Environment Matters, Geothermal in Costa Rica

by Susan Fox Hodgson

The stained-glass window is by Ken Upwort. COURTESY OF THE HOTEL DON CARLOS, SAN JOSÉ, COSTA RICA. PHOTOS BY S. HODGSON.

Oranges, reds, yellows, blues, and greens: the feathers of Costa Rican birds and the petals of Costa Rican flowers dazzle. But the essence of Costa Rica lies in the single gray volcano, only seen in the photo on second glance. Its smallness emphasizes how, in an overwhelmingly volcanic country, abundance can make volcanism invisible. Call it *The Purloined Letter* syndrome, but you can live in Costa Rica for a lifetime without realizing the total volcanic nature of the place.

How volcanic is it? In all, over 100 volcanic "edifices" cover Costa Rica, including the volcanoes themselves plus vast lava fields—measured in tens of kilometers, cinder cones, hot springs, and more. The exact number of volcanoes is unclear. In a country of 19,730 square miles, about 19% smaller than the state of West Virginia, one Costa Rican map includes 15 volcanoes, but more show up elsewhere. Causes for confusion include that newer volcanoes tend to form within parts of older ones and single magmatic systems form multiple volcanic features. In fact, the current Miravalles volcano is a resurgent volcano within the caldera of the Paleo-Miravalles volcano.

In all, Costa Rica has seven historically active volcanoes, including Arenal, one of the world's most active volcanoes whose present eruptive cycle began in 1968.

According to the International Geothermal Association, out of 25 producing countries, Costa Rica is the 7th largest producer of geothermal electricity in the world. About 78% of Costa Rican electricity is from hydro, but 13% comes from geothermal production, 7% from fossil fuels, and 3% from wind and biomass systems. Excess generation is sold to other Central American countries through an electrical-transmission inter-tie system.

The country's geothermal development started, perhaps, in 1959 when a colleague from El Salvador alerted geologists at the Instituto Costaricense de Electricidad (ICE)—the Costa Rican Electricity Institute—to the country's possibly vast geothermal potential. At Costa Rica's request in 1963 and 1964, the United Nations sent in geothermal experts, who agreed strongly. However development was postponed until the energy crisis of 1973, when interest reawakened.

Then ICE—still charged today with generating and distributing electricity in the country—sent Dr. Alfredo Mainieri Protti to Italy for a year of geothermal studies. At the time a young geologist, he now directs the nation's geothermal projects. When Dr. Mainieri returned home in 1975, work began in earnest on locating and developing the most promising geothermal areas. Recently asked to explain the success of Costa Rica's geothermal development, he said it was because, from the

Costa Rica Ranks Third in Environmental Performance

Costa Rica ranks third in the worldwide *2010 Environmental Performance Index* released on January 28, 2010, by Yale and Columbia University researchers. Iceland and Switzerland are first and second, and the US is 61st.

The report ranks 163 countries on performances in 10 categories, including, environmental health, air quality, water resource management, biodiversity and habitat, forestry, fisheries, agriculture, and climate change. The complete report is available at www.epi.yale.edu.

beginning, the country based what it did on scientific findings.

So in 1976 using scientific data, Costa Rica selected a location for development along the foothills of Miravalles volcano—just northwest of the active Arenal, naming the area Miravalles Geothermal Field. Today the field's water-dominated reservoir is penetrated by 33 production wells, with an average water temperature of 240 °C. Residual waters are re-injected by gravity into 14 wells, which play dominant roles in recharging the reservoir (Mainieri, 2010). The field's five power plants generate 165.5 MWe and data indicate "… the field has reached its maximum installable capacity that the known reservoir can maintain continuously during its useful life (Mainieri, 2010)."

From the beginning, geothermal development in Costa Rica was undertaken with environmental sensitivity. At Miravalles, environmental monitoring began in 1987, long before the first power plant was commissioned in 1994 (Guido-Sequeira, 2010). An *Environmental Impact Assessment (EIS)* was made for Miravalles Geothermal Field in 1998, the first in the country, forever changing the model for any new, large project in Costa Rica (Guido-Sequeira, 2010). Most land ICE purchased at Miravalles had been clear cut for cattle grazing 200-to-300 years ago, and ICE began planting what would become about 362,000 trees on the property, making it home for *flora* and *fauna* once difficult to find (Guido-Sequeira 2010).

