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Preliminary

INITIAL DRAFT

ORE-IDA DRILLING AND TEST REPORT

ORE-IDA NO. 1 WELL

at

Ontario, Oregon

by

GeothermEx, Inc.

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Ore-Ida Resource Report

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PART I

PRELIMINARY

Original Geothermal Prospect Concept

The selection of a site for a geothermal test well program at Ontario, Oregon, was based on a large body of regional and local geological and geophysical data from published and unpublished sources. These data were originally summarized in the Ore-Ida Technical Proposal, Volume I (Ore-Ida, 1977). They were supplemented in reports by CH2M-X Hill (1978) and by Gardner and Koenig (1978). They have been reviewed again here as a background against which to evaluate the significance of the results obtained from the drilling of the Ore-Ida Foods No. 1 well, at Ontario.

The Ontario, Oregon, site is located in the center of the western Snake River Plain, geomorphic province. This province is an arcuate structural and topographic depression which extends from about 25 miles (45 km) northwest of Ontario, eastward and northeastward across southern Idaho, to the vicinity of Yellowstone Park, Wyoming. The western limb of the depression is referred to as the Snake River Basin. This basin is bounded on the north by the mountainous region of central Idaho and on the south by the Owyhee uplift. At its northwest end it is terminated against the Blue Mountains uplift of east-central Oregon.

The existence of geothermal potential in the Snake River Basin is suggested by the history of late Cenozoic volcanism and tectonic activity. This general evidence is supported by the occurrence of thermal waters in springs and shallow water wells around the basin margins, in the Bruneau-Grandview area and at Givens Hot Spring on the south; at Cow Hollow, the Owyhee River Canyon and Vale on the northwest, and at Boise and Weiser on the north. Further evidence occurs in the relatively high geothermal gradients encountered in some deep hydrocarbon exploratory test wells drilled in the basin.

A limited amount of geothermal exploration has taken place in the basin, consisting of temperature-gradient hole drilling, geochemical studies of thermal waters and local geological and geophysical work. However, only one deep test, the Phillips Petroleum Company Chrestesen A-1 (northwest quarter of Section 29, T. 11 N., R. 3 W.), near Weiser, has been drilled exclusively as a deep geothermal test. Apart from small-scale local uses of thermal waters from hot springs and shallow wells, no significant geothermal production has yet been established.

Several factors must combine to provide a geothermal resource of significant value. These include the existence of elevated temperatures and porous rocks capable of producing a useful fluid volume. In addition, these conditions must occur at depths at which they can be exploited with economic advantage. The studies discussed in the following sections of the report were carried out to determine if the conditions in the Ontario area are favorable for the development of the design resource and to assist in selecting a drillsite and designing an appropriate drilling program.

Geologic Setting

Predictions concerning the subsurface geology at the Ontario, Oregon, geothermal test site are dependent on data derived from the regional stratigraphic and structural setting. This regional data is derived from outcrop areas at the margins of the basin and from the scattered deep hydrocarbon and geothermal exploratory test wells drilled within the basin.

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Regional Stratigraphy

Pre-Miocene. The oldest rocks in the area consist of a great thickness of intensely deformed metasedimentary and metavolcanic rocks of Permian through Middle Jurassic age. They have been intruded by granitic stocks of Late Cretaceous and possibly Early Cenozoic age in the Owyhee and Blue Mountains and by the Idaho Batholith in central Idaho (plate). The Owyhee and central Idaho plutons appear to be part of a continuous, or formerly continuous, north-trending zone, now disrupted by the Snake River depression (Taubenick, 1971).

One deep well, the Phillips Petroleum Chrestesen A-1, drilled near Weiser, at the northern edge of the Snake River basin, penetrated granitic rocks. None of the wells in the axial part of the basin have reached pre-Tertiary horizons. Thus, the nature of the basement there is speculative. It may consist of downdropped granitic and metamorphic rocks, or it may be a wedge of new basaltic crust emplaced in a zone of rifting as the basin developed, partially or wholly replacing the granitic and metamorphic terrain (Hill, 1963).

The pre-Tertiary basement is separated from the overlying section by a profound unconformity. Plutonic rocks of Eocene age, falling in the range from 39 to 54 million years, have been identified in the Owyhee and central Idaho regions (Armstrong, 1975). Early Cenozoic sedimentary and volcanic rocks have not been reported in those parts of the surrounding uplifts adjacent to the basin and none of the deep wells in the basin have penetrated rocks recognized to be older than Miocene. Thus, the contention that the Snake River Basin had begun to develop in Oligocene time as proposed by Axelrod (1968) is not supported by any evidence that volcanic or sedimentary rocks of early Cenozoic age actually accumulated here.

Miocene. Beginning in Middle or Late Miocene time, deposition of sedimentary and volcanic rocks was widespread throughout the region. Assemblages of these rocks from several of the outcrop areas bordering the present basin are shown in table . The section on the north side of the basin, near Weiser, consists of a thick section of lava flows interbedded with variable but subordinate amounts of altered tuff. The lavas are chiefly basalt containing calcic plagioclase, clinopyroxene and magnetite. Olivine or olivine pseudomorphs are usually present. Some flows contain olivine or plagioclase phenocrysts but most units are non-porphyritic. Two textural types are common. One is uniformly fine-grained and the other is ophitic, containing large clinopyroxenes. Some flows are slightly diktytaxitic (McIntyre, 1976). These rocks have been referred to as Columbia River Basalt in earlier publications. The best evidence of the thickness and character of the section occurs in the Phillips Chrestesen A-1 well, where about 6,850 feet of basalt flows interbedded with thin tuffs were penetrated.

In the Weiser area, the lava flow sequence is overlain by fine-grained sedimentary and volcaniclastic sedimentary rocks consisting of pumice lapilli tuff, vitric tuff altered to clay, and coarse arkosic sandstone. They are locally interbedded with or overlain by mafic lava and are intruded by dissordant to quasi-concordant basic rocks dated 10.0 $\pm$ .6 m.y. (McIntyre, 1976). These sedimentary rocks are at least partly equilivant to the Payette Formation of Late Miocene (Barstovian) age. However, due to poor exposures and uncertain contacts they may also include some overlapping sediments of the Idaho Group.

Further to the south and southeast, the section has been described as consisting of three units (Kirsham, 1931; Savage, 1958, 1961). The lowest is basalt, referred to as "Lower Columbia River Basalt." The middle unit is the Payette Formation, composed of fine-grained tuff, clay, silt, diatomite and coarse grained arkosic sandstone. This formation is highly lenticular and contains a Barstovian vertebrate fauna. It is overlain by basalt flows referred to as the "Upper Columbia River Basalt." The basalts in both the upper and lower sequence range from fine-equigrained rocks to coarse-grained diabase and porphyry. Many flows are vesicular or amygdaloidal.

A number of stratigraphic changes involving the interbedding of sedimentary units and basalt apparently take place between Weiser and Emmet but no detailed data have been published on these relationships.

The Miocene rocks in the Owyhee uplift, flanking the south side of the basin, are composed of more diverse lithologic types than those to the north. The section in the Silver City area consists of a "Lower Basalt" containing more than 2,500 feet of alkali olivine basalt. This basalt, dated provisionally at 16.6 m.y. old, is equivalent in age but mineralogically distinct from the tholeitic Columbia River Basalt. This section is overlain by a thick sequence of rhyolite and latite flows, tuffs and minor volcaniclastic sediments. The upper part of the section has been dated 15.6 to 15.7 m.y. old (Panze, 1975). South of the Bruneau-Oreana area, these rocks are overlain by 1,000 to 2,000 feet of latite flows and tuffs of the Idavada Formation (Malde _et al._, 1963). The Idavada Formation is of uncertain age in this area but it may be part of the Miocene section.

Along the northern end of the uplift, the Sucker Creek Formation, a thick assemblage of volcaniclastic sedimentary rocks of Barstovian age, is made up of interbedded ash flow tuffs and basalts. It appears to be

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equivalent to the Silver City volcanic section (Panze, 1975). Rhyolite flows locally overlie the Sucker Creek Formation near Owyhee Dam. Both formations are overlain by the Owyhee Basalt. This formation is about 1,300 feet thick. It contains numerous flows interbedded with abundant lenticular scoria and tuff beds. A wide variety of basalt textures are present, with the lower part of the section being more olivine rich and ophitic, while the upper part is microporphyritic and contains some flows with trachytic texture (Kittleman et al., 1965; Corcoran et al., 1962). The abundance of dikes and pyroclastic material indicates that many if not all of the flows were erupted from local vents.

Although it is difficult to typify the earlier parts of the upper Miocene rock suite in this region, it appears to be distinctive from younger rocks in containing a high proportion of predominately volcanic units. These may be basaltic, as along the north side of the basin, or contain large amounts of acidic rocks as well, along the south side of the basin. As a whole, sedimentary units make up a smaller proportion of the total rock volume than they do in the younger parts of the section.

Correlations between the Miocene surface sections exposed at the edge of the basin and the deep wells within the basin are generally uncertain due both to facies changes across the area and to uncertainties regarding the value of radiometric ages determined from well samples. However, several of these wells do appear to have penetrated parts of the Miocene volcanic section. Of these, the Phillips Petroleum Chrestesen No. A-1 encountered a thick section of Columbia River Group basalts, as noted above. Both the Halbouty James No. 1 well (southeast quarter Section 27, T. 4 N., R. 1 W.) and the Chevron Highland Land and Livestock No. 1 well (northwest quarter Section 24, T. 6 N., R. 5 W.) encountered basalts which are probably equivalent to the "Columbia River Basalt" or Owyhee Basalt. In this well, the underlying interbedded tuffs, volcaniclastic sediments and basalts are probably equivalent to the Sucker Creek Formation. In neither of these wells are the formation boundaries clearly defined.

Miocene volcanic rocks appear to be the units most likely to contain extensive aquifers with flow potentials capable of supporting geothermal development. By analogy with basalt aquifers explored in areas of Oregon and Washington, two types of porosity potential may occur. One consists of zones of high porosity and good permeability associated with flow breccias, interflow scoria zones and vesicular and brecciated flow tops. The other type of porosity is contained in a diffuse network of cooling joints and fractures in the lava flow interiors. In sections of this type, the porosity and permeability are low and the volume of fluids produced is proportional to the thickness of the flow section penetrated. Data on the porosity actually encountered in these rocks are limited. A few zones of lost circulation have been reported but they are not sufficient to outline regional aquifers. Formation tests were generally not carried out in oil and gas test wells because the basalts were not associated with the most important shows of hydrocarbons. Thus, there is no direct evidence concerning the nature and distribution of reservoir potential in the Snake River Basin basalts.

<u>Late Miocene (Barstovian-Clarendonian) to Quaternary</u>. It is uncertain from the data now available whether the Miocene volcanic section is thicker in the Snake River Basin than in the flanking uplifts. However, by late Miocene time a major period of basin development began, continuing episodically into the Pleistocene. During this period,

subsidence took place along northwest-trending fault zones along the margins, while as much as 8,000 feet or more of lacustrine and fluvial sediments interbedded with subordinate amounts of basalt flows were deposited in the basin. The original depositional basin extended onto the edges of the Owyhee, Central Idaho and Blue Mountains, where subsequent uplift has exposed them.

Although the sedimentary and volcanic rock types are similar throughout the basin, the proportions of each vary rapidly from one area to another. This has given rise to difficulties in correlation and to the use of different formational nomenclature in the main outcrop areas (table). The best defined and most completely described stratigraphic section in the region is that in the Vale-Owyhee Reservoir area, Malheur County, Oregon (Kittleman et al., 1965; Corcoran et al., 1962). These stratigraphic units have been used by Newton and Corcoran (1962) in subsurface studies of the basin and appear to be the most appropriate nomenclature to utilize in the present study.

The section consists of three formations making up the Idaho Group, as defined by Kittleman et al. (1965). The oldest of these is the Deer Butte Formation. This unit rests on the Owyhee Basalt along an erosional and possibly angular unconformity. In the Owyhee River Canyon area it consists of about 1,000 to possibly 3,000 feet of volcanic sandstone, siltstone, claystone, vitric ash, arkosic sandstone, conglomeratic sandstone, thin basalt flows and shallow basaltic intrusions. The outcrop areas are probably close to the original edge of the deposition basin and coarse-grained sediments, representing a relatively high energy environment of deposition, are well-represented. Characteristic features of the sediments are the abundance of feldspar in the coarse sandstones

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and the abundant glass shards and pumice in the volcanic sandstones. The associated basalt flows are generally coarse-grained, holocrystalline, with ophitic texture. Flow tops are more or less vesicular. The Deer Butte Formation contains a vertebrate fauna of Late Miocene, Barstovian to possible Clarendonian, age. It was excluded from the Idaho group by Corcoran et al. (1962) on the basis of a pronounced unconformity separating it from the overlying Grassy Mountain Formation.

The Grassy Mountain Formation, middle formation of the Idaho Group, reaches a maximum thickness of about 1,100 feet in the type area west of the Owyhee River, but is generally thinner in the outcrop sections. It consists of interbedded pumice, arkosic and tuffaceous sandstone, thin granite cobble conglomerate, altered volcanic sandstone and flows of olivine basalt. The arkosic and tuffaceous sandstones resemble those of the Deer Butte Formation. The percentage of basalt flows interbedded in the total section varies greatly in different localities. The basalts are generally coarse-grained holocrystalline and ophitic. Porphyritic flows with very large plagioclase phenocrysts occur, and vesicular flow tops are common. The flow units are mostly less than 100 feet thick. The age of the Grassy Mountain formation is Clarendonian and Hemphillian, based on the occurrence of vertebrate faunas.

The Chalk Butte Formation is the uppermost unit of the Idaho Group in the western Snake River Basin recognized by Corcoran et al. (1962). It unconformably overlies Sucker Creek Formation, Owyhee Basalt and the older units of the Idaho Group at one place or another around the edges of the basin. In surface exposures at the basin margin, the Chalk Butte sediments are several hundred feet thick. These sections are not representative due either to erosion at the top or to their position near the edge of the original depositional basin. The lithologic types present in surface outcrops consist of tuffaceous conglomerate, sandstone and siltstone, with smaller amounts of fine ash, clay, diatomite and limestone. Both fluvial and lacustrine environments are represented. No basalt flows are interbedded in the surface section in this part of the basin. A Pliocene (Hemphillian) age has been assigned to the formation on the basis of vertebrate fossils found in it. Additional thin fluvial gravels and silts overlie the Chalk Butte Formation equivalents and are included in the Idaho Group exposed in the Nampa-Caldwell area (plate).

Several deep oil and gas exploratory wells have been drilled in the Idaho Group and correlations between some of these subsurface sections and the surface outcrop units have been made by Newton and Corcoran (1963). In the subsurface, the upper, non-volcanic part of the Idaho Group can be tentatively correlated with the Chalk Butte Formation. Only a few wells have been drilled into the sedimentary and volcanic rocks underlying the Chalk Butte. Correlations in this older part of the section are uncertain. The section in the H. K. Riddle Kiesel Estate No. 1 well (Section 8, T. 19 S., R. 47 E.), was divided into two parts by Newton and Corcoran (1963). The interval from the surface to a depth of 4,230 feet was assigned to the "Upper Idaho Sediments" (Chalk Butte Formation). In this well, some interbedded basalt flows were included in the lower part of the unit. Below 4,270 feet, the section was designated "Grassy Mountain Basalt Series." It consists of interbedded basalt flows and sedimentary rocks from 4,270 to 4,550 feet, and mainly basalt from 4,550 to the total depth of 5,106 feet. A comparison of this well with the more recently drilled Chevron Highland Land and

Livestock No. 1 well (Section 24, T. 6 N., R. 5 W.) suggests that the massive basalt section below 4,550 feet is part of the thickest and most continuous basalt sequence in the local area and that it may be correlative with the Columbia River Group or Owyhee Basalt rather than the Grassy Mountain.

Late Cenozoic Intrusive Rocks. Late Tertiary or Quaternary igneous activity characteristic of the central and eastern Snake River Plain extends about as far west as Caldwell, Idaho. Further to the west the only young igneous activity thus far recognized are two small intrusives. One of these, exposed at ____________ is composed of ____________. Another, encountered in the El Paso Natural Gas Company Federal No. 1 well (Section 5, T. 20 S., R. 44 E.) encountered thin diorite or gabbro intrusives and finally bottomed in intrusive rhyolite or dacite. These intrusives appear to be older than at least some of the Chalk Butte Formations but younger than Grassy Mountain Formations. They may be genetically related to the Double Mountain anticline in which they occur.

Predicted Section at the Ontario, Oregon, Wellsite

The thickness and character of the section likely to be encountered at a site in the vicinity of Ontario, Oregon, has been summarized below and in table . It has been based on regional stratigraphic data and on local seismic refraction work carried out for this report. The section is described from the surface down.

Idaho Group. The Idaho Group in the western Snake River Basin is characteristically made up of an upper unit of sedimentary rocks and a lower, consisting of interbedded sediments and basalt flows. The best-defined base of this section in the subsurface is the top of a thick, massive, basalt flow sequence. In the Ontario area, reflection seismic data suggest that the top of a reflector, possibly this massive basalt, occurs at a depth of about 6,200 feet.

Internally the Idaho Group can be subdivided in several ways but correlations with standard surface section members is difficult. In the wells closest to Ontario, the upper part of the section, above the first occurrence of basalt, varies from 3,820 feet in the Riddle Kiesel well to over 4,011 feet in the Ohio Kramlich No. 1 (Section 5, T. 9 N., R. 4 W.). Most, if not all of this part of the section appears to be equivalent to the Chalk Butte Formation. The lower part of the Idaho Group, consisting of variable proportions of relatively thin basalt flows interbedded with sediments, is believed to be equivalent to the Grassy Mountain and Deer Butte Formations of the surface section in the Owyhee uplift. This section is interpreted here to extend from 3,820 to 4,550 feet in the Riddle Kiesel well, a thickness of 730 feet. Based on regional gravity data the Kiesel well appears to be higher structurally than the Ontario area and the interbedded basalt and sediment section as well as the overlying entirely sedimentary section may be thinner here than at Ontario.

<u>Columbia River Group or Owyhee Basalt</u>. The massive basalt sequences encountered in the Riddle Kiesel well from a depth of 4,500 to the total depth of 5,106 feet (606+ feet), and in the Chevron Highland Livestock well from a depth of 4,170 to about 5,375 feet (1,200 feet ±) are tentatively interpreted here to be the most likely correlative of the thick basalt flow sequences found on the surface in the Owyhee Basalt and the Columbia River Group. Too few complete penetrations occur to

establish thickness trends in the subsurface. It is assumed here that at least 1,200 feet of section made up predominately of basalt will be present at Ontario.

Sucker Creek(?) Formation. Interbedded basalt, tuff, claystone, siltstone and sandstone underlie the main basalt sequence in the Chevron Highland Livestock well, from a depth of 5,375 feet to the total depth of 11,963 feet. This section contains more abundant basalt flows than is characteristic of the surface outcrops of the Sucker Creek Formation and its true relationship to the established stratigraphic units in the area is uncertain.

Structure

The Snake River Basin is the western limb of an arcuate rift or compound graben extending across southern Idaho. Regional seismic surveys indicate that although the upper or granitic layer of the crust appears to be either absent to thin and intermittant, the total crust is thicker than that in the Basin and Range province to the south. This thick crust consists of thin, hot intermediate layer on top of a thick, hot, lower crust. It appears that the granitic layer has been altered, remelted, or is absent because of rifting and has been replaced by upward-moving mantle differentiate (Prodehl, 1970; Hill and Pakiser, 1967). This crustal model provides an explanation for the regionally high heat flow.

The Snake River Basin axis and most of the major structures associated with it trend in a northwest direction. This structural trend is strongly discordant to the north to northeast strike of the majority of the structures in the Basin and Range province to the south and the central Idaho uplift to the north (plate). The basin has apparently developed during several episodes of downfaulting followed by sedimentation which has sometimes transgressed over the fault zones. Unconformities occur along the south side of the basin between all of the major formations but the most notable occurs at the base of the Chalk Butte Formation (Upper Idaho Group) which rests on Sucker Creek Formation, Owyhee Basalt as well as the Grassy Mountain Formation from place to place. Important structures may be buried beneath this unconformity and lack expression in younger beds.

The amount of structural relief along the fault zone bordering the northwestern margin of the basin is indicated by a comparison of the elevation of the top of the Columbia River Group basalt near the basin edge with that of possible correlative basalt within the basin. In the Phillips Chrestesen No. 1 well, at the north edge, the top of the basalt occurs at about 2,500 feet above sea level, while at Ontario the reflector tentatively identified as massive basalt on seismic profiles, is at a depth of about 4,100 feet below sea level. This indicates structural relief of about 6,600 feet between the two areas. The amount of structural relief along the south side of the basin is more difficult to estimate but is likely to be of similar magnitude.

Gravity data described later indicate that there is considerable structural relief within the basin. The largest positive gravity anomaly is a long complex feature with several culminations, extending for about 50 miles from the vicinity of Nampa, Idaho to Malheur Butte, Oregon. This feature is paralleled on both the north and south by gravity lows. Stratigraphic changes, particularly an increase of basalt in the section in this area could contribute to the anomaly, but some of the effect is likely to be due to a large structural uplift in which the Miocene basalts are brought closer to the surface than in surrounding areas. It is interesting to note that the surface expression of this feature, if visible at all, is much less than would be expected from the amount of deep relief implied from the gravity data. This may indicate that the structure is largely buried by overlapping Upper Idaho Group sediments. The nature of this structure is not well known from published data. It is assumed here that the deep structure is a complex horst ridge bounded by important faults. The Upper Idaho Group sediments may be anticlinal over it. Several hydrocarbon test wells have been drilled on this structural trend but the off-structure well control is too limited to demonstrate the amount of structural relief and to compare the amount of basalt in the on- and off-structure sites.

In addition to the large northwest striking uplift, moderately detailed gravity data in the western part of the basin also show a major positive gravity anomaly striking north for 15 miles from Fruitland, Idaho through Payette and to the north a few miles. This trend is characteristic of the Basin and Range fault structures which are present of the region outside of the Snake River Basin, and it may indicate that the fragments of this disrupted fault trend are present beneath the basin. The exact location of the faults suggested by the gravity data cannot be defined on the basis of the limited control data available to this project. Subsurface information from deep wells are inadequate to define features of the intrabasin structure or to locate specific faults. Seismic surveys have been carried out by several exploration groups which would assist in structural definition. With the exception of the survey of one small area at Ontario, carried out for this project, all of the data are proprietary and not available for use here.

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Structure at the Ontario, Oregon, Drillsite

The surface in the vicinity is covered by varying amounts of alluvium overlying poorly-lithified sediments of the Upper Idaho Group. Exposures of bedrock are too poor to permit field mapping of any structures that might be present. Interpretations of aerial photographs to define geomorphic lineaments of possible structural origin are not known to have been made in this area. On the basis of regional gravity data, the site is located on the west flank of the north-trending Fruitvale-Payette gravity high and at least 5 miles north of the major northwest-trending Nampa-Malheur Butte anomaly. Although the structural significance of these features is uncertain, it is probable that the site is in a relatively structurally low part of the basin, although not in one of the deep closed lows appearing on the gravity maps. As noted above, the gravity data are not adequate for the location of specific faults which might be present.

All of the detailed structural data related to the site were derived from six reflection seismograph lines surveyed for this project (Applegate and Donaldson, 1978; Eis, 1978; Appendix ___). The quality of the seismic data vary from excellent to poor. Seven possible faults were detected, numbered I to VII on the accompanying plate ___. Faults I, II and III are the best-defined. They are associated with a northwest-trending horst block located in the southern part of Ontario.

(Insert, development & dip)

Two additional faults, numbers IV and V, based on less reliable data, were mapped in the northeastern part of Ontario, near the drillsite selected for the Ore-Ida No. 1 test well.
(Insert trend, dip & displacement)

The remaining two possible faults (VI and VII) are based on questionable data and require confirmation (Applegate and Donaldson, 1970).

The significance of faults to the location of the drillsite lies in their potential for enhancing fracture porosity in their vicinity and in the possibility that the fault zone may act as a conduit for ascending geothermal fluid.

In addition to faulting, interpretation of the seismic data suggested that "basement," here defined as the top of a massive basalt flow sequence, is apparently nearly flat-lying and is present at a depth of 6,000 to 6,200 feet (Ise, 1978).

Gravity

The regional reconnaissance Bouguer gravity map accompanying this report has been assembled from two sources (plate ___). That part covering southern Idaho is from Mabey (1974), while the adjacent area of Oregon is from private sources. The bases, scales and contour intervals are different in each source. They have been compiled here at a common scale, but no attempt has been made to reconcile the data.

The strike of the gravity contours conforms to the known regional structural grain, with northerly trends predominating on either side of the Snake River Basin and northwesterly trends characterizing the basin itself. The basin itself is dominated by a strong, narrow, northwest-trending positive anomaly from the vicinity of Nampa, Idaho, to Malheur Butte, Oregon, a distance of about 50 miles. This positive element is flanked by gravity lows. The relief between the highest and lowest areas varies from 30 to 50 milligals. This gravity pattern has been interpreted to represent an intra-basin graben filled with a great thickness of dense basalt at relatively shallow depth, and underlain by a deeper system of basalt-fill fissures (Hill, 1963). If this interpretation is correct, wells drilled on this feature should encounter much thicker sections of Grassy Mountain or older basalt above depths of 10,000 feet than occurs in flanking lows. At present, only one deep well has been drilled on this structure. This is the Chevron Highland Livestock well which reached a depth of 11,963 feet. The section encountered below the sedimentary rocks of the Upper Idaho Group did contain a considerable aggregate thickness of basalt, both as thick flow-on-flow sequences and interbedded with sedimentary rocks. However, there are no comparably deep wells located off the anomaly with which this section can be compared. In another interpretation, the anomaly could be caused, at least in part, by a horst buried beneath a relatively thin section of Idaho Group sediments, in which the normal section of Columbia River Group or equivalent basalts have been brought closer to the surface than in adjacent areas. This model also can not be tested with available well data.

