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THE ERUPTION CHARACTERISTICS OF A RECENTLY ACTIVE GEYSER AT ORAKEIKORAKO GEOTHERMAL AREA

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ABSTRACT

A dormant geyser at Orakeikorako geothermal area began erupting on November 4, 1982, and continued erupting until June 19, 1983. During this time, the eruption interval gradually increased from 2–3 hours to >10 hours by June 7. The decline in activity appears to have been related to declining water levels on the adjacent Artist's Palette. An unusual characteristic of the geyser was its sensitivity to atmospheric pressure changes. The sensitivity increased significantly as the eruption interval increased, and this factor may be a useful precursor of the imminent cessation of geyser activity in other geothermal areas.

INTRODUCTION

On November 4, 1982, a dormant geyser situated on the Golden Fleece terrace of Orakeikorako geothermal area suddenly began erupting. (Fig. 1, feature 126). During the ensuing two months the proprietors of the area reported seeing up to 8 eruptions a day. The geyser quickly became a major tourist attraction at Orakeikorako. On February 1, 1983, a 2-channel, 24-hour temperature recorder was installed near the geyser to study both its eruptive behaviour, and its effect on nearby thermal features. A characteristic play for each eruption, and a fairly predictable periodicity emerged from this study. However variations in the eruption interval lasting from several days to weeks were also observed. The monitoring was therefore continued for several months using a 7-day event recorder. By the time the geyser stopped erupting on June 19, 1983, over 380 eruptions had been recorded. In this paper, a preliminary analysis of the results is presented. A more detailed analysis will be published later.

PREVIOUS ACTIVITY

Feature 126 is one of a cluster of inter-connected springs and pools at the southern edge of Golden Fleece terrace (Fig. 1). These features have flowed or geysered infrequently in the past, with active years corresponding to periods of above-normal rainfall (Lloyd, 1972). The first documented geysering of feature 126 was on December 2, 1961, when it erupted water and debris 3 m high every 10 minutes (Lloyd, 1972). However the eruptions stopped within 24 hours. In mid-May, 1976, Scott (1976) inspected the area after reports that a recently dormant geyser (feature 128 had commenced erupting twice daily. The author witnessed an eruption which lasted for 10 minutes, and comprised intermittent bursts of water to a height of 5–7 m. The feature had begun to overflow about 1 hour 50 minutes before the eruption commenced. After the eruption, the water level receded below the surface, and surface water drained back into tho vent. According to the proprietor of the area, Mr Terry Spitz (pers. comm.), the eruptions continued for about a month. Between June 1976 and November 1982, the only flawing feature on Golden Fleece terrace was feature 120.

TEE 1983 ERUPTION PATTERN

During February 1983, feature 126 erupted on average every 4-8 hours, with most eruptions being remarkably similar. A typical eruption consisted of 6 plays lasting a total of 26 minutes (Pig. 2). The plays were separated by lulls when the water level receded below the overflow level. This multiple thrust type of eruption suggests that several interconnected chambers were feeding the geyser at depth (Anderson, et al., 1978).

The eruption sequence started with the water level being about 50 cm below the overflow level. Boiling in the western edge of the vent increased in intensity and the rate of rise of the water level accelerated. Within 10 minutes, the pool was overflowing and 5 seconds later the eruption commenced. Water was ejected in several directions, with the average eruption height being 5-6 m, and the maximum height >8 a. A prominent jet of water which originated from the west side of the vent was ejected at a 45° angle onto the top of the Golden Fleece terrace above feature 125. About 1 min 40 secs after the eruption commenced, the column of water collapsed, and water drained back into the vent. Three minutes after the start of the eruption a second play began which was very similar to the first, and lasted about 1 min 30 secs. A further 3 play8 followed at about 5 min, 8 min and 11 min after the start of the first play. These last 3 plays each lasted 50–60 secs. After the fifth play, the water level receded out of site (>1.5 m depth) and deep rumbling suggested that it had receded to considerable depth. Although surface water continued to drain into the vent, the boiling at depth maintained a continuous steam flow from the vent. After a gap of about 13 minutes,

