WELL REPORT

ON

SUNEDCO #1-A C.H. STOCKS

FRANKLIN Co., IDAHO

GEO THERM EX

OCTOBER, 1978

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

GEOLOGY OF
SUNEDCO C. H. STOCK 1-A
GEOTHERMAL TEST,
FRANKLIN COUNTY,
IDAHO

for
Sunoco Energy Development Co.
Dallas, Texas

by
GeothermEx, Inc.
James R. McIntyre
James B. Koenig

October 1978

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

ILLUSTRATIONS

Plates

Rolled
Separately

1. Annotated compilation of temperature data, Sunedco Stocks 1-A geothermal test
2. Geologic sketch map of the Preston prospect area (modified from Oriel and Platt, 1968)
3. Geologic cross sections of the Preston prospect and vicinity.

Figures

After Page

1. Stratigraphic sequence of the Precambrian and lowermost Cambrian Formations (from Trimble, 1976) 3
2. Interpretive stratigraphy, Sunedco C. H. Stocks 1-A geothermal test 8

Tables

1. Chemical Analyses of Thermal Water from the Northern Cache Valley Area, Franklin County, Idaho (from Mitchell, 1976 and this report) 6

Appendices

- A. Sample Descriptions, Sunedco C. H. Stocks 1-A geothermal test
- B. A Review of Samples and an Interpretation of the Section in Sunedco C. H. Stocks No. 1 (Temperature Gradient Hole 1001)

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Location

Sunedco C. H. Stocks 1-A is located 1,100 feet north of the south line and 1,880 feet east of the west line of section 6, T. 15 S., R. 39 E., in northern Cache Valley, Franklin County, Idaho. It is approximately 6 miles northeast of Preston, Idaho, from which it can be reached by following Highway 91 north to Hot Springs Road, then on that road to the Stocks Ranch, from which an unimproved farm road leads to the well site. The site is situated in level, cultivated fields approximately one-half mile west of a ridge of outcropping bedrock known as Little Mountain. The elevation of the derrick floor was 4,776.5 feet above sea level.

Summary of Drilling Operations

The hole was spudded on July 16, 1978. A 26-inch hole was drilled to 331 feet and 20-inch casing was set at 294 feet. No logs were run before setting this casing. The Baroid mud logging unit was not on the site and no samples or mud temperature data were obtained until the well had reached a depth of 340 feet.

After setting casing, drilling continued with mud in a 17-1/2-inch hole to a depth of 1,529 feet. Logs were run as listed below, and 13-3/8-inch casing was then set at 1,493 feet. A 12-1/4-inch hole then was drilled with air to 1,623 feet, where water entry into the hole made it necessary to return to drilling with mud. The hole was drilled to 3,715 feet, logs were run as indicated below, and a 9-5/8-inch liner was set at a depth of 3,717 feet. Drilling continued with air in an 8-3/4-inch hole to a depth of 4,534, whereupon aeriated water was substituted as the drilling fluid, because of water entry into the hole. The hole reached a depth of 5,479 feet, where 3 bit-cones were lost. While fishing for these, the skirt from the magnet assemblage also was lost in the hole. During attempts to mill up this junk, large quantities of cuttings from uphole stuck the bit and drill collars. Most of the drill string was recovered, but 308 feet of fish was left in the hole. The hole was then logged as noted below. Drilling was suspended on August 28, and the rig moved off. The top of the fish is at 5,076 feet. This is also the plugged-back depth of the hole. The well was left in condition to re-enter in case additional logging or other work is to be conducted.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Logging

The following logs were run in this hole:

I. Schlumberger:

<u>Log</u>	<u>Run No.</u>	<u>Data</u>	<u>Interval, feet</u>
Compensated Neutron-Gamma Ray	1	7/21/78	299-1,519
Induction Electrical-Gamma Ray	1	7/21/78	299-1,520
Induction Electrical-Gamma Ray	2	8/8/78	1,392-3,714
Gamma Ray, through casing	1	8/8/78	10- 340
Induction Electrical-Gamma Ray	3	8/28/78	3,720-5,062
Temperature Survey	1	7/21/78	96-1,526
Temperature Survey	2	8/8/78	0-3,710
Temperature Survey	3	8/8/78	0-3,712
Temperature Survey	4	8/28/78	0-5,068
Caliper	1	8/28/78	3,720-5,068

II. Kuster Wireline Temperature Bomb: At selected intervals (see plate 1 for tabulation of all temperature surveys).

III. Bariod: A Baroid mud log covers the hole from 340 to 5,479 feet. This log records drilling data, lithology, temperature of the drilling fluid, H₂S, CO₂ and hydrocarbon gases.

Geology

This section outlines the geological setting, the original prospect concept, the stratigraphic, structural and temperature data recovered from the well, and the status of the prospect after drilling.

GEOLOGIC SETTING

The Preston prospect is located in the northern end of Cache Valley, a major graben of Late Cenozoic age occurring near the northeastern edge of the Basin and Range province. The graben floor is covered with dissected Pleistocene lacustrine sediments, which overlay a thick Late Tertiary tuffaceous sequence of fluvial and lacustrine origin. Pre-Cenozoic rocks, ranging from Precambrian to Middle Paleozoic age, are well-exposed in the flanking Bear River Range to the east, the southern Bannock Range to the west, and in small intra-valley horsts.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

The oldest rocks in the region occur in the Albion and Raft River Ranges, 90 to 100 miles east of Cache Valley, and in the Brigham City-Ogden area of the Wasatch Mountains and in Fremont Island, 50 to 150 miles south of the Preston area. In the Albion Range these consist of the Green Creek Complex, made up of biotite-quartz-plagioclase-microcline gneiss, associated with plagioclase-quartz-biotite schist and quartz-plagioclase-hornblende amphibolite. The age of these rocks is at least 2.4 billion years (Armstrong, 1968). To the south, in Utah, the oldest rocks belong to the Farmington Complex, consisting of granitic gneiss and migmatite, with lesser amounts of amphibolite; and to the Little Willow Series, composed chiefly of quartz-feldspar and quartz-muscovite schists, granitic gneiss and migmatite (Condie, 1969). The distinguishing character of all these rocks is their high metamorphic grade relative to the younger Precambrian rocks of the region.

In the immediate vicinity of the prospect (plate 2), two Precambrian sequences are exposed, both of which are younger than the Farmington and/or Green Creek Complexes. The older is the Pocatello Group, which occurs extensively in the Bannock Range and in Little Mountain. The base of the Pocatello Group is not exposed in the area. However, rocks which appear to be correlative with the Pocatello overlie the Farmington Complex at Fremont Island, Utah (Condie, 1969).

The Pocatello Group sequence is shown in figure 1. In the Preston area, the Scout Mountain member makes up most or all of the exposed section. No detailed section description is available for these rocks. However, the bulk of the several thousand-foot-thick Scout Mountain section consists of diamictite, made up of silt- and sand-sized angular grains of quartz and feldspar in a chloritic or sericitic groundmass. Large clasts, ranging from granule to cobble and even boulder size, are scattered through it. The origin of this peculiar rock type is debatable; it may be a subaqueous glacial deposit. This rock type grades laterally and vertically into purer quartzite, phyllite, and fine-grained green-schist. Thin calcite or dolomite marble units also are present. The section has been cut by diabase dikes and silts, now converted to chlorite-actinolite-albite greenstones (Trimble, 1976; Condie, 1967).

The overlying younger Precambrian rocks consist of a thick sequence of quartzites, containing minor amounts of argillite and limestone. These rocks are widely distributed in the eastern Basin

Figure 1-Stratigraphic sequence of the Precambrian and lowermost Cambrian formations. (from Trimble, 1976)

JAMES B. KOENIG (415) 524-9242

MURRAY C. GARDNER (503) 482-2605

and Range Province. Their depositional configuration resembles that of the overlying Paleozoic rocks, with great thicknesses lying in a belt extending from southern Nevada and southeastern California northeastward through western Utah, eastern Nevada and southeastern Idaho. To the east of this zone, in Wyoming and eastern Utah, except for the Uinta Mountains, these rocks are thin or absent.

During Paleozoic and Early Mesozoic time, as much as 50,000 feet of limestone, dolomite, minor quartzite and shale was deposited in the axial part of the Cordilleran geosyncline of eastern Nevada-western Utah-southeastern Idaho. In the same period, only about 6,000 to 10,000 feet of equivalent materials accumulated on the Wyoming-eastern Utah shelf area. The marked zone of thickening between the shelf and the miogeosyncline appears to have exercised an important control on structures formed later, in the Laramide and Sevier orogenies (Armstrong and Oriel, 1965).

Commencing in Jurassic time, the depositional axes shifted eastward across the hingeline zone, probably as a response to uplift and deformation in the old basinal area to the west. In Cretaceous time, this wave of compressional deformation and uplift passed eastward across the hingeline zone while the depositional axis of the Cretaceous seas migrated into Wyoming and eastern Utah, in front of the deformational zone. The major structures of this episode are an arcuate series of subparallel anticlines and synclines cut by major low-angle thrust faults. The thrust fault closest to the Preston prospect lies along the east side of the Bear River Range, and dips to the west at a low angle. The location of the root zone of this thrust relative to the prospect area is uncertain. Widely different alternatives suggest that the older Precambrian (Pocatello) rocks are in the footwall zone, or that the thrust may actually pass beneath them.

The Early Cenozoic history of the Cache Valley area is poorly known, as no deposits of this age have been identified. Probably it was an upland area subjected to extensive erosion. Later, perhaps as early as late Miocene time, the onset of Basin-and-Range faulting created an extensive basin in the region, in which large amounts of tuffaceous fluvial and lacustrine clays, sands and gravels were deposited. In Cache Valley, as much as 7,000 to 8,000 feet of these sediments, referred to the Salt Lake Formation, may be preserved in some areas. The tuffaceous material in this section may be derived from volcanism in the Snake River Plain (S. Oriel, 1978, oral communication).

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

The climax of Basin-and-Range faulting appears to have occurred after deposition of the Salt Lake Formation, probably in late Pliocene time and ending in the Pleistocene. No recent faulting has been reported in Cache Valley, although there has been historic seismicity in Malad Valley, to the west.

The most important structures of this period are the north-trending normal faults forming the boundary between the Cache Valley graben and the Bannock and Bear River Range horsts bounding it on the west and east, respectively. The displacement on each of these fault systems may reach 8,000 to 10,000 feet in areas of greatest movement. Both the horsts and grabens are cut by subsidiary faults. One of the most important secondary structures is the Little Mountain horst complex, within the Cache Valley graben. The trend of the faults associated with this feature is to the northwest, oblique to the main range-front faults. In addition, a long, poorly defined lineament has been noted on ERTS imagery (Mitchell, 1976). This feature trends east-northeast along the Bear River near Preston. The structural significance of this feature is uncertain from the data now available.

Structural lowlands formed during Basin-and-Range faulting are either closed basins, or parts of larger closed basin complexes which were covered by lakes during parts of Quaternary time. At this time, Cache Valley was occupied by an arm of Lake Bonneville into which the Bear River built a delta of silts and gravels reaching a local thickness of several hundred feet. Changes in local base-level in the Lake Bonneville-Great Salt Lake drainage system have caused the Bear River to dissect this fill and cut prominent terraces in northern Cache Valley, near the well site.

