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Pagosa Springs, Colorado: A Rural Green Community Moving From Geothermal Heating to Geothermal Power

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ABSTRACT

Pagosa Springs, Colorado has a long history of using geothermal resources to heat much of the down town area. They were pioneers in the direct use of geothermal fluids in late 1980s when the city drilled two wells which were used to heat a number of buildings and supply geothermal water to a major spa complex in the city. Recent development of low temperature binary technology has allowed the city of Pagosa Springs and a private investor, Pagosa Verde, LLC, to consider the potential of generating electrical power from the resource.

Investigations have defined the potential of a larger resource than previously thought with a predicted geo-thermometer temperature of over 120°C. Recently, Pagosa Verde, LLC, in cooperation with the Colorado School of Mines, have conducted extrusive geologic and geophysical studies identifying significant structural controls on the system. These structures are potential targets for geothermal gradient drilling followed by exploration drilling scheduled for the spring and summer of 2014. Given positive results of the exploration drilling, a program of production drilling, power plant engineering, and construction will occur in 2015.

A unique portion of the Pagosa Springs project is the collaboration of public and private sectors to develop a project. The city of Pagosa Springs, Archuleta County and a private company, Pagosa Verde, LLC, have joined together to develop this project. They have also developed a team consisting of the State of Colorado, United States Department of Energy, and private equity to provide funding support. Because of the remote location of Pagosa Springs, small increments of power to their system would be beneficial. This project could be an example of the potential of geothermal to serve small rural communities throughout the Western United States as well as remote areas throughout the world utilizing lower temperature resources, new binary technology and innovative funding partnerships.

1. INTRODUCTION

Given the cyclical nature of the national, state and local economies, a diversified revenue stream provides for a more sustainable community. Many communities in Colorado have a heightened desire to become more self-sufficient, utilizing natural resources in a more sustainable manner. In an effort to move the Town of Pagosa Springs toward self-sufficiency and sustainability, the Town staff has been investigating initiatives that add value for the citizens, preserve the environment, while also generating future revenue for the Town. One of these areas of investigation is the community's geothermal resource.

Located in southern Colorado, 400 miles southeast of Denver, the Town of Pagosa Springs sits on one of the largest geothermal aquifers in Colorado. It has a long history of using geothermal resources for heating. They were pioneers in the direct use of geothermal fluids in late 1980 when the city drilled two wells which were used to heat a number of buildings and supply geothermal water to a major spa complex in the city. Current usage of the geothermal resource is limited to three bathing spas and winter heating for a number of downtown business, homes, and schools.

This study found the city system is interconnected hydrologically with pressure interference between the springs and Well 1 during flow testing. Over the past several years, the Town has sponsored research to document the geothermal aquifer's capacity more fully. Recent development of low temperature binary technology has allowed the City of Pagosa Springs and a private investor, Pagosa Verde, LLC, to consider the potential of generating electrical power from the resource.

2. DISCUSSION

Initial studies of the Pagosa Springs system were conducted by Barrett and Pearl in the 1970s and by Galloway in 1980. Activities included the drilling of several geothermal gradient wells and a heat flow study showing a thermal anomaly within the City of Pagosa Springs. In late 2010, through a study by Dr. John Lund of the National Renewable Energy Labs of Golden, Colorado and Gerry Huttrer, geothermal geologist and principle of Geothermal Management Company, Inc. of Frisco, Colorado it was summarized the geothermal system is controlled by faults. It was also postulated that the city is not over the thermal up-flow zone but in an outflow area with the major up-flow of the system to the south and southwest of the city. The NREL report was followed by a Geothermal Management Company, Inc. study of the aquifer's capacity though stress tests on individual wells and ongoing monitoring of wells in downtown Pagosa Springs.

Over the past two years, students and professors from the Colorado School of Mines traveled to Pagosa Springs to study the community's geothermal aquifer. Their 2012 study found several new fault lines (on Reservoir Hill, north of Pagosa Springs, at the airport) that may be carrying geothermal waters.

The available geology maps for the Pagosa area do not show the presence of faults at the spring because of the lack of surficial evidence to support their existence. The most prominent fault in the area is the 8 Mile Mesa Fault, approximately 2 miles

southwest of the Pagosa Springs and striking in the northwest-southeast direction. This fault is shown in the geologic map in Figure 1 and the cross section in Figure 2.

