A PROGRAMMATIC VIEW OF GEOTHERMAL RESERVOIR ENGINEERING

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I will make my remarks brief in the interest of getting on with the scientific subject of this workshop, which I like to regard as the science of geothermal reservoirs. To be more specific, we are not concerned here with the science or technology of how to find and how to assess the energy potential of these reservoirs (albeit impossible to make a clean separation between the related technologies); but rather our purpose is to focus on the behavior of reservoirs under the stimulus of production and commercial extraction of heat.

At NSF we feel this is a highly opportune moment to convene such a group as this. Many research and development efforts are now underway in this area, and many have reached that point where significant results have been achieved and where new data and new questions are being generated at a rapid pace. (In a moment I will review the recent history of how many of these efforts were initiated through the NSF Geothermal Program.)

Therefore, NSF is pleased to support Stanford University in sponsoring this workshop, and in behalf of the Foundation I want to welcome you here. We have attempted to gather those who are currently active in geothermal reservoir engineering research and who are in the forefront of new knowledge and experience of this rapidly expanding field.

In this objective, I think Dr. Paul Kruger and his colleagues at Stanford have succeeded admirably. The response to workshop invitations, I understand, has been enthusiastic and almost 100% in acceptances. Some request!; to attend had to be discouraged, not because the people are not smart enough and not because they lack a legitimate interest in the subject area and findings of the workshop. Rather, attendance had to be constrained to a manageable size so as *to* enable fruitful and spontaneous exchange of ideas among the active researchers in the field.

Because there is a wide community of interest in these matters:, I have asked Stanford to prepare a report summarizing the papers, discussions and findings of these three days. They have agreed to do this, and the report will be made available to all who are interested. Furthermore, I fully expect to see numerous conferences and symposia in the coming year devoted to this and other areas of geothermal science. These meetings, at which many of you will present papers, will provide ample opportunity for the diffusion of new and current knowledge to the whole community of technical and commercial interest.

I want to extend a special welcome to the workshop participants who have come here from other countries. You are not only welcome in our country to participate in this workshop, but we look with anticipation to

strengthen personal and professional relationships with you that will be of mutual benefit in our research efforts in the future.

Now, it may interest you to know how some of the U. S. efforts were started. The first project to be initiated by NSF was right here at Stanford. Paul Kruger in Stanford's Civil Engineering Department had some ideas about tapping steam out of a rubble chimney created by an underground explosion in hot rock, and he wanted to explore the thermal and mass transfer processes to be expected in such a situation and to find ways to extract the heat. Henry Ramey, over in the Petroleum Engineering Department, wanted answers to questions of fundamental behavior of hot water and steam that had arisen in his consulting practice at The Geysers and out of his extensive experience in hot water flooding and other thermal stimulation methods in oil reservoirs. This project was started in July 1972.

Take a look at Figure 1, and see how the funding has progressed at NSF in this important area. Our funding in reservoir engineering research has peaked in FY 1975 as in every area of the NSF Geothermal Program, It is interesting to note in retrospect, that 20% of the $13.4 million total investment in geothermal energy by NSF over a five-year period has been devoted to reservoir engineering. The investment grew at a somewhat lesser rate in the early period than did the program as a whole, but following the formation of ERDA in FY 1975, It has become a larger fraction of the whole. This increased relative emphasis derives from our policy to focus, not on the engineering applications, not on the utilization technology and the pilot plants and the demonstration plants, and not on the institutional and non-technical barriers to utilization, but rather on the fundamental science problems inhibiting the fullest development of the resource, Clearly, problems concerning reservoir phenomena comprise a significant part of this concern for new fundamental knowledge, and the NSF program is moving in that direction.

Finally, for a word on our currently active projects, each of which will be reported at this workshop, please look at figure 2. Here I have listed the grantee institutions, the research area of each project, the principal investigator, and the cumulative funding through FY 1975. The status of the research represented on this list will unfold in the three days ahead of us.

It is going to be a very stimulating three days, as not only the NSF research is described but also that of the U. S. Geological Survey, in the ERDA laboratories, in the field and in laboratories of private U. S. companies, and in foreign countries with active geothermal programs and who are represented here today.

