ALUTO-LANGANO GEOTHERMAL FIELD, ETHIOPIAN RIFT VALLEY: PHYSICAL CHARACTERISTICS AND THE EFFECTS OF GAS ON WELL PERFORMANCE

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(Received June 1992; accepted for publication October 1992)

Abstract—This study, which focuses on the Aluto-Langano geothermal field, is part of the on-going investigations of the geothermal systems in the Ethiopian Rift Valley. Aluto-Langano is a water-dominated gas-rich geothermal field, with a maximum temperature close to 360°C, in the Lakes District region of the Ethiopian Rift Valley. The upflow zone for the system lies along a deep, young NNE trending fault and is characterized by bulging. As a result, the deep upflow zone loses some water as steam and produces a cooler saline shallow aquifer. The high partial pressure of carbon dioxide (about 30 bar in the reservoir) depresses the water table and restricts boiling to deeper levels. The main aquifer for the system is in the Tertiary ignimbrite, which lies below 1400 m. The capacity of the existing wells is close to 7 MW; the energy potential of the area is estimated to be between 3000 and 6000 MW, yr km⁻², or 10-20 MW, km⁻² for over 30 years.

INTRODUCTION

There is growing evidence that human life originated in this part of the globe, and, since geothermal phenomena are presumably also ancient, thermal waters in Ethiopia must have been used for balneological purposes for a very long time. However, the idea of investigating this country's geothermal resources for electric power development originated in the 1960s and investigations commenced in 1970 with a joint Ethiopian Government and United Nations venture. This survey proved the presence of high heat flow in the Rift as a whole and identified numerous geothermal areas.

Aluto-Langano is located about 200 km south of Addis Ababa in the Lakes District (Fig. 1). After preliminary scientific studies, exploratory drilling commenced in Aluto-Langano in 1981. To date, a total of eight wells have been drilled, of which five are productive. The chemical characteristics of the fluid and the alteration minerals of the drill cores are described elsewhere (Belaineh, 1983; Altaye, 1985; Kebede, 1985a, b; Teklemariam, 1985; Gebregziabher, 1986; Gizaw, 1989). The deep fluids in Aluto-Langano, like most nearby surface waters, are of the sodium bicarbonate type. Deep wells have encountered a layer of pyroclastic sediments, acid volcanics (lavas and breccias), lacustrine sediments, rhyolite lavas, bimodal lavas (basalt with minor rhyolite) and ash flow tuffs (welded and unwelded) (Fig. 2).

This study is a part of investigations carried out during 1987-1989 at the University of Leeds (Gizaw, 1989). Drilling information, temperature and pressure data were taken from geothermal Exploration Project data files. All measurements were performed after long term discharge (LA-1, LA-2 and LA-5 are non-productive wells) and are believed to represent stable well conditions. Whenever multiple values of measured temperature and pressure were reported, the latest values (closest to the date of chemical sampling) were used for quantitative
Fig. 1. Geological map of the Aluto-Langano geothermal field (Kornegay et al., 1985, as modified in Gebregziabher, 1986). (1) Alluvial deposits of central depression; (2) younger rhyodacitic dome; (3) pumice tephra; (4) intermediate rhyodacitic domes and tephra; (5) older rhyodacitic domes and tephra; (6) Awarshu ignimbrite; (7) rhyolite domes; (8) hyaloclastic cones; (9) halo Scyn ignimbrite; (10) collapsed pre-Aluto volcano; (11) trachyte and basalt; (12) recent lava flow; (13) faults; (14) craters; (15) inferred faults; (16) caldera rim; (17) springs; and (18) deep wells.

calculations. Kuster mechanical pressure and temperature gauges were used for well logging. Pressure measurements have an accuracy of about \( \pm 4 \) bar while temperature measurements are considered reliable to between \( \pm 5 \) and \( \pm 10^\circ \)C accuracy (UN, 1987). CO\(_2\) and H\(_2\)S were determined in the steam condensates in the field by potential and iodometric titrations, respectively. The gas composition in the total discharge is calculated based on the concentration
of non-alkali-condensable gases (as determined by gas chromatography), the condensable gases and steam fraction. Partial pressures were calculated on the basis of Henry's law constants, using regression equations (Henley et al., 1984) and WATCH1 (Aarnosson et al., 1983).

