GEOTHERMAL DEVELOPMENT AT LIHIR ISLAND, PAPUA NEW GUINEA

P. F. BIXLEY

Lihir Gold Limited, PO Box 789 Port Moresby, Papua New Guinea

SUMMARY – Geothermal power development at Lihir Island in PNG has posed some unusual challenges. These arise from the geothermal resource, the mining environment and from the isolated location. The mining and geothermal infrastructure are both confined within the Luise caldera, a gravity collapse structure on the northeastern coast of Lihir Island. The original purpose of geothermal wells was to assist the mining operations by depressurising and cooling parts of the geothermal resource ahead of mining operations. The potential to harness at least some of the local geothermal energy has always been recognised and when the first deep production wells had been drilled and tested, a feasibility study was made to examine the technical feasibility of small sale geothermal power generation. A 6MW backpressure plant was approved in June 2002 and commissioned in May 2003. As drilling and testing new wells proceeded the geothermal potential was revised and a further 30MW geothermal generation project was approved in June 2003 for commissioning early in 2005.

1. INTRODUCTION

Lihir Island is located about 700km NE of the national capital, Port Moresby, and forms part of the New Ireland Province of Papua New Guinea (Figure 1)

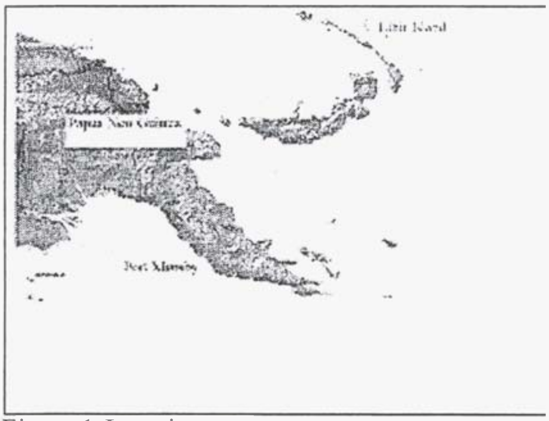

Figure 1: Location map

The geothermal resource at Lihir is located within the Luise Caldera, a gravity collapse structure on the east coast of Lihir Island (Figure 2). The caldera measures approximately 5 x 3 kilometres with the Luise Harbour on its northeastern side. The caldera rim rises to about 600 metres above sea level with the central area of the collapse structure where the mineralisation is located up to 100 metres above sea level. Most of this flatter area is required for development of the mine pit or to stockpile lowgrade ore for later processing. The geothermal resource is generally offset to the north and west from the present mine pit.

Most of the remaining area is around the caldera walls is fairly rugged, unstable and difficult to develop suitable drilling sites. The rig used to complete the first 27 geothermal wells required a minimum footprint of 40x80 metres. The first eight wells were drilled from two adjacent pads located at the southwestern margin of the mine pit. The later wells were all drilled from single-well pads within and around the pit area and on the lowgrade stockpiles. As the mine has developed, the amount of space remaining to locate these large rig pads has become more limited. At the present time the large geothermal rig has been demobilised and a new rig specification for geothermal drilling is being developed. One of the important requirements will be for minimal footprint with flexible rig layout which can be adapted to work within the limited space that is available.

To date 27 geothermal wells have been drilled. Of these 10 are deep deviated wells with drilled depths up to 1800m and vertical depths around 1000 metres (Bixley et al, 2001) and the remainder are medium depth – 400 to 800m – vertical wells. In addition to the geothermal wells, 26 wide diameter dewatering wells (20 inch "production" casing with 13-3/8 perforated liner) have been drilled to depths of 300-450 metres.

To allow mining to proceed near the in-pit depressurisation wells, the wells must be plugged from time-to-time and the casing cut down as the benches are developed. For these wells the casing is plugged with a temporary drillable packer and cement grout, then the wellhead is removed. When the mining reaches the final pit shell at the well location, the wellhead can be reinstalled, the plug removed and the well re-opened for production. These workovers are completed using a modified diamond coring rig.

