Geothermal Exploration in Central America: Panama

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ABSTRACT

Panama's electricity supplies are near capacity with frequent outages occurring. Primary energy supplies come from thermal-electric and hydropower plants. Currently, Panama is not producing electricity using geothermal resources. The location of Central America along the tectonically active margin between the Cocos and Caribbean tectonic plates is the main reason for the existence of many high temperature geothermal areas in Central America. The Cordillera Central volcanic arc supplies most of the high enthalpy resources found in the region, which are associated with active and dormant volcanoes, caldera structures, and other volcano-tectonic structures; thus, Panama's location along the Quaternary volcanic belt is favorable for geothermal exploration. Estimated geothermal potential of Panama is calculated as 450 MW. In central and western Panama various places have been studied for its geothermal potential since the mid-70s. To help solve energy demand problems in Panama, Blackrock Geoscience investigated the La Yeguada region in western Panama to determine the potential of geothermal resources for energy development. Study areas investigated include El Potrero, San Jose, Chitra, La Tetilla and El Pedregoso located in and around the La Yeguada Volcanic Complex. The investigation included geologic reconnaissance, fault analysis, carbon dioxide surveys, geochemical sampling and analysis, review of geophysical data, and temperature gradient drilling and logging.

1. Introduction

This study was funded by the U.S. Trade and Development Agency for the purpose of investigating the potential for electrical energy development utilizing geothermal resources in Panama. The area of study is in the La Yeguada region in the Veraguas Province of western Panama. The scope of work includes geologic reconnaissance, fault analysis, carbon dioxide soil

gas surveys, geochemical analysis, geophysical studies and temperature gradient drilling and logging. This paper discusses the results of these activities.

The dominant geographical feature in Panama is the central spine of mountains and hills that form the continental divide. The range between Costa Rica and the Panama Canal is referred to as the Cordillera Central (Fig. 1). The Cordillera Central volcanic arc has ben studied extensively since late 60s. It is defined as a major volcanic range that forms the backbone of western Panama. The Quaternary volcanic chain consists of a northern belt of strato-volcanoes and a southern belt of relatively small intrusive complexes. de Boer et al. (1988) have recognized ten major volcanoes in the northern belt as well as small domes and cones along the mountain range. La Yeguada Volcanic Complex is one of these major volcanoes located in the Cordillera Central in western Panama (Fig. 1).

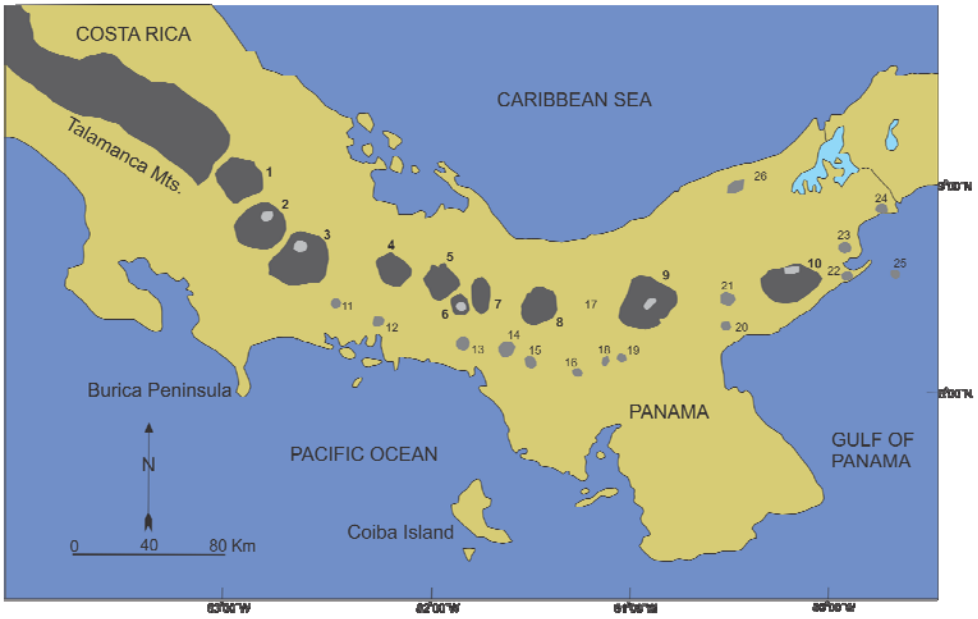

Figure 1: Major volcanic centers in Cordillera Central. No. 9 denotes the study area, La Yeguada Volcanic Complex (after de Boer et al., 1988).