The Quaternary history of the region includes the extrusion of basalt in Gem Valley and of basalt flows and rhyolite domes in the Blackfoot lava field and the Snake River Plain, to the north of Cache Valley. However, Cenozoic volcanics are absent from the prospect area, with the exception of small lamprophyric intrusions in the Salt Lake Formation south of Oneida narrows, and a lava flow or sill under Cache Valley, between Cornish and Lewiston, Utah (Mitchell, 1976). Small basalt dikes of unknown age occur south of Twin Lakes Reservoir in Little Mountain and in Five-Mile Canyon, near Dayton, Idaho.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

SUMMARY OF THE ORIGINAL PROSPECT CONCEPT

Within this geologic setting, the main geothermal manifestations near the prospect area are Wayland (Battle Creek) Hot Spring (SE/4, NW/4, Sec. 8, T. 15 S., R. 38 E.) and Squaw Hot Spring and hot well (center, W/2, Sec. 17, T. 15 S., R. 39 E.). Travertine deposits in the northeast corner of Sec. 7, T. 15 S., R. 39 E. indicate a formerly active spring area, possibly thermal.

On the basis of geochemical thermometry, the springs are estimated to be fed from a reservoir with a temperature as high as 150°C (silica) or 200°C (Na-K-Ca) (Mitchell, 1976). These are the highest calculated reservoir temperatures anywhere along the hingeline structure in southern Idaho and northern Utah. It is also notable that these thermal waters have the highest total dissolved solids (TDS) of groundwater in the region (table 1). Conversely, the presence of travertine indicates that the Na-K-Ca geothermometer is out of equilibrium, and that temperatures indicated by this alkali method are too high by some unknown amount corresponding to the degree of Ca depletion.

Geothermal prospects require the presence of a heat source, reservoir rocks and a trap for fluids. In the geologic setting outlined above, the heat source of heat appears to be deep circulation of groundwater along the large range-front faults in an area of average to above average temperature gradient and heat flow.

Both Wayland and Squaw Hot Springs are on trend with faults indicated by surface geology or gravity. A shallow potential reservoir is sand and gravel beds in the Salt Lake Formation. However, these are considered to be too shallow for development of adequate temperature. A deeper, hotter reservoir was postulated in fractures in the underlying Precambrian metamorphic rocks. Only in the deepest parts of the Cache Valley graben are the Tertiary sediments likely to be of significance as reservoirs. Fractured Precambrian rocks associated with the fault zones are the only reasonable choice as reservoir in the vicinity of Little Mountain.

Factors leading to the development of a confined body of geothermal fluids in this setting are difficult to predict. In some systems, vein minerals deposited by saturated fluids in fractures around the reservoir periphery may seal the reservoir. In other areas, hydrothermal clays in bedrock or overlying rocks provide a cap rock. Most commonly, the seal is incomplete, and considerable leakage takes place at the surface.

TABLE 1
CHEMICAL ANALYSES OF THERMAL WATERS FROM THE NORTHERN CACHE VALLEY AREA
FRANKLIN COUNTY, IDAHO

(Chemical constituents in milligrams per liter)
(Mitchell, 1976, and Environmental Analysis Laboratories, for this report)

Spring or well identification number & name	Temperature (°C)	Well depth below land surface (meters)	Discharge (l/min)	Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Total alkalinity as bicarbonate ion (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Phosphate (PO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Ammonia (NH ₃)	Specific conductance (Cond)	Field (pH)	Total dissolved solids	Sodium adsorption ratio (SAR)
12S-40E-36acd1S	35		10	54	265.0	68.0	563	127.0	704.0	0.0	788.0	0.01	632.0	2.2	0.93	3.40	1.3	4,149	6.6	3,020	8.0
36aca1S	33		10	52	259.0	64.0	517	137.0	704.0	0.0	755.0	0.01	633.0	1.9	0.37	3.40	1.2	4,199	6.6	2,932	7.5
12S-41E-31cac1S	66		20	60	208.0	50.0	458	98.0	718.0	0.0	533.0	0.01	532.0	1.9	0.11	2.80	1.6	3,229	6.4	2,499	7.4
31cdb1S	61		50	64	178.0	50.0	460	102.0	576.0	0.0	530.0	0.01	530.0	1.9	0.21	2.90	1.5	3,379	6.5	2,324	7.9
31cca1S	56		10	63	172.0	50.0	460	100.0	583.0	0.0	538.0	0.01	532.0	1.9	0.76	2.80	0.8	3,189	6.5	2,335	7.9
Maple Grove Hot Springs																					
13S-41E-7aca1S	78		20	84	85.0	30.0	492	82.0	494.0	0.0	256.0	0.01	596.0	1.1	0.07	2.30	1.4	2,909	6.6	1,953	11.7
7aca2S	72		100	85	93.0	29.0	501	82.0	495.0	0.0	261.0	0.02	601.0	1.1	0.12	2.30	1.3	2,979	6.8	1,980	11.6
7aca3S	60		935	86	93.0	25.0	492	80.0	494.0	0.0	251.0	0.01	584.0	1.0	0.06	2.30	0.9	2,899	6.8	1,939	11.7
Ren Meek Well																					
14S-39E-36ada1	40	12		89	24.0	6.6	368	22.0	513.0	0.0	13.0	0.01	322.0	9.6	0.10	0.58	1.1	1,809	6.9	1,246	17.2
Battle Creek Hot Springs																					
15S-39E-8bcd1S	82		50	109	174.0	19.0	3,161	552.0	696.0	0.0	35.0	0.01	5,241.0	6.0	0.11	3.50	7.6	16,619	6.7	9,326	60.8
8bcd2S	43		2,160	107	166.0	15.0	3,071	535.0	697.0	0.0	29.0	0.01	5,048.0	6.0	0.42	3.40	7.3	15,439	6.5	9,026	61.2
8bcd3S	81			109	162.0	19.0	3,053	533.0	757.0	0.0	37.0	0.01	5,034.0	6.0	0.28	3.60	7.2	15,949	6.5	9,062	60.5
8bcd4S	84		5	97	215.0	24.0	4,184	686.0	610.0	0.0	33.0	0.01	6,967.0	6.4	0.06	5.30	10.0	18,479	6.8	12,033	72.2
Squaw Hot Springs Well																					
15S-39E-17bcd1	84	7	115	124	279.0	24.0	4,368	782.0	791.0	0.0	35.0	0.02	7,398.0	4.3	0.12	4.30	8.1	20,459	6.5	12,895	67.4
Squaw Hot Springs																					
15S-39E-17acc1S	73		450	126	241.0	26.0	3,844	533.0	866.0	0.0	23.0	0.02	6,396.0	4.8	0.06	4.60	9.7	16,859	6.6	11,396	62.8
17bcd1S	69		140	126	135.0	23.0	4,184	708.0	816.0	0.0	27.0	0.03	6,877.0	4.3	0.16	4.20	7.3	20,519	6.5	12,062	87.6
Myron Fennesbeck Well																					
16S-38E-24acd1	23	157	4,165	74	78.0	27.0	68	18.0	418.0	0.0	4.3	0.03	91.0	0.5	0.08	0.42	0.1	889	6.8	686	1.7
Analyses by U.S. Bureau of Reclamation																					
Suneco																					
CH Stocks I-A	47-53	313	4,536	30	17	0.86	1,200	81	410	86	100	—	1,400	8.4	—	—	—	3,000	9.6-10	3,300	—
"	49	406	—	28	15	2.3	1,100	80	290	62	79	—	1,300	8.6	—	—	—	3,400	9	3,000	—
"	—	1,170	—	3.8	57	10	2,100	180	390	60	20	—	3,400	4.0	—	—	—	3,300	7	5,000	—

CORPORATION

Environmental Analysis Laboratories

2030 Wright Avenue
Richmond, California 94804
(415) 235-2633
(TWX) 910-382-8132

Sunedco C. H. Stocks 1-A

Water samples from:

1,030 ft

1,337

3,848

ANALYSIS REPORT

Customer: Mr. Chris Klein
GeothermEx
901 Mendocino Avenue
Berkeley, CA 94707

Date: December 7, 1978Samples Received: August 21, 1978LFE Reference No. 05300-0507

Purchase Order No.: _____

Analysis	Units	1337 F 527-5-1	3848 F 527-5-2	1030 F 527-5-3	1337 Fa 527-5-4	3848 Fa 527-5-5	1030 Fa 527-5-6
Bicarbonate	mg/l	290	610	640			
Carbonate	mg/l	62	93	140			
Sulfate	mg/l	79	20	100			
Chloride	mg/l	1,300	3,400	1,400			
Fluoride	mg/l	8.6	4.0	8.4			
Boron	mg/l	1.4	1.9	1.5			
Silica	mg/l	28	3.8	30			
Total dissolved solids	mg/l	3,000	5,000	3,000			
Specific conductance	μ mhos/cm	4,600	8,000	4,800			
Calcium	mg/l	-	-	-			
Magnesium	mg/l	-	-	-			
Potassium	mg/l	-	-	-			
Sodium	mg/l	-	-	-			

Martha Waters, Supervisor
Environmental Laboratory

Analysis are performed according to EPA or State of California recommended methods when applicable.
LFE Environmental is a State of California Approved Laboratory for complete chemical, bacteriological,
and bioassay analyses.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Data available for the definition of the Preston prospect are of several kinds. Surface geology was obtained from unpublished U. S. Geological Survey mapping (Oriel and Platt, 1968). Published regional gravity studies of Cache Valley outlined the general configuration of pre-Tertiary rocks (Peterson and Oriel, 1970; Stanley, 1972); a reconnaissance gravity survey of northern Cache Valley was carried out by Sunedco (Ramo, 1974) to define the important faults (plate 3 A and B). Further, a magnetotelluric survey performed for Sunedco indicated a large area underlain by very low resistivity materials beginning at a depth variously estimated from 3,500 to 5,500 feet. Finally, nine temperature-gradient holes were drilled to depths of 88 to 500 feet. These holes outlined the western, northern and southern flanks of a shallow temperature-gradient anomaly centered around Little Mountain. Unfortunately, the eastern flank of this anomaly was uncontrolled, and the overall size of the feature thus was unknown.

Two deeper gradient holes were drilled to supplement these data. One, the C. H. Stocks No. 1, located 2,870 feet north of the south line and 2,700 feet east of the west line of Sec. 6, T. 15 S., R. 39 E., was drilled to a depth of 1,492 feet. The samples from this hole were re-examined by this writer, and a report on them is included here as Appendix A. The other hole, numbered 1002, drilled 250 feet west of the east line and 1,250 feet north of the south line of Sec. 7, T. 15 S., R. 39 E., was drilled to a depth of 946 feet. Temperatures measured in these holes indicated high gradients in the shallow section (above about 300 to 400 feet) and with low gradients or isothermal conditions at greater depths, down to at least 1,500 feet (Geothermal Services, 1978).

At the time of drilling C. H. Stocks 1-A, additional temperature-gradient data were obtained by trade with Chevron Resources Co. These provided closure on the east side of the gradient high, and modified its format to a narrow, linear zone, typical of fault-controlled features.

It should be noted that the highest part of the shallow temperature-gradient anomaly is not coincident with the apex of the magnetotelluric anomaly, and that the location selected was designed to test this magnetotelluric feature.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

SUMMARY OF DATA FROM C. H. STOCKS 1-A

Information relative to stratigraphy, reservoir properties, structure, temperature, composition of some deep groundwater and of associated gases was obtained from this well. These data are summarized below, and in plates 1, 2 and 3 A and B.

Stratigraphy

Sample descriptions prepared by the GeothermEx well-site geologist are included as Appendix B. These are significantly more detailed than the description on the Baroid mud log. In addition, an interpretive summary of the major rock units is given in figure 2, based on sample descriptions and the character of the gamma ray and electrical logs.

