New Developments in Colorado Geothermal Energy Projects

John “Hank” Held and Fred Henderson III
Mt. Princeton Geothermal LLC

Keywords
BLM lease sales, Colorado potential, MT surveys, regulatory barriers

ABSTRACT

Current Colorado geothermal electrical energy projects include the Mt. Princeton Hot Springs and Poncha Hot Springs efforts in Chaffee County, Colorado, which completed primary geologic, geochemical, and geophysical studies including MT studies finished in spring 2012. Other activities include continued study of the enhanced geothermal sedimentary basin coal bed methane project in the Raton Basin of Pioneer Natural Resources Co. The City of Aspen is drilling a geothermal well for direct use in the middle of Aspen. The long awaited BLM/USFS lease sale at Waunita Hot Springs was limited by excessive stipulations which drove off interested developers. The Mt. Princeton and Poncha Hot Springs projects are being funded for deep reservoir confirmation and testing this Fall. If confirmed and permitted, these projects will be producing Colorado’s first geothermal electrical energy by 2013-2014.

Developments

Colorado an Emerging or Greenfield Geothermal State

Colorado is an emerging state for geothermal electrical energy development. While Colorado has not developed any geothermal electrical energy to date, it is ranked 4th (MIT, 2006) in the United States for thermal heat / acre. Recent GEA (Jennejohn, 2010) surveys show most of the installed 2010 US geothermal Production (MW) is in California (83%), and Nevada (14%), followed by 7 other states (3%). Recent 2010 developing projects (MW) are also disproportionately located in California (48%) and Nevada (25%) followed by Utah (12%), Idaho (9%), Oregon (5%), and eight other states (1%). While common exploration philosophy favors expenditures in “elephant country” where principal and historical production have occurred, this situation does little to help develop geothermal energy potential in other Greenfield states. The National Ocean and Atmosphere Administration (NOAA) Geophysical Data Center in Boulder lists 1,661 hot springs in the above states and 15 other Greenfield states throughout the United States, many of which might produce geothermal electrical energy.

Large Scale Direct Use

Colorado is experiencing development of some ground source heat pump and other direct use applications. Three projects are being drilled, permitted or planned to produce deeper geothermal waters for large scale direct heating of public and other infrastructure. These include deep (to 1,500’ or more) drilling projects in the Cities of Aspen and Eagle, and proposals for Pagosa Hot Springs.

Sedimentary EGH

While Department of Energy (DOE) and other studies are looking at Colorado for potential Enhanced Geothermal Projects, only one is in the pre-feasibility stage. This is a project to produce deep, “fracked” geothermal sedimentary basin water from beneath existing coal bed methane production by Pioneer Natural Resource Co. in the Raton Basin, near Trinidad, Colorado. Studies by the Colorado Geological Survey (Paul Morgan) point to several other similar sedimentary basins in Colorado that could support this type of enhanced geothermal energy production.

Binary Closed – Cycle Hydrothermal

Efforts to explore for and develop hot spring – type, non-consumptive, binary, closed cycle geothermal electrical energy have included a number of studies in several counties in Colorado. Figure 1 shows the 10 top hot springs candidates for geothermal electrical energy production. This ranking was prepared by the Colorado Geological Survey (Paul Morgan) and is ranked primarily on hottest probable reservoir temperatures based on geothermometer calculations and other parameters. To date, number 1 ranked Waunita Hot Springs in Gunnison County has been studied with limited thermal gradient measurements, but development is now questionable because the only bidder in a BLM/USFS lease sale in February 2012 was the primary owner of the surface estate of split estate lands in the lease parcel (see Barriers below).
Current geothermal activity in Colorado is referred to in this paper as being in one of three stages of development: Stage I, land access, geology, geochemistry, and geophysics, including thermal gradient and magnetotelluric (MT) studies; Stage II, deep reservoir confirmation and test drilling with down hole geophysics, and Stage III, plant development, production and reinjection drilling and connecting piping and final permitting.

The only current active binary hydrothermal projects underway in Colorado are Stage II ready projects at Mt. Princeton and Poncha Hot Springs in Chaffee County, Colorado. These are two hot springs sites separated by about 25 miles along the Rio Grande Rift Zone in the Upper Arkansas Valley. They are described below. They have completed most or all of planned Stage I geological, geochemical, and geophysical studies. Magnetotelluric (MT) studies have been conducted by the Dewhurst Group in late 2011 and early 2012. The results of the MT studies indicate strong, deep (~3,000') MT conductors generally down dip of the primary rift edge – or Basin and Range type normal to lystic faulting at both sites. In both sites, the conductors indicate good deep reservoir (2,500’ – 3,500’ for 300°F waters) targets for Stage II reservoir drilling tests and confirmation.