Although northwest trending anomalies dominate the map, a strong north-trending positive anomaly extends for about 15 miles from the vicinity of Fruitland to north of Payette, Idaho. Not enough subsurface data is available to determine the structural significance of this anomaly, but it may be caused by a fault-bounded block belonging to the trend which extends toward the basin from the northern and southern margins. The gravity data are insufficiently detailed to closely define the location of the fault zones which are likely to be associated with either the northwest or north-trending features. Smaller-scale structures are also beyond the limits of resolution of these reconnaissance surveys.

The Ontario site area is located north of the Nampa-Malheur Butte trend and is on the lower west slopes of the Fruitland-Payette anomaly. To the west it is bounded by a deep gravity low. It is anticipated that a well drilled at Ontario will have either a thicker section of low density sediments (Upper Idaho Group) overlying basalt or a thinner aggregate section of basalt than locations on the anomaly axes.

Aeromagnetic Survey

The Total Field Magnetic Anomaly Map (plate ___) produced for this project from the data banks by the Geophysics Group at Oregon State University in 1978 has several interesting features. Significant area-wide trends as well as local features are observed in the 430 square km (130 square miles) within the map boundaries.

A very steep regional gradient appears with magnetic highs to the east. There is a decline from as much as 300 gammas in the east to zero (0) gammas in the west.

Within this overview, there is a linear magnetic high which runs northward from the western side of Ontario for about 14 km (9 miles). Closure on this feature is about 40 gammas within 2.6 km (1.7 miles) distance to the east and west. It is not possible to rationalize this magnetic anomaly from the observed geology. It may reflect a buried fault, with west side up, bringing volcanic rocks surfaceward.

Two negative magnetic features occur on the map, centered about 4 km (2.5 miles) east and 14 km (9 miles) north of Ontario (center). The anomaly just east of Ontario coincides with the deep sediments at the confluence of the Malheur and Snake Rivers. It has a diameter of 6 km (3.5 miles) of closure, with relief of about 20 gammas. The second negative feature extends northward, off the mapped area. It has closure of about 10 gammas. The two features can be connected by a northerly oriented axial line. The trace of the axis would approximately coincide with the course of the Snake River.

There is no apparent reason from surface geology for the steep magnetic high east of Ontario. Some single lines of equal magnetic intensity near the northeast boundary of the magnetic low just east of Ontario trend northwesterly, but this is very tenuous support of northwesterly trending structures. The intense gradient 12 km (7 miles) northeast of Ontario, trending northwest, may indicate fault control near the margins of the Snake River depression, but Riens Estate No. 1, in S. 9, T. 8 N., R. 3 W., shows that the Idaho Group sediments are 1.4 km (4,800 feet) thick 22 km (14 miles) east of Ontario.

We may classically assume that the linear to circular high magnetic anomalies in the Ontario area signify relative thinning of nonmagnetic sections of sedimentary rocks, positions of Quaternary basaltic

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eruptive centers and diabasic intrusive masses. Intense gradients bordering magnetic highs and lows may indicate fault control. It is difficult to assign these classical conditions to any of the magnetic anomalies at Ontario.

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PART II

OPERATIONAL HISTORY AND DATA RECOVERED

History of Drilling Operations

The Ore-Ida Foods No. 1 well is located in the northeast quarter of Section 3, T. 18 S., R. 47 E., in the town of Ontario, Malheur County, Oregon. The drilling contractor was Montgomery Drilling Company, Bakersfield, California, using a National 55 rig. Mud-engineering services were provided by Western Mud Sales and Services Company, Bakersfield, California. The drilling operation was supervised by Mr. William Hathaway, drilling engineer, in association with GeothermEx, Inc., of Berkeley, California, who also carried out the wellsite geology responsibilities. A mud-logging unit was provided and staffed by Energy Log, Sacramento, California. Geophysical and temperature log services were provided by Welex, Woodland, California, and Pressure Service, Elk Grove, California.

The well was spudded in at 9:00 A.M., 18 August 1979. A 17-1/2-inch hole was drilled to 925 feet, where 13-3/8-inch casing was set on 22 August. The mud-logging unit was in operation from 54 feet to total depth. No geophysical or temperature logs were run before setting 13-3/8-inch casing. This part of the hole was drilled with 67- to 68-pcf (pounds-per-cubic-foot) lignosulfonate mud with a viscosity of 38 to 42 ____________(units?).

After installing the blow-out preventers, drilling resumed in a 12-1/4-inch hole from 925 to 7,154 feet, where geophysical logs and temperature surveys were run by Welex on 18 to 20 September. Drilling continued to 7,958 feet, where a second suite of geophysical and temperature logs were run on 1 and 2 October. The mud was gradually changed from about 67 pcf, viscosity 38 _______, pH 9.0, at 925 feet, to 82 pcf, viscosity 43 ______, pH 11.5, at 7,152 feet. This change was made to control sloughing and to keep the hole clean. The mud weight was inadvertently increased to 88 pcf while drilling at 7,169 feet. Concurrently, lost circulation was encountered. Circulation was regained by slowly reducing the mud weight to 82 pcf and adding lost circulation material. A mud cooling unit was installed at a depth of 7,655 feet. This unit operated intermittently thereafter for the duration of the drilling operation. Drilling continued to a depth of 8,188 feet. Core number 1 was cut from 8,188 to 8,216 feet. Twenty-six feet of core were recovered. Then 9-5/8-inch casing was run to 8,183 feet. Blow-out preventers were reinstalled and tested. Below 8,183 feet, an 8-1/2-inch hole was drilled to a total depth of 10,054 feet, reached on 8 November. The drilling fluid was changed to water from 8,183 to 8,400 feet. Drilling in this interval was characterized by excessive sloughing and fill on bottom, culminating in a stuck drill pipe. The mud weight was built back to 83 to 85 pounds per cubic foot and the bad drilling conditions were corrected. On reaching the total depth, geophysical and temperature logs were run from 8 to 10 November, and 7-inch slotted liner was suspended from 8,142 to 10,038 feet, on 13 November. The slots extend from 8,187 to 10,036 feet, are 125 mesh, in 8 rows, 2 inches long, with 6-inch centers. The mud in the hole was replaced with water in preparation for testing. While waiting on testing equipment, additional wireline temperature surveys were run in selected intervals. The testing operations were conducted from 16 to 18 November and from 24 through 27 November. The results are described below. After completion of these tests, the rig was released on 27 November, at 12:00 noon. The hole was left suspended pending further testing. A total of ______days were spent on drilling, _______days on logging and testing, and _______days on rig repairs and other non-drilling operations.

Detailed records of the drilling operations are included in Appendix G, Summary of Drilling Operations; Appendix H, Daily Geological Reports; and Appendix E, Well Testing.

Down Hole Logs and Surveys

The following is a list of surveys carried out in the hole. The actual survey results will be found in the appendices indicated.

Geophysical well logs. All of these logs were run by Welex, based in Woodland, California (see table ___). Copies of the logs are included in Appendix I.

Temperature surveys. The Welex logs, Pressure Service wireline survey data, and maximum-reading thermometer records can be found in Appendix J. For convenience, the maximum-reading thermometer data are also tabulated in table ___.

Dipmeter survey. This survey was carried out by Welex. The data sheets can be found in Appendix C.

Date	Run	Interval
10/2/79	1	925-7,956 feet
11/9/79	2	8,180-9,931 feet

b. Temperature Buildup on Bottom

Date	Period	Time on Bottom (10,054 feet) (hours)
11/16/79	1:00 A.M. - 5:00 A.M.	4
11/17/79	12:26 A.M. - 4:30 A.M.	4
11/18/79	10:30 P.M. - 2:30 A.M.	4
11/18/79	5:00 A.M. - 9:00 A.M.	4
11/25/79	8:50 P.M.-12:50 A.M.	4

3. Maximum-Reading Thermometer Data (obtained while running other surveys)

Survey	Date	Run	Time Since Last Circulation (hours)	Depth (feet)	Time on Bottom (minutes)	Maximum Temperature (°F)
Totco	8/25/79	-	1	3,151	45	126
Totco	9/3/79	-	2	4,565	40	165
Totco	9/7/79	-	10	5,212	40	192
Totco	9/10/79	-	7	5,805	60	200
Totco	9/12/79	-	7	6,200	30	230
Welex Dual Induction	9/18/79	1	11	7,150	--	236
Welex Fracture Finder	9/18/79	1	15	7,148	--	255
Welex Acoustic Velocity	9/18/79	1	19	7,148	--	264
Welex Density	9/19/79	1	29	7,150	--	302
Welex Dual Induction	10/1/79	2	7-3/4	7,956	--	235
Welex Acoustic Velocity	10/1/79	2	11-3/4	7,952	--	270
Welex Dual Induction	11/8/79	3	13	10,053	--	320
Fracture Welex Finder	11/8/79	3	15	10,047	--	368

TABLE

TEMPERATURE SURVEYS

1. Welex Temperature Logs (Continuous Recording)

Run	Date	Hours After Last Circulation	Interval	Log Bottom Hole Temperature	Maximum-Reading Thermometers
1	9/18/79	8	0 - 7,150	222°F	
2	9/19/79	24	0 - 7,150	272°F	
3	9/19/79	39-1/4	0 - 7,150	293°F	305°, 314°, 314°, 323°, 328°
4	9/20/79	50-3/4	0 - 7,140	295°F	290°, 318°, 318°
5	10/1/79	26-1/4	0 - 7,958	267°F	286°, 300°
6	10/2/79	39-1/4	0 - 7,958	270°F	316°, 318°, 332°
7	10/2/79	44-1/4	6,000 - 7,958	283°F	288°, 304°, 308°
8	11/9/79	29	0-10,053	336°F	317°, 317°
9	11/10/79	50	0 - 9,400±	Unknown, tool stopped	320°, 350° (at 9,300 ±)

2. Pressure Service

a. Wireline Survey

Date	Time	Run	Log Interval (feet)	Station Interval (feet)	Time on Bottom (minutes)
11/15/79	6:56 P.M.	1	7,000-10,000	200	30
11/15/79	9:58 P.M.	2	7,000-10,000	200	30
11/16/79	12:58 A.M.	3	7,000-10,000	200	30
11/17/79	?	?	7,000 - 9,870	200	30
11/24/79	2:30 A.M.	-	6,000 - 9,960	Variable	6

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TABLE

GEOPHYSICAL LOGS

Log Type	Date	Run	Interval	Scale	Comments
Dual Induction Guard Log	9/18/79	1	925- 7,150	1"= 50'	
	10/1 /79	2	7,150- 7,956	1"= 50'	
	11/8 /79	3	8,182-10,053	1"= 50'	No log 7,956-8,182
	9/18/79	1	925- 7,150	1"= 20'	
	10/1 /79	2	7,150- 7,956	1"= 20'	
	11/8 /79	3	8,182-10,053	1"= 20'	No log 7,956-8,182
Compensated Acoustic Velocity Log (with Gamma Ray and Caliper)	9/18/79	1	925- 7,148	1"= 50'	
	10/1 /79	2	7,148- 7,952	1"= 50'	
	11/8 /79	3	8,182-10,048	1"= 50'	No log 7,952-8,182
	9/18/79	1	925- 7,148	1"= 20'	
	10/1 /79	2	7,148- 7,952	1"= 20'	
	11/8 /79	3	8,182-10,048	1"= 20'	No log 7,952-8,182
Compensated Density Log (with Gamma Ray and Caliper)	9/19/79	1	925- 7,150	1"= 50'	
	10/3 /79	2	7,150- 7,955	1"= 50'	
	11/8 /79	3	8,182-10,053	1"= 50'	No log 7,955-8,182
	9/18/79	1	925- 7,150	1"= 20'	
	10/3 /79	2	7,150- 7,955	1"= 20'	
	11/8 /79	3	8,182-10,053	1"= 20'	No log 7,955-8,182
Fracture Finder-Microseismogram Log	9/18/79	1	925- 7,148	1"= 20'	
	10/1 /79	2	7,148- 7,952	1"= 20'	
	11/8 /79	3	8,180-10,047	1"= 20'	No log 7,952-8,180
Neutron-Microseismogram Log-- cased hole (with Collar Log)	11/9 /79	1	6,800- 8,198	1"= 20'	

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Deviation surveys. Totco wireline deviation surveys were made regularly during drilling. The results of these surveys are listed below:

Depth	Deviation	Depth	Deviation
925'	0°15'	5,151'	1°30'
2,049'	1°15'	5,834'	1°30'
2,584'	1°45'	6,261'	1°00'
3,131'	1°45'	7,320'	0°30'
3,652'	0°15'	7,660'	0°30'
4,722'	1°30'	9,068'	0°45'

Mud log. A mud logging unit was provided and staffed by Energy Log. The unit operated from a depth of 54 feet to the total depth of 10,054 feet. The unit recorded the drilling rate, lithology, mud flow line temperatures, ditch gas analysis including CO_2, H_2S and total hydrocarbon gases. A chromatograph analysis of the gases was carried out below 4,120 feet. A synopsis of mud character and various operational occurrences were also included. A copy of the log is contained in Appendix D.

Testing Operations

A testing program was carried out to evaluate the productive potential of intervals in which porosity was calculated to be present from log analysis. The testing program was restricted to depths below 6,500 feet, within the zone in which temperatures of interest to this project could be obtained. The logs of porous intervals higher in the well were examined for porosity and hydrocarbon gas saturation but none appeared worthy of testing for their hydrocarbon potential alone. A detailed discussion of the logs can be found in Appendix F. The intervals with the best porosity potential are summarized below. It should be noted that all intervals above 8,183 feet are behind the 9-5/8-inch casing and all below that depth are covered by the 7-inch slotted liner.

Interval (ft)	Comments
6,580- 6,665	Several thin porous zones are present in this sandstone interval.
6,950- 7,015	Sandstone in this zone contains the best evidence of permeability in the section.
7,050- 7,140	Fractured basalt/diabase, possible zone of lost circulation.
8,160	Fractured basalt/diabase.
8,200- 8,240 8,330- 8,390	Discontinuous fractured zones in basalt/diabase, of doubtful value.
8,450	Fractured tuff, of doubtful value.
8,475- 8,510	Fractured basalt/diabase, of doubtful value.
8,730- 8,840	Fractured basalt/diabase.
8,970- 8,990	Discontinuous fracture zones in basalt/diabase, of doubtful value.
9,020- 9,240	Fractures in basalt/diabase.
9,790- 9,810	Fractures in basalt/diabase and tuff(?), of doubtful value.
9,880- 9,890 9,920- 9,930	Fractures in basalt/diabase, of doubtful value.
9,985-10,010	Fractures in basalt/diabase.

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Testing was carried out in several stages, beginning at the bottom of the hole. Details of testing procedures can be found in Appendix E.

1. All of the zones between 8,183 feet and 10,054 feet, covered by the 7-inch slotted liner, were tested together, as follows:

    11/16/79. Ran in with drill pipe to 6,012 feet, pumped in one barrel of foamer and blew well around with nitrogen down the drill pipe. Well would not unload. Ran drill pipe to 10,014 feet and blew well around with nitrogen.

    11/17/79. Perforated slotted liner, four 4-inch SSB jets per foot, in the intervals 8,730-8,750, 8,760-8,780, 8,790-8,810, 8,820-8,840, 9,020-9,040, 9,050-9,070, 9,080- 9,100, 9,110-9,130, 9,150-9-170, 9,190-9,210, 9,220-9,240, 9,790-9,810, 9,875-9,895. The perforator would not penetrate below 9,897 feet. Ran drill pipe to 10,014 feet, blew well with nitrogen.

2. The zones above 8,183 feet are behind 9-5/8-inch casing. The following were perforated by shooting four 4-inch SSB jets per foot in selected intervals.

    11/24/79. The casing was perforated from 5,980-6,000, 6,580-6,640, 6,955-7,015, 7,060-7,140, 7,770-7,790, 7,905-7,925 and

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8,320-8,340 feet. The drill pipe was run in to 8,350 feet on 11/25/79. Blew the well with nitrogen down the drill pipe.

A wireline pressure survey was run.

11/26/79. Perforated additional intervals from 6,975-7,015, 7,060-7,140, 7,770-7,790 and 7,905-7,925 feet. Ran drill pipe to 7,950 feet and blew well with nitrogen down the drill pipe.

Ran wireline pressure survey to 7,900 feet.

Fluid rose from 6,855 to 6,091 (764 feet) in 3 hours. The calculated rate of influx is 13 gallons per minute.

Subsurface Geology

This part of the report contains a summary of the stratigraphy and reservoir character, structural data, thermal regime and hydrocarbon occurrences found in the hole.

Stratigraphy. The section encountered during the drilling of the well has been recorded on the mud log (Appendix D) and in the sample descriptions made with a binocular microscope by the wellsite geologist (Appendix A). In addition, selected samples have been thin-sectioned and examined with a petrographic microscope (Appendix B). These descriptive data combined with the geophysical logs (Appendix I) provide a clear picture of the lithologic character and unit boundaries of the strata found in this well. A graphic summary of the lithologies is shown on plate ___. Correlation of the section with that in other wells or with surface stratigraphic units defined at the margins of the basin is difficult. The units outlined below reflect the most obvious changes in the sequence in the well; they do not conform to the correlation framework of Newton and Corcoran (1963). The relationship of the well to regional stratigraphy will be discussed in a later section of the report.

The well was spudded in Quaternary alluvium, the base of which appears to be in the unlogged part of the hole above a depth of 60 feet. The major units below this depth were as follows:

60'-4,570'. The predominant sedimentary lithologies of this interval are weakly-indurated siltstone, silty claystone and non-fissile claystone. Subordinate amounts of sandy siltstone and sandstone are present in several intervals. The fine-grained sediments are light to medium gray or light tan. The recognizable minerals consist of clay, quartz, altered volcanic glass and traces of mica. The sandstones and silty sandstones are light gray, very fine to medium-grained. They contain subangular to subrounded quartz, feldspar, mica and occasional minor red-brown to black siliceous rock fragments. Recognizable glass shards are sometimes present. A silty matrix is common. Minor lithologic types in this part of the section consist of thin silty limestones as beds or concretionary zones, and thin, white, very fine-grained, altered tuffs. The tuffs are particularly well developed in the intervals from 3,585 to 3,800 feet and from 4,125 to 4,160 feet. Porosities have been calculated from geophysical logs for the cleanest-appearing sandstones. These range widely from 10 or 11 percent to as high as 45 percent in one thin interval, but most of the porosities range from 25 to 33 percent. Intervals for which porosities have been calculated are listed in Appendix F.

All of the zones in this interval with calculated porosity potential are at too low a temperature to be of interest for production of geothermal fluids of the type required for this project and none of these zones were tested. In the past, sandstones in this interval have been explored for hydrocarbon gas by several wells. The gas occurrences encountered in this hole are discussed in a later section of this report. None appeared to warrant testing.

This part of the section is similar to the Chalk Hills Formation, defined by Corcoran et al. (1962) as the upper member of the Idaho Group in this area. The section is comparable in character to that in nearby wells but appears to contain less abundant sandstones. The base of the interval is the top of the first basalt/diabase and the section defined in this way is about 4,500 feet thick. This is several hundred feet thicker than a comparable interval in nearby wells (table ___).

The base of the upper unit of the Idaho Group has been picked in this well at the first major change in lithology. This is the first occurrence of basalt/diabase. An alternative subdivision could be made, in which the base of the section is moved down to about 5,300 feet. This interpretation is supported by dipmeter data which suggest that an unconformity may exist at about this depth. In this case, two basalt/diabase units (4,570-4,665 feet and 5,150-5,302 feet) would be added to the unit. This alternative subdivision agrees more closely with the breakdown of the section used by Newton and Corcoran (1963), as extended to the H. K. Riddle Kiesel Estate No. 1 well (southwest quarter, Section 8, T. 19 S., R. 47 E.) (plate ___). However, in either interpretation of the boundary, the igneous and sedimentary rocks on both sides are similar to one another and the regional significance of the stratigraphic boundary is uncertain.

4,570'-8,135'. The top of this interval is the first basalt/diabase unit encountered in the hole. Alternatively, as noted above, the top of this unit may be drawn at about 5,300 feet, on the basis of dipmeter evidence of an unconformity at about that depth. Although the presence of igneous rocks characterizes the interval, they are a subordinate part of it. The depths at which they occur are listed below:

Interval (ft)	Thickness (ft)	Log Defining the Unit
4,570-4,665	95	Acoustic Velocity
5,150-5,302	152	Acoustic Velocity, Gamma Ray
5,580-5,660	80	Acoustic Velocity
6,030-6,292	262	Acoustic Velocity, Density
7,015-7,145	130	Acoustic Velocity

These rocks make up an aggregate thickness of 719 feet in a total interval of 3,565 feet. The base of the unit is defined

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TABLE

COMPARISON OF THICKNESS OF SUBSURFACE STRATIGRAPHIC INTERVLAS

Amount	Ore-Ida Foods No. 1 (feet)	Riddle Kiesel Estate No. 1 (feet)	Chevron Highland Livestock No. 1 (feet)	Oroco Johnson No. 1 (feet)
Surface to top of first basalt/diabase	4,570	3,820	3,760	3,992?
First basalt to top of massive basalt	3,565	680±	410 maximum	------
Thickness of basalt-dominated section	1,919+	606+	1,205+ (Correlations uncertain)	------

here as the top of the first thick basalt/diabase in an underlying section made up mainly of that rock type.

The so-called basalt/diabase rocks in this part of the section are known only from cuttings. Megascopically they are all similar to one another. They consist of a phaneritic, holocrystalline, fine-grained, basic rock. No orientation of mineral grains was noted. The main minerals recognized are thin, tabular, white to glassy plagioclase feldspar crystals surrounding or surrounded by brown glassy pyroxene. Olivine is difficult to recognize but opaque, black, magnetic minerals are common. Many samples show a diffuse greenish color due to partial alteration. Secondary minerals, probably lining fractures, are soft, green serpentine and chlorite-like materials. Traces of quartz, calcite and zeolite(?) also occur in fractures. No evidence of vesicles, amygdules or red coloration, characteristic of basalt flow tops, was seen. The texture as well as the absence of features commonly found in flows suggest that these rocks might be diabases, perhaps present as intrusives rather than as basalt flows. However, flows with similar textures have been reported from the Columbia River Group by Savage (1958), Owyhee Basalt by Corcoran <u>et al</u>. (1962) and from the Deer Butte Formation.

Petrographic studies show that these rocks are mildly altered ophitic to subophitic, intergranular and intersertal olivine basalts or diabases, with no recognizable flow textures. These more-detailed studies could not resolve the uncertainty as to whether the rocks are flows or hypabyssal intrusives.

One notable exception in the character of these rocks occurs from 6,085 to 6,240 feet. This material is made up of an aphanitic, granular matrix containing scattered fragments of pyroxene, plagioclase and magnetite crystals. The matrix has been extensively altered to chlorite and mica with laminar orientation surrounding the larger broken crystals. The rock may be an altered pyroclastic, or it may be of cataclastic origin.

The sedimentary rocks interbedded with the basalt/diabase units consist of claystone, siltstone, sandstone and altered tuff. They differ only slightly in character from the sediments above 4,570 feet. The fine-grained rocks are more brown-gray than gray, and both sandstones and tuffs are more abundant than in the upper part of the hole. All of these rocks may also be slightly better-indurated than those above. However, in the absence of the interbedded basalt/diabase units it is unlikely that the sediments would appear to be sufficiently distinctive in character to warrant separation from those in the interval above 4,570 feet.

Evidence of porosity in fractured intervals in basalt/diabase and in sandstones is suggested by the geophysical logs of this interval. The best apparent porosity development in the igneous rocks occurs from 6,050 to 6,202 feet and 7,050 to 7,140 feet. Lost circulation occurred while drilling at 7,160 feet, possibly associated with the second zone. Only this zone is located in the interval with temperatures high enough to be of interest to the project. The sandstones in the sedimentary section have porosities interpreted to range from 10 to as high as 29 percent locally. The best evidence for both porosity and permeability in the range of acceptable temperatures occurs from 6,595 to 6,650 feet and 6,970 to 6,980 feet (Appendix F). Formation testing was carried out through perforations in the casing opposite both of these intervals as well as other selected zones from 5,980 to 8,340 feet. After blowing the hole with nitrogen above 7,950 feet, the water level rose 764 feet in 3 hours. This indicates a flow of about 13 gallons per minute from the entire zone of casing performations. All of these zones were tested together and the precise source of the fluid is uncertain.

Correlations of this interval with adjacent wells and the formal stratigraphic units of the region are uncertain. The 3,820 foot-thick section of interbedded basalt/diabase and sedimentary rocks in the Ore-Ida well from 4,570 to 8,135 feet may be correlative with the 730-foot-thick section between 3,820 feet and 4,500 feet in the Riddle Kiesel well. In that well, the interval has been assigned to the"Grassy Mountain Basalt," middle Idaho Group, by Newton and Corcoran (1963). In an alternative correlation preferred here, it may be equivalent to the combined Grassy Mountain and Deer Butte Formations of the northern Owyhee uplift surface section (Corcoran et al., 1962).

8,135'-10,054' (T.D.). The top of this interval was chosen at the top of the first massive basalt and the section is characterized by a predominance of thick basalt/diabase units separated by relatively thin sedimentary interbeds. The sediments amount to an aggregate of about 490 feet of the 1,919-foot interval. Under a binocular microscope the igneous rocks are mainly phaneritic, fine to very fine-grained, holocrystalline rocks, made up of randomly oriented plagioclase laths surrounding or surrounded by brown pyroxene. The amount of olivine is uncertain but a black magnetic opaque mineral is common. The texture and composition of these igneous rocks appear to be similar to those in the 4,570 to 8,135-foot interval. They differ slightly in containing a significant percentage of associated aphanitic to porphyritic and glomeroporphyritic samples. The fine-grained rocks are partly altered to green secondary minerals. Chlorite and serpentine-like minerals, derived from alteration along fractures, are common. No vesicles, amygdules or oxidized material which would suggest flow tops were observed in the samples. The rocks have been tentatively called basalt/diabase here, as above, until more conclusive evidence of their mode of occurrences can be found.