2. La Yeguada Volcanic Complex

The La Yeguada Volcanic Complex (LYVC), which has been generated by the oblique northeastern subduction of the Nazca plate (Defant et al., 1991), is located in Pacific slope of the Cordillera Central (Fig. 1). It is considered one of the potentially active volcanoes in Panama (Simkin et al., 1981). La Yeguada Volcanic Complex displays a complex geology (Fig. 2). Two major periods of volcanic activity exist in the region: 1. An older episode between 13 Ma and 7.5 Ma, and following a quiescent period, 2. A younger episode beginning at approximately 2.5 Ma. The rocks formed during the older episode, the old group, are primarily low-K basalts, basaltic andesites, andesites, high-K basalts and rhyolites. In contrast, the rocks formed during the younger episode, the young group, consists of only dacites. Several Miocene basaltic to andesitic dikes (Los Pozos dikes) striking approximately N60°E intrude the La Yeguada and Canazas formations of the old group (Defant et al., 1991).

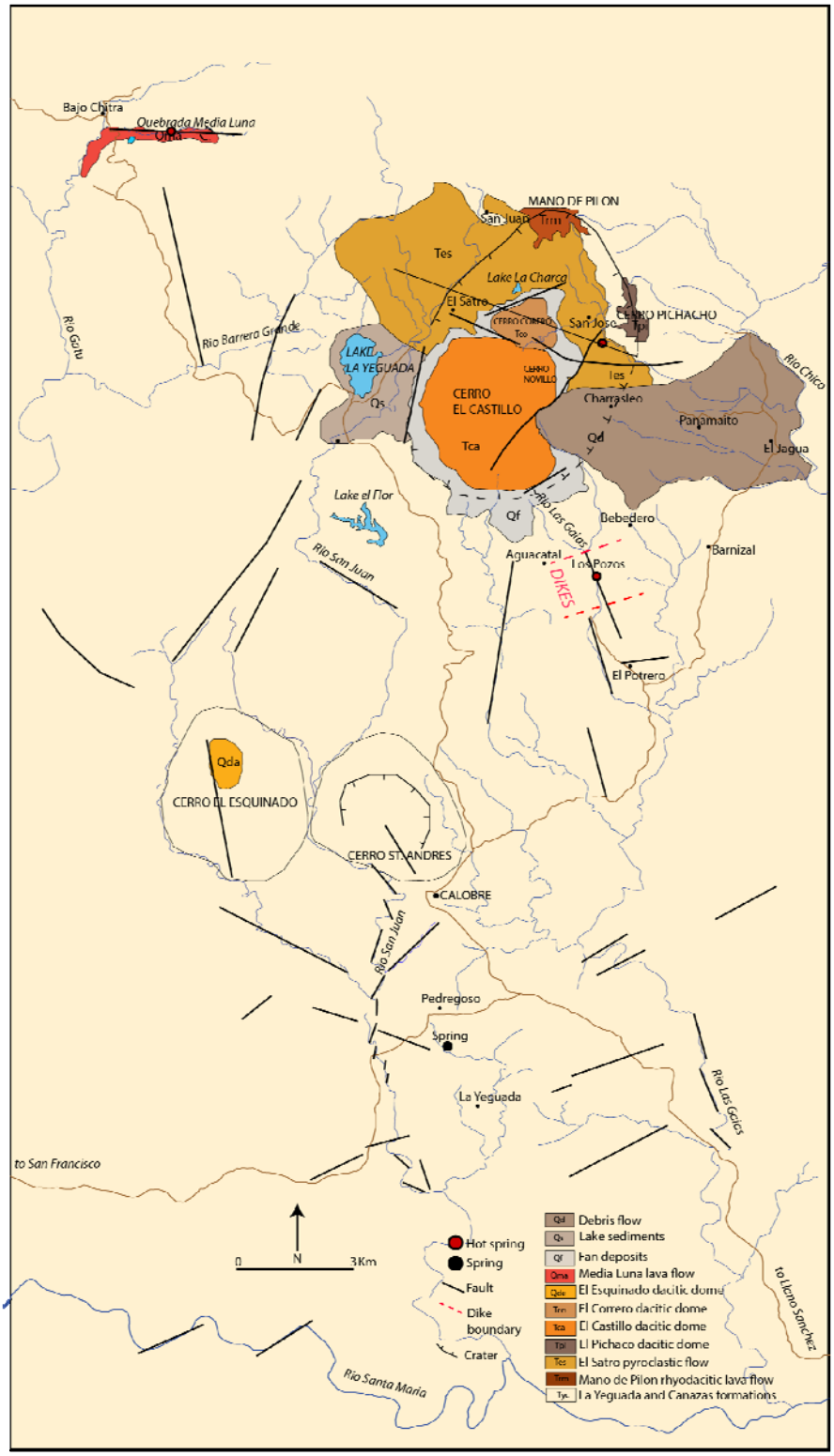

Figure 2: Geologic map of the La Yeguada Volcanic Complex and surroundings (modified after Defant et al., 1991).

3. Hot Springs

There are three hot spring areas in the La Yeguada area (Fig. 3): 1) Chitra hot spring, along the Media Luna stream located to the northwest of the La Yeguada crater (43.1 °C), 2) San Jose hot spring, located near San Jose village in the La Yeguada crater (28.3 °C), and 3) El Potrero hot springs, located to the south of the La Yeguada crater, along the Guias River (53.1°C).

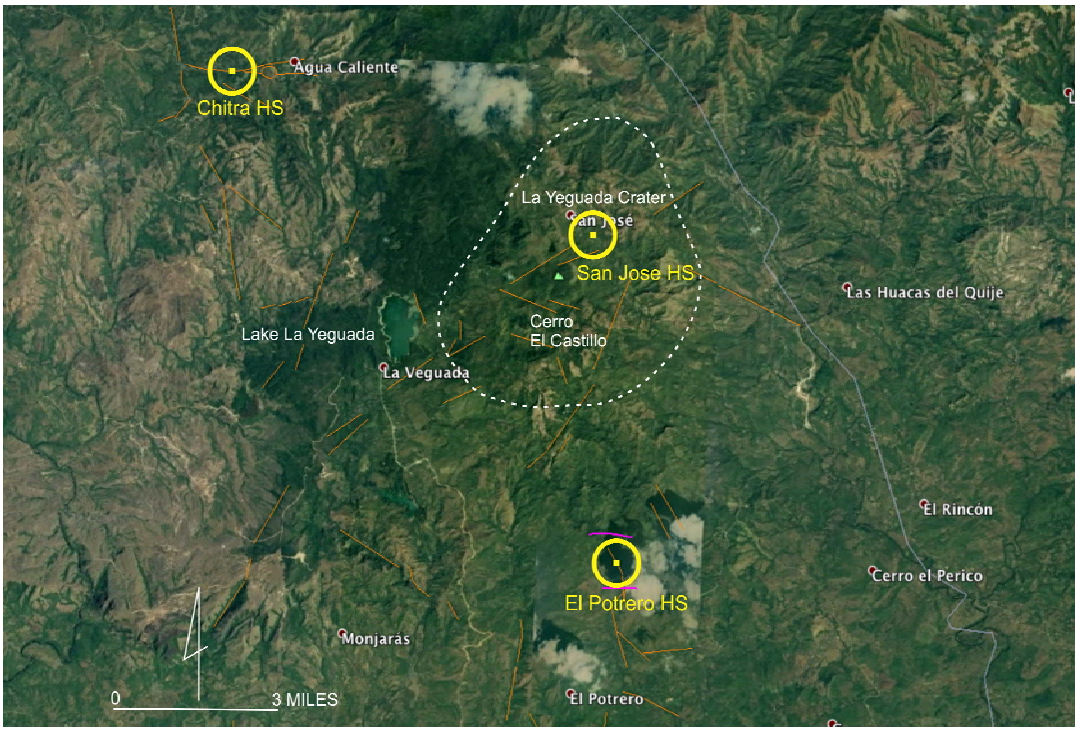

Figure 3: Hot spring locations (yellow circles) in La Yeguada Volcanic Complex.