Today two new geothermal fields are under development, both within the Rincón de la Vieja volcanic complex about a two-hour ride west-northwest of Miravalles. (The volcanic complex includes Rincón de la Vieja National Park, where no development is allowed.) One of the new fields, Las Pailas, lies on the southwestern side of the volcanic complex. In the southernmost part of Las Pailas, a good geothermal reservoir has been found, wells have been drilled, and electricity from a binary power plant will be on line in the second half of 2011, producing another 41 MWe, gross, or 35 MWe, net (Mainieri, 2010).

About 12 km west-northwest of Las Pailas is the second new field, Borinquen, located on the northwestern extreme of the area of the Rincón de la Vieja volcanic complex under exploration. Current information confirms the presence at Borinquen of the same important thermal anomaly measured at Las Pailas Geothermal Field—the one associated with the magma chamber of Rincón de la Vieja volcano. An initial plant-feasibility study is underway (Mainieri, 2010).

Some lands in the Rincón de la Vieja volcanic complex on the southwest—adjoining but outside the national park—are owned by the Guanacaste Dry Forest Conservation Fund, a Nonprofit Governmental Organization headed by Dr. Daniel Janzen and managed by the Guanacaste Conservation Area (*see* map).

The Las Pailas Geothermal Field—perhaps one day—will extend into the Dry Forest Conservation Fund area, where it will be renamed the Mundo Nuevo ("New World") Geothermal Field. As a first step toward beginning work in Mundo Nuevo Field, ICE has signed a contract of mutual cooperation and care with the country's Ministry of the Environment, Energy, and Telecommunications and the Guanacaste Dry Forest Conservation Fund. Together they

A view of Miravalles volcano and its cloud-covered pinnacle. Over the trees, the small puffs of steam billow from geothermal wells. Miravalles Geothermal Field extends along the volcanic foothills into a flatter area left of the photo.

Daniel Janzen & The Guanacaste Dry Forest

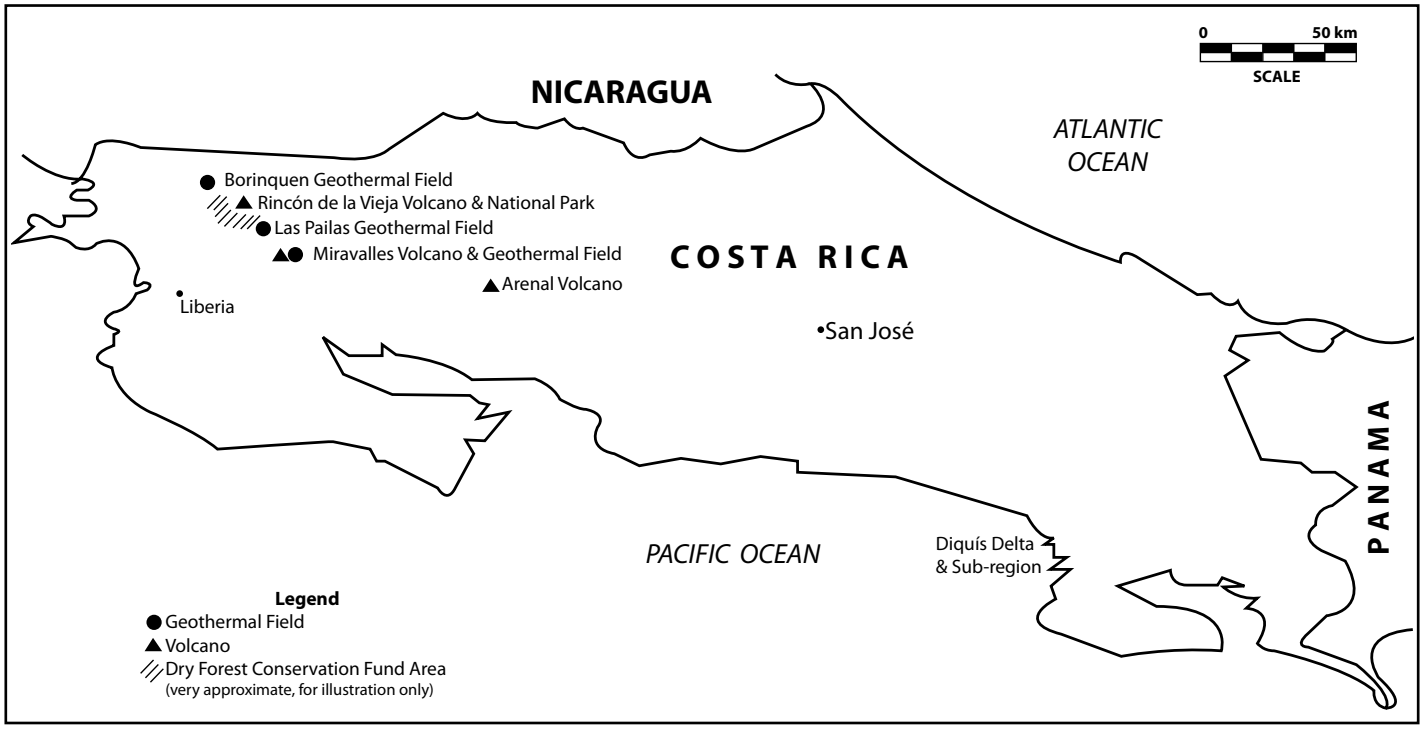
Dr. Daniel Janzen heads The Guanacaste Dry Forest Conservation Fund, a Nonprofit Governmental Organization managed by the Guanacaste Conservation Area. In 1989, he spoke in Davis, California, about his work in Costa Rica. Portions of his presentation and a private interview afterwards follow (Hodgson, 1990).

