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INTER-OFFICE MEMORANDUM

SUBJECT: Beulah, Oregon: Heat Flow Results to Date DATE March 19, 1976

TO: W. M. Dolan, H. J. Olson, H. D. Pilkington, J. Roth, G/T Staff ✓

FROM: A. L. Lange

The accompanying figures represent the latest compilation of thermal data from the Beulah Reservoir area, adding data from five recent holes to that of the 8 holes logged in Summer 1975. The results incorporate also conductivity values supplied by D. Blackwell.

Thermal gradients (Figure 1)

In computing thermal gradients, I rechecked the logs previously analysed by Joe Meigs and Dean Pilkington. In most cases I found little or no disagreement with their values; in one or two, however, I favored a slightly different portion of the log - the deepest portion, when there were discontinuities. The gradients supplied by Blackwell sometimes varied from mine, but fell within his standard deviation figure. The log of Station 3 was erratic, probably due to circulation locally in the hole. Two alternate values (of each parameter) were computed, but were ignored in the drawing of contours. Because gradients are a composite effect of both heat flow and lithology, they are not the best quantity to interpret; hence, my comments will be made in connection with Figure 3 instead.

Depth to 200° isotherm (Figure 2)

A quantity that I feel is instructive is the depth below surface to a particular isotherm, in this case 200°, under the assumption that the thermal gradient remains constant with depth; i.e., increases linearly. Depths are computed from the formula:

$$\text{Depth (km)} = \frac{200° - T_{\text{surface intercept}}}{\text{Gradient (°C/km)}} .$$

The plot would be effectively the reciprocal of the gradient, except for the fact that the surface intercept varies from hole to hole. The resulting surface is depicted with depressions contoured. It is evident from the map that a 2km-boomerang-shaped ridge follows the western edge of the Malheur River in the vicinity of the reservoir.

Heat Flow (Figure 3)

Values are computed from the formula:

Heat Flow (h.f.u.) - Conductivity X Gradient/100.

Conductivities were supplied by Dave Blackwell. In the case of changes of lithology within the hole, I employed the value corresponding to the thermal gradient used. Heat flow values computed from measured conductivities are shown without parentheses. Values in parentheses used conductivities extrapolated by Blackwell from measured values in similar lithologies in the Harney Basin to the south. The minus sign following the value indicates that a terrain correction (10-20% of the value) should be subtracted. Terrain corrections have not been determined.

Based on a world mean of 1.5hfu, and a regional background of 1.5-2.0hfu, the values at Beulah are not unusual. When slight corrections are applied for terrain effects, the thermal highs will all fall below 3. Nevertheless, structural expressions are evident in the plot, notably the "boomerang" referred to above. In terms of geology, its northwest leg follows the axis of a major syncline, while the south leg is aligned along the graben's west-bounding fault extending along the west side of the reservoir. A 16-ohmmeter .05hz MT anomaly and a 10-ohmmeter 8hz anomaly fall directly upon the thermal high in the vicinity of Station 6 and they are linearly aligned with it (see my memo, 16 March 1976). This is the locality of mapped alteration. The trends displayed in the boomerang feature correspond to those revealed in the gravity plot of the earlier memo. The thermal high represented by Station 10 falls on a positive gravity lobe, but we have no telluric coverage in that region.

Blackwell determined a gradient of 110°C/km for Station 3, resulting in a heat flow value of 3.6⁻, but he places a question mark on these figures. The best I could see in the data was a value of 1.9⁻. His anomalous area therefore is broader-based or "ghost-shaped" (Figure 4). I feel that another hole is needed before the pattern can be defined in the region of Station 3.

Conclusions

The heat flow high bordering Beulah Reservoir on the west expresses circulating thermal fluids along the graben-bounding fault and faults associated with the syncline controlling the Malheur River valley to the northwest. The latter circulation effect is borne out by the telluric lows on that same structure. Heat flow values are 10 to 20% less than shown at many sites, due to terrain. In Blackwell's words:

> "All of the high values are in valleys where significant terrain corrections are to be expected, probably on the order of 10-20% and if allowance is made for these corrections, the observed values are barely anomalous. The gradients are fairly high because of the low thermal conductivities. If there is a contrast in heat flow, it seems to be between low and normal, not between normal and high values. The area of higher heat flow is circular and centered about Beulah reservoir."

