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INTER-OFFICE MEMORANDUM

SUBJECT: Results of a Heatflux Experiment in One-meter Trenches DATE June 29, 1976

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

FROM: A. L. Lange

An experiment using the Amax heatflux device (hereafter referred to as "Bozo") was conducted in the vicinity of Roosevelt Hot Springs, Beaver County, Utah, between the dates 13 May and 9 June 1976. The purpose of the experiment was to test the possibility that relative heatflow readings could be measured at a depth of one meter in soil to an accuracy adequate for reconnaissance purposes. The idea relies on the fact that surface temperature fluctuations decrease exponentially with depth in the ground. In alluvium, diurnal variations are negligible at one meter; while the seasonal cycle can be seen in well logs to a depth of about 20m. Barring unusual subsurface environments, heat flows registered in this manner at sites of similar lithology, terrain, altitude and solar attitude should bear the same relationship to one another as do the heat-flows computed from thermal gradients and conductivity measurements in drill-holes. John Deymonaz conducted the experiment at drillhole sites for which thermal gradient values were available. A. Lange assisted at Sites 2, 8, and 121.

Field Procedure:

A trench was excavated near the measured drillhole in level alluvium that remains unshaded during most of the day (Figure 1). Each layer of soil (about 10cm) was segregated in a pile and covered with an insulating space blanket until the hole could be filled in. In this way, we attempted to restore the temperature environment in the hole to minimize equilibrium time. During excavation, soil temperatures were measured in the walls of the trench at depths of 3, 25, 50, 75 and 100cm, using our thermal probe. It generally took between one and two hours to dig the trench. Bozo was then installed on the floor of the hole, and the signal cord brought out to the chart recorder on the surface. The hole was then filled. Recording was then begun, using both the HP-7155A strip-chart recorder and the Weatherwise thermograph, set in the nearest shade. Bozo generally approached equilbrium by the second day but was left to record for at least four days, and in one case 9 days. Equilibrating time depends on the thermal shock experienced by the device while being transported between sites. Later in the experiment Bozo was protected during each move by being carried in an insulated layer of soil from the previous hole.

Five sites were occupied in the order DH 8, 2, 121, 5, 13, and again 2 (Figure 4). Site 2 was chosen as the reference station because it was the least anomalous. It was intended that the repeating of Site 2 at the end of the experiment (in a new adjacent trench) would permit us to correct for the seasonal thermal drift during the interval of the experiment.

Results:

Outdoor shade temperatures ranged over about 20°C during the diurnal cycle (Figure 2), with a mean around 17° during late May. This fluctuation was not detectable on the 15.3hfu/cm scale used for recording. Because the absolute heatflow at the reference station was -58hfu, it would be necessary to supply a bias voltage to be able to utilize the more sensitive scales.

Soil temperature profiles were obtained at three sites. The two on hand are reproduced in Figure 3. They show good agreement and are within 0.15°C at the one-meter depth. This procedure affords an excellent check on the suitability of the thermal environment, and should be done at every site.

Comparison of the Bozo readings (after equilibrium) with the calculated drillhole heatflow values is depicted in the bar chart of Figure 4. The borehole results are plotted on the left as determined by D. Blackwell (except DH-121, computed by ourselves). He used conductivity assumptions of 1.7 units for dry alluvium, 2.2 for saturated soil, and 5.0 for granite at depth. His values for the different materials are shown by different colors. The Bozo readings are plotted on the right after having been adjusted for Blackwell's value of 2.0hfu at Site 2.

Despite the considerable uncertainties in Blackwell's heatflow determinations, the Bozo results at Sites 5, 8, and 121, relative to 2, are in good agreement. At Site 13, however, something happened that I cannot explain. This was the last site occupied before repeating the base and the result bears no relationship to the borehole results. The instrument was then returned to Site 2 and installed in an adjacent trench. The heatflow had then risen from -58 to -13.7hfu, absolute, during an interval of 23 days. This change is much more than would be expected for the seasonal drift and is in the wrong direction. With warming weather, heatflow should have decreased. Because of this erratic behavior, drift corrections could not be made.

The encouraging results of the first 4 stations seem to be invalidated by those of the last station and the final base reading. I cannot account for this sudden misbehavior; however, it points out the need of a continuous monitor at the base. This would allow one to correct for seasonal drift systematically.

Recommendations:

There is strong evidence that the one-meter burial technique is a valid reconnaissance tool; however, further testing is necessary to establish its reliability. I recommend the following procedures:

A) A reference heatflux device should be maintained at the base throughout the duration of the roving measurements.

B) Soil-temperature profiles should be read at every site, and sites that do not conform should be rejected. A one-meter, water-filled pipe installed in the trench, would permit convenient repeated logging.

C) More accurate determinations of conductivities in the boreholes are needed in order to better evaluate the results.