In the presentation, Dr. Janzen said 210,000 acres of Costa Rican tropical dry forest, cloud forest, and rain forest became Guanacaste National Park on July 25, 1989. The park—not only made up of pristine, natural areas—includes old farms, pastures, and other long-cleared sites. But Dr. Janzen believes enough undisturbed land remains in the park to provide the seeds needed to restore the entire park area. He coordinates restoration work and says the parts of the park already recovering are used for education, ecotourism, and research, adding, "The technical part of making a forest re-grow is easy. It's the social decision to do it that's difficult."

After the Davis talk, Dr. Janzen was asked privately what he thought about developing geothermal-power projects within the boundaries of Costa Rican National Parks. Excerpts from his reply follow.

Dr. Janzen: "They're thinking about opening another geothermal project inside our park. I have no problem with any of that. The way I see it is I don't mind at all paying five percent of the surface area of a big national park if you can keep society feeling like you and society are working together. That implies the park and the project work together. It's not an adversarial situation. Rather, it is one where they work to minimize the damage from whatever the project is.

"The interaction between the environment and the park system on the one hand, and the geothermal company on the other hand, should be a true collaborative interaction, with both of them working to make it not be a problem. If it's an adversarial situation, somebody's going to lose. The second thing is, if the geothermal company itself is a profit-making organization, which normally it is, I think it's entirely fair for some portion of that profit to go to the actual maintenance of the park or other reserve containing this unit."



Map of geothermal development in Costa Rica. DRAFTED BY CHI-MENG MOUA, GRC.

are honing a template for geothermal work in an environmentally protected area—to be called the "Mundo Nuevo Geothermal Bio-Development."

Thus Costa Rica's geothermal future means deciding—among many other things—how to least affect the plants and animals in the complex and varied ecosystems flourishing on the volcanic slopes. Under Costa Rican law, such natural areas are the patrimony of each citizen, legally protected—often under national park status—in about 25% of the country. On the one hand, the Costa Ricans wish to develop geothermal sites with the best potential, but on the other, often find such sites lie within natural preserves where

Power Plant Unit 3 in Miravalles Geothermal Field. Plumes leaving the cooling towers are essentially clean water vapor. All trees in the photo were planted by ICE. The southern edges of the Rincón de la Vieja volcanic complex are at the far right, partly shrouded in clouds. Barely seen are some of the wind turbines built along the distant ridge line, a remnant of the caldera of the ancient Paleo-Miravalles volcano. Electricity from the wind field went on line in December 2009.

