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AMAX EXPLORATION, INC.

A SUBSIDIARY OF AMAX INC.

GEOTHERMAL BRANCH

INTER-OFFICE MEMORANDUM

SUBJECT: A Geothermal Model For the Cove Fort Area, Utah DATE: Feb. 25, 1980

TO: W. M. Dolan

FROM: H. D. Pilkington

cc: H. J. Olson
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INTRODUCTION

The development of a geothermal model for the Cove Fort area of southwestern Utah has been an ongoing process since the acquisition of the Best, OK and Thermex properties in 1976. It is the purpose of this memorandum to document the geothermal exploration in the area and at the same time establish the evolution of my geothermal model for the Cove Fort area.

UNION OIL FORMINCO #1

In August of 1976 AMAX signed a bottom hole contract with Union Oil Company on a geothermal test hole called Forminco #1 (Figure 1). The hole was abandoned August 29, 1976 at a depth of 1040 feet after encountering serious lost circulation problems and spending approximately one million dollars. We learned that drilling in the Paleozoic section could be a very expensive exercise, but we did not learn much about the geothermal system. The hole was collared into Bullion Canyon volcanics which range from 21 to 30 m.y. in age. The volcanics were altered and contained disseminated pyrite, gypsum and native sulphur which appear to be related to the present day hydrothermal system in the Cove Fort-Sulphurdale area. However, we did not learn much about the thermal regime. The volcanic rocks extended to a depth of 240 feet where rocks of the Coconino Sandstone of Permian age were encountered. The bottom of the Coconino occurs at 560 feet where the limestones of the Pakoon formation were encountered. Below 720 feet very few returns were obtained because of lost circulation. The bottom of the hole was in a brown "sandy" dolomite. Quartz-pyrite occur sporadically between 240 and 720 feet and probably represents a mid-Tertiary hydrothermal event.

AMAX SHALLOW THERMAL WELL PROGRAM

AMAX completed an extensive shallow temperature gradient hole drilling program in the Fall of 1976, and a second program in the Spring of 1977. Our drilling results plus a diligent search for existing holes led to the development of a reasonably detailed heatflow map covering approximately 1600 square miles. Seven distinct thermal anomalies were outlined (Figure 2). The Cove Fort thermal anomaly is a very large feature (Plate I) which has a surface expression of approximately 100 square miles. Four distinct sub-cells have been outlined within the Cove Fort thermal anomaly.

GEOLOGIC INVESTIGATION

From December of 1976 through March of 1977 some geologic reconnaissance was undertaken in the Cove Fort area in an attempt to understand the thermal anomaly. The area examined was west of I-15 and south of Black Rock Road. The geologic map of Utah shows the area to be underlain by Quaternary rocks of the Sevier River Formation and Quaternary basalts associated with Cinder Crater.

In the area south of Cinder Crater the rocks mapped as Sevier River Formation turned out to be a series of rhyolitic volcanic rocks (Plate II) consisting of intrusive dikes, crystal tuffs and crystal lithic tuffs. The volcanic rocks crop out over an area about fifteen square miles. The rhyolite dikes cut the granitic rocks of the Mineral Mountain pluton; therefore, could range in age from as young as 9 m.y. to as much as 20 m.y. depending upon whose radiometric age you like. Since there was some question as to age we dated one sample of crystal tuff from the east side of Cedar Grove which gave a date of 8.5 ± 0.4 m.y. Additional geologic mapping and perhaps some additional age dating will be needed to relate the young rhyolites to their proper place in the stratigraphic sequence in the Cove Fort Area. It has been reported (Personal communication, Joe Moore, URI) that T. A. Steven of the U.S.G.S. has found the rhyolitic rocks resting upon alluvial gravels in this general area. The alluvial materials may be correlative with the Sevier River Formation, in which case our radiometric age date is probably valid. However, the alluvial sediments may be Quaternary in age which would make the rhyolitic rocks much younger than heretofore suspected.

The basalts of the Cove Fort area are all thought to be pre-Bonneville in age. Several ages of basalts have been distinguished. The oldest, and most extensive flows are the diabasic olivine tholeiites which crop out extensively north of Cove Creek and as far northwest as Black Rock siding in the Escalante valley (Plate II). Condie and Barsky (1972) have dated these rocks at 0.92 to 0.97 m.y. Clark (1976) has mapped the basalts west of Manderfield as a part of the older sequence although no radiometric dates are available to confirm his field relationships. The older basalts rest upon lacustrine marls deposited in a pre-Bonneville lake as seen in the anticlinal feature north of Black Rock Road. (Plate II). Zimmerman (1961) found fossils in the marls which provide a Plio-Pleistocrine age for the rocks which could make them time correlative with the Sevier River Formation.

