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GEOTHERMAL DRILLING IN THE SUMMERLAND BASIN, BRITISH COLUMBIA, 1990.

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Introduction

The Tertiary basins in the interior of British Columbia present opportunities for the development of geothermal resources. The weakly lithified beds, characteristic of these basins, are poor thermal conductors that commonly blanket older more conductive crystalline basement rocks. The low conductivity combines with the natural dissipation of heat from the earth's interior to produce a high geothermal gradient, producing temperatures rather higher than normal below the surface. In addition to this, the inherent structural weakness of these young cover rocks facilitates faulting and fracturing allowing the entry of groundwater into the strata and the possible development of warm water reservoirs at depth.

The first phase of a drilling project, Hole No. EPG/GSC 495, began in March 1990 at Summerland, sponsored by the Okanagan-Similkameen Community Futures Association (based in Penticton), the Geological Survey of Canada and the British Columbia Ministry of Energy, Mines and Petroleum Resources. The object of this project was to test the geothermal potential of the Summerland basin with a view to developing a low-grade thermal source for space heating of greenhouses or other large buildings.

Geological Setting

The Summerland basin is an Eocene volcanic caldera that was once part of a larger contiguous mass of volcanic and sedimentary rocks known as the "Penticton Tertiary outlier" (Church, 1982). The rocks in the Summerland basin consist of several of the major units of the Penticton Group such as the basal conglomerates (Kettle River Formation), massive volcanic beds (Marron Formation), feldspar porphyry trachyandesite lavas and breccia (Marama Formation) and fluvial and lacustrine sedimentary rocks (White Lake

Formation). The total stratigraphic thickness of this assemblage is in excess of 1000 metres (Figures 1 and 2). A drill hole through to the keel of the basin in a central location would be expected to encounter most of the stratigraphic units.

Rifting and graben development caused by crustal extension along the Okanagan valley occurred about 50 million years ago (Church, 1973). At this time and subsequently the rocks of the Summerland area were tilted and folded into an elliptical 5 by 10 kilometre synclinal trough, forming a natural catchment area for resupply of groundwater. Down dip on the beds the lateral movement of groundwater is impeded by and possibly ponded against the Summerland fault at the southeast margin of the basin where down-faulted strata are juxtaposed against impervious massive granite.

At depth, groundwater is channelled through permeable strata, joints, bedding planes and faults, becoming trapped in porous units such as conglomerate and sandstone beds and lenses of breccia in fault zones. In the clastic beds porosity and permeability is greatly reduced because of carbonate cement and abundant interstitial volcanic dust. Consequently much of the available groundwater is believed to be contained in the fractures. Slippage, as the result of folding, between the individual beds and along formation contacts, is believed to be the most promising mechanism for the formation of aquifers at depth.

Previous Research

Investigation of the thermal regime of the crust of the interior of the Cordillera began in 1963 with the drilling of a 600 m well in the White Lake Basin, near the Dominion Observatory (Jessop and Judge, 1971) and has continued to recent years (Davis and Lewis, 1984).

The search for renewable energy sources began prior to the energy crisis of the mid-70s. To this end, Energy, Mines and Resources Canada and the British Columbia Ministry of Energy, Mines and Petroleum Resources have supported a number of geothermal energy projects. The Geothermal Potential Map of British Columbia (Church et al., 1983) was preceded by more detailed investigations suggesting geothermal potential in the White Lake basin and other Tertiary outliers in south-central British Columbia (Church, 1973).

The first borehole in the area was sponsored by the federal government as part of the Geothermal Energy Program (Lewis and Werner, 1982). This was a diamond-drill hole intended to test the geophysical and geological properties of granitic rocks just south of the Summerland basin. Later, a second hole, the "Mraz Well", was drilled to a depth of 200 metres to test the bedded Tertiary rocks in the southern part of the basin. Lewis (1984) confirmed a regional high heat flow and suggested targets for further research. He concluded that a more quantitative evaluation of the geothermal reserve required additional test wells.