The well was spudded in non-lithified silts, sands and gravels of Quaternary age deposited along the margin of Lake Bonneville, during the Provo Stage (Oriel and Platt, 1968). Sampling did not begin until a depth of 340 feet, below the base of the Quaternary sediments, so that the thickness of the unit is unknown.

From some point above 340 feet, to a depth of approximately 1,180 feet, the section consisted of unconsolidated light-grey bentonitic clay, interbedded with thin sand layers. Below 1,180 feet, the thickness of sandy gravels increases to the bottom of the unit, between 2,100 to 2,150 feet. Gravels in this part of the section contain clasts of weathered hematite and limonite-stained phyllite, quartz and greenschist derived from Precambrian bedrock. The interval from 1,520 to about 1,730 feet has a particularly strong red-brown color. From above 340 to 2,100 or 2,150 feet, this unit is correlative with the Salt Lake Formation of Late Tertiary age. Significant water flows were encountered in this gravel zone.

The underlying rock sequence is of Precambrian age to total depth. The location of the precise top of this section is uncertain. The first unweathered greenschist containing fresh pyrite occurred at about 2,100 feet. However, the electrical and gamma ray logs suggest that the metamorphic assemblage begins at 2,150 feet. The Precambrian section consists of alternating intervals

Figure 2. Interpretive Stratigraphy
 Sunedco C.H. Stocks 1-A Geothermal Test
 (based on samples, gamma ray & electric log)

Salt Lake
Formation

Prec
Pocatello Fm.
Scout Mt. member
(Little Mt.)

Albion?

Precambrian
Pocatello Fm.,
Scout Mountain
Member(?):
greenschist
facies meta-
sedimentary rocks

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

of chlorite-muscovite-quartz-albite(?) greenschist; quartzitic greenschist similar to the above except that quartz is the dominant mineral and the rock is poorly foliated; medium- to dark-grey phyllite; nearly pure quartzite and phyllitic marble. All of the samples are more or less pyritic. Evaluation of the resistivity logs suggests that thin zones of very low resistivity, such as those occurring at 2,750, 3,720-3,725, 4,240-4,270 and 4,710-4,720 feet, represent high concentrations of metallic minerals, perhaps pyrite. Traces of a magnetic sulfide, perhaps pyrrhotite also were noted. Small amounts of vein quartz and calcite are present throughout the section. No evidence of hydrothermal alteration was seen overprinted on the pervasive greenschist-stage regional metamorphic facies.

The section from 2,100 to about 3,700 feet appears to be correlative with the Scout Mountain member of the Pocatello Formation. Below 3,700 feet, slight increases in the coarseness of muscovite and chlorite crystals, and the occasional occurrence of biotite in the greenschist, suggested that the older, more highly metamorphosed rocks seen in the Albion Range, might have been reached (S. Oriel, 1978, oral communication). However, in retrospect, none of these rocks from 3,700 feet to total depth reaches the amphibolitic and gneiss stage of recrystallization characteristic of the older rocks. Thus, the entire section tentatively is correlated with the Pocatello Formation.

The reservoir potential in this section is confined to fracture porosity and permeability. No formation tests were carried out. The lack of evidence of large fluid entries or zones of lost circulation while drilling suggests that no important reservoir zones were penetrated to total depth. However this does not preclude fault-associated reservoir potential at greater depths.

Structure

Data from C. H. Stocks 1-A have been plotted on a cross-section (plate 1), along with an interpretation of faults based on gravity and surface data, and with data from deep temperature-gradient holes. A strong change in elevation of the top of the Precambrian between C. H. Stocks No. 1 temperature-gradient hole and the C. H. Stocks No. 1-A deep test indicates that there is a normal fault with as much as 1,800 feet of displacement, downward

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

to the west, between the holes. The dip of the fault plane is unknown but probably high, as it does not appear that this fault was cut by No. 1-A. Based on various dip interpretations, it may be present at depths of 1,000 to 3,000 feet below the present bottom of the hole. A second west-dipping fault appears to border Little Mountain, to the east. This fault apparently was cut by C. H. Stocks No. 1 gradient hole. Fracturing associated with it was probably responsible for the lost circulation encountered in that hole. This fault also may pass beneath the C. H. Stocks 1-A deep test at some unknown depth. Finally, an east-dipping normal fault appears to be present beneath the Deep Creek drainage lineament in Sec. 7, T. 15 S., R. 39 E. Further support to a fault in this position is given by the slope of the gravity gradient in this area. This fault may also pass beneath C. H. Stocks 1-A.

No cores were taken in this hole. Thus, no attitudes on bedding or foliation were obtained. Further, there was no evidence in the form of lost circulation, fluid entry or abundant vein material that a major fracture zone was intercepted by the hole above total depth.

Temperature Data

Temperature data from this hole consists of Baroid mud-temperature curves, Schlumberger temperature surveys, and a Kuster Amerada "bomb" wireline survey. All of these curves have been plotted on plate 2. As in the adjacent temperature-gradient holes, the steepest gradient occurs at shallow depth. Below about 600 feet in Stocks 1-A, the gradient declined to between 1°F and 2°F/100 feet. The highest temperatures obtained were 252°F and 5,250 feet (Kuster), about 60 hours after breaking circulation and, the following day, 253°F at 5,015 feet (Schlumberger), about 6 hours after breaking circulation.

A comparison of the various temperature curves indicates that the average Baroid mud curve, the Schlumberger curves and the Kuster curve have generally parallel traces and give similar gradients. The absolute temperatures recorded are dependent on the conditions under which the data were obtained and on the amount of time which elapsed between breaking circulation and the survey. Equilibrium of about 260° to 270°F at 5,250 feet is estimated from the observed rate of recovery.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Composition of Fluids from the Hole

A continuous gas analysis was recorded by the Baroid gas chromatograph. Both H₂S and CO₂ were present in various parts of the hole; the former as a trace to 3 ppm (2,300-3,330; 2,790-2,800; 3,230-3,300; 5,460-5,400 feet), and the latter in varying amounts over considerable intervals: 2,300-2,330 (trace), 2,790-2,850 (trace), 3,250-3,300 (500-1,000 ppm), 4,050-5,165 (trace to 500 ppm), 4,210-4,500 (trace to 1,000 ppm); 4,500-4,550 (500 to 4,500 ppm), 4,670-4,870 (500->20,000 ppm), 5,330-5,360 (2,000 ppm) and 5,420-5,480 (1,800 to 3,000 ppm). These gas occurrences have been plotted on the temperature curves (plate 2). They do not appear to be associated with temperature fluctuations or zones of fluid entry, but may represent seepage from small fractures.

Samples of formation water were collected from three zones while the hole was being cleaned out and the fluids unloaded during air drilling. The point of origin of the fluids is not precisely known. Analyses of three samples are given on table 1. They appear so strange that they must be questioned, and probably should be ignored. For example, SiO₂ is ridiculously low (3.8 ppm) in the deepest sample (from 1,170 feet). It could reflect removal of silica by combination with cement or drilling mud additives; more likely it represents dilution with drilling fluid. Total solids, conductance, chloride, sodium and potassium are far below levels reported in nearly thermal springs (Squaw and Battle Creek); fluoride is abnormally high; pH is almost unbelievably (9 to 10 pH units) high. Sulfate is higher than in Squaw and Battle Creek Hot Springs, but not abnormally so. It appears from this that a cool, silica-poor water source was used as drilling fluid. This fluid has diluted formation fluid to a point of meaninglessness. Possibly, too, reactions with drilling mud additives have changed fluid pH, and possibly other characteristics.

Conclusions

Two questions are considered here, as a follow-up to the drilling of C. H. Stocks 1-A. The first concerns the conclusiveness of the well as a test of the original prospect concept. The second is concerned with evaluation of the remaining prospect potential in the Preston area.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

In the original prospect concept, the well was located at an optimum place on the magnetotelluric anomaly and on the west flank of a shallow temperature-gradient anomaly, near its apex. The objective of the test was to evaluate the significance of these features. With regard to the magnetotelluric anomaly, the hole depth appears to have been sufficient to examine the upper part of a feature producing such an anomaly. Two possibly anomalous conditions were found. One is the local concentration of pyrite and other metallic minerals at several horizons in the Precambrian. The other consisted of the questionable occurrence of moderately(?) saline warm water in fractures in this section. These conditions are now being evaluated by geophysicists to determine if either or both together could produce the magnetotelluric anomaly.

If they could not, then it must be concluded that the anomaly-producing conditions, if real, are beyond the depth penetrated and have not yet been tested.

A comparison of the shallow temperature anomaly with data from C. H. Stocks 1-A to a depth of 300 feet conforms in gradient to the shallow pattern. A comparison of the deeper temperatures with the gradient holes shows a conformable drop in gradient, although the isothermal conditions found in the gradient holes were not encountered in the deep test. The combined data indicate that the highest temperatures and gradients in the shallow zone are located along faults immediately adjacent to Little Mountain. At depths of perhaps 6,500 to 10,000 feet these higher temperatures may be found directly beneath the site of C. H. Stocks 1-A. Thus the C. H. Stock 1-A well did not test the temperature anomaly either near the surface or at depth.

Reservoir temperature in the Preston prospect, based on the SiO_2 concentration of waters from Wayland and Squaw Hot Springs, is about 150°C (300°F), at a minimum. It is evident that C. H. Stocks 1-A did not reach the reservoir from which these spring waters had migrated. Projections (see above) place the potential reservoir at a minimum of 6,500 feet, and more likely at 7,500 feet or deeper.

From the preceding discussion, it appears that the hole may not have completely evaluated the magnetotelluric anomaly, and that it probably was too far west to test the apex of the temperature gradient anomaly and too shallow to test the high-

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

temperature zone at depth. Therefore, untested prospect potential still appears to exist in a narrow band extending along both flanks of Little Mountain, associated with the marginal fault zones. The size and economic significance of this prospect area remains uncertain from the data available.

Recommendations

1. A re-evaluation of the validity, cause and probably depth of the magnetotelluric anomaly should be made, based on the C. H. Stocks 1-A data.
2. At least one additional temperature survey, and possibly a second, should be made in the hole to determine the true equilibrium temperature and gradient.
3. The original shallow gradient data, plus all data obtained in trade should be combined with the C. H. Stocks 1-A data, to more clearly define the size and productive limits of the anomalous area around Little Mountain. If these data are inadequate, then drilling a minimum number of additional gradient holes should be undertaken to complete the prospect definition.
4. On completion of this data review, if a viable prospect remains with an areal extent indicative of significant economic potential, and with possibility of an economically attractive temperature at drillable depth, the C. H. Stocks 1-A hole can be deepened to the economic depth limit. If the review indicates that the remaining anomaly cannot be tested from the C. H. Stocks 1-A site, then the drilling of or participation in a new test which is more favorably located should be considered.
5. If the review does not indicate that a prospect of significant size or temperature for power generation remains untested, then consideration should be given to testing the hot-water productive capacity of the existing hole to determine if the water volume, temperature and chemical character permit the beneficial use in some industrial or agricultural operation.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

