TBC-25

AMAX EXPLORATION, INC.
A SUBSIDIARY OF AMAX INC.

GEOTHERMAL BRANCH

INTER-OFFICE MEMORANDUM

SUBJECT: Review of the Teledyne Two-Dimensional Wave Number Filtering of the Alum Thermal Data

March 29, 1983

TO: H. J. Olson

FROM: H. D. Pilkington

cc: W. Lodder
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In May of 1982 Teledyne Geotech proposed a consortium to develop a method of filtering hot spring noise from shallow temperature gradient data. With the hot spring "noise" removed it was hoped that more reliable depth-temperature projections could be made. The consortium fell through; however, Teledyne does contract to apply the technique to shallow thermal data. As a test of the method we contracted Teledyne to apply the technique to sixty (60) shallow thermal gradient holes at McCoy (Pilkington, 1983,a.). Since the results agreed well with our intermediate depth thermal gradient well data and also with the hydrogeochemical data it was decided to apply the technique to the Alum data.

AMAX supplied Teledyne with twenty-one (21) depth temperature logs, lithologic logs and a thermal well map for the Alum area. Teledyne chose thermal gradients from the 30 meter interval whenever possible to generate the thermal gradient map shown in Figure 1. The map was generated for a surface elevation of 5,210 feet, the average wellhead elevation and no terrain corrections have been applied to the data. Thermal gradient profiles were constructed along lines A-A', B-B' and C-C' (Fig. 1) which were located so that they would include the intermediate depth thermal gradient wells. The Teledyne two-dimensional wave number filtering technique was then applied to the three profiles and subsurface temperature estimates were made for the location of well 56-29, 24-33 and 21-30 (Li and Marvin, 1982).

The depth-temperature curve for well 56-29 is plotted on Figure 2. The depth-temperature profile based upon my interpretation of the Teledyne data (Li and Marvin, 1982) is also shown (Fig. 2). Note the excellent agreement between the actual temperatures measured in well 56-29 at 400 meters and below (120^{o}C) and those predicted by Teledyne for profile

A-A'. The temperature profile indicates isothermal conditions continue to a depth of approximately 900 meters. From a depth of 900 meters to 1,300 meters the predicted gradient is 225°C/km. Below 1,300 meters the modeled temperatures are isothermal at about 210°C, which agrees reasonably well with the silica mixing model temperatures of 208°C for a fluid which boiled on the way to the surface (Pilkington, 1983,b.) or 240°C if the fluids have cooled conductively.

The AMAX depth-temperature curve for well 24-33 is shown on Figure 3. My interpretation of the Teledyne data (Li and Marvin, 1982) is also shown as a depth-temperature profile. At 400 meters the bottom hole temperature of the well was approximately 20°C less than that predicted by the Teledyne data. If we project the AMAX data downward it will intersect the Teledyne data at 700 meters using an average gradient of 70°C/km. At 700 meters the Teledyne generated temperature curve rolls over to become isothermal at a 120°C and remains so to a depth of 900 meters. From 900 meters to 1,300 meters the temperatures increase at a rate of 200°C/km. Below 1,300 meters the predicted temperatures begin to roll over and become isothermal at 220°C below 1,500 meters.

Figure 4 shows the AMAX depth-temperature curve for well 21-30 and my interpretation of the Teledyne subsurface temperature predictions for that location. At 600 meters in well 21-30 the bottom-hole temperature was 91°C and the temperature predicted by the Teledyne data is 107°C. When one projects the AMAX thermal data downward it intersects the Teledyne data at about 700 meters and a temperature of 110°C. The Teledyne depth-temperature profile is isothermal from 600 to 900 meters. Below 900 meters the temperature increase at a rate of 162°C/km to a depth of 1,400 meters where a roll over begins at 1,500 meters the predicted temperatures are 210°C and the profile has not yet become isothermal.

