GL03993-3 of 4

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MEAGER CREEK GEOTHERMAL SYSTEM, BRITISH COLUMBIA, PART I: EXPLORATION AND RESEARCH PROGRAM

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Abstract

The Meager Creek geothermal area, 150 km north of Vancouver, B.C., centres on a large intermediate Cenozoic volcano. The reservoir systems feeding two independent hot springs on opposite flanks have been partially defined by geologic mapping (Read), resistivity (Shore), shallow drilling, and other operations. Interim conclusions bearing on current exploration are that the targets are water-dominated reservoirs at depths of 1000-2000 m in volcanic feeder pipes or nearby open fractures; that natural diffusion from these takes place slowly through weakly permeable fractured quartz diorite "basement"; and that the waters re-equilibrate with low temperature minerals and lose their geochemical memories in transit. The current program leans heavily on a newly developed pole-pole resistivity method (Shore), and is aimed at developing targets for 2000-metre exploratory drill holes.

Introduction. Independent investigations of the geothermal potential of the Meager Creek area were started in 1973 by the British Columbia Hydro and Power Authority and by the federal Department of Energy Mines and Resources (EMR). B.C. Hydro's goals are the commercial development of steam. The B.C. Geothermal Resources Act of 1973 provides B.C. Hydro, a Crown Corporation, with the right to extract geothermal energy (Nevin and Stauder,1976). EMR is charged with geological mapping, pure geophysical research, and Canada-wide assessments of geothermal resource potential as outlined by Jessop (1975). Souther (1976) describes a Cordilleran program and (1978) a current synthesis of Canadian projects.

Initial selection of the Meager Creek area was made on the weight of its large Cenozoic central volcano of intermediate composition flanked by hot spring systems. These are the Pebble Creek hot spring to the northeast, a dilute sodium bicarbonate brine flowing at 100 litres per minute, and the Meager Creek hot spring to the south, a dilute sodium chloride brine flowing at 500-1000 lpm. Maximum temperatures recorded in both are about 60°C.

The Meager Creek area is located about 150 km north of Vancouver, at latitude 50° 34'N and longitude 123° 23' W. It is 70 km from two 230 kV and one 500 kV power lines through which B.C. Hydro transmits power to the Vancouver load centre.

Geographic features which affect exploration methods include extremely high relief (see map), heavy and commercially valuable timber at elevations up to about 4000 feet (1200 m); only scattered outcrops, except between tree line at 5000 feet (1500 m) and the irregular lower edge of the permanent snowfield at about 6500 feet (2000 m); and no road access until 1977.

Recent Work. Four commercially important operations have been conducted since the report by Nevin and Stauder(1976). The first of these was geologic mapping by Read(1977; and this volume) at a scale of 1:10,000, under contract from EMR. Read's work provides not only certain geological and spatial factors acting on control of reservoirs, but also a distinct sense of the evolution of the volcanic edifice.

Hammerstrom and Brown (1977), also under contract from EMR, have shown that trace elements in both the Meager Creek and Pebble Creek hot springs have re-equilibrated at temperatures of 60-80°C, and offer no clues as to the 'upstream' thermal history. The waters are in equilibrium with the observed alteration assemblage kaolinite-laumontite-calcite-chalcedony.

Dipole-dipole resistivity surveys have outlined the southern or Meager Creek reservoir. The northern or Pebble Creek reservoir has been reconnoitered, first by a self-potential survey, and in 1977 by a new computer-controlled multiple electrode pole-pole resistivity method which is described by Shore (this volume). The fourth increment of commercially important information consists of three additional research wells drilled to depths of 60 to 90 m on the south reservoir. The hottest of these had a bottomhole gradient of 37°C per 100 m.

EMR continues to sponsor various surveys in the region, particularly aimed at the deep geophysics of the crust. In 1977 four 200-m holes were drilled, one at the edge of the Meager Creek area. All returned geothermal gradients of about double the crustal norm (J.F. Lewis, in preparation.)