**Lessening of Barriers**

Colorado can provide some valuable lessons learned in initiating geothermal electrical energy exploration and production in emerging geothermal Greenfield states. Some of these are briefly describe below.

**Inexperienced Institutions**

Prior to experience with the Mt. Princeton and Poncha Hot Springs Projects, the various Colorado offices of some federal agencies (BLM, USFS), state offices and local governments had not dealt with permitting and regulating binary, closed cycle geothermal projects since the 1980’s. As such, the current agencies have had to learn about geothermal energy and review (for those who have done so) how geothermal projects operate and how they either fit their regulatory rules or how such rules might be modified to fit geothermal development. This has been a time consuming learning process for all involved. While hardly complete, this process is moving forward in Colorado.

**Conflicting Federal, State, Local Jurisdictions**

Geothermal wells are regulated by the Colorado Division of Water Resources (DWR) under Colorado Water Law. Geothermal resources have come under various agencies including the Colorado Division of Oil and Gas in the past. While moved for regulation to the DWR in the early 1990’s, no agency has direct over sight for geothermal development in Colorado, unlike for oil and gas and minerals. The Colorado Geological Survey (CGS) is the only state agency who has provided studies in support of geothermal resources. In a short sighted cost reduction move, its parent agency, the Colorado Department of Natural Resources, may reduce or eliminate the important energy, mineral and geothermal resource role of the CGS this year.

As per the US Steam Act of 1970, the USFS and BLM regulate geothermal activities under mineral, not water law. This became apparent during the 2009 – 2010 BLM Split Estate Lease sale at Mt. Princeton. The confusing overlap of regulation under the state water law and federal mineral law jurisdictions and repeated postponements caused considerable public uproar during the lease sale process. Original investors were driven away because of adverse public reaction, delaying the Mt. Princeton project by one year. Subsequently, the state agencies and the BLM developed a procedural memorandum of understanding for similar future sales. With the lessons learned from this imperfect process, the BLM office in Gunnison scheduled a February 2012 geothermal lease sale at Tomici Dome (Waunita Hot Springs) without postponement. However the excessive, multiple stipulations included in the lease sale discouraged bidding by investors.

In 2008 The US BLM issued a Programmatic Environmental Impact Statement (PEIS) recommending which federal lands should be closed to geothermal leasing and best management practices for geothermal leasing and development on the remaining lands administered by the federal government. The area of the San Luis Valley in south-central Colorado administered by the San Luis Field Valley Office (SLVFO) of the BLM was omitted from this PEIS by an oversight. The SLVFO is currently preparing an amendment environmental assessment with public review of their proposed regulatory process before any actual developments have been proposed.

Complicating the federal - state jurisdiction issues, Colorado is currently sorting out jurisdictional issues between state interests in economic development of its resources and local jurisdictional...
control of land use planning and development. Local authorities were given a more formal role in geothermal regulation by state statute in 2010. After some debate, several counties with geothermal potential are currently working on a common approach to deal with special land use permitting of geothermal plants and developments.

Restrictive Federal Regulation and the Mt. Princeton and Waunita Hot Springs “Failed” Lease Sales

There have now been two relatively recent BLM / USFS geothermal lease sales in Colorado; the two year long split estate lease sale at Mt. Princeton in February 2010 and lease sale at Waunita Hot Springs in February 2012. These “first” geothermal lease sales in Colorado since the 1980s involved many issues such as the jurisdictional ones mentioned above. However, in both sales, the required environmental studies resulted in many restrictive stipulations apparently unacceptable to those interested in commercial geothermal development. In both cases, the nominating companies didn’t even show up at the sales. Some other companies known to be possible bidders also did not show up at the sales. Comments overheard blamed excessive, non realistic economic stipulations for not bidding. In both cases, the leases were bought at low value by local landowners who appear to be more interested in protecting their lands than actual geothermal development. It appears the federal process may not have considered the time value of money, the problems of fund raising for geothermal development, or their mandated role of balancing public land issues with economic development of energy resources on their lands for public benefit.

Figure 2 shows the location of geothermal hot springs in Colorado with relation to USFS and BLM lands. It is hoped that future lease sale will do a better job of including economic trade off considerations in developing reasonable stipulations that won’t discourage industry from developing these potentially useful geothermal resources. The geothermal industry and its representative should support such arguments to the federal agencies.

Status Mt. Princeton and Poncha Springs Projects

Stage I Geology, Geochemistry and Geophysics

Planned Stage I geologic, geochemical and geophysical studies including some thermal gradient drilling were conducted 2006 - 2010 by Mt. Princeton Geothermal LLC. Support was provided by successive Colorado School of Mines geophysical field camps in 2008 - 2010. Additional support was provided by the Colorado Geological Survey and the Colorado Governor’s Energy Office during various phases of work. This work benefited from numerous studies done by state agencies during the 1970’s and 1980’s. Also important was the geothermal studies including about 40 thermal gradient holes drilled by AMAX Exploration Company 1973-1975. Figure 3 summarizes this work at Mt. Princeton.