A petrographic study of selected cuttings and of a single core were carried out (Appendix B). The phaneritic rocks are mildely altered olivine basalts or diabases essentially identical to ~~those~~ those in the 4,570 to 8,135-foot interval. The associated aphanitic to porphyritic rocks are finer grained basalts lacking olivine, and bearing features characteristic of flow rocks including flow-oriented crystals, occasional fine amygdules, and (rare) glass. Generally, the olivine basalts/diabases and the finer flow basalts are quite distinct, leaving open the possibility that at least some of the former are intrusives

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There is no evidence of a sharp ~~textural or~~ compositional break between the basalt/diabase of this and the preceding intervals and there may be no real genetic difference between them.

The sedimentary rocks between flows consist mainly of fine-grained devitrified, more or less silicified white tuff, tuffaceous sandstone and light to medium brown-gray siltstone. Quartz-feldspath Sand and siltstones which resemble tuff appear in thin-section samples from 9810-9820 and 10,010-10,020 (Appen B)

No evidence of flow-top vesicular or breccia zones was observed. Fractures are scattered widely throughout the basalt/diabase and silicified tuff. A cumulative total of 400 to 500 feet of section with potential fracture porosity is present based on analysis of the geophysical logs (Appendix F). As noted above in the discussion of well testing, the entire interval was tested as a unit, through the slotted liner. No significant amount of formation fluid was obtained. From this it appears that the fractures are not open and intercommunicating.

This basalt/diabase-dominated interval is believed to be correlative with the massive basalt occurring below 4,500 feet in the Riddle Kiesel well and below 4,170 feet in the Chevron Highland Land and Livestock No. 1 well (northwest quarter of Section 24, T. 6 N., R. 5 W.). The incomplete section in the Kiesel well was included in the "Grassy Mountain Basalt" by Newton and Corcoran (1963). In view of its thickness in the more recently drilled wells in the area, it is considered here to be correlative with the main Miocene basalt sequences of the Owyhee Basalt or Columbia River Group.

The top of the massive basalt at 8,135 feet is believed to be the horizon predicted to occur at about 6,000 feet by

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reflection seismograph studies carried out in the Ontario area, prior to drilling the well (Applegate and Donaldson, 1978). This basalt interval was the main reservoir objective of the well. Between 8,135 feet and the total depth of 10,054 feet an aggregate thickness of about 2,150 feet of basalt/diabase was penetrated. There is no evidence that the base of the basalt/diabase dominated section had been reached at the bottom of the hole.

Structure. Structural data from the hole are limited to the dipmeter survey in the interval from 925 to 7,956 and 8,180 to 9,931 feet, to possible evidence of faulting based on lithology and to inferences about structurebased on correlations between this well and others in the region.

The dipmeter data are variable both in amount and azimuth of dip. However, some trends are discernable (Appendix G). They are listed in table ___. The most prominent structural break occurs in the change from a predominantly southwest azimuth above the basalt/diabase at 5,150-5,300 feet to the southeast or east-southeast azimuth below. This change does not occur at one of the important lithologic boundaries but may represent a major structural event in the overall history of subsidence of the basin in which the Snake River Group was being deposited. Based on very limited data, the southeast dip persists at least as deep at the 9,240 to 9,510 feet. The significance of this possible unconformity is discussed in a later section of the report.

Other, more local changes are not well enough defined to evaluate, except in the 5,660 to 6,030-foot interval. A discordant northeast azimuth and higher than normal dips are found here, confined to a section of tuffaceous and silty sandstone. The exceptional dip and azimuth here may reflect cross-bedding or a structural disturbance near a fault.

The only direct evidence of structure in the rock samples occurs in the possible cataclastic textures reported in the basalt/diabase from 6,085 to 6,240 feet. This material may come from a fault zone, although a non-structural origin is possible. Correlations in the area are too poor to indicate whether section has been duplicated or cut out across either the dipmeter anomaly or the possible cataclastic zone. Either of these zones might represent the faults designated IV or V, suggested from the reflection seismic survey carried out in the Ontario area for this project (Applegate and Donaldson, 1978; Ise, 1978).

The structural implications of thickening in the section between the Ore-Ida well and other deep holes in the region support the earlier indications from gravity data that this well lies in a basinal position rather than on one of the major intrabasin uplifts. The well correlations also indicate a major period of basin subsidence contemporaneous with deposition of the sedimentary and basalt/diabase from 4,570 to 8,135 feet. Regional implcations of the well data are discussed in a later section of this report.

<u>Thermal regime</u>. Temperature data from the well are compiled in Appendix I and much of this data has been plotted on plate ____, in conjunction with other well data.

<u>CO_2 and H_2S gas occurrences</u>. Both of these gases commonly occur in association with geothermal fluids, both in the reservoirs and in halos around the main fluid systems. In the Ore-Ida Foods No. 1 well, they were monitored and recorded on the mud log (Appendix D). Of these gases, CO_2 is present in widely varying amounts throughout the well. The variations reflect both actual entries of the gas into the hole and its varying retention in the mud due to changes in bacterial action, changes in mud pH and viscosity. From 4,000 to 7,150 feet the average CO_2 content was relatively high. It decreased in the sedimentary section from 7,150 to 8,135 feet and increased again in the predominantly volcanic section from 8,135 to 9,250 feet. It was variable, but generally lower, in the volcanic and sedimentary interval below 9,250 feet. In view of the non-geologic factors which influenced the occurrence of this gas, no clear relationship of the zones of high concentration and potential geothermal fluid-containing zones is apparent in this hole.

The level of H_2S gas in the mud was near or below the level of detection (1 ppm or less) throughout the hole, with the exception of two narrow zones. One of these occurred in the interval from 6,105 to 6,185 feet, where a peak of about 7 ppm was recorded near an interval of increased penetration rate in basalt/diabase (6,105 to 6,115 feet). This interval may be a gas-bearing fracture. The second zone occurred from 8,660 to 8,750 feet where a slight increase with a peak of 2 ppm, also in basalt/diabase, was recorded.

H_2S and CO_2 logs of this well do not show maxima which can be uniquely associated with zones of porosity determined from log analysis.

Hydrocarbon occurrences. The Snake River Plain has been the site of several episodes of drilling for hydrocarbons, and non-commercial gas shows have been encountered in several wells in the region. Although the primary purpose of the Ore-Ida well was to test the geothermal potential of the prospect, the manner of drilling and logging the hole was sufficiently similar to that of a hydrocarbon test well that the oil and gas potential was also determined here. The possibility of the occurrence of hydrocarbon gases was important both for the economic potential of the gas and for the hazards to drilling that non-economic pockets of high-pressure gas might create.

Hydrocarbon gas abundances are relatively high above a depth of 7,250 feet and are particularly low below 9,150 feet. The highest concentrations occurred in the sandy interval from 6,585 to 7,015 feet, in an interval with evidence of significant porosity and permeability on geophysical logs. Other peaks in the ditch gas curve occurred opposite thin sandstones from 1,090 to 1,105 feet and 1,440 to 1,455 feet. Small peaks occur opposite other thinly bedded sandstones or siltstones in the interval from 1,000 to 3,250 feet. This general interval is comparable to that in which the major gas shows have been reported in other wells. Methane is the most abundant but not the only hydrocarbon gas present. The gas chromatograph indicated that detectable quantities of C_2 through C_5 gases also occur.

Based on analysis of the gas shows and of the geophysical logs, the gas saturation was not adequate in any zone to warrant testing. Flow testing in the interval of high apparent porosity and permeability from 6,580 to 6,665 feet was not carried out separately from other zones in the broad interval from 5,980 to 8,340 feet. However, no significant amounts of gas were recovered.

In addition to gas shows, traces of solid bitumen were observed lining fractures in the bottom foot of core No. 1 (8,188 to 8,215 feet). This material gave a yellow flourescence and a cut flourescence with chloroethane.

PRELIMINARY

PART III

RE-EVALUATION OF GEOTHERMAL PROSPECTING AT ONTARIO, OREGON AND IN ADJACENT PARTS OF THE SNAKE RIVER BASIN

Introduction

The results from the drilling of the Ore-Ida Foods No. 1 deep geothermal test have a two-fold significance for geothermal prospecting in the Snake River Basin. One of these concerns the evaluation of additional drillsites in the Ontario area and the potential for developing production to meet the design specifications of the Ore-Ida project. The other, concerns the application of this well data to geothermal prospecting in the Snake River Basin in general. Conclusions relating to both will be presented in this section of the report. These conclusions will be supplemented by recommendations for additional work which would be directed toward reducing exploration risk in prospecting in this region.

As discussed earlier in this report, the essential ingredients required for a successful geothermal exploration result are the existence of temperatures at or above the level required for the anticipated uses, the presence of reservoir rocks within the zone of the desired temperatures and containing porosity and permeability capable of sustaining fluid production at economic levels, all occurring together at depths from which the fluid can be produced with economic advantage. The choice of sites at which these conditions can be met with the highest probability of success depends on the availability of adequate stratigraphic structural, hydrologic and temperature gradient data. While much important data of this type has been accumulated both by public agencies and by private companies involved in hydrocarbon and geothermal exploration, several important geologic problems remain which bear on the existence of an exploitable geothermal resource require further study.

Evaluation of the Ontario, Oregon, area.

The Ore-Ida Foods No. 1 well was drilled in order to develop a flow of 900 gallons per minute of water at about 310 °F. The actual conditions found are summarized below.

Temperature gradient. Equilibrium temperatures of 300°F occur at a depth of about _______ in the Ore-Ida well. The gradient continued to increase at an average rate of _____°F per 100 feet for the remainder of the hole to a total depth of 10,054 feet. The equilibrium temperature at total depth is estimated to be _____°F. It appears that the project temperature requirements can be met at economically attractive depths in the Ontario area, if an adequate fluid flow could be obtained.

Reservoir Potential. The rocks most likely to contain reservoir potential within the depth interval of favorable temperature are basalt flows. Basalt units are interspersed through the Ore-Ida well section from a depth of 4,570 feet to 8,135 feet and an aggregate of 1,425 feet of flows occurs in the 1,919 foot section below a depth of 8,135 feet. However, the depth to the top of this predominately basalt section is approximately 2,000 feet deeper at the wellsite than was inferred from reflection seismograph data before the well was drilled. Although a thick section of basalt has been penetrated, no important zones of high porosity and permeability were encountered. Large basalt intervals have been included in formation tests but there is no evidence that diffuse fractures are capable of producing an aggregate fluid volume approaching a useful level.

Structure. Resolution of structural details by a reflection seismograph survey was attempted in the Ontario area. The main objectives of this work were to locate faults which might enhance fracture reservoir potential and to indicate the depth of the main basalt objective. It is uncertain whether the faults predicted to occur in the well area were intercepted by the hole. If they were, there was no apparent improvement in reservoir character that could be attributed to them. The estimates of depth to the main basalt sequence based on this work were in error by about 2,000 feet.

Economic aspects. Although the existence of reservoir potential has not been demonstrated in the Ontario area, the temperature and well-depth parameters of a hypothetical basalt reservoir are better-defined than before. Assuming the existence of a reservoir at depths of 8,000 to 9,000 feet, with temperatures in the range from ____°F to _____°F, fluid production at a rate of ________ gallons per day would be required to equal the thermal equivalent of ______ barrels of oil. Assuming a well cost of __________, an outline of the feasibility of further drilling at Ontario can be obtained. It should be noted that no exploration risk related to finding a reservoir of this capacity can be established on the basis of data now available, except that it appears to be high on the basis of the Ore-Ida Foods No. 1 well experience.

Effect on Prospecting at Ontario. In order to justify additional drilling in the Ontario area it would be necessary to demonstrate that there is a good probability of finding adequate reservoir conditions. There is no evidence from the data available at this time that this can be done. A review of the seismograph data using information obtained from the Ore-Ida well might contribute additional structural information, but this would not answer the major question regarding the existence of a reservoir.

Recommendations for the Ontario Site

Significance of the Ore-Ida Well to Geothermal Prospecting in the Snake River Basin

The Ore-Ida Foods No. 1 well was the second deep geothermal test well drilled in the western Snake River Basin. It should be noted that the Ontario site was not chosen on the basis of basin-wide studies which selected it as having exceptional prospect merit. Rather, the site was chosen on the basis of the value of a hypothetical, plausible, resource to an already established user. The site was justified on the basis of several assumptions about the region. These assumptions are summarized below with some conclusions regarding their validity.

1. Heat Flow, Temperature Gradients and the Energy Potential of the Resource.
   a. Present view of area with high heat flow/temperature gradients.
   b. Any possibility of electrical grade temperatures?
2. Reservoir Rock
   a. Assumptions that basalt sections contain regional aquifers interflow, breccia and diffuse fractures--not really demonstrated from existing wells.
   b. Enhancement of reservoirs by proximity to faults (not adequately tested hypothesis).

c. Note that existing correlations in subsurface and from wells to surface are questionable due to limited data in both surface and subsurfaces.

3. Structure

   a. Assumptions about the meaning of gravity anomalies may be questionable (increase of basalt vs. block uplift).

   b. Any data of value for use in seismic interpretations?

4. Hydrology

   a. What basic circulation patterns have been proposed?

   b. What is present opinion of it?

Recommendations

1. Modify heat flow pattern to correspond to Ore-Ida data.

2. Work to identify and define vertical and lateral distribution of stratigraphic units in the subsurface.

   a. Review lithologic correlations by examining well samples from key wells for comparison with Ore-Ida.

   b. Possible petrographic studies of basalt from wells and key surface sections as an aid to correlation.

   c. Possible chemical analyses of basalts (or collection of data from others) as basis for correlation.

   d. Review of all deep well log data--porosity analysis--to determine if a regional aquifer condition might exist in basalt.

3. Acquisition of more detailed gravity work to refine structure. Model it with use of deep well data.

4. Ultimately obtain seismic data over important structures to define possible drillsites.

5. Possible lineament study to refine structural interpretation from air photos (collect if available--do, if not).
6. Hydrology--review (and revise?) the hydrologic model for the basin relative to geothermal prospecting.
7. Can any further shallow data be collected on temperatures, from water well data search or from field measurements?

EG&G Idaho, Inc.

P. O. Box 1625
Idaho Falls, Idaho 83401

November 26, 1979

Mr. J. L. Griffith, Chief
Research & Engineering Branch
Idaho Operations Office - DOE
Idaho Falls, Idaho 83401

FLOW TESTS OF ORE-IDA NO. 1, 8183 TO 10,054 FOOT RANGE, CONTRACT NO. DE-AC07-78ET28424 - Scz-188-79

Dear Mr. Griffith:

Nitrogen lifting and flow testing of the Ore-Ida No. 1 Well was witnessed by Mr. F. W. Childs at Ontario, Oregon from November 16 through November 19, 1979. In Boise, enroute to Ontario on November 15, the program was discussed with CH2M Hill and some logs of the well were picked up from Dr. James Applegate at Boise State University.

At the beginning of testing, the configuration of the well was as follows. A 9-5/8 in. diameter casing was cemented from the surface to 8183 feet. A 7 in. diameter liner was hung from the casing from 8142 feet to 10,038 feet. The liner was perforated with 2 in. x 1/8 in. slots (16 slots per foot) from 8186 feet to 10,036 feet. The remainder of the hole to a total depth of 10,054 feet was left open. The bottom of the liner was closed by a bull plugged collar. The top of the liner was sealed against the casing by a Burns lead seal liner hanger.

Initially, the water level was at 400 feet. The initial nitrogen lift removed the water from 400 feet to 6,000 feet deep. Approximately 91,000 scf of nitrogen was used. An instrumentation bomb was placed in the hole at 9960 feet for a period of four hours to measure pressure and temperature. Preliminary data indicated a water flow of about 0.3 gpm.

The second nitrogen lift removed water from about 6,000 feet to the bottom of the liner, about 10,000 feet. The instrumentation bomb was placed below the liquid level for four hours to again measure pressure and temperature. The preliminary data indicated a liquid flow of 1 gpm.

It was decided to perforate as deeply as possible (radially) behind the slotted liner in order to get an indication of high temperature mud damage. If a significant flow could be produced from the liner section by deep perforations, it would indicate significant high temperature mud damage and might produce the flow necessary to complete the project. If the perforating did not produce any additional flow, then it would indicate that there was a low probability of mud damage inhibiting significant flow unless that damage had invaded the formation deeper than could be penetrated by the perforation guns.

After reviewing the logs, six zones of the liner below 8313 feet were found to be promising. From the bottom up, four sections were minor and two were of major size. For some reason, the lowest two sections could not be reached when trying to set the perforating guns. The four main sections that were actually perforated are shown in the table below.

Well Depth	Perforated		Total Zone	% Perforated
9895 - 9875 ft	20 ft	of	20 ft	100%
9810 - 9790 ft	20 ft	of	20 ft	100%
9240 - 9020 ft	140 ft	of	220 ft	64%
8840 - 8730 ft	80 ft	of	110 ft	73%
	260 ft			

To achieve maximum penetration, the largest available shape charges were used, type SSB. These 22-23 gm charges were rated to a penetration depth of 30 inches in hard sandstone. Twenty feet of hole was shot with each gun run at the standard spacing of 4 shots per foot. Thirteen runs were made for a total of 260 feet of perforated hole or 1,040 perforations. It was expected that each perforation would be on the order of 5/8 to 3/4 inch in diameter.

Since the penetration shooting was done under water, 100 barrels had been added. The hole was nitrogen lifted for a third time to drop the water level depth from about 8300 feet down to 10,000 feet again. Following this 3rd nitrogen lift, the instrumentation bomb was again placed in the hole below the liquid level and pressure and temperature data recorded for four hours. The preliminary pressure rise data indicated that the liquid flow was approximately 1.3 gpm. The lack of significant flow increase indicates that either the mud damage exceeds about 30 inches or this section of the hole is unproductive. Since chemical logging and other logs indicate little permeability or presence of geothermal water constituents, it is considered unlikely that these particular zones are being prevented from producing due to high temperature mud cake damage unless this damage extends greater than 30 inches into the formation.

In preparing to perforate the zones in the 7,000-8,000 foot range which are behind the cemented 9-5/8 in. diameter casing, 300 barrels of water were added to cover the zone to be perforated. At that point, the operator attempted to lift the drill string while the pipe rams were tightly closed. The resulting stress broke the drill string 8 in. above the rotary table and caused damage to the pulleys in the crown block. It is expected that the rig will be down for repairs, primarily at the owners cost, until Monday, November 26, 1979.

bcc: J. W. Moffitt
I. W. Childs
PON/PRDA Ltr File
Route: DiBello/Jones
Nelson/Strawn
Childs
Central File

Following completion of the rig repair, it is planned to perforate 7 zones between 8340 feet and 5980 feet as shown on the table below.

Planned Perforation Zones

Well Depth	Zone Length (ft.)	Geothermal	Gas
8340 - 8320	20	X	
7925 - 7905	20	X	
7790 - 7770	20	X	
7140 - 7060	80	X	
7015 - 6955	60	X	X
6640 - 6580	60	X	X
6000 - 5980	20		X
	260 ft.		

Each zone will be perforated with the large type SSB shaped charge at the rate of four shots per foot throughout the entire length. Two of the zones show potential for both geothermal and gas production. The small zone around 6,000 feet was mentioned only in terms of gas potential, in addition, its temperature of 250-260° F is below the target temperature of 300-320°F. Ore-Ida (GeothermEx) was cautioned to observe the flows from the lower zones prior to shooting the 6,000 foot zone to avoid endangering the usability of production from below if it were of marginal temperature.

After both of the two nitrogen lifts to 10,000 feet, a small but continuous steam flow was noted from the well until it was quenched by adding cold water for succeeding operations. It is possible that the well could continue to develop on its own if it was left open for a week or more similar to the experience on one of the wells at Raft River. If there was a suitable work over rig available in the nearby area, it would have been recommended to release the drilling rig and leave the well in the open condition for an extended period to evaluate the possibility of self-development. Due to the high cost of bringing a work-over rig to the Ontario area, development will continue using the drilling rig prior to its release. It is recommended, if possible, to leave the well open to allow maximum self-development after the release of the drilling rig. Suitable monitoring and safety equipment would be installed.

Very truly yours,

J. A. Hanny for

R. J. Schultz, Manager
Hydrothermal Energy Commercialization

FWC:jd

cc: J. C. Austin, CH2M Hill
R. N. Chappell, DOE-ID
L. L. Mink, DOE-ID
R. W. B[illegible] Ore-Ida Foods
S. M. Prestwich, DOE-ID
R. W. Kiehn, EG&G Idaho, Inc.

PARTICIPANTS - Ore-Ida Foods Meeting of November 27, 1979

Ore-Ida Foods, Inc.

Dean C. Bent, Factory Production Manager
Jack P. Collins, Manager of Technical Services Planning
Rick D. Fergerson, Research Engineer
John C. Glerum, General Manager, Purchasing
Glen R. Green, General Manager, Research Engineering
Mr. Lee Nelson, Controller, Technical Services
Robert W. Rolf, Manager Technical Services (PON Principal Investigator)

Ch2M Hill, Inc.

John C. Austin, PON Project Manager
Roger R. Bissell, Manager, Industrial Energy Systems

GeothermEx, Inc.

Dr. Murray C. Gardner, Geologist/Drilling Consultant
Dr. James B. Koenig, President, Geologist

Other

R. N. Chappell, DOE-ID
F. W. Childs, EG&G Idaho, Inc.
Bill N. Hathaway, Hathaway Engineering, Drilling Engineer
S. M. Prestwich, DOE-ID

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PRELIMINARY

ORE - IDA No. 1, ONTARIO, OREGON

QUALITATIVE ANALYSIS OF WELL LOGS

INTRODUCTION - This analysis of the well logs from the subject well was performed in the field on November 10 - 11, 1980. ~~Being~~ It is essentially a well-site analysis ~~it~~ and is qualitative. Much useful information can be gained by a thorough, quantitative analysis of the data on a computer.

Table 1 lists the well~~s~~ logs run in this well with other relevant information. All downhole logs listed in Table 1 were run by Welex. The quality of logs in general was good. However, for the Neutron log, no direct porosity scale or API unit scale was given, thereby making ~~any~~ quantitative use of the neutron log impossible. Dip logs showed dip angle, azimuth and the relative correlation quality for each correlation interval. The Microseismogram-Cased Hole log also provided casing collar locator, relative neutron response and relative amplitude of the compressional wave. Fracture Finder-Microseismogram Log also provided self potential, caliper, and Shear Wave Amplitude data. Compensated Density Log-Neutron provided also gamma ray, caliper, and density correction ($\Delta\rho$) curves. Compensated Acoustic Velocity Log also presented self potential, caliper and time depth integrator data. Dual Induction Guard Log provided self potential along with deep induction, medium injuction, and shallow guard logs. The log No. 25 listed in Table 1 was prepared by the Energy Well Logging Service. The log No. 26 in Table 1 was prepared by GeothermEx. Logs 1 through 24, and 27 in Table 1 were run by Welex. The Computer Analyzed Log Systems (CAL) of Welex, listed as log 27 in Table 1, was not useful for this study. This is so because CAL is designed for petroleum wells in sedimentary formation. For tuffs and silicified "siltstones" (Type 3), or basalts and diabase (Type 4), CAL information is practically meaningless because true matrix properties of thes non-seimentary lithologies are not known. However, these matrix properties can be derived and a complete analysis performed by a statistical approach aided by a computer.

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The aim of this qualitative analysis was:

1. Indentification of Lithology
2. Detection of Fractures and Porous Zones
3. Detection and Estimation of Gas Content in Formation
4. Estimation of the Equilibrium Formation Temperature.

IDENTIFICATION OF LITHOLOGY

From the cuttings log it was seen that the lithologic types encountered in this well can be grouped under four classes:

1. Sandstone
2. Siltstone and Claystone
3. Tuffs and Silicified "Siltstones"
4. Basalts and Diabase

A careful examination of all available well logs allowed establishment of a set of diagnostic criteria for each of the lithologic types. Table 2 provides these criteria. It should be noted that these criteria can be quantified by more detailed study, preferably a computer-based statistically-oriented approach. ~~Time and budget available to this project were not sufficient for a detailed log interpretation effort~~. In the above classification the silicified "siltstone" type as described in the cuttings log probably represents tuffites.

Alterations due to hydrothermal or other causes appear to change sharply the log response of the lithologic types in this well. For example, diabase when fresh has a Δt of 45 to 50 μ sec/ft. When hydrothermally altered it increases to as high as 100 μ sec/ft. Similarly, diabase and basalt when fresh display densities in the range of 2.9 to 3.0 gms/cc. When altered, these lithologies display densities as low as 2.45 gms/cc. for basalt and 2.80 gms/cc for diabase. Gamma ray declines due to alteration of diabase - from 60 to 20 API units in typical cases. Thus, it is possible to delineate hydrothermally altered zones and, possibly, the extent of hydrothermal alteration in a quantitative analysis. No such analysis has been attempted here. The importance of delineating hydrothermal alteration may be

(i) in exploration for purposes of correlation and development of a genetic model for the geothermal system.

(ii) and if presence of pores or fractures can be correlated to hydrothermal alteration well, completion decisions can be easier.

