other)

Secondary Water Use 25- *

Tertiary Use of Water 26- *

Depth of Hole 27- 2502. *

Depth of Well 28- 2502. *

Source of Depth Data ① 29- D *

Water Level 30- 850. *

Date Measured 31- 07/13/1961 * (month day year)

Source ① 33- S *

Method of Measurement 34- A C E G H L M R S T V Z * (airline, calibrated airline, estimated, pressure gage, calibrated pressure gage, geophysical logs, manometer, reported, steel tape, electric tape, calibrated electric tape, other)

Site Status 37- D E F G H O P R S T V X Z * (dry, recently flowing, flowing, nearby flowing, nearby recently flowing, obstruction, pumping, recently pumped, nearby pumping, nearby recently pumped, foreign substance, surface water effects, other)

Activity Status 273- *

Source of Geohydrologic Data ① 36- *

Pump Used 35- * (no)

Measuring Point 266- . *

Measuring Point Date 267- / / * (month day year)

OWNER IDENTIFICATION (1)

R-158 * T- A D M * (add, delete, modify)

Date of Ownership 159 # / / * (month day year)

Name: Last 161- *

First 162- *

Middle Initial 163- *

OTHER SITE IDENTIFICATION NUMBERS (1)

R-189 * T- A D M * (add, delete, modify)

Ident 190 # *

Assigner 191- *

New Card Same R & T

Ident 190 # *

Assigner 191- *

SITE VISIT DATA (1)

R-186 * T- A D M * (add, delete, modify)

Date of Visit 187# / / * (month day year)

Name of Person 188- *

FIELD WATER QUALITY MEASUREMENTS (1)

R-192 * T- [✓ A] D M * (add, delete, modify)

Date 193 # 07/13/1961 * (month day year)

Geohydrologic Unit 195 # 121IDVD *

New Card Same R thru 195

Temperature 196 # 00010 * Degrees C 197- 53.0 *

Conductance 196 # 00095 * µ Mhos 197- 394. *

Other (STORET) Parameter 196 # 00400 * Value 197- 9.5 *

Other (STORET) Parameter 196 # * Value 197- . *

FOOT NOTES

① Source of Data Codes

S	D	O	A	R	L	G	Z
reporting agency	driller	owner	other gov't	other reported	logs	geologist	other

UNI) STATES DEPARTMENT OF THE INTE)R
GEOLOGICAL SURVEY
GROUND WATER ANALYSIS

"~~A~~" Site" Ⓐ

Location Mountain Home Air Force Base State Idaho County ~~Elmore~~ Owyhee

Latitude 4~~2°2~~0N Longitude 11~~5°4~~00 Seq.No.

Date collected May 3, 1965 Point of coll. Raw water pump

Source Deep well No. 1 Local well No. ~~09S05E04~~

Owner U.S.A.F. - 9th Aero Space Wing Water use Domestic

Depth (ft) ~~522~~ Cased to (ft) Diam. (in) Date drilled

W.L. ~~480~~ Yield ~~1,000~~ gpm WBF

Treatment None Appear. when coll. Clear

Collected by S/Sgt Waters; T/Sgt Cole Remarks Sampled after pumping 3 minutes

9S 5E 4dad1 424012115515501

Specific conductance (micromhos at 25° C) 402 pH 9.5 Temp. (°F) 140

	ppm	epm		ppm	epm
Silica (SiO_2)	78		Bicarbonate (HCO_3)	58	0.95
			Carbonate (CO_3)	37	1.23
Calcium (Ca)	.8	0.04	Sulfate (SO_4)	27	.56
Magnesium (Mg)	.1	.01	Chloride (Cl)	12	.34
Sodium (Na)	92	4.00	Fluoride (F)	20	1.05
Potassium (K)	1.0	.03	Nitrate (NO_3)	.2	.00
		93°C			
	Na-K-Ca				
Total		4.08	Total		4.13

	ppm		ppm
		Dissolved solids:	
Aluminum (Al)		Residue on evap. at 180° C	304
		Calculated	309
Iron (Fe)	12		
		Hardness as $CaCO_3$	2
Manganese (Mn)	.0	Noncarbonate	0
		Color	5
		Carbon dioxide (CO_2) calculated	.0

