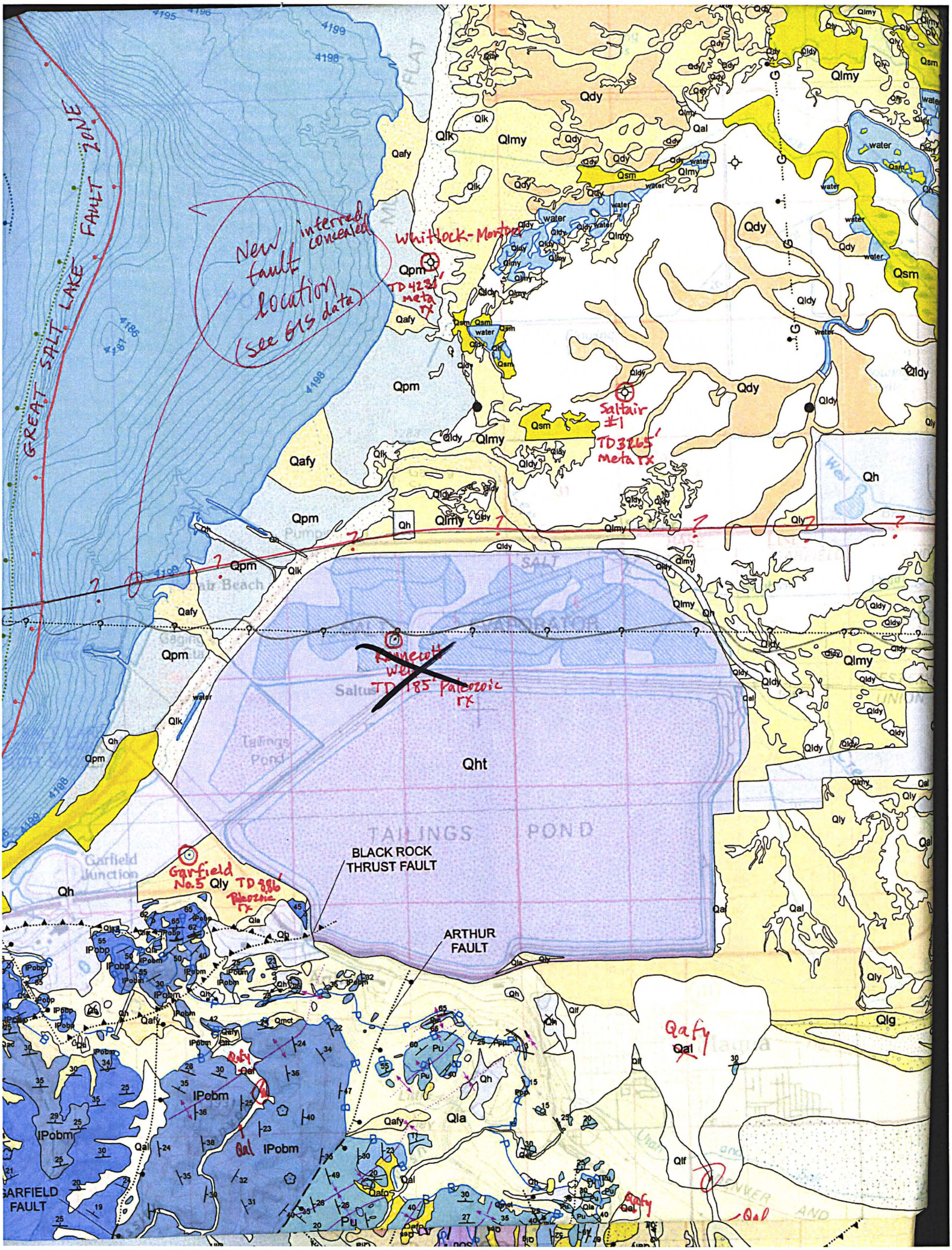
GREAT SALT LAKE FAULT ZONE
New fault location (see GIS data)
inferred concealed
Whitlock-Mostpet
TD 4234' meta rx
Saltair #1
TD 3265' meta rx
Kennecott well
TD 185' Paleozoic rx
Garfield No.5 Qly TD 886' Paleozoic rx
BLACK ROCK THRUST FAULT
ARTHUR FAULT
GARFIELD FAULT
TAILINGS POND
Tailings Pond
Garfield Junction
Qpm
Qafy
Qlk
Qlmy
Qldy
Qsm
Qh
Qht
Qly
Qal
Qlg
Qlf
Qla
IPobm
Pu
Qmct
water

WELLPRT Well Log Information Listing

Version: 2003.09.18.00 **Rundate: 10/09/2003 01:54 PM**

WIN 4529

WRNUM/Appl. No
93590I2M00

Utah Division of Water Rights

Water Well Log

LOCATION:
N 1750 ft W 96 ft from SW CORNER of SECTION 1 T 1S R 3W BASE SL Elevation: feet
25 OF 26

35

OWNER(S):
OWNER: Kennecott Plant Projects Group
ADDRESS: P.O. Box 112
CITY: Bingham Canyon STATE: UT ZIP: 84006-01
REMARKS: 128015697014

DRILLER ACTIVITIES:
ACTIVITY # 1 NEW WELL
DRILLER: LANG EXPLORATORY DRILLING INC LICENSE #: 568
START DATE: 11/14/1993 COMPLETION DATE: 11/15/1993