Arthur L. Lange

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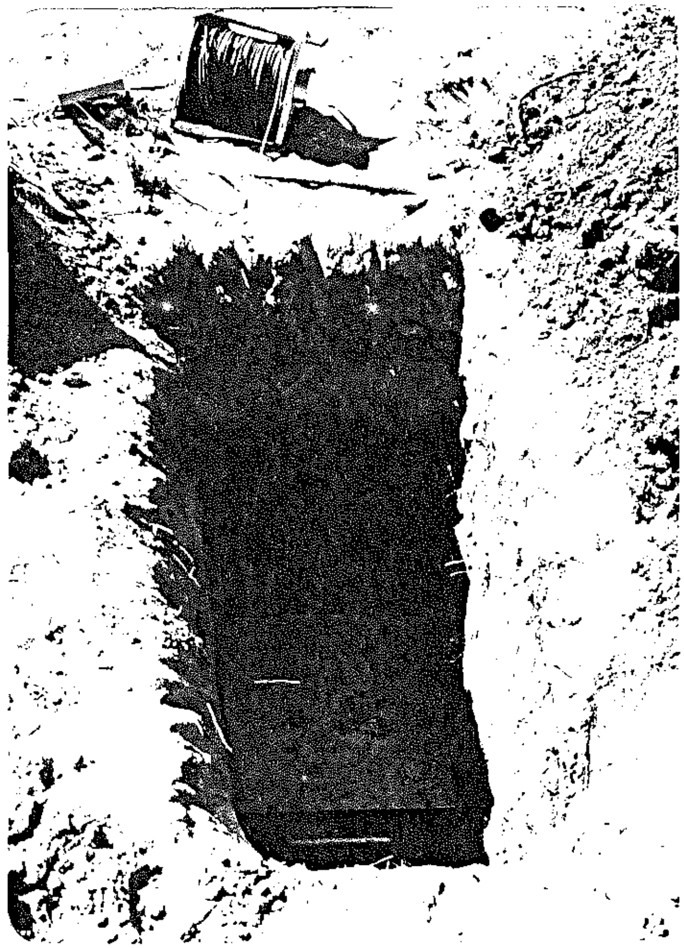

A.

B.

Figure 1. Heatflux device burial site (1-meter depth), at Drillhole 2. A) Device in hole; thermal probe has been used to obtain soil-temperature profile; B) Layers of soil have been separated so that they could be replaced in approximately their original temperature regime (in practice, the soil is kept covered).