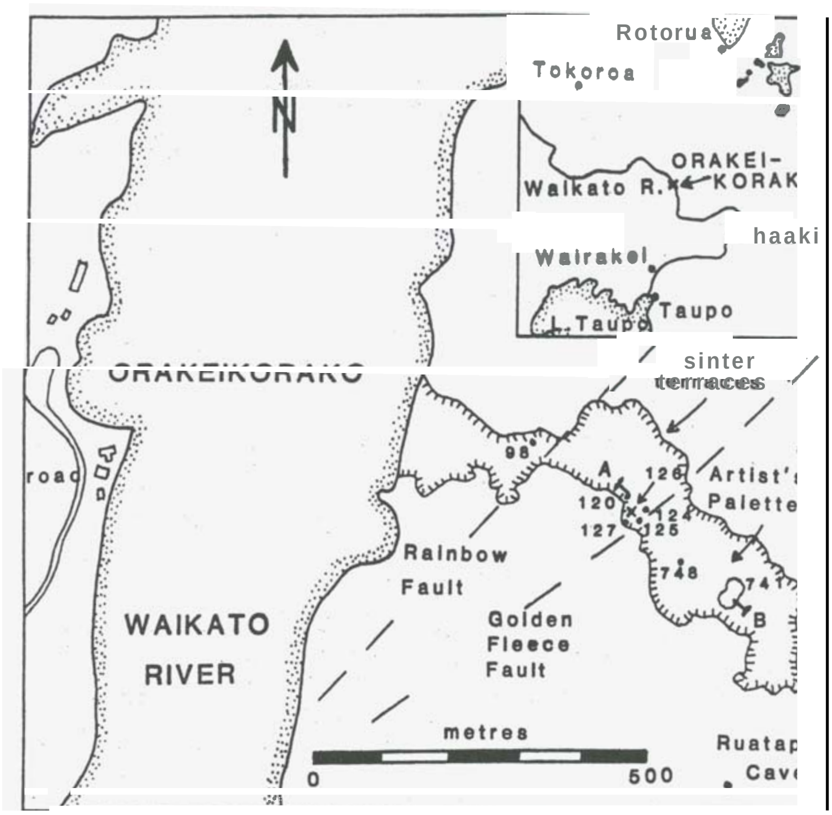

Fig 1: Central portion of Orakeikorako geothermal area. The numbers are from Lloyd (1972), and they refer to specific thermal features: 126 is the recently active geyser: 124 is commonly known as the Cauldron; 125 is Dreadnought Pool; 120 is Manganese Pool, 741 is the Palette Pool; 98 is Hochstetter Pool, and 748 and 127 are unnamed features. A-B is the cross-section in Fig. 6.

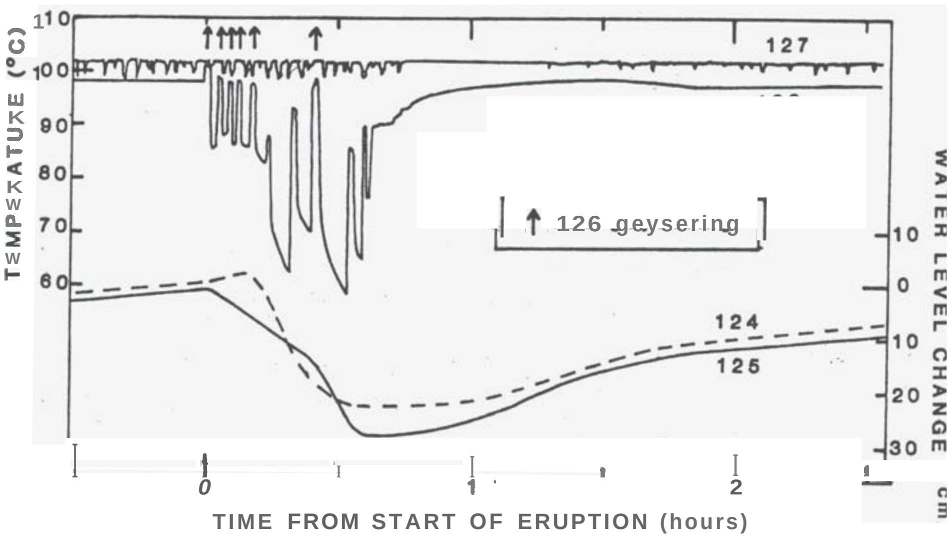

Fig. 2: Response of features 124, 125, and 127 to the eruption of feature 126.

