Hydrothermal resources of western Colorado

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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, geopressed, 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 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

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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, Cement Creek-Ranger Hot Springs, Ouray, the Animas Valley north of Durango 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 10¹⁰ to 3.41 x 10¹⁰ 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 (Table 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

Figure 1. Thermal springs and wells in western Colorado. Numbers refer to Table 1.
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 1. Characteristics of thermal areas in western Colorado (adapted from Pearl, 1979).**

<table>
<thead>
<tr>
<th></th>
<th>Maximum Discharge (gpm)</th>
<th>Maximum Total Dissolved Solids (mg/l)</th>
<th>Maximum Temperature (°C)</th>
<th>Estimated Reservoir Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Antelope W.S., Mineral Co.</td>
<td>3E</td>
<td>151</td>
<td>32</td>
<td>52</td>
</tr>
<tr>
<td>2. Birdie W.S., Mineral Co.</td>
<td>3E</td>
<td>150</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>3. Cebolla H.S., Gunnison Co.</td>
<td>3</td>
<td>1,450</td>
<td>40</td>
<td>52</td>
</tr>
<tr>
<td>4. Cement Creek Warm Spring, Gunnison Co.</td>
<td>80</td>
<td>390</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td>5. Colonel Chinn Hot Water Well, Delta Co.</td>
<td>–</td>
<td>–</td>
<td>42</td>
<td>43</td>
</tr>
<tr>
<td>6. Conundrum H.S., Pitkin Co.</td>
<td>50</td>
<td>1,910</td>
<td>32</td>
<td>50</td>
</tr>
<tr>
<td>7. Craig Warm Water Well, Moffatt Co.</td>
<td>24</td>
<td>896</td>
<td>39</td>
<td>70</td>
</tr>
<tr>
<td>8. Dotsero W.S., Eagle Co.</td>
<td>500E</td>
<td>10,000</td>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td>9. Dunton H.S., Dolores Co.</td>
<td>25</td>
<td>1,260</td>
<td>42</td>
<td>70</td>
</tr>
<tr>
<td>10. Dutch Crowley Artesian Well, Archuleta Co.</td>
<td>–</td>
<td>101</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>11. Eoff Artesian Well, Archuleta Co.</td>
<td>50E</td>
<td>–</td>
<td>39</td>
<td>60</td>
</tr>
<tr>
<td>12. Geyser W.S., Dolores Co.</td>
<td>200E</td>
<td>1,620</td>
<td>28</td>
<td>120</td>
</tr>
<tr>
<td>13. Glenwood Springs, Garfield Co.</td>
<td>2,260</td>
<td>20,000</td>
<td>50</td>
<td>77</td>
</tr>
<tr>
<td>14. Hot Sulphur Springs, Grand Co.</td>
<td>150</td>
<td>1,200</td>
<td>44</td>
<td>150</td>
</tr>
<tr>
<td>15. Juniper H.S., Moffatt Co.</td>
<td>13</td>
<td>1,150</td>
<td>33</td>
<td>75</td>
</tr>
<tr>
<td>16. Lemon H.S., San Miguel Co.</td>
<td>10</td>
<td>2,760</td>
<td>33</td>
<td>150</td>
</tr>
<tr>
<td>17. Orvis H.S., Ouray Co.</td>
<td>1</td>
<td>2,250</td>
<td>52</td>
<td>90</td>
</tr>
<tr>
<td>18. Ouray H.S., Ouray Co.</td>
<td>100</td>
<td>1,500</td>
<td>69</td>
<td>90</td>
</tr>
<tr>
<td>19. Pagosa Springs, Archuleta Co.</td>
<td>265</td>
<td>3,200</td>
<td>58</td>
<td>150</td>
</tr>
<tr>
<td>20. Paradise H.S., Dolores Co.</td>
<td>30</td>
<td>6,530</td>
<td>46</td>
<td>457</td>
</tr>
<tr>
<td>21. Penny H.S., Pitkin Co.</td>
<td>200E</td>
<td>2,820</td>
<td>46</td>
<td>90</td>
</tr>
<tr>
<td>22. Piedra River Hot Spring, Archuleta Co.</td>
<td>50</td>
<td>–</td>
<td>42</td>
<td>–</td>
</tr>
<tr>
<td>23. Pinkerton H.S., La Plata Co.</td>
<td>54</td>
<td>3,900</td>
<td>33</td>
<td>125</td>
</tr>
<tr>
<td>24. Rainbow H.S., Archuleta Co.</td>
<td>45</td>
<td>161</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>25. Ranger H.S., Gunnison Co.</td>
<td>132</td>
<td>465</td>
<td>27</td>
<td>60</td>
</tr>
<tr>
<td>26. Rico, Dolores Co.</td>
<td>12</td>
<td>2,790</td>
<td>44</td>
<td>503</td>
</tr>
<tr>
<td>27. Routil H.S., Routt Co.</td>
<td>50</td>
<td>552</td>
<td>64</td>
<td>175</td>
</tr>
<tr>
<td>28. S. Canyon H.S., Garfield Co.</td>
<td>17</td>
<td>800</td>
<td>48</td>
<td>130</td>
</tr>
<tr>
<td>29. Steamboat Springs, Routt Co.</td>
<td>140</td>
<td>6,170</td>
<td>39</td>
<td>130</td>
</tr>
<tr>
<td>30. Sinking Springs, Archuleta Co.</td>
<td>24</td>
<td>899</td>
<td>27</td>
<td>60</td>
</tr>
<tr>
<td>31. Stratten W.S., La Plata Co.</td>
<td>20</td>
<td>–</td>
<td>28</td>
<td>–</td>
</tr>
<tr>
<td>32. Tripp-Trumble H.S., La Plata Co.</td>
<td>44</td>
<td>3,240</td>
<td>44</td>
<td>70</td>
</tr>
<tr>
<td>33. Waunita H.S., Gunnison Co.</td>
<td>50</td>
<td>575</td>
<td>80</td>
<td>225</td>
</tr>
</tbody>
</table>

E = Estimated

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

<table>
<thead>
<tr>
<th>Use</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigeration of food products</td>
<td>Wood chip drying</td>
</tr>
<tr>
<td>Biomass processing for fuel and fertilizer</td>
<td>Feedlot warming</td>
</tr>
<tr>
<td>Agricultural product growing</td>
<td>Tropical gardens</td>
</tr>
<tr>
<td>Agricultural product processing</td>
<td>Greenhouse operations</td>
</tr>
<tr>
<td>Nahcolite-dawsonite processing</td>
<td>Power generation</td>
</tr>
</tbody>
</table>

**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
collection, 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 develop-
ment can occur, however, better resource definition is needed to
accurately define the location, size, and temperatures of the indi-
vidual systems. An active group of developers are needed who are
willing and able to develop and sell the low to moderate tempera-
ture geothermal resources.

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