The most 1990 well (No. EPB/GSC 495) is located on the Boerboom farm, just south of Eneas Creek approximately 1 kilometre northwest from the centre of Summerland, (Fig. 1). Details of location and drilling are to be found in Appendix 2. The location of this hole was chosen based on a combination of geology and proximity to a potential user. The Boerboom farm proved to be well positioned on the west limb of the basin where a drill hole of reasonable depth could penetrate to the base of the Tertiary pile. This optimized the blanket effect and increased the possibility of intercepting a warm water aquifer at the contact of the Tertiary beds with the underlying granite. The farm is a large user of electricity for heating greenhouses, and is the kind of energy user that is well suited to the application of low-temperature geothermal development.

The Summerland well of 1990

The new well began as a 6-inch (15.2 cm) diameter rotary hole. From 10 March to 15 May it was drilled to a depth of 544 m, penetrating 56 metres of gravel and glacial till before entering bedrock. The hole was completed by BQ diamond drilling (21 July to 31 July) to a depth of 712 m.

The geological profile of the bedrock in this hole shows mostly alternating ash flows and lava flows typical of the Nimpit member of the Marron Formation, that is tan to dark grey trachyte/trachyandesite with small phenocrysts of diopsidic pyroxene and microlites of plagioclase and alkali feldspar in a fine-grained matrix. Quartz is rarely seen. Some admixture of shale and coal with the volcanic fragments recovered from the rotary drilling suggests penetration of part of the White Lake Formation or intercalation of similar sedimentary rocks in the volcanic pile.

The petrography of the lower, cored section of the drill hole is consistent with the chip samples obtained above. Most of this section appears to be Nimpit tuff-breccia with a few interlayered lava flows and crosscutting dikes. Flattening and welding of pumice fragments is seen at several levels. The angle between bedding and core axis averaged 45 degrees.

A temporary water flow of about 100 litres per minute was reported at a depth of about 150 m. Water movement is also believed to be responsible for hematization in shear zones such as between 569 and 573 m and by the local abundance of calcite and laumontite filled fractures between 554 and 557 m. Further indications are provided by the thermal log, as described below.

Thermal results

The Summerland well has been assigned number 495 in the EPB/GSC system. A complete log at five-metre intervals was run on 16 August 1990, 16 days after the end of drilling. Measurement errors in temperature probably do not exceed 0.005 K and in depth do not exceed 0.2 m at any point. Calibration errors of the thermometer system probably do not exceed 0.005 K. The temperature in the well would not have completely returned to equilibrium at that time, but since the final phase of drilling lasted for only 10 days, after a break of 67 days, the anticipated errors are small, probably less than 0.1 K. The data are given in Appendix 1 and are illustrated as a plot of temperature against depth in Fig.3.

The depth reached by probe during logging was 706 m, and there was a suggestion of sticking when lifting the probe from the bottom. There may be some loose fragments of rock intruding into the well, forming a crevice into the which the probe tip could slide. The indication of fractured rock in the lowermost core supports this supposition.

Temperature gradient is reasonably uniform at 34 mK/m below 450 m, i.e. in diamond-drilled portion, as shown in Fig.4. Here the drilling disturbance is much less than the upper portion and this gradient value is probably accurate to within 1%. In the upper part of the section the gradient appears to be more varied, resulting from a combination of greater drilling disturbance and greater variability of thermal properties of the rocks.

The temperature plot shows a hint of a water movement at 523 m, but this may be attributable to drilling disturbance. There are multiple small disturbances at 50 to 350 m, but another log after a period of six months is needed for reliable interpretation of these.

The temperature at the greatest depth reached by the log is 33.28°C at 706 m, and the thermal gradient is 34 mK/m in the lower part of the hole. Continuation of the well to the basal conglomerates, where a useful aquifer may be found, will encounter increasing temperature, depending on the depth. Extrapolation predicts that a temperature of approximately 36.5°C will be found at 800 m, 39.9°C at 900 m, and 43.3°C at 1000 m etc. These temperatures are adequate for a geothermal system if an aquifer that is capable of supplying sufficient quantities of water is found.