REFERENCES

- Armstrong, F. C. and Cressman, E. R., 1963, The Bannock thrust zone, southeastern Idaho: U. S. Geol. Survey Prof. Paper 374-J.
- Armstrong, F. C. and Oriel, S. S., 1965, Tectonic development of the Idaho-Wyoming thrust belt: Amer. Assoc. Petrol. Geol. Bull., V. 49, p. 1847-1866.
- Armstrong, R. L., 1968, Mantled gneiss domes in the Albion Range, southern Idaho: Geol. Soc. Amer. Bull., V. 79, p. 1295-1314.
- Bjorklund, L. J. and McGreevy, L. J., 1971, Ground-water resources of Cache Valley, Utah and Idaho: Utah Dept. Nat. Resources, Tech. Pub. No. 36.
- Compton, R. R., 1972, Geologic map of the Yost quadrangle, Box Elder County, Utah, and Cassia County, Idaho: U. S. Geol. Survey Misc. Geol. Inv. Map I-672.
- Condie, K. C., 1967, Petrology of the Late Precambrian tillite(?) association in northern Utah: Geol. Soc. Amer. Bull., V. 78, p. 1317-1344.
- Condie, K. C., 1969, Geologic evolution of the Precambrian rocks in northern Utah and adjacent areas: Utah Geol. and Mineral. Surv. Bull. 82, p. 71-95.
- Crittenden, M. D. Jr., Schaeffer, F. E., Trimble, D. E. and Woodward, L. E., 1971, Nomenclature and correlation of some upper Precambrian and basal Cambrian sequences in western Utah and southeastern Idaho: Geol. Soc. Amer. Bull., V. 82, p. 581-602.
- McGreevy, L. J. and Bjorklund, L. J., 1970, Selected hydrologic data, Cache Valley, Utah and Idaho: U. S. Geol. Survey Open File, Utah Basic Data Release No. 21.
- Mitchell, J. C., 1976, Geochemistry and geologic setting of the thermal waters of the northern Cache Valley Area, Franklin County, Idaho: Idaho Dept. Water Res., Water Info. Bull. No. 30, pt. 5.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

- Oriel, S. S. and Platt, L. B., 1968, Reconnaissance geologic map of the Preston quadrangle, southeastern Idaho: U. S. Geol. Survey Open-File Report.
- Peterson, D. L. and Oriel, S. S., 1970, Gravity anomalies in Cache Valley, Cache and Box Elder Counties, Utah, and Bannock and Franklin Counties, Idaho; in Geological Survey Research, 1970: U. S. Geol. Survey Prof. Paper 700-C, p. C114-118.
- Ramo, A. O., 1974, Reconnaissance geology and gravity survey of Preston Geothermal Prospect, Cache Valley, Idaho: Sunedco, unpublished report.
- Stanley, W. D., 1972, Geophysical study of unconsolidated sediments and basin structure in Cache Valley, Utah and Idaho: Geol. Soc. Amer. Bull., V. 83, p. 1817-1830.
- Trimble, D. E., 1976, Geology of the Michaud and Pocatello quadrangles, Bannock and Power Counties, Idaho: U. S. Geol. Survey Bull. 1400.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

APPENDIX A

Sample Descriptions,
Sunedco C. H. Stocks 1-A Geothermal Test

Depth, ft.		Description
From	To	
0	10	No Sample (N.S.)
10	20	N.S.
20	30	N.S.
30	40	N.S.
40	50	N.S.
50	60	N.S.
60	70	N.S.
70	80	N.S.
80	90	N.S.
90	100	N.S.
100	110	N.S.
110	120	N.S.
120	130	N.S.
130	140	N.S.
140	150	N.S.
150	160	N.S.
160	170	N.S.
170	180	N.S.
180	190	N.S.
190	200	N.S.
200	210	N.S.
210	220	N.S.
220	230	N.S.
230	240	N.S.
240	250	N.S.
250	260	N.S.
260	270	N.S.
270	280	N.S.
280	290	N.S.
290	300	N.S.
300	310	N.S.
310	320	N.S.
320	330	N.S.
330	340	tuffaceous siltstone-v.f.gr. ss., lt. gry., altered; tr. chalcedony; sl. calc.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
340	350	clay, med. gray.-tan, sl. silty, disperses in H ₂ O, bentonitic.
350	360	as above
360	370	as above
370	380	clay, med. gray.-brn., sl. silty, as above.
380	390	as above
390	400	as above
400	410	as above
410	420	as above
420	430	as above
430	440	as above; large clasts qtzte., pink, sub-ang.
440	450	as above
450	460	as above
460	470	as above
470	480	as above
480	490	as above
490	500	as above; silty & tuffaceous
500	510	as above
510	520	as above
520	530	as above
530	540	as above; residue of pyrite, qtzte. clasts, fine glass-shard tuff, qtz.
540	550	as above
550	560	as above
560	570	as above
570	580	as above; grn.-gry. when wet
580	590	as above
590	600	as above; pos. more silty & tuff.
600	610	as above
610	620	as above; dk. grn.-gry. when wet
620	630	as above
630	640	as above
640	650	as above
650	660	as above
660	670	clay, lt. gry.-brn.; dk. gry.-brn. wet, bentonitic, silty-tuffaceous, disperses in H ₂ O.
670	680	as above
680	690	as above
690	700	as above
700	710	as above
710	720	as above
720	730	as above
730	740	as above

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
740	750	as above
750	760	as above
760	770	as above
770	780	as above
780	790	as above
790	800	as above
800	810	as above
810	820	as above
820	830	as above
830	840	as above
840	850	as above
850	860	as above
860	870	as above
870	880	as above
880	890	as above
890	900	as above
900	910	as above
910	920	as above
920	930	as above
930	940	as above
940	950	as above
950	960	as above
960	970	as above
970	980	as above
980	990	as above
990	1000	clay, tan-gry., brn.-gry. wet, silty-tuffaceous; disperses in H ₂ O.
1000	1010	as above
1010	1020	as above
1020	1030	as above
1030	1040	as above
1040	1050	as above
1050	1060	clay, as above; sandy; clasts, qtz., qtzte., tr. tuff, v.f.gr., lt. gry.
1060	1070	clay, as above; sandy
1070	1080	as above
1080	1090	as above
1090	1100	as above
1100	1110	as above
1110	1120	as above

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
1120	1130	as above
1130	1140	as above
1140	1150	as above
1150	1160	as above; increasing sand.
1160	1170	as above
1170	1180	as above
1180	1190	as above
1190	1200	as above
1200	1210	tuff or tuff-siltst., lt. gry., sandy, w. sm. frags. of ls., metagwke(?) & greenstone(?); altered, sl.-mod., indurated.
1210	1220	as above
1120	1230	tuff or tuff siltst., as above; large frag. welded pumicious tuff, altered.
1230	1240	as above
1240	1250	gravel, gravelly sand, grains loose, no matrix, mostly sub-ang. frags. greenschist & lt. gry. phyllite; some limonite stain; tr. qtz. vein.
1250	1260	as above; lim. stain.
1260	1270	as above; most frags. sub-ang.-ang., few sub-round; lim. stain.
1270	1280	as above; lim. stain (note stain is on outside surface of frags.)
1280	1290	as above; lim. stain.
1290	1300	as above; lim. stain; tr. altered porph. volc.(?)
1300	1310	as above; lim. stain.
1310	1320	as above; lim. stain; tr. meta-diorite.
1320	1330	gravel, sandy-gravel, ang.-sub-ang.; phyllite, greenschist, metadiabase(?); lim. stain, vein qtz., metavolc(?); tr. lim & calcite.
1330	1340	as above; lim. stain.
1340	1350	as above
1350	1360	as above
1360	1370	as above
1370	1380	as above
1380	1390	as above
1390	1400	as above
1400	1410	as above
1410	1420	as above
1420	1430	as above
1430	1440	as above; increase lim. stain; several frags. sub-round.
1440	1450	as above
1450	1460	as above
1460	1470	as above; tr. sub-round frags.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
1470	1480	as above; lim. stain; tr. qtzte. clasts; tr. sub-round frags.
1480	1490	as above
1490	1500	N.S.
1500	1510	N.S.
1510	1520	N.S.
1520	1530	gravel, sandy, or sand, gravelly; minor lim. stain on grains; clasts phyllite, greenschist, qtz., qtzte., metadiabase, marble; hematite stain on many grains.
1530	1540	sand, gravelly; red-brn. overall color; crse. phyllite grains & pebbles, qtz., qtzte., greenschist.
1540	1550	sand, gravelly, red-brn., as above.
1550	1560	sand, red-brn., f.-m. gr., ang.-sub-ang.; phyllite, qtzte., greenschist.
1560	1570	gravel, red-brn. cast, sub-ang.-sub-round; phyllite, greenstone(?), metadiabase; qtz., qtzte.
1570	1580	gravel, sandy, red-brn., clasts, as above.
1580	1590	sand, red-brn., f.-m. gr., sub-ang.-sub-round; phyllite, qtzte., greenschist, qtz.
1590	1600	as above.
1600	1610	as above.
1610	1620	as above.
1620	1630	sand, gravelly, clasts & grains red-brn., as above.
1630	1640	as above.
1640	1650	sand, very gravelly, clasts & grains red-brn., as above.
1650	1660	gravel, sandy, clasts red-brn. stain; sub-ang.-round; phyllite, qtzte., vein calcite.
1660	1670	sand, gravelly, clasts red-brn., as above.
1670	1680	sand, crse., red-brn., minor gravel; clasts phyllite, tr. qtz, tr. greenstone, vein calcite.
1680	1690	sand, red-brn. as above, tr. vein calcite.
1690	1700	as above
1700	1710	as above
1710	1720	sand, med. brn. & red-brn. grains, sub-ang.-sub-round; phyllite, tr. qtzte., vein calcite.
1720	1730	sand, med. brn.; minor red-brn., as above.
1730	1740	sand, med. brn., minor red-brn., crse. grn. clasts metadiabase, phyllite, tr. qtz.
1740	1750	sand, med. brn., minor red-brn. as above.
1750	1760	sand, med. brn. & red-brn., as above; clasts phyllite qtzte., minor metadiabase(?).
1760	1770	sand, med. brn. & red-brn., as above; tr. vein qtz.; tr. lim. pseudo./pyrite xls.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
1770	1780	sand, med. brn. minor red-brn., as above.
1780	1790	sand, med.-brn. red-brn., as above.
1790	1800	sand, tan-med.-brn., tr. red-brn., med.-crse. grn., ang.-sub-round, as above; phyllite, metadiabase(?), qtz. & qtzte.
1800	1810	sand, tan-med. brn., tr. red-brn., as above, tr. lim. vein filling.
1810	1820	sand, tan-med. brn., tr. red-brn., as above.
1820	1830	sand, med-brn.-red-brn., as above.
1830	1840	sand, tan-med.-brn., tr. red-brn., as above; tr. lim. vein filling.
1840	1850	sand, tan-med.-brn., as above.
1850	1860	as above.
1860	1870	sand, crse. grn., tan-med. brn., red-brn., sub-ang.-sub-round, qtz., metadiabase, phyllite, qtzte.
1870	1880	sand, as above, tan-med. brn., tr. qtz.-biotite gneiss/schist(?)
1880	1890	sand, as above, tan-med. brn.
1890	1900	sand, as above, tan.; tr. lim.
1900	1910	sand, as above, tan-med. brn.
1910	1920	sand, as above, med. brn. stain; clasts qtzte., phyllite, qtz.-biotite schist(?).
1920	1930	sand, as above, med. brn. stain; qtz.-biotite schist(?), qtzte., phyllite.
1930	1940	sand, as above, med. brn. stain; tr. wh. tuff.
1940	1950	sand, as above, tan-med. brn. stain; tr. wh. biotite xl. tuff.
1950	1960	sand, as above, med. brn. stain, minor wh. biotite xl. tuff.
1960	1970	sand, as above, med. brn. stain; minor wh. biotite xl. tuff.
1970	1980	sand, m. gr., minor crse. gr., minor red-brn. stain; qtz., minor tuff & phyllite.
1980	1990	sand, m. grn., ang.-sub-round; clasts qtz., minor tuff, phyllite, qtzte., phyllite, qtz.-biotite.
1990	2000	sand, m.-crse. gr., tan stain, sub-ang.-sub-round; clasts schists(?), qtzte.
2000	2010	sand, pebbly, crse. gr., tr. red-brn. stain, ang.-sub-round; tr. greenstone, tuff, qtzte., phyllite, qtz.
2010	2020	sand, pebbly, tan-brn., as above.
2020	2030	sand, pebbly, as above, clasts phyllite, greenstone, qtz., chalcedony, lim. xl. tuff or rhyolite porph.
2030	2040	sand, pebbly, as above.
2040	2050	sand, as above; increasing clay in matrix or interbedded.
2050	2060	as above.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
2060	2070	sand, brn. stain, clayey f.-m. gr., sub-ang.-sub-round; phyllite, qtzte., qtz., qtz.-biotite gneiss.
2070	2080	sand, brn. stain, med.-crse. gr., sub-ang.-sub-round, clayey, as above.
2080	2090	greenschist, v.f.xln., m.-lt. grn.-gry., qtzose., calc., pyritic; much caving sand, as above.
NOTE Bedrock may be as high as first occurrence of unaltered pyrite at 2080-2090 sample, although the sample is heavily contaminated with uphole material. By 2140-2150 the sample appears to be a greenschist, quartzose, calcareous, pyritic, with thin grey phyllite partings. (Cuttings are all approx. same size, color and angularity.)		
2090	2100	greenschist, as above; tr. phyllite, lt. gry.; much caving sand, as above.
2100	2110	greenschist, as above; much caving sand as above.
2110	2120	as above.
2120	2130	as above; fresh pyrite, in veinlets and dissem.
2130	2140	as above.
2140	2150	as above; tr. qtzte.
2150	2160	greenschist, as above, qtzose. & calc., pyritic.
2160	2170	as above, pyritic.
2170	2180	as above, pyritic, tr. phyllite.
2180	2190	as above, pyritic.
2190	2200	as above.
2200	2210	as above.
2210	2220	as above.
2220	2230	greenschist, as above, med. grn.-gry., v.f. xln., qtzose., calc. & pyritic.
2230	2240	as above.
2240	2250	greenschist, as above; tr. gry. phyllite.
2250	2260	greenschist, m. grn.-gry., v.f.-f. gr., qtzose, calc., pyritic; tr. phyllite, m. gry.
2260	2270	greenschist, very qtzose., pyritic; w. phyllite, lt. gry.
2270	2280	greenschist, qtzose., calc., pyritic; w. phyllite, as above.
2280	2290	greenschist and phyllite, as above; pyritic.
2290	2300	as above.
2300	2310	as above.
2310	2320	greenschist, lt. grn.-gry., f. xln., qtzose, sl. calc., pyritic; w. phyllite, lt. gry.
2320	2330	as above.
2330	2340	phyllite, lt. gry., v.f.xln.; w. greenschist, lt. grn., qtzose, pyritic.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
2340	2350	phyllite, as above; minor greenschist, as above; pyritic.
2350	2360	as above.
2360	2370	greenschist and minor phyllite, pyritic, as above.
2370	2380	as above.
2380	2390	greenschist, as above, pyritic; tr. qtze.
NOTE Apparent decrease in foliation around 2380. Rock below is quartzitic greenschist. This continues to about 2530, where foliation increases again. Pyrite abundance decreases at about 2400.		
2390	2400	greenschist, as above, pyritic; tr. qtztc. greenschist.
2400	2410	greenschist, m. grn.-gry., qtztc. (qtz.-albite-chlorite), v. f. xln., weak foliation; tr. pyrite.
2410	2420	greenschist, weak foliation, as above; less pyrite.
2420	2430	greenschist, as above; tr. pyrite.
2430	2440	as above.
2440	2450	as above.
2450	2460	as above.
2460	2470	as above.
2470	2480	as above.
2480	2490	as above; tr. pyrite and phyllite.
2490	2500	as above; tr. pyrite.
2500	2510	greenschist, qtztc., weak voliation, as above; minor phyllite, lt. gry.; tr. pyrite.
2510	2520	as above.
2520	2530	as above.
2530	2540	greenschist, lt. grn.-gry., lt. silver-gry., v.f.-f.xln., qtzose., pyritic, calc.
2540	2550	greenschist & phyllite, lt. grn.-gry.-silver-gry., v.f. xln., qtzose., calc., pyritic, as above.
2550	2560	as above.
2560	2570	as above; pyrite abundance increases (3-5%).
2570	2580	as above.
2580	2590	as above.
2590	2600	as above.
2600	2610	as above.
2610	2620	as above; phyllite-greenschist, pyrite decreases.
2620	2630	phyllite, m. dk. gry., v.f. xln., minor greenschist, tr. pyrite.
2630	2640	phyllite-greenschist, as above; tr. pyrite.
NOTE Qtztc. greenschist cuttings are non-foliated or weakly foliated compared to the greenschist and phyllite. They are v.f. xln., and break into angular, blocky cuttings. Qtztc. greenschist and green-schist appear to be intergradational.		