Recommendations

Additional gradient holes are needed in the vicinity of Beulah Reservoir, particularly near Station 3. Perhaps one additional hole is warranted in the vicinity of Station 10. If higher values than those already found do not turn up, the property should be regarded as being of marginal interest.

Arthur L. Lange

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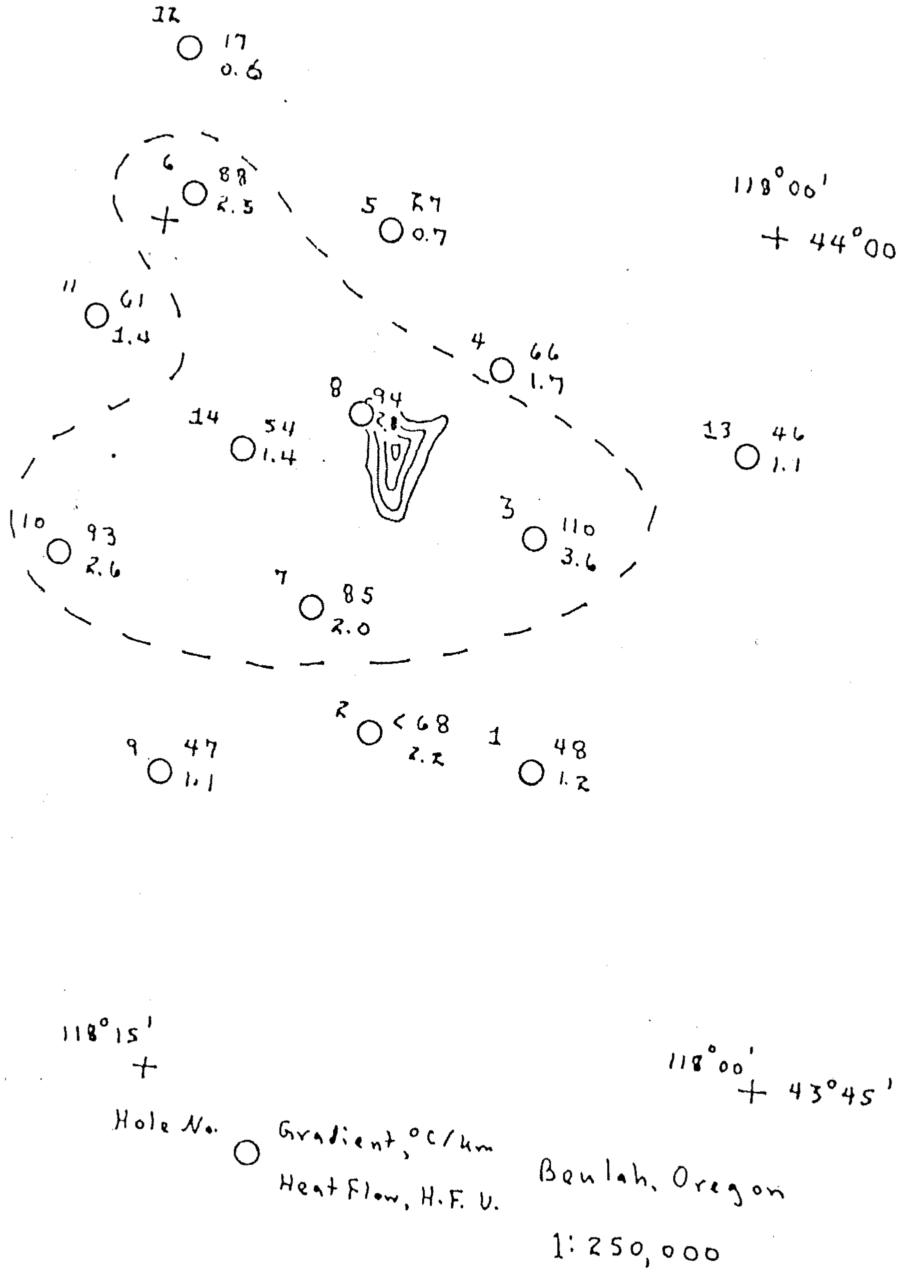

Figure 4. Thermal gradients and heatflow at Beulah according to Blackwell (private communication).