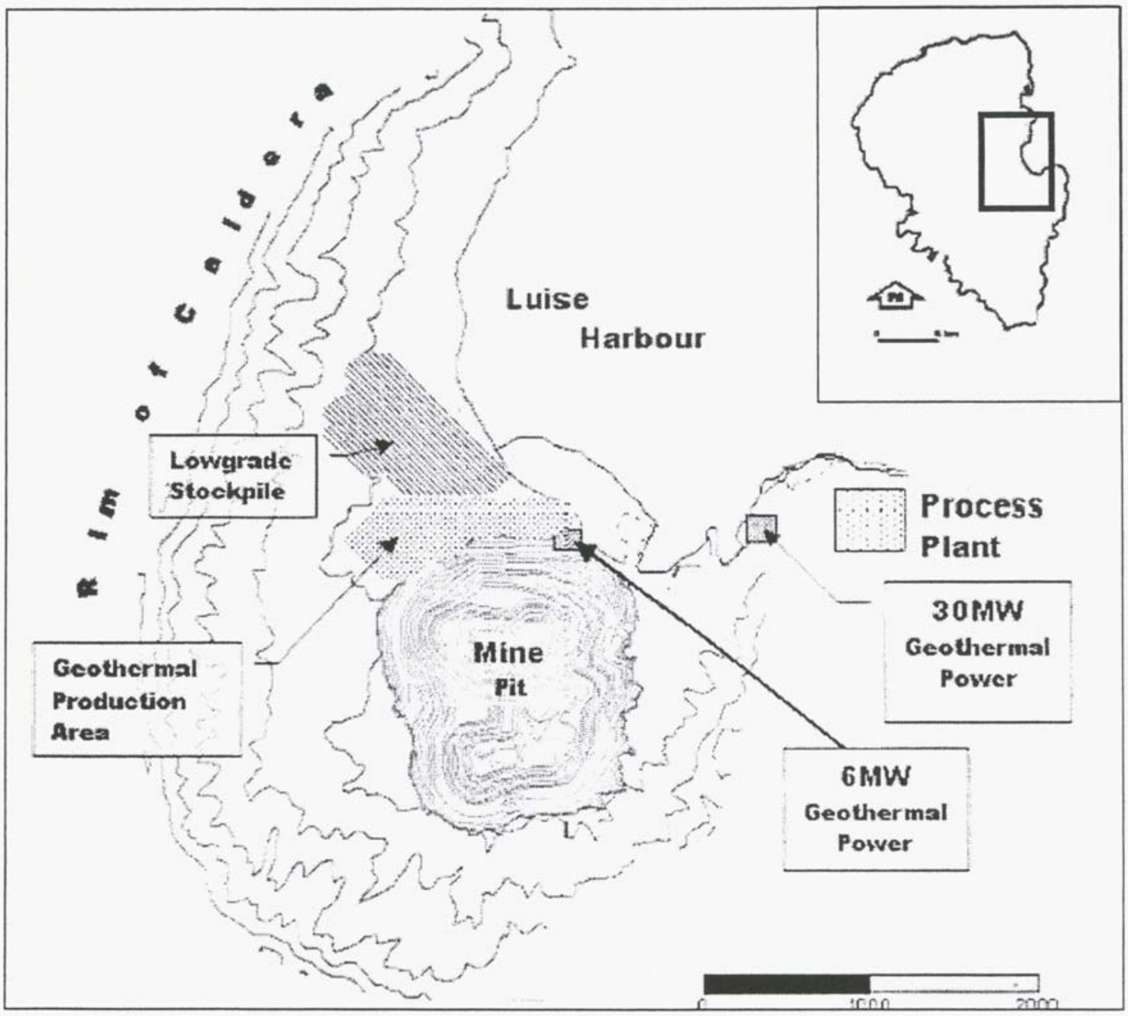

Figure 2: Lihir mine and geothermal development areas. Contours are at 100 metres intervals with the caldera rim 5-600m above sea level. Inset Lihir Island showing project area.