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
2640	2650	greenschist, v.f. xln., lt. grn.-gry., Qtzose, calc., pyritic; minor phyllite, m. gry., v.f. xln.
2650	2660	greenschist & phyllite, as above; tr. pyrite.
2660	2670	greenschist & phyllite, as above; minor Qtztc. greenschist, weak foliation; tr. pyrite.
2670	2680	as above.
2680	2690	greenschist, m. grn.-gry., v.f. xln., weak foliation (Qtz.-albite-chlorite); tr. phyllite; tr. pyrite.
2690	2700	greenschist, Qtztc., & phyllite, as above.
2700	2710	greenschist, Qtztc., & greenschist, lt. grn. silver-gry., v.f.xln.; tr. phyllite, m. gry.; tr. pyrite.
2710	2720	greenschist, lt. grn.-silver-gry., v.f.xln.; minor Qtztc. greenschist; tr. pyrite.
2720	2730	greenschist, as above; tr. Qtztc. greenschist & pyrite.
2730	2740	greenschist, Qtztc., lt.-m. grn.-gry., v.f.xln., weak foliation; tr. greenschist & pyrite.
2740	2750	greenschist, Qtztc., as above; w. minor greenschist; tr. pyrite, as above.
2750	2760	greenschist, w. minor Qtztc. greenschist, as above.
2760	2770	greenschist, as above; increasing pyrite.
2770	2780	greenschist, as above; Qtzose., pyritic.
2780	2790	greenschist, as above; less pyrite.
2790	2800	greenschist, med. gry.-grn., v.f.xln., Qtzose; tr. pyrite in veinlets & dissem.
2800	2810	greenschist, as above; tr. pyrite.
2810	2820	as above.
2820	2830	greenschist, as above; minor Qtztc. greenschist; tr. pyrite.
2830	2840	greenschist, as above; tr. pyrite.
2840	2850	greenschist, m. grn.-gry., Qtztc., v.f.xln., poor foliation, (Qtz.-albite-chlorite); tr. pyrite.
2850	2860	greenschist, as above; tr. pyrite.
2860	2870	greenschist, Qtztc., m. grn.-gry., v.f.xln., poor foliation, as above; tr. calcite & pyrite.
2870	2880	greenschist, Qtztc., as above; tr. pyrite.
2880	2890	greenschist, as above; tr. vein Qtz.
2890	2900	greenschist, med. grn.-gry., Qtztc., v.f.g., poorly foliated; tr. vein Qtz., calcite, pyrite.
2900	2910	greenschist, as above; tr. pyrite.
2910	2920	as above.
2920	2930	greenschist, as above.
2930	2940	as above.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
2940	2950	greenschist, m. grn.-gry., v.f.xln., weak foliation (qtz.-albite-chlorite); tr. pyrite.
2950	2960	greenschist, as above; tr. dissemin. pyrite.
2960	2970	as above.
2970	2980	greenschist, grn.-gry., v.f.xln., (qtz.-albite-chlorite), weak foliation; tr. pyrite.
2980	2990	greenschist, as above; tr. pyrite.
2990	3000	greenschist, as above.
3000	3010	greenschist, as above; tr. phyllite; tr. pyrite.
3010	3020	greenschist, lt. gry.-lt. grn.-gry. (chlorite, muscovite, qtz.); tr. pyrite.
3020	3030	greenschist, as above; w. qtzite. greenschist, as above; tr. pyrite.
3030	3040	as above.
3040	3050	greenschist, as above.
3050	3060	greenschist, as above; tr. pyrite.
3060	3070	greenschist, as above; tr. qtzite. greenschist; tr. qtz. & pyrite dissemin. & veinlets.
3070	3080	greenschist, qtzite. greenschist, as above.
3080	3090	greenschist, qtzite. greenschist, as above; tr. qtz. & pyrite.
3090	3100	greenschist, qtzite. greenschist, as above; tr. pyrite; tr. phyllite, dk. gry.
3100	3110	greenschist, as above; tr. phyllite, dk. gry.; tr. qtz. & pyrite.
3110	3120	as above.
3120	3130	greenschist, as above; w. phyllite, lt.-md. gry.; tr. qtz. & pyrite.
3130	3140	as above.
3140	3150	as above.
3150	3160	greenschist w. phyllite, as above; minor qtz.; tr. pyrite.
3160	3170	as above.
3170	3180	greenschist w. phyllite, as above; tr. qtz., calcite, pyrite.
3180	3190	phyllite, w. greenschist, as above; minor qtz. or qtzite.; tr. pyrite.
3190	3200	phyllite, m.-dk. gry.; minor greenschist; tr. qtz. & pyrite.
3200	3210	phyllite, dk. gry., tr. greenschist; tr. qtz. & pyrite.
3210	3220	as above.
3220	3230	phyllite, as above; minor greenschist & qtzite.; tr. pyrite.
3230	3240	phyllite, as above; minor interlam. qtz. or qtzite.; minor greenschist, pyrite, calcite.
3240	3250	phyllite, as above; w. greenschist; tr. qtzite(?); tr. pyrite.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
3250	3260	phyllite; minor greenschist, qtz. or qtzte.; as above; tr. pyrite and calcite.
3260	3270	phyllite, minor greenschist, as above; tr. qtz., qtzte., pyrite & calcite.
3270	3280	phyllite, minor greenschist, as above; tr. qtz., qtzte.(?), calcite, pyrite.
3280	3290	phyllite, as above; w. minor interlam. qtz. or qtzte.; tr. greenschist, pyrite & calcite.
3290	3300	qtzte., lt. gry., micaceous; w. phyllite, as above; tr. pyrite.
NOTE Biotite becomes more apparent and xl. size increases beginning about 3300. Large albite plates are notable below this depth, and chlorite is less evident.		
3300	3310	qtzte., lt. gry., micaceous (muscovite; biotite increases in coarseness); tr. albite(?); minor phyllite, m. gry.; tr. pyrite.
3310	3320	qtzte., lt. gry., as above; tr. phyllite & pyrite.
3320	3330	qtzte., as above; minor phyllite; tr. pyrite.
3330	3340	phyllite, lt.-m. gry., or v.f. gr. schist (biotite-muscovite), w. qtzte.; tr. pyrite.
3340	3350	phyllite or v.f.xln. schist, as above; with qtzte.; tr. pyrite.
3350	3360	as above.
3360	3370	qtzte., lt. gry., micaceous (biotite-musovite), tr. albite(?); w. minor phyllite; tr. pyrite.
3370	3380	qtzte., as above; tr. pyrite.
3380	3390	qtzte., lt.-m. gry., w. v.f. dissem. biotite increasing; tr. pyrite & qtz.
3390	3400	qtzte., as above; less biotite; tr. pyrite.
3400	3410	qtzte., lt.-m. gry., with biotite-muscovite; tr. phyllite.
3410	3420	qtzte., lt.-m. gry., micaceous (biotite-muscovite, tr. chlorite), tr. albite(?), schistose; w. phyllite.
3420	3430	qtzte., as above; tr. chlorite(?) & albite; w. minor greenschist(?).
3430	3440	greenschist, m. gry., (biotite-albite-qtz.-chlorite rk., weakly foliated).
3440	3450	greenschist, as above; tr. calcite & qtz.
3450	3460	greenschist, as above.
3460	3470	as above.
3470	3480	greenschist, as above; notable albite in lg. plate-like xls., twinned; tr. pyrite.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
3480	3490	greenschist, qtztc., as above; twinned albite.
3490	3500	as above.
3500	3510	greenschist, as above.
3510	3520	greenschist, m. grn.-gry., v.f.xln., biotite-albite-qtz.-chlorite.
3520	3530	as above.
3530	3540	greenschist, qtztc., m. gry., qtz.-biotite-albite-chlorite(?), v.f.xln.
3540	3550	greenschist, qtztc., as above; tr. pyrite.
3550	3560	greenschist, qtztc., as above; tr. "micro qtz.-biotite gneiss."
3560	3570	greenschist, m. grn.-gry., v.f.xln., chlorite-biotite-albite-qtz.
3570	3580	greenschist, as above; & minor qtztc. greenschist.
3580	3590	greenschist & qtztc. greenschist, as above; tr. pyrite.
3590	3600	greenschist & qtztc. greenschist, as above.
3600	3610	as above.
3610	3620	as above.
3620	3630	as above.
3630	3640	greenschist, m. grn.-gry., v.f.xln., chlorite-biotite-albite-qtz.; minor greenschist, qtztc., weak foliation.
3640	3650	greenschist, as above; tr. calcite xls. from open fracture.
3650	3660	greenschist, as above; w. minor qtztc. greenschist.
3660	3670	greenschist, as above.
3670	3680	greenschist, as above; tr. vein calcite.
3680	3690	greenschist, as above; tr. pyrite, vein calcite, magnetite(?).
3690	3700	as above.
3700	3710	as above.
3710	3720	greenschist, as above; tr. vein qtz., increasing dissem. pyrite.
3720	3730	greenschist, m. grn.-gry., v.f.xln., chlorite-biotite-albite(?)-qtz.; & minor qtzte. or greenschist; tr. pyrite, calcite, qtz.
3730	3740	greenschist, as above; w. qtztc. greenschist; tr. pyrite, qtz., calcite.
3740	3750	greenschist, as above; increasing albite; minor qtztc. greenschist.