Environmental considerations

Potential harmful effects of geothermal development depend mainly on chemical properties of the water taken from the well. Other considerations include the adequate disposal of the cooled water and, in view of the known natural accumulation of young uranium in the peat of nearby Prairie Flats (Culbert, 1980; Culbert and Leighton, 1988), the presence of radioactive trace-elements in the water.

Two water samples from the upper part of the well were sent to the laboratories of Chemac Environmental Services at Kelowna. These samples showed some suspended rock material in the water, a normal result of recent drilling, but otherwise these waters have a low content of dissolved solids. Water of this quality may possibly be disposed of in surface streams or used for irrigation.

Nothing can be said at present about the quality of water that may be found in the basal conglomerate, and if such water is found in the future it will need to be carefully tested.

Scintillometer tests were made of the well site before drilling, of rocks in the immediate neighbourhood and of rock samples as they were recovered. Testing of rock cuttings from the well showed no anomalous uranium concentrations nor high radioactive levels, and all readings on the recovered rock cuttings were below those of local surface rocks (Leaming, personal communication, 1990). However, as above, any other well drilled will need similar testing.

Future programme

The termination of the well before reaching the lowest strata of the Summerland Basin leaves the main objective of the drilling unfulfilled. No geothermal resource has yet been demonstrated, but the most likely location for such a resource has not been reached. The next step must be the completion of the well to achieve this objective. Funding for continuation of drilling has not yet been arranged (January 1991), but it is important to finish the task that has been undertaken. It is estimated that a further 100 to 300 m of drilling is needed.

If a geothermal resource of close to 40°C is demonstrated the immediate research objective will have been achieved. The municipality or the user will then need to assess the optimum use of the resource on the basis of location, purpose and economic factors. If the deep geothermal resource is not found at this location the prospects for other parts of the basin must be considered to be poor.

Regardless of the conclusions concerning a deep resource, a further question has been opened by the drilling done and by developments in systems involving shallow groundwater and heat pumps. Carleton University in Ottawa is using water from shallow wells at a temperature of about 9°C for heating and air-conditioning of large buildings onthe campus. The Town of Springhill has developed water from a flooded mine at a temperature of about 18°C for heating of industrial premises within the Town. Since the Summerland drill site has been found to be underlain by 56 m of clays and gravels and temperature in this zone is between 10 and 11°C, it is possible that adequate supplies of water exist beneath Summerland for similar development. Such use of water would need to be coordinated with other needs of the community, for example for stability of domestic water wells. A comprehensive study of the water available and the various demands upon it might be an appropriate successor to the current project.

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Appendix 1

Temperature data for Hole No. 495 - Summerland 16 August 1990

depth	temp	depth	temp	depth	temp	depth	temp
20.4	10.46	197.7	14.83	374.3	21.59	548.8	27.93
24.8	10.26	204.5	15.17	379.2	21.86	554.0	28.10
29.8	10.05	209.9	15.40	383.9	22.02	558.8	28.26
35.3	10.29	214.5	15.51	389.2	22.24	563.9	28.44
40.3	10.43	219.6	15.93	394.0	22.39	568.6	28.60
45.4	10.49	224.7	16.25	398.9	22.61	573.8	28.77
50.5	10.61	230.0	16.36	404.3	22.80	578.5	28.92
54.9	10.87	234.6	16.45	409.0	23.02	583.6	29.09
59.9	10.98	238.8	16.62	414.0	23.23	588.8	29.26
65.1	10.99	244.5	16.77	419.3	23.36	593.4	29.42
70.0	11.03	249.6	17.00	424.0	23.50	598.4	29.58
75.0	11.10	254.1	17.16	429.3	23.70	603.4	29.78
79.7	11.24	260.0	17.48	433.9	23.86	608.5	29.94
84.7	11.42	264.6	17.82	439.1	24.03	613.5	30.12
90.4	11.53	269.7	17.96	443.7	24.27	618.5	30.29
94.7	11.65	274.7	18.11	448.9	24.46	623.5	30.45
100.2	11.74	279.6	18.30	454.1	24.63	628.4	30.64
105.1	11.83	284.7	18.48	459.1	24.80	633.2	30.80
110.0	11.87	289.9	18.63	464.2	24.98	638.1	30.98
119.7	12.06	294.4	18.74	468.8	25.13	643.4	31.16
125.1	12.24	299.5	18.99	473.8	25.31	648.3	31.32
130.0	12.41	304.4	19.16	478.8	25.52	653.6	31.50
134.9	12.63	309.5	19.28	483.9	25.69	658.4	31.66
139.6	12.81	314.5	19.36	489.0	25.86	663.2	31.83
144.3	13.00	319.7	19.63	494.0	26.03	668.5	32.00
148.8	13.14	324.5	19.86	498.8	26.21	673.5	32.17
154.7	13.22	329.4	20.02	503.9	26.40	678.2	32.33
159.5	13.28	334.3	20.24	508.8	26.56	688.0	32.65
164.8	13.49	339.3	20.51	513.7	26.67	693.2	32.83
169.4	13.76	344.1	20.61	519.1	26.80	698.2	33.00
174.7	13.98	349.0	20.74	524.0	26.96	703.2	33.17
179.4	14.17	354.5	20.94	528.9	27.25	706.1	33.28
184.2	14.33	359.4	21.17	533.7	27.44		
189.6	14.42	364.2	21.30	538.5	27.60		
194.4	14.53	368.9	21.40	544.0	27.78		

