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HYDROTHERMAL RESOURCES OF WESTERN COLORADO*

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INTRODUCTION

In Colorado west of the Continental Divide there are 34 thermal areas containing approximately 103 thermal springs and wells (fig. 1). The surface temperatures of the waters in these areas range from a low of 23°C to a high of 80°C. The temperatures, discharge, total dissolved solids and estimated reservoir temperatures of the thermal systems of western Colorado are summarized in Table 1.

The surface temperatures of the thermal waters found in western Colorado are not excessively hot as contrasted to such higher temperature geothermal systems as hot dry rock, geopressured, and dry steam found elsewhere in the western United States. Consequently the geothermal resources of Colorado are classified as hot-water hydrothermal resources.

The hydrogeological conditions and resources of the hydrothermal systems of western Colorado have been discussed by numerous authors. For a complete listing of all authors who have written on the thermal springs of western Colorado the reader is referred to the references at the end of this paper.

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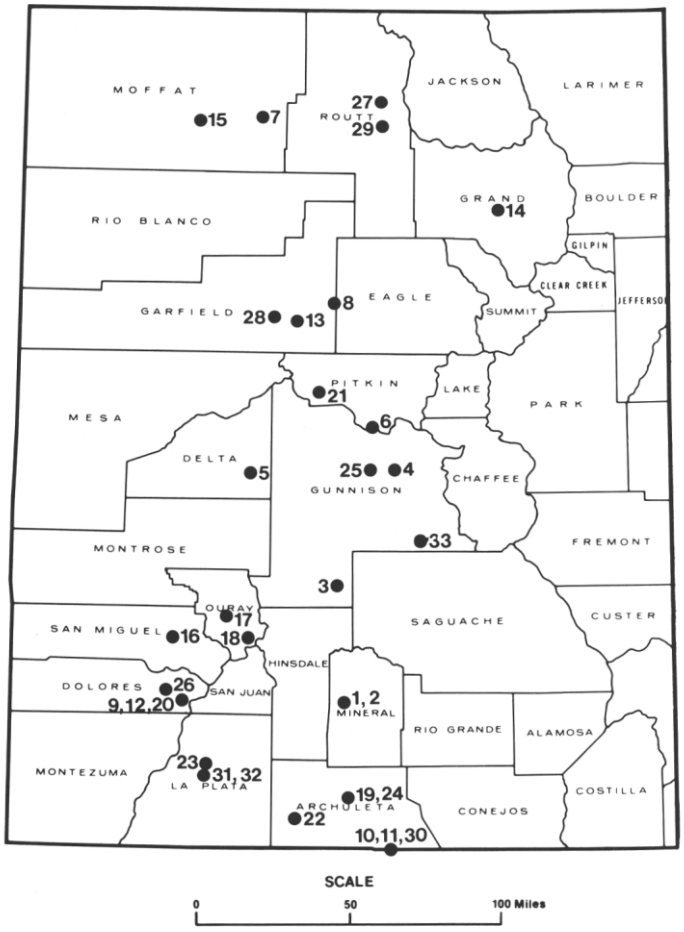

Figure 1. Thermal springs and wells in western Colorado. Numbers refer to Table 1.

With one exception, Routt Hot Springs, north of Steamboat Springs, all thermal areas in western Colorado are geologically associated with sedimentary rocks. The geological conditions of the thermal areas vary from the relatively simple structural conditions at South Canyon Hot Springs, west of Glenwood Springs and Pagosa Springs in southwestern Colorado to the highly complex structural environment which exists at Rico and Ouray in southwestern Colorado. Evaluation of the geological conditions of each thermal area has shown that all thermal waters are associated with faults and in several instances the springs are located at the intersection of two faults. This is in agreement with geological controls of most thermal systems throughout the world.

The Colorado Geological Survey, with U.S. Department of Energy funding, is currently engaged in a limited exploration program to evaluate the following resource areas in western Colorado: Steamboat-Routt Hot Springs, Hot Sulphur Springs, Waunita Hot Springs, Cement Creek-Ranger Hot Springs, Ouray, the Animas Valley north of Durango and Wagon Wheel Gap Hot Springs. Upon completion of this program in 1982, reports will be available to interested parties, which will, as accurately as possible, depict the geological and hydrogeological characteristics of each system.

USES OF THERMAL WATERS

For many years the thermal waters of western Colorado have been used for a variety of purposes. For example, thermal waters have been used for space heating at Pagosa Springs since the turn of the century; however, the main use of thermal waters has been for recreation and medicinal purposes at Juniper Hot Springs, Steamboat Springs, Hot Sulphur Springs, Waunita Hot Springs, Ce- bolla Hot Springs, Ouray, Orvis Hot Springs, Lemon Hot Springs, Dunton, Tripp-Trimble Hot Springs, and Wagon Wheel Gap Hot Springs.

As part of the Colorado geothermal resource assessment program the author (Pearl, 1979) attempted to estimate the size and energy contained in each thermal system in western Colorado. To make these calculations some basic assumptions about the reservoir depth, structural controls, and size of the thermal reservoir were made. These calculations showed that the energy content of the thermal systems ranged from a low of 2.1 x 1012 B.T.U.'s of thermal energy at South Canyon Hot Springs to a high of 1.43 x 1015 B.T.U.'s of thermal energy at Wagon Wheel Gap Hot Springs. The total amount of thermal energy estimated to be contained in all the thermal systems of western Colorado ranges from 1.34 x 10" to 3.41 x 10" B.T.U.'s (Pearl, 1979).

