TEC-9

3/10/76

VALE AND NORTH VALE, OREGON

Thermal conductivity measurements have been described in a separate report. Attached to this report are two tables, one of heat flow, geothermal gradient, thermal conductivity values for the holes south of Vale, Oregon (holes identified as V) and a second table for the geothermal gradient, thermal conductivity, and heat flow values for the holes north of Vale, Oregon (holes with the NV identifier). The values beneath the geothermal gradients are the standard error of the mean of the gradient. Since thermal conductivity samples were not available for most of these holes estimates of thermal conductivity have been made based on experience in the area. In the case of the Vale holes experience has been that the thermal conductivity values of the siltstones and "sandstones" of the Idaho Group will have thermal conductivity values on the order of 3.0 ± 0.3 mcal/cmsec°C. Claystones will have thermal conductivity values on the order of 2.5 ± 0.3 mcal/cmsec°C. In the case of the drill holes south of Vale several of the holes were drilled into terrace gravels which have a very high thermal conductivity. Even allowing for a high porosity the thermal conductivity values of these holes are still 20-30% above those of the remainder of the drill holes. For the north series of holes, thermal conductivity values are assumed to be 3.0 for the siltstones and 2.5 for the clays. Several holes were drilled in "sandstone" and the thermal conductivity of these units is particularly difficult to estimate. As noted in the section describing thermal conductivity there are some reasonably lithified chert pebble conglomerates and gravels which have *in situ* thermal conductivity values on the order of 4.2 mcal/cmsec°C. It might be that the rock cut by NV-10 is of this type. Such a thermal conductivity value would make the low gradient observed in NV-10 correlate with a heat flow value typical of the remainder of the heat flow values. Also the terrain correction could be quite large at this hole location although it is difficult to tell exactly what direction the terrain correction would go.

The geothermal gradient and heat flow values were available for AMAX and DOGAMI holes in the Vale area are shown in the attached figure. The DOGAMI data is based on all the published Ore Bin articles. North of the Malheur River the bulk of the measurements are approximately normal for the area, i.e. gradients on the order of 55 to 70°C/km and heat flow values on the order of 1.4 - 2.0 μcal/cm^{2}sec. Thermal conductivity values for the rock units are quite low and thus the high gradients correspond for normal heat flow values. The highest heat flow values observed in this area are observed in NV-17. There are also two high values along Willow Creek (NV-3 and a state hole). There are 3 high values of gradient observed east of Willow Creek, two in holes drilled by the DOGAMI during March, 1975, and NV-16, just north of the Malheur River near Malheur Butte. In general it would appear that all of the high values north of the Malheur River are closely associated with shallow depths to the Grassy Mountain or Owyhee Basalt, for example the value indicated by >110 (one of the DOGAMI holes) was drilled into a small exposure of the Grassy Mountain or Owyhee Basalt. This hole had an artesian water flow at 30°C from a depth of 60 m.

Thus on the basis of the present data the high heat flow values north of the Malheur River appear to be isolated and there appear to be no large areas of high heat flow although certainly the general vicinity of hole NV-17 is worthy of further study. South of the Malheur River the pattern is more interesting as there is a much larger area with above normal heat flow values. I have attempted to contour the geothermal gradient values on the figure. This contouring is speculative but worthy of discussion. The first possible correlation that I've seen between some of the anomalous heat flow values and in the various hot springs in the area appears to be showing up. On the basis of this contouring I can speculatively connect the hot springs along the Malheur River, Vale hot springs and possibly Ontario hot springs with an essentially north-south band of high heat flow. This band might be offset or represent two anomalies one north and one south of the Malheur River. If this contouring is valid it would appear that there is an anomalous area of heat flow on the order of 10-12 km wide and extending for a length of approximately 50 km or more. The average heat flow values of this anomaly zone are on the order of 3-4.0 $\mu cal/cm^2 sec$ and the gradients range from 100-120$^oC/km$ except along the very narrow zone in East Cow Hollow. The fact that this anomaly band could connect with Malheur Butte, one of the most recent intrusive features in the area, may or may not also be important. It seems likely that this anomaly must be reflected in the basement geology since the aquifers appear to be the basalts interlayered with and below the Idaho Group sedimentary units.

Unfortunately it's still not clear whether there is any high temperature water associated with this region or whether it is mostly lower temperature. Apparently the Chevron well drilled in Idaho did intersect temperatures on the order of 200^oC. It would appear from the relative gradients in two places that such temperatures, if they exist beneath this anomaly, would occur at depths on the order of 1.5 - 2 km. The detailed transect along the southern part of the anomaly that was drilled in late summer 1975 appears to have been slightly to the east of the anomaly and had just entered it at the end. This result suggests that the extremely high anomaly present just to the north, which appears to be northwest-southwest oriented, is at angle to the main underlying anomaly proposed here.