An attempt was made to identify the feed zones and to correlate the chemically determined gas contents with the measured temperatures and pressures. The physical processes operating in the system were assessed and the gas effect described.

AQUIFERS AND THE GAS EFFECT IN THE ALUTO-LANGANO DEEP WELLS

The Lakes District waters are generally of the sodium bicarbonate type (UN, 1973; Gizaw, 1985, 1989). In contrast to the NaCl case, data are not available on the influence of NaHCO₃ on the boiling point/depth curve. Therefore, the effects of both salts on the boiling point/depth of water have been assumed to be similar. Since the geothermal fluids in the Aluto-Langano deep wells are relatively dilute (<0.2% by wt. of either NaCl or NaHCO₃), and since even 2% NaCl does not cause significant change in the boiling curves (see Fig. 8), boiling point/depth curves are drawn assuming hydrostatic pressure for pure water (Haas, 1971).

LA-1 and LA-2

LA-1 and LA-2 are non-productive deep wells with maximum temperatures of 86 and 116°C, respectively (Figs 1, 3). Neither well encountered permeable zones (Fig. 4). Only minor circulation loss zones were observed at shallow depths, which were cased-off afterwards (Table 1). Moreover, the bentonite mud that was used during drilling probably reduced the permeability further. As a result, fluid circulation in these wells is limited and drilling fluids (Lake
Fig. 3. Temperature and pressure profiles of LA-1 and LA-2. T16 (5-7-83), T16 (7-7-82), and P5 (14-16-82) runs were done after 252, 300, and 124 days of shut-in time, respectively. The P2 (15-11-82) run was done just before drilling was completed. Data from Geothermal Exploration Project data file. The boiling point/depth curve is drawn assuming hydrostatic pressure for pure water (Heins, 1971).

Table 1. Physical data of deep wells (Geothermal Exploration Project data file)

<table>
<thead>
<tr>
<th>Well LA-</th>
<th>Elev. (m)</th>
<th>Total depth (m)</th>
<th>Solid cased to (m)</th>
<th>Bblnd (m)</th>
<th>7&quot; Liner Slotted (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1611</td>
<td>1317</td>
<td>702</td>
<td>690–731</td>
<td>731–1317</td>
</tr>
<tr>
<td>2</td>
<td>1723</td>
<td>1602</td>
<td>892</td>
<td>981–901</td>
<td>901–1602</td>
</tr>
<tr>
<td>3</td>
<td>1921</td>
<td>2144</td>
<td>748</td>
<td>723–1030</td>
<td>1030–2140</td>
</tr>
<tr>
<td>4</td>
<td>1956</td>
<td>2062</td>
<td>774</td>
<td>725–746</td>
<td>746–2035</td>
</tr>
<tr>
<td>5</td>
<td>2038</td>
<td>1467</td>
<td>725</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1962</td>
<td>2201</td>
<td>754</td>
<td>724–1499</td>
<td>1499–2201</td>
</tr>
<tr>
<td>7</td>
<td>1891</td>
<td>2448</td>
<td>956</td>
<td>938–1788</td>
<td>1788–2449</td>
</tr>
<tr>
<td>8</td>
<td>1896</td>
<td>2500</td>
<td>721</td>
<td>667–1867</td>
<td>1867–2464</td>
</tr>
</tbody>
</table>
Fig. 4. Circulation loss during drilling: LA-1 to LA-8. lpm is liters per minute. Data from Geothermal Exploration Project data files.
Fig. 5. Temperature and pressure profiles of LA-3 and LA-6. T19 (4-11-88), T64B (30-12-87) and P19 (31-12-87) runs were done after 28, 169 and 27 days of shut-in time, respectively. P29 (10-11-83) run was done after 6 days of bleeding, while the wellhead pressure stabilized at 31 bar gauge. Data from Geothermal Exploration Project data file. The boiling point-depth curve is drawn assuming hydrostatic pressure of pure water (Haas, 1971).

Langano for LA-1 and Bulbula river for LA-2) are still found after 5 years of heat-up (Gizaw, 1989). The pressure profiles of these wells are close to cold-hydrostatic (Fig. 3).