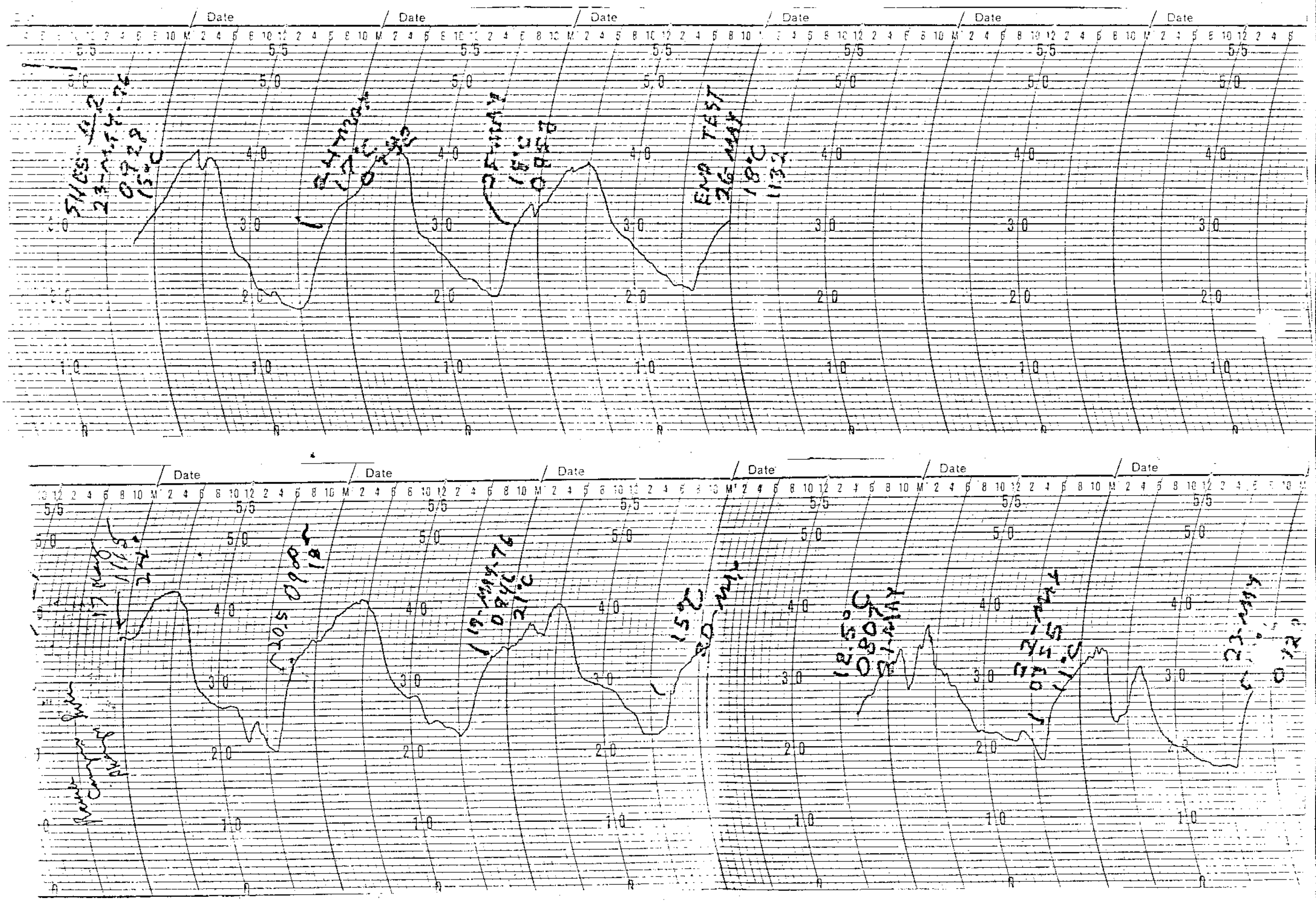

Figure 2. Thermograph record at Drillhole 121, 17-26 May 1976.