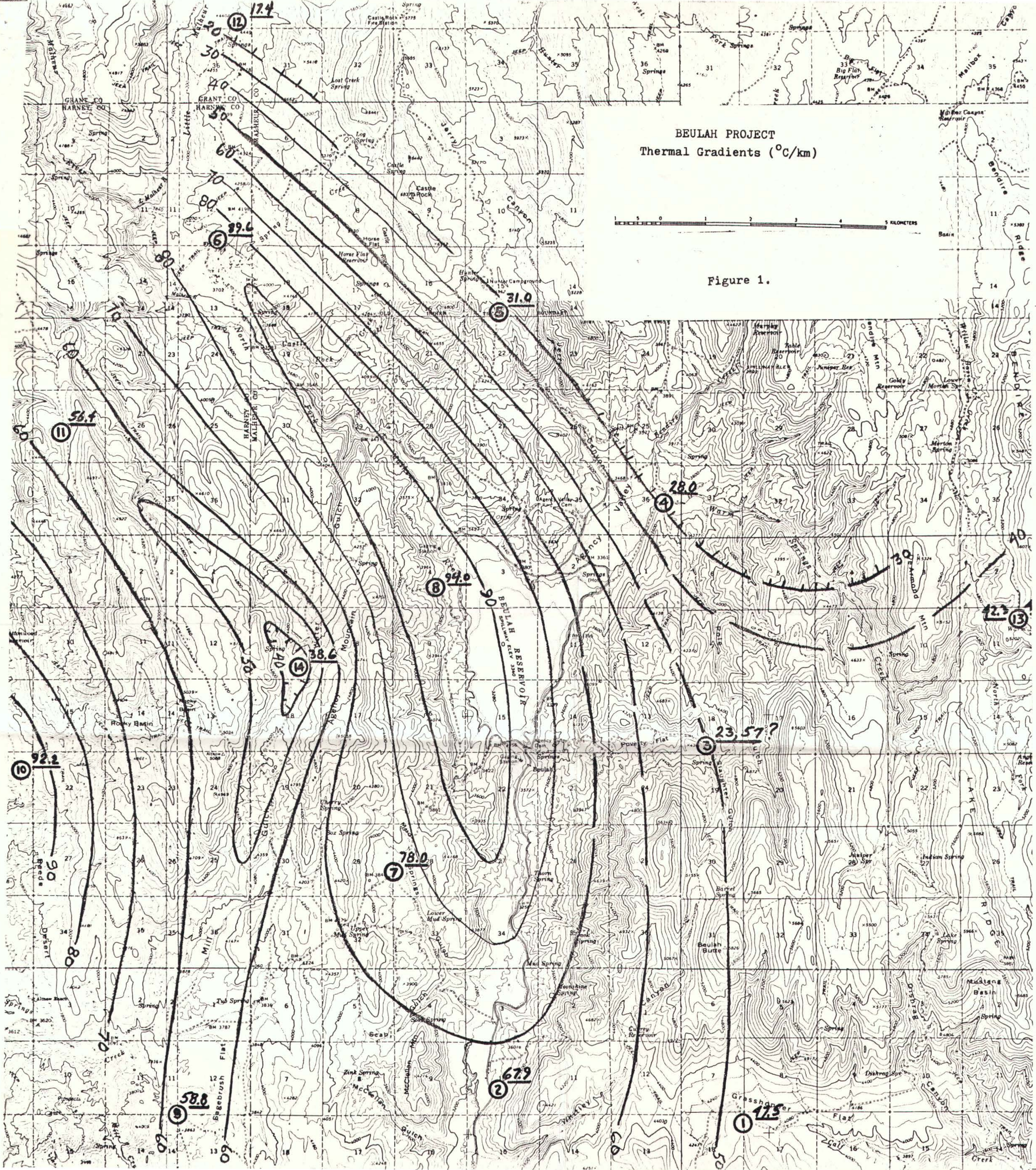
BEULAH PROJECT
Thermal Gradients (°C/km)
5 KILOMETERS
BEULAH RESERVOIR
17.4
89.6
31.0
56.4
28.0
94.0
38.6
42.3
23.57?
92.2
78.0
67.9
58.8
17.3

Figure 1.