BOREHOLE INFORMATION:

Depth(ft) From	To	Diameter(in)	Drilling Method	Drilling Fluid
0	20	10.0	CONV SINGLE WALL	DRY
20	25	5.75	DUAL WALL REV CIRC	DRY
25	185	5.75	DUAL WALL REV CIRC	WATER

LITHOLOGY:

Depth(ft) From	To	Lithologic Description	Color	Rock Type
0	5	SILT,SAND,GRAVEL SILTY SANDY GRAVELLY COLLUVIUM		
5	35	LOW-PERMEABILITY TAN/LIGHT BROWN SANDSTONE	TAN/LT BROWN	SANDSTONE
35	185	LOW-PERMEABILITY TAN/LIGHT GRAY QUARTZITE GOOD QUALITY H20	TAN/LT GRAY	QUARTZITE

WATER LEVEL DATA:

Date	Time	Water Level (feet) (-)above ground	Status
11/19/1993		70.91	

CONSTRUCTION - CASING:

Depth(ft) From	To	Material	Gage(in)	Diameter(in)
+3	40	STEEL	.250	7.00
+2.50	81	P.V.C SCH 80	.500	2.50

CONSTRUCTION - SCREENS/PERFORATIONS:

Depth(ft) From	To	Screen(S) or Perforation(P)	Slot/Perf. siz	Screen Diam/Length Perf(in)	Screen Type/# Perf.
81	140	PERFORATION	.020	2.50	LONGYEAR

CONSTRUCTION - FILTER PACK/ANNULAR SEALS

Depth(ft) From	To	Material	Amount	Density(pcf)
0	28	PORTLAND CEMENT	8	16
28	50	PURE GOLD GROUT	5	15
50	54	BEN SEAL		
54	64	100 MESH SAND		

64	72	16 X 40 SAND
72	185	10 X 20 SAND

GENERAL COMMENTS:

CONSTRUCTION INFORMATION:
Well head configuration: Locking cap on 7" casing
Casing Joint Type: Flush Perforator used: None
Well Development: No data
Pump: N/A
Comments: No data
additional data not available

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

Non-Production Well: 1059013M00 WIN: 434550

Owner *Note any changes*

KENNECOTT UTAH COPPER LLC
C/O BRIAN VINTON
4700 DAYBREAK PARKWAY
SOUTH JORDAN, UT 84095

Contact Person/Engineer: Brian Vinton

Well Location *Note any changes*

N 3202 E 1082 from the SW corner of section 15, Township 1S, Range 3W, SL B&M

Location Description: (address, proximity to buildings, landmarks, ground elevation,local well #)

Drillers Activity Start Date: 2/24/11 Completion Date: 4/6/11

Check all that apply: ☒ New ☐ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use:

If a replacement well, provide location of new well. _____ feet north/south and _____ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	49	19"	Conventional Mud	Bentonite
49	540	12¼"	Flooded R/C Mud	Polymer, Bentonite
540	860	7-7/8"	Conventional Mud	Polymer, Bentonite

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture,degree of weathering, hardness, water quality, etc.)
0	240											Clay		Generally silty
240	255											Sand		Fine to medium
255	405											Clay		Silty, trace sand
405	460											Silt		Clayey, trace sand
460	560											Sand & Gravel		Silty
560	750											Gravel		
750	860											Limestone		

RECEIVED
MAY 05 2011
WATER RIGHTS
SALT LAKE

Static Water Level

G: +9.21
Date 3/21/11 Water Level F: +8.25 feet Flowing? ☒ Yes ☐ No
Method of Water Level Measurement Clear Tube If Flowing, Capped Pressure _____ PSI
Point to Which Water Level Measurement was Referenced Ground Surface Elevation approx. 4200 ft.
Height of Water Level reference point above ground surface 0 feet Temperature 23.3 / 20.4 degrees ☒ C ☐ F

[redacted] *Well Log* [redacted]

Date	Test Method	Yield (CFS)	Drawdown (ft)	Time Pumped (hrs)
08/21/1964	PUMP	7.966	128	48

WATER QUALITY DATA AVAILABLE

GENERAL COMMENTS:
DEPTH DRILLED 885 FT. DEPTH OF COMPLETED WELL 886 FT.

WIN 12621
59-5280 WRNMM
59-1196

WELLPRT Well Log Information Listing

Version: 2003.09.18.00 **Rundate: 10/10/2003 10:38 PM**

Utah Division of Water Rights

Water Well Log

LOCATION:
S 1520 ft E 1060 ft from NW CORNER of SECTION 15 T 1S R 3W BASE SL Elevation: feet

DRILLER ACTIVITIES:
ACTIVITY # 1 WELL REPLACEMENT
START DATE: 06/12/1964 COMPLETION DATE: 08/21/1964

BOREHOLE INFORMATION:

Depth(ft) From	To	Diameter(in)	Drilling Method	Drilling Fluid
0	885	20	CABLE	

LITHOLOGY:

Depth(ft) From	To	Lithologic Description	Color	Rock Type
0	7	OTHER		TOPSOIL
7	135	CLAY	BLUE	
135	198	CLAY	BROWN	
198	235	CLAY,SAND	BLUE	
235	265	CLAY	BROWN	
265	470	CLAY,SAND	BLUE	
470	546	CLAY,GRAVEL	BROWN	
546	650	OTHER		CONGLOMERATE
650	658	CLAY,GRAVEL		
658	685	OTHER		CONGLOMERATE
685	708	CLAY,GRAVEL		
708	762	COBBLES		
762	816	CLAY,GRAVEL		
816	843	COBBLES		
843	875	CLAY,GRAVEL	RED	
875	882	CLAY,GRAVEL	BROWN	
882	886	OTHER CONGLOMERATE	BLACK	LIMESTONE

WATER LEVEL DATA:

Date	Time	Water Level (feet) (-)above ground	Status
08/21/1964		5.00	STATIC

CONSTRUCTION - CASING:

Depth(ft) From	To	Material	Gage(in)	Diameter(in)
0	885	NEW	.38	20

CONSTRUCTION - SCREENS/PERFORATIONS:

Depth(ft) From	To	Screen(S) or Perforation(P)	Slot/Perf. siz	Screen Diam/Length	Perf(in)	Screen Type/# Perf.
546	650	PERFORATION	.38	3	10	
675	764	PERFORATION	.38	3	12	
815	845	PERFORATION	.38	3	12	

CONSTRUCTION - FILTER PACK/ANNULAR SEALS

Depth(ft) From	To	Material	Amount	Density(pcf)
0	200	CEMENT		

WELL TESTS:

d
es-
pping

From Antelope Island Mapping files

. . . from the desk of

Howard R. Ritzma
Utah Geological Survey

2-25-75

Craig Mann advises me that he has talked to Darrol Wixson with Amoco about age dates in the Great Salt Lake Basin. Craig is with ~~Morton~~ Gulf in Casper.

Amoco has dated volcanics from the L. A. Whitlock No. 1 Morton well, section SE/NW 24 - 1N - 3W, depths 2330 - 2807. These have yielded ages of 33.4 - 36.4 m.y. which is roughly equivalent to the Alta Stock, Keetley Volcanics and Norwood Tuff. The well drilled to 4,231 and topped Precambrian at 3,654. Top of Tertiary is picked at 1,432.

HRR 2/25/75

Don Higgins 6/11
Randy Chamberlain
298-1000

12/90 may be able to help get info
Robert G. Raynolds Amoco
303-830-4654

RESISTIVITY
ohms. m^2/m

LONG NORMAL
50
500
5000

UGS scout card

UTAH
SALT LAKE COUNTY
WILDCAT (W)

PETROLEUM INFORMATION
DENVER CASPER
ROCKY MOUNTAIN
OIL INFORMATION

Twp 1n-3w
Section 24
se se nw
(2120 s/n 2120 e/w)

OPR: Woodlay-Garson, Inc.

WELL #: 1 Whitlock-Morton Salt Co.

ELEV: 4202 Gr.

*TOPS: Log-Sample

Valley Fill surface to TD.

Tertiary 1432

Top Pe @ 3654'

(DC Mann (Gulf-Casper) to H.R.R., 2/25/75) ~(See Heylmun, 1955)

Lat. 40° 07' 50"

Long. 112° 07' 58"

DSTS. & CORES:

SPUD: 12-2-56 COMPL: 12-25-56

TD: 4231 PB:

CSG: 10-3/4" @ 600

PERF:

PROD. ZONE:

INIT. PROD:

D & A in Valley Fill.
This information at State O+G Div also - no shows

U8-650321

*For Electric Logs on Rocky Mountain Wells—Ask Us!

OdG contin has log of activities

Volcanics 2330-2807

K-Ar 33.4 to 36.4 my. (Oligocene)