Mt. Princeton Geothermal LLC

Mt Princeton Geothermal Project Map

Figure 3. Mt. Princeton Project geoscience data. Black lines: faults, surface and seismic. Red round areas: SP upwelling geothermal waters; brown lines: isothermal gradient contours from inner 200 °C/km to outer 50 °C/km. Small dots: shallow domestic wells, red > 100°F. Blue squares 2010 BLM lease.

Tentative Geothermal Gradient Contours

Figure 4. Thermal gradient anomaly (red), faulting (brown), and surface hot spring tufa blankets (yellow). Poncha Springs Project (Henderson, Morgan, 2011).
Stage I geological and geophysical studies including thermal gradient drilling were conducted by the City of Salida, owner of the Poncha Springs Hot Springs. This work was supported by Hendco Services, the Colorado Geological Survey, the Colorado School of Mines summer geophysical field camps in 2009-2010 and the Colorado Governor’s Office with DOE funding in 2010-2011. Mt. Princeton Geothermal LLC concluded agreements with the City of Salida and conducted a MT survey by The Dewhurst Group in 2011-2012. Figure 4 shows some results of the thermal gradient studies at the Poncha Springs site.

**MT Surveys Completed**

In 2011, Mt. Princeton Geothermal LLC negotiated agreements with an Investor group to fund stage II deep (~3,000’) reservoir confirmation and test wells at both the Poncha and Mt. Princeton Hot Springs sites. As a preliminary step, the investor group wanted to have MT surveys run at both sites. Mt. Princeton Geothermal LLC contracted with the Dewhurst Group to conduct these MT surveys in late 2011 – early 2012. The final results of the MT studies were received in spring of 2012. They have been evaluated and some additional land positions acquired for Stage II deep reservoir drilling. At both sites, target conductors were indentified. These strong, deep (3,000’) MT conductors are located generally down dip of the Rio Grande Rift Zone basin boundary normal to lystric faulting at both sites. The MT conductors appear to confirm good deep reservoir targets (2,500’ – 3,500’ for ~300°F waters) for Stage II reservoir drilling confirmation and testing. Figures 5 and 6 show the preliminary results of the MT surveys at Poncha and Mt. Princeton Hot Springs sites respectively.

**Funding for Stage II Deep Reservoir Confirmation 2012-2013**

The Stage I studies and the MT survey results are being evaluated by an outside consulting company. Based on their recommendations and the interests of the investor group, reservoir test drilling and confirmation is being planned for one or both of the sites for the fall –winter of 2012-2013. The drilling will include slim and / or production size wells to estimated depths to 2,500’ to 3,000’ to intercept anticipated reservoir temperatures of 250 °F – 300 °F. Testing will include pump stress tests, geochemistry and downhole geophysics. The actual time lines for Stage II are currently being scheduled and funded.

**Stage III Development 2013-2014**

Stage III development should begin in 2013 based on the results of the Stage II deep reservoir confirmation and tests. Actual Stage III development could be in place by the 2014. If so, it will be the first geothermal electrical energy production in the Greenfield emerging geothermal state of Colorado.

**Colorado and Greenfield State Potential**

**Colorado and TriState Potential**

The overall potential for binary, closed cycle geothermal electrical energy production in Colorado is unknown. But the successful development of the Mt. Princeton and Poncha Hot Spring sites will show the potential for other similar hot springs sites. Figure 7 shows the location of known Colorado hot springs and their relation to transmission lines. Fifty seven hot springs
are listed by the Colorado Geological Survey. If a third of these hot springs can be commercially developed similar to the 10-15 MW potential we believe will occur at the Poncha and Mt. Princeton hot springs sites, then a potential of about 300 MW exists in Colorado that could be developed this decade.

Figure 8 shows a similar study of hot springs and transmission lines in the four Greenfields states served by TriState Generating and Transmission Association, Inc composed of 44 rural co-ops. Clearly, a much larger MW potential exists in this four state area.

**US Greenfields Potential**

The data base at the NOAA Geophysical Data Base list 1,661 hot springs in over 30 states. Many of the central and eastern states are Greenfield states with some geothermal potential. It is suggested that many of these hot springs sites deserve study and consideration as binary, closed cycle geothermal electrical energy resources for future development.

**References**

Henderson, Morgan, Olson, 2009; “Results from the Mt. Princeton Geothermal 500 Foot Temperature Gradient Study”, Colorado Governor’s Energy Office.


Paul Morgan, CGS, personal communication; 2009-2012.