NOTE Base of greenschist at about 3740-3840 in an interval of poor samples. Light-grey, slightly micaceous quartzite below may be part of older Precambrian(?).

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
3750	3760	N.S.; drilling with air: sample f., blew away.
3760	3770	as above.
3770	3780	as above.
3780	3790	poor sample, rock powder residue (qtz. grains, minor green-schist, poss. partly fault gouge(?)).
3790	3800	as above.
3800	3810	as above.
3810	3820	as above.
3820	3830	as above.
3830	3840	qtz. or qtzte., milky to glassy grns.; minor phyllite, v.f.xln., gry., muscovite-biotite; tr. pyrite; samples v. sm. size, fast drilling with air.
3840	3850	as above.
3850	3860	as above.
3860	3870	phyllite, m. gry., muscovite-biotite; minor qtz. or qtzte.; tr. pyrite.
3870	3880	as above.
3880	3890	as above.
3890	3900	qtzte., lt. gry.; tr. phyllite, as above; tr. qtz.
3900	3910	as above.
3910	3920	as above.
3920	3930	phyllite, lt.-m. gry., muscovite-biotite, tr. chlorite(?); minor qtzte.; tr. vein qtz., pyrite.
3930	3940	as above.
3940	3950	as above.
3950	3960	as above.
NOTE Air drilled cuttings below 3710 are very fine; it is difficult to interpret the original rock appearance.		
3960	3970	qtzte., with phyllite, as above; tr. pyrite; samples v.f.
3970	3980	as above.
3980	3990	qtzte., as above; w. phyllite, m.-dk.- gry.; tr. green-schist; tr. pyrite; poor sample (v. sm. & v. lg. chips mixed).
3990	4000	as above.
4000	4010	as above.
4010	4020	as above.
4020	4030	as above.
4030	4040	as above.
4040	4050	phyllite, m.-dk. gry.; minor qtzte., lt. gry.; tr. green-schist; tr. pyrite, qtz.
4050	4060	as above.
4060	4070	phyllite, m.-dk. gry., muscovite-biotite; tr. pyrite; minor qtz. & qtzte.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
4070	4080	as above.
4080	4090	phyllite, dk. gry.; tr. pyrite.
4090	4100	as above.
4100	4110	qtzte., lt. gry.; minor phyllite, as above; tr. pyrite (cuttings v. sm.)
4110	4120	as above.
4120	4130	as above.
4130	4140	as above.
4140	4150	as above.
4150	4160	as above.
4160	4170	qtzte., minor phyllite, as above.
4170	4180	qtzte., minor phyllite, as above; increasing pyrite xls. & veinlets; tr. qtz. (mixed lg. & v. sm. cuttings).
4180	4190	as above.
4190	4200	phyllite, dk. gry.; tr. pyrite xls. & veinlets.
4200	4210	phyllite, as above; tr. qtzte.; lt. gry.; tr. pyrite vein.
4210	4220	as above.
4220	4230	as above.
4230	4240	as above.
4240	4250	as above; tr. qtz.
4250	4260	as above
4260	4270	phyllite as above; with qtzte., micaceous, m. gr.; tr. pyrite.
4270	4280	as above.
4280	4290	as above.
4290	4300	qtzte., lt. gry., sl. micaceous, f.-crse. gr.
4300	4310	qtzte., as above; tr. pyrite.
4310	4320	qtzte., as above; minor phyllite, dk. gry.; tr. greenschist, tr. pyrite.
4320	4330	qtzte., lt. gry., sl. micaceous, f.-crose. gr.
4330	4340	qtzte., as above; tr. pyrite.
4340	4350	qtzte., as above; minor phyllite, dk. grn. (caving?); tr. pyrite.
4350	4360	qtzte., as above; tr. phyllite; tr. pyrite.
4360	4370	qtzte., as above.
4370	4380	qtzte., as above.
4380	4390	qtzte., as above; minor phyllite, m.-dk. gry.; tr. pyrite.
4390	4400	as above.
4400	4410	N.S. (blew away).
4410	4420	N.S. (blew away).
4420	4430	qtzte., micaceous, lt.-m. gry.; minor phyllite, m.-dk. gry.; tr. pyrite.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
4430	4440	qtzte., as above; minor phyllite, lg. cuttings (caving?); tr. pyrite.
4440	4450	qtzte., as above; tr. phyllite, m. gry., tr. pyrite.
4450	4460	as above.
4460	4470	as above.
4470	4480	as above.
4480	4490	as above.
4490	4500	as above.
4500	4510	qtzte., lt.-m. gry., micaceous; tr. phyllite, dk. gry.; tr. pyrite.
4510	4520	qtzte., minor phyllite, as above; tr. vein quartz; tr. pyrite.
4520	4530	as above.
4530	4540	qtzte., as above; w. phyllite grading to muscovite schist, lt. grn.-blk.; tr. pyrite.
4540	4550	as above.
4550	4560	as above; tr. vein qtz.
4560	4570	qtzte., tr. phyllite, as above; tr. pyrite.
4570	4580	qtzte., as above; minor phyllite; tr. pyrite.
4580	4590	as above.
4590	4600	as above.
4600	4610	qtzte., minor phyllite, as above.
4610	4620	qtzte., as above; tr. phyllite; tr. pyrite.
4620	4630	qtzte., lt. gry., micaceous; minor phyllite, m.-dk. gry.; tr. pyrite, muscovite; tr. v.f.xln. greenschist(?).
4630	4640	as above.
4640	4650	qtzte., as above; tr. phyllite and greenschist(?); tr. pyrite.
4650	4660	qtzte., tr. phyllite, as above; tr. muscovite, pyrite.
4660	4670	qtzte., tr. phyllite, as above; tr. muscovite flakes, pyrite.
4670	4680	phyllite or v.f.xln. schist, m.-dk. gry., muscovite, tr. chlorite, qtz.; qtzte., micaceous; tr. pyrite.
4680	4690	phyllite or v.f.xln. schist, as above; tr. qtzte., micaceous; tr. vein qtz., pyrite.
4690	4700	qtzte., lt. gry., micaceous, w. phyllite or schist, as above.
4700	4710	phyllite, m.-dk. gry.; tr. qtzte., micaceous.
4710	4720	phyllite or v.f.xln. schist, as above; tr. qtzte., micaceous; tr. pyrite.
4720	4730	phyllite or v.f.xln. schist, as above; minor muscovite-chlorite schist, v.f.xln., lt. grn.-gry.; tr. qtzte.
4730	4740	phyllite/schist, muscovite-chlorite schist, as above.

NOTE Change in character at 4740, from predominately grey- to dark grey phyllite/schist to light green-grey muscovite-chlorite-quartz schist. Schists and phyllites are borderline: mostly phyllite, but occasionally crystal size reaches schist stage.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
4740	4750	phyllite/schist, lt. grn.-gry., v.f.xln., silvery muscovite-chlorite-qtz.
4750	4760	as above.
4760	4770	as above.
4770	4780	as above.
4780	4790	as above.
4790	4800	phyllite/schist, lt.-md. grn.-gry., muscovite-chlorite-qtz., v.f.xln., chlorite increasing.
4800	4810	as above.
4810	4820	as above.
4820	4830	as above.
4830	4840	as above.
4840	4850	as above.
4850	4860	phyllite/schist, as above; tr. pyrite.
4860	4870	N.S.
4870	4880	phyllite/schist, lt.-m. grn.-gry., v.f.xln.; tr. qtz. or qtzte.
4880	4890	phyllite/schist, as above.
4890	4900	phyllite/schist, as above; tr. qtz. or qtzte.
4900	4910	phyllite/schist, mg. grn.-gry., v.f.xln., muscovite-chlorite, tr. qtz., sl. calc.; tr. vein qtz.
4910	4920	phyllite/schist, as above.
4920	4930	phyllite/schist, as above; tr. phyllite, dk. gry.
4930	4940	phyllite/schist, as above.
4940	4950	phyllite/schist, as above; minor qtzte., lt. gry.
4950	4960	phyllite/schist, v.f.xln., lt. grn.-gry. & m.-dk. gry.; w. qtzte., lt. gry., micaceous, sl. calc.
4960	4970	phyllite/schist, as above; minor qtzte.
4970	4980	phyllite/schist, minor qtzte., as above; tr. pyrite; tr. dk. gry. phyllite.
4980	4990	phyllite/schist, minor qtzte., as above; tr. dk. gry. phyllite.
4990	5000	as above.
5000	5010	phyllite or v.f.xln. schist, calc. m.-lt. grn.-gry., muscovite-chlorite; minor qtzte.; tr. phyllite, dk. gry.
5010	5020	phyllite, dk. gry.-silvery; w. phyllite/schist, calc., lt.-m. grn.-gry.; tr. qtzte.; tr. pyrite.
5020	5030	phyllite & phyllite/schist, as above; tr. pyrite; tr. qtzte.
5030	5040	phyllite/schist, calc., m. grn.-gry.; w. phyllite, dk. gry. & qtzte.; tr. pyrite.
5040	5050	phyllite, as above; w. phyllite/schist, calc.; minor qtzte.; tr. pyrite.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.		Description
From	To	
5050	5060	phyllite, as above; tr. qtzte.
5060	5070	phyllite, tr. qtzte., as above; tr. phyllite/schist; tr. vein qtz.
5070	5080	phyllite, as above; tr. vein qtz., magnetic Fe sulfide.
5080	5090	phyllite, as above; tr. vein qtz., pyrite.
5090	5100	as above.
5100	5110	as above; tr. magnetic Fe sulfide.
5110	5120	phyllite, as above; tr. qtzte., vein qtz., pyrite, mag. Fe sulfide.
<p>NOTE Trace of brassy (tarnished(?)) magnetic mineral in phyllite and quartzite. Pyrrhotite(?) or other magnetic iron sulfide. Occurs in very small quantities; less abundant than pyrite. Slight increase in interval 5110-5120. Note traces of granular calcite in green phyllite, possible thin marble laminae, interval 5120-30, 5190-5250.</p>		
5120	5130	phyllite/schist, lt. grn.-gry.; w. qtzte., micaceous, lt. grn.; tr. phyllite, dk. gry.; tr. marble(?), lt. gry.; tr. pyrite.
5130	5140	qtzte., lt. gry.; minor phyllite/schist, m. grn.-gry., sl. calc.; tr. pyrite.
5140	5150	phyllite/schist, lt. grn.-gry., minor thin wh. marble lam.; tr. pyrite.
5150	5160	phyllite/schist, minor marble, as above.
5160	5170	phyllite/schist, marble, as above.
5170	5180	phyllite/schist, minor marble, as above.
5180	5190	phyllite/schist, minor marble, as above; tr. pyrite.
5190	5200	phyllite/schist, lt.-m. grn.-gry., muscovite-chlorite; with marble, wh.; tr. pyrite.
5200	5210	phyllite/schist, as above; marble in thin lam.; tr. amphibole, blk.
5210	5220	phyllite/schist, as above; w. marble lam.; tr. micro biotite.
5220	5230	phyllite/schist, as above; marble lam.; tr. micro biotite.
5230	5240	as above.
5240	5250	as above; tr. micro biotite.
5250	5260	phyllite/schist, gry. & grn.-gry., muscovite-chlorite; tr. micro biotite; thin marble lam.; tr. pyrite.
5260	5270	marble, wh., w. phyllite/schist lam., as above; tr. micro biotite.
5270	5280	marble, phyllite/schist lam., as above.
5280	5290	marble, lt. gry.; minor phyllite/schist partings (muscovite-chlorite).