during which time boiling water briefly surged back into the bottom of the vent and then receded out of sight several times, a sixth play occurred. This was just as powerful as the earlier plays, and lasted 60-70 secs. The water level again receded out of sight for about 10 mins, apart from brief reappearances in the bottom of the vent. Over the next 3-4 hours, the water level rose slowly in the vent, to be about 50 cm below the surface just before the next eruption.

This sequence is shown by the temperature variations measured at the accessible base of vent (1.5 m depth, Fig. 2). Plays coincide with the temperature peaks exceeding 98°C, the first play being the hottest at 102°C. The cool periods before and after the sixth play occurred when the water level receded below the the bottom of the vent. About 1 hour after the eruption ceased, the temperature reached a maximum of 99°C, and then cooled by between 0.5-1°C over the next half hour. This may have been caused by the excess heat in underlying rock being dissipated as the first recharge water entered the vent.

About 80% of the eruptions followed this pattern closely. Of the remainder, about half did not have the delayed sixth play, while the other half had four instead of five plays in the first 10 minutes. There was no obvious cause for these anomalous eruptions. Between March and June the interval between eruptions lengthened significantly. This caused the second to fifth plays to merge into one long play, although several strong bursts could still be distinguished during the play. The total eruption time also increased by around 10%. Most of the increased time between eruptions appeared to be associated with the much longer time for the water level to rise from around 50 cm depth to the overflow level. It was clearly more difficult for the fluid pressure beneath the vent to recover sufficiently to cause another overflow and trigger an eruption. After the eruptions ceased in June, 1983, the water level in feature 126 remained at about 70 cm below the overflow level.

The total discharge during an eruption was very difficult to estimate because the water was ejected over a relatively large area, and a significant fraction flowed back into the vent after each play. The best estimate for the net discharge was an average outflow of 10 l/s for 500 secs, or a total volume of 5 m^3.

The eruptions of feature 126 confirmed that at least 3 neighbouring features were interconnected. The water levels in Features 124 and 125 both declined by 20-25 cm with each eruption (Fig. 2). In contrast the level of pool 127, and the flow of spring 120 appeared to be unaffected. However the temperature at 2 m depth in pool 127 showed a systematic thermal response due to the eruptions. This pool stood about 1 m above the overflow level of feature 126, so it may be more closely connected to features on the Artist's Palette than to feature 126. The brief temperature fluctuations in pool 127 were most frequent and of greatest amplitude at the time of the eruption. Between 15 and 60 minutes after the eruption they were absent. These fluctuations appeared to be caused by brief drops in the water level of pool (<10 cm) which caused cooler water to be drawn past the sensor.

EFFECT OF ATMOSPHERIC PRESSURE

Typical examples of the changes in eruption interval of the geyser during the period of monitoring are shown in Fig. 3. The four, 10-day periods are approximately 1 month apart, and have been selected mainly because they contained a complete sequence of eruptions. The average eruption interval increased from <5 hours in early February, >10 hours in June. During this time the day to day variation in eruption interval also increased significantly. Occasionally eruptions were very regular for several days (e.g. March 25-27). At other times, a bimodal eruption interval was apparent (e.g. March 22-25). However most of the variation in eruption interval clearly correlates with atmospheric pressure variations. The positive correlation observed here is apparently an unusual phenomenon. In his review of geyser behaviour, Reinhold (1980) cites only examples with negative correlation between eruption interval and atmospheric pressure. The positive correlation for feature 126 is demonstrated in Fig. 4 by plotting the eruption interval against the average atmospheric pressure during that interval for each of the time periods shown in Fig. 3. Three of the lines have a high correlation coefficient (0.8-0.9). Part of the reason for lower coefficient on the fourth line is the relatively small variation in pressure during that time period. The three periods with a high correlation coefficient indicate that the geyser's sensitivity to atmospheric pressure changes increased almost 3-fold as the average eruption interval increased between February and June.