Interim Conclusions. The map shows the extent of the geothermal reservoirs and anomalous areas known to date. Our interim conclusions, to be used to guide continued exploratory work, have evolved from work reported by Read (this volume) and Shore (this volume), and other data.

1. The major part of the rock underlying the valley floors is fractured Cretaceous quartz diorite, with some younger intrusives and septa of phyllite and metavolcanic rock. In the main it is only weakly permeable. Diffusion of hot water from the presumed sources--open and high temperature reservoirs--takes place slowly with attendant chemical re-equilibration and substantial heat loss.

2. As in much of the Pacific Northwest, the rock and overburden are saturated with water to within a few metres of the surface. Temperature gradients in shallow wells have to be interpreted subjectively and cautiously, since the effects of the hydrologic system on the thermal regime cannot be isolated in the early exploratory stages. Heat flow values are subject to large errors unless the circumstances are unusally well controlled.

3. The geophysical anomalies considered important are generally at interpreted depths of 1000 m or more beneath the surface. Since the ground water column extends to the surface, the interpreted reservoirs are likely to exist at hydrostatic pressure of 100 atmospheres or more, which is inconsistent with a vapour-dominated system, as described and defined by White, Muffler, and Truesdell (1971). The commercial target is a water-dominated system.

4. The south or Meager Creek reservoir, as it is presently known, is a tabular body which occupies about 5 sq. km and dips gently to the north under the volcanic edifice. The leading hypothesis is that it consists of a slow discharge plume from a presumably permeable feeder pipe for the southermost volcanics, as noted by Nevin Sadlier-Brown Goodbrand Ltd. (1975), and Lewis and Souther (1978).

5. The north or Pebble Creek reservoir (see map) is a conduit of unknown configuration subjacent to the Pebble Creek hot spring and has been extended about 8 km along the Lillooet River by various geophysical means: dipole-dipole resistivity surveys using X spacings of 300 m to n = 4; self-potential traverses; and deep pole-pole resistivity surveys. The shallow anomalies (1000 m or less) are not yet controlled by shallow drilling and their thermal nature has not been confirmed. The geophysical environment is subject to considerable "noise" from conductive river gravels, deposits of glacial outwash clays, and minor disseminated pyrite. The deep pole-pole anomaly defines a geologically valid resistivity low, but may derive in part from a septum of pyritic and graphitic(?) phyllite. While the thermal nature of the geophysical extension to the northern reservoir is not yet confirmed, we do have some insight into structural and thermal controls: A strong system of regional faults parallels the Lillooet valley and probably slices through many of the overburden-covered rock units in the valley floor. The latest eruptions (Read, this volume) came from the vicinity of the northern part of this reservoir less than 2500 years B.P.

Current Program. The exploration effort is putting considerable weight on the multiple pole-pole resistivity method. Development of the method evolved (Shore, this volume) from the desire for a deeper ratio of penetration versus electrode spread under conditions of extreme topography and forest cover. The speed of data acquisition and the information on anisotropic resistivity properties are important added benefits.

Deep drilling is currently in the preliminary planning stages. We can anticipate that much of the exploratory drilling will be conducted in quartz diorite. We can also expect a low rate of penetration from conventional oil field or geothermal drilling tools. The owner would sustain high footage costs and would assume all risks for delays and unexpected events. The present oil and gas boom in the Canadian prairies, and the remoteness of Meager Creek from such fields, would lead to problems in obtaining a rig for this unorthodox job. However, a large diamond drill, generally used for metal exploration and geotechnical work, would be ideally suited for geothermal drilling at Meager Creek if properly equipped with a reinforced tower, special draw works, and the appropriate blowout preventor or rotating head. It would have a high and predictable penetration rate, a lower footage cost, and much lower risk factors, some of which would be assumed by the contractor. Thus the slim hole is under serious consideration for the first several 2000 m exploratory wells.