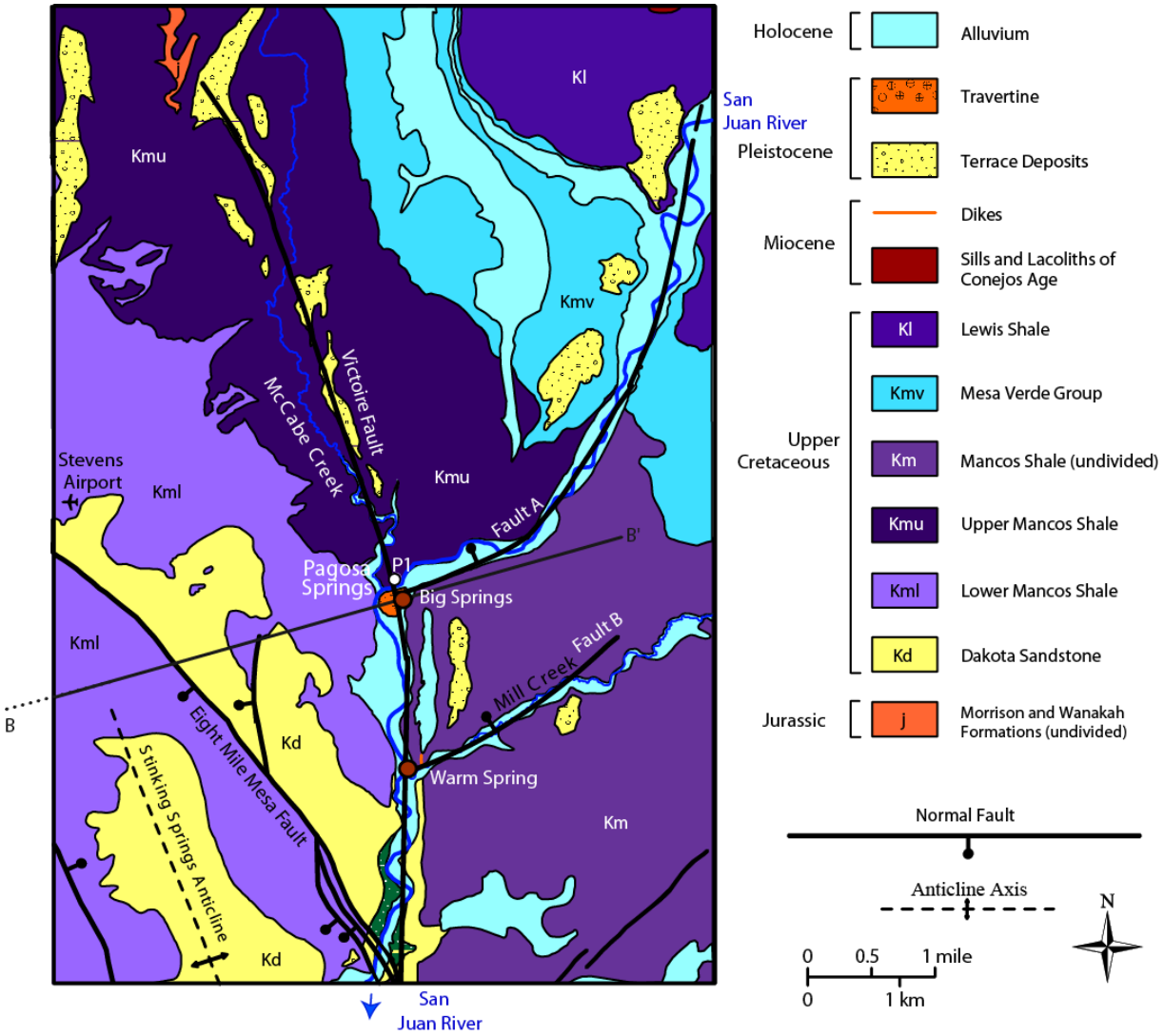

Figure 1. Map of the geology in the study area adapted from Galloway (1981). Interpreted faults from this research are shown as a thick red dashed or dotted lines.