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, Ft.		Description
From	To	
5290	5300	marble, w. phyllite/schist, as above.
5300	5310	as above.
5310	5320	marble, as above; minor phyllite/schist, as above.
5320	5330	as above.
5330	5340	marble, as above; phyllite, m. gry.; tr. phyllite/schist, grn.-gry.; tr. pyrite.
↑ 5340	5350	marble, phyllite, as above; tr. pyrite & mag. Fe sulfide.
5350	5360	phyllite, m. gry., w. marble, as above; tr. pyrite.
5360	5370	phyllite, minor marble, as above; tr. pyrite
5370	5380	phyllite, minor marble, as above; minor qtzte.; tr. phyllite/schist.
5380	5390	phyllite/schist, sl. calc., lt.-m. grn.-gry.; minor qtzte., wh.; marble, wh.; phyllite, gry.
5390	5400	phyllite/schist, as above; tr. vein qtzte.; tr. marble; tr. pyrite; tr. qtzte.
5400	5410	phyllite/schist, as above; minor qtzte.; tr. marble, pyrite, vein qtz.
5410	5420	phyllite/schist, minor qtzte., as above; tr. pyrite; tr. phyllite, dk. gry.
5420	5430	phyllite/schist, minor qtzte., as above; tr. vein qtz., pyrite.
5430	5440	as above.
5440	5450	phyllite/schist, calc., m. grn.-gry., muscovite-chlorite; tr. qtzte.; tr. pyrite.
5450	5460	phyllite/schist, as above; tr. qtzte.
5460	5470	phyllite/schist, as above; minor marble(?), wh. (as laminations?); tr. qtz., pyrite.
5470	5480	phyllite/schist, marble(?), as above; minor qtzte.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

APPENDIX B

A Review of Samples and an Interpretation of the Section in Sunedco C. H. Stocks No. 1 (Temperature Gradient Hole 1001)

C. H. Stocks No. 1 (2-78-1001) is located 2,870 feet north of the south line and 2,700 feet east of the west line of Section 6, T. 15 S., R. 39 E., Franklin County, Idaho. This location is approximately 2,000 feet northeast of the Sunedco C. H. Stocks 1-A deep geothermal test and is only about 400 feet west of Precambrian bed-rock exposed in Little Mountain. The total depth of this hole is 1,500 feet.

Geothermal Services, Inc. (GTS) prepared a description of the cuttings and ran several temperature surveys of the hole, described in their report of May 23, 1978. A summary of the GTS data is shown in figure B1 and table B1.

The aim of the present review is to attempt to relate the section found in the gradient hole with that in the deep test and to relate the section to stratigraphic units recognized in the surrounding surface outcrops. For this purpose, the samples were examined under a binocular microscope, and a lithologic log was prepared (table B2). It should be noted that all of the metamorphic rocks are very fine-grained and frequently are on the borderline between major textural classes. Thus, names given by different workers to the same sample may legitimately be different. No detailed thin-section studies have been performed to attempt to resolve the nomenclatural differences.

1. Major Units in the Section

In the present review, the following major units were recognized. Their tentative correlation with the regional section is indicated.

<u>Depth, ft.</u>	<u>Age and Description</u>
0- 70	<u>Pleistocene</u> - sand, tan, silty, fair sorting, sub-angular and subrounded grains of quartz, tuff, phyllite, etc.; unconsolidated.

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

Depth, ft.	Age and Description
70- 260	<u>Salt Lake Formation</u> - siltstone and clay, light to medium grey, tuffaceous.
260- 270	No sample.
270-1,500	Precambrian (Scout Mountain member, Pocatello Formation). Subdivided as follows: <u>270-710</u> - Metagreywacke(?), silty, or silty slate, dark grey-black, cleavage weakly developed; very pyritic. <u>710-830±</u> - Metadiabase, light to medium grey-green; composed of actinolite, chlorite and possibly albite. <u>830±-850</u> - Metagraywacke(?), silty, as in 270-710 interval. <u>850-1,030</u> - Granofels (possibly recrystallized metagraywacke), medium grey, very finely crystalline, holocrystalline, salt and pepper texture; quartz, feldspar and an unidentified dark mineral, possibly biotite. <u>1,030-1,300</u> - Metagraywacke(?), silty, or slate, silty; black; pyritic; possibly graphitic. <u>1,300-1,500</u> - Quartzite, light to medium green-grey or grey; quartz, chlorite and unidentified dark mineral in the matrix.

2. Comparison with the GTS Description and Summary Log

There are some obvious differences in the descriptions and unit boundaries between the GTS log (figure B1; table B1) and the log given here. In the Precambrian section the GTS slate-argillite unit (290-710 feet) approximately corresponds to the silty meta-graywacke or silty slate of this description (270-710 feet). The GTS chlorite schist from 710 to 830 corresponds to metadiabase on the present log, which mostly has been converted to actinolite-chlorite greenschist. The interval from 830 to 1,070 on the GTS log, called gneiss, is described as granofels herein. The term granofels is preferred because gneissic texture was not seen. Recrystallized rocks of this type are commonly found associated with metadiabase intrusions in the area (S. S. Oriel, oral communication, 1978).

Figure B1

JAMES B. KOENIG (415) 524-9242
MURRAY C. GARDNER (503) 482-2605

From 1,070 to 1,320±, the slate-argillite of the GTS log corresponds very approximately to the section from 1,030 to 1,300 of the present log, described here as silty metagreywacke(?) or silty slate. Below 1,320, to total depth, the GTS log records both gneiss and schist-phyllite. The full description (table B1) called the gneiss aporphyroblastic granofels. It appears more likely that the rock is quartzite, with an undetermined dark mineral in its matrix.

3. Possible Correlation with Rocks Exposed in Little Mountain and Vicinity

The units described in table B2, correspond to those mapped by Oriel and Platt (1968) in Little Mountain and the adjacent area. From the surface to 70 feet the material appears to be Pleistocene Lake Bonneville sediment. In the interval from 70 to 260 feet the tuffaceous clays are correlative with the Salt Lake Formation (Pliocene?). The various metamorphic rocks from 270 feet to 1,500 feet are similar to rocks occurring in the Scout Mountain Member of the Pocatello Formation. The lithology here called silty metagraywacke(?) may be the matrix of a thick and extensive diamictite portion of the Scout Mountain.

4. Correlation with the Sunedco C. H. Stocks 1-A Geothermal Test

There is a large increase in thickness of the Salt Lake Formation between the two wells, from 190 feet of clay and siltstone in the gradient hole to about 850 feet of clay and siltstone, underlain by about 970 feet of clay, sand and gravel, in the deep test. This implies that a fault separates the two holes, with the deep test area downthrown as much as 1,600 feet to the west. The Precambrian section in the two holes is difficult to compare. The metagraywacke(?), metadiabase and granofels of the gradient hole were not recognized as present in the deep test. The only part of the gradient hole section which closely resembles the deep test is the quartzite occurring between 1,300 and 1,500 feet in the shallower hole. This is somewhat similar to quartzite occurring in the deep test from about 4,100 to 4,670 feet. No structural conclusions can be drawn with confidence, owing to the uncertainty of this correlation. If, however, the correlation is correct, the Precambrian shows nearly 2,000 feet of relief between the two holes. This may be caused by fault offset (one or several faults, young or old), steep dip of Precambrian beds, erosion, or some combination of these.

TABLE B1
FIELD DATA SHEET
LITHOLOGY
LOG

HOLE NO. 2-78-1001
DATE 5/6/78
PROJECT GEOLOGIST
David Lloyd

HOLE NUMBER 1001

SOURCE MAP 2-78

REMARKS I believe that most, if not all the mica
that is visible in samples below 215' is from
the L.C. material (fine micatex plus organics)

DEPTH		LITHOLOGY
TO	FROM	
20	GL	Sub litharenite: unconsolidated, beige, med-fine grain, sub-round to sub-angular, well sorted sand. Q=80→90% R=10→15% F=1→5%.
		Quartz grains: 80% of grains are frosted, 15% clear, glassy and very angular, 5% very angular ^{with clear} rose qtz.
30'	20'	Sub litharenite: unconsolidated, brownish-beige, sub-angular to sub-round, well sorted, silti-fine sand. Q=85% R=10% F=5%
40'	30'	Very Coarse Sub litharenite: unconsolidated, beige, angular, moderately sorted, very-coarse sand. Q=85-90% R=10→15% F="Trace".
		Quartz: 50% frosted rose qtz, 50% frosted and colorless, 2-5% clear glassy.
		Rock frags: black and green meta rock frags, green meta fragments very well rounded.
60'	40'	Medium-fine grained Sub litharenite: unconsolidated, beige, sub-round to sub angular, moderately-well sorted, medium to very-fine grained, silti sand.
		Q=85→90% frosted (20→30% rose qtz) R=10→15% F=trace. 5→10% mud.