At this time I would recommend several steps. First, further shallow measurements in the vicinity of possible heat flow anomalies is indicated in the two heat flow anomalies indicated: the one with a single measurement (NV-17) in the vicinity of the western margin of the map, and the other major heat flow anomaly associated with the north-south trending band of high heat flow values. Two, correlation of this data with other geophysical and geological data in order to evaluate the underlying controls. Since this anomaly should probably be related to differences of basalt topography within a predominently sedimentary section other geophysical data such as gravity or magnetic anomalies should be clearly associated with the heat flow anomaly. Third, interpretation of the geochemical data in view of a possible connection of the hot springs is appropriate. Finally, a test of some sort in order to determine whether the temperatures in the system are high enough to justify further exploration is critical.

VALE, OREGON

Geothermal Gradient, Thermal Conductivity and Heat Flow Values

Hole No.	Depth Interval meters	Geothermal Gradient °C/km	Thermal Conductivity mcal/cmsec°C	Heat Flow μcal/cm²sec	Direction of Terrain Corr.	Lithology
V-1	20-43	119.3 7.5	3.0	3.6	-	Clay and Sand
V-2		-				
V-3	25-50	89.8 6.9	3.0	2.7	+	Sand
V-4	20-49	90.5 1.7	3.0	2.7	+	Sand and Clay
V-5	20-49 37-49	84.3 108.8	3.0	2.5-3.3	+	Sandy Clay
V-6	20-49	52.5 7.1	3.0	1.6	(+)	Sandy Clay
V-7		-				
V-8	20-49	87.8 9.9	3.0	2.6	-	Clay
V-9	15-38	60.0 3.7	3.0	1.8	?	Sandy Clay
	38-45	31.4 2.8	(5.7)x			Basalt
V-10	17-21	(35)	(5.1)x			Basalt
	21-33	59.2 7.3	3.0	1.8		Sandy Clay
V-11	15-28	73.3 8.8	3.4	2.2-2.9		Basalt and Cinders

Hole No.	Depth Interval meters	Geothermal Gradient °C/km	Thermal Conductivity mcal/cmsec°C	Heat Flow μcal/cm²sec	Direction of Terrain Corr.	Lithology
V-12	19-30	63.8 11.8	(3.4)?	1.9	(+)	Gravel and Clay
V-13	17-30	71.8 2.4	3.0	2.2	+	Siltstone
V-14	15-21	103.1 5.7	3.0	3.1	-	Siltstone
	21-30	76.9 6.8		2.3		Siltstone
V-15	15-30	55.4 4.4	(3.9)	2.2	+	Siltstone
V-16	15-30	81.3 2.6	3.0	2.4	+	Siltstone
V-17	17-30	102.1 7.6	3.9	4.0	+	Tuff and Gravel
V-18	15-30	94.7 5.9		2.7	+	Siltstone
V-19	21-29	73.1	2.5	1.8	-	Clay

NORTH VALE, OREGON

Geothermal Gradient, Thermal Conductivity and Heat Flow Values

Hole No.	Depth Interval meters	Geothermal Gradient °C/km	Thermal Conductivity mcal/cmsec°C	Heat Flow $\mu cal/cm^2 sec$	Direction of Terrain Corr.	Lithology
NV-1	16-31	68.8 3.6	2.5	1.7	0	Clay
NV-2	12-47	51.3 11.7				
	40-47	53.6 8.7	3.0	1.6	0	Vol. SS.
NV-3	17-33	105.9 7.0	2.5	2.6	(-)	Tuffaceous Clays
NV-4	13-50	69.2 6.5	2.5	1.7	+	?
NV-5	20-45	48.4 4.7	3.0	1.5		Tuffaceous Sandstone
NV-6	19-49	51.4 6.5	2.5-3.0	1.4±0.1	0	Clay and Sandstone
NV-7	16-49	54.9 5.9	2.5-3.0	1.5±0.1	(-)	Clay or Siltstone
NV-8	16-44	65.0 2.6	3.0	2.0	?	Siltstone
NV-9	35-44	57.8 3.0	3.0	1.7	0	Siltstone
NV-10	16-39	34.6 4.4	3.0?	1.0	?	Sandstone

Hole No.	Depth Interval meters	Geothermal Gradient $^{o}C/km$	Thermal Conductivity $mcal/cmsec^{o}C$	Heat Flow $\mu cal/cm^{2}sec$	Direction of Terrain Corr.	Lithology
NV-11	24-42	70.0 5.4	3.0	2.1	0	Gravel and Sand
NV-12	15-50	65.3 4.9	2.5-3.0	1.8±0.1	0	Clay and Sand
NV-13	25-50	62.5 5.6	2.5	1.6	0	Clay
NV-14	14-39	83.6 7.8	3.0?	<2.5	(-)	Sand
NV-15	13-49	74.8 2.2	2.5-3.0	2.1	(-)	Tuff and Sandstone
NV-16	20-50	117.0 3.9	3.0	3.5	-	Sand
NV-17	13-51	184.1 5.3	3.0	5.5		Siltstone
NV-18	15-49	78.8 4.9	2.5	2.0		Clay