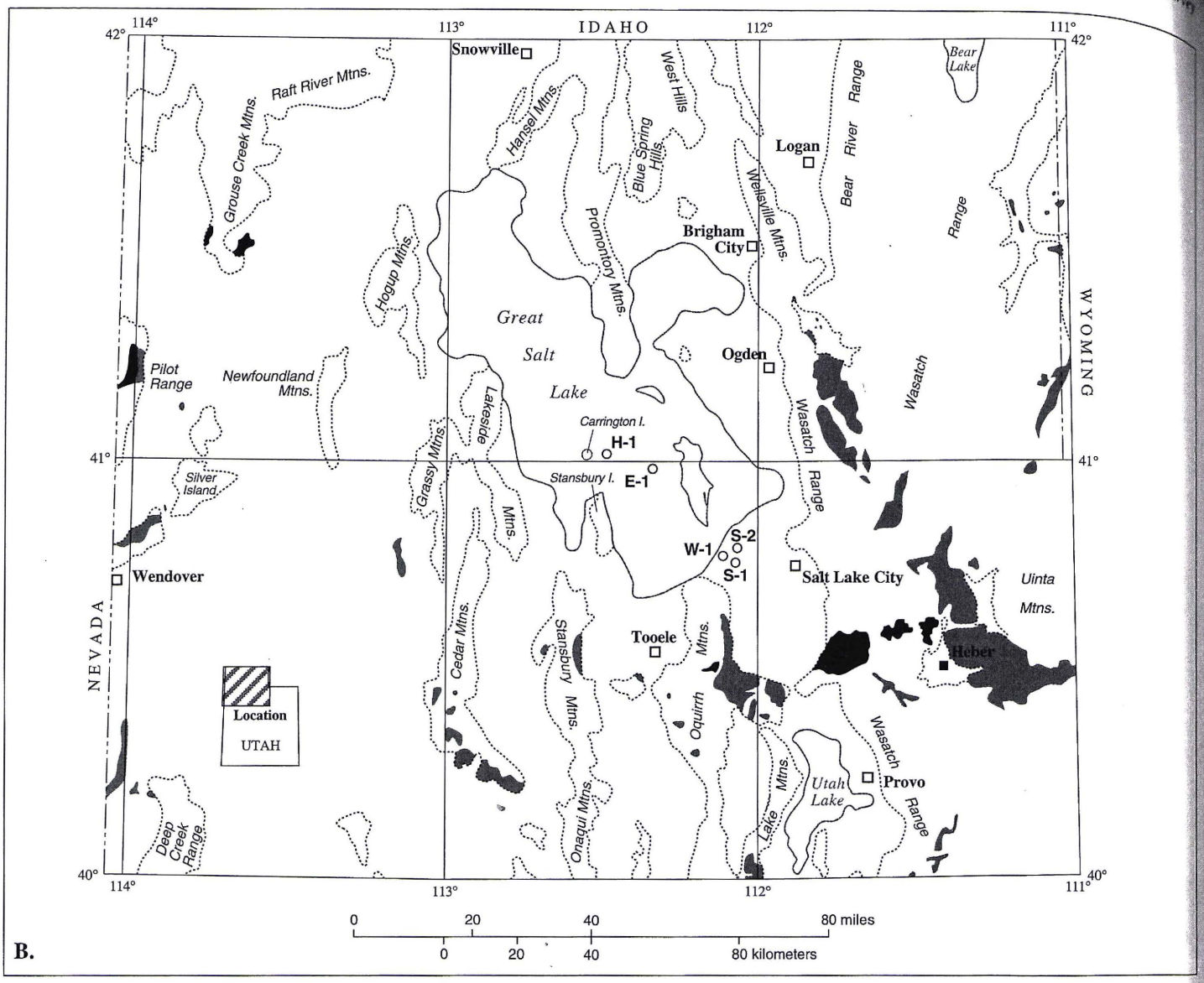

Figure 16B. *Middle Eocene to middle Oligocene volcanic and volcaniclastic deposits (mostly of intermediate composition) and related rocks (grey); and intrusive igneous rocks (black). Note the belt of igneous activity south of Antelope Island.*

and others (in press) summarized chronologic data and correlations of these and other Tertiary outcrops in northern Utah.

Drill holes in the Great Salt Lake basin

Several drill holes in Great Salt Lake west and northwest of Antelope Island penetrated upper Tertiary sections up to 15,000 feet (4,600 m) thick (figure 1) (Bortz and others, 1985). The oldest Tertiary rock is Miocene in most wells, though one well (State L-1, section 12, T. 5 N., R. 7 W.) penetrated volcanic tuff near the bottom that Bortz and others (1985) dated at 29.0 ±1.3 Ma (late Oligocene). In nine wells, the Tertiary strata rest unconformably on Paleozoic rock. In the two wells closest to Antelope Island, the State E-1 (section 19, T. 3 N., R. 4 W., about 1 mile [1.6 km] west of the island), and the State H-1 (section 11, T. 3 N., R. 6 W.), about 7 miles [11 km] west of the island), Tertiary rocks rest on probable Precambrian Farmington Canyon Complex rocks (figure 1). In the State E-1, the Tertiary-Precambrian contact may be a fault (W.A. Yonkee, verbal communication, 1991). Four wells bottomed in upper Tertiary strata.

Several other wells were drilled in the valley floor 3 to 8 miles (5-13 km) southeast of the south tip of the island. Of these, three are particularly interesting. The Whitlock-Morton 1 (W-1 on figure 1) (section 24, T. 1 N., R. 3 W.) encountered the top of the Tertiary at about 1,430 feet (436 m), and the top of the Precambrian (high-grade metamorphic rocks) at about 3,650 feet (1,110 m), based on geophysical logs. The 2,300 to 2,800 foot (700-850 m) interval cut volcanic rocks that were dated at about 34 and 37 Ma (adjusted using new decay constants according to Dalrymple, 1979) (Howard Ritzma, unpublished data, 1975). These ages are slightly younger than the ages we obtained on Antelope Island, but are still within the period of late Eocene to early Oligocene volcanism. The 2,800 to 3,650 foot (850-1,110 m) interval probably consists of early Tertiary clastic deposits.

The Saltair 1 well (S-1 on figure 1) (section 29, T. 1 N., R. 2 W.) encountered the Quaternary/Tertiary contact at 1,328 feet (405 m) and the Tertiary/Precambrian contact at 3,070 feet (936 m) (Howard Ritzma, unpublished notes, 1975).