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TABLE - 1

WELL LOGS RUN IN ORE - IDA No.1 WELL

Log Type	Date	Top of Logged Interval (Ft)	Bottom of Logged Interval (Ft)
1. Dual Induction guard log	9/18/79	925	7150
2. "	10/1/79	7150	7956
3. "	11/8/79	8182	10053
4. Compensated Acoustic Velocity	9/18/79	925	7148
5. "	10/1/79	7148	7952
6. "	11/8/79	8182	10048
7. Compensated Density Log-Neutron	9/18/79	925	7250
8. "	10/3/79	7150	7955
9. "	11/8/79	8182	10038
10. Fracture Finder Micro-Seismogram Log	9/18/79	925	7148
11. "	10/1/79	7148	7952
12. "	11/8/79	8180	10047
13. Micro-Seismogram Log-Cased Hole	11/9/79	6800	8198
14. Dip Log	9/18/79	925	7955
15. "	11/9/79	8180	9931
16. Temperature Log, Run No.1	9/18/79	0	7150
17. Temperature Log, Run No.2	9/19/79	0	7150
18. Temperature Log, Run No.3	9/19/79	0	7150

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TABLE 1 (Cont'd)

Log Type	Date	Top of Logged Interval (Ft)	Bottom of Logged Interval (Ft)
19. Temperature Log, Run No.4	9/20/79	0	7140
20. Temperature Log, Run No.5	10/1/79	0	7958
21. Temperature Log, Run No.6	10/2/79	0	7958
22. Temperature Log, Run No.7	10/2/79	6000	7958
23. Temperature Log, Run No.8	11/9/79	0	10053
24. Temperature Log, Run No.9	11/10/79	0	9360
25. Drilling Log, Mud Log, and Cuttings Log	For the entire drilling period	55	10055
26. Cuttings and Core Log of Binocular Microscope Description	For the entire drilled section	30	10040
27. Computer Analyzed Log System	Based on Welex logs	6000	7900

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TABLE - 2

DIAGNOSTIC CRITERIA FOR LITHOLOGIC TYPES - ORE-IDA No. 1

LITHOLOGIC TYPE	DRILLING RATE	HOLE ENLARGEMENT	SELF POTENTIAL	GAMMA RAY	CONDUCTIVITY
1. Sandstone	High	Sometimes negative enlargement due to mud cake	Moderate	Moderate (80 to 140 API)	Moderate
2. Siltstone & Claystone	Moderate to high	Occasional	None	Moderate (80 - 150 API)	—
3. Tuffs & Silicified "Siltstone"	Moderate	Unusual	Low	High (>200 API) - offscale	—
4. Basalts & Diabase	Slow	In Fractured Sections	Low, Wandering	Low (20 to 70 API)	Very Low

TABLE - 2 (Cont'd)

LITHOLOGIC TYPE	SONIC TRAVEL TIME	BULK DENSITY	NEUTRON LOG RESPONCE	DIP LOG RESPONCE	OTHER CHARACTERISTICS
1 Sandstone	Moderate (55 to 100 μ sec/ft when compacted)	Moderate (2 - 2.6 gms/cc)	Moderate to low porosity	Excellent correlation quality, numerous correlation intervals	Occational Mudcake buildup
2. Siltstone & Claystone	High (100 - 110 μsec/ft)	Moderate (2.4 - 2.6 gms/cc)	High porosity	Excellent Correlation quality, Numerous correlation Intervals	—
3. Tuffs & Silicified "Siltstone"	High (Upto 150 μsec/ft)	Low (2.4 - 2.5 gms/cc)	Low porosity	—	Characteristic High Δt on Microseismogram
4. Basalts & Diabase	Moderate (45 to 100 μ sec/ft)	High (Upto 3.0 gms/cc)	High porosity	Poor correlation Quality and very Few correlation Intervals	Convective Heat flow on Temperature Log

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With the help of the log response criteria presented in Table 2, the drill cuttings log, mud log, and particularly the excellent data on binocular microscope study of the cuttings, the entire well section was divided into individual zones. Each zone has a distinct lithologic description. The advantage of this zonation technique over a section based on drill cuttings alone are many. The most important advantage is that while cuttings data can define lithologic boundaries within a few tens of feet at best (because of difference in velocities of cuttings because of density difference) the log-derived data can be accurate to a foot or so. Moreover, erroneous identification of lithology is quite possible when using cuttings (because of their small size). Once the logs can be "calibrated" as to their log responses (as done in Table 2), log response becomes an accurate tool for lithologic zonation. Figure .... shows the lithologic zonation in this well as derived from drill cuttings data and log responses. In preparing Figure .... it was observed that the binocular microscopic study of cuttings (Appendix A) agreed much closer with the log responses than did the well-site drill cuttings report (Log 25 in Table 1). It should be pointed out that using Appendix A and preferably a thin section petrographic study, one can develop a finer "calibration" of log responses to lithology. ~~so that~~ subtle~~x~~ lithologic variations and hydrothermal alterations in the section can even be recognized.

Note: The figure no. we should refer to c interpret. cross-section

DETECTION OF FRACTURES & POROUS ZONES

Fractures in geothermal systems can be detected and evaluated to varying degrees of certainty from various well logs. The best evaluation procedure is to combine the fracture detection criteria from various well logs and come up with an overall probability of occurance and general nature of the fractures at various depths in a well. Based on the available well logs, the following fracture detection criteria have been applied to the subject well (Sanyal, et al, 1979

1. Drilling Rate - Usually fractured intervals display faster drilling rates.
2. Mud Circulation Data - Most fracture zones cause lost circulation of mud.
3. Drill Cuttings Data - Drill cuttings sometimes show "drusy" quartz indicating partial filling of fractures.
4. Self Potential - Igneous rock formations do not usually display self potential unless fractured, when mud-filtration through fractures may give rise to a streaming potential.

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5. Conductivity - Igneous rock formations usually display very low conductivity unless fractured. In fracture zones shallow-investigation resistivity logs show higher conductivity because of the presence of mud in fractures.

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6. Separation between Shallow Guard and Industion Logs - In fractured igneous formations the shallow guward log should show higher conductivity than the induction logs which have a higher depth of investigation.

7. Hole Enlargement - Fractured sections often show hole enlargement.

8. Three-Arm and One-Arm Caliper Data-- When there is an inclined fracture, the hole usually becomes non-circular in cross section due to preferential hole enlargement in the direction of the fracture. A three-arm caliper gives an average diameter of the ~~well. But~~ the one-arm caliper with a pad-mounted device (such as the density tool) tends to give the maximum width of the borehole. This is so because the caliper are in such a tool is pressed very hard against the borehole wall, ~~and~~ when the tool is pulled up during logging the caliper arm tends to align itself and extend in the direction of the maximum width. Thus for a fracture zone the one-arm caliper gives a larger diameter than the three-arm one.

9. $\Delta\ \rho$ Curve - When the caliper log shows that a borehole is smooth but the $\Delta\ \rho$ curve shows large corrections to the density reading it may imply either mudcake buildup or the presence of fractures. In igneous lithology mudcake buildup is not common; hence an unusual value of $\Delta\ \rho$ in a smooth section of the hole indicates fractures.

10. Neutron and Density Logs - In an igneous formation, fractures usually account for most of the porosity unless there is vesicular porosity. Hence neutron and density logs should indicate relatively higher porosities in fractured zones.

11. Comparison of Sonic and Density Porosities - In fractured zones, sonic log-derived porosity will be lower than the density log-derived porosity because sonic log does not "see" most fractures. Unfortunately, in this well it is difficult to do this comparison because to calculate proosities one needs the properties of the matrix. Even though in the last section we have mentioned that lithologic zonation in this well was possible, accurate matrix values for each lithology can not be determined without a more quantitative approach.

12. Compressional Wave Amplitude - Fracture zones cause a reduction in the amplitude of the compressional sonic wave.

13. Microseismogram - Fracture zones cause interference in sonic waves. As a result, in the full wave-train presentation in the microseismogram fracture zones are indicated by interference patterns.

14. Rock Strength - The mechanical strength of a rock is proportional to $\rho/(\Delta t)^2$ where ρ is the bulk density and Δt is the travel time of the compressional sonic wave. A rock with high mechanical strength can undergo brittle fracture; a rock with low strength does not usually show brittle fracturing.

PRELIMINARY

In Table 3 we have listed all suspected fracture zones in the subject well with check marks for the satisfied criteria. A question mark in Table 1 implies that it is not clear whether the criterion is satisfied or not. Based on the number of satisfied criteria, we have concluded whether a zone is fractured, probably fractured, or possibly fractured.

In the subject well the fracture zones appeared to be confined to basalts. There are some permeable zones in the sandstone sections in this well which have intergranular rather than fracture porosity. For such zones many of the criteria used in Table 3 are not relevant.

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DETECTION & ESTIMATION OF GAS CONTENT

The mud log in the subject well shows significant methane gas concentration above 7200 ft., primarily in the sedimentary intervals. Considering reported gas shows in several wells in this region, it is possible that this well may have free gas saturation. The usual indication of gas saturation in a well is the fact that neutron log-derived porosity is lower than the density log-derived porosity. However it is not possible to verify this condition in this well for two reasons:

(1) Excessive hole enlargement (often greater than 12 in.) renders density log data unreliable, and

(2) Bulk density of the rock matrix can not be estimated accurately.

Another approach is to calculate the gas saturation from the resistivity data. However we have no knowledge of the formation water resistivity. Assuming that the SP generated at the permeable sand section at 6950-7010 ft. is the static SP (without any streaming potential) we can calculate the approximate resistivity of the formation water as 0.07 ohm. meters. Assuming a matrix density of 2.70 gms/cc for these silicified sediments we get a porosity value (ϕ_D) of about 28 percent for this zone, which is close to ϕ_N also. This estimate is probably reasonable because the hole is in guage and the sand is relatively clean. Assuming the conventional water saturation equation to be valid for this well, we calculate a water saturation of 24 percent from the resistivity value for this zone (induction resistivity reading used without correction). This indicates 76 percent gas saturation, which appears to be too high to be realistic.

Because of the uncertainties in the calculated water saturation value, we can not consider the above calculation reliable. In particular, although the hole section in this zone is in guage, the neutron log-derived porosity appears to be greater than the density log-derived porosity for any reasonable assumed matrix density. This is exactly opposite of what is expected from a relatively clean gas sand. It is hoped that the question of gas saturation will be settled when this section is perforated, stimulated, and tested.

In a more detailed analysis one can calculate the formation water resistivity from log response crossplots and calculate more reliable values of water saturation.

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PRELIMINARY

TABLE 3

A LIST OF SUSPECTED FRACTURE ZONES

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	REMARKS
	CRITERIA														
9985 - 10010	?			X	X	X						X	X	X	Possibly Fractured
9924 - 9936					X		X	X		X		X	X	X	Probably Fractured
9792 - 9806	X			?	X					?		X	X	X	Possibly Fractured
9880 - 9890	X					X					X	X	X	X	Possibly Fractured
9300 - 9510												X			Possibly Fractured
9020 - 9235			X		X	X	X	X		X	X	X	X	X	Fractured
8970 - 8990	X				X	X	X			?		X	X	X	Probably Fractured
8730 - 8840						X	X	X		?		X	X	X	Probably Fractured
8640 - 8670						X		X				X	X	X	Possibly Fractured
8450 - 8520			X	X?		X	X	X		?		X	X	X	Probably Fractured
8320 - 8400					X	X	X	X		?		X	X	X	Probably Fractured
8178 - 8216			X	X			X						X		Possibly Fractured
7050 - 7130		X		X	X	?	X	X		?		X	X	X	Fractured
6950 - 7010	X		X	X			*			X					Permeable, Intergranular
6580 - 6670	X		X	X			*								Permeable, Intergranular

* Mud cake buildup

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PRELIMINARY

ESTIMATION OF THE EQUILIBRIUM FORMATION TEMPERATURE

As listed in Table 1, nine temperature logs were run in the suject well. Maximum recording thermometer readings from other logs also provide information about the formation temperature. However all sudh data provide transient temperature values. To obtain the equilibrium formation temperature a geothermal well needs to be shut in for several weeks. There are techniques of calculation of the equilibrium temperature from the transient temperature data, the most common being the Horner technique. In this technique the treanient well temperature (T_{ws}) at a specific depth is noted as a function of the time (Δt) since mud circulation in the well stopped. If the total mud circulation time (t_p) before logging is known, then a plot of T_{ws} versus Horner dimensionless time, given by $(t_p + \Delta t)/\Delta t$ is made. According to the theory of the Horner technique such a plot should be linear. A straight line is fitted through the data points on Horner plot. When extrapolated to a Horner time of unity this line gives the equilibrium formation temperature (Ti).

It is now established that the conventional Horner technique is not strictly applicable in most practical cases (Roux and Sanyal, 1980). This is because the boundary condition of constant heat flow rate at the wellbore before circulation stops is not realistic. Roux and Sanyal (1980) present theorectical Horner plots for various values of a dimensionless circulation time (t_{pD}) considering the boundary condition of constant wellbore temperature before circulation is stopped. This latter boundary condition is more realistic in geothermal wells where the temperature gradient is very small due to convection. In most geothermal wells the temperature gradient is steep above the reservoir but is very small within. In many practical cases the boundary condition at the wellbore is neither the one assumed in the conventional Horner technique nor the one assumed by Roux and Sanyal (1980), although closer to the

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latter. Figure 1 shows the true Horner plot and the modified Horner plots. It should be noted that the modified Horner plots are curvilinear and funtions of t_{pD}.

In the subject well the temperature data for depths below 7960 ft. are inadequate for a reliable analysis. Hence 7960 ft. was chosen to be the deepest point for which a transient temperature analysis was worth while. The total circulation time for this depth was 23 hours. Table 4 shows the relevant numerical data. Maximum recorded temperature from the Logs 2, 11, and 5 of Table 1 and from the Temperature Log Runs #5, #6, and #7 were utilized in this analysis. The data are plotted as a Horner plot on Figure 2. Before the data on Table 4 and Figure 2 can be analyzed it must be remembered that the analysis will be of limited accuracy for the following reasons:

1. Circulation was interrupted more than once, thereby invalidating the basic premise of this approach that the well has undergone a single circulation.
2. Exact values of t_p and Δt can not be ascertained unless a specially careful record of circulation and logging history is available.
3. Data show much scatter. For example, the two or three maximum recording thermometer values provided with each temperature log differed considerably. In Figure 2 those data points considered relatively reliable are circled. Only these points have been used for analysis.
4. There may have been a significant convective component in heat flow at this depth and at several other intervals because of either mud filtrate invasion or flow through colder aquifers. These conditons have not been considered.

Figure 2 shows that the extrapolated temperature (T^*_{ws}) for a Horner time of unity is 347°F.

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PRELIMINARY

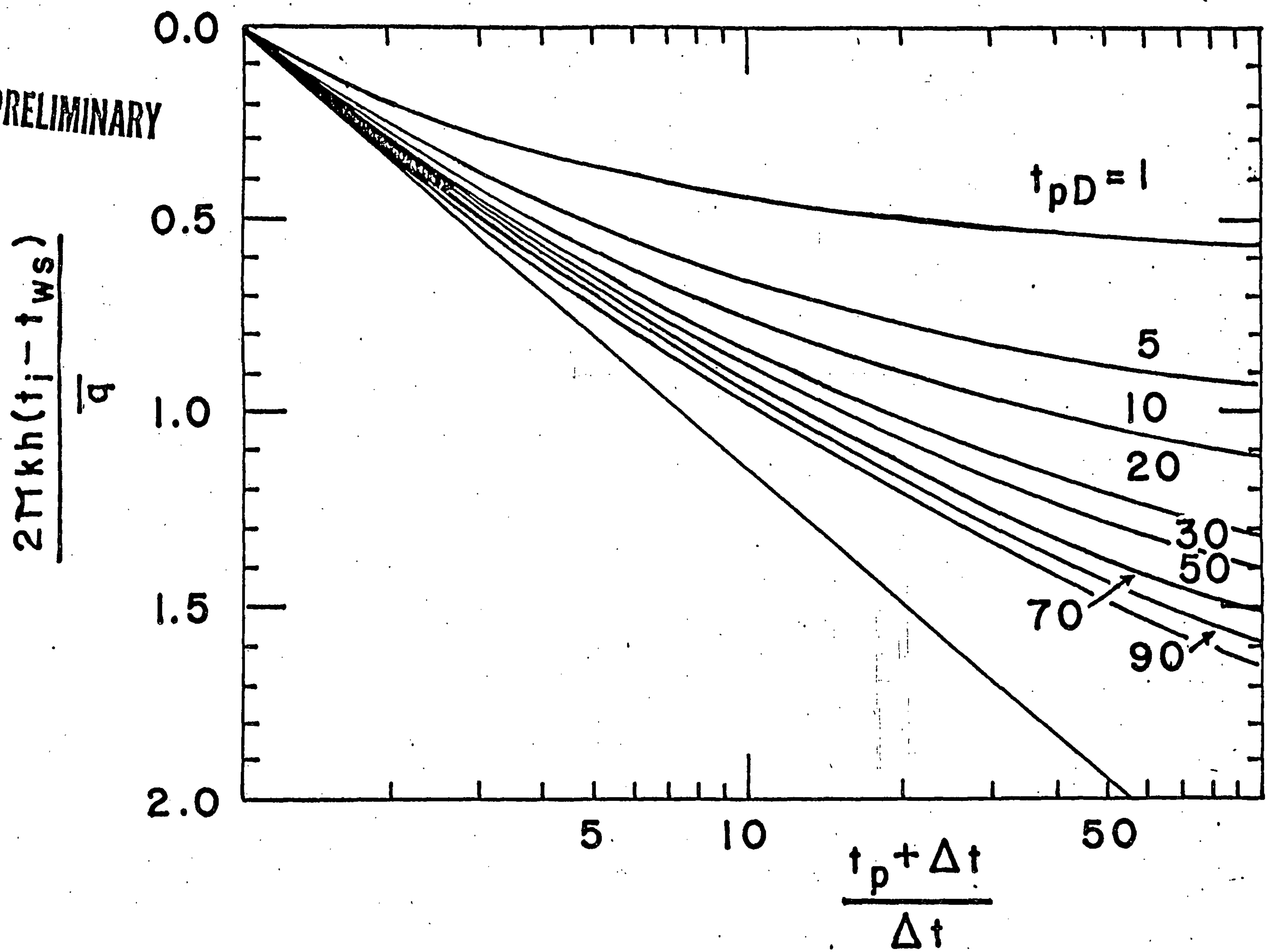

FIGURE 1

MODIFIED HORNER PLOT

(From Roux & Sanyal, 1980)

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PRELIMINARY

TABLE 4

EQUILIBRIUM TEMPERATURE CALCULATION

Depth = 7960 Ft.

Depth Reached at 20:30 hours on 9/29/79

Circulation Stopped at 19:30 hours on 9/30/79

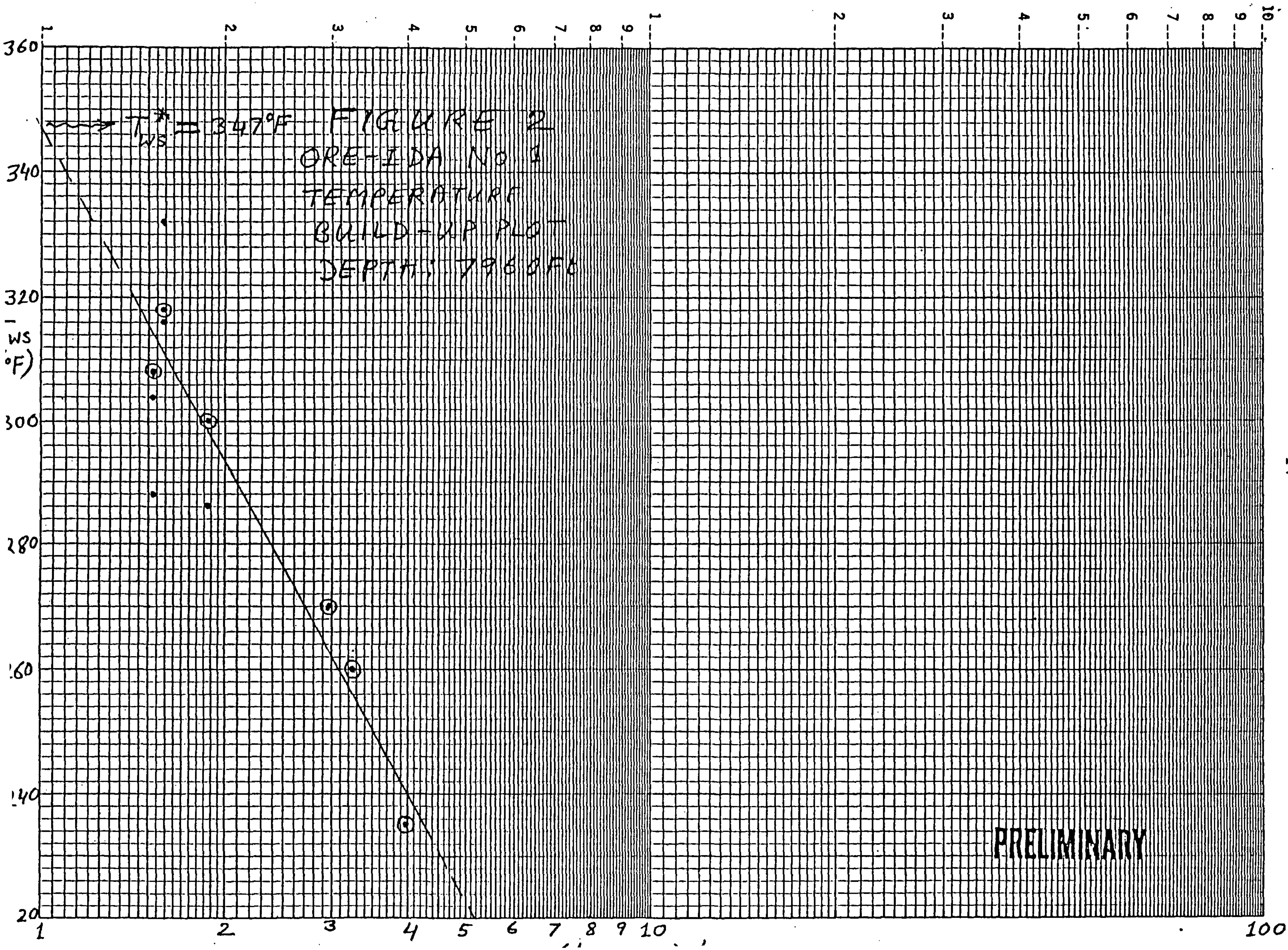
Total Circulation time (t_p) = 23.0 hours

Temperature Buildup data:

	Log Type	Date Run	Δt(hrs.)	$(t_p + \Delta t)/\Delta t$	T_{ws}(°F)
1.	Dual Induction Guard Log	10/1	7.75	3.97	235
2.	Fracture Finder-Micro Seismogram	10/1	10.25	3.24	260
3.	Compensated Acoustic Log	10/1	11.75	2.96	270
4.	Temperature Log, Run #5	10/1	26.25	1.88	300,286
5.	Temperature Log Run #6	10/2	39.25	1.59	316,318,332
6.	Temperature Log Run #7	10/2	44.25	1.52	304,288,308

K•E SEMI-LOGARITHMIC • 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 4972



PRELIMINARY

The t_{pD} is defined as:

$$t_{pD} = Kt/c_p \rho r_w^2$$

where K = Thermal conductivity of the formation,

c_p = specific heat of the formation,

ρ = bulk density of the formation,

r_w = wellbore radius, and

t = circulation time.

Many of these parameters are unknown for this well. However for most geothermal wells the value of $(K/c_p \rho r_w^2)$ is of the order of 0.4 per hour. Assuming this value the t_{pD} for this case is

$$t_{tp} \doteq 0.4t$$
$$= 9.2$$

From Figure 1 it is seen that for $t_{pD} = 9.2$, the modified Horner plot shows a strong curvature, which is not seen in Figure 2. This may imply that the conventional Horner technique may be adequate for this case. However, the true curvature may be masked by the data scatter or the value of t_p or $(Kt_p/c_p \rho r_w^2)$ may be much higher in which case the modified Horner plot may be almost linear. This problem has not been resolved.

REFERENCES

Sanyal, S.K., L.E. Wells, and R.E. Bickham: "Geothermal Well Log Interpretation-State of the Art", Final Report, Contract No. X48-96245-1, Published by the Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Roux, B. and Sanyal, S.K.:"An Improved Approach to Estimating True Reservoir Temperature from Transient Temperature Data", Presented at the 50th California Regional Meeting of the SPE of AIME, Pasadena, California, April 26-28, 1980.

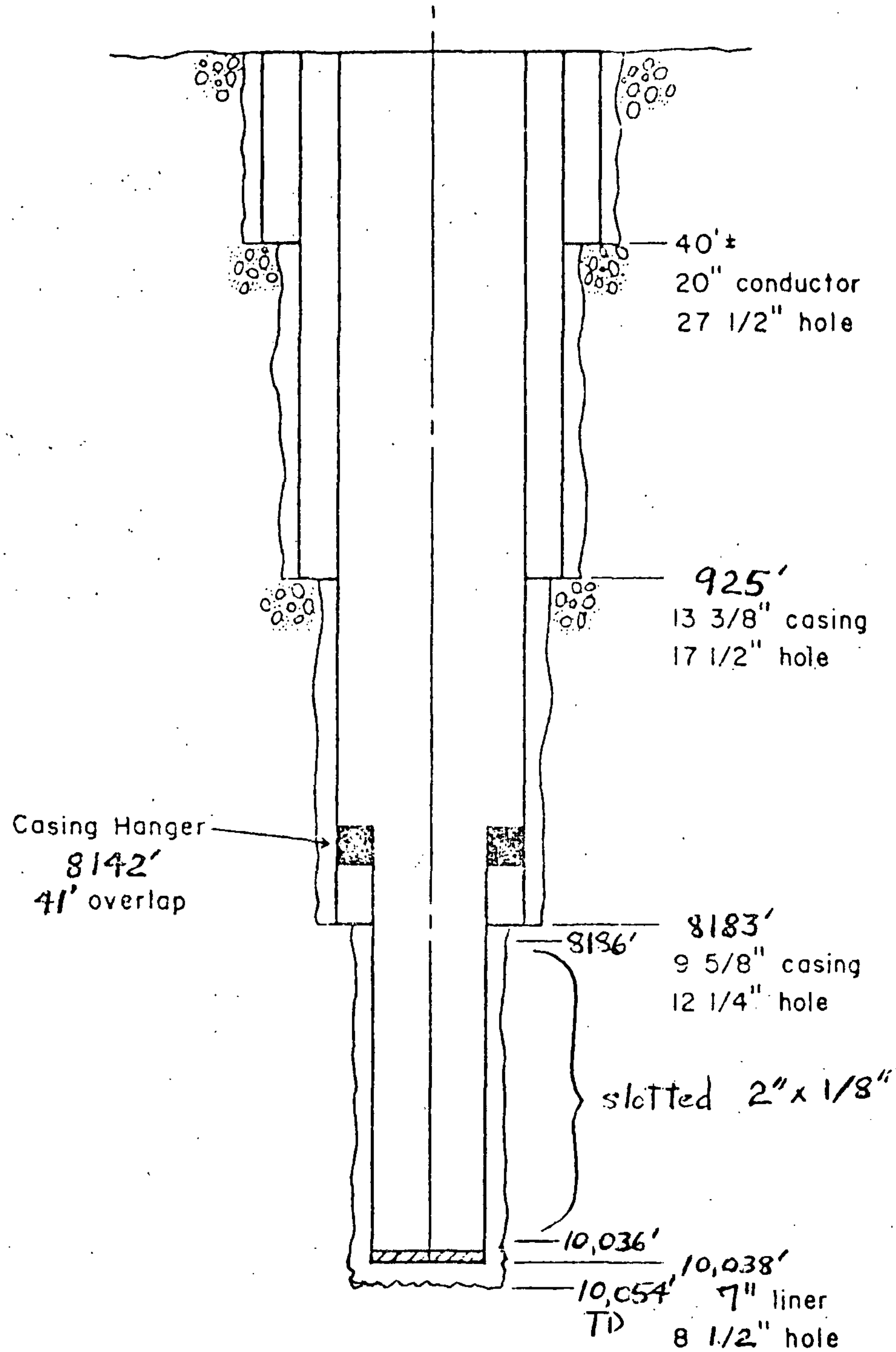


Figure 4. Well casing design

ORE-IDA NO. 1 WELL

EG&G Idaho

NOTEGRAM

FORM EG&G-460
(Rev. 9-76)

To: D W Struhsacker UURI
B Harold LASL Dept. Address

Date 9/2/80

From Frank Childs Dept. Address EG&G Idaho, Inc

Previously reported loss of pressure at Ore-Ida No. 1 in Ontario, Oregon was inaccurate. The main valve was closed when installing the new pressure gage and the well head bled off from 120 psig to zero during the next two weeks. Apparently, the well was vented shortly on or before 8/22 to verify pressure followed by the recovery and venting on 8/26 which is enclosed.