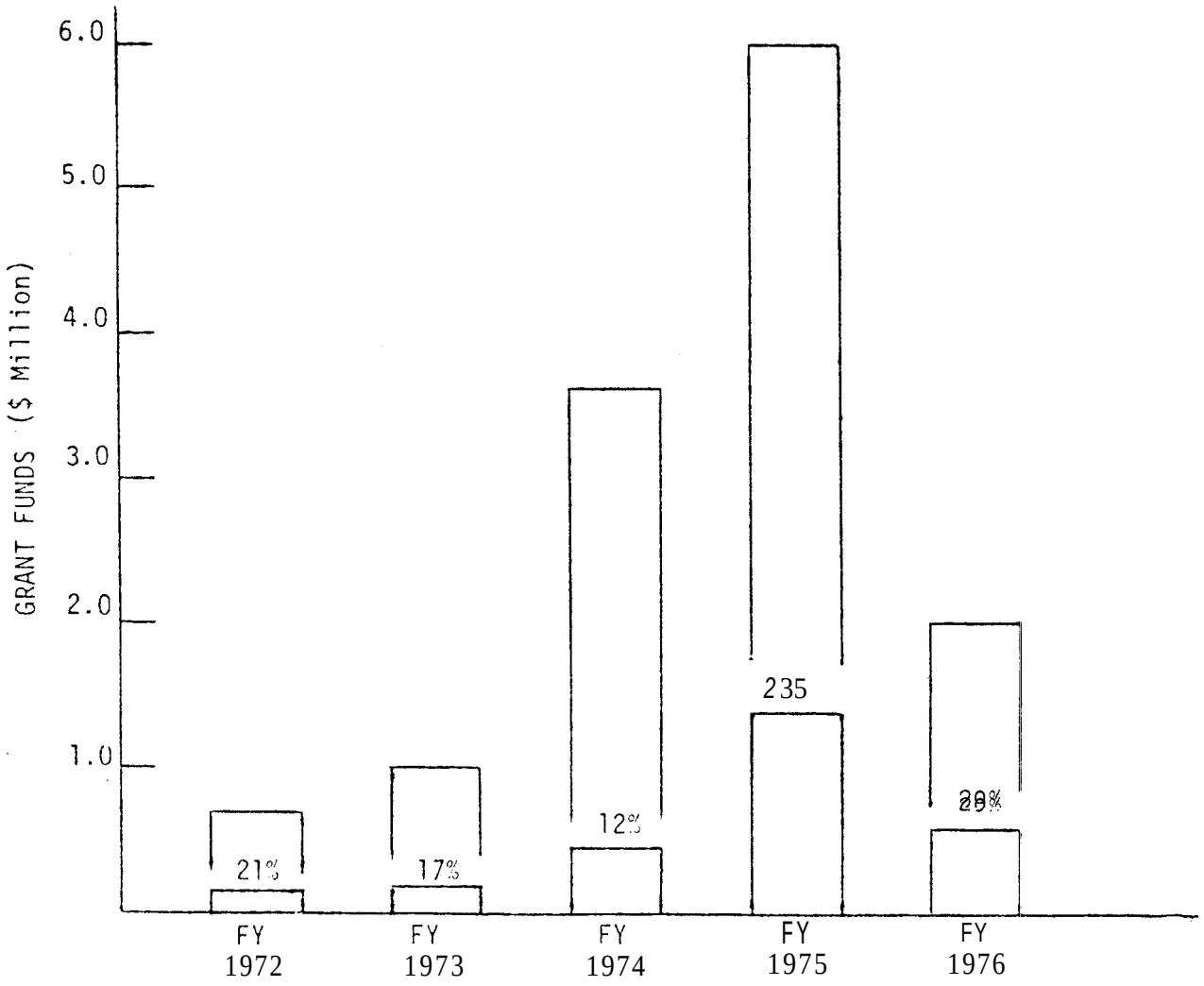

Figure 1. Reservoir Engineering Support in the Geothermal Energy Program of The National Science Foundation.

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GEOTHERMAL ENERGY PROGRAM
RESERVOIR ENGINEERING PROJECTS

Institution	Research	Principal Investigator(s)	Funding thru FY75
Stanford U.	laboratory experiments in heat and mass transfer	Henry Ramey, Jr. Paul Kruger	$ 586,700
Penn State U.	laboratory experiments in reservoir chemistry	Hugh Barnes, Wayne Burnham	402,000
Princeton U.	numerical modeling of Wairakei field by finite element method	George Pinder	249,500
Colorado U.	numerical modeling problems by finite difference methods	David Kassoy	248,300
Systems Science	numerical modeling of Salton Sea field by finite difference methods	John Pritchett	378,000
U. of Hawaii*	numerical modeling of coastal aquifer problem	Ping Cheng	61,100
Northwestern U.	rock mechanics problems in stimulation of geothermal reservoirs	Hans Weertman	213,900

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Transferred to ERDA under Hawaii Geothermal Project

Figure 2