The Saltair 2 well (S-2 on figure 1) (section 16, T. 1 N.,

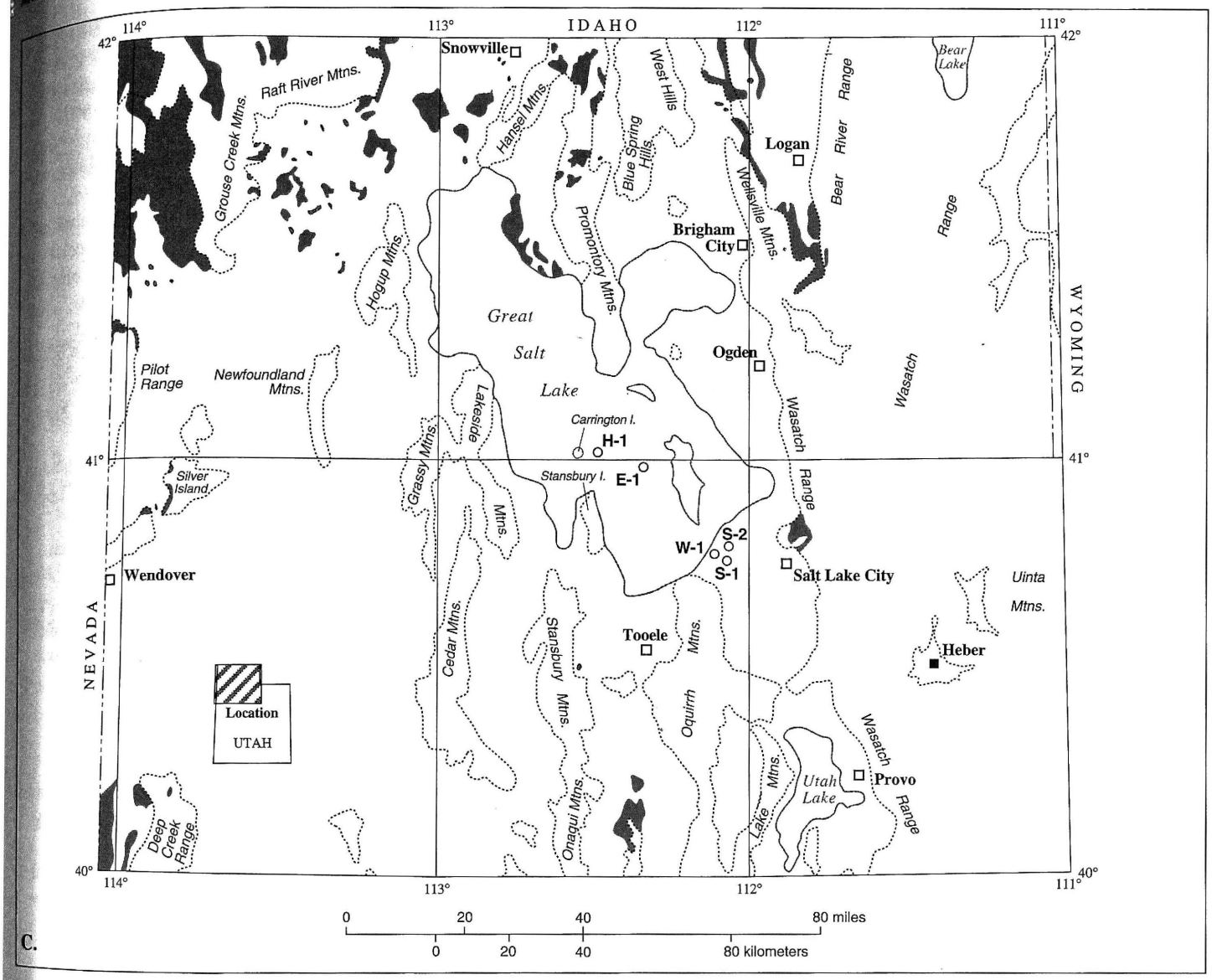

Figure 16C. *Miocene through Pliocene (and possibly some early Pleistocene) fluvial, lacustrine, and volcaniclastic strata, tuff and volcanic ash (mostly rhyolitic), and basalt. These rocks are commonly assigned to the Salt Lake Formation. Though not shown because of Quaternary cover, thousands of feet of rocks of this age also fill the basins between the faulted ranges. The outcrops shown on the map are relatively small remnants of these "basin-fill" rocks preserved on the flanks of upthrown blocks.*

R. 2 W.) bottomed at 3,207 feet (978 m), but the information on the well is unreliable. The Utah Geological Survey sample library holds two boxes of core from the Saltair 2 well, one labeled as the 1,721-1,740 foot (525-530 m) interval and the other as the 3,200-3,207 foot (975-978 m) interval. Both boxes contain only high-grade metamorphic rock. Based on our interpretation of the basin configuration, an examination of geophysical well logs, and the description of the geology penetrated in the nearby Saltair 1 well, we estimate the Tertiary-Precambrian contact is below the 3,000 foot (910 m) interval. We believe that the samples in the higher-interval box are mislabeled and are part of the lower-interval samples. Alternatively, the well may have penetrated a displaced section such as a slump block.

Summary of Regional Correlation

Tertiary deposits on Antelope Island have a lithologic sequence similar to other Tertiary deposits in north Utah (figure 16A-C) (Miller, 1990; Miller and others, in press). This sequence consists of: (1) basal clastic, generally conglomeratic strata, commonly with red coloration, of probable late Paleocene to Eocene age that unconformably overlie Paleozoic or Precambrian rocks; (2) locally overlying and interfingering lacustrine beds in north Utah and east Nevada of late Paleocene to late Eocene age; (3) intermediate-composition volcanic and volcaniclastic deposits of mostly middle and late Eocene age interlayered with, and overlying the lacustrine beds, or overlying the conglomeratic beds where lacustrine beds are absent; (4) generally limited or missing strata of known or assumed Oligocene age; and (5) overlying coarse fluvial to fine-grained lacustrine deposits, vitric tuffs, rhyolite, and locally, basalt, that range from Miocene to Pleistocene in age. The Tertiary section on Antelope Island conforms to this basic sequence.