Several coincidences are apparent as one studies the curves shown in Figure 2-4. First the best correlation between the observed data and the wave number filtered data occurs on profile A-A' (Fig. 1) which runs parallel to the structural grain of both the Tertiary rocks and the Paleozoic basement rocks (Pilkington, 1981). The data set along profile A-A' (Li and Marvin, 1982) contains a long wave length contribution which may be indicative of a deep heat source. The second point which should

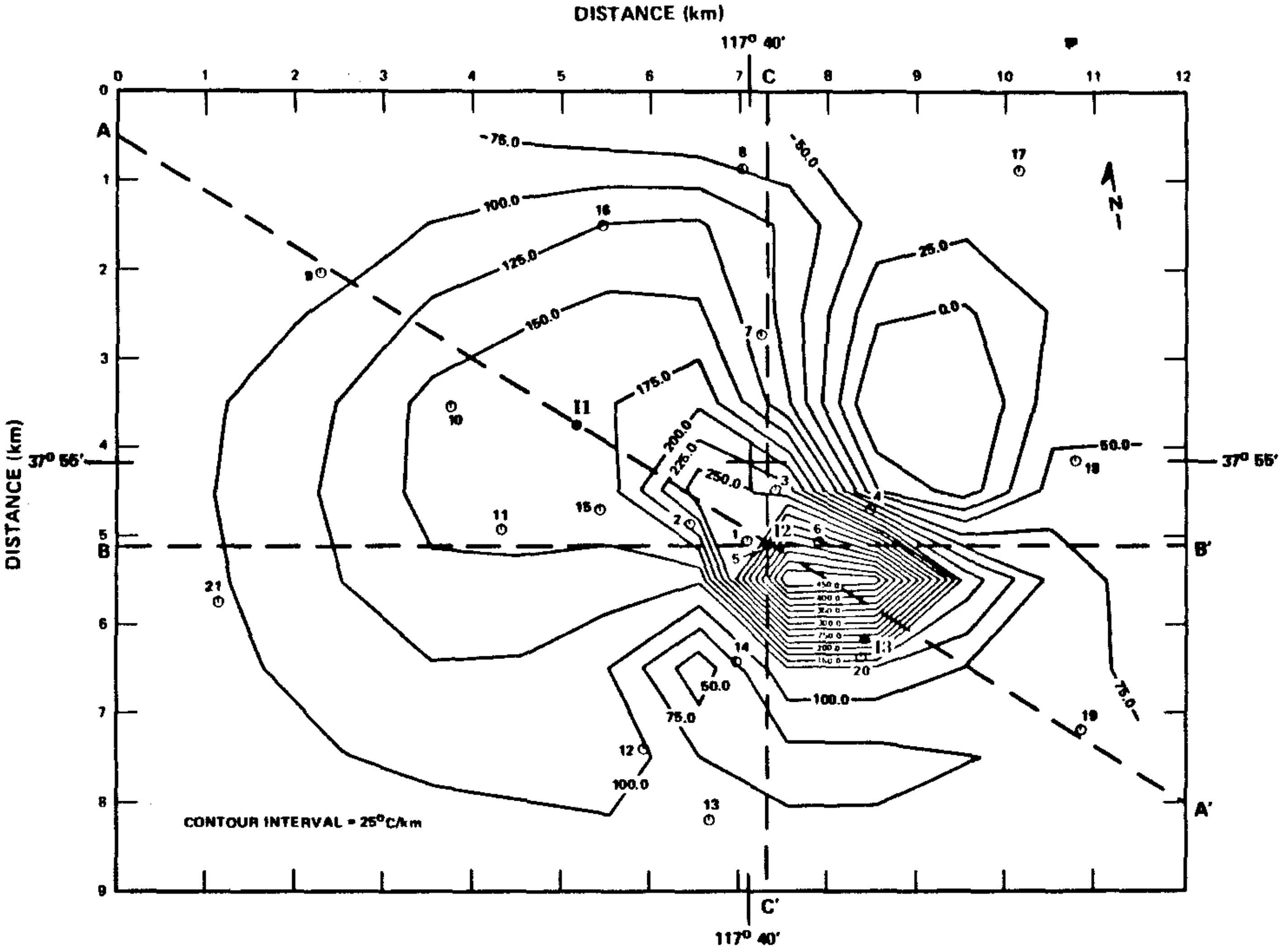

FIGURE 1. SURFACE GRADIENTS AT ALUM,
NEVADA ELEVATION = 5012 FT,
SURFACE FIT ≅ 2.5%.