The younger basalts in the Cove Fort field are those associated with Cinder Crater, Crater Knoll, Cedar Grove and Red Knoll (Plate II). These younger basalts have been dated at 0.85 m.y. Drilling of the thermal gradient holes around Cinder Crater established that the younger basalts rest upon unconsolidated gravels and gypsum bearing sands which in turn rest upon the 0.9-1.0 m.y. olivine basalts.

PASSIVE SEISMIC SURVEY

From June 14 to July 2, 1977, Microgeophysics Corporation conducted a passive seismic survey in the Cove Fort area. A total of 18 days of recording was done using four to eight stations any given day, and the station array was modified each day. A total of 52 stations were occupied during the survey. Three types of results were obtained including microearthquakes, micronoise, and P-wave delay or attenuation.

The microearthquake data (Plate III) suggest tectonic activity along a graben structure. The eastern fault runs north-south from a point about two miles east of Cove Fort. The western fault border runs northeast-southwest along Dog Valley. The microearthquake activity terminates along a west-northwest zone.

The micronoise anomaly (Plate III) suggests the graben structure outlined north of Black Rock Road by the microearthquakes continues to the south. The west-northwest trending zone seperates the micronoise anomaly into a northern and a southern segment. The segments are southeast of Dog Valley and west of Cinder Crater respectively.

The P-wave delay and attenuation data again gives anomalous response in the Dog Valley area and also in the area west of Cinder Crater (Plate III). The attenuation data coincide with the P-wave delay anomalies which suggests the anomalies may be related density of fracturing within the graben area.

A zone of P-wave advance occurs along the west-northwest trending structure in the area along Cove Creek west of Cove Fort (Plate III). The velocity advance may be related to silicification along a shear zone.

LANDSAT PHOTO ANALYSIS

In mid-summer of 1977 the U. S. Geological Survey issued an Open-File Report 77-568 on the Calderas of the Marysvale Volcanic field by Cunningham and Stevens. After reading the report I began to study the LandSat photo of the area in detail. Distinct circular features on the photo can be outlined for the Bullion Canyon Caldera (21-30 m.y.) the Red Hills Caldera (17-21 m.y.) and the Mount Belknap Caldera (17-19 m.y.) as shown on Plate IV. In general, volcanic activity associated with the Red Hills and Mount Belknap Calderas started in the east and shifted westward at about 1 million year intervals. Within the Red Hills Caldera for example, the oldest activity started with ash flow tuffs from a vent on the east side about 21 m.y. ago and culminated with the emplacement of a volcano pluton of granitic rocks about 20 m.y. ago. In the next million years, 19-18 m.y. ago, the activity shifted to a vent area near the center of the circular feature where ash flow eruptions again occurred. A local caldera at Red Hills, slightly more than a kilometer in diameter, formed at the end of activity. In the succeeding million years, 18-17 m.y. ago, the activity shifted to the western side of the circular feature in the vicinity of Grey Hills where rhyolite ash flows and domes were emplaced. The last igneous episode in the area appears to have been emplacement of rhyolite dikes and uranium-molybdenum-fluorite veins between 13 and 10 m.y. ago. Thus for a given volcanic center, activity covering a 9-10 m.y. time span appears to be reasonable.

A circular feature is present on the Land Sat photo in the Cove Fort area. Does the feature have any significance in terms of a geothermal model for Cove Fort? I think that it does and interpret the feature as follows.

The Basin and Range deformation began approximately 17 m.y. ago. The deformation in the Cove Fort area is somewhat complicated by its proximity to the Wasatch hinge line which forms the structural boundary between the Great Basin and the Colorado Plateau. The Cove Fort graben developed after the Marysvale volcanic activity hence, must be younger than 17 m.y. and since it displaces a part of Mineral Mountain pluton it may be as young as 9 m.y. In fact the deformation associated with the formation of the Cove Fort graben and the Mineral Mountain horst (Figure 3) very probably were responsible for re-setting the radiometric clock and explains the discordant ages reported for the pluton. Lacustrine sediments were accumulating in the graben as evidenced by the rocks exposed in the anticline north of Black Rock Road (Plate II). At about 8.5 m.y. ago a magma reached a high level in the crust and formed a domal feature in the Cove Fort area. Degassing of the magma formed rhyolitic ash flow tuff, crystal lithic tuffs and rhyolite domes of the Four Mile Ridge area. The doming and volcanic activity effectively allowed the release of magmatic pressures without the development of a collapse caldera. The Four Mile Ridge is thought to be a tuff pipe (Figure 4). The doming and volcanic activity divided the graben into the Beaver Valley basin on the south and the Cove Fort basin on the north. Lacustrine and fluvial sediments continued to be deposited in each of the basins.