FIELD DATA SHEET
LITHOLOGY
LOG

HOLE NO. 2-78-1001
DATE 5/6/78
PROJECT GEOLOGIST
David Lloyd

HOLE NUMBER 1001

SOURCE MAP 2-78

REMARKS _____

DEPTH		LITHOLOGY
TO	FROM	
70'	60'	Very coarse phyllarenite: Multicolored (black, brown and green), sub-rounded, very coarse sand to granule phyllarenite. Q = 30% (frosted rose and uncolored). R = 70% mostly green meta, some thin argillaceous shale. F = trace. note: most cuttings too fine to catch; very few returns; drillers reported that drill bit torqued thru this fm.
80' ←	70'	Coarse, lithic sand. quartz and meta frags. drillers did not catch sample.
170'	80'	Siltstone: Lithified, medium light gray, medium grained siltstone. Individual grains discernable under hand lens; may or may not have finer matrix. Most fracture surfaces show a "micro vesicular" texture (moderately spaced, spherical holes 1 to 3 mm in diam). Note: at 80' thin horizon of large (1-3 mm) rounded, glassy, qtz grains imbedded in siltstone matrix.
		Yellow ocre color on occasional shale partings, but on the whole bedding is not readily discernible
180'	170'	Transitional. (On contact somewhere within this interval.

FIELD DATA SHEET LITHOLOGY LOG

HOLE NO. 2-78-1001
DATE 5/6/78
PROJECT GEOLOGIST
David Lloyd

HOLE NUMBER 1001

SOURCE MAP 2-78

REMARKS _____

DEPTH		LITHOLOGY
TO	FROM	
215'	180'	Mud: very light gray (slight pinkish cast), fine silty clay.
330'	215'	Armillite: very fine to extremely fine grain (under hand lens) lithified shale. Thin bedded, light, medium and dark gray in color, with incipient slaty cleavage poorly developed. Much lost circulation from this fm. No returns 210'-220' and 310' → 330'.
460'	330'	Semi-slate; armillite: medium to dark gray, pyrite bearing, weakly foliated slate. Some surfaces exhibit phyllite sheen.
710'	460'	Slate: dark gray, pyrite bearing, good slaty cleavage. Occasional very thin planes (0.25 mm thick) of qtz and calcite. Frequent LC in the slates. Slates shuff off and contaminate sample throughout rest of hole.
820	710	Actinolite - calcite - chlorite schist
850'	820'	Mixed chlorite schist and granofels.

FIELD DATA SHEET
LITHOLOGY
LOG

HOLE NO. 2-78-1001
DATE 5/6/78
PROJECT GEOLOGIST
David Lloyd

HOLE NUMBER 1001

SOURCE MAP 2-78

REMARKS _____

DEPTH		LITHOLOGY
TO	FROM	
1020	850	Granofels: very fine grain, salt and pepper, micro-gneissic texture. Qtz, feldspar, and mafics; minor pyrite. Too fine grain to identify mafic constituents. Overall color: med dk gray w/ a slight greenish cast.
1220'	1020'	Slightly phyllitised, pyrite bearing, dark-gray to black, slate. May have some dolomite of the same color and similar texture ^{in the} some interbeds (some cuttings fizz ever so slightly w/ HCl). (Natural-X log supports carbonate interbeds).
1250	1220'	Milky green, fine grain ^(phyllite) semi-schist. foliation evident but not strongly developed. too fine grained w/ fuzzy boundaries to identify mineral constituents, except for Qtz.
1300'	1250'	Black, slightly phyllitised, pyrite bearing slate and fine grain, micro-gneissic granofels.
1310'	1300'	Bad LC no returns

HOLE NO. 2-78-1001
DATE 5/6/78
PROJECT GEOLOGIST
david lloyd

HOLE NUMBER 1001

SOURCE MAP 2-78

REMARKS _____

[illegible]

TABLE B2 Lithologic Description
Sunedco C.H. Stocks-No1 Temperature Gradient Hole

Lithology	Description	Correlation
sand, lt. tan, f. gr. sub-ang., >90% qtz., fair-good sort., unconsol.	Pleistocene Sediments
as above
sand, v. lt. tan, as above
sand, tan, f. gr., few med. gr., fair sort., sub-ang.-sub-rnd., unconsol.
sand, tan, f.-v.f. gr., silty, fair sort., sub-ang.-sub-rnd., unconsol.
as above
sand, tan, m. gr., fair-poor sort., sub-ang.-sub-rnd., unconsol.
silt, tan- lt. brn., w. lg. frags. dk. gry., hard, calc. siltst; tuffaceous(?)
siltst., lt. gry., sl. calc.; tuff(?); salt/pepper
clay, silty, lt. gry.
siltst., lt.-m. gry., sl. calc., hard, tuff(?); salt/pepper	Salt Lake Formation (Pliocene?)
as above
as above
no returns
siltst., lt. gry., sl. calc., much l.c. matr.
siltst., as above
as above
as above
clay, lt. gry., sl. silty, unconsol.
as above
clay, as above; silty, tuff(?)	— ? — ? —
no returns
argillite, m.-dk. gry., pyritic; tr. greenstone, aphan., non-foliate
metagwke., (?), m. gry.-gry., v.f. gr.
no returns
poor sample; metagwke(?) as above; minor tuff or tuff; siltst. caving; tr. vein qtz.
poor sample; metagwke(?) as above
metagwke, or qtzte., v.f. gr., m.-dk. grn.-gry.
metagwke., as above; tr. argillite, m. gry., sl. foliate.
metagwke., dk. gry., v.f. gr.-silty; poorly devel. secondary cleavage; tr. qtzte., lt. gry., v.f. gr.	Pocatello Formation (Precambrian)
poor sample; metagwke(?)
no returns
poor sample
poor sample
metagwke.(?), as above; much tuff caving
as above
poor sample	
	metagwke.(?), m.-dk. gry., v.f. gr. siltst.; minor qtzte., lt. gry., v.f. gr.; tr. pyrite.	
	metagwke.(?), as above; w. qtzte., m.-gry., v.f. gr.; tr. pyrite	
	qtzte., m.-lt. gry., v.f. gr.; minor metagwke.(?), dk. gry.; siltst.; tr. pyrite.	
	qtzte., as above, m.-dk. gry.; minor metagwke(?); as above	
	qtzte., metagwke.(?), as above	
	metagwke.(?), m.-dk. gry., v.f. gr.-siltst.	
	metagwke. or silty argillite, dk. gry.	
	metagwke., dk. gry., v.f. gr.-siltst.; tr. pyrite.	
	metagwke.(?), m. gry., v.f. gr., w. slate, m. gry., sl. fol.	
	metagwke.(?), m.-dk. gry., v.f. gr.-siltst.; poor cleavage/fol.	
	as above	
	slate or v.f. xln. phyllite, lt. gry., weak cleavage; pyritic	
	metagwke(?), v.f. gr., m.-dk. gry., weak cleavage or foliation	

	as above
	metagwke(?) or silty slate, weak cleavage or foliation; tr. pyrite
	as above
	as above
	no returns
	poor sample; metagwke. or silty slate, as above; tr. pyrite
	metagwke(?), m.-dk. gry., v.f. gr., or silty slate, weak cleavage.
	as above
	as above; tr. pyrite
	as above; tr. pyrite
	slate(?), silty, dk. gry., or metagwke., silty.
	metagwke.-siltst., dk. gry., poor cleavage.
	no returns
	metagwke-siltst., as above; tr. pyrite
	slate(?), silty, dk. gry.; tr. pyrite; fair cleavage
	slate(?), silty, as above
	as above; tr. pyrite
	slate(?), as above; increasing pyrite, in veinlets; tr. qtzte., m. gry., v.f. gr.
	slate(?), as above; pyrite; tr. qtzte.
	slate(?), silty, as above; pyrite; tr. qtzte.
	slate, dk. gry., blocky, pyritic, with qtzte.(?), grn., qtz.-albite-chlorite
	metadiabase., lt.-m.-grn., chlorite, calcite, albite(?), actinolite(?);
	as above minor slate, as above.
	metadiabase(?), as above; soft, partly altered to clay; tr. pyrite & slate
	metadiabase, as above
	metadiabase, as above; minor slate, dk. gry., as above; tr. pyrite
	no returns
	no returns
	metadiabase(?), lt.-m. gry.-grn., albite-chlorite-actinolite(?)
	as above
	no return
	metadiabase, as above
	metadiabase, as above; w. minor metagwke.(?), blk., v.f. gr.-siltst., v. pyritic; no cleavage/foliation.
	metagwke.(?), blk., v.f. gr.-siltst., v. pyritic, non-foliated; w. minor metadiabase, as above
	metagwke.(?), as above; minor granofels(?), lt. gry., salt/pepper pyritic; minor metadiabase
	granofels(?) m. gry., feld., qtz(?) & unident. blk. mineral; abdt. pyrite; tr. metagwke.(?) as above
	poor sample; granofels(?) as above; tr. metadiabase & metagwke(?)
	granofels(?) as above; tr. metadiabase; tr. pyrite
	granofels(?) as above; dk. mineral biotite in part.
	granofels(?) as above; salt/pepper; qtz.(?), feld., biotite(?); tr. pyrite
	no returns
	no returns
	poor sample; granofels(?), salt/pepper, qtz.(?), feld., biotite(?), v.f. xln.; tr. pyrite
	no returns
	granofels, m. gry., salt/pepper; v. fl., pyritic
	granofels(?) as above; tr. pyrite
	granofels(?) as above
	poor sample; granofels(?), as above
	poor sample; as above
	granofels. m. gry., v.f. xln., holoxln., equigran.; pyritic.

	no returns
	granofels, as above; pyritic
	granofels, as above; tr. qtzte, wh.; pyritic
	metagwke. - siltst., dk. gry. v. pyritic, poor cleavage, or slate; graphitic(?), pyrite v.f. xln., dissem.
	metagwke. - siltst., or slate, blk., pyritic; as above
	as above
	as above
	as above
	as above
	as above
	as above; tr. qtzte, v.f. gr.
	no returns
	metagwke. - siltst. or slate, as above; tr. qtzte.; v. pyritic, graphitic(?); tr. qtzte.
	as above
	as above
	as above, minor qtzte
	as above, tr. qtzte
	as above
	as above
	as above
	as above
	metagwke., blk., silty; v. pyritic; lg. bluish qtz. gr.
	metagwke. (siltst.?) or slate, blk., v. pyritic
	metagwke. or slate, as above, blk., pyritic, w. qtzte.(?), grn., qtz.-chlorite-albite(?)
	qtzte.(?), m. grn.-gry., v.f. gr., qtz.-chlorite-feld.(?), minor metagwke.(?), dk. gry. pyritic
	metagwke. (siltst.) or slate, dk. gry., pyritic; w. qtzte.(?) as above
	as above
	metagwke. (siltst.)? or slate, as above; tr. pyrite, vein qtz.
	metagwke., as above; tr. phyllite, lt. grn., muscovite-chlorite; tr. qtzte.; tr. vein
	metagwke., dk. gry., (siltst. & ss.-size), pyritic; tr. grn. phyllite, granofels ^{qtz, pyrite}
	no returns
	qtzte, dk. gry., dk. matrix; tr. metagwke. or slate, dk. gry.
	qtzte, as above
	as above; tr. pyrite
	no returns
	qtzte, lt. gry. & grn.-gry., qtz.-chlorite-feld(?), or qtzte. greenschist (non-foliated)
	qtzte, lt. gry., tr. grn., qtz.-feld(?) - chlorite; tr. pyrite
	qtzte, lt.-m. gry., tr. grn.
	qtzte, lt.-m. gry.; tr. pyrite
	as above
	poor sample
	poor sample
	poor sample
	poor sample
	metagwke. - siltst., or slate, dk. gry., pyritic; w. qtzte., m. gry
	qtzte, m. gry. & grn.-gry.; tr. pyrite
	no returns
	qtzte, m. gry; tr. metagwke./slate, dk. gry.
	qtzte, lt. gry.