The positive correlation is readily explained by the well-documented negative correlation between atmospheric pressure variations and water levels in geothermal areas. At Orakeikorako, Lloyd (1972) found that the Palette Pool (741) was the best example of this, having a 100% barometric efficiency (i.e. a 1mb rise in atmospheric pressure causes a 1 cm drop in water level). If feature 126 had a similar response, the subsurface pressure necessary to cause an overflow would also depend on atmospheric pressure. During atmospheric pressure lows, the water level may stand 10-20 cm higher than normal, and a lower subsurface pressure would be sufficient to cause overflow. This also explains the increased sensitivity to atmospheric pressure as the eruption interval lengthened. A decline in the regional, subsurface fluid pressure would increase the recharge time for fluid pressure to return to the critical pressure required for overflow. The effect of water level changes caused by atmospheric pressure changes therefore becomes progressively more important as the regional fluid pressure approaches this critical pressure.

LONG-TERM CHANGES

The Long-term change in eruption interval discussed above, is emphasized in Fig. 5 by averaging the eruption intervals over 1 week time segments.

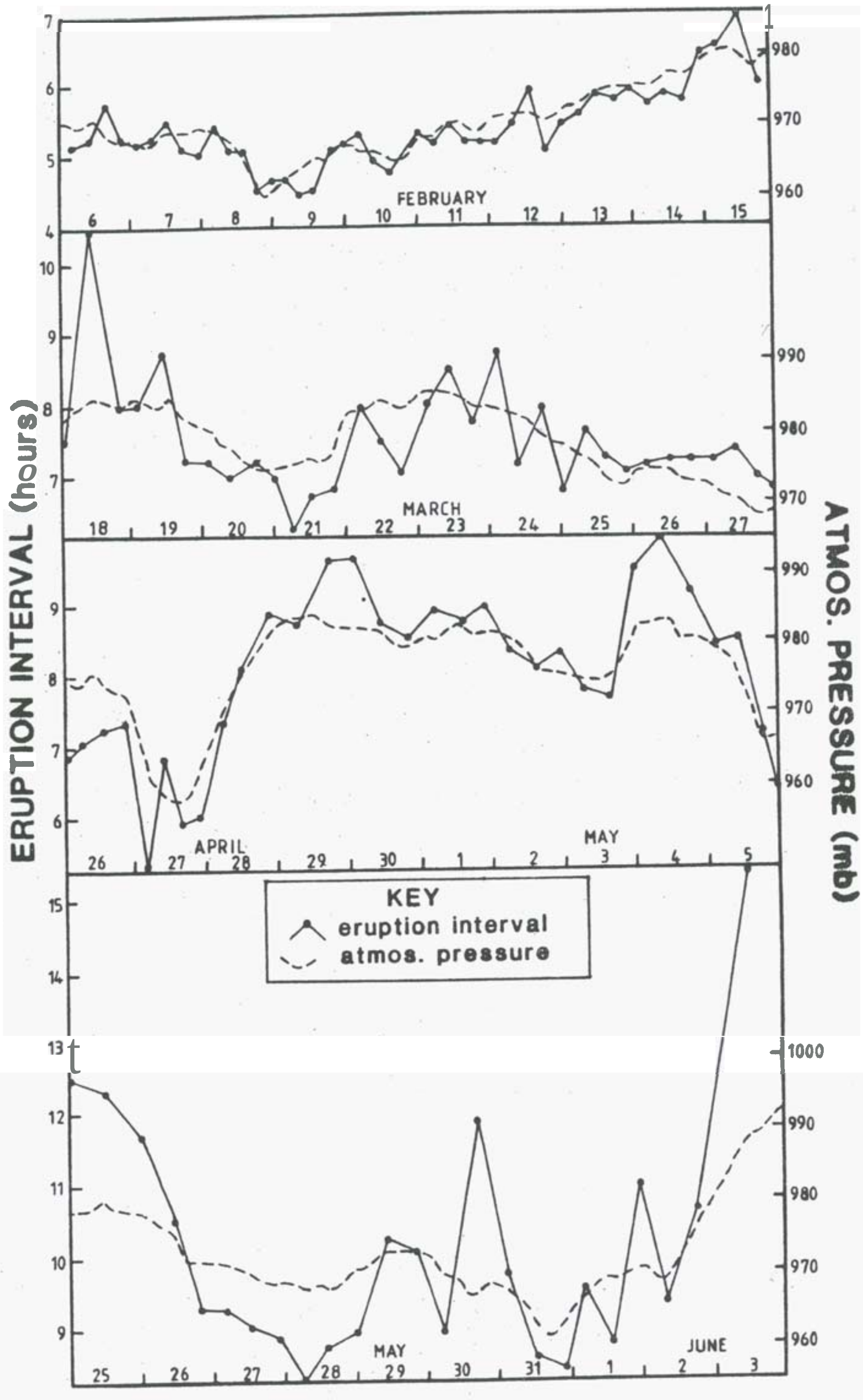

Fig. 3: Variation in eruption interval of feature 126 compared with atmospheric pressure changes measured at Wairakei Power Station during four, 10-day periods.

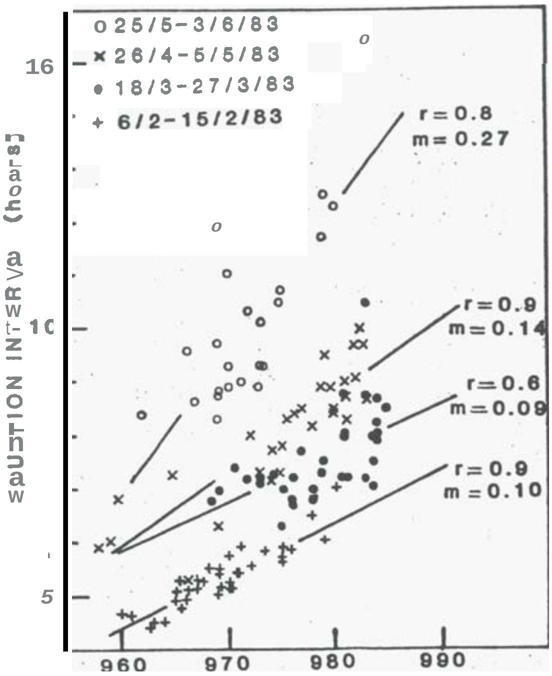