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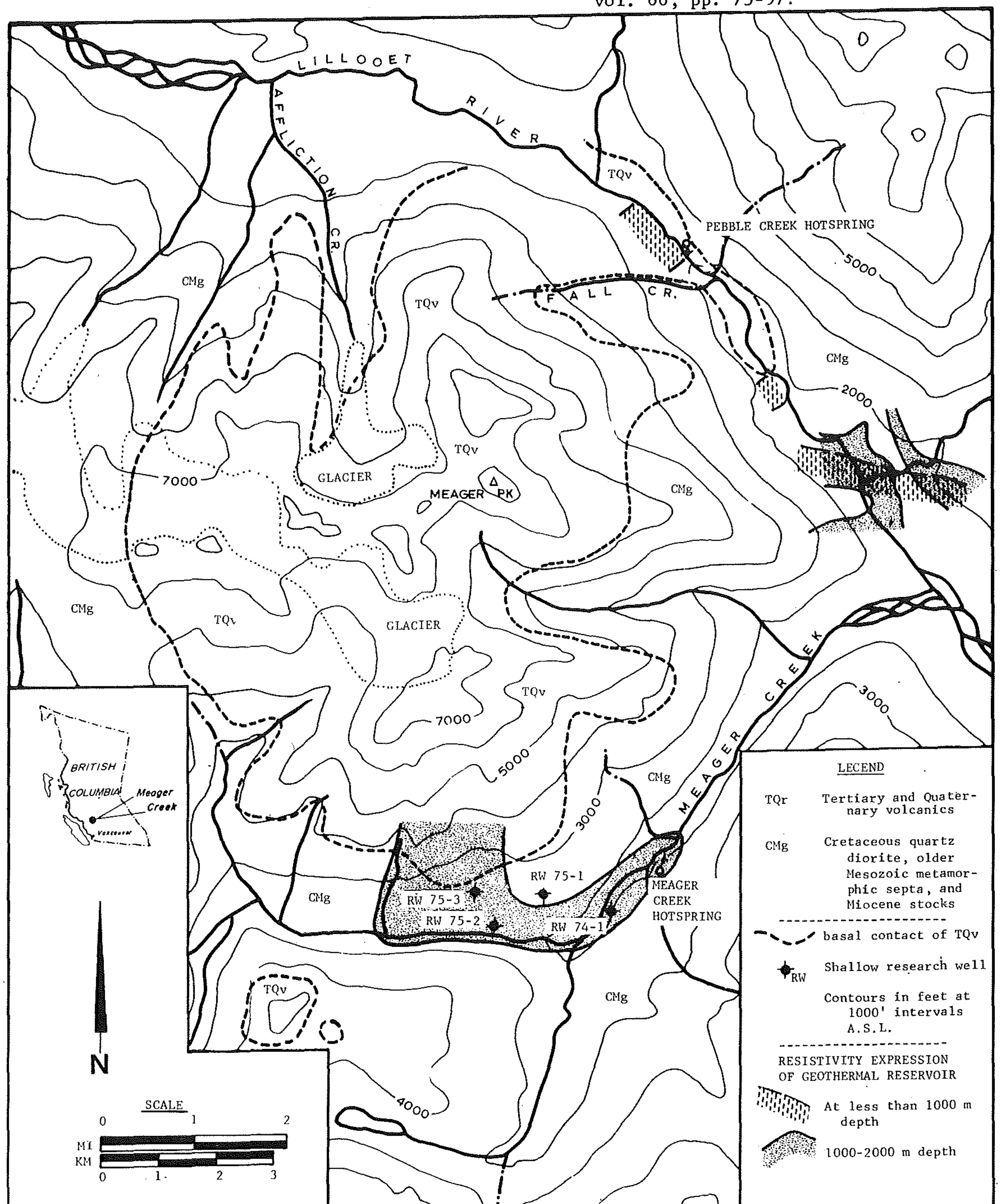

GENERAL MAP OF MEAGER CREEK GEOTHERMAL AREA, B.C.