Frank

PUT IT IN WRITING — WRITTEN MESSAGES SAVE TIME, PREVENT ANNOYING INTERRUPTIONS AND ERRORS

FRANK CHILDS Received 8-29-80
EG&G

RECEIVED
AUG 28 1980
CH2M HILL
BOISE

August 27, 1980

MEMO TO: G. R. GREEN

FROM: R. D. FOGERSON R D Fogerson

SUBJECT: GEOTHERMAL WELL DEPRESSURIZATION AND MONITOR OF PRESSURE BUILDUP

cc: R. W. Rolf
J. Austin

At the request of John Austin, the geothermal well was depressurized (4:00 p.m., 8/26/80) and daily monitoring of the well repressurization will be redone. John stated this is information that DOE would be interested in.

The well read 114 psi last Friday, 8/22/80, and 120 psi on the following Monday and today. The depressurization sequence was as follows:

Time, seconds	Remarks
0	120 psig
1	Loud hiss, considerable vapor
15	0 psig, 1/2 cup black water released, loud constant hiss changes to quieter, cyclic hiss
75	Well is quiet although gas still obviously issuing by visual observation and well head vibrating (most likely from gas evolving from solution)
90	Vibration stopped, gas issuing visually
180	Gas issuing visually, valve shut off

RDF:jnh

$\boxed{\rho_b/\Delta t^2 \text{ vs caliper}}$

γ, neutron, Δt, histogram

$\rho_b - \Delta t$ cross-plot
caliper z

Dr. Subir Sanyal
3761 Barrington Drive
Concord, Calif. 94518

he has

$\rho_b - \phi_N$ - cal. on z 5296 - 5560

$\rho_b - \phi_N$ - all

γ

calipers on z

4660 - 5137
5296 - 5560
5651 - 6026
6294 - 7008
7015 - 7135
7147 - 7798
7803 - 7926
8155 - 8404
8466 - 8826
8863 - 9238
9253 - 9577
9581 - 9938

~~Δt~~ $\rho_b - \phi_N$ Δt

4571 - 4610	6294-7008
5152 - 5287	7147-7798
5572 - 5644	7803-7926
6031 - 6286	8155-8404
7015 - 7135	8466-8826
4660 - 5137	8863-9238
5296 - 5560	9253-9577
5651 - 6026	9581-9938

5000 gm Fe 650°C .09 cal/gm/°C

400 gm ice −40°C .5 cal/gm/°C

80 kal/gm

$5000 \times .09 \times (650 - T)$

450

$400 \times .5 \times 40 + 400 \times 80$

200

Ore Ido

bit	hole	casing		liner
30"	0 - 54'	20"	to 40'	
17½"	54 - 925	13⅜	to 925	
12¼"	925 - 8221	9⅝	to 8123	
8½	8221 - TD	7"	liner 8142' - 10038'	

11-13-80

Ted Glenn, UURI

Barbara Arney, LASL

(John Austin, CH2M)

Subject: Transmittal of Ore-Ida No1 Well, Drilling Mud Chem. Analyses

Here is only data available right now due to catching Dick McAtee in the middle of moving. Hope you get it in time for ~~the~~ the Monday meeting.

FW Childs
EG & G Idaho

CENTURY LABORATORIES
a division of J-U-B ENGINEERS, Inc.
250 SOUTH BEECHWOOD AVENUE, SUITE II • BOISE, IDAHO 83705 • (208) 376-2257

Richard McAtee
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, Idaho 83401

RESULTS OF ANALYSIS

The following test results are on water fractions extracted from drilling muds which were collected from the No. 1 test well at Ore-Ida, Ontario, Oregon.

Date Received: November 8, 1979

Lab No.	Sample ID	pH, Units	Tot. Alkalinity, mg/L	HCO_3, mg/L	CO_3, mg/L	OH, mg/L	Ca, mg/L
5248	9800 i	10.9	6604	2574	4030	0	235
5249	9800 o	10.7	6393	2342	4051	0	232
5250	9850 i	10.4	5855	2479	3376	0	217
5251	9900 i	10.4	5328	2501	2827	0	195
5252	9900 o	10.3	5518	2817	2701	0	245
5253	9950 o	10.3	5486	2806	2680	0	251
5254	10,000 i	10.3	5043	2595	2448	0	245
5255	10,000 o	10.3	4631	2437	2194	0	230
5256	10,050 o	10.3	5096	2290	2806	0	247
5257	10,000 w	7.7	1614	1614	0	0	115

i = in
o = out
w = water

Respectfully submitted,

CENTURY LABORATORIES

Gary Shook, Lab Supervisor

DATE

EG&G Drilling Mud SAMPLES

AMPLE→ EST↓		9850	9900 In	9900	9950	10,000 In	10,000	10,050			
Chloride	mg/l	572	511	460	486	537	588	664	Chloride		
Conductivity	umho/cm	13,500	13,200	11,800.	12,200	12,800	14,600	16,300	Conductivity		
Fluoride	mg/l	6.3	5.5	4.8	5.0	5.2	8.3	7.5	Fluoride		

ORE-IDA LOGS — 12¼ 12¼ 8½

① ② ③

Comp. Acoustic Vel. Log ① 9-18-79 925-7148 7152 13⅜ 925

② 10-1-79 7148-7952 7960 "

③ 11-8-79 8182-10048 10054 8⅝ 8182

incl. caliper all runs, SP runs 2 & 3

Dual Induction Guard Log 9-18-79 925-7150

10-1-79 7150-7956

11-8-79 8182-10053

① R_m, R_{mf}, R_{mc} 1.20 @ 100°F, .98 @ 98°, 1.46 @ 99°

1.34 @ 66°, 1.10 @ 68°, 1.64 @ 64°

Ligno Sulf-mud 1.21 @ 52°, 1.03 50°, 1.43 @ 50°

TS circ. 11 hrs 7¾ 13

BHT 236°F, 235, 320

Compensated Density Log - Neutron

9-18-79 925-7250

10-3-79 7150-7955

11-8-79 8182-10038

Microseismogram Log - Cased Hole all-9-79 6800-8198

CCL, Neutron, "3-D" + AMP.

Fracture Finder Micro-seismogram log 10-1-79 (run 2)

7148-7952, 925, 7960

Caliper - SP - Amp + "3-D"

925-7148, 925, 7152 9-18-79 (run one)

Amp. + 3D"

Fracture Finder Micro-Seismogram Log (run 3)
11-8-79 8180 - 10047, 8180, 10054
SP, Caliper, Amp. + 3D"

Dip Log Calculations
run 1 9-18-79 run 2 11-9-79
925 - 7955, 925, 7154 ; 8180-9931, 8180, 10054

~~Mud Log~~ by Energylog (Mud log) by
Energy Well Logging Service

lithology, Drilling Rate, In + Out temp., CO_2, H_2S.
bit record

ORE-IDA TEMPERATURE LOGS

RUN ONE	9-18-79	0-7150	7150	8	—
TWO	9-19-79	0-7150	"	24	✓
THREE	"	0-7150	"	39¼	✓
FOUR	9-20-79	0-7140	"	50¾	✓
FIVE	10-1-79	0-7958	7960	26¼	✓
SIX	10-2-79	"	"	39¼	✓
SEVEN	10-2-79	6000-7958	"	44¼	✓
EIGHT	11-9-79	0-10053	10054	29	✓
NINE	11-10-79	0-9360	"	N/A	✓

~~[illegible]~~

FINAL 7-11-80

Still to Finish

1. Temp. Log #5
2. Geology
3. Depth on right side
4. Resistivity scale - change ohms to ohm-m & #'s on scale
5. Title

WELL LOG COMPOSITE

ORE-IDA NO. 1

ORE-IDA FOOD INCORPORATED / DOE

GEOTHERMAL WELL

ONTARIO, OREGON

October, 1980

ESL

6. Metric units

Susan Prestwich 3/11/80

2 sites picked

southern site might be best.

Highland well - offset

Structurally higher

3000' - 4000' range hole problems

7160' - no indication of

significant mud loss

- Thinks diabase units are flows -

Temperature logs 8. 11-9-79 0 - 10053
9. 11-10-79 0 - 9360

~~Oneida~~ ORE - IDA NO. 1

Energylog - mud log. 7154 10054

Welex Logs 12½ + 8½ bits

Dip Log	9-18-79	925 - 7958	925 13⅜
	11-9-79	8180 - 9931	8183 9⅝
Fracture Finder	9-18-79	925 - 7148	
" "	11-8-79	8180 - 10047	
Comp Acoust Vel. Log	9-18-79	925 - 7148	
	10-1-79	7148 - 7952	
	11-8-79	8182 - 10048	
Comp Den Log	9-18-79	925 - 7250	
(Cal. + γ + Neut)	10-3-79	7150 - 7955	
no neutron scale	11/8/79	8182 - 10038	
Dual Induction Guard Log	9-18-79	925 - 7150	
	10-1-79	7150 - 7956	
	11-8-79	8182 - 10053	
Temperature Log	1. 9-18-79	0 - 7150	
	2. 9-19-79	"	
	3. 9-19-79		
	4. 9-20-79	0 - 7140	
	5. 10-1-79	0 - 7958	
	6. 10-3-79	" 6000 - 7958	

EG&G Idaho, Inc.

FORM EG&G-561
(Rev. 1-77)

MEMO OF CONVERSATION

PERSON CALLING: F. W. Childs DATE 12-14-79

REPRESENTING: EG&G Idaho, Inc. TIME 8:45 A.M.

PERSON CALLED: Glen Green PHONE NUMBER (503) 889-8611

REPRESENTING: Ore-Ida Foods, Inc.

CITY: Ontario, Oregon

SUBJECT: Ore-Ida No. 1 Well
Informal Flow Test Results

DISTRIBUTION

EG&G	DOE-ID
R. J. Schultz	R. N. Chappell
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PON/PRDA Ltr File	L. L. Mink
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Nelson/Strawn/Childs	S. M. Prestwich
Central Files	

After noting water leakage from the flange joint at the wellhead, the following was done:

12-11-79: Cracked valve slightly for a few seconds; gas/liquid mixture expelled; no odor to gas; will get pressure and let flow.

12-13-79, P.M.: Shut-in pressure was 49 psig. Opened 2-in. valve for one minute; 30 sec. of water then mixture, water, mixture etc., until shut off. Pressure recovered to 20 psig almost immediately.

12-14-79, A.M.: Shut-in pressure was 40 psig. Opened valve and got a ~~solid~~ bubbly stream of water for almost ten minutes. Water warmed up enough to "steam" a little bit in the cold weather, but no idea what temperature was reached. The horizontal 2-in. pipe threw water 10-12 ft with about a 6 ft drop. Water was turbid, brown, opaque, silty, but had much less silt than is seen in nearby drain ditch after a rain storm.

17-79 68 psig shut in
Western Call 12-19-79

Wm. Hathaway is sending Glen an X-seal "O"-ring for the flange. Glen wants to get his yardwork done prior to dumping any more water. He will mail a water sample to me today for analysis while he gets his yardwork done. Then we can determine if geothermal water can be put in drainage ditch which runs to the Snake River or must be run over to Ore-Ida's storage ponds. The latter will be more expensive.

I cautioned Glen that if well flows while flange is removed, flow might increase substantially as the down-hole water column warms up. Pumping cold water down the hole could quench it, but GeothermEx/Hathaway should be consulted for a safe procedure prior to removing the blind flange.

SIGNATURE FW Childs

~~(CONTINUE ON REVERSE SIDE)~~

LOGIN UA-OREGON

A *7> WELLOG ~~Z~~ ORID-1

CO C_PLOT2

wait till get 2 out

CO C_PLOT3

wait till get 3 out

CO C_PLOT4

#7 hasn't been done

you can't have one executing while the other is plotting

#1 + 7 done

Ted -

I talked w/ Susan Prest -

today. She says Dick

McAtee (526-0258) in Tony

Allan's geochem group @ EG&G

feels from fluoride geochem

& Cl, No others -- that

there may be fluid entries

at 6250 and 9400 in

Ore Ida well

Mike

GeoThermex Inc.
James B. Koenig
901 Mendocino Ave
Berkeley Calif 94707

films, 5 blues, 1 sepia
415 - 524 - 9242
415 - 525 - 7096

Welex, 1801 Oak Street
Bakersfield, Calif. 93301

Preliminary

INITIAL DRAFT

ORE-IDA DRILLING AND TEST REPORT

ORE-IDA NO. 1 WELL

at

Ontario, Oregon

by

GeothermEx, Inc.

FWC

TABLE OF CONTENTS

FWC

TABLE OF CONTENTS (cont.)

Ore-Ida Resource Report

File Received 3-10-80

PART I

PRELIMINARY

Original Geothermal Prospect Concept

The selection of a site for a geothermal test well program at Ontario, Oregon, was based on a large body of regional and local geological and geophysical data from published and unpublished sources. These data were originally summarized in the Ore-Ida Technical Proposal, Volume I (Ore-Ida, 1977). They were supplemented in reports by CH2M-X Hill (1978) and by Gardner and Koenig (1978). They have been reviewed again here as a background against which to evaluate the significance of the results obtained from the drilling of the Ore-Ida Foods No. 1 well, at Ontario.

The Ontario, Oregon, site is located in the center of the western Snake River Plain, geomorphic province. This province is an arcuate structural and topographic depression which extends from about 25 miles (45 km) northwest of Ontario, eastward and northeastward across southern Idaho, to the vicinity of Yellowstone Park, Wyoming. The western limb of the depression is referred to as the Snake River Basin. This basin is bounded on the north by the mountainous region of central Idaho and on the south by the Owyhee uplift. At its northwest end it is terminated against the Blue Mountains uplift of east-central Oregon.

The existence of geothermal potential in the Snake River Basin is suggested by the history of late Cenozoic volcanism and tectonic activity. This general evidence is supported by the occurrence of thermal waters in springs and shallow water wells around the basin margins, in the Bruneau-Grandview area and at Givens Hot Spring on the south; at Cow Hollow, the Owyhee River Canyon and Vale on the northwest, and at Boise and Weiser on the north. Further evidence occurs in the relatively high geothermal gradients encountered in some deep hydrocarbon exploratory test wells drilled in the basin.

PRELIMINARY

A limited amount of geothermal exploration has taken place in the basin, consisting of temperature-gradient hole drilling, geochemical studies of thermal waters and local geological and geophysical work. However, only one deep test, the Phillips Petroleum Company Chrestesen A-1 (northwest quarter of Section 29, T. 11 N., R. 3 W.), near Weiser, has been drilled exclusively as a deep geothermal test. Apart from small-scale local uses of thermal waters from hot springs and shallow wells, no significant geothermal production has yet been established.

Several factors must combine to provide a geothermal resource of significant value. These include the existence of elevated temperatures and porous rocks capable of producing a useful fluid volume. In addition, these conditions must occur at depths at which they can be exploited with economic advantage. The studies discussed in the following sections of the report were carried out to determine if the conditions in the Ontario area are favorable for the development of the design resource and to assist in selecting a drillsite and designing an appropriate drilling program.

Geologic Setting

Predictions concerning the subsurface geology at the Ontario, Oregon, geothermal test site are dependent on data derived from the regional stratigraphic and structural setting. This regional data is derived from outcrop areas at the margins of the basin and from the scattered deep hydrocarbon and geothermal exploratory test wells drilled within the basin.

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Regional Stratigraphy

Pre-Miocene. The oldest rocks in the area consist of a great thickness of intensely deformed metasedimentary and metavolcanic rocks of Permian through Middle Jurassic age. They have been intruded by granitic stocks of Late Cretaceous and possibly Early Cenozoic age in the Owyhee and Blue Mountains and by the Idaho Batholith in central Idaho (plate). The Owyhee and central Idaho plutons appear to be part of a continuous, or formerly continuous, north-trending zone, now disrupted by the Snake River depression (Taubenick, 1971).

One deep well, the Phillips Petroleum Chrestesen A-1, drilled near Weiser, at the northern edge of the Snake River basin, penetrated granitic rocks. None of the wells in the axial part of the basin have reached pre-Tertiary horizons. Thus, the nature of the basement there is speculative. It may consist of downdropped granitic and metamorphic rocks, or it may be a wedge of new basaltic crust emplaced in a zone of rifting as the basin developed, partially or wholly replacing the granitic and metamorphic terrain (Hill, 1963).

The pre-Tertiary basement is separated from the overlying section by a profound unconformity. Plutonic rocks of Eocene age, falling in the range from 39 to 54 million years, have been identified in the Owyhee and central Idaho regions (Armstrong, 1975). Early Cenozoic sedimentary and volcanic rocks have not been reported in those parts of the surrounding uplifts adjacent to the basin and none of the deep wells in the basin have penetrated rocks recognized to be older than Miocene. Thus, the contention that the Snake River Basin had begun to develop in Oligocene time as proposed by Axelrod (1968) is not supported by any evidence that volcanic or sedimentary rocks of early Cenozoic age actually accumulated here.

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Miocene. Beginning in Middle or Late Miocene time, deposition of sedimentary and volcanic rocks was widespread throughout the region. Assemblages of these rocks from several of the outcrop areas bordering the present basin are shown in table . The section on the north side of the basin, near Weiser, consists of a thick section of lava flows interbedded with variable but subordinate amounts of altered tuff. The lavas are chiefly basalt containing calcic plagioclase, clinopyroxene and magnetite. Olivine or olivine pseudomorphs are usually present. Some flows contain olivine or plagioclase phenocrysts but most units are non-porphyritic. Two textural types are common. One is uniformly fine-grained and the other is ophitic, containing large clinopyroxenes. Some flows are slightly diktytaxitic (McIntyre, 1976). These rocks have been referred to as Columbia River Basalt in earlier publications. The best evidence of the thickness and character of the section occurs in the Phillips Chrestesen A-1 well, where about 6,850 feet of basalt flows interbedded with thin tuffs were penetrated.

In the Weiser area, the lava flow sequence is overlain by fine-grained sedimentary and volcaniclastic sedimentary rocks consisting of pumice lapilli tuff, vitric tuff altered to clay, and coarse arkosic sandstone. They are locally interbedded with or overlain by mafic lava and are intruded by dissordant to quasi-concordant basic rocks dated 10.0 ± .6 m.y. (McIntyre, 1976). These sedimentary rocks are at least partly equilivant to the Payette Formation of Late Miocene (Barstovian) age. However, due to poor exposures and uncertain contacts they may also include some overlapping sediments of the Idaho Group.

Further to the south and southeast, the section has been described as consisting of three units (Kirsham, 1931; Savage, 1958, 1961). The lowest is basalt, referred to as "Lower Columbia River Basalt." The middle unit is the Payette Formation, composed of fine-grained tuff, clay, silt, diatomite and coarse grained arkosic sandstone. This formation is highly lenticular and contains a Barstovian vertebrate fauna. It is overlain by basalt flows referred to as the "Upper Columbia River Basalt." The basalts in both the upper and lower sequence range from fine-equigrained rocks to coarse-grained diabase and porphyry. Many flows are vesicular or amygdaloidal.

A number of stratigraphic changes involving the interbedding of sedimentary units and basalt apparently take place between Weiser and Emmet but no detailed data have been published on these relationships.

The Miocene rocks in the Owyhee uplift, flanking the south side of the basin, are composed of more diverse lithologic types than those to the north. The section in the Silver City area consists of a "Lower Basalt" containing more than 2,500 feet of alkali olivine basalt. This basalt, dated provisionally at 16.6 m.y. old, is equivalent in age but mineralogically distinct from the tholeitic Columbia River Basalt. This section is overlain by a thick sequence of rhyolite and latite flows, tuffs and minor volcaniclastic sediments. The upper part of the section has been dated 15.6 to 15.7 m.y. old (Panze, 1975). South of the Bruneau-Oreana area, these rocks are overlain by 1,000 to 2,000 feet of latite flows and tuffs of the Idavada Formation (Malde et al., 1963). The Idavada Formation is of uncertain age in this area but it may be part of the Miocene section.

Along the northern end of the uplift, the Sucker Creek Formation, a thick assemblage of volcaniclastic sedimentary rocks of Barstovian age, is made up of interbedded ash flow tuffs and basalts. It appears to be equivalent to the Silver City volcanic section (Panze, 1975). Rhyolite flows locally overlie the Sucker Creek Formation near Owyhee Dam. Both formations are overlain by the Owyhee Basalt. This formation is about 1,300 feet thick. It contains numerous flows interbedded with abundant lenticular scoria and tuff beds. A wide variety of basalt textures are present, with the lower part of the section being more olivine rich and ophitic, while the upper part is microporphyritic and contains some flows with trachytic texture (Kittleman <u>et al</u>., 1965; Corcoran <u>et al</u>., 1962). The abundance of dikes and pyroclastic material indicates that many if not all of the flows were erupted from local vents.

Although it is difficult to typify the earlier parts of the upper Miocene rock suite in this region, it appears to be distinctive from younger rocks in containing a high proportion of predominately volcanic units. These may be basaltic, as along the north side of the basin, or contain large amounts of acidic rocks as well, along the south side of the basin. As a whole, sedimentary units make up a smaller proportion of the total rock volume than they do in the younger parts of the section.

Correlations between the Miocene surface sections exposed at the edge of the basin and the deep wells within the basin are generally uncertain due both to facies changes across the area and to uncertainties regarding the value of radiometric ages determined from well samples. However, several of these wells do appear to have penetrated parts of the Miocene volcanic section. Of these, the Phillips Petroleum Chrestesen No. A-1 encountered a thick section of Columbia River Group basalts, as noted above. Both the Halbouty James No. 1 well (southeast quarter Section 27, T. 4 N., R. 1 W.) and the Chevron Highland Land and Livestock No. 1 well (northwest quarter Section 24, T. 6 N., R. 5 W.) encountered basalts which are probably equivalent to the "Columbia River Basalt" or Owyhee Basalt. In this well, the underlying interbedded tuffs, volcaniclastic sediments and basalts are probably equivalent to the Sucker Creek Formation. In neither of these wells are the formation boundaries clearly defined.

Miocene volcanic rocks appear to be the units most likely to contain extensive aquifers with flow potentials capable of supporting geothermal development. By analogy with basalt aquifers explored in areas of Oregon and Washington, two types of porosity potential may occur. One consists of zones of high porosity and good permeability associated with flow breccias, interflow scoria zones and vesicular and brecciated flow tops. The other type of porosity is contained in a diffuse network of cooling joints and fractures in the lava flow interiors. In sections of this type, the porosity and permeability are low and the volume of fluids produced is proportional to the thickness of the flow section penetrated. Data on the porosity actually encountered in these rocks are limited. A few zones of lost circulation have been reported but they are not sufficient to outline regional aquifers. Formation tests were generally not carried out in oil and gas test wells because the basalts were not associated with the most important shows of hydrocarbons. Thus, there is no direct evidence concerning the nature and distribution of reservoir potential in the Snake River Basin basalts.

Late Miocene (Barstovian-Clarendonian) to Quaternary. It is uncertain from the data now available whether the Miocene volcanic section is thicker in the Snake River Basin than in the flanking uplifts. However, by late Miocene time a major period of basin development began, continuing episodically into the Pleistocene. During this period, subsidence took place along northwest-trending fault zones along the margins, while as much as 8,000 feet or more of lacustrine and fluvial sediments interbedded with subordinate amounts of basalt flows were deposited in the basin. The original depositional basin extended onto the edges of the Owyhee, Central Idaho and Blue Mountains, where subsequent uplift has exposed them.

Although the sedimentary and volcanic rock types are similar throughout the basin, the proportions of each vary rapidly from one area to another. This has given rise to difficulties in correlation and to the use of different formational nomenclature in the main outcrop areas (table). The best defined and most completely described stratigraphic section in the region is that in the Vale-Owyhee Reservoir area, Malheur County, Oregon (Kittleman et al., 1965; Corcoran et al., 1962). These stratigraphic units have been used by Newton and Corcoran (1962) in subsurface studies of the basin and appear to be the most appropriate nomenclature to utilize in the present study.