THICKNESS OF VALLEY FILL IN THE JORDAN VALLEY EAST OF THE GREAT SALT LAKE, UTAH

By TED ARNOW and R. E. MATTICK, Salt Lake City, Utah; Denver, Colo

Work done in cooperation with the Utah State Engineer

Abstract.—A seismic-refraction profile in the Jordan Valley, east of the Great Salt Lake, Utah, showed three velocity layers. The upper two are correlated with valley fill of Quaternary and Tertiary age, whereas the lowest is correlated with consolidated rock. The computed thickness of the fill along the seismic profile ranges from about 600 to 4,800 feet.

As part of an investigation of the water resources of Salt Lake County, Utah, the U.S. Geological Survey must determine the amount of ground water that is discharged toward Great Salt Lake through valley fill in the north end of the Jordan Valley. In order to help calculate the thickness of the fill, a refraction seismic study was made across the valley during 1965. On the basis of the seismic work and interpretation of the logs of several nearby wells, the valley fill has been divided into units of Quaternary and Tertiary age and the thickness of each unit calculated.

SEISMIC SURVEY

The refraction survey was based on 10 shotpoints spread over a total length of about 15 miles (fig. 1). Depths to the first refracting horizon were computed by the method of Hawkins (1961), and depths to the deeper refractors were computed using the graphical method of Slotnick (1950). Three major velocity layers were found (fig. 2). The seismic velocity in the near-surface layer ranges from about 5,700 to about 5,900 feet per second, in the second layer it ranges from about 8,700 to about 12,500 fps, and in the third layer it ranges from 15,000 to 15,800 fps. The three layers are interpreted in descending order as Quaternary deposits, Tertiary deposits, and consolidated rocks of several ages.

Quaternary deposits

The uppermost layer is believed to be of Quaternary age. It can be traced continuously along the seismic profile, and the velocity in this layer is characteristic of an unconsolidated water-saturated material. Logs of wells drilled near the profile indicate that this material is predominantly interbedded clay, silt, fine sand, and medium sand. Thin beds of tuff were described by Eardley and Gvosdetsky (1960, pl. 1) and by Berry and Crawford (1932, p. 54) in wells 2 and 4, respectively, at the western and eastern parts of the profile.

The computed thickness of the Quaternary deposits ranges from about 600 to 2,500 feet. The minimum thickness is near the west end of the profile, and the layer thickens to about 1,500 feet at shotpoint 4. It thins east of shotpoint 4, reaching a thickness of about 760 feet between shotpoints 5 and 6, and thickens again toward the east to a calculated thickness of 2,480 feet at shotpoint 9. East and southeast of shotpoint 9, where seismic data are unavailable, the gravity map suggests that the uppermost layer continues to thicken.

The description of well 2 by Eardley and Gvosdetsky (1960) states that the well, which was cored to a total depth of 650 feet, bottomed in sediments of Aftonian age of the Pleistocene. Berry and Crawford (1932, p. 54) report mollusca of Pleistocene age to a depth of 884 feet in well 4. The electrical log for well 3 (fig. 3) does not indicate any change in formation between 512 feet (the top of the log) and a depth of about 970 feet where the marked change in spontaneous potential and gradual change in resistivity indicates a change in the physical characteristics of the sediments. Although neither electrical nor seismic information is