Igneous activity within the general Cove Fort area appears to have subsided for a time. The next surge occurred in the Twin Peaks area (Plate IV) where rhyolitic domes, ash flow tuffs, volcaniclastics, pumice and obsidian are dated at 2.27 to 2.32 m.y. (Haugh, 1978). Haugh postulates that the silicic volcanism is related to a Glenco-type subsidence caldera; however, I would relate the activty to a tuff pipe emplacement at the top of a volcano pluton. The Twin Peaks volcanism may well be a cupola protruding from the same high level magma chamber which formed the Four Mile Ridge volcanism. The Twin Peaks volcanism formed an effective dam across the northern end of the Cove Fort graben.

The next phase of igneous activity appears to be the outpouring of flood basalts onto the floor of the Cove Fort graben starting about 2 m.y. ago continuing periodically for about 1 m.y. (Plate IV). The flood basalts erupted along the north-south fractures related to the Cove Fort graben.

Approximately 1.0 m.y. ago another silicic magma reached a high level in the crust. The magma emplacement resulted in the formation of a large domal feature, approximately 25 km in diameter, to form in the Cove Fort area (Plate IV). Its emplacement appears to have been controlled by the structural intersection of the Wasatch hinge line, the strong west-northwest trending structural zone, and the Basin and Range structures. A northeasterly trending graben developed on the domal structure (Plate IV). The initial volcanic activity associated with this plutonic emplacement was the subalkaline to calc-alkaline rocks associated with a northeasterly trending fracture in the central part of the present day Cove Fort graben. The volcanics have been dated as 0.85 ± 0.04 m.y. (Plate IV).

ELECTRICAL SURVEYS

In the fall of 1977, AMAX initiated a Self-Potential survey and some magnetotelluric work in the Cove Fort area. The work was done under contract by Terraphysics from the last week in November through the first week in December.

The results of the SP survey are shown in contour form on Plate V. The results of the SP survey show three distinct mono-polar anomalies at Dog Valley, Antelope Valley and Cinder Crater. Throughout the remainder of the area the SP results are rather uniform. How does the SP fit with the geothermal model? According to Bob Corwin (Personal communication, 1980) the large negative anomalies at Cinder Crater and Antelope Valley may be in response to (1) a broad thermal high, (2) a steam zone or (3) near surface cold water movements related to recharge. The Dog Valley anomaly appears to be related to heat transfer along the intersection of the Baker Canyon fault and the thrust fault (Plate II).

The Antelope Valley and Cinder Crater SP anomalies lie within the present day northeasterly trending Cove Fort graben (Plate IV). The Cinder Crater anomaly coincides with the eruptive center for the 0.85 ± 0.04 m.y. old subalkaline to calc-alkaline volcanics in the Cove Fort area. Thus we might expect to have a thermal anomaly at depth in the area. The lack of a thermal anomaly at the surface (Plate I) is probably the result both downward percolating groundwater and lateral flow off the shield volcano (Cinder Crater) along interflow boundaries. A suggestion of thermal anomaly is preserved on the southwest side of Cinder Crater; however, it is also thought to be supressed due to groundwater. At least part of the SP anomaly is thought to be related to the near surface groundwater movement. The Antelope Valley SP anomaly does not coincide with young volcanics and is probably comparable with the Dog Valley anomaly.

The lack of a significant SP response over the main parts of the thermal anomaly (Plate I and V) is probably related to the depth of the water table. In other words the SP does not see deeply enough to pick up the thermo-electric effects of the moving waters.