Earlier (Barrett and Pearl, 1978), using mathematical geothermometer models, calculated the estimated reservoir temperatures of the individual thermal systems of western Colorado. Their calculations indicate that the estimated temperatures range from a low of 20°C to a high of 225°C ([able 1). These are not exceptionally high temperatures; consequently it is projected that the ultimate use of the thermal waters will be for direct application purposes. There may be several exceptions to this. For those areas where the estimated reservoir temperatures range between

Table 1. Characteristics of thermal areas in western Colorado (adapted from Pearl, 1979).

	Maximum Discharge (gpm)	Maximum Total Dissolved Solids (mg/l)	Maximum Temperature (°C)	Estimated Reservoir Temperature (°C)
1. Antelope W.S., Mineral Co.	3E	151	32	52
2. Birdsie W.S., Mineral Co.	3E	150	30	52
3. Cebolla H.S., Gunnison Co.	3	1,450	40	200?
4. Cement Creek Warm Spring, Gunnison Co.	80	390	25	60
5. Colonel Chinn Hot Water Well, Delta Co.	–	–	42	43?
6. Conundrum H.S., Pitkin Co.	50	1,910	32	50
7. Craig Warm Water Well, Moffatt Co.	24	896	39	70
8. Dotsero W.S., Eagle Co.	500E	10,000	32	45
9. Dunton H.S., Dolores Co.	25	1,260	42	70
10. Dutch Crowley Artesian Well, Archuleta Co.	–	101	70	80
11. Eoff Artesian Well, Archuleta Co.	50E	–	39	60
12. Geyser W.S., Dolores Co.	200E	1,620	28	120
13. Glenwood Springs, Garfield Co.	2,260	20,000	50	77
14. Hot Sulphur Springs, Grand Co.	150	1,200	44	150
15. Juniper H.S., Moffatt Co.	13	1,150	33	75
16. Lemon H.S., San Miguel Co.	10	2,760	33	35?
17. Orvis, H.S., Ouray Co.	1	2,250	52	90
18. Ouray H.S., Ouray Co.	200	1,500	69	90
19. Pagosa Springs, Archuleta Co.	265	3,200	58	150
20. Paradise H.S., Dolores Co.	30	6,530	46	45?
21. Penny H.S., Pitkin Co.	10	2,820	46	90
22. Piedra River Hot Spring, Archuleta Co.	50	–	42	–
23. Pinkerton H.S., La Plata Co.	54	3,900	33	125
24. Rainbow H.S., Archuleta Co.	45	161	40	50
25. Ranger H.S., Gunnison Co.	132	465	27	60
26. Rico, Dolores Co.	12	2,790	44	50?
27. Routt H.S., Routt Co.	50	552	64	175
28. S. Canyon H.S., Garfield Co.	17	800	48	130
29. Steamboat Springs, Routt Co.	140	6,170	39	130
30. Stinking Springs, Archuleta Co.	24	899	27	60
31. Stratten W.S., La Plata Co.	10	–	28	–
32. Tripp-Trimble H.S., La Plata Co.	1	3,240	44	70
33. Waunita H.S., Gunnison Co.	50	575	80	225

E = Estimated

150°C and 225°C, the resource could be used for the generation of electricity. Several thermal areas in western Colorado are currently being evaluated by major energy companies for this purpose.

With the increasing cost and growing shortage of energy, more extensive use of geothermal energy in western Colorado is envisioned for the future, especially for space heating purposes. A study by Coe (1978) showed that in 17 communities in western Colorado some or all of the total heating requirements could be obtained from nearby thermal waters. Some of the other potential uses for thermal waters in western Colorado are summarized in Table 2.

Table 2. Possible use of thermal waters in western Colorado. Adapted from Coe (1978).

Refrigeration of food products	Wood chip drying
Biomass processing for fuel and fertilizer	Feedlot warming
Agricultural product growing	Tropical gardens
Agricultural product processing	Greenhouse operations
Nahcolite-dawsonite processing	Power generation

CONSTRAINTS ON THE DEVELOPMENT OF GEOTHERMAL ENERGY

While the geothermal resources of western Colorado appear to offer great promise, their development is lagging for a variety of reasons, mainly that the resources are primarily the low to moderate type and will be used for direct application purposes. In most instances these uses are small projects with low return on investment. Consequently the major energy companies with sufficient exploration and development capital are not interested in developing them. This leaves their development to private individuals, a few small geothermal development companies, or local governments. As these entities usually do not have adequate funds available, they have had to seek outside financial assistance. During the past few years, the Federal Government has provided development monies for direct-use geothermal projects through a series of insurance, grant, or loan programs. In a number of instances, such as at Pagosa Springs in southwestern Colorado, these programs have been very successful in helping to develop a specific resource.

Another constraint to the development of the low to moderate geothermal resources of western Colorado is a definite lack of geological knowledge about each system. Prospective developers,

who are not resource development oriented, are very reluctant to develop a resource when there is no information available that they can use in making reliable cost estimates regarding resource location, drilling costs, and amounts of energy to be expected.

A perceived constraint, which usually proves to be groundless, is the engineering problems associated with the use of geothermal fluids. Scaling, corrosion and noxious gases are all problems that usually can be solved with proper engineering treatment.

CONCLUSION

The hydrothermal geothermal resources of western Colorado are a largely untapped resource that appear able to supply large amounts of energy for a variety of purposes. Before this development can occur, however, better resource definition is needed to accurately define the location, size, and temperatures of the individual systems. An active group of developers are needed who are willing and able to develop and sell the low to moderate temperature geothermal resources.

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