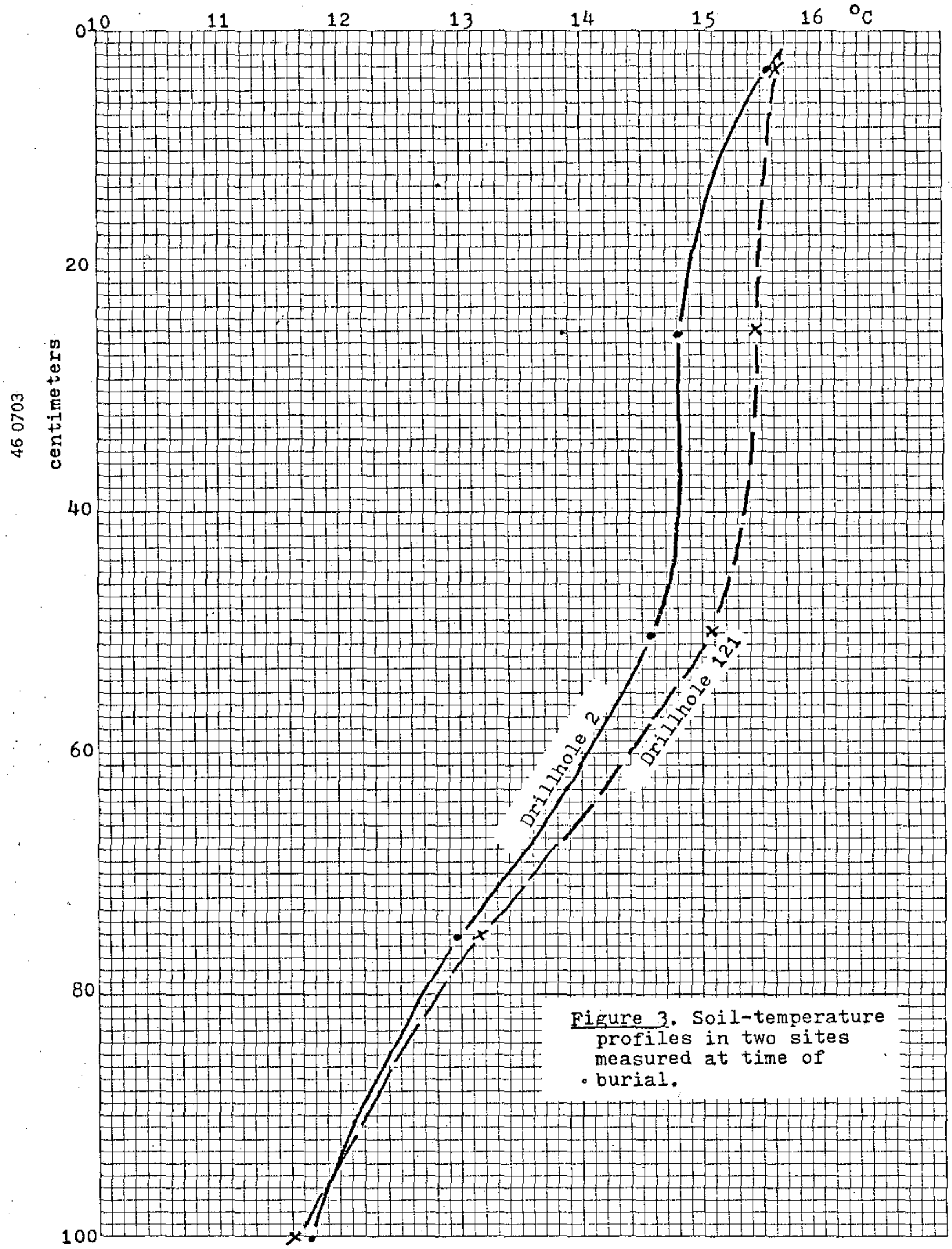

Figure 3. Soil-temperature profiles in two sites measured at time of burial.

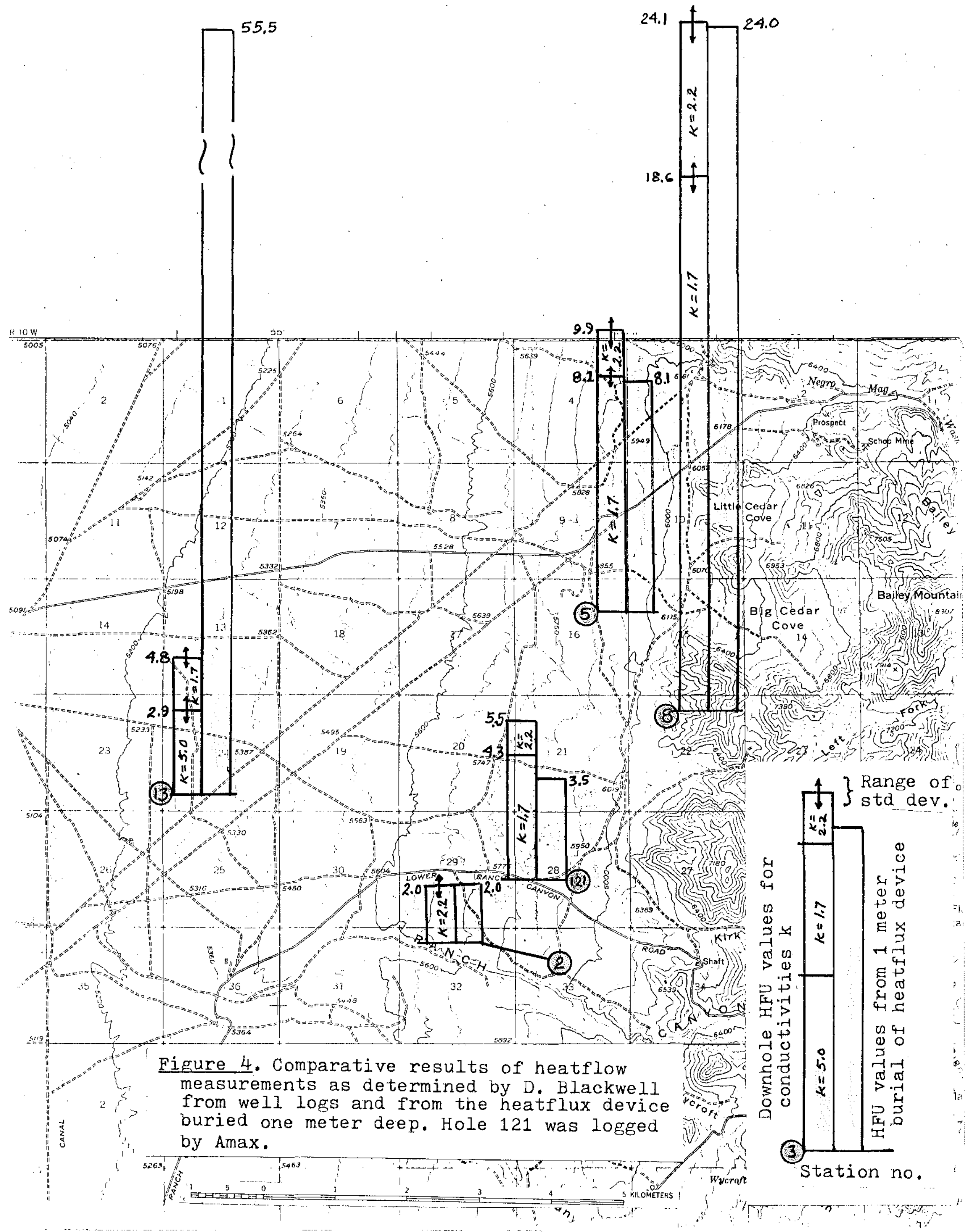

Figure 4. Comparative results of heatflow measurements as determined by D. Blackwell from well logs and from the heatflux device buried one meter deep. Hole 121 was logged by Amax.