Fig. 4: Correlation between the eruption interval of feature 126 and average atmospheric pressure during the interval. r is the calculated correlation coefficient; m is the slope of the correlation line (units of hours/mb).

The average eruption interval increased steadily from around November-December 1982 to the end of May, 1983. This coincided with falling water level on the Artist's Palette. During the first 3 weeks of June, the eruption interval increased greatly and became highly variable. This presaged the demise of the geyser which erupted for the last time on June 19, 1983.

The relatively sudden increase in the eruption interval is difficult to explain if the rate of fall of fluid pressure beneath the geyser remained the same in June as in the earlier months. There is evidence, however, that regional ground-water level around the geyser did decline rapidly during June 1983. Water level measurements in pool 748 on the Artist's Palette dropped by 70 cm between 7–16 June, compared to only 7 cm during the 3 preceeding weeks, and very little change subsequently. The scanty observations on the water level in the Palette Pool (741) suggest that it could have fallen by around 2 m at this time. Although the water levels in features 124 and 125 did not change significantly when the geyser ceased erupting, the water level in feature 127 fell by over 2 m and this feature is now dry. Spring 120 also had a noticeably decreased flaw. V-notch measurements in September 1983 confirmed that its flaw was 0.5±0.02 l/s compared to 0.6±0.02 l/s in February 1983.