Lab. No. FMJ 12343 Field No. Project

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

2GW
Dec. 1953

WATER ANALYSIS

424012115515501 9S5E 4dad1

Location At Mountain Home Air Force Base, Idaho County Owyhee ~~Elmore~~ *
Source Deep well Depth (ft) Diam (in.)
Cased to (ft) Date drilled 1961 Point of coll. Site A, at pump
Owner USAF, Mt. Home AFB
Treatment Use Dom., Air Cond.
WBF Sand WL 500' Yield 100 gpm
Temp (°F) Appear. when coll. Clear
Collected May 18, 1964 By Charles Freeman
Remarks

	ppm	epm		ppm	epm
Silica (SiO_2)	88		Bicarbonate (HCO_3)	56	0.92
Aluminum (Al)			Carbonate (CO_3)	38	1.27
Iron (Fe)	2.3				
Manganese (Mn)	.0		Sulfate (SO_4)	27	.56
			Chloride (Cl)	12	.34
			Fluoride (F)	20	1.05
Calcium (Ca)	1.5	0.07			
Magnesium (Mg)	.0	.00	Nitrate (NO_3)	.5	.01
Sodium (Na)	94	4.09			
Potassium (K)	1.1	.03			
Total		4.19	Total		4.15

	ppm		
		Specific conductance (micromhos at 25° C)	407
Dissolved solids:			
Calculated	312	pH	9.4
Residue on evaporation at 180°C	281		
		Color	5
Hardness as $CaCO_3$	4		
Noncarbonate	0	Carbon dioxide (CO_2) calc.	.1

Lab No PNW 10600 Field No. Project

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER ANALYSIS

95-5E-4dad1 S. Bruneau

Location Mountain Home, Idaho (Missile Base Site A) County Owyhee

Source Drilled Well Depth (ft) 2552 ~~2,000~~ Diam (in.) 10

Cased to (ft) 2,000 Date drilled 1959 Point of coll. Missile Site A

Owner Mountain Home Air Force Base, Idaho

Treatment Use Domestic

WBF Lava rock and sand WL Yield 200 gpm pump

Temp (°F) Appear. when coll. Clear

Collected April 8, 1963 - 1000 hours By S/Sgt. Cordell

Remarks Field No. 6 424012115515501 [illegible]

	ppm	epm		ppm	epm
Silica (SiO_2)	83		Bicarbonate (HCO_3)	56	0.92
Aluminum (Al)			Carbonate (CO_3)	38	1.27
Iron (Fe)	1.9				
Manganese (Mn)	.0		Sulfate (SO_4)	26	.54
			Chloride (Cl)	13	.37
			Fluoride (F)	20	1.05
Calcium (Ca)	1.0	0.05			
Magnesium (Mg)	.0	.00	Nitrate (NO_3)	.2	.00
Sodium (Na)	92	4.00			
Potassium (K)	1.0	.03			
Total		4.08	Total		4.15

[illegible]

	ppm		
		Specific conductance (micromhos at 25° C)	403
Dissolved solids:			
Calculated	304	pH	9.4
Residue on evaporation at 180° C	303		
Hardness as $CaCO_3$	2	Color	5
Noncarbonate	0	Carbon Dioxide (CO_2) calc.	.1

Lab. No. PNW 8793 Field No. Project

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

2GW
Dec. 1953

WATER ANALYSIS

9S5E4dadl 424012115515
278

Location Bruneau, Idaho (13 miles ~~S.E.~~ S.W.) County Owyhee
Source Deep Well; well ~~No. C/T~~ Site A Depth (ft) 577 ~~700~~ Diam (in.)
Cased to (ft) Date drilled Point of coll. Cooling tower
Owner USAF; Mt. Home AFB
Treatment Use Condensing, Dom.
WBF WL Yield 50 gpm
Temp (°F) 85 Appear. when coll. Clear
Collected March 13, 1964 By Ray Lewis
Remarks Sample collected by mistake; may not be representative.

	ppm	epm		ppm	epm
Silica (SiO_2)	81		Bicarbonate (HCO_3)	65	1.07
Aluminum (Al)			Carbonate (CO_3)	35	1.17
Iron (Fe)	.33				
			Sulfate (SO_4)		
			Chloride (Cl)	13	.37
			Fluoride (F)	18	.95
Calcium (Ca)	1.0	0.05			
Magnesium (Mg)	.0	.00	Nitrate (NO_3)		
Sodium (Na)	98	4.26			
Potassium (K)					
Total			Total		

	ppm		
		Specific conductance (micromhos at 25° C)	415
Dissolved solids:			
Calculated		pH	9.2
Residue on evaporation at 180°C	313		
		Color	5
Hardness as $CaCO_3$	2		
Noncarbonate	0		