The wells selected for power generation were originally located and drilled as depressurisation wells and are outside the current pit area. These will be connected with standard two-phase pipeline to separating stations outside the ultimate pit. However in the longer term (5-10 years) some of the production wells and pipelines will need to be relocated as the pit expands. This will be achieved either by temporary abandonment as above or by drilling new wells to the production target zones from outside the pit boundary.

2. POWER SYSTEM

The local electrical power system also has some peculiar characteristics not found in other geothermal power developments. Lihir is an island and not connected to a larger power grid system. The generated power is solely used for the process plant and mine, plus associated infrastructure – camps, offices, housing and local villages. Of the total 55MW load, about 30MW derives from the oxygen plant with some other large individual uses such as ball mills and mine dewatering. Less than 5% of the total load is used offsite. The present generation plant comprises 11 6MW heavy fuel oil generators, plus the 6 MW backpressure geothermal unit.

3. GEOTHERMAL RESOURCE

The first eight wells were deep deviated wells, with drift angles about 60” from vertical, reaching around 1000 metres below sea level. The deep resource fluid at this depth has composition similar to seawater with up to 100,000 g/l TDS. The successful deep producers tap liquid conditions at about 250°C at vertical depths about 1000 metres. Maximum temperatures of more than 300°C have been measured at 1000 metres depth in the deep wells drilled toward the western margin of the “caldera”.

On production, wells producing this fluid suffer rapid buildup from calcite scale and become totally choked in as little as three weeks. Trials with downhole injection of various scale inhibitors have now been carried out in four wells to determine which products are most effective with the Lihir fluid chemistry and the dose rates required to eliminate formation of scale in the wellbore. These trials have shown that with existing inhibitor formulations, injection rates of more than 10 times those used for scale control in typical New Zealand installations are required to eliminate scale formation at Lihir.

The deep well program was completed at the end of 1999 and was followed in 2000 through to 2003 with three further drilling campaigns to complete a series of medium depth depressurisation wells, plus additional dewatering wells. Nearly all of the depressurisation wells have been 4-800 metres deep and vertical. These wells have located a highly productive zone at depths of 5-600m below sea level. The productive wells have their feed zones in boiling conditions at about 240-250°C, with several wells having a potential to produce more than 10MWe equivalent. Production tests have demonstrated that these wells have a greatly reduced scaling potential compared with the deep liquid wells. This is to be expected as the production zone is at boiling point conditions with some steam-only feeds in the shallower zones. The combination of low scaling potential and high production rates favours these wells over the deep wells for power generation.

4. 6MW DEVELOPMENT

On completion of the deep drilling program a feasibility study for geothermal power generation showed that a small pilot backpressure plant using steam produced from the deep wells was a viable option, as long as wellbore scaling could be controlled. The continuing drilling and well testing results in the meantime showed that using mid-depth production fi-om wells drilled to the north of the pit would be a better option than the deep production as there would be reduced or no scale inhibitor required for the production wells. Approval to proceed with the 6MW station was given in June 2002. The Geothermal Development Assoociates generation package using refurbished naval turbines with new gearbox and electrical components was chosen ahead of more modem new plant as it had significant timing and cost advantages and the difference in efficiency is not an issue in this case. The plant was commissioned in May 2003 less than 12 months after approval. This plant now saves Lihir Gold about $200,000 per month in fuel oil costs.

5. 30MW DEVELOPMENT

Part of the 6MW strategy was to use the plant to prove to confirm the viability of using geothermal steam for power generation in the mining environment before looking at larger scale development. While the 6MW plant was still under construction a feasibility study for an additional 30MW was carried out. At this time the final geothermal depressurisation wells were being completed with an average potential of around 10MW each. In July 2003 approval was given to proceed with an additional 33MW geothermal development. This is due to be commissioned early in 2005.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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