3. Structural Geology

The study area has undergone a very intense tectonic activity as reflected by the geomorphology and by the drainage that is controlled by faults. The Media Luna stream, the Guias River in the north, and the San Juan and Santa Maria rivers in the south display drainage patterns controlled by the faults. Hot springs are observed along or at the intersection points of the faults. La Yeguada caldera has been cut by long, major faults (Fig. 2). These faults intersect each other southwest of San Juan village and a hot spring is located at the intersection point. Gravimetric data from an earlier study verify the existence of the faults located in La Yeguada crater. Another major fault, which extend in N-S direction, is observed along the Guias River. Hot springs are observed where the fault and the dikes intersect in El Potrero area.

4. Geochemical Survey

Blackrock Geoscience collected water samples from eight locations in the La Yeguada area for geochemical analysis. Geothermometers and multicomponent geothermometry were applied to the samples. Based on the results of the geothermometry, the La Yeguada resource appears to be a viable low temperature resource.

5. Carbon Dioxide (CO_2) and Noble Gas Measurements in the Area

Eight locations were chosen for a carbon dioxide soil gas survey: San Jose village, El Potrero (Los Pozos), Chitra, San Juan River north, San Juan River south, San Juan River riverbed, El Pedregoso, and El Potrero Quarry. A subset of these locations were selected for noble gas sampling.

The soil gas survey was conducted using the LI-COR LI-8100A soil gas flux analyzer. SoilFluxPro software is utilized for data analysis. For noble gas sample collection, the Noble Gas Laboratory of the University of Utah cooperated with Blackrock Geoscience in supplying equipment and samplers and performing the analysis. Gas samples were collected by using either copper tube samplers or diffusion samplers or both.

Carbon dioxide values appear to correlate with distance to hot springs supporting the idea that these springs are the surficial manifestations of connections to the deeper subsurface for both fluids and gasses.

6. Temperature Gradient Drilling and Logging

Blackrock Geoscience selected temperature gradient drilling locations based on geologic surveys, carbon dioxide soil gas survey results, geochemistry analyses, and access. Core drilling was performed by Island Oil Exploration. Access was a major factor in drilling site selection. Temperature gradient holes were drilled at four sites in the La Yeguada area: Chitra, El Potrero, El Pedregoso, and La Tetilla (Fig. 4). Depths of holes range from 174 m to 492 m.

Logging results of all the gradient holes drilled show steadily increasing gradients with no temperature reversals. Overall, the cores consist dominantly of basaltic to rhyolitic lava flows and tuffs, with minor basaltic intrusives. Sand and conglomerate are also present in varying amounts, as well as significant amount of claystone. Faults and brecciated zones are observed throughout the cores.

7. Conclusions

Results indicate a promising geothermal resource in the La Yeguada area of Panama. Extensive faulting is present throughout the study area. Carbon dioxide soil gas flux measurements show anomalous values associated with the occurrence of hot springs. Geochemistry results indicate a low temperature geothermal resource is present. Drilling results show an increasing gradient with

no temperature reversals below the shallow groundwater zone. Drill cores indicate zones of faulting and alteration. Further exploration of the area is recommended.