LA-3 and LA-6

LA-3 and LA-6 are the hottest wells in the Aluto-Langano geothermal field (Fig. 1). The maximum measured temperatures are 340 and 363°C, respectively (Fig. 5). The Na/K, Mg/K, H₂SiO₄, H₂S, and H₂CO₃ geothermometers in particular, and fluid chemistry in general, suggest similar temperatures for these wells (Gizaw, 1989). The permeability of these wells (especially LA-3) is not particularly good (Fig. 4). Circulation loss was significant in LA-3 in only the first 300 m near the surface and below 2000 m. This is probably due to the relatively extensive alteration in the basalt zone of the wells (Belaine, 1983; Altay, 1985; Kebede, 1985a, b; Teklemariam, 1985; Gizaw, 1989), which can reduce the permeability substantially. The tendency in LA-6 is the same except that circulation loss is greater and the shallow loss
extends deeper, to about 500 m. Hence, the mass flow rate (Table 4) of LA-6 exceeds that of LA-3. The pressures in these wells are higher (Fig. 6) than in other deep wells. Below about 700 m, the measured pressure in LA-6 slightly exceeds the boiling point pressure profile. The feed zones in LA-3 and LA-6 are believed to be close to bottomhole (∼2100 m, 340°C; and ∼2150 m, 360°C) or possibly deeper, especially in the case of LA-6. It also appears that there is a shallow aquifer at ∼700 m at the contact zone of acid volcanics and basalt (Figs 2, 3). Shallow ground water entry is prevented in these wells by the presence of solid casing down to 750 m depth.

Boiling conditions in LA-3 and LA-6 appear to extend from bottomhole up to about 700 m depth (a vertical extent exceeding 1400 m; see Fig. 5). If conductive cooling is assumed negligible, boiling in LA-3 and LA-6 reduces temperatures by 56 and 87°C, i.e., 20 and 33% of water must have been boiled to steam, respectively, corresponding to a 2.6°C temperature drop for each percent of water vaporized. This amount of boiling transfers most of the dissolved gases from the liquid phase to the steam phase (Gizaw, 1989). At shallow depth, the gas pressure (Table 2) builds up in the casing, and depresses the standing water level. This gas pressure build up and the shallow aquifer cause boiling to cease at about 700 m.

As a result, the temperature in the casing decreases by more than 100°C within 200 m in LA-6. Conversely, if there was no gas effect (27 bar at feed zone), boiling would have started at shallow depth (by about 400 m) and extended nearly to the wellhead. Due to the effect of gas, boiling in LA-6 occurred at greater depth, drilling to over 2200 m has not penetrated beneath the boiling

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**Fig. 6.** Pressure profiles of the Atoto-Langano deep wells. Data from Geothermal Exploration Project data file.
### Table 1. CO₂ permeability determined by gas breakthrough

<table>
<thead>
<tr>
<th>Well</th>
<th>P (psi)</th>
<th>T (°F)</th>
<th>V (ml)</th>
<th>L (ft²)</th>
<th>D (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-1</td>
<td>1000</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>W-2</td>
<td>2000</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>W-3</td>
<td>3000</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

### Table 2. Partial pressure of CO₂ in the deep wells

<table>
<thead>
<tr>
<th>Well</th>
<th>P (psi)</th>
<th>T (°F)</th>
<th>V (ml)</th>
<th>L (ft²)</th>
<th>D (bar)</th>
</tr>
</thead>
<tbody>
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<td>W-1</td>
<td>1000</td>
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<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>W-2</td>
<td>2000</td>
<td>200</td>
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<tr>
<td>W-3</td>
<td>3000</td>
<td>300</td>
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<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>
zone. When shut, the wellhead pressures of both LA-3 and LA-6 are mainly gas pressure; i.e., the gas phase dominates near the wellhead, while the water phase dominates at depth and the steam phase develops between the two.

The temperature profiles of LA-3 and LA-6 overlap, starting from 700 m downwards to about 1800 m, below which LA-6 exceeds LA-3 (Fig. 5). This suggests that excess enthalpy superheated steam is probably entering well LA-6. The method suggested by D'Amore and Celati (1983), applied at 360°C, indicates that the original LA-6 vapor fraction is insignificant. Furthermore, stable vertical pressure gradients in geothermal systems frequently exceed hydrostatic by up to 10%, so that saturated liquid temperatures may be somewhat higher at depth than would be expected from the hydrostatic boiling point/depth relation (Grant, 1979; Grant et al., 1982). If the boiling point/depth curve is drawn on a 110°C hydrostatic pressure gradient, LA-6 would follow the boiling point/depth curve down to bottomhole. Consequently, LA-6 is considered as a normal enthalpy well in which the discharge enthalpy corresponds to the enthalpy of steam saturated water at the feed zone temperature (≈360°C). The excess pressures in LA-6 and LA-3 are interpreted as a characteristic of the upflow zone (see also Fig. 10).

