Property Rights to Geothermal Resources

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Sho Sato and Thomas D. Crocker

with Technical Analysis by L.J.P. Muffler

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Property Rights to Geothermal Resources†
(Part One)

Sho Sato* and Thomas D. Crocker**

with

Technical Analysis of Geothermal Resources
by L.J.P. Muffler***

I
THE SCOPE OF THE STUDY

The term "geothermal energy" may be defined broadly as the earth's heat energy, and heat flows from the depths of the earth to its surface in all areas. Most of this heat energy cannot be controlled given the existing technical and economic limits of engineering skill, and it therefore goes unused. Only in those areas where there are heat anomalies can the energy be harnessed. Geothermal energy is being exploited currently only in areas where fluid is present in hot rock formations beneath the surface of the earth. Heat is transmitted from the hot rock to the fluid, which is then extracted from the subsurface formation and used as a source of heat energy. Where there is no fluid to transmit the heat, injection of a fluid will be necessary.¹

† We gratefully express our appreciation to the National Science Foundation for having supported this project. The statements and opinions expressed in this article are those of the authors, and they do not necessarily represent the views of the National Science Foundation.

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¹ The geological and engineering aspects of geothermal resource exploitation are more
The essential ingredient giving value to geothermal resources is heat energy. It is important to keep this in mind. Heat affects the enthalpy of the geothermal fluid, which in turn determines the amount of work that can be produced. Geothermal resources are unique in this respect and therefore do not fit comfortably into the traditional classifications of water or mineral resources. Nonetheless, there has been much speculation as to whether their allocation should be governed by a property regime applicable to water or other resources. Of course, it is possible that neither allocative regime should apply due to the unique character of this resource.

This article examines the current status of the property regime governing geothermal resources and investigates alternative regimes with a view to identifying that system which promotes the most efficient allocation of resources. It is divided into two parts. This, the first part, explores the current status of proprietary claims to geothermal resources. The second part analyzes the various property regimes which might be applied to geothermal resources and proposes a system based on governmental licensing. The study begins with a brief technical discussion providing the geological and engineering information necessary to an understanding of the article. This is followed by a discussion of the property rights to geothermal resources in California's Imperial Valley.

We have selected the Imperial Valley as a microcosm for this study because the pattern of landownership in the Valley exposes the basic problems inherent in any study of the property regime for geothermal resources. A critical issue in this discussion is whether rights to geothermal resources are retained by the state and federal governments under the express mineral reservations required by the various statutes governing the patenting fully discussed in the text accompanying notes 14-67 infra. We have confined our consideration to the hot-water geothermal system, discussed in the text accompanying notes 10-19 infra, since it appears to be the most prevalent in the United States, although it may not necessarily have the greatest potential. Furthermore, it appears to pose the problem of characterization of the resource—as "water," "mineral," or sui generis—most acutely. While we believe that much of the analytical framework in this paper is applicable to other geothermal systems, an independent study of each type of system is appropriate since the physical attributes of each may warrant a different allocative regime. This is especially true with respect to the hot dry rock system which requires injection of a fluid and may also be true of the magma system. Thus any reference to geothermal resources in this study is to the hot-water system unless otherwise indicated.


Discussion of the allocative regime for geothermal resources in the private sector remains unabated. See Schlauch & Worcester, Geothermal Resources: A Primer for the Practitioner, 9 LAND AND WATER L. REV. 327, 357-61 (1974); Olpin, supra, at 137-42.

3. For reports on geothermal potential and status of development in California, see JET PROPULSION LABORATORY, REPORT ON THE STATUS OF DEVELOPMENT OF GEOTHERMAL ENERGY RESOURCES IN CALIFORNIA (1976); CAL. DEP'T OF WATER RESOURCES, WATER AND POWER FROM GEOTHERMAL RESOURCES IN CALIFORNIA, AN OVERVIEW (1974).
of land in the Valley. General mineral reservations should be construed by considering what the government intended to grant to the patentee, rather than whether it intended to reserve ownership of a specific resource. If this approach is followed, geothermal resources are included within the general mineral reservation because the purpose of patents containing such reservations is to grant only a limited estate to the patentee.

This general argument of construction is followed by a detailed analysis of proposals seeking to allocate rights to geothermal resources by classifying them as "water" or "mineral." General mineral reservations usually do not include groundwater, and for that reason some have argued that geothermal resources, a complex system of water heated by contact with hot rock, are "water" and therefore are not included within the reservations. Another approach to the problem of construing the reservations seeks to determine whether geothermal resources are "minerals" as that term is used in the reservations. Both of these rather mechanical approaches fail to consider the policies underlying mineral reservations and should be rejected in favor of the constructional approach discussed above.

Even the classification approaches, however, lead to the conclusion that geothermal resources are reserved to the patenting government. The unique characteristic of geothermal resources—heat energy—should preclude their classification as "water." Furthermore, if they are to be classified at all, geothermal resources should be classified as "mineral" because, exactly like more commonplace substances classified as minerals, geothermal resources consist of economically valuable subsurface matter not specifically excluded from the reservations.

Patents without express general mineral reservations present a more difficult problem. Although a respectable argument may be made that the federal government has impliedly reserved rights to geothermal resources underlying lands patented without an express reservation, any such argument faces serious difficulties in view of the implicit congressional assumption in the enactment of the Geothermal Steam Act of 1970\(^4\) that the federal government had not impliedly reserved these resources. This issue has not yet been definitively resolved. However, the resolution of this issue against the government would not necessarily mean that the patentee or his successor has the right to exploit the resource. Even when the government has no proprietary claims to the resource, the sovereign bears the responsibility of providing an allocative regime for the resource. The legislature may fulfill that responsibility by express definition of the nature of property rights in the resource, or the courts may do so through the development of common law property rules.

The final section of the first part of this article discusses the consequences of potential judicial or legislative determinations that the federal

government has not reserved geothermal resources underlying some or all of the lands patented by it. Two major questions are involved: first, does state or federal law govern the rights to geothermal resources; and second, should the rent from the unique resource be awarded as a windfall to surface owners? The section concludes with an argument against application to geothermal resources of the common law doctrine that surface ownership carries with it absolute ownership of all that lies beneath the surface of the land, in the absence of a severance of the mineral estate. The common law doctrine has been rejected in other areas, notably the control of percolating groundwater and airspace, in favor of a rule which protects only justified expectations of surface-related uses.

The second part of this article, to be published in the next issue of this journal, deals with the nature of the property regime which the authors believe should be considered for geothermal resources. Based on the conclusion that a sovereign can exercise substantial control over the development of geothermal resources underlying lands in private ownership through its power to define property rights, the second part seeks to define the attributes of an efficient property regime for the resource. Various regimes currently applied to geothermal resources are considered and possible leasing practices are analyzed. The regime suggested by our analysis is one in which rights to geothermal resources are assigned by license, disregarding overlying landownership. Furthermore, licenses should be issued by competitive bidding in order to assure the most efficient allocation of the rights to the resource.

II

TECHNICAL ANALYSIS OF GEOTHERMAL RESOURCES

A. Energy Sources

Most of the energy sources traditionally used by man—sunlight, wind, rivers, tides, food, wood, coal, oil, and gas—are ultimately derived from solar energy. Each year nearly $10^{25}$ joules of solar energy are received by the earth. Although nearly all of this energy is quickly re-radiated into space, a small but significant fraction is temporarily stored on or above the earth's surface as the kinetic energy of winds, rivers, and tides, and as combustible material produced by living organisms. A small part of this combustible material persists