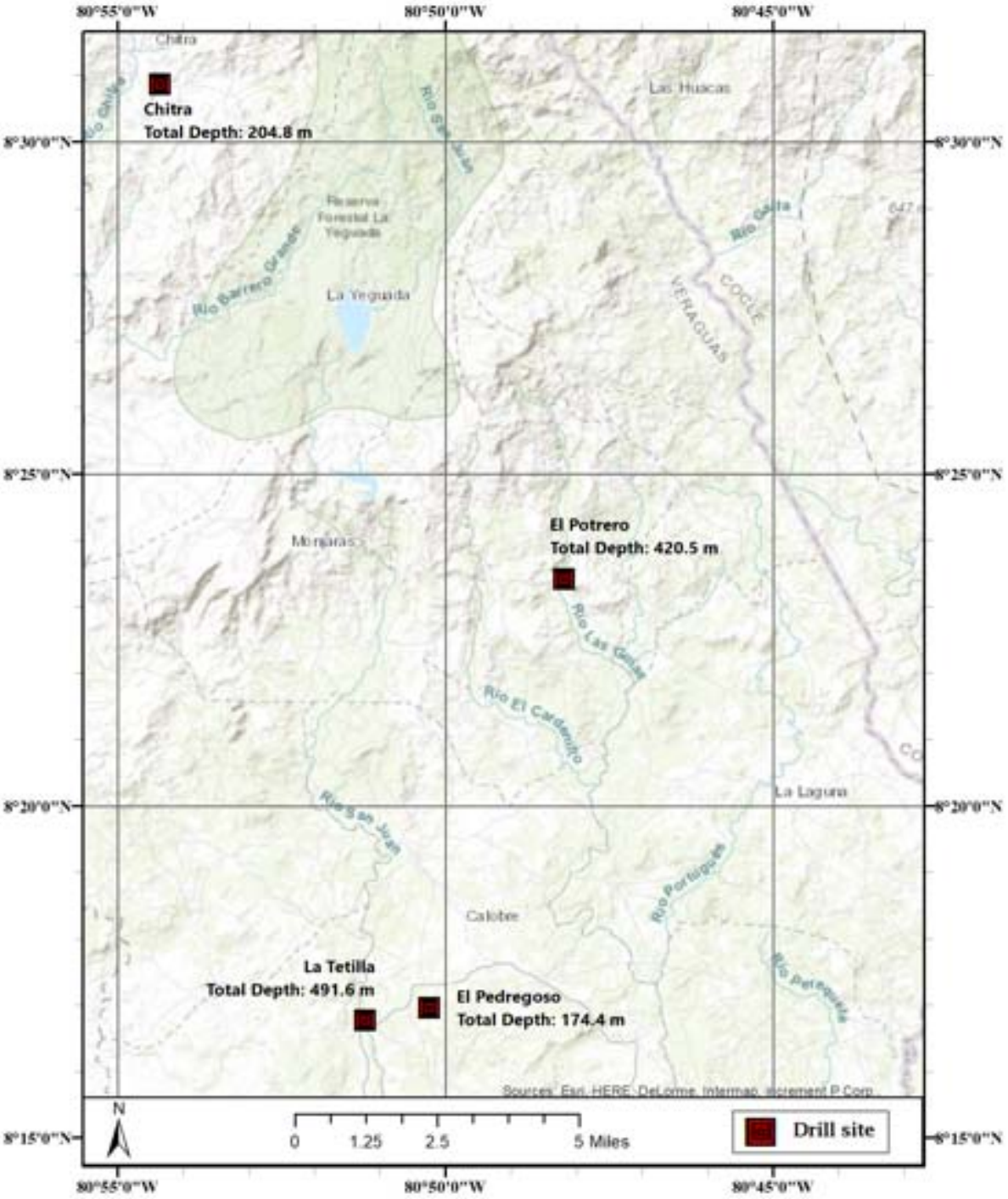

Figure 4: Locations of temperature gradient drilling sites in La Yeguada area.

REFERENCES

de Boer, J. Z., Restrepo, J. F., Clark, L. F., 1988. Quaternary calc-alkaline volcanism in western Panama: regional variation and implication for plate tectonic framework. J. South Am. Earth Sci. 1, 275-293.

Defant, M. J., Richerson, P. M., de Boer, J. Z., Stewart, R. H. Maury, R. C., Bellon, H., Drummond, M. S., Feigenson, M. D., and Jackson, T. E., 1991. Dacite genesis via both slab melting and differentiation: petrogenesis of La Yeguada Volcanic Complex, Panama. Journal of Petrology, vol. 32, part 6, 1101-1142.

Simkin, T., Siebert, L., McClelland, L., Bridge, D., Newhall, C., and Latter, J. H., 1981. Volcanoes of the World. Smithsonian Institution, Hutchinson Ross Publishers, Washington, DC, USA.