The relationship between the water level on the Artist's Palette and the features at the base of the Golden Fleece terrace is sketched in Fig. 6. This figure suggests that the recharge fluid for the geyser probably originated from beneath the Palette. This also indicates that the fall in the

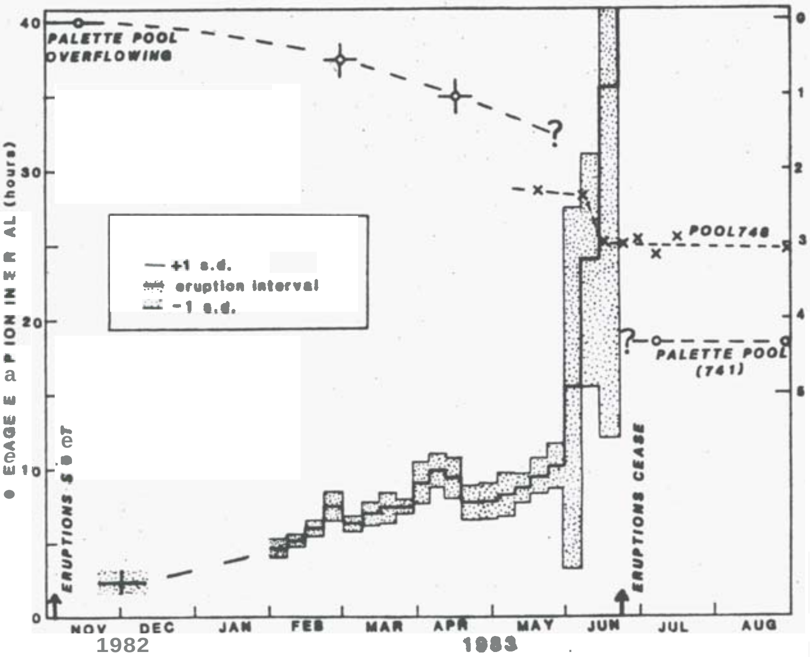

Fig. 5: Comparison of the weekly average eruption interval of feature 126 with the water level in pools 748 and 741 on the Artist's Palette.

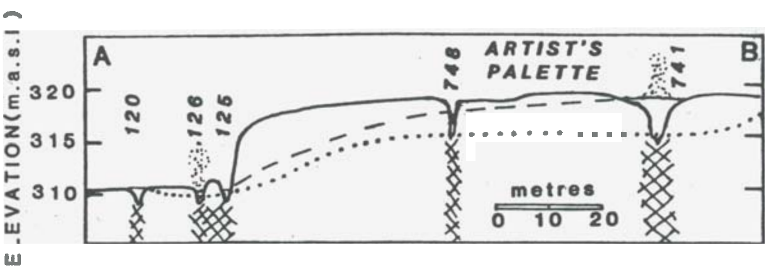

Fig. 6: Cross-section from Golden Fleece terrace to the Artist's Palette (located on Fig. 1). Dashed line is the inferred piezometric surface during February 1983 when feature 126 was erupting frequently. Dotted line is the surface after the geyser ceased erupting on June 19, 1983. Hatching suggests zones of extensive fissuring linking the surface features to a lateral zone of high permeability at depth.

water level on the Palette and the increased eruption interval of feature 126 were closely connected.

The cause of the sudden decline in groundwater levels during June 1983 is unknown. One speculation is that it was tectonically induced. During mid June 1983, major movement occurred within the Taupo Fault zone (Otway, 1983). Although most of the observed movement and the earthquake activity was concentrated near Lake Taupo, some earthquakes were also felt at Orakeikorako (T. Spitz, pers. comm.).

CONCLUSIONS

This study has demonstrated the extreme sensitivity of the geyser, feature 126, to pressure changes. An inferred fa31 in the geyser's recharge pressure of 0.3±0.1 bar (equivalent to 3±1 m of water level decline) was sufficient to change the geyser from erupting more than 8 times a day, to no eruptions. As this pressure declined, atmospheric pressure changes of less than ±0.02 bar became an increasingly significant factor influencing the geyser's eruption interval. This may be a useful precusor signifying the impending demise of geysers in other geothermal areas. Once a geyser becomes sensitive to atmospheric pressure changes, a fluid pressure decline of a similar magnitude will obviously have a major effect on the geyser activity.

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