The section consists of three formations making up the Idaho Group, as defined by Kittleman et al. (1965). The oldest of these is the Deer Butte Formation. This unit rests on the Owyhee Basalt along an erosional and possibly angular unconformity. In the Owyhee River Canyon area it consists of about 1,000 to possibly 3,000 feet of volcanic sandstone, siltstone, claystone, vitric ash, arkosic sandstone, conglomeratic sandstone, thin basalt flows and shallow basaltic intrusions. The outcrop areas are probably close to the original edge of the deposition basin and coarse-grained sediments, representing a relatively high energy environment of deposition, are well-represented. Characteristic features of the sediments are the abundance of feldspar in the coarse sandstones and the abundant glass shards and pumice in the volcanic sandstones. The associated basalt flows are generally coarse-grained, holocrystalline, with ophitic texture. Flow tops are more or less vesicular. The Deer Butte Formation contains a vertebrate fauna of Late Miocene, Barstovian to possible Clarendonian, age. It was excluded from the Idaho group by Corcoran _et al_. (1962) on the basis of a pronounced unconformity separating it from the overlying Grassy Mountain Formation.

The Grassy Mountain Formation, middle formation of the Idaho Group, reaches a maximum thickness of about 1,100 feet in the type area west of the Owyhee River, but is generally thinner in the outcrop sections. It consists of interbedded pumice, arkosic and tuffaceous sandstone, thin granite cobble conglomerate, altered volcanic sandstone and flows of olivine basalt. The arkosic and tuffaceous sandstones resemble those of the Deer Butte Formation. The percentage of basalt flows interbedded in the total section varies greatly in different localities. The basalts are generally coarse-grained holocrystalline and ophitic. Porphyritic flows with very large plagioclase phenocrysts occur, and vesicular flow tops are common. The flow units are mostly less than 100 feet thick. The age of the Grassy Mountain formation is Clarendonian and Hemphillian, based on the occurrence of vertebrate faunas.

The Chalk Butte Formation is the uppermost unit of the Idaho Group in the western Snake River Basin recognized by Corcoran _et al_. (1962). It unconformably overlies Sucker Creek Formation, Owyhee Basalt and the older units of the Idaho Group at one place or another around the edges of the basin. In surface exposures at the basin margin, the Chalk Butte sediments are several hundred feet thick. These sections are not representative due either to erosion at the top or to their position near the edge of the original depositional basin. The lithologic types present in surface outcrops consist of tuffaceous conglomerate, sandstone and siltstone, with smaller amounts of fine ash, clay, diatomite and limestone. Both fluvial and lacustrine environments are represented. No basalt flows are interbedded in the surface section in this part of the basin. A Pliocene (Hemphillian) age has been assigned to the formation on the basis of vertebrate fossils found in it. Additional thin fluvial gravels and silts overlie the Chalk Butte Formation equivalents and are included in the Idaho Group exposed in the Nampa-Caldwell area (plate).

Several deep oil and gas exploratory wells have been drilled in the Idaho Group and correlations between some of these subsurface sections and the surface outcrop units have been made by Newton and Corcoran (1963). In the subsurface, the upper, non-volcanic part of the Idaho Group can be tentatively correlated with the Chalk Butte Formation. Only a few wells have been drilled into the sedimentary and volcanic rocks underlying the Chalk Butte. Correlations in this older part of the section are uncertain. The section in the H. K. Riddle Kiesel Estate No. 1 well (Section 8, T. 19 S., R. 47 E.), was divided into two parts by Newton and Corcoran (1963). The interval from the surface to a depth of 4,230 feet was assigned to the "Upper Idaho Sediments" (Chalk Butte Formation). In this well, some interbedded basalt flows were included in the lower part of the unit. Below 4,270 feet, the section was designated "Grassy Mountain Basalt Series." It consists of interbedded basalt flows and sedimentary rocks from 4,270 to 4,550 feet, and mainly basalt from 4,550 to the total depth of 5,106 feet. A comparison of this well with the more recently drilled Chevron Highland Land and

Livestock No. 1 well (Section 24, T. 6 N., R. 5 W.) suggests that the massive basalt section below 4,550 feet is part of the thickest and most continuous basalt sequence in the local area and that it may be correlative with the Columbia River Group or Owyhee Basalt rather than the Grassy Mountain.

Late Cenozoic Intrusive Rocks. Late Tertiary or Quaternary igneous activity characteristic of the central and eastern Snake River Plain extends about as far west as Caldwell, Idaho. Further to the west the only young igneous activity thus far recognized are two small intrusives. One of these, exposed at ____________ is composed of ____________. Another, encountered in the El Paso Natural Gas Company Federal No. 1 well (Section 5, T. 20 S., R. 44 E.) encountered thin diorite or gabbro intrusives and finally bottomed in intrusive rhyolite or dacite. These intrusives appear to be older than at least some of the Chalk Butte Formations but younger than Grassy Mountain Formations. They may be genetically related to the Double Mountain anticline in which they occur.

Predicted Section at the Ontario, Oregon, Wellsite

The thickness and character of the section likely to be encountered at a site in the vicinity of Ontario, Oregon, has been summarized below and in table . It has been based on regional stratigraphic data and on local seismic refraction work carried out for this report. The section is described from the surface down.

Idaho Group. The Idaho Group in the western Snake River Basin is characteristically made up of an upper unit of sedimentary rocks and a lower, consisting of interbedded sediments and basalt flows. The best-defined base of this section in the subsurface is the top of a thick, massive, basalt flow sequence. In the Ontario area, reflection seismic data suggest that the top of a reflector, possibly this massive basalt, occurs at a depth of about 6,200 feet.

Internally the Idaho Group can be subdivided in several ways but correlations with standard surface section members is difficult. In the wells closest to Ontario, the upper part of the section, above the first occurrence of basalt, varies from 3,820 feet in the Riddle Kiesel well to over 4,011 feet in the Ohio Kramlich No. 1 (Section 5, T. 9 N., R. 4 W.). Most, if not all of this part of the section appears to be equivalent to the Chalk Butte Formation. The lower part of the Idaho Group, consisting of variable proportions of relatively thin basalt flows interbedded with sediments, is believed to be equivalent to the Grassy Mountain and Deer Butte Formations of the surface section in the Owyhee uplift. This section is interpreted here to extend from 3,820 to 4,550 feet in the Riddle Kiesel well, a thickness of 730 feet. Based on regional gravity data the Kiesel well appears to be higher structurally than the Ontario area and the interbedded basalt and sediment section as well as the overlying entirely sedimentary section may be thinner here than at Ontario.

Columbia River Group or Owyhee Basalt. The massive basalt sequences encountered in the Riddle Kiesel well from a depth of 4,500 to the total depth of 5,106 feet (606+ feet), and in the Chevron Highland Livestock well from a depth of 4,170 to about 5,375 feet (1,200 feet ±) are tentatively interpreted here to be the most likely correlative of the thick basalt flow sequences found on the surface in the Owyhee Basalt and the Columbia River Group. Too few complete penetrations occur to establish thickness trends in the subsurface. It is assumed here that at least 1,200 feet of section made up predominately of basalt will be present at Ontario.

Sucker Creek(?) Formation. Interbedded basalt, tuff, claystone, siltstone and sandstone underlie the main basalt sequence in the Chevron Highland Livestock well, from a depth of 5,375 feet to the total depth of 11,963 feet. This section contains more abundant basalt flows than is characteristic of the surface outcrops of the Sucker Creek Formation and its true relationship to the established stratigraphic units in the area is uncertain.

Structure

The Snake River Basin is the western limb of an arcuate rift or compound graben extending across southern Idaho. Regional seismic surveys indicate that although the upper or granitic layer of the crust appears to be either absent to thin and intermittant, the total crust is thicker than that in the Basin and Range province to the south. This thick crust consists of thin, hot intermediate layer on top of a thick, hot, lower crust. It appears that the granitic layer has been altered, remelted, or is absent because of rifting and has been replaced by upward-moving mantle differentiate (Prodehl, 1970; Hill and Pakiser, 1967). This crustal model provides an explanation for the regionally high heat flow.

The Snake River Basin axis and most of the major structures associated with it trend in a northwest direction. This structural trend is strongly discordant to the north to northeast strike of the majority of the structures in the Basin and Range province to the south and the central Idaho uplift to the north (plate). The basin has apparently developed during several episodes of downfaulting followed by sedimentation which has sometimes transgressed over the fault zones. Unconformities occur along the south side of the basin between all of the major formations but the most notable occurs at the base of the Chalk Butte Formation (Upper Idaho Group) which rests on Sucker Creek Formation, Owyhee Basalt as well as the Grassy Mountain Formation from place to place. Important structures may be buried beneath this unconformity and lack expression in younger beds.

The amount of structural relief along the fault zone bordering the northwestern margin of the basin is indicated by a comparison of the elevation of the top of the Columbia River Group basalt near the basin edge with that of possible correlative basalt within the basin. In the Phillips Chrestesen No. 1 well, at the north edge, the top of the basalt occurs at about 2,500 feet above sea level, while at Ontario the reflector tentatively identified as massive basalt on seismic profiles, is at a depth of about 4,100 feet below sea level. This indicates structural relief of about 6,600 feet between the two areas. The amount of structural relief along the south side of the basin is more difficult to estimate but is likely to be of similar magnitude.

Gravity data described later indicate that there is considerable structural relief within the basin. The largest positive gravity anomaly is a long complex feature with several culminations, extending for about 50 miles from the vicinity of Nampa, Idaho to Malheur Butte, Oregon. This feature is paralleled on both the north and south by gravity lows. Stratigraphic changes, particularly an increase of basalt in the section in this area could contribute to the anomaly, but some of the effect is likely to be due to a large structural uplift in which the Miocene basalts are brought closer to the surface than in surrounding areas. It is interesting to note that the surface expression of this feature, if visible at all, is much less than would be expected from the amount of deep relief implied from the gravity data. This may indicate that the structure is largely buried by overlapping Upper Idaho Group sediments. The nature of this structure is not well known from published data. It is assumed here that the deep structure is a complex horst ridge bounded by important faults. The Upper Idaho Group sediments may be anticlinal over it. Several hydrocarbon test wells have been drilled on this structural trend but the off-structure well control is too limited to demonstrate the amount of structural relief and to compare the amount of basalt in the on- and off-structure sites.

In addition to the large northwest striking uplift, moderately detailed gravity data in the western part of the basin also show a major positive gravity anomaly striking north for 15 miles from Fruitland, Idaho through Payette and to the north a few miles. This trend is characteristic of the Basin and Range fault structures which are present of the region outside of the Snake River Basin, and it may indicate that the fragments of this disrupted fault trend are present beneath the basin. The exact location of the faults suggested by the gravity data cannot be defined on the basis of the limited control data available to this project. Subsurface information from deep wells are inadequate to define features of the intrabasin structure or to locate specific faults. Seismic surveys have been carried out by several exploration groups which would assist in structural definition. With the exception of the survey of one small area at Ontario, carried out for this project, all of the data are proprietary and not available for use here.

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Structure at the Ontario, Oregon, Drillsite

The surface in the vicinity is covered by varying amounts of alluvium overlying poorly-lithified sediments of the Upper Idaho Group. Exposures of bedrock are too poor to permit field mapping of any structures that might be present. Interpretations of aerial photographs to define geomorphic lineaments of possible structural origin are not known to have been made in this area. On the basis of regional gravity data, the site is located on the west flank of the north-trending Fruitvale-Payette gravity high and at least 5 miles north of the major northwest-trending Nampa-Malheur Butte anomaly. Although the structural significance of these features is uncertain, it is probable that the site is in a relatively structurally low part of the basin, although not in one of the deep closed lows appearing on the gravity maps. As noted above, the gravity data are not adequate for the location of specific faults which might be present.

All of the detailed structural data related to the site were derived from six reflection seismograph lines surveyed for this project (Applegate and Donaldson, 1978; Eis, 1978; Appendix ___). The quality of the seismic data vary from excellent to poor. Seven possible faults were detected, numbered I to VII on the accompanying plate ___. Faults I, II and III are the best-defined. They are associated with a northwest-trending horst block located in the southern part of Ontario.

(Insert, development & dip)

Two additional faults, numbers IV and V, based on less reliable data, were mapped in the northeastern part of Ontario, near the drillsite selected for the Ore-Ida No. 1 test well.

(Insert trend, dip & displacement)

The remaining two possible faults (VI and VII) are based on questionable data and require confirmation (Applegate and Donaldson, 1970).

The significance of faults to the location of the drillsite lies in their potential for enhancing fracture porosity in their vicinity and in the possibility that the fault zone may act as a conduit for ascending geothermal fluid.

In addition to faulting, interpretation of the seismic data suggested that "basement," here defined as the top of a massive basalt flow sequence, is apparently nearly flat-lying and is present at a depth of 6,000 to 6,200 feet (Ise, 1978).

Gravity

The regional reconnaissance Bouguer gravity map accompanying this report has been assembled from two sources (plate ___). That part covering southern Idaho is from Mabey (1974), while the adjacent area of Oregon is from private sources. The bases, scales and contour intervals are different in each source. They have been compiled here at a common scale, but no attempt has been made to reconcile the data.

The strike of the gravity contours conforms to the known regional structural grain, with northerly trends predominating on either side of the Snake River Basin and northwesterly trends characterizing the basin itself. The basin itself is dominated by a strong, narrow, northwest-trending positive anomaly from the vicinity of Nampa, Idaho, to Malheur Butte, Oregon, a distance of about 50 miles. This positive element is flanked by gravity lows. The relief between the highest and lowest areas varies from 30 to 50 milligals. This gravity pattern has been interpreted to represent an intra-basin graben filled with a great thickness of dense basalt at relatively shallow depth, and underlain by a deeper system of basalt-fill fissures (Hill, 1963). If this interpretation is correct, wells drilled on this feature should encounter much thicker sections of Grassy Mountain or older basalt above depths of 10,000 feet than occurs in flanking lows. At present, only one deep well has been drilled on this structure. This is the Chevron Highland Livestock well which reached a depth of 11,963 feet. The section encountered below the sedimentary rocks of the Upper Idaho Group did contain a considerable aggregate thickness of basalt, both as thick flow-on-flow sequences and interbedded with sedimentary rocks. However, there are no comparably deep wells located off the anomaly with which this section can be compared. In another interpretation, the anomaly could be caused, at least in part, by a horst buried beneath a relatively thin section of Idaho Group sediments, in which the normal section of Columbia River Group or equivalent basalts have been brought closer to the surface than in adjacent areas. This model also can not be tested with available well data.

Although northwest trending anomalies dominate the map, a strong north-trending positive anomaly extends for about 15 miles from the vicinity of Fruitland to north of Payette, Idaho. Not enough subsurface data is available to determine the structural significance of this anomaly, but it may be caused by a fault-bounded block belonging to the trend which extends toward the basin from the northern and southern margins. The gravity data are insufficiently detailed to closely define the location of the fault zones which are likely to be associated with either the northwest or north-trending features. Smaller-scale structures are also beyond the limits of resolution of these reconnaissance surveys.

The Ontario site area is located north of the Nampa-Malheur Butte trend and is on the lower west slopes of the Fruitland-Payette anomaly. To the west it is bounded by a deep gravity low. It is anticipated that a well drilled at Ontario will have either a thicker section of low density sediments (Upper Idaho Group) overlying basalt or a thinner aggregate section of basalt than locations on the anomaly axes.

Aeromagnetic Survey

The Total Field Magnetic Anomaly Map (plate ___) produced for this project from the data banks by the Geophysics Group at Oregon State University in 1978 has several interesting features. Significant area-wide trends as well as local features are observed in the 430 square km (130 square miles) within the map boundaries.

A very steep regional gradient appears with magnetic highs to the east. There is a decline from as much as 300 gammas in the east to zero (0) gammas in the west.

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Within this overview, there is a linear magnetic high which runs northward from the western side of Ontario for about 14 km (9 miles). Closure on this feature is about 40 gammas within 2.6 km (1.7 miles) distance to the east and west. It is not possible to rationalize this magnetic anomaly from the observed geology. It may reflect a buried fault, with west side up, bringing volcanic rocks surfaceward.

Two negative magnetic features occur on the map, centered about 4 km (2.5 miles) east and 14 km (9 miles) north of Ontario (center). The anomaly just east of Ontario coincides with the deep sediments at the confluence of the Malheur and Snake Rivers. It has a diameter of 6 km (3.5 miles) of closure, with relief of about 20 gammas. The second negative feature extends northward, off the mapped area. It has closure of about 10 gammas. The two features can be connected by a northerly oriented axial line. The trace of the axis would approximately coincide with the course of the Snake River.

There is no apparent reason from surface geology for the steep magnetic high east of Ontario. Some single lines of equal magnetic intensity near the northeast boundary of the magnetic low just east of Ontario trend northwesterly, but this is very tenuous support of northwesterly trending structures. The intense gradient 12 km (7 miles) northeast of Ontario, trending northwest, may indicate fault control near the margins of the Snake River depression, but Riens Estate No. 1, in S. 9, T. 8 N., R. 3 W., shows that the Idaho Group sediments are 1.4 km (4,800 feet) thick 22 km (14 miles) east of Ontario.

We may classically assume that the linear to circular high magnetic anomalies in the Ontario area signify relative thinning of nonmagnetic sections of sedimentary rocks, positions of Quaternary basaltic

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eruptive centers and diabasic intrusive masses. Intense gradients bordering magnetic highs and lows may indicate fault control. It is difficult to assign these classical conditions to any of the magnetic anomalies at Ontario.

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PART II

OPERATIONAL HISTORY AND DATA RECOVERED

History of Drilling Operations

The Ore-Ida Foods No. 1 well is located in the northeast quarter of Section 3, T. 18 S., R. 47 E., in the town of Ontario, Malheur County, Oregon. The drilling contractor was Montgomery Drilling Company, Bakersfield, California, using a National 55 rig. Mud-engineering services were provided by Western Mud Sales and Services Company, Bakersfield, California. The drilling operation was supervised by Mr. William Hathaway, drilling engineer, in association with GeothermEx, Inc., of Berkeley, California, who also carried out the wellsite geology responsibilities. A mud-logging unit was provided and staffed by Energy Log, Sacramento, California. Geophysical and temperature log services were provided by Welex, Woodland, California, and Pressure Service, Elk Grove, California.

The well was spudded in at 9:00 A.M., 18 August 1979. A 17-1/2-inch hole was drilled to 925 feet, where 13-3/8-inch casing was set on 22 August. The mud-logging unit was in operation from 54 feet to total depth. No geophysical or temperature logs were run before setting 13-3/8-inch casing. This part of the hole was drilled with 67- to 68-pcf (pounds-per-cubic-foot) lignosulfonate mud with a viscosity of 38 to 42 ____________(units?).

After installing the blow-out preventers, drilling resumed in a 12-1/4-inch hole from 925 to 7,154 feet, where geophysical logs and temperature surveys were run by Welex on 18 to 20 September. Drilling continued to 7,958 feet, where a second suite of geophysical and temperature logs were run on 1 and 2 October. The mud was gradually changed from about 67 pcf, viscosity 38 _______, pH 9.0, at 925 feet, to 82 pcf, viscosity 43 ______, pH 11.5, at 7,152 feet. This change was made to control sloughing and to keep the hole clean. The mud weight was inadvertently increased to 88 pcf while drilling at 7,169 feet. Concurrently, lost circulation was encountered. Circulation was regained by slowly reducing the mud weight to 82 pcf and adding lost circulation material. A mud cooling unit was installed at a depth of 7,655 feet. This unit operated intermittently thereafter for the duration of the drilling operation. Drilling continued to a depth of 8,188 feet. Core number 1 was cut from 8,188 to 8,216 feet. Twenty-six feet of core were recovered. Then 9-5/8-inch casing was run to 8,183 feet. Blow-out preventers were reinstalled and tested. Below 8,183 feet, an 8-1/2-inch hole was drilled to a total depth of 10,054 feet, reached on 8 November. The drilling fluid was changed to water from 8,183 to 8,400 feet. Drilling in this interval was characterized by excessive sloughing and fill on bottom, culminating in a stuck drill pipe. The mud weight was built back to 83 to 85 pounds per cubic foot and the bad drilling conditions were corrected. On reaching the total depth, geophysical and temperature logs were run from 8 to 10 November, and 7-inch slotted liner was suspended from 8,142 to 10,038 feet, on 13 November. The slots extend from 8,187 to 10,036 feet, are 125 mesh, in 8 rows, 2 inches long, with 6-inch centers. The mud in the hole was replaced with water in preparation for testing. While waiting on testing equipment, additional wireline temperature surveys were run in selected intervals. The testing operations were conducted from 16 to 18 November and from 24 through 27 November. The results are described below. After completion of these tests, the rig was released on 27 November, at 12:00 noon. The hole was left suspended pending further testing. A total of ______days were spent on drilling, ________days on logging and testing, and ________days on rig repairs and other non-drilling operations.

Detailed records of the drilling operations are included in Appendix G, Summary of Drilling Operations; Appendix H, Daily Geological Reports; and Appendix E, Well Testing.

Down Hole Logs and Surveys

The following is a list of surveys carried out in the hole. The actual survey results will be found in the appendices indicated.

Geophysical well logs. All of these logs were run by Welex, based in Woodland, California (see table ___). Copies of the logs are included in Appendix I.

Temperature surveys. The Welex logs, Pressure Service wireline survey data, and maximum-reading thermometer records can be found in Appendix J. For convenience, the maximum-reading thermometer data are also tabulated in table ___.

Dipmeter survey. This survey was carried out by Welex. The data sheets can be found in Appendix C.

Date	Run	Interval
10/2/79	1	925-7,956 feet
11/9/79	2	8,180-9,931 feet

b. Temperature Buildup on Bottom

Date	Period	Time on Bottom (10,054 feet) (hours)
11/16/79	1:00 A.M. - 5:00 A.M.	4
11/17/79	12:26 A.M. - 4:30 A.M.	4
11/18/79	10:30 P.M. - 2:30 A.M.	4
11/18/79	5:00 A.M. - 9:00 A.M.	4
11/25/79	8:50 P.M.-12:50 A.M.	4

3. Maximum-Reading Thermometer Data (obtained while running other surveys)

Survey	Date	Run	Time Since Last Circulation (hours)	Depth (feet)	Time on Bottom (minutes)	Maximum Temperature (°F)
Totco	8/25/79	-	1	3,151	45	126
Totco	9/3/79	-	2	4,565	40	165
Totco	9/7/79	-	10	5,212	40	192
Totco	9/10/79	-	7	5,805	60	200
Totco	9/12/79	-	7	6,200	30	230
Welex Dual Induction	9/18/79	1	11	7,150	--	236
Welex Fracture Finder	9/18/79	1	15	7,148	--	255
Welex Acoustic Velocity	9/18/79	1	19	7,148	--	264
Welex Density	9/19/79	1	29	7,150	--	302
Welex Dual Induction	10/1/79	2	7-3/4	7,956	--	235
Welex Acoustic Velocity	10/1/79	2	11-3/4	7,952	--	270
Welex Dual Induction	11/8/79	3	13	10,053	--	320
Fracture Welex Finder	11/8/79	3	15	10,047	--	368

TABLE

TEMPERATURE SURVEYS

1. Welex Temperature Logs (Continuous Recording)

Run	Date	Hours After Last Circulation	Interval	Log Bottom Hole Temperature	Maximum-Reading Thermometers
1	9/18/79	8	0- 7,150	222°F	
2	9/19/79	24	0- 7,150	272°F	
3	9/19/79	39-1/4	0- 7,150	293°F	305°, 314°, 314°, 323°, 328°
4	9/20/79	50-3/4	0- 7,140	295°F	290°, 318°, 318°
5	10/1/79	26-1/4	0- 7,958	267°F	286°, 300°
6	10/2/79	39-1/4	0- 7,958	270°F	316°, 318°, 332°
7	10/2/79	44-1/4	6,000- 7,958	283°F	288°, 304°, 308°
8	11/9/79	29	0-10,053	336°F	317°, 317°
9	11/10/79	50	0- 9,400±	Unknown, tool stopped	320°, 350° (at 9,300 ±)

2. Pressure Service

a. Wireline Survey

Date	Time	Run	Log Interval (feet)	Station Interval (feet)	Time on Bottom (minutes)
11/15/79	6:56 P.M.	1	7,000-10,000	200	30
11/15/79	9:58 P.M.	2	7,000-10,000	200	30
11/16/79	12:58 A.M.	3	7,000-10,000	200	30
11/17/79	?	?	7,000- 9,870	200	30
11/24/79	2:30 A.M.	-	6,000- 9,960	Variable	6

TABLE

GEOPHYSICAL LOGS

Log Type	Date	Run	Interval	Scale	Comments
Dual Induction Guard Log	9/18/79	1	925- 7,150	1"= 50'	
	10/1 /79	2	7,150- 7,956	1"= 50'	
	11/8 /79	3	8,182-10,053	1"= 50'	No log 7,956-8,182
	9/18/79	1	925- 7,150	1"= 20'	
	10/1 /79	2	7,150- 7,956	1"= 20'	
	11/8 /79	3	8,182-10,053	1"= 20'	No log 7,956-8,182
Compensated Acoustic Velocity Log (with Gamma Ray and Caliper)	9/18/79	1	925- 7,148	1"= 50'	
	10/1 /79	2	7,148- 7,952	1"= 50'	
	11/8 /79	3	8,182-10,048	1"= 50'	No log 7,952-8,182
	9/18/79	1	925- 7,148	1"= 20'	
	10/1 /79	2	7,148- 7,952	1"= 20'	
	11/8 /79	3	8,182-10,048	1"= 20'	No log 7,952-8,182
Compensated Density Log (with Gamma Ray and Caliper)	9/19/79	1	925- 7,150	1"= 50'	
	10/3 /79	2	7,150- 7,955	1"= 50'	
	11/8 /79	3	8,182-10,053	1"= 50'	No log 7,955-8,182
	9/18/79	1	925- 7,150	1"= 20'	
	10/3 /79	2	7,150- 7,955	1"= 20'	
	11/8 /79	3	8,182-10,053	1"= 20'	No log 7,955-8,182
Fracture Finder-Microseismogram Log	9/18/79	1	925- 7,148	1"= 20'	
	10/1 /79	2	7,148- 7,952	1"= 20'	
	11/8 /79	3	8,180-10,047	1"= 20'	No log 7,952-8,180
Neutron-Microseismogram Log--cased hole (with Collar Log)	11/9 /79	1	6,800- 8,198	1"= 20'	

Deviation surveys. Totco wireline deviation surveys were made regularly during drilling. The results of these surveys are listed below:

Depth	Deviation	Depth	Deviation
925'	0°15'	5,151'	1°30'
2,049'	1°15'	5,834'	1°30'
2,584'	1°45'	6,261'	1°00'
3,131'	1°45'	7,320'	0°30'
3,652'	0°15'	7,660'	0°30'
4,722'	1°30'	9,068'	0°45'

Mud log. A mud logging unit was provided and staffed by Energy Log. The unit operated from a depth of 54 feet to the total depth of 10,054 feet. The unit recorded the drilling rate, lithology, mud flow line temperatures, ditch gas analysis including CO_2, H_2S and total hydrocarbon gases. A chromatograph analysis of the gases was carried out below 4,120 feet. A synopsis of mud character and various operational occurrences were also included. A copy of the log is contained in Appendix D.

