Geothermal Energy

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COORDINATION OF GEOTHERMAL RESEARCH
International Contacts

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During the period 27 June to 7 August 1980 the Coordinator attended a meeting of the NATO-CCMS project in Paris and visited institutions in France and the United Kingdom. All visits were short, approximately one half day each, for the purpose of exchanging information on current projects and objectives.

Camborne School of Mines

The Camborne School of Mines is an old and well-known technical college, giving courses in all aspects of 'hard-rock' mining. It moved to its present location, half way between Camborne and Redruth, about 1975, and it now gives courses up to bachelor's degree level. The western tip of Cornwall has been mined for tin since the days of the Phoenicians, and abandoned and unmarked shafts are a recurring hazard. The relics of many worked-out nineteenth century mines can be seen, and some mines are still in operation. The tin is found in the Cornwall granites, which outcrop in several places in the peninsula, including Land's End itself. The School of Mines is located on the edge of the Carnmenellis outcrop.

The main contact was with Dr. Peter Hackett, Principal of the College, A. Batchelor, in charge of the geothermal project, unfortunately had to be in London on the appointed day.

The Cornwall granites were intruded very rapidly in late Devonian to early Permian time. They show no evidence of multiple stage intrusion. Background radioactivity is high and uranium contents as high as 400 ppm have been measured. The average of 11 heat flow measurements in Cornwall is 128 mW/m^2, about double the world average, and the associated heat production data have an average of 7.4 $\mu W/m^3$. Temperature gradients are in the range 27-47 mK/m. On the basis of the 'stable continental' geothermal

province, as represented by the eastern United States, the heat flow related to this heat production should be about 90 mW/m^2. However, the extent to which the eastern United States can be considered as the world norm has yet to be established. When British data of heat flow(Q) and heat generation(A) are plotted, results from the granites of Cornwall and Durham force a linear relation of very high slope:

$$Q = 23.4 + 16.0A$$

(Richardson and Oxburgh, 1978). These results are encouraging in the search for hot dry rock, and they indicate the need for similar measurements in the granites of the Canadian Maritime Provinces.

The geothermal energy programme at Camborne began in 1976 and is aimed at investigating the hot dry rock potential of the Cornwall Granites, particularly the Carnmenellis. The first set of holes was drilled to a depth of 50m to test fracture connections between adjacent holes. The holes were also used by a team of engineers working for the British nuclear waste disposal programme, who did heating experiments. This not only spoiled the holes for the geothermal programme, but it stirred up such local hostility that the School of Mines was forced to dissociate itself from the experiments and to abandon the site.

A second site was chosen and four new holes were drilled to 300m. Three of them have been fractured by explosive techniques and connections have been established. It has been found possible to pump down water at 10°C and to recover it from a neighbouring well at 22°C for an energy gain of about 10 kW. The undisturbed rock seems to be very impermeable, and water losses in all tests have been very small. Close contacts have been

maintained with the Los Alamos geothermal team, and working visits have been made in both directions.

A three-year programme of drilling to 1500m at the same site is now planned. Funding is expected to be £7 million, with the source being 85% United Kingdom Government, 15% European Economic Community. Drilling will begin in April 1981 and four holes are planned with borehole geophysics and hydrofracturing to follow. In response to my question about a small college (teaching staff 22) being involved with a large programme of this sort, Dr. Hackett admitted that he was apprehensive that it could prove to be something of a cuckoo in the nest.

NATO - CCMS Geothermal Meeting

The NATO - CCMS Geothermal Project held a 'follow-up' meeting at the offices of the French Foreign Ministry in Paris on 15 July 1980. The meeting was arranged by the United States, the project leaders, in association with France. Only 18 people attended any part of the meeting, and the countries represented were United States (5), France (4), Canada (1), New Zealand (1), West Germany (1), Italy (2), Iceland (1), Austria (1), Sweden (1), and Mexico (1). The chairman was Dr. Paul Witherspoon of Lawrence Berkeley Laboratories, acting for Dr. James Bresee, who, after leading the Project for six years and making all the preparations for this meeting, was prevented from attending by financial constraints.

The agenda is attached as an appendix to this report. All speakers were asked to submit a written version of their presentation, and these will be compiled into a published proceedings.

The highlight of the meeting was the presentation by Frank Studt of New Zealand. He described how the attitude to reinjection of geothermal fluid has changed completely in New Zealand from strong opposition to willing acceptance, some of the reasons being:

- Wairakei now discharges directly to the Waikato River, and although environmental effects are not severe this could not reasonably be increased;
- there is now a 'Waikato River Authority' to rule on such disposal;
- Wairakei draw-down has propagated 8 km to Taupo;
- subsidence of Wairakei has reached 5m in places, which is not important there but would be at Broadlands, where the river would flood if similar subsidence were to occur;
- a steam cap has developed in the Wairakei reservoir, and this is difficult to dissipate.

He advocated reinjection at a temperature of at least 150°C in order to maintain reservoir pressure and to prevent silica deposition. Reinjection wells should be on the margin of the reservoir. Wells have been known to return to a production capability after being used for reinjection. (These comments, of course, apply to hot water reservoirs only, i.e. fluid dominated reservoirs above 200°C).

Eric Willis of the United States, described the Helical Screw Expander, a type of turbine that accepts a two-phase fluid. Tests so far indicate an efficiency of 39-40% in goethermal application, and field tests are to be run in Italy, Mexico and New Zealand.