Lab No PNW 10191 Field No. Project

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

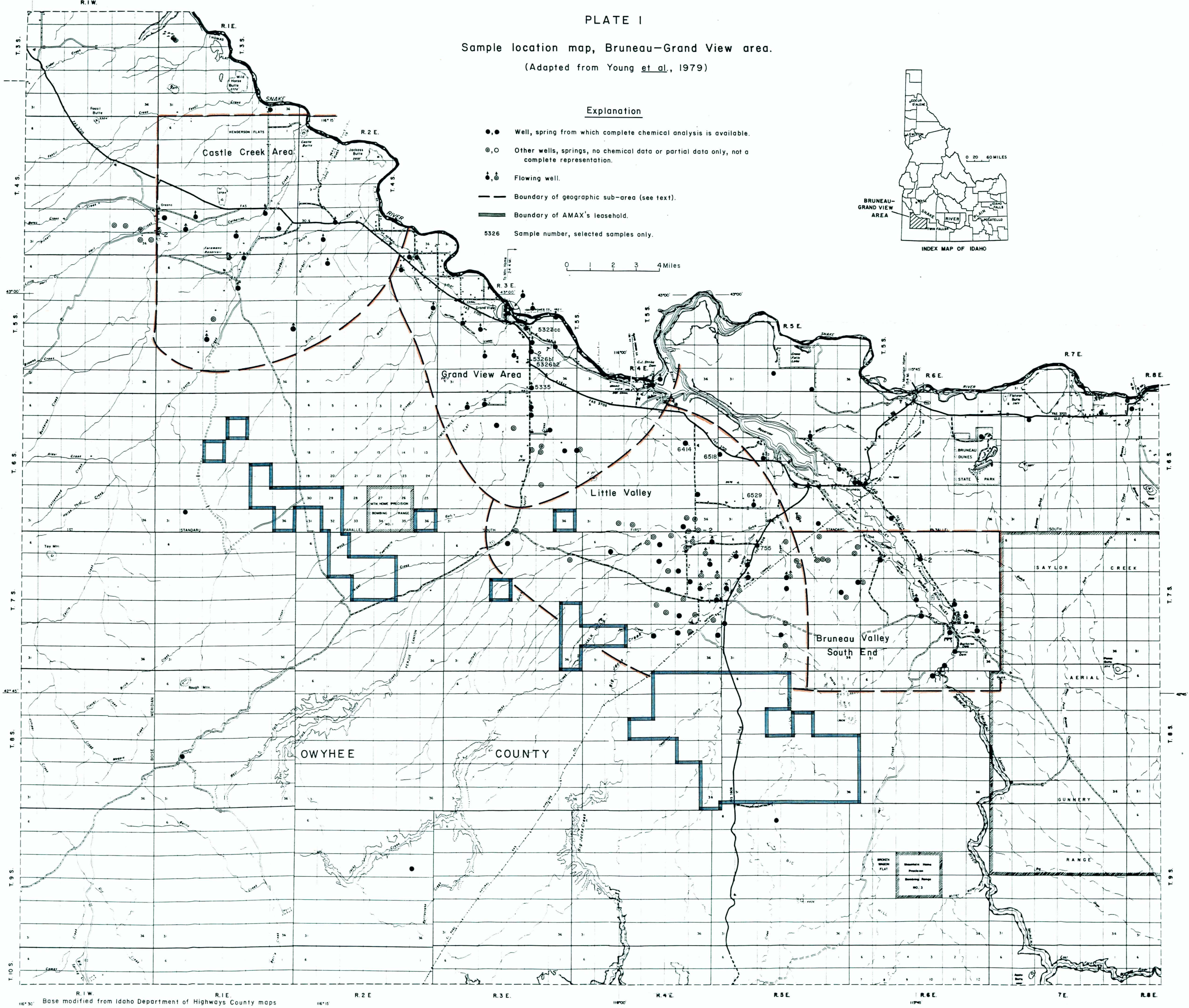


PLATE I

Sample location map, Bruneau–Grand View area.

(Adapted from Young *et al.*, 1979)

Explanation

●,●	Well, spring from which complete chemical analysis is available.
◎,○	Other wells, springs, no chemical data or partial data only, not a complete representation.
↟,↟	Flowing well.
— —	Boundary of geographic sub-area (see text).
▬	Boundary of AMAX's leasehold.
5326	Sample number, selected samples only.

Base modified from Idaho Department of Highways County maps