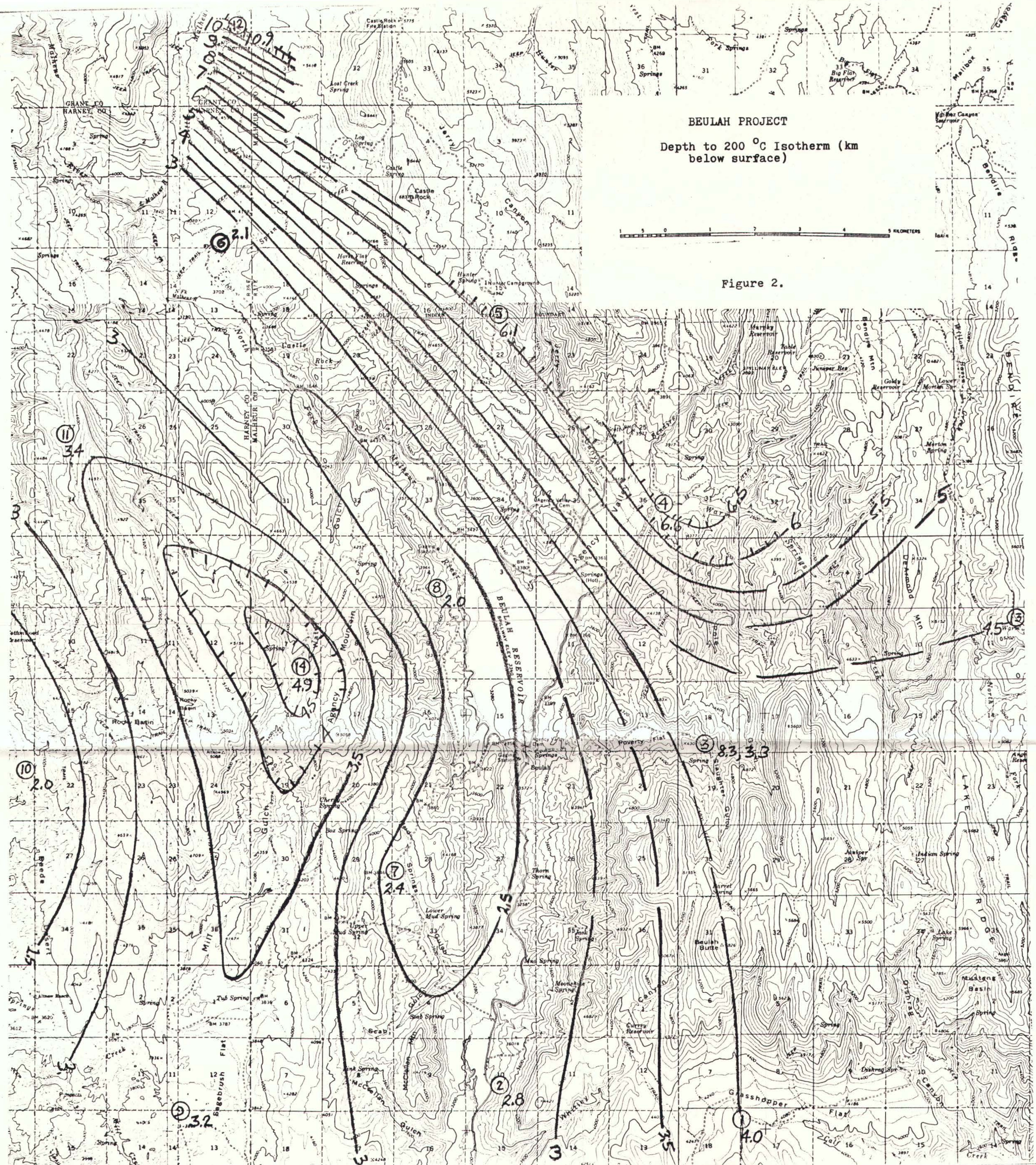
BEULAH PROJECT
Depth to 200 °C Isotherm (km below surface)
KILOMETERS
BEULAH RESERVOIR
Beulah
Beulah Butte
Agency
Grasshopper Flat
Poverty Flat
Sagebrush Flat
Rocky Basin
Mustang Basin
HARNEY CO
MALHEUR CO
GRANT CO

Figure 2.