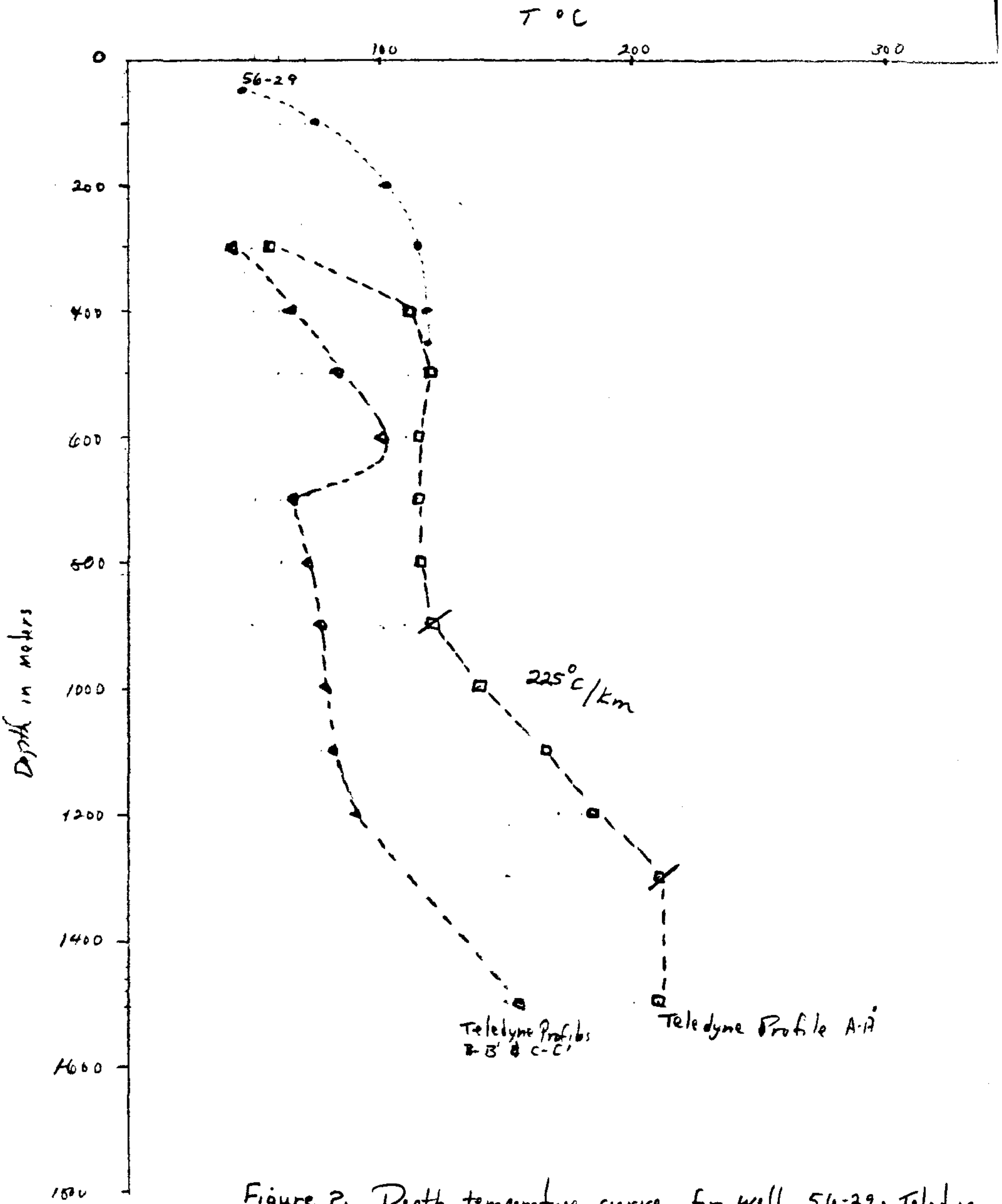

Figure 2. Depth temperature curve for well 56-29; Teledyne depth temperature profile for lines B-B' and C-C', and Teledyne profile for line A-A' at the location of well 56-29.