LA-4 and LA-5

LA-4 is a producing well with a maximum temperature of 235°C (Fig. 7). By contrast, LA-5 is a non-producing well drilled on the top of Aluto-Langano volcanic complex. Nevertheless, their temperature profiles are fairly similar.

LA-4 has a high temperature gradient down to about 750 m, is almost isothermal down to 1400-1500 m, below which the temperature drops. An isothermal profile can occur when liquid water flows in the well, upwards or downwards, between two feeds (Grant, 1979). These two end points (700-800, 1445 m) are identified as inflow zones, the inflow at 1445 m being dominant. The rapid temperature and pressure build up (Fig. 7) at about 1445 m suggest that the main aquifer of LA-4 occurs at this depth. LA-4 is one of the relatively permeable wells in the area (Fig. 4). Circulation losses during drilling were higher at shallow (<800 m) and deeper levels (>1400 m), being consistent with the permeable zones. The rapid temperature decline and fast pressure build up in the casing above ≈800 m depth correspond to the shallow aquifer. The hot waters in LA-4 and LA-5 boil before entering the wells. Hence, LA-4 has the most saline fluid and gas-rich steam in the field (Table 2). The pressure profile of LA-4 is close to hydrostatic except at shallower depths. The gas pressure at 235°C in LA-4 is 66 bar (Table 2), which is about 66% of the total pressure. The difference between the total pressure (≈100 bar) and the gas pressure is the water vapor pressure at the feed zone (235°C). Conversely, the water would have boiled if large quantities of gas had not been present in the well. Effectively, the gases bubble out from the water phase, depress the level of the water table and constitute the wellhead pressure when the well is shut-in.

Temperature and circulation loss measurements suggest that LA-5 intercepted permeable aquifers at about 700 m and 1500 m (Figs 4, 7). The pattern of circulation loss in LA-5 is similar to that of LA-4, but the degree of loss is much less in LA-5, especially at deeper levels. No flow occurs from the deeper aquifer because of the low temperature (≈170°C) and the poor permeability overlying it. Unfortunately, the shallow aquifer is probably masked by the solid casing (casing down to 725 m). Even if the aquifer had not been cased-off, it is doubtful that the well would have discharged, since the temperature is relatively low (≈212°C). The system is fault controlled along LA-3 and LA-6 (Figs 1, 10). Whether a well taps the upflow depends on how far it is from the controlling fault, NNW-SSW. Both LA-4 and LA-5 were drilled in the outflow zone. LA-4 is closer to the upflow zone than LA-5, so that drilling deeper (>1807 m) is unlikely to discharge LA-5 (see, for example, LA-7 on the other side of the fault, which is 248 m deep).
LA-7

LA-7 is the second deepest well in the Aluto-Langano geothermal field (2448 m). Its temperature profile is very similar to that of LA-4. They are both characterized by high temperature gradients at shallow level followed by a nearly isothermal region, and finally by a temperature inversion (Fig. 8). Two inflow zones at about 900 and 1350 m may be identified at the end points of the isothermal region, where permeability is relatively high. Temperature and pressure profiles, circulation loss, Na/K geothermometer and the discharge enthalpy unequivocally locate the main aquifer of the well at about 1350 m. Unfortunately, this aquifer is in the plain (blind) liner (Table 1). The drilling circulation-loss record (Fig. 4) and the relatively high mass flow rate (Table 4) obtained from LA-7 suggest that this well encountered more
permeability than most of the others. The high temperature gradient above ≈900 m is similar to that in well LA-4, presumably for the same reasons. Below 1350 m, the high formation permeability resulted in total circulation loss, and cold water inflow at ≈2100 m is therefore responsible for a temperature inversion in the well. LA-7 is the only productive well to tap two widely separated aquifers (at 1350 m, and ≈2100 m). The fluid from the main aquifer at 1350 m either flows about 400 m upward outside the liner and enters the well interior within the annular space between the top of the liner and the casing shoe, or alternatively flows downward from the 1350 m level outside the liner and enters the well ≈400 m deeper when it reaches the perforated region. This fluid constitutes the discharge composition of the well after mixing with the cold water (≈130°C) coming from about 2100 m. This cold water mixture nearly attains the temperature of the main aquifer by conductive heating (from about 1350 m up to 900 m).