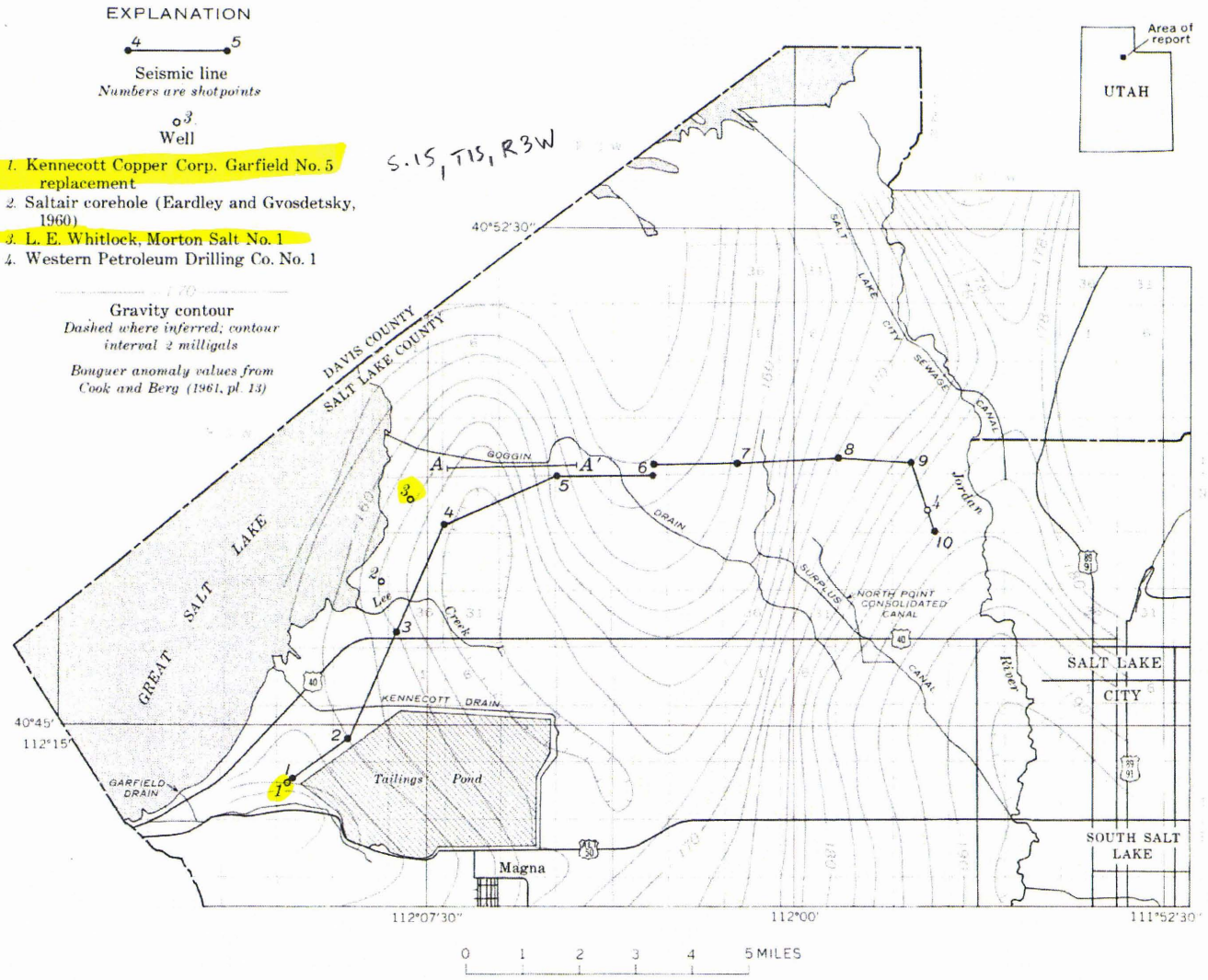

FIGURE 1.—Map of the northern part of the Jordan Valley, Utah, showing line of seismic profile, well locations, and Bouguer gravity anomalies.

diagnostic of age, the decrease of resistivity at about 970 feet in well 3 and the increase of velocity from 5,700 to about 9,000 fps between the upper and middle layers is here correlated with the base of the Quaternary deposits.

Tertiary deposits

The intermediate velocity layer is believed to be of Tertiary age. It appears only in the central and west-central part of the seismic profile, and the velocities in this layer are characteristic of semiconsolidated sediments. Only well 3 near the profile is known to have penetrated this layer. The log of well 3 indicates that the layer primarily contains unconsolidated sediments, but a total of about 300 feet of volcanic rock, possibly andesite, was penetrated between depths of 2,300 and 2,800 feet. Part or all of the second layer may be in the Salt Lake Formation, but without diagnostic fossils or an age determination, a definite identification cannot be made.

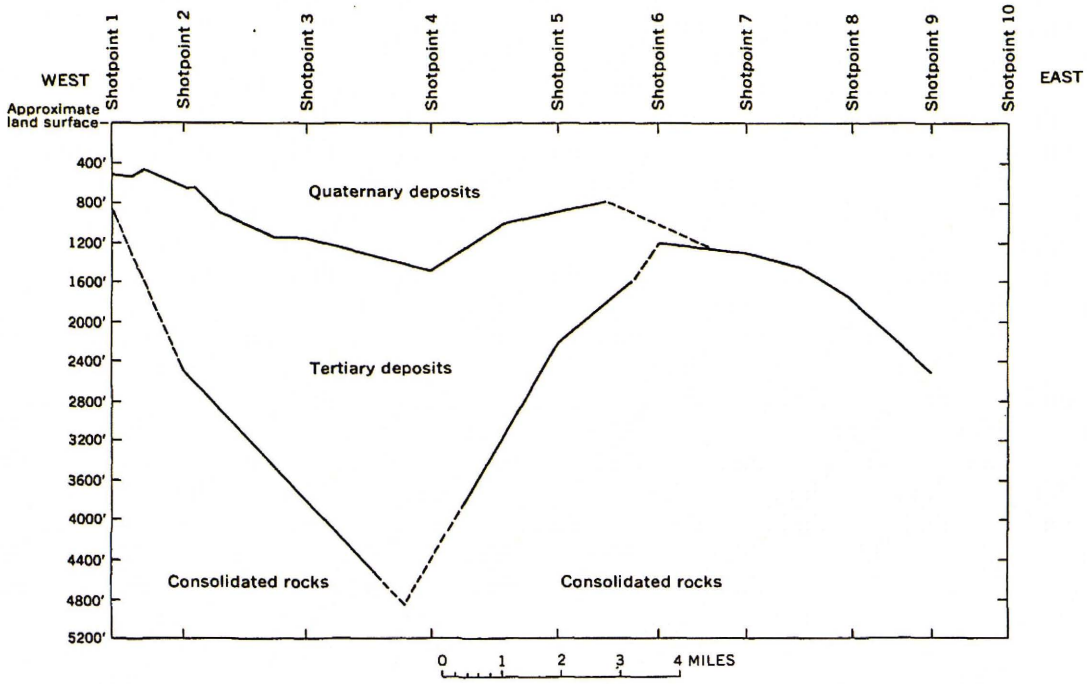

FIGURE 2.—Computed depth of three velocity layers along seismic profile in the Jordan Valley, Utah. Boundaries are dashed where inferred.