The results of the MT survey (Plate VI) provide another line of evidence in support of emerging geothermal model. Line A-A' clearly shows the bounding faults for the Cove Fort graben. Highly resistive rocks are found on the footwall sides and the graben is characterized by low resistivity. The P-wave advance area, as outlined by the passive seismic survey (Plate III), may correspond to the zone of intermediate resistivities beneath the graben floor. Line B-B' shows the eastern boundary fault and some of the minor faults within the graben. The line did not extend far enough to the west to see the western boundary fault. The C-C' profile shows a low resistivity layer at a depth of 10 km which may correlate with the P-wave delay as outlined by the passive seismic survey (Plate III). Perhaps line B-B' should be extended another three miles to the west, and another line should be done along the road from the Sulphurdale exit to the Mineral Mountains.

UNION OIL HOLES 42-7 AND 31-33

In 1977 AMAX joined the Cove Fort-Sulphurdale geothermal unit of Union Oil Company. As members of the unit we would receive the data from the unit wells which Union was required to drill. On November 11, 1977 Union spudded well 42-7 northeast of the Sulphurdale mine (Fig. 1). The hole was collared in Bullion Canyon volcanics, a series of latite and quartz latite crystal tuffs and tuff breccias. At a depth of 2040 feet the hole penetrated the Coconino Sandstone of Permian age. Drilling in the Paleozoic sediments proceeded slowly with lots of lost circulation problems to a depth of 4790 feet. Both the Tertiary volcanics and the Paleozoic sediments have been subjected to one and perhaps two hydrothermal events. Pyrite and minor amounts of pyrrhotite, chalcopyrite and galena were noted throughout the interval 0 to 4790 feet. At 3360 feet the sulfides were associated with strong quartz veining. Moore and Samberg (1979) postulate that the sulfide mineralization is mid-Tertiary hydrothermal phase associated with plutonic activity 21-23 m.y. ago. However, Cunningham and Stevens (1977) discuss alteration and mineralization including uranium-molybdenum-fluorite, in the Marysvale area dated 10 - 13 m.y. Therefore, the mineralization we observe in the drill holes may represent a mid-Tertiary event with a superimposed Late Tertiary event.

Below 2800 feet anhydrite and/or gypsum occurs in the cuttings. The presence of sulfates suggests downward movement of acid waters formed by the mixing of hydrogen sulfide and meteoric waters. It is very likely that some of the pyrite found with the gypsum is also the product of the acid waters. The hydrogen sulfide activity is a part of the present day geo- thermal system.

Below a depth of 4790 feet in hole 42-7 the rocks exhibit the effects of thermal metamorphism (Fig. 5). Between 4790 and 6120 feet the rocks are hornfelsed, that is they are recrystallized but do not develop new minerals. From a depth of 6120 feet to a depth of 7070 feet the rocks exhibit progressively more minerals typical of the Albite-Epidote hornfels facies such as chlorite, epidote, tremolite, talc, phlogopite and biotite. Two small dikes of quartz-feldspar were encountered in this interval.

Between 7070 feet and 7440 feet the mineralogy is indicative of the hornblende hornfels facies such as quartz, epidote, grossulanite diopside, and brucite (Plate I). Below 7440 feet the presence of Wollastonite suggests the metamorphism has reached the pyroxene hornfels facies. A quartz feldspar dike was cut between 7540 and 7570 feet. It is important to note that the metamorphic effects increase progressively with depth and are not simple contact aureoles surrounding each quartz feldspar dike.

Drilling on hole 42-7 was completed on March 6, 1978 and testing continued into May 1978. Geothermal fluids at about 150°C were encountered at 2190 feet in the Coconino sandstone. In the underlying Paleozoic carbonate rocks the temperatures were depressed by a "cold water" entry at about 2790 feet, then increase gradually to about 4000 feet where fluids at about 163°C are encountered. The temperatures of the well increased very slowly below 4,000 feet. Union Oil Company attempted to unload the well with nitrogen to induce flow. The test was successful and the well started flowing at a rate of ±48,000 lbs/hr. and both the pressure and flow rate dropped slowly over the seven hour test to about ±43,000 lbs/hr. The estimated reservoir temperature based upon the Na-K-Ca geothermometer from waters collected at 5660 feet is 211° C (personal communication, David Tarbell, Univ. of Pennsylvania).

Under the terms of the unit Union Oil had to begin another well as of May 26, 1978. Well 31-33 was spudded in May 24, 1978 approximately 3.5 km east of Cove Fort (Figure 1). The hole was collared in Bullion Canyon volcanics which extend to a depth of 1010 feet. The volcanics are weakly altered throughout and become more intensely altered at the base. The alteration begins as propylitic and become chloritric at depth. Disseminated pyrite is common throughout the altered rocks and below 800 feet galena and chalcopyrite occur as well (Figure 6).