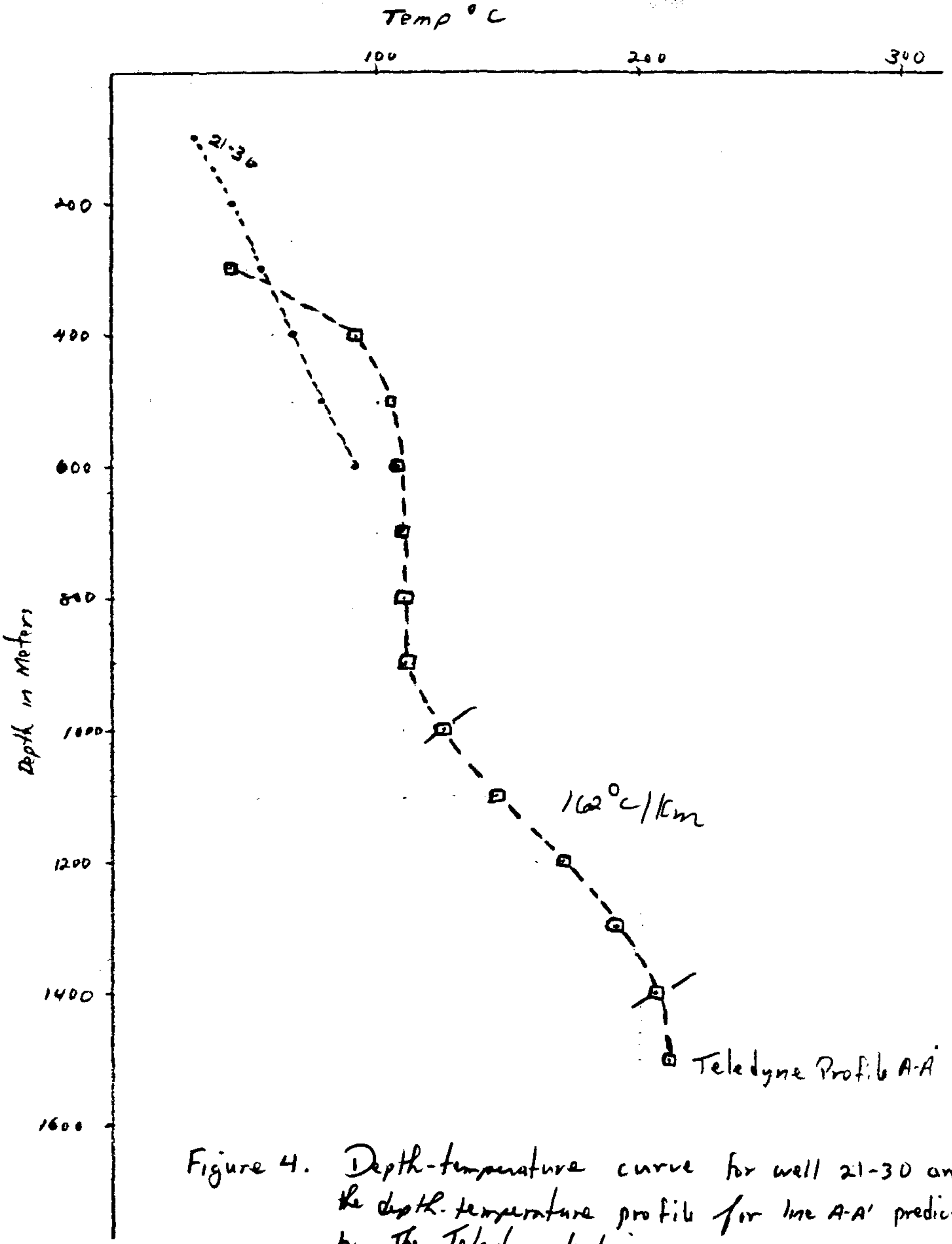

Figure 4. Depth-temperature curve for well 21-30 and the depth-temperature profile for line A-A' predicted by The Teledyne technique.