The computed thickness of the second layer ranges from 0 to about 3,400 feet. It was traced continuously on the seismic profile between shotpoints 2 and 6, but it did not appear at shotpoint 1 or east of shotpoint 6. It reaches a maximum thickness of about 3,400 feet near shotpoint 4, where the profile crosses a gravity low.

Consolidated rocks

The lowest layer can be traced across almost the entire profile, and the velocities in this layer are characteristic of consolidated rocks. The driller's log for well 1 states that the well penetrated black limestone at a depth of 882 feet (Iorns and others, 1966, p. 88). An increase of resistivity on the electrical log of well 3 at a depth of about 3,650 feet indicates that the well penetrated consolidated rock at about that depth, and a core taken at 4,126 feet suggests that the rock is a conglomerate. Well 3 was correlated with shotpoint 3 because both are located on the —164 milligal gravity contour (fig. 1). The depth to consolidated rock of

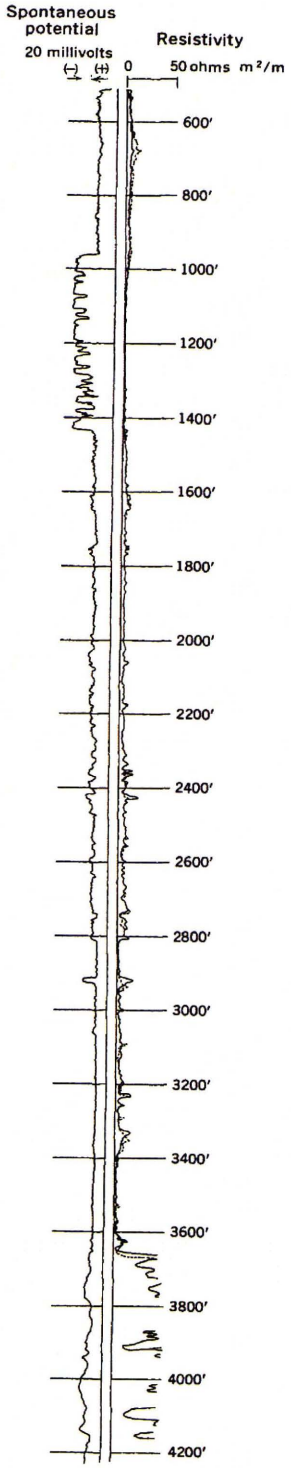

FIGURE 3.—Electrical log of the L. E. Whitlock, Morton Salt No. 1 well, Salt Lake County, Utah.

3,650 feet correlates reasonably well with the calculated depth of about 3,800 feet that was determined at shotpoint 3 to be the depth to the lowest refracting layer.

The depth to consolidated rock between shotpoints 4 and 5 was computed along profile *A*–*A*′ and projected to the line of the profile in figure 2. Because of the projection, the low point on the profile appears to be between shotpoints 3 and 4, rather than being between shotpoints 4 and 5 as indicated by the gravity map.

GRAVITY MAP

A Bouguer gravity map of the area east of the Great Salt Lake (after Cook and Berg, 1961, pl. 13) is shown overlain on figure 1. The results of the gravity interpretation are in reasonable agreement with the computed total thickness of unconsolidated Quaternary and Tertiary sediments, which ranges from about 600 to 4,800 feet along the seismic profile. As density is closely related to velocity, the high velocity contrast between the consolidated rocks (15,000–15,800 fps) and the overlying unconsolidated material (5,700 and about 9,000 fps) suggests that the major part of the gravity anomalies arises from variations in thickness of the unconsolidated sediments. An average density contrast of about 0.3 gram per cubic centimeter between these sediments and the underlying consolidated rocks can account for the change in thickness from 800 to 4,800 feet as computed at shotpoints 1 and 4.

REFERENCES

Berry, E. G., and Crawford, A. L., 1932, Preliminary notes on the mollusca of Lake Bonneville: Utah Acad. Sci., Arts, and Letters Proc., v. 9, p. 53–54.

Cook, K. L., and Berg, J. W., Jr., 1961, Regional gravity survey along the central and southern Wasatch front, Utah: U.S. Geol. Survey Prof. Paper 316–E, p. 75–89.

Eardley, A. J., and Gvosdetsky, Vasyl, 1960, Analysis of Pleistocene core from Great Salt Lake, Utah: Geol. Soc. America Bull., v. 71, p. 1323–1344.

Hawkins, L. V., 1961, The reciprocal method of routine shallow seismic refraction investigations: Geophysics, v. 26, no. 6, p. 806–819.

Iorns, W. V., Mower, R. W., and Horr, C. A., 1966, Hydrologic and climatologic data collected through 1964, Salt Lake County, Utah: U.S. Geol. Survey open-file rept. [Also duplicated as Utah Basic-Data Release No. 11.]

Slotnick, M. M., 1950, A graphical method for the interpretation of refraction profile data: Geophysics, v. 15, no. 2, p. 163–180.