Between 1010 feet and 1140 feet the rocks are composed of red-brown siltstones and minor very fine-grained sandstones and minor amounts of limestone. The rocks are described as Price River Conglomerate by Moore and Sanberg (1979); however I believe that they represent the Moenkopi formation of Triassic age. The red brown siltstones are unconformably overlain by the Bullion Canyon volcanics and rest unconformably upon a light to dark gray limestone which I correlate with the Kiabab limestone of Permian age. The Kiabab was characterized by numerous lost circulation zones and at least three hydrogen sulfide entries. The limestone exhibits recrystallized calcite blebs, quartz veining and disseminated sulfides. At 2960 a cold water entry was encountered which may be associated with a reverse fault which repeats part of the section. At a depth of 3430 feet poor returns of red-brown siltstone typical of the Moenkopi formation were obtained. From about 2400 feet to 4800 feet the rocks are calcareous siltstones typical of the Queantweep formation. The hole probably bottomed in the Pakoon limestone of Lower Permian age. The calcareous siltstones exhibit low-grade metamorphism which have produced minor amounts of chlorite without significant recrystallization.

The drilling results from Union Oil Company wells 42-7 and 31-33 lend support for the hypothesis that the heat source for the Cove Fort area is centered below the present day Cove Fort graben near the center of the circular feature shown on Plate IV. The increased thermal metamorphism observed between 31-33 and 42-7 suggests we are approaching the heat source. Also the presence of quartz porphyry dikes in 42-7 are thought to represent small apophyses projecting above the volcano pluton postulated to lie beneath the circular feature.

SYNTHESIS OF DEEP DRILLING AND GEOTHERMAL MODEL

What have the production drilling tests told us about the thermal anomaly? The mountain front fault on the west edge of the Tushar Mountains is the southeastern boundary fault for the Cove Fort graben. That fault acts as a conduit for heat and fluids as seen on Plate VII. Convective heat transfer along the fault will adequately explain the sub-cell observed in the heatflow southeast of Cove Fort. Similarly each of the other sub-cells can be related to convective heat transfer along one or more faults. The thrust fault appears to play a major role in controlling heat transfer as does the west-northwest structural zone. The drilling also established that the water table is deep in the area, 400 to 700 meters which means that convective cells under the various heatflow anomalies are still more deeply buried. The presence of a geothermal reservoir in the Cove Fort area has been confirmed by hole 42-7 and 31-33, and suggest that the hot water system is confined to the Paleozoic rocks underlying the Tertiary volcanics. There is no leakage of the thermal waters to the surface in the form of hot springs at the present time. No fossil evidence of thermal springs such as siliceous sinter or travertine has been found in the Cove Fort area. White et. al., (1971) suggest that in systems where the water table is depressed, the surface features reflect degassing of the hydrothermal waters at depth. Thus the evolution of hydrogen sulfide as detected in some of the altered areas around Cove Fort and the H_2S encountered when drilling the production tests is thought to be related to the boiling of the geothermal fluids at the water table. The escaping hydrogen sulfide combines with meotoric water at the surface to form sulphuric acid which then results in the acid-alteration. Oxidation of the hydrogen sulfide at the surface results in the formation of native sulphur.

GRAVITY ANALYSIS

In the spring of 1979, AMAX ran a detailed gravity line over the Cinder Crater area in hopes that data might shed some light on the validity of the proposed geothermal model for the Cove Fort area. In January 1980 Fred Berkman did a computer analysis of an east-west line across the Cinder Crater area which is shown on Plate VIII. The results show a distinct normal fault along the east and west sides of the Mineral Mountains and Tushar Mountains respectively. Beneath the Cinder Crater area a horst block or domal feature is present which may reflect uplift caused by the volcano pluton at depth.

