GEOTHERMAL WELL DRILLING AT PRODUCTIVE ZONES IN THE KIRISIMA GEOTHERMAL FIELDS

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ABSTRACT

The Ginyu fault, which is the major reservoir in the Kirishima geothermal area, is characterized by a wide of fracture zone and several small fractures.
In a geological viewpoint, the Ginyu fault has a echelon arrangement with a width of about 100-200m. So, we need to penetrate through this fault zone. Lost circulation occurs during drilling wells at the zone.
We met various problems in drilling through this fault zone, but judging from our experience, it has been solved. We drill through this zone speedy as possible, consequently we use fresh water and try to use hot water from discharging wells for drilling fluid. A drilling course crosses the fault plane at right angles because the driiling course is the shortest length.

INTRODUCTION

The Kirishima geothermal area is located on the south western slope of the Kirishima volcano in the northern part of Kagoshima prefecture, in Kyushu. The Kirishima volcano stretches over the border of Kagoshima and Miyazaki pref. There are twenty five volcanos, such as Mt. Karakunidake, Takachiho, Shinmoedake, etc, and there are many hot springs. Kirishima volcanos belong to Kirishima-Yaku national park.
Exploration of the Kirishima geothermal area was commenced in 1971. 21 exploratory wells, 8 small diameter and 13 large diameter wells, have been drilled. The 9 wells, within the 13 large diameter wells, were drilled as dischargeing welles.
Altogether long term discharge and injection tests had been carried out until 1987 for the feasiblity of the development in the Ginyu area.

DRILLING OF THE GINYU FAULT

The Ginyu fault is one of the active geothermal zones in the Kirishima geothermal area. At first, well KE1-2 with small diameter was drilled in the Ginyu area in 1981. The shape of the Ginyu fault has been known and we discovered the reservoir at the Ginyu fault. Following the results of well KE1-2, wells KE1-7, 17, 19 and 22 with a large diameter were drilled to the north of well KE1-2 to intercept the Ginyu fault at deeper part.
When all wells penetrated through the Ginyu fault, it was found the drilling break bit load decreased sharply. The width of conspicuous changes were 7.4 m in well of KE1-7, 2.3 m in KE1-17, and 6.0 m in KE1-22. From the result of the drilling and the geophysical logging, these zones were decided as a geothermal reservoir.

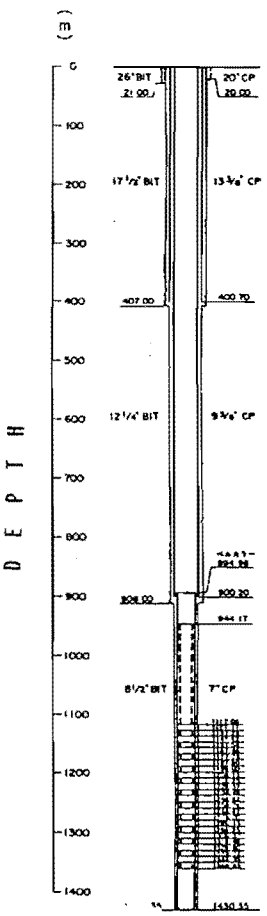

Fig 1 Casing program

CASING PROGRAM

The casing program is shown in the following. (KE1-17)

Hole Size (inch)	Depth (ft)	Depth (m)	Casing Size (inch)
26	691	21	20
17½	1,339	408	13 3/8
12¼	2,972	906	9 5/8
8½	4,928	1,502	7
			7″Liner (632m)
about 300 m length of 7″ casing was sloted; 6% open ratio.			

FEATURES OF THE GINYU FAULT

The Ginyu fault is characterized by the following features.

1) fault system is echelon arrangement.
2) has a width of about 100-200 m.
3) hard to cave at the wall of bore hole.
4) many complete losses of circulation occurs. And plugging materials have no effect.

DRILLING AT COMPLETE LOST CIRCULATION

The exploratory wells with small diameter were drilled with diamond bits and spindle type drilling equipment before 1982.
The wells can be drilled with complete loss of circulation at the coring, we can drill the reservoir zone without any trouble, because cuttings are grinding and exceeding small. However when loss of circulation occurs on drilling with large diameter and if the cuttings are not lifted to the ground and do not enter fissures of the lost zone, we have to give up drilling halfway because of stuck pipe.
In other words, it is necessary to lift the cuttings to the ground or to enter the cuttings at fault fissures. This is the problem how to drill deeply and safty when we encounter lost circulation at production-liner hole.
In the Ginyu fault, it is difficult to lift formation cuttings to the surface, but the cuttings are able to enter the foult-fissure with drilling fluid. In this case, we suggest that it is no problem for skin damage. Because when we have a initiating discharge,a part of the cuttings are removed with flow and otheres run away in the fissure.