The partial pressure of CO₂ at 220°C is 35 bar and the gas effect in this well is similar to that of LA-4. Apart from LA-7, the partial pressure of CO₂ and the temperature of the productive wells have an inverse relationship (Fig. 9). If the plain liner in LA-7 had not prevented the free flow of the fluid from the main aquifer, and if drilling had ceased at ≈1500 m, the partial pressure of LA-7 would probably be about 70 bar and fit the P_{CO₂}-temperature correlation. Hence, it appears that the dilution is about 50% and the cold water inflow has no gas.

LA-8

LA-8 is the deepest (2500 m) but not the hottest well in Aluto-Langano (Fig. 8). The temperature gradient of this well is fairly low (39°C km⁻¹ from 2100 to up to 700 m). The fluid does not boil after entering the well; the heat loss is believed to be mainly through conductive cooling.

Like other producing wells, the pressure profile of LA-8 exceeds hydrostatic at shallow levels but falls below hydrostatic at depth (Figs 6, 8). The permeability of the well is quite limited to depths <700 m and >1800 m (Fig. 4). Based on temperature profiles, permeability, and rate of pressure build up (P4, P6), the main aquifer in the well is between 1500 and 2100 m, ≈282°C. The rapid heating up (T10, T16) between 700 and 800 m suggests another minor aquifer at about 700 m (230°C). Solid casing down to 721 m covers the shallow permeable zones. The wellhead pressure (mainly the gas pressure, around 40 bar) fluctuates too much too soon, compared with that of the other wells. Blow-out was experienced during drilling. It is possible that the well is fed by two aquifers (700-800 m, 2100 m) where the shallow aquifer (gas pocket) causes variable gas flow through the annular space between the casing shoe and the liner top.
The discharge enthalpies were calculated (lip pressure method; James, 1962) in order to evaluate the total discharge composition and the production capacity of the Aluto-Langano deep wells (Table 4). At the time of sampling for the present investigation, most wells were not discharging, so data gathered close to the date of chemical sampling were used to calculate the discharge enthalpies. Except for well LA-6, the discharge enthalpies estimated assuming saturated water at the feed zone temperatures and the discharge enthalpies calculated by the lip pressure method agree fairly well (Table 4). To calculate total discharge compositions, enthalpies based on feed zone...
temperatures were used. For field capacity evaluation, the (somewhat lower) enthalpies obtained from the lip pressure method were employed.

James (1982; personal communication) in Grant et al. (1982) suggested a method for correcting enthalpies using the lip pressure technique for the effects of the presence of gas, based on the mass fraction of CO₂. However, as far as the calculation of the mass fraction of CO₂ is concerned, it appeared to be incorrect (Gizaw, 1989, 1992). A better correction may be obtained based on the CO₂ mole fraction (Table 3). Therefore, in the present work, the mole fraction correction method was used: \( P_k = P_i (1 - x_{CO₂}) \), where \( P_k \) and \( P_i \) are corrected and raw lip pressures, respectively, and where \( x_{CO₂} \) is the mole fraction of CO₂ at the lip pressure. The presence of other gases was ignored (the CO₂ mole fraction exceeds 97% of the total gases at Alto-Langano). The corrected and raw discharge enthalpies are listed in Table 4. The variation is within the accuracy of the lip pressure method (3%); nevertheless, the corrected enthalpies are used for output calculations.

The electrical equivalents of the discharges are calculated assuming 10% efficiency conversion. As can be seen from Table 4, permeability limits the production capacity of the wells in Alto-Langano more than temperature does. The output of the producing wells is around 80 MW. The wellhead pressure of LA-7 is too low for connection to a future power plant (ELC, 1986); the total electrical output of the remaining wells (LA-3, LA-4, LA-6, LA-8) is about 7 MW.

Using the Na/K ratio, Gizaw (1989) indicated that the upflow zone of the Alto-Langano geothermal field is a high temperature zone in Alto volcanic complex along the NNE fault (Figs 1, 10) encompassing LA-3 and LA-6.