UNION OIL HOLE 14-29

Union Oil Company was required under the terms Cove Fort-Sulphurdale Geothermal Unit to drill a production test well every six months until production had been established. A well was required to spud in by December 26, 1978; however, Union Oil requested a six month delay from the U. S. Geological Survey. The delay was granted, and well 14-29 was not spudded in until May 25, 1979. Rocks of the Bullion Canyon volcanic sequence were penetrated to a depth of 800 feet. The alteration and amount of disseminated pyrite and chalcopyrite increase with depth. A conglomerate made up of quartzite clasts in a red calcareous siltstone matrix occurs from 800 to 850 feet and is probably the Price River conglomerate. A lost circulation zone was encountered which suggests that the hole had passed into the Paleozoic carbonate section. Drilling proceeded to a depth of 2620 feet on July 6, 1979 when Union Oil Company decided to abandon the hole. The bottom hole temperature was 92^{o}C. Since Union had not met the drilling requirements of the Unit Agreement the unit was dissolved. Very little useful information was gained from well 14-29 with regard to the geothermal system at Cove Fort.

SUMMARY

After over three years of geothermal exploration in the Cove Fort area and periodic cogitation over the results the following geothermal model has emerged. The general Cove Fort area has been the focus of igneous activity for at least 8 m.y. The igneous activity which I believe to be the heat source for the Cove Fort geothermal system began about 8 m.y. ago with the generation and emplacement of a large magma which resulted in the formation of a broad gentle dome approximately 25-30 km in diameter. A small copula rose into a high level crustal position to form a volcano pluton. The copula was small and the degassing which occurred did not lead to the development of a caldera, instead a tuff pipe formed. The volcano pluton was emplaced along ring fractures on the south edge of the broad regional dome.

The next surge of activity occurred in the Twin Peaks area where a volcano pluton was emplaced 2.27 to 2.32 m.y. ago. I would suggest the volcano pluton represents a cupola projecting above the parent magma chamber described above. The cupola and resulting volcano pluton were emplaced along the ring fractures on the north side of the regional dome.

Approximately 1-2 million years ago relaxation of the stresses associated with the Basin and Range structures occurred which allowed flood basalts to pour out along some structures. The flood basalts poured out onto the floor of the basins. Extension must have been initiated again as seen by the faults developed in the basalts.

Starting about 0.9 m.y. ago another surge of magma rose from the magma chamber into a high level crustal position. The magma movement renewed the regional tumescence. The domal structure was formed within the tensional and shear stress fields associated with the Wasatch hingeline. The resulting stress orientations caused the development of the northeast trending graben across the dome. The tensional stress permitted a pressure release in the magma chamber and the outpouring of the alkaline to cali-alkaline volcanics of Cinder Crater, Red Knoll and Crater Knoll vents. Small quantities of magma was emplaced along the old ring fractures to form the rhyolite domes and associated volcanics in the Mineral Mountains.

The geothermal system at Cove Fort is thought to be the result of the interaction of a vapor plume from the pluton (Henley and McNabb, 1978) and groundwater convection (Cathles, 1972). The pluton was emplaced into crustal rocks which had been "prepared" by the earlier magmatic and tectonic activity. The ground preparation provides fractures to greater depths than usual, thus allowing deep penetration by groundwater and also facilitating the escape of the vapor plume from the magma. The rate of convection and the amount fluid circulated depends upon (1) the permeability of the country rock, (2) the permeability of the intrusive, (3) the water content of the magma, (4) size of the intrusive, (5) temperature of the intrusive and (6) depth of burial.

A schematic diagram (Figure 7) illustrates the geothermal model proposed for Cove Fort. The magma was emplaced at a depth of approximately 4 km. The resulting volcano pluton probably stood 4-6 km above the general magma chamber and had a half width of 3-4 km. The Tertiary Bullion Canyon volcanics provide an effective barrier to the upwelling fluids; therefore, no hot springs are found at the surface. Degassing of the geothermal fluids beneath the impermeable volcanics is responsible for the hydrogen sulfide eminations observed in the area.

Figure 8 illustrates the hypothetical effects of the convective cooling of a pluton with an assumed permeability of 0.25 millidarcies and the depth of burial is assumed to be equal to the width of the pluton. The maximum expression of surface heatflow is 40 HFU after 20,000 years. Note that the heatflow is highest at the margin of the pluton and that the isotherms are depressed over the center of the intrusive. Furthermore, note how the isotherms pinch in with depth so that if an exploration well were to be drilled at a distance of 2.5 to 3.5 km from the center of the pluton one would get a temperature roll-over with depth.

The above model fits the observed parameters reasonably well. The surface heatflow of 26 HFU suggests either that the Cove Fort geothermal system has not yet reached maturity or that it has started to decline. Also, to better portray the system we would have to incorporate the effects of conductive heatflow within the impermeable Tertiary volcanics which would increase the time required to achieve maximum surface heatflow.

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