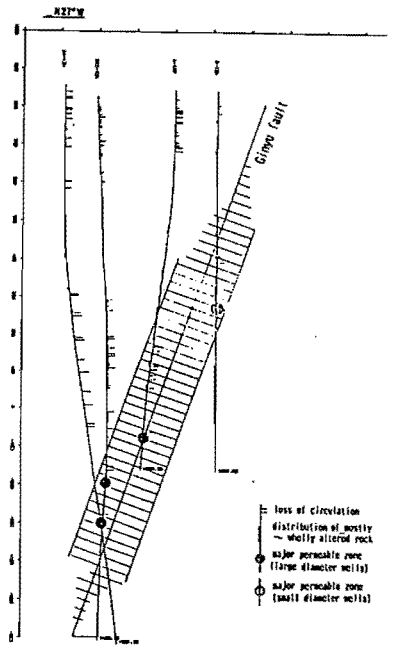

Fig 2 The intercepted points of wells at the Ginyu fault.

DRILLING PRODUCTION-LINER HOLE

Nine discharging wells were drilled until the present time. We drilled from conductor to intermediate hole with mud drilling technique and the production-liner hole with mud fluid drilling and aerated fluid drilling technique.
In the case of encountering the lost circulation zone during drilling the production-liner hole, we used the following method at the Ginyu area.

① Drilling with fresh water. ～ KE1-7
② Drilling with mud fluid. ～ KE1-17
③ Drilling with fresh water and hot water from the discharging well. ～ KE1-22

DRILLING WITH FRESH WATER

The discharging well KE1-7 was drilled with rotary drilling method for the first time in the Kirishima geothermal field. When we drilled the lost circulation zone,we only inperfectly grasped a size of the fissure. So we drilled with fresh water to prevent a bad effect of mud and cuttings from entering the geothermal reservoir.However the water supply was not enough in compared with pumping rate. And we might wait for long time to store water in a pond.

We suggested that if we use fresh water for drilling fluid, the mud filter cake would not be made to prevent the wall of the bore hole from caving.
For the reasons mentioned above, we decided to stop drilling well KE1-7 to the 95.9 m deeper from the lost circulation zone to prevent drill pipes from being stuck.

DRILLING WITH MUD FLUID

As a result of the Ginyu area, the shape of the Ginyu fault has been revealed, we understood that the thickness of the Ginyu fault was important. So we intended to drill through the Ginyu fault. For that purpose, drilling with only fresh water was not able to prevent the wall of the bore hole from caving. So it was neceesary that we used mud fluid to make mud cake on the wall. And we used blind drilling technique with mud fluid in KE1-17 well production-liner hole. We could not avoid the damage from the mud entering the fault-fissure, but we suggested that if the mud entered the fault, the mud would discharge with the geothermal fluid .
For the reasons mentioned above, we continued using mud drilling technique. As the result, well KE1-17 was drilled for 343 m by blind drilling.

DRILLING WITH FRESH WATER AND HOT WATER FROM THE DISCHARGING WELL

From the experience of drilling exploratory wells, the Ginyu fault has been made up of one big fissure and several small fissures.
To drill through the fracture zone of the Ginyu fault, we intercepted the bleeding point of the production-liner hole of the discharging well with mud fluid without lifting cuttings out to the ground. But we had to pay a great deal of money for the mud material. Therefore we tried to drill with hot water fluid. Hot water drilling technique has following merits and demerits.

MERITS
1. Less drilling cost than other drilling techniques.
2. Not necessary to spend a lot of time for storing water.
3. Don't have a bad effect on the geothermal reservoir by drilling fluid.

DEMERITS
1. Can not avoid a collapse.
2. Necessary to cool hot water before pumping.
3. Slip velocity increases in lifting the cuttings.

We sent hot water to the drilling job site from the discharging well KE1-17 through the 10 inches pipes. In the drilling site, we mixed hot water with fresh water at the time of bit changing and D.P. making connection, we send the mud fluid into the hole for lifting the cuttings to loss of circulation zone.
As the result, well KE1-22 was drilled for 439 m by blind drilling.