Most of the other papers were reports of progress on current projects or national programme reviews. Jacques Halfon of France described EEC

cooperative projects in Germany and expressed doubts of the need for the work on the Carnmenellis Granites in the United Kingdom. These remarks were clearly politically motivated.

The chairman asked the meeting for comments on the usefulness of such meetings and on the need for further meetings. I replied that the early meetings had proved extremely useful to me as a means of learning at first hand what was being done in different countries and different geological settings. It was generally agreed that such meetings were useful and should perhaps be held at intervals of about two years. It was also agreed that the small size of the meeting greatly facilitated discussion, in marked contrast to the International Geological Congress, which was in progress in another part of Paris.

Visit to BRGM

On 16 July I visited the offices of the Bureau de Recherches Géologiques et Minières (BRGM) at Orléans, at a distance from Paris of about one hour by train. I spoke to A. Clot, deputy head of the geothermal department, A. Gérard, chief of the division of research and exploration, and M. Coudert, a geophysicist.

BRGM is a government-affiliated organisation, but its income is derived from contracted research. The most comparable Canadian organisation that I can think of is the Nova Scotia Research Foundation. BRGM has actively promoted geothermal energy research in sedimentary areas of France, including the Paris Basin, the Aquitaine Basin, the Limagne Basin and the Rhinegraben. The clients may bemunicipalities, looking for sources of heat for large apartment buildings, or industrial agencies, looking for heat for greenhouses or other purposes.

The experience of BRGM has been similar to ours in some respects, but they are far ahead of us and we could learn a great deal from them:

- The project path of using existing data, building up to geological feasibility studies and test drilling, is normally similar to our path at Regina;
- In early projects initial estimates of water temperature were too high, again similar to our Regina experience;
- Their production wells are often finished with a gel insulation around the casing, using cement only where necessary for mechanical strength or formation separation;
- a 7" casing is often cut some distance below the surface to allow the installation of a pump in the 9 5/8" casing, thus increasing the pumping capability. This was discussed at Regina at one time, but it was rejected as unnecessary for the heat load of the sports building.

M. Coudert may visit Canada in October, and it may be possible to arrange a meeting with L. Vigrass (Univ. of Regina) and the author.

Visit to University of Oxford

On 7 August I visited the Dept. of Geology and Mineralogy at the University of Oxford, where most of the recent work on regional geothermal patterns in the United Kingdom has been done. The leader of this work, R. Oxburgh, had moved to Cambridge some two years previously, but I was not able to arrange a visit to him. Unfortunately the visit to Oxford turned out to be rather disappointing. I was received by M. Worthington, a seismologist, who explained that S. Richardson, the remaining staff member

involved in geothermics, was absent since he is now employed 80% of the time by British Petroleum, working on the maturation of hydrocarbons. With the work done here over the last two years by Jacek Majorowicz, this strengthens our opinion that much remains to be done in linking geothermics with studies of maturation of hydrocarbons.

I was able to see the divided bar assembly and to discuss various technical aspects of it with a graduate student who was using it. It seems probable that geothermal work at Oxford will decline rapidly. I do not know if this work will be picked up at Cambridge, but there will be an opportunity for some British university to establish a good continuing geothermal programme.

Reference

S.W. Richardson and E.R. Oxburgh. Heat flow, radiogenic heat production and crustal temperatures in England and Wales. Jl. Geol. Soc. Lond., 135, 323-337, 1978.

CCMS GEOTHERMAL CONFERENCE
French Foreign Ministry, Salle de Sous-sol, Tues., July 15, 1980
AGENDA
Paul Witherspoon, Chairman

9:00 - 9:20 a.m.	"Computerized International Geothermal Information Systems", Sid Phillips, Lawrence Berkeley Laboratory, Berkeley, California.
9:20 - 9:30	Discussion Period
9:30 - 10:30	"French Experience with Direct Use of Geothermal Energy", Jacques Halfon, Secretariat d'Etat a la Recherche, Paris.
	"Direct Use Geothermal Developments in Canada", Alan M. Jessop, Div. of Seismology & Geothermal Studies, Ottawa, Canada.
	"Icelandic Experience with Direct Use of Geothermal Energy", Karl Ragnars, National Energy Authority, Reykjavik, Iceland.
10:30 - 10:40	Discussion Period
	BREAK
11:00 - 11:40	"Geothermal Fluid Injection Experience in New Zealand", Frank Studt, Kingston, Reynolds, Thom & Allardice Ltd., Auckland, New Zealand.
	"Reservoir Engineering Studies at Cerro Prieto", Paul Witherspoon, Lawrence Berkeley Laboratory, Berkeley, California.
11:40 - noon	Discussion Period
	LUNCH
2:00 - 2:40 p.m.	"International Testing of Helical Screw Power Plants", Cliff McFarland, Department of Energy, Washington, D.C. Eric Willis
	"Turkish Experience with the Geothermal Power Plant", Orhan Mertoglu, Mineral Research & Exploration Institute of Turkey, Ankara, Turkey.
2:40 - 2:50	Discussion Period
	BREAK
3:10 - 3:50	"Hot Dry Rock Research in Europe", Oskar Kappelmeyer, Geological Survey of Germany, Hanover, West Germany.
	"Status of Hot Dry Rock Research in the U.S.", Fraser Goff, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.
3:50 - 4:00	Discussion Period