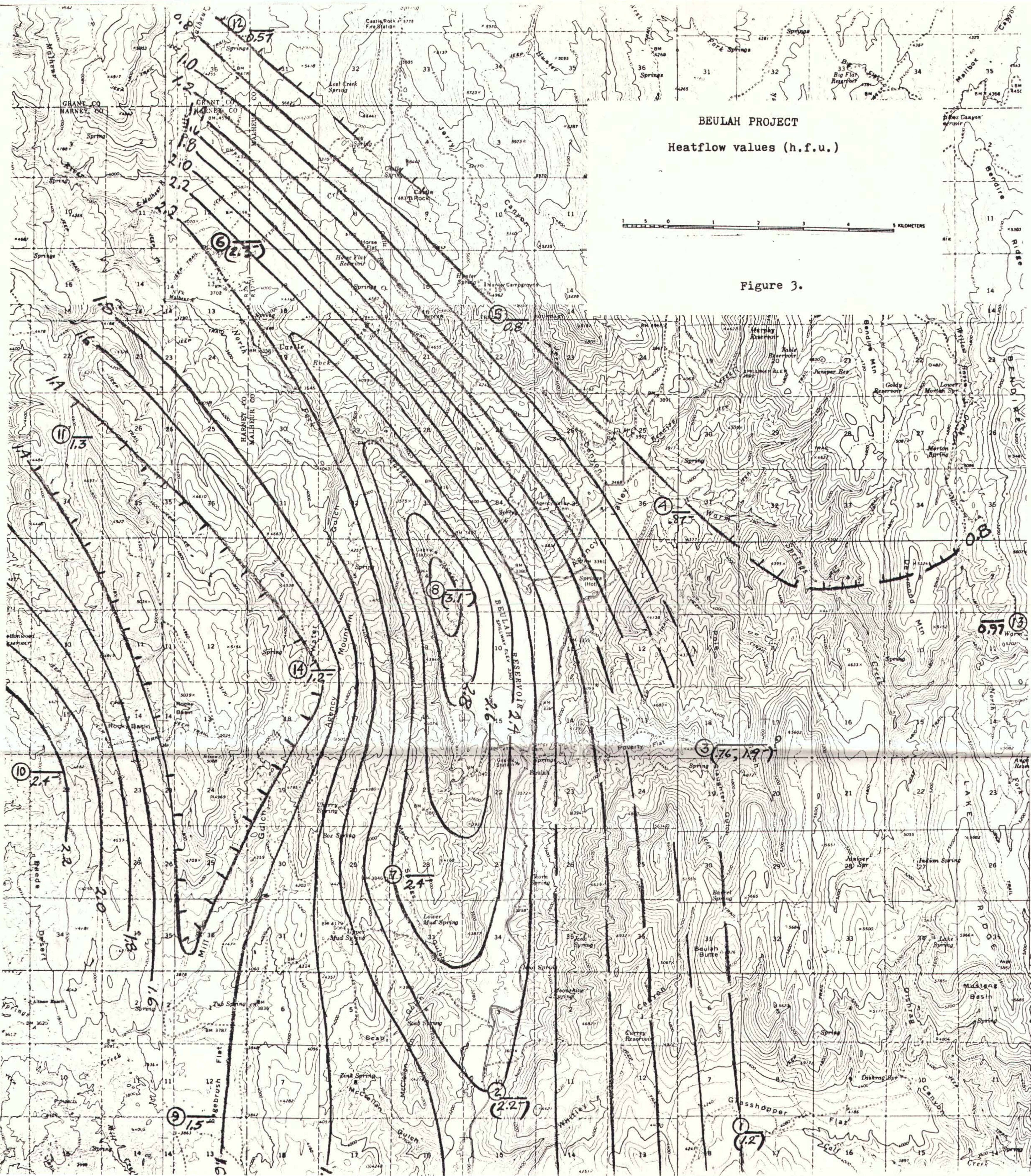
BEULAH PROJECT
Heatflow values (h.f.u.)
5 KILOMETERS
BEULAH RESERVOIR
Castle Rock
Agency Valley
Poverty Flat
Beulah Butte
Grasshopper Flat
Mustang Basin
GRANT CO
HARNEY CO
MALHEUR CO
Rocky Basin
Sagebrush Flat

Figure 3.