Testing Operations

A testing program was carried out to evaluate the productive potential of intervals in which porosity was calculated to be present from log analysis. The testing program was restricted to depths below 6,500 feet, within the zone in which temperatures of interest to this project could be obtained. The logs of porous intervals higher in the well were examined for porosity and hydrocarbon gas saturation but none appeared worthy of testing for their hydrocarbon potential alone. A detailed discussion of the logs can be found in Appendix F. The intervals with the best porosity potential are summarized below. It should be noted that all intervals above 8,183 feet are behind the 9-5/8-inch casing and all below that depth are covered by the 7-inch slotted liner.

Interval (ft)	Comments
6,580- 6,665	Several thin porous zones are present in this sandstone interval.
6,950- 7,015	Sandstone in this zone contains the best evidence of permeability in the section.
7,050- 7,140	Fractured basalt/diabase, possible zone of lost circulation.
8,160	Fractured basalt/diabase.
8,200- 8,240 8,330- 8,390	Discontinuous fractured zones in basalt/diabase, of doubtful value.
8,450	Fractured tuff, of doubtful value.
8,475- 8,510	Fractured basalt/diabase, of doubtful value.
8,730- 8,840	Fractured basalt/diabase.
8,970- 8,990	Discontinuous fracture zones in basalt/diabase, of doubtful value.
9,020- 9,240	Fractures in basalt/diabase.
9,790- 9,810	Fractures in basalt/diabase and tuff(?), of doubtful value.
9,880- 9,890 9,920- 9,930	Fractures in basalt/diabase, of doubtful value.
9,985-10,010	Fractures in basalt/diabase.

PRELIMINARY

Testing was carried out in several stages, beginning at the bottom of the hole. Details of testing procedures can be found in Appendix E.

1. All of the zones between 8,183 feet and 10,054 feet, covered by the 7-inch slotted liner, were tested together, as follows:

   11/16/79. Ran in with drill pipe to 6,012 feet, pumped in one barrel of foamer and blew well around with nitrogen down the drill pipe. Well would not unload. Ran drill pipe to 10,014 feet and blew well around with nitrogen.

   11/17/79. Perforated slotted liner, four 4-inch SSB jets per foot, in the intervals 8,730-8,750, 8,760-8,780, 8,790-8,810, 8,820-8,840, 9,020-9,040, 9,050-9,070, 9,080- 9,100, 9,110-9,130, 9,150-9-170, 9,190-9,210, 9,220-9,240, 9,790-9,810, 9,875-9,895. The perforator would not penetrate below 9,897 feet. Ran drill pipe to 10,014 feet, blew well with nitrogen.

2. The zones above 8,183 feet are behind 9-5/8-inch casing. The following were perforated by shooting four 4-inch SSB jets per foot in selected intervals.

   11/24/79. The casing was perforated from 5,980-6,000, 6,580-6,640, 6,955-7,015, 7,060-7,140, 7,770-7,790, 7,905-7,925 and

8,320-8,340 feet. The drill pipe was run in to 8,350 feet on 11/25/79. Blew the well with nitrogen down the drill pipe.

A wireline pressure survey was run.

11/26/79. Perforated additional intervals from 6,975-7,015, 7,060-7,140, 7,770-7,790 and 7,905-7,925 feet. Ran drill pipe to 7,950 feet and blew well with nitrogen down the drill pipe.

Ran wireline pressure survey to 7,900 feet.

Fluid rose from 6,855 to 6,091 (764 feet) in 3 hours. The calculated rate of influx is 13 gallons per minute.

Subsurface Geology

This part of the report contains a summary of the stratigraphy and reservoir character, structural data, thermal regime and hydrocarbon occurrences found in the hole.

Stratigraphy. The section encountered during the drilling of the well has been recorded on the mud log (Appendix D) and in the sample descriptions made with a binocular microscope by the wellsite geologist (Appendix A). In addition, selected samples have been thin-sectioned and examined with a petrographic microscope (Appendix B). These descriptive data combined with the geophysical logs (Appendix I) provide a clear picture of the lithologic character and unit boundaries of the strata found in this well. A graphic summary of the lithologies is shown on plate ___. Correlation of the section with that in other wells or with surface stratigraphic units defined at the margins of the basin is difficult. The units outlined below reflect the most obvious changes in the sequence in the well; they do not conform to the correlation framework of Newton and Corcoran (1963). The relationship of the well to regional stratigraphy will be discussed in a later section of the report.

The well was spudded in Quaternary alluvium, the base of which appears to be in the unlogged part of the hole above a depth of 60 feet. The major units below this depth were as follows:

60'-4,570'. The predominant sedimentary lithologies of this interval are weakly-indurated siltstone, silty claystone and non-fissile claystone. Subordinate amounts of sandy siltstone and sandstone are present in several intervals. The fine-grained sediments are light to medium gray or light tan. The recognizable minerals consist of clay, quartz, altered volcanic glass and traces of mica. The sandstones and silty sandstones are light gray, very fine to medium-grained. They contain subangular to subrounded quartz, feldspar, mica and occasional minor red-brown to black siliceous rock fragments. Recognizable glass shards are sometimes present. A silty matrix is common. Minor lithologic types in this part of the section consist of thin silty limestones as beds or concretionary zones, and thin, white, very fine-grained, altered tuffs. The tuffs are particularly well developed in the intervals from 3,585 to 3,800 feet and from 4,125 to 4,160 feet. Porosities have been calculated from geophysical logs for the cleanest-appearing sandstones. These range widely from 10 or 11 percent to as high as 45 percent in one thin interval, but most of the porosities range from 25 to 33 percent. Intervals for which porosities have been calculated are listed in Appendix F.

All of the zones in this interval with calculated porosity potential are at too low a temperature to be of interest for production of geothermal fluids of the type required for this project and none of these zones were tested. In the past, sandstones in this interval have been explored for hydrocarbon gas by several wells. The gas occurrences encountered in this hole are discussed in a later section of this report. None appeared to warrant testing.

This part of the section is similar to the Chalk Hills Formation, defined by Corcoran et al. (1962) as the upper member of the Idaho Group in this area. The section is comparable in character to that in nearby wells but appears to contain less abundant sandstones. The base of the interval is the top of the first basalt/diabase and the section defined in this way is about 4,500 feet thick. This is several hundred feet thicker than a comparable interval in nearby wells (table ___).

The base of the upper unit of the Idaho Group has been picked in this well at the first major change in lithology. This is the first occurrence of basalt/diabase. An alternative subdivision could be made, in which the base of the section is moved down to about 5,300 feet. This interpretation is supported by dipmeter data which suggest that an unconformity may exist at about this depth. In this case, two basalt/diabase units (4,570-4,665 feet and 5,150-5,302 feet) would be added to the unit. This alternative subdivision agrees more closely with the breakdown of the section used by Newton and Corcoran (1963), as extended to the H. K. Riddle Kiesel Estate No. 1 well (southwest quarter, Section 8, T. 19 S., R. 47 E.) (plate ___). However, in either interpretation of the boundary, the igneous and sedimentary rocks on both sides are similar to one another and the regional significance of the stratigraphic boundary is uncertain.

4,570'-8,135'. The top of this interval is the first basalt/diabase unit encountered in the hole. Alternatively, as noted above, the top of this unit may be drawn at about 5,300 feet, on the basis of dipmeter evidence of an unconformity at about that depth. Although the presence of igneous rocks characterizes the interval, they are a subordinate part of it. The depths at which they occur are listed below:

Interval (ft)	Thickness (ft)	Log Defining the Unit
4,570-4,665	95	Acoustic Velocity
5,150-5,302	152	Acoustic Velocity, Gamma Ray
5,580-5,660	80	Acoustic Velocity
6,030-6,292	262	Acoustic Velocity, Density
7,015-7,145	130	Acoustic Velocity

These rocks make up an aggregate thickness of 719 feet in a total interval of 3,565 feet. The base of the unit is defined

PRELIMINARY

TABLE

COMPARISON OF THICKNESS OF SUBSURFACE STRATIGRAPHIC INTERVLAS

Amount	Ore-Ida Foods No. 1 (feet)	Riddle Kiesel Estate No. 1 (feet)	Chevron Highland Livestock No. 1 (feet)	Oroco Johnson No. 1 (feet)
Surface to top of first basalt/diabase	4,570	3,820	3,760	3,992?
First basalt to top of massive basalt	3,565	680±	410 maximum	------
Thickness of basalt-dominated section	1,919+	606+	1,205+ (Correlations uncertain)	------

PRELIMINARY

here as the top of the first thick basalt/diabase in an underlying section made up mainly of that rock type.

The so-called basalt/diabase rocks in this part of the section are known only from cuttings. Megascopically they are all similar to one another. They consist of a phaneritic, holocrystalline, fine-grained, basic rock. No orientation of mineral grains was noted. The main minerals recognized are thin, tabular, white to glassy plagioclase feldspar crystals surrounding or surrounded by brown glassy pyroxene. Olivine is difficult to recognize but opaque, black, magnetic minerals are common. Many samples show a diffuse greenish color due to partial alteration. Secondary minerals, probably lining fractures, are soft, green serpentine and chlorite-like materials. Traces of quartz, calcite and zeolite(?) also occur in fractures. No evidence of vesicles, amygdules or red coloration, characteristic of basalt flow tops, was seen. The texture as well as the absence of features commonly found in flows suggest that these rocks might be diabases, perhaps present as intrusives rather than as basalt flows. However, flows with similar textures have been reported from the Columbia River Group by Savage (1958), Owyhee Basalt by Corcoran et al. (1962) and from the Deer Butte Formation.

Petrographic studies show that these rocks are mildly altered ophitic to subophitic, intergranular and intersertal olivine basalts or diabases, with no recognizable flow textures. These more-detailed studies could not resolve the uncertainty as to whether the rocks are flows or hypabyssal intrusives.

PRELIMINARY

One notable exception in the character of these rocks occurs from 6,085 to 6,240 feet. This material is made up of an aphanitic, granular matrix containing scattered fragments of pyroxene, plagioclase and magnetite crystals. The matrix has been extensively altered to chlorite and mica with laminar orientation surrounding the larger broken crystals. The rock may be an altered pyroclastic, or it may be of cataclastic origin.

The sedimentary rocks interbedded with the basalt/diabase units consist of claystone, siltstone, sandstone and altered tuff. They differ only slightly in character from the sediments above 4,570 feet. The fine-grained rocks are more brown-gray than gray, and both sandstones and tuffs are more abundant than in the upper part of the hole. All of these rocks may also be slightly better-indurated than those above. However, in the absence of the interbedded basalt/diabase units it is unlikely that the sediments would appear to be sufficiently distinctive in character to warrant separation from those in the interval above 4,570 feet.

Evidence of porosity in fractured intervals in basalt/diabase and in sandstones is suggested by the geophysical logs of this interval. The best apparent porosity development in the igneous rocks occurs from 6,050 to 6,202 feet and 7,050 to 7,140 feet. Lost circulation occurred while drilling at 7,160 feet, possibly associated with the second zone. Only this zone is located in the interval with temperatures high enough to be of interest to the project. The sandstones in the sedimentary section have porosities interpreted to range from 10 to as high as 29 percent locally. The best evidence for both porosity and permeability in the range of acceptable temperatures occurs from 6,595 to 6,650 feet and 6,970 to 6,980 feet (Appendix F). Formation testing was carried out through perforations in the casing opposite both of these intervals as well as other selected zones from 5,980 to 8,340 feet. After blowing the hole with nitrogen above 7,950 feet, the water level rose 764 feet in 3 hours. This indicates a flow of about 13 gallons per minute from the entire zone of casing performations. All of these zones were tested together and the precise source of the fluid is uncertain.

Correlations of this interval with adjacent wells and the formal stratigraphic units of the region are uncertain. The 3,820 foot-thick section of interbedded basalt/diabase and sedimentary rocks in the Ore-Ida well from 4,570 to 8,135 feet may be correlative with the 730-foot-thick section between 3,820 feet and 4,500 feet in the Riddle Kiesel well. In that well, the interval has been assigned to the "Grassy Mountain Basalt," middle Idaho Group, by Newton and Corcoran (1963). In an alternative correlation preferred here, it may be equivalent to the combined Grassy Mountain and Deer Butte Formations of the northern Owyhee uplift surface section (Corcoran et al., 1962).

8,135'-10,054' (T.D.). The top of this interval was chosen at the top of the first massive basalt and the section is characterized by a predominance of thick basalt/diabase units separated by relatively thin sedimentary interbeds. The sediments amount to an aggregate of about 490 feet of the 1,919-foot interval. Under a binocular microscope the igneous rocks are mainly phaneritic, fine to very fine-grained, holocrystalline rocks, made up of randomly oriented plagioclase laths surrounding or surrounded by brown pyroxene. The amount of olivine is uncertain but a black magnetic opaque mineral is common. The texture and composition of these igneous rocks appear to be similar to those in the 4,570 to 8,135-foot interval. They differ slightly in containing a significant percentage of associated aphanitic to porphyritic and glomeroporphyritic samples. The fine-grained rocks are partly altered to green secondary minerals. Chlorite and serpentine-like minerals, derived from alteration along fractures, are common. No vesicles, amygdules or oxidized material which would suggest flow tops were observed in the samples. The rocks have been tentatively called basalt/diabase here, as above, until more conclusive evidence of their mode of occurrences can be found.

A petrographic study of selected cuttings and of a single core were carried out (Appendix B). The phaneritic rocks are mildely altered olivine basalts or diabases essentially identical to ~~that~~ those in the 4,570 to 8,135-foot interval. The associated aphanitic to porphyritic rocks are finer grained basalts lacking olivine, and bearing features characteristic of flow rocks including flow-oriented crystals, occasional fine amygdules, and (rare) glass. Generally, the olivine basalts/diabases and the finer flow basalts are quite distinct, leaving open the possibility that at least some of the former are intrusives

PRELIMINARY

There is no evidence of a sharp ~~textural or~~ compositional break between the basalt/diabase of this and the preceding intervals and there may be no real genetic difference between them.

The sedimentary rocks between flows consist mainly of fine-grained devitrified, more or less silicified white tuff, tuffaceous sandstone and light to medium brown-gray siltstone. Quartz-feldspathic sand and siltstones which resemble tuff appear in thin-section samples from 9810-9820 and 10,010-10,020 (Appendix B).

No evidence of flow-top vesicular or breccia zones was observed. Fractures are scattered widely throughout the basalt/diabase and silicified tuff. A cumulative total of 400 to 500 feet of section with potential fracture porosity is present based on analysis of the geophysical logs (Appendix F). As noted above in the discussion of well testing, the entire interval was tested as a unit, through the slotted liner. No significant amount of formation fluid was obtained. From this it appears that the fractures are not open and intercommunicating.

This basalt/diabase-dominated interval is believed to be correlative with the massive basalt occurring below 4,500 feet in the Riddle Kiesel well and below 4,170 feet in the Chevron Highland Land and Livestock No. 1 well (northwest quarter of Section 24, T. 6 N., R. 5 W.). The incomplete section in the Kiesel well was included in the "Grassy Mountain Basalt" by Newton and Corcoran (1963). In view of its thickness in the more recently drilled wells in the area, it is considered here to be correlative with the main Miocene basalt sequences of the Owyhee Basalt or Columbia River Group.

The top of the massive basalt at 8,135 feet is believed to be the horizon predicted to occur at about 6,000 feet by reflection seismograph studies carried out in the Ontario area, prior to drilling the well (Applegate and Donaldson, 1978). This basalt interval was the main reservoir objective of the well. Between 8,135 feet and the total depth of 10,054 feet an aggregate thickness of about 2,150 feet of basalt/diabase was penetrated. There is no evidence that the base of the basalt/diabase dominated section had been reached at the bottom of the hole.

Structure. Structural data from the hole are limited to the dipmeter survey in the interval from 925 to 7,956 and 8,180 to 9,931 feet, to possible evidence of faulting based on lithology and to inferences about structurebased on correlations between this well and others in the region.

The dipmeter data are variable both in amount and azimuth of dip. However, some trends are discernable (Appendix G). They are listed in table ___. The most prominent structural break occurs in the change from a predominantly southwest azimuth above the basalt/diabase at 5,150-5,300 feet to the southeast or east-southeast azimuth below. This change does not occur at one of the important lithologic boundaries but may represent a major structural event in the overall history of subsidence of the basin in which the Snake River Group was being deposited. Based on very limited data, the southeast dip persists at least as deep at the 9,240 to 9,510 feet. The significance of this possible unconformity is discussed in a later section of the report.

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Other, more local changes are not well enough defined to evaluate, except in the 5,660 to 6,030-foot interval. A discordant northeast azimuth and higher than normal dips are found here, confined to a section of tuffaceous and silty sandstone. The exceptional dip and azimuth here may reflect cross-bedding or a structural disturbance near a fault.

The only direct evidence of structure in the rock samples occurs in the possible cataclastic textures reported in the basalt/diabase from 6,085 to 6,240 feet. This material may come from a fault zone, although a non-structural origin is possible. Correlations in the area are too poor to indicate whether section has been duplicated or cut out across either the dipmeter anomaly or the possible cataclastic zone. Either of these zones might represent the faults designated IV or V, suggested from the reflection seismic survey carried out in the Ontario area for this project (Applegate and Donaldson, 1978; Ise, 1978).

The structural implications of thickening in the section between the Ore-Ida well and other deep holes in the region support the earlier indications from gravity data that this well lies in a basinal position rather than on one of the major intrabasin uplifts. The well correlations also indicate a major period of basin subsidence contemporaneous with deposition of the sedimentary and basalt/diabase from 4,570 to 8,135 feet. Regional implcations of the well data are discussed in a later section of this report.

<u>Thermal regime</u>. Temperature data from the well are compiled in Appendix I and much of this data has been plotted on plate ___, in conjunction with other well data.

$\underline{CO_2}$ and H_2S gas occurrences. Both of these gases commonly occur in association with geothermal fluids, both in the reservoirs and in halos around the main fluid systems. In the Ore-Ida Foods No. 1 well, they were monitored and recorded on the mud log (Appendix D). Of these gases, CO_2 is present in widely varying amounts throughout the well. The variations reflect both actual entries of the gas into the hole and its varying retention in the mud due to changes in bacterial action, changes in mud pH and viscosity. From 4,000 to 7,150 feet the average CO_2 content was relatively high. It decreased in the sedimentary section from 7,150 to 8,135 feet and increased again in the predominantly volcanic section from 8,135 to 9,250 feet. It was variable, but generally lower, in the volcanic and sedimentary interval below 9,250 feet. In view of the non-geologic factors which influenced the occurrence of this gas, no clear relationship of the zones of high concentration and potential geothermal fluid-containing zones is apparent in this hole.

The level of H_2S gas in the mud was near or below the level of detection (1 ppm or less) throughout the hole, with the exception of two narrow zones. One of these occurred in the interval from 6,105 to 6,185 feet, where a peak of about 7 ppm was recorded near an interval of increased penetration rate in basalt/diabase (6,105 to 6,115 feet). This interval may be a gas-bearing fracture. The second zone occurred from 8,660 to 8,750 feet where a slight increase with a peak of 2 ppm, also in basalt/diabase, was recorded.

H_2S and CO_2 logs of this well do not show maxima which can be uniquely associated with zones of porosity determined from log analysis.

Hydrocarbon occurrences. The Snake River Plain has been the site of several episodes of drilling for hydrocarbons, and non-commercial gas shows have been encountered in several wells in the region. Although the primary purpose of the Ore-Ida well was to test the geothermal potential of the prospect, the manner of drilling and logging the hole was sufficiently similar to that of a hydrocarbon test well that the oil and gas potential was also determined here. The possibility of the occurrence of hydrocarbon gases was important both for the economic potential of the gas and for the hazards to drilling that non-economic pockets of high-pressure gas might create.

Hydrocarbon gas abundances are relatively high above a depth of 7,250 feet and are particularly low below 9,150 feet. The highest concentrations occurred in the sandy interval from 6,585 to 7,015 feet, in an interval with evidence of significant porosity and permeability on geophysical logs. Other peaks in the ditch gas curve occurred opposite thin sandstones from 1,090 to 1,105 feet and 1,440 to 1,455 feet. Small peaks occur opposite other thinly bedded sandstones or siltstones in the interval from 1,000 to 3,250 feet. This general interval is comparable to that in which the major gas shows have been reported in other wells. Methane is the most abundant but not the only hydrocarbon gas present. The gas chromatograph indicated that detectable quantities of C_2 through C_5 gases also occur.

Based on analysis of the gas shows and of the geophysical logs, the gas saturation was not adequate in any zone to warrant testing. Flow testing in the interval of high apparent porosity and permeability from 6,580 to 6,665 feet was not carried out separately from other zones in the broad interval from 5,980 to 8,340 feet. However, no significant amounts of gas were recovered.

In addition to gas shows, traces of solid bitumen were observed lining fractures in the bottom foot of core No. 1 (8,188 to 8,215 feet). This material gave a yellow flourescence and a cut flourescence with chloroethane.

PRELIMINARY

PART III

RE-EVALUATION OF GEOTHERMAL PROSPECTING AT ONTARIO, OREGON AND IN ADJACENT PARTS OF THE SNAKE RIVER BASIN

Introduction

The results from the drilling of the Ore-Ida Foods No. 1 deep geothermal test have a two-fold significance for geothermal prospecting in the Snake River Basin. One of these concerns the evaluation of additional drillsites in the Ontario area and the potential for developing production to meet the design specifications of the Ore-Ida project. The other, concerns the application of this well data to geothermal prospecting in the Snake River Basin in general. Conclusions relating to both will be presented in this section of the report. These conclusions will be supplemented by recommendations for additional work which would be directed toward reducing exploration risk in prospecting in this region.

As discussed earlier in this report, the essential ingredients required for a successful geothermal exploration result are the existence of temperatures at or above the level required for the anticipated uses, the presence of reservoir rocks within the zone of the desired temperatures and containing porosity and permeability capable of sustaining fluid production at economic levels, all occurring together at depths from which the fluid can be produced with economic advantage. The choice of sites at which these conditions can be met with the highest probability of success depends on the availability of adequate stratigraphic structural, hydrologic and temperature gradient data. While much important data of this type has been accumulated both by public agencies and by private companies involved in hydrocarbon and geothermal exploration, several important geologic problems remain which bear on the existence of an exploitable geothermal resource require further study.

Evaluation of the Ontario, Oregon, area.

The Ore-Ida Foods No. 1 well was drilled in order to develop a flow of 800 gallons per minute of water at about 310 °F. The actual conditions found are summarized below.

Temperature gradient. Equilibrium temperatures of 300°F occur at a depth of about _______ in the Ore-Ida well. The gradient continued to increase at an average rate of _____°F per 100 feet for the remainder of the hole to a total depth of 10,054 feet. The equilibrium temperature at total depth is estimated to be _____°F. It appears that the project temperature requirements can be met at economically attractive depths in the Ontario area, if an adequate fluid flow could be obtained.

Reservoir Potential. The rocks most likely to contain reservoir potential within the depth interval of favorable temperature are basalt flows. Basalt units are interspersed through the Ore-Ida well section from a depth of 4,570 feet to 8,135 feet and an aggregate of 1,425 feet of flows occurs in the 1,919 foot section below a depth of 8,135 feet. However, the depth to the top of this predominately basalt section is approximately 2,000 feet deeper at the wellsite than was inferred from reflection seismograph data before the well was drilled. Although a thick section of basalt has been penetrated, no important zones of high porosity and permeability were encountered. Large basalt intervals have been included in formation tests but there is no evidence that diffuse fractures are capable of producing an aggregate fluid volume approaching a useful level.

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Structure. Resolution of structural details by a reflection seismograph survey was attempted in the Ontario area. The main objectives of this work were to locate faults which might enhance fracture reservoir potential and to indicate the depth of the main basalt objective. It is uncertain whether the faults predicted to occur in the well area were intercepted by the hole. If they were, there was no apparent improvement in reservoir character that could be attributed to them. The estimates of depth to the main basalt sequence based on this work were in error by about 2,000 feet.

Economic aspects. Although the existence of reservoir potential has not been demonstrated in the Ontario area, the temperature and well-depth parameters of a hypothetical basalt reservoir are better-defined than before. Assuming the existence of a reservoir at depths of 8,000 to 9,000 feet, with temperatures in the range from ____°F to _____°F, fluid production at a rate of ________ gallons per day would be required to equal the thermal equivalent of ______ barrels of oil. Assuming a well cost of __________, an outline of the feasibility of further drilling at Ontario can be obtained. It should be noted that no exploration risk related to finding a reservoir of this capacity can be established on the basis of data now available, except that it appears to be high on the basis of the Ore-Ida Foods No. 1 well experience.