Appendix 2

Summary of well data

Location of the hole:

UTM 11 305740 5498350

49-36.5N 119-41.3W

Elevation 505 m (all estimated from 1:50,000 map)

Dates of drilling: 10 March to 15 May to 544 m and 21 July to 31 July to TD.

Total Depth: 712 m

Hole casing: to 544 m with B casing, and open from 544 m to TD.

Samples: cuttings to 544 m, but labelled to 582 m; cores from 544 m to TD. All labels are in feet. Cuttings are kept as sets of washed samples, one at MEMPR in Victoria and one at GSC/ISPG in Calgary. Cores are stored at GSC/ISPG.

Figures

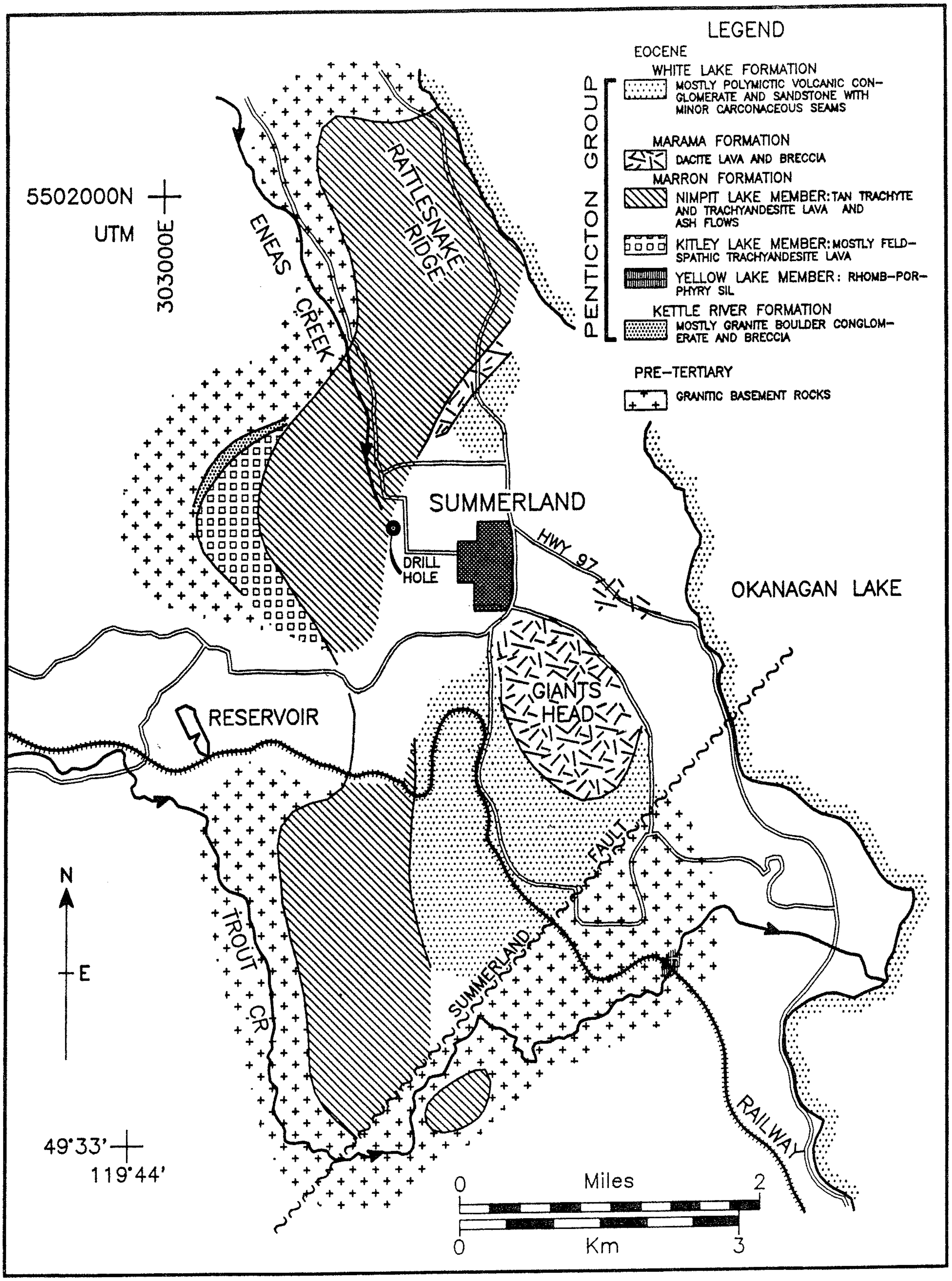

Fig.1 Map of the Summerland Basin with the location of the 1990 well

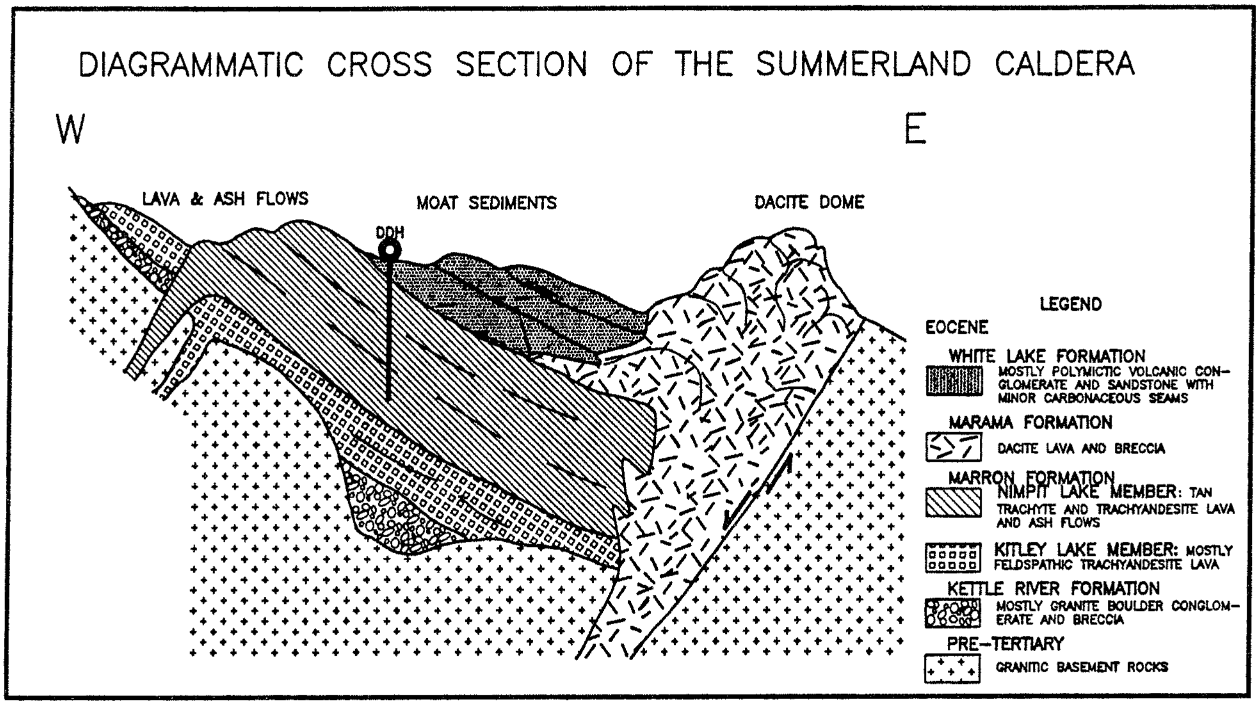