CONCLUSION

We repeated trial and error in drilling in the Kirishima geothermal area. A problem in penetrating the geothermal reservoir is how to drill through a lost circulation zone.
We can drill with the mud fluid drilling technique in the Ginyu area. If we encounter lost returns, we make plugs with L.C.M. and we drill securing to lift cuttings to the ground. If we can not prevent lost returns, we have to drill through the production-liner hole with blind drilling with hot water and fresh water continuously and speedy.
The Ginyu fault zone is 100-200m width. So we would drill enough more than 300m to penetrate the fault zone within several days.

ACKNOWLEDGEMENTS

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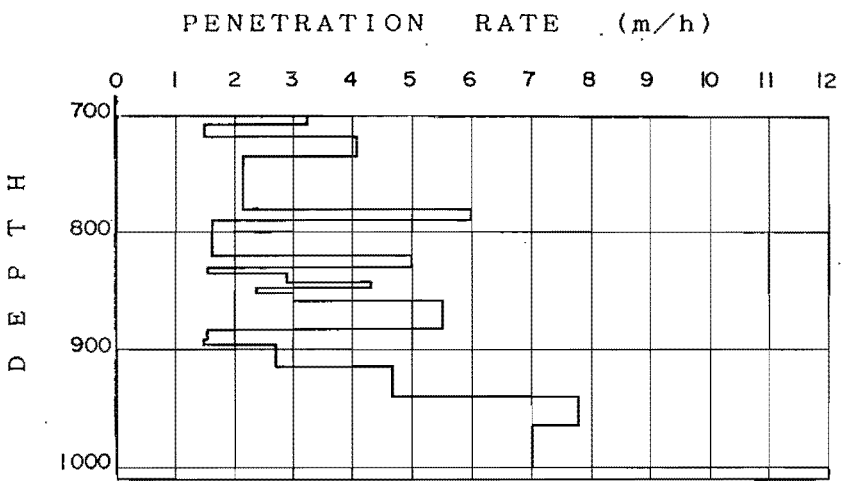
KE1－7



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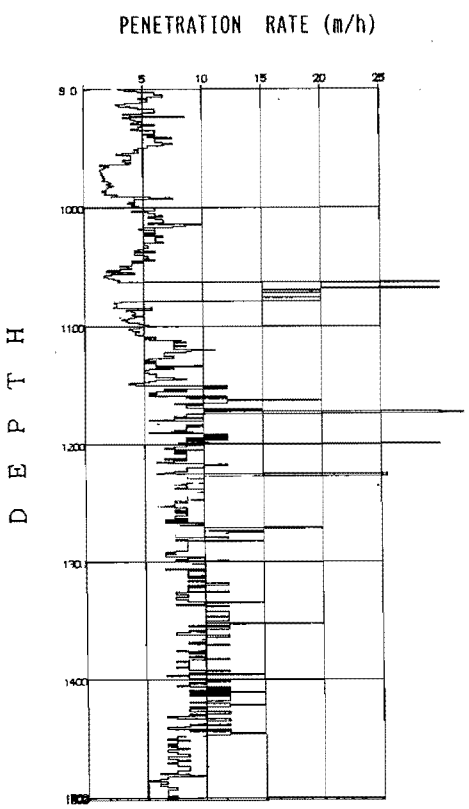

KE1－22

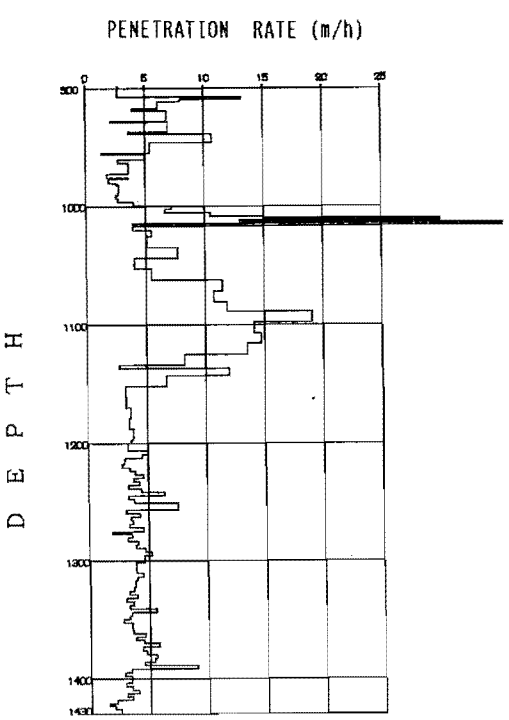

Fig 3 Penetration rate