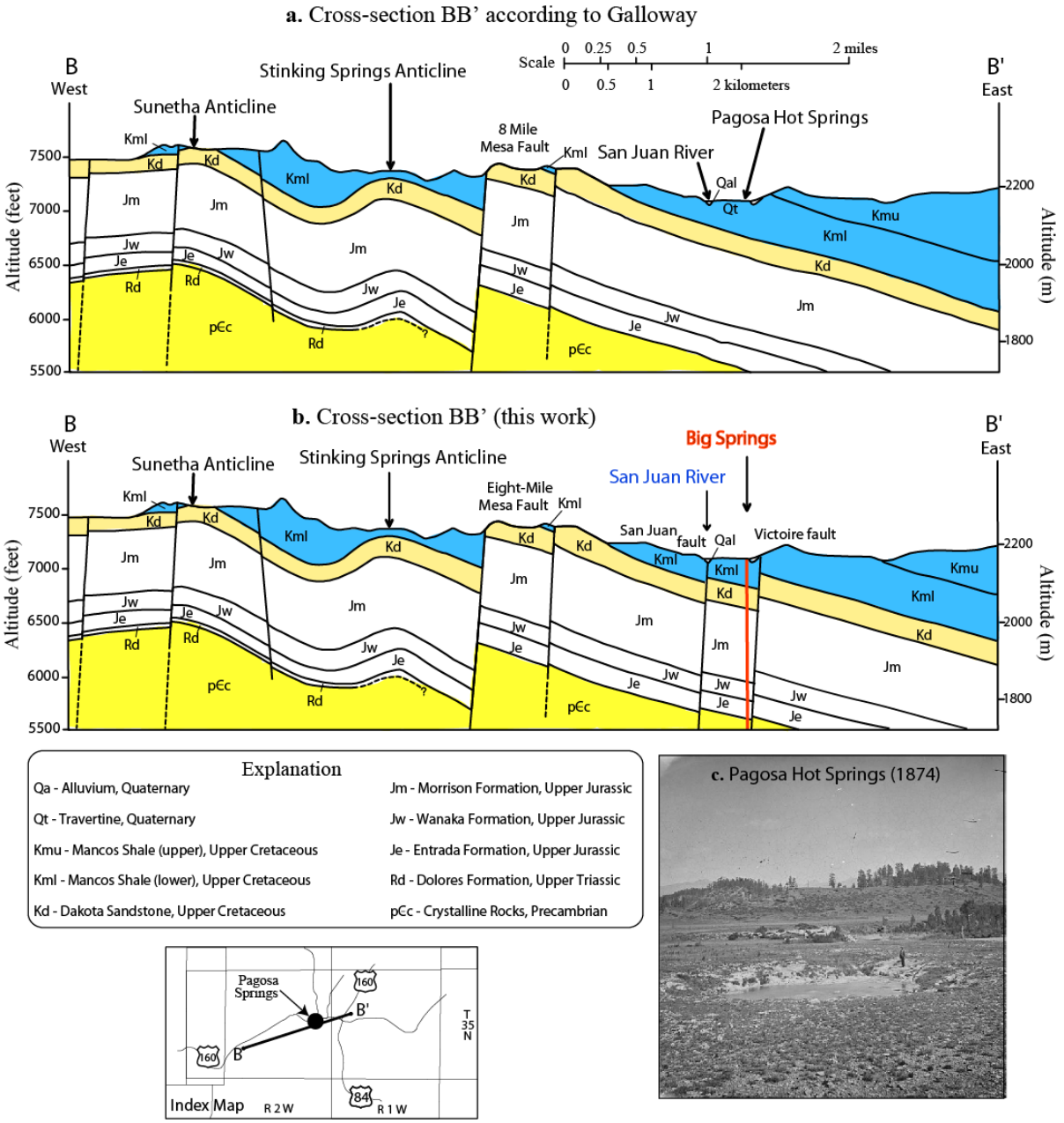

Figure 2. Profile BB'. a. The geological cross-section modified from Galloway (1981). Formations are general uniform in thickness, unless eroded at the surface, and dip in a northeastern direction. b. Modified cross-section. The faults in the cross section are from mapped faults in the Pagosa Springs area. We have added the vertical conduit of the Big Springs showing that the Big Springs have a root located below the Dakota formation. c. The picture shows the Big Springs in 1874. The mound around the pool is a travertine.

Erosion stripped away early Laramide Formations and units called the Mancos shale and Dakota sandstone in the Pagosa Springs area, which Galloway (1980) identifies as the two near surface aquifers in the region. The Dakota's lower and upper members are medium to course grained and conglomeratic and fine to medium grained sandstones, respectively. The Mancos shale (typical thickness of 680+or – 40 m) is a dark-grey to black fissile shale inter-bedded with thin discontinuous sandstones and limestones. The Mancos shale is divided into upper and lower parts based on the amount of calcareous materials. A layer of carbonaceous, dark shale separates these sandstone members (Wood et al., 1948; Galloway, 1980). The Jurassic sedimentary packages below the Dakota sandstone and Mancos shale formations are the Morrison, Wanakah, and Entrada formations. The sedimentary formations of the Pagosa area are relatively uniform in thickness and dip gently (5-10°) to the northeast. Below the Jurassic formations lies the Precambrian basement rock.

Recently, Pagosa Verde, in cooperation with the Colorado School of Mines, have conducted extrusive geologic and geo-physical studies identifying significant structural controls on the system. These structures are potential targets for geothermal gradient drilling

followed by exploration drilling scheduled for the fall of 2014. Given positive results of the exploration drilling, a program of production drilling, engineering, and construction will occur in 2015.

3. SUMMARY

A unique portion of the Pagosa Springs project is the collaboration of public and private sectors to develop a project. The City of Pagosa Springs and a private company, Pagosa Verde, LLC, have joined together to develop this project. They have also developed a team consisting of the County of Archulete, the State of Colorado, and the United States Department of Energy to provide funding support.

Many of the community residents have dedicated time to the geothermal heating and greenhouse partnerships, propelling both initiatives forward in a manner that has earned the respect and participation from the citizens, and secured a positive relationship with the Governor's Energy Office's Geothermal Working Group. Jerry Smith of Pagosa Verde, LLC, is one of the people who have been actively advancing geothermal research in the Pagosa Springs area.

In support of Pagosa Verde, LLC's research efforts, on March 5, 2013, the Town Council approved $9,000 to assess the merits of further testing and development of the geothermal resource for electricity production. Archuleta County is a full partner with the Town in this initiative. The County also appropriated $9,000.

Because of the remote location of Pagosa Springs, small increments of power to the system would be beneficial. This project could be an example of the potential of geothermal to serve small rural communities throughout the Western United States as well as remote areas throughout the world utilizing lower temperature resources and new binary technology. Thus far, the Pagosa Verde research has reinforced the feasibility of deploying a geothermal electric utility.

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