Based on the thermal energy of saturated water and rock (Banwell, 1963), the temperature (220–330°C) and the porosity of the system, (7%; Gizaw, 1989), the energy potential of the area is estimated to be between 3000 and 6000 MW yr km⁻³ or 10–20 MW km⁻³ for over 30 years. There are not enough data to delineate the upflow zone from the NNE. Similarly, the thickness of the reservoir (ignimbrite layer) is not known. Even so, we may reasonably estimate the
minimum probable temperature as about 220°C (corresponding to a Na/K ratio of 7). Note also that the ignimbrite layer is probably thicker (wells LA-4, LA-6 and LA-8 bottomed in this formation and no wells have fully penetrated it; see Fig. 2). If the upflow zone extends 1 km NNE of well LA-6, then the area of the upflow zone is about 7 km² (with reservoir volume ≈4 km³ or more) which suggests a potential of 40–80 MW, for over 30 years. The main source of uncertainty in this estimate is the size of the upflow zone.

CONCLUSIONS

Aluto-Langano is a high enthalpy, water-dominated, gas-rich geothermal field in the Lakes District of the Ethiopian Rift Valley. The maximum temperature of the system is near 360°C. In gas-rich geothermal systems like Aluto-Langano, an understanding of the effect of gases on chemical and physical processes and a knowledge of the depth of the aquifer(s) in a well are critical in assessing well performance. The upflow zone lies along a deep, open, young NNE trending fault zone encompassing wells LA-3 and LA-6. The zone is characterized by boiling. Boiling produces low temperature but more concentrated fluids at shallow levels (e.g. well LA-4), distinct from the reservoir fluid.

Except for LA-3 and LA-6, the Aluto-Langano wells exhibit temperature inversions and are located in the outflow zone. The decrease in temperature at shallow depths in LA-3 and LA-6 arises mainly from boiling. Superficially similar shallow temperature distributions in other wells are apparently due to shallow permeable zones. Between 250 and 360°C, fluid temperature decreases about 2.5°C per percent of water boiled. Pressure profiles measured in the productive wells are generally slightly lower than hot water hydrostatics. The pressure profiles in LA-3 and LA-6 converge at about 160 bar (at ~2100 m depth), which probably corresponds to the stable reservoir pressure.

The partial pressure of carbon dioxide is high (~30 bar) at reservoir conditions. The gas concentrations are about the same at depth in all the wells, but the relatively low temperatures in
some of the wells (particularly LA-4 and in LA-7) result in higher gas partial pressures. In shut-in wells, internal upward convection and fluid cooling result in steam condensation and rapid gas pressure build up within the casing above 700 m depth; this gas partial pressure represents most of the wellhead shut-in pressure. The high gas pressure depresses the liquid level and restricts boiling to greater depths.

The most important aquifer in the system is the Tertiary ignimbrite, which generally lies below 1400 m. Circulation loss records and measured temperature profiles also indicate the presence of an aquifer at ~700 m depth at the contact zone of acid volcanics and basalt layers. The basin which overlies the main ignimbrite aquifer is sealed with alteration minerals and may therefore serve as a reservoir caprock. On the whole, the permeability of the system is fairly low.

The output of the present five producing wells is close to 7 MW, even though the energy potential of the area is estimated to be between 3000 and 6000 MW, yr km⁻² or 10–20 MW, km⁻³ for over 30 years. The size of the upflow zone is not known. If a well is drilled NNE of LA-6 it may be better understood. It appears that permeability limits the production capacity of the wells in the Aluto-Langano geothermal field more than temperature does. There was an attempt to perform an interference test between wells LA-3 and LA-6, though it was not successful. There is, however, a plan to do pressure-transient experiments in future.

Acknowledgements—The author gratefully acknowledges the permission of the Geothermal Exploration Project, E.I.G.S., to use the data. He is indebted to Dr Bruce Yardley of the University of Leeds for his imnumerable suggestions and advice throughout this investigation. Thanks are also due to the Project staff, especially Dr. Albrecht Eidersen, Ato Molla Belachew and the Measurement and Reservoir Engineering staff for their cooperation. He would like to express his gratitude to the geothermal staff, particularly Ato Negussie Mckuria and Ato Askaw Techa, for collecting the chemical samples.

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