1159 2nd Avenue
Salt Lake City, Utah 84103

February 18, 1977

Mr. Dean Pilkington
AMAX Exploration
4704 Harlan Street
Denver, Colorado 80212

Dear Dean:

Heat probe bills 3/23

Here is an invoice for the day I spent in Denver a couple of weeks ago. I'm splitting my transportation expenses with AMAX and the USGS so I've divided the cost of my airplane ticket and car rental in half. In view of the short time we had to spend on each area my impressions are qualitative, but here are a few of my comments on some of the areas we looked at.

The Cove Fort area looks very attractive from the size of the anomaly that has been blocked out and the amount of recent volcanism in the area. In view of the large size and complexity I would suggest doing thermal conductivity for the wells so that you don't get a false picture of the deeper gradients from the shallow gradients. The whole area is characterized by a number of what appear to be good aquifers, i.e. the basalts, limestones, valley fill, etc. so that the heat flow and gradient data must be very carefully interpreted. Extrapolation of shallow (or even deeper) gradient data is dangerous without firm geochemical data on the reservoir temperature, a resistivity target at depth, a geological target, or some basis upon which to interpret the gradient data. The areas where shallow data are questionable, such as beneath the basalts in the southwest part of the area and in the area of isothermal sections at depth in the southeast part of the area, need to be identified and the hydrologic controls on this circulation identified so that the depth needed for useful gradient data for extrapolation to depth, determined. What may be happening in parts of the area is mushrooming of the isotherms (see the sketch). That is hot water moving up along faults may be flowing laterally at relatively shallow depths along the hydraulic gradient, mixing or not with shallow ground water. In a case like this the upflow zones must be identified by fluid geochemistry, resistivity, gravity, or some structural technique.

What I'm saying is that the area looks complicated and in the time I had to look at it nothing simple jumped out at me. This area looks like a good candidate for intermediate depth slim hole drilling in view of the complexity of the shallow data and the lack of definitive geochemistry, etc. As far as the gradient data are concerned, I think one or more targets should be outlined and detailed at 1/2 km spacing, perhaps with occasional 150 m deep holes.

I'm still intrigued by the Mt. Princeton area. I think that if you get some thermal conductivity values for the holes the gradients out in the valley (30-40°C/km) will result in normal heat flow values (2 HFU or so). If they do the results are important because that means that shallow water flow is not disturbing the gradients. This area still looks similar to Roosevelt to me in many ways. The new gravity profiles show a complete lack of contrast between the range and the valley, which is very peculiar. Terrain profiling over the alluvium and the granite should establish the presence of absence of a shallow density contrast. Seismic refraction or reflection studies to determine thickness of valley fill and nature of the gravity ridge east of Mt. Princeton hot springs would be very valuable. I would like to see heat flow data east of the hot springs and in the range; however, I recognize the problems (drilling difficulties in one area and access in the other). Close-spaced holes along and perpendicular to the fault would also be useful. If a reservoir is present it must be along or west of the range bounding fault and/or associated with the major cross structures where the hot springs are located.

The Livermore Area looks like a tough nut. All the evidence is that the geothermal gradients from the shallow holes can be extrapolated to depth. Unfortunately the gradients are low enough that the depth to a possible steam reservoir is marginally within drillable depths. The anomaly seems continuous with the steam reservoir anomaly to the northwest so there seems a good possibility of steam somewhere. For this property the interpretation of the gradient and heat flow data is crucial as, if you decide to drill a deep hole a near miss would be very costly. I think more detailed heat flow holes along a profile perpendicular to the structure are important. At this time I would like to propose that I do some mathematical modeling of the anomaly. I suggest this for two reasons. First, the depth to which the surface data must be extrapolated is very great and somple linear projections are probably not sufficient. Secondly, the modeling should give some idea of what the shape of the reservoir is for comparison with structural information and the modeling can indicate the most useful surface sites for new heat flow data. If you are interested, I think about 2-3 days of time would be sufficient (including computer time, etc.).

As a general comment, I get the impression that for many of the prospects, the geological mapping and structural analysis are lagging the geophysics. For interpretation of the geophysics, geological models are vital and I would suggest more emphasis on the geological aspects of the prospects if possible.

Thanks for the opportunity to go over some of these areas with you. I hope that these comments are of some use.

Sincerely,

Dave

David D. Blackwell