Effect on Prospecting at Ontario. In order to justify additional drilling in the Ontario area it would be necessary to demonstrate that there is a good probability of finding adequate reservoir conditions. There is no evidence from the data available at this time that this can be done. A review of the seismograph data using information obtained from the Ore-Ida well might contribute additional structural

PRELIMINARY

information, but this would not answer the major question regarding the existence of a reservoir.

Recommendations for the Ontario Site

Significance of the Ore-Ida Well to Geothermal Prospecting in the Snake River Basin

The Ore-Ida Foods No. 1 well was the second deep geothermal test well drilled in the western Snake River Basin. It should be noted that the Ontario site was not chosen on the basis of basin-wide studies which selected it as having exceptional prospect merit. Rather, the site was chosen on the basis of the value of a hypothetical, plausible, resource to an already established user. The site was justified on the basis of several assumptions about the region. These assumptions are summarized below with some conclusions regarding their validity.

1. Heat Flow, Temperature Gradients and the Energy Potential of the Resource.
   a. Present view of area with high heat flow/temperature gradients.
   b. Any possibility of electrical grade temperatures?
2. Reservoir Rock
   a. Assumptions that basalt sections contain regional aquifers interflow, breccia and diffuse fractures--not really demonstrated from existing wells.
   b. Enhancement of reservoirs by proximity to faults (not adequately tested hypothesis).

PRELIMINARY

c. Note that existing correlations in subsurface and from wells to surface are questionable due to limited data in both surface and subsurfaces.

3. Structure

   a. Assumptions about the meaning of gravity anomalies may be questionable (increase of basalt vs. block uplift).

   b. Any data of value for use in seismic interpretations?

4. Hydrology

   a. What basic circulation patterns have been proposed?

   b. What is present opinion of it?

Recommendations

1. Modify heat flow pattern to correspond to Ore-Ida data.

2. Work to identify and define vertical and lateral distribution of stratigraphic units in the subsurface.

   a. Review lithologic correlations by examining well samples from key wells for comparison with Ore-Ida.

   b. Possible petrographic studies of basalt from wells and key surface sections as an aid to correlation.

   c. Possible chemical analyses of basalts (or collection of data from others) as basis for correlation.

   d. Review of all deep well log data--porosity analysis--to determine if a regional aquifer condition might exist in basalt.

3. Acquisition of more detailed gravity work to refine structure. Model it with use of deep well data.

4. Ultimately obtain seismic data over important structures to define possible drillsites.

PRELIMINARY

5. Possible lineament study to refine structural interpretation from air photos (collect if available--do, if not).
6. Hydrology--review (and revise?) the hydrologic model for the basin relative to geothermal prospecting.
7. Can any further shallow data be collected on temperatures, from water well data search or from field measurements?

EG&G Idaho, Inc.
P.O. BOX 1625, IDAHO FALLS, IDAHO 83415

July 25, 1980

Mr. Robert W. Rolf
Ore-Ida Foods, Inc.
P.O. Box 10
Boise, ID 83702

TEMPERATURE LOG OF ORE-IDA NO. 1 WELL, ONTARIO, OREGON, CONTRACT NO. DE-FC07-78ET28424 - FWC-18-80

Dear Bob:

Enclosed is the temperature log of the Ore-Ida No. 1 geothermal well taken on July 11, 1980. Minor corrections of the data for both temperature and depth are recommended. They are indicated below with their derivia-tions indicated on the data graph.

$$\text{Depth}_{\text{Actual}} = 0.99613 \times \text{Depth}_{\text{Log}} \quad (\text{ft})$$

$\text{Depth}_{\text{log}} = \text{Depth}_{\text{actual}} \div .99163$

$$\text{Temp}_{\text{Actual}} = 32.0 + 1.005236\,(\text{Temp}_{\text{Log}} - 30.8)\ (°\text{F})$$

UURI will digitize this data and send the results to this same distribution list, so that duplication of data reduction is not necessary.

The temperature at the bottom closure plate of the liner at 10,038 ft was determined to be 360°F. The total depth of the hole as drilled was 10,054 ft.

Observations made during logging were: during probe retrieval, gobs of what appeared to be crude oil were accumulating and falling off the stripper, lubricator, pully, etc.; the well smelled bad; and the water seemed to be loaded with natural gas. Natural gas shows were noted during drilling but were judged non-commercial in quantity.

No shut-in pressure was obtained since the gage was broken. Ore-Ida will be asked to replace it and report the shut-in pressure.

Very truly yours,

[signature] for F. W. Childs

F. W. Childs
Program Management Branch

jd

Enclosure:
As stated

cc: J. C. Austin, CH2M Hill
R. Hanold, LASL– MS 570 Los Alamos, P.O. Box 1663 87545
D. Struhsacker, UURI
M. K. Tucker, DOE-ID
Childs

EG&G Idaho, Inc.
P.O. BOX 1625, IDAHO FALLS, IDAHO 83415

April 18, 1980

Ms. Debra Struhsacker
ESL-UURI
420 Chipeta Way, Suite 120
Salt Lake City, UT 84108

PRELIMINARY INFORMATION ORE-IDA NO. 1 WELL - FWC-13-80

Dear Debbie:

As we discussed on the telephone, I am enclosing the presently available drilling and test information for the geothermal well drilled by Ore-Ida Foods, Inc. under DOE's geothermal PON program. The well is on Ore-Ida's property at their Ontario, Oregon frozen food processing plant. It has a TD of 10,054 ft and a predicted bottom hole temperature of 400-430°F. An artesian flow of 1-2 gpm has been running continuously since December 1979.

The well was seeking 700 gpm of 320°F fluid which would have been used for potato processing and space heating. This would have taken care of about 50% of the plant's energy requirements, about 97,000 MWh annually or 33.2×10^{10} Btu/yr.

The enclosed materials are:

1. Initial draft Ore-Ida Drilling and Test Report (incomplete)
2. Figure - Well Casing Design
3. Four plates for the above draft report
4. Quantitative analysis of Well Logs (section for above report)
5. Appendix D, Mud Log
6. Mud Log Morning Report and Show Forms
7. Flow Tests of Ore-Ida No. 1, 8183 to 10,054 ft range (EG&G ltr, Scz-188-79)
8. Ore-Ida PON Conference Record for November 27, 1979 (by F. W. Childs, EG&G).

Additional information will be transmitted as it becomes available. Feel free to call me on FTS 583-9512 or commercial (208) 526-9512.

Very truly yours,

Frank W Childs

Frank W. Childs
Geothermal Commercialization

jd

Enclosures:
As stated

cc: w/o enclosures
J. C. Austin, CH2M Hill
Robert Hanold, LASL
L. L. Mink, DOE-ID
R. W. Rolf, Ore-Ida
Mort Smith, LASL
M. K. Tucker, DOE-ID

PRELIMINARY SECTION OF

ORE-IDA DRILLING AND TEST REPORT

SECTION: Qualitative Analysis of Well Logs

by

GeothermEx, Inc.

TABLE OF CONTENTS

QUALATATIVE ANALYSIS OF WELL LOGS

December 3, 1979

CONFERENCE RECORD

TITLE AND NUMBER:	Ore-Ida PON DE-AC07-78ET28424
CONTRACTOR NAME:	Ore-Ida Foods, Inc.
MEETING DATE/PLACE:	November 27, 1979 at Ore-Ida Plant, Ontario, Oregon

PARTICIPANTS:

See attachment 1

SUBJECTS DISCUSSED:

1. Recent stimulation operations on the Ore-Ida No. 1 Well
   11-24-79 Pressure rise from second instrument bomb (first one dropped) indicated about 8 gpm for 24 hours after nitrogen lift following perforation of 7 zones in the upper region (8340-5980 ft).
   11-26-79 Re-shot (total 8 holes/ft) 4 zones from 7925 to 6955 ft. Nitrogen lifted.
   11-27-79 Pressure rise from 4 hour bomb measurement indicated flow of about 13 gpm.
   Some low pressure steam flow after lift was quenched by water influx.
   Running 3-1/2 inch drill pipe into liner to check for obstruction.

2. Well Characteristics Noted
   a. Estimated equilibrium temperatures
      305° F @ 7000 ft; 400-430° F @ 10,000 ft.
   b. Average temperature gradient 3.7° F/100 ft.
   c. One extra 20 ft perforation zone sought natural gas (6000-5980 ft). Insignificant natural gas found.

3. Estimated Expenditure to Date for DOE

$ 205,000	Non-drilling
2,150,000	Drilling
75,000	Demobilization
50,000	Laydown pipe and clean up
$2,480,000	Versus contract of $2,556,000

   Expect all invoices within 30 days.

4. Amoco payment to GeothermEx and GeothermEx will deduct that amount from their billing to CH2M Hill.

5. Completion Plan
   a. Mud pit - clean out, fill and compact
   b. Well head - blind flange with 2-inch ball valve and pressure gage
      - fence or cover for security
   c. Wood cellar - cover for now, may cement later
   d. Storm drain - repair
   e. Core and cuttings - store or transfer to UURI

6. DOE will keep contract open for possible future tests of the well
   a. Minor logging tests
   b. Stimulation - possibly through DOE's National Stimulation Program
   c. Hot dry rock use through LASL is possibility.

7. Reports
   a. Item 8 of contract "Well Test Plan" will be the drilling report
   b. Item 10 of contract "Preliminary Design Report" will be issued
   c. Revised resource assessment; implications for future geothermal development - proposed report; DOE will consider funding it.

8. Other Potential Sources of Drilling Funds (in Congress now)
   a. Loan Guarantee being revised, or
   b. Reimburse contractor if well not successful.

DECISIONS REACHED:

1. Release Montgomery Drilling Rig No. 7 immediately.
2. Complete well per discussion and let stand a few months.
3. Determine applicability to National Stimulation Program after Drilling Report completed.
4. If needed, DOE will supplement contract funding in January after drilling invoices are in.

REQUIRED ACTIONS:

1. R. N. Chappell - Determine DOE's interest/method of funding of revised geothermal assessment report.
2. S. M. Prestwich - Determine if core sample and cuttings ought to be transferred to UURI.
3. R. N. Chappell - Coordinate future use recommendations with DGE; and with LASL if appropriate.

F. W. Childs

F. W. Childs

Distribution:

J. C. Austin, CH2M Hill
R. N. Chappell, DOE-ID
J. O. Lee, DOE-ID
L. L. Mink, DOE-ID
S. M. Prestwich, DOE-ID
R. W. Rolf, Ore-Ida Foods

opposite a ~~pov~~ non-veined, unfractured, massive rock. The structural ~~dry~~ disruption may be real for some intercepts, particularly where correlated to temperature log anomalies and ~~high por~~ high porosity or fracture events on other logs.

Temperature logs have been interpreted in terms of ~~potential per~~ intervals that exhibit potentially permeability. These intervals are listed below.

4075-4125 ft
5400-5700 "
6100-6350 "
7100-7300 "
8200-8400 "
8500-8550 "
8750-8800 "
9150-9300(?) "

These intervals are only qualitative determinations and only the one between 7100 and 7300 ft ~~[illegible]~~ had any reported lost circulation

EG&G Idaho, Inc.

P. O. Box 1625
Idaho Falls, Idaho 83401

November 26, 1979

Mr. J. L. Griffith, Chief
Research & Engineering Branch
Idaho Operations Office - DOE
Idaho Falls, Idaho 83401

FLOW TESTS OF ORE-IDA NO. 1, 8183 TO 10,054 FOOT RANGE, CONTRACT NO. DE-AC07-78ET28424 - Scz-188-79

Dear Mr. Griffith:

Nitrogen lifting and flow testing of the Ore-Ida No. 1 Well was witnessed by Mr. F. W. Childs at Ontario, Oregon from November 16 through November 19, 1979. In Boise, enroute to Ontario on November 15, the program was discussed with CH2M Hill and some logs of the well were picked up from Dr. James Applegate at Boise State University.

At the beginning of testing, the configuration of the well was as follows. A 9-5/8 in. diameter casing was cemented from the surface to 8183 feet. A 7 in. diameter liner was hung from the casing from 8142 feet to 10,038 feet. The liner was perforated with 2 in. x 1/8 in. slots (16 slots per foot) from 8186 feet to 10,036 feet. The remainder of the hole to a total depth of 10,054 feet was left open. The bottom of the liner was closed by a bull plugged collar. The top of the liner was sealed against the casing by a Burns lead seal liner hanger.

Initially, the water level was at 400 feet. The initial nitrogen lift removed the water from 400 feet to 6,000 feet deep. Approximately 91,000 scf of nitrogen was used. An instrumentation bomb was placed in the hole at 9960 feet for a period of four hours to measure pressure and temperature. Preliminary data indicated a water flow of about 0.3 gpm.

The second nitrogen lift removed water from about 6,000 feet to the bottom of the liner, about 10,000 feet. The instrumentation bomb was placed below the liquid level for four hours to again measure pressure and temperature. The preliminary data indicated a liquid flow of 1 gpm.

It was decided to perforate as deeply as possible (radially) behind the slotted liner in order to get an indication of high temperature mud damage. If a significant flow could be produced from the liner section by deep perforations, it would indicate significant high temperature mud damage and might produce the flow necessary to complete the project. If the perforating did not produce any additional flow, then it would indicate that there was a low probability of mud damage inhibiting significant flow unless that damage had invaded the formation deeper than could be penetrated by the perforation guns.

After reviewing the logs, six zones of the liner below 8313 feet were found to be promising. From the bottom up, four sections were minor and two were of major size. For some reason, the lowest two sections could not be reached when trying to set the perforating guns. The four main sections that were actually perforated are shown in the table below.

Runs	Well Depth	Perforated		Total Zone	% Perforated
1	✓ 9895 - 9875 ft	20 ft	of	20 ft	100%
1	✓ 9810 - 9790 ft	20 ft	of	20 ft	100%
7	9240 - 9020 ft	140 ft	of	220 ft	64%
4	8840 - 8730 ft	80 ft	of	110 ft	73%
13		260 ft			

To achieve maximum penetration, the largest available shape charges were used, type SSB. These 22-23 gm charges were rated to a penetration depth of 30 inches in hard sandstone. Twenty feet of hole was shot with each gun run at the standard spacing of 4 shots per foot. Thirteen runs were made for a total of 260 feet of perforated hole or 1,040 perforations. It was expected that each perforation would be on the order of 5/8 to 3/4 inch in diameter.

Since the penetration shooting was done under water, 100 barrels had been added. The hole was nitrogen lifted for a third time to drop the water level depth from about 8300 feet down to 10,000 feet again. Following this 3rd nitrogen lift, the instrumentation bomb was again placed in the hole below the liquid level and pressure and temperature data recorded for four hours. The preliminary pressure rise data indicated that the liquid flow was approximately 1.3 gpm. The lack of significant flow increase indicates that either the mud damage exceeds about 30 inches or this section of the hole is unproductive. Since chemical logging and other logs indicate little permeability or presence of geothermal water constituents, it is considered unlikely that these particular zones are being prevented from producing due to high temperature mud cake damage unless this damage extends greater than 30 inches into the formation.

In preparing to perforate the zones in the 7,000-8,000 foot range which are behind the cemented 9-5/8 in. diameter casing, 300 barrels of water were added to cover the zone to be perforated. At that point, the operator attempted to lift the drill string while the pipe rams were tightly closed. The resulting stress broke the drill string 8 in. above the rotary table and caused damage to the pulleys in the crown block. It is expected that the rig will be down for repairs, primarily at the owners cost, until Monday, November 26, 1979.

DOE/BRDA File [illegible]
Route: DiBello/Jones
Nelson/Strawn
Childs
Central File

4075-4125
5400-5700
6100-6350
7100-7300
8200-8400
8500-8550
8750-8800
9150-9300

Following completion of the rig repair, it is planned to perforate 7 zones between 8340 feet and 5980 feet as shown on the table below.

Planned Perforation Zones

Well Depth	Reperf	Zone Length (ft.)	Geothermal	Gas
8340 - 8320		20	X	
7925 - 7905	✓	20 ✓	X	
7790 - 7770	✓	20 ✓	X	
7140 - 7060	✓	80 ✓	X	
7015 - 6955	✓ (7015-6975)	60 (40')	X	X
6640 - 6580		60	X	X
6000 - 5980		20		X
		~~200~~ ft. (160') Reperf		
		280 ft (8 Runs)		

Each zone will be perforated with the large type SSB shaped charge at the rate of four shots per foot throughout the entire length. Two of the zones show potential for both geothermal and gas production. The small zone around 6,000 feet was mentioned only in terms of gas potential, in addition, its temperature of 250-260° F is below the target temperature of 300-320° F. Ore-Ida (GeothermEx) was cautioned to observe the flows from the lower zones prior to shooting the 6,000 foot zone to avoid endangering the usability of production from below if it were of marginal temperature.

After both of the two nitrogen lifts to 10,000 feet, a small but continuous steam flow was noted from the well until it was quenched by adding cold water for succeeding operations. It is possible that the well could continue to develop on its own if it was left open for a week or more similar to the experience on one of the wells at Raft River. If there was a suitable work over rig available in the nearby area, it would have been recommended to release the drilling rig and leave the well in the open condition for an extended period to evaluate the possibility of self-development. Due to the high cost of bringing a work-over rig to the Ontario area, development will continue using the drilling rig prior to its release. It is recommended, if possible, to leave the well open to allow maximum self-development after the release of the drilling rig. Suitable monitoring and safety equipment would be installed.

Very truly yours,

J. G. Haung for

R. J. Schultz, Manager
Hydrothermal Energy Commercialization

FWC:jd

cc: J. C. Austin, CH2M Hill
R. N. Chappell, DOE-ID
L. L. Mink, DOE-ID
R. W. Rolf, Ore-Ida Foods
S. M. Prestwich, DOE-ID
R. W. Kiehn, EG&G Idaho, Inc.

MEMO OF CONVERSATION

FORM EG&G 561
(Rev. 1-77)

PERSON CALLING: F. W. Childs

DATE: 11-26-79

REPRESENTING: EG&G Idaho, Inc.

TIME: 10:00 A.M.

PERSON CALLED: Roger R. Bissell (and Dr. Murray C. Gardner)

PHONE NUMBER: FTS 554-1111
345-5310

REPRESENTING: CH2M Hill (GeothermEx)

CITY:

SUBJECT: Well Drilling

Ore-Ida No. 1

DISTRIBUTION

EG&G	DOE-ID
~~F. W. Childs~~	R. N. Chappell
PON/PRDA Ltr File	L. L. Mink
Route: DiBello/Jones	S. M. Prestwich
Nelson/Strawn/Childs	
Central Files	

With Roger Bissell consulting Dr. Gardner, it was determined that only 4 of the 7 zones in the upper range of perforations would be reperforated to bring the number of perforations from 4 to 8 perforations per foot.

Zones deleted from reperforating were:

8340-8320 ft	Avoid additional damage to liner
6640-6580 ft	Low temperature if there were flow
6000-5980 ft	Low temperature and only gas expected (no significant gas was found by initial perforations)

The meeting at Ontario, Oregon tomorrow will begin when Chappell, Prestwich and Childs arrive; 9:00-9:30 A.M.

Mr. Childs will find out about suitability and availability of LBL flow measuring spinner currently at Raft River.

SIGNATURE

(CONTINUE ON REVERSE SIDE)

EG&G Idaho, Inc.

FORM EG&G-561
(Rev. 1-77)

MEMO OF CONVERSATION

PERSON CALLING: F. W. Childs — DATE: December 19, 1979

REPRESENTING: EG&G Idaho, Inc. — TIME: 2:00 P.M.

PERSON CALLED: Glen Green — PHONE NUMBER: FTS 423-4111 (503) 889-8611

REPRESENTING: Ore-Ida Foods

CITY: Ontario, Oregon

SUBJECT: Ore-Ida No. 1
Informal Flow Tests

DISTRIBUTION

~~EG&G~~	DOE-ID
R. J. Schultz	R. N. Chappell
S. G. Spencer	J. O. Lee
PON/PRDA Ltr file	L. L. Mink
Route: DiBello/Jones	C. R. Nichols
Nelson/Strawn/Childs	S. M. Prestwich
~~Central Files~~	

This is a follow-up to the Memo of Conversation for the same parties dated 12-14-79, in which significant artesian flow (estimated 150-200 gpm) was reported for a brief (10 minute) test. Continued report follows:

12-18-79 0700 hours - Shut in pressure was 64 psig.
Opened 2-in. ball valve and got estimated 15-20 gpm at estimated 75° F after 4-5 minutes. Flowed well for 20 hours.

12-19-79 Flow measured at 1.62 gpm with 5 gallon can and stopwatch.
Temperature taken with thermometer was 80° F. Water was turbid, brown, silty, etc., and unchanged since earlier flows. Occasionally, some gas emerged and was highlighted by bubbles due to residual detergent in the water.

The metal flange seal arrived and was installed. Graveling of the area will be done and the well reopened to flow late today.
A valve will be located (EG&G) and installed (Ore-Ida) so that the well may be logged down through it. The current installation has a 2-inch ball valve, but it is installed horizontally after a 90-degree bend.

SIGNATURE FW Childs

~~(CONTINUE ON REVERSE SIDE)~~

December 3, 1979

CONFERENCE RECORD

TITLE AND NUMBER: Ore-Ida PON
DE-AC07-78ET28424

CONTRACTOR NAME: Ore-Ida Foods, Inc.

MEETING DATE/PLACE: November 27, 1979 at Ore-Ida Plant, Ontario, Oregon

PARTICIPANTS:

See attachment 1

SUBJECTS DISCUSSED:

1. Recent stimulation operations on the Ore-Ida No. 1 Well
   11-24-79 Pressure rise from second instrument bomb (first one dropped) indicated about 8 gpm for 24 hours after nitrogen lift following perforation of 7 zones in the upper region (8340-5980 ft).
   11-26-79 Re-shot (total 8 holes/ft) 4 zones from 7925 to 6955 ft. Nitrogen lifted.
   11-27-79 Pressure rise from 4 hour bomb measurement indicated flow of about 13 gpm.
   Some low pressure steam flow after lift was quenched by water influx.
   Running 3-1/2 inch drill pipe into liner to check for obstruction.

2. Well Characteristics Noted
   a. Estimated equilibrium temperatures
      305° F @ 7000 ft; 400-430° F @ 10,000 ft.
   b. Average temperature gradient 3.7° F/100 ft.
   c. One extra 20 ft perforation zone sought natural gas (6000-5980 ft). Insignificant natural gas found.

3. Estimated Expenditure to Date for DOE

$ 205,000	Non-drilling
2,150,000	Drilling
75,000	Demobilization
50,000	Laydown pipe and clean up
$2,480,000	Versus contract of $2,556,000

   Expect all invoices within 30 days.

4. Amoco payment to GeothermEx and GeothermEx will deduct that amount from their billing to CH2M Hill.

Conference Record (cont.)

5. Completion Plan
   a. Mud pit - clean out, fill and compact
   b. Well head - blind flange with 2-inch ball valve and pressure gage
      - fence or cover for security
   c. Wood cellar - cover for now, may cement later
   d. Storm drain - repair
   e. Core and cuttings - store or transfer to UURI

6. DOE will keep contract open for possible future tests of the well
   a. Minor logging tests
   b. Stimulation - possibly through DOE's National Stimulation Program
   c. Hot dry rock use through LASL is possibility.

7. Reports
   a. Item 8 of contract "Well Test Plan" will be the drilling report
   b. Item 10 of contract "Preliminary Design Report" will be issued
   c. Revised resource assessment; implications for future geothermal development - proposed report; DOE will consider funding it.

8. Other Potential Sources of Drilling Funds (in Congress now)
   a. Loan Guarantee being revised, or
   b. Reimburse contractor if well not successful.

DECISIONS REACHED:

1. Release Montgomery Drilling Rig No. 7 immediately.
2. Complete well per discussion and let stand a few months.
3. Determine applicability to National Stimulation Program after Drilling Report completed.
4. If needed, DOE will supplement contract funding in January after drilling invoices are in.

REQUIRED ACTIONS:

1.	R. N. Chappell	- Determine DOE's interest/method of funding of revised geothermal assessment report.
2.	S. M. Prestwich	- Determine if core sample and cuttings ought to be transferred to UURI.
3.	R. N. Chappell	- Coordinate future use recommendations with DGE; and with LASL if appropriate.

F W Childs

F. W. Childs

Distribution:

J. C. Austin, CH2M Hill
R. N. Chappell, DOE-ID
J. O. Lee, DOE-ID
L. L. Mink, DOE-ID
S. M. Prestwich, DOE-ID
R. W. Rolf, Ore-Ida Foods

Attachment 1

PARTICIPANTS - Ore-Ida Foods Meeting of November 27, 1979

Ore-Ida Foods, Inc.

Dean C. Bent, Factory Production Manager
Jack P. Collins, Manager of Technical Services Planning
Fargerson? Rick D. Fergerson, Research Engineer
~~John C. Glerum, General Manager, Purchasing~~
Glen R. Green, General Manager, Research Engineering
M. Lee Nelson, Controller, Technical Services
Robert W. Rolf, Manager Technical Services (PON Principal Investigator)

Ch2M Hill, Inc.

John C. Austin, PON Project Manager
Roger R. Bissell, Manager, Industrial Energy Systems

GeothermEx, Inc.

Dr. Murray C. Gardner, Geologist/Drilling Consultant
Dr. James B. Koenig, President, Geologist

Other

R. N. Chappell, DOE-ID
F. W. Childs, EG&G Idaho, Inc.
Bill N. Hathaway, Hathaway Engineering, Drilling Engineer
S. M. Prestwich, DOE-ID

Mark Mathews 11/17/80

2"/100'

	Δt	IND/SP	R_b/ϕ_N logs
8200'			
8360 - 8400	shaly	-ve	
8500	descrip.	streaming pot. or	spiky
8660	cycle skipping?	clay	char.
8800			sometimes same as ϕ_N
9000		quad ind	sometimes
9200		similar in places	opposite
9480		&	
9520		diff. other places	
9780		plugging	

γ-ray sat - H scale in several places

didn't look higher in hole.

~ 4600

~ 5300

~ 7100