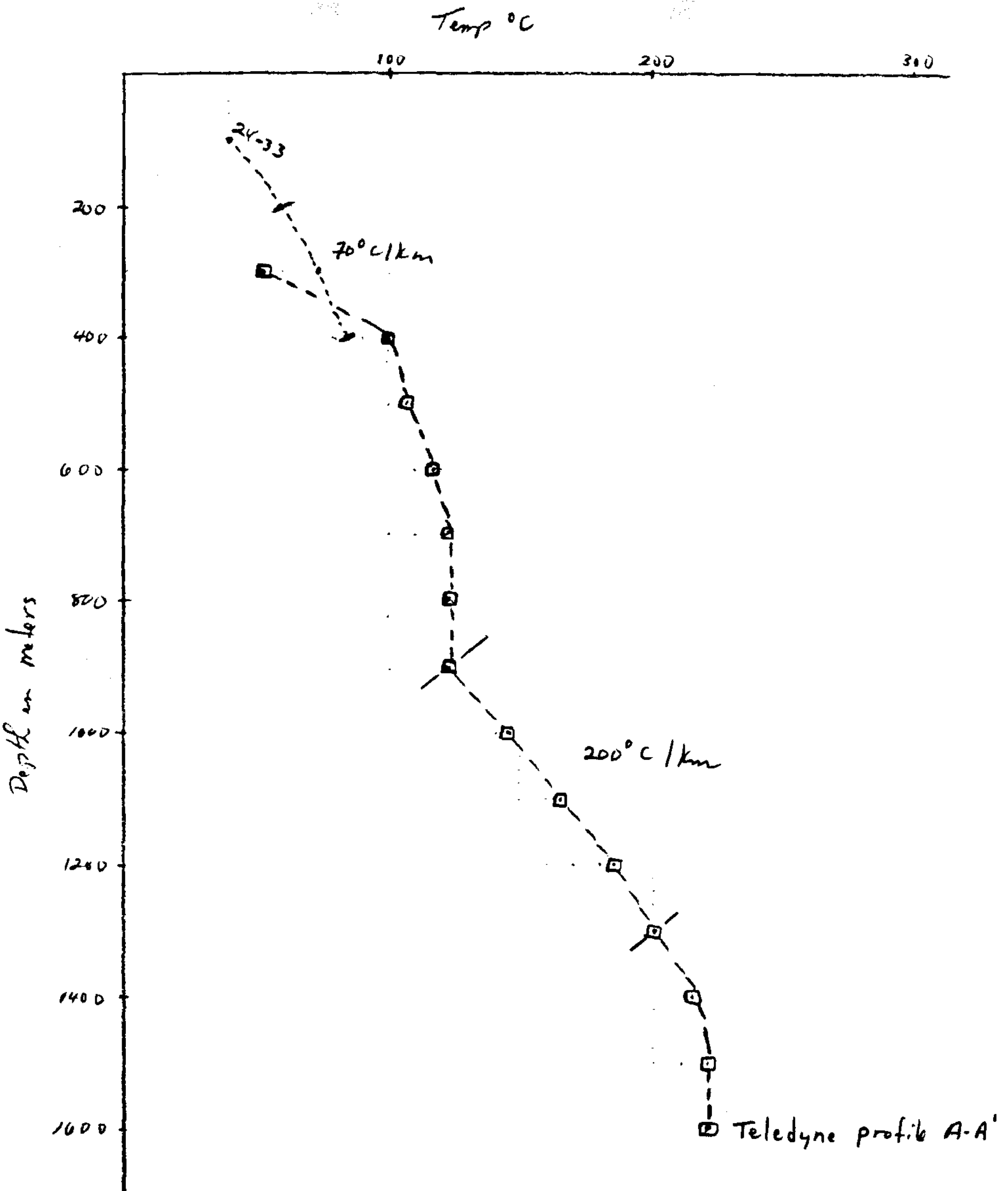

Figure 3. Depth temperature curve for well 24-33 and the depth temperature profile for line A-A' predicted by the Teledyne technique for well 24-33.

be made is that the profiles generated all have a shallow isothermal zone at temperatures of 110-120°C. Below the shallow isothermal zone the profiles all show a 300 to 400 meter interval with rather high conductive gradients before rolling over to become isothermal at 210 to 220°C. Thirdly, the temperatures predicted by the Teledyne wave number filtering technique agree well with the reservoir temperatures predicted by the chemical geothermometers.

The geologic cross section in Figure 5 is a composite based upon data from wells 56-29, 24-33 and 21-30 and the information gained from Fred Berkman's analysis of the aeromagnetic and the gravity data. The basement appears to be an arch. The arch may be an erosional remnant or may represent a Tertiary structure. The structure of the Tertiary Esmeralda Formation consists of a series of west-northwest trending folds. One possible interpretation of the folds is that they are the product of gravitational gliding off the arched Paleozoic surface. The dashed blue lines (Fig. 5) represent the 100° and 200° isotherms based upon the Teledyne data.

Summary and Conclusions

1. A part of the west-northwest elongation of the thermal anomaly appears to be related to a deep heat source.

2. The Alum area appears to be underlain by two separate geothermal reservoirs; a shallow reservoir with temperatures in the 100-120°C range which is closely related to the Tertiary-Paleozoic contact and a deeper potential reservoir with temperatures of 210-220°C.

3. The depths to the high temperature reservoir vary from a minimum of 1,300 meters to over 1,500 meters (Figs. 2-4).

4. The coincidence of observed data with the Teledyne data lends a certain amount of credibility to the Teledyne data. Similarly the coincidence reservoir temperatures predicted by the silica mixing model (Pilkington, 1983 b) and that of the high temperature reservoir predicted by the Teledyne data is encouraging.