Dr. Alfredo Mainieri Protti, photo left, and Ing. Hartman Guido-Sequeira check the valves on a geothermal well in Miravalles Geothermal Field. Dr. Mainieri directs geothermal development in Costa Rica and Ing. Guido-Sequeira is the field environmental manager.

development is forbidden. How the situation will be resolved, as electrical demand rises, remains unclear.

Energy-Efficiency Center

On January 6, 2010, the US and Costa Rican Governments signed a *Memorandum of Understanding*, creating an Energy Efficiency Center in Costa Rica to train and certify professionals in energy-efficient technology and auditing procedures. The center will help to expand the technical-knowledge base and capabilities of countries across Central America—and support Costa Rica's goal of becoming carbon-neutral by 2021. Center partners include ICE; the Costa Rican Ministry of the Environment, Energy, and Telecommunications; the University of Costa Rica (the future center location); the US Department of Energy (which donated $100,000); and the Natural Resources Defense Council.

At the signing ceremony, Pedro Pablo Quirós, ICE Executive President, said, "These natural resources destined to generate energy ought to be rigorously cared for in themselves, and in their development and subsequent uses—always in direct benefit to the largest groups of the country."

Sr. Óscar Arias Sánchez, President of Costa Rica, has long supported developing his country's geothermal resources. At a speech in Davis, California, on October 23, 1991, he said that rich and poor nations alike must help protect the world's natural resources. Afterwards, President Arias remarked privately, "I support the development of Costa Rica's geothermal resources at Miravalles Geothermal Field (Hodgson, 1992)." ■

Among those at the ceremony creating the Energy Efficiency Center were, from left to right, Peter Brennan of the US Embassy in Costa Rica; Pedro Pablo Quirós, Executive President of ICE; and Sr. Óscar Arias, President of Costa Rica and an honorary witness. PHOTO COURTESY OF THE US EMBASSY, COSTA RICA.

Geothermal Archaeology

"Costa Rica was an ancient cultural frontier," says archaeologist Michael Snarskis (Snarskis, 2008). "It was a dynamic, fluctuating zone between two major spheres of Pre-Columbian cultural influence: Mesoamerica (central Mexico through El Salvador and parts of Honduras) and northern South America, primarily Colombia." In Costa Rica, several indigenous groups—present from at least 10,000 to 11,000 B.C.—used the volcanic materials found around them to fashion objects for their everyday and religious lives. Here are three examples.

Costa Rica's famous Pre-Columbian spheres, this one of the volcanic rock andesite, are a hallmark of the Diquís Delta Sub-region (home to several indigenous groups) in the southwest (see map). Probably thousands of spheres have been found in many sizes—some over two meters in diameter. Some speculate the spheres originally were placed in astronomical arrangements (Graham, 1981). PHOTO BY S. HODGSON, FROM THE GARDEN OF THE MUSEO NACIONAL DE COSTA RICA. PRINTED WITH PERMISSION.

This anthropomorphic petroglyph is incised on an andesite boulder at Las Pailas Geothermal Field. A stylized human (note the legs and feet) wears an exaggeratedly large crocodile headdress with the typical, ceremonial, re-curved back of the upper snout—the meaning of this is unknown. Michael Snarskis says similar forms are seen, especially in Africa Tripods from the central Caribbean watershed. This watershed—while quite far from the Caribbean Sea itself—emphasizes the crocodile deity. PHOTO BY S. HODGSON.

The pendant made of gold (or a gold-copper alloy) is of a man masked as an avian raptor wearing a crocodile headdress. The two crocodile heads—each with the same re-curved back of the upper snout seen on the petroglyph—extend from the sides of the headdress. Four repetitions of the curve decorate the top of the headdress, as do two on either side of the face.

A master goldsmith in the Diquís Sub-region created the pendant as a single piece by using the lost wax process. The splayed, anthropomorphic figure is typical of work from this area and probably was made c. 700 to 1550 A.D. The gold itself, a legacy of volcanism, is often deposited by geothermal fluids.
PHOTO BY DIRK BAKKER, REPRINTED WITH PERMISSION OF MICHAEL SNARSKIS.

***Note:** Archaeologist Michael Snarskis lives in San José, Costa Rica. He offers individual and group archaeological tours and may be reached at snarskis@racsa.co.cr.*

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