Fig.2 Postulated cross-section of the Summerland Basin

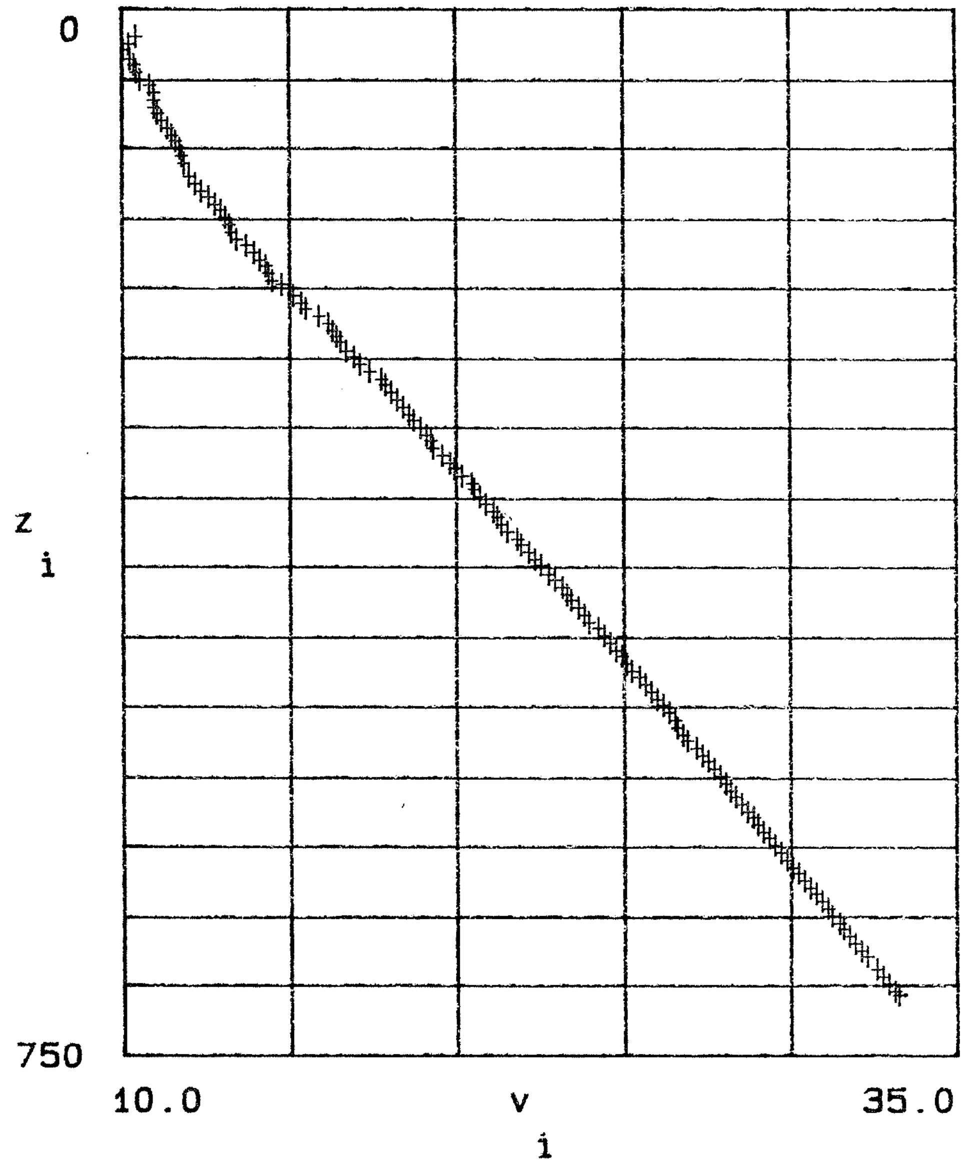

Figure 3. Temperature log of 16 August 1990

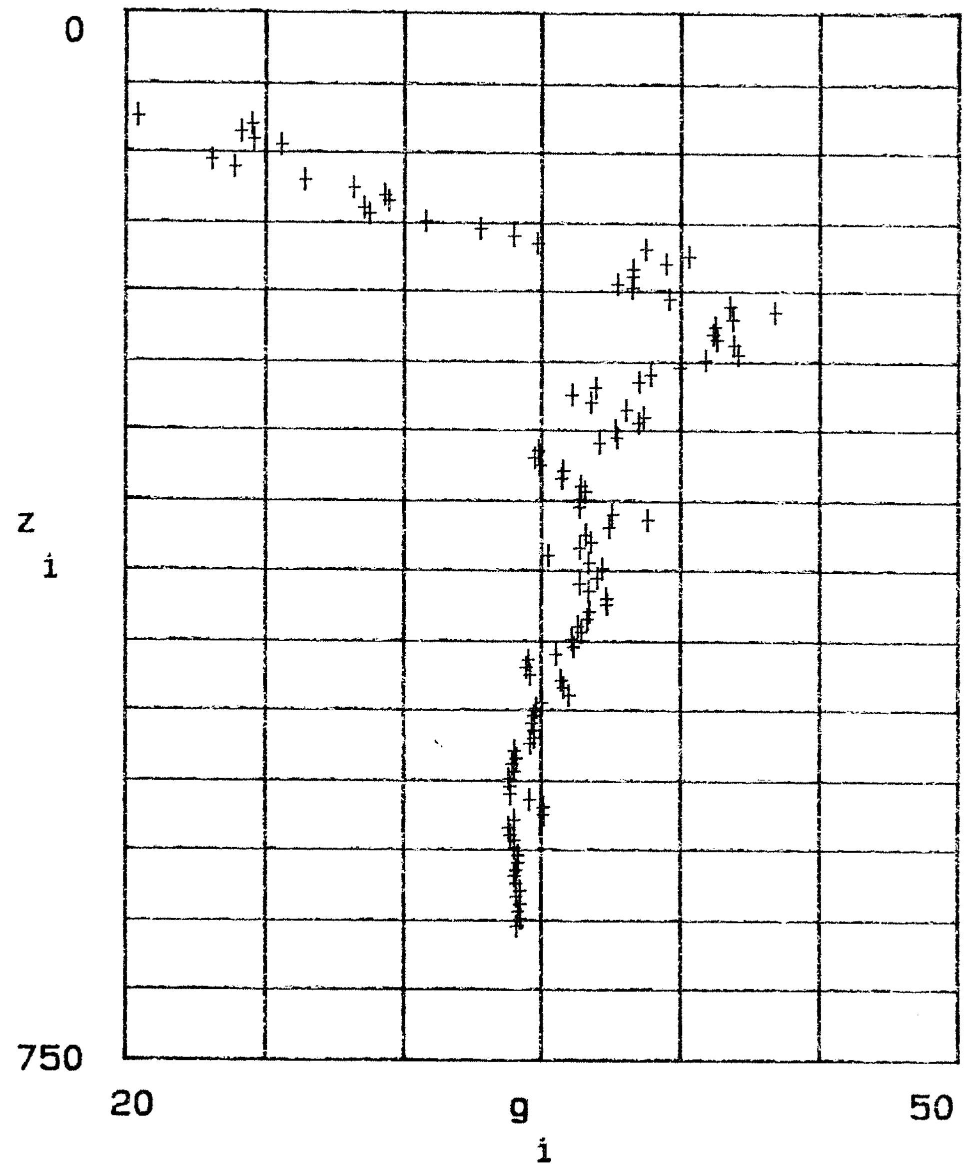

Figure 4. Temperature gradient of 16 August 1990