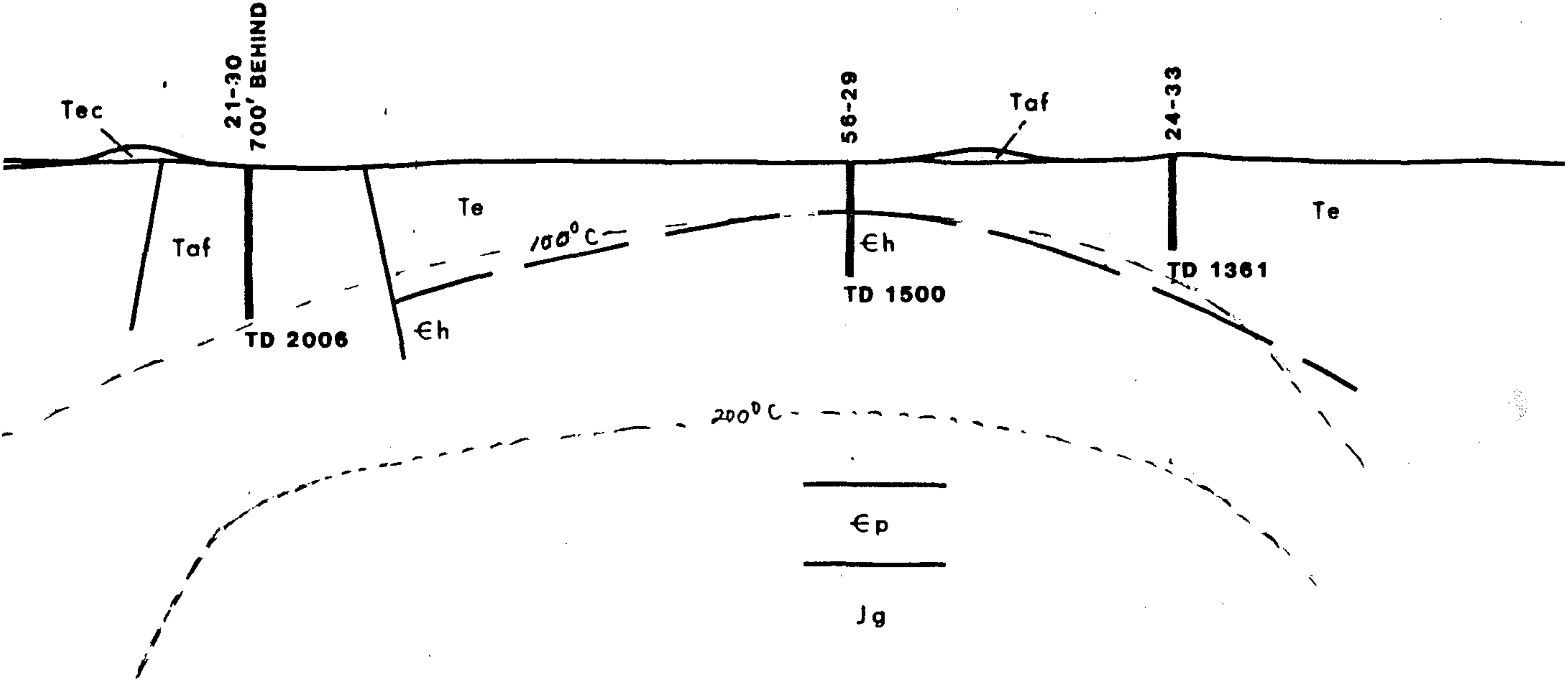

Figure 5

NORTHWEST-SOUTHEAST CROSS-SECTION THROUGH 21-30, 56-29 & 24-33

Scale 1": 2000'

– – – – – Isotherms based upon Teledyne data

5. The incorporation of the observed data from wells 31-32 and 51-29 will give us another good check point.

6. The wave number filtering technique will provide a great deal of help in the engineering of a deep test for discovery.

7. After reviewing the observed data and the Teledyne wave number filtered data I recommend that we now should consider using the observed data from the five intermediate depth thermal gradient wells for a downward continuation attempt. The downward continuation should be from a plane about 1,000' below the surface.

H. D. Pilkington

HDP/c

REFERENCES

Li, T.M.C., and Marvin, P. R., 1982, Summary report on wave number filtering applied to Alum thermal data, Teledyne Geotech Report.

Pilkington, H. D. , 1981, Geology of the Alum area, Esmeralda County, Nevada; AMAX Exploration, Inc., Report.

Pilkington, H. D., 1983 a., Review of the geothermal potential of the McCoy prospect; AMAX Exploration, Inc. IOM.

Pilkington, H. D., 1983 b., Preliminary hydrogeochemical analysis of the Alum area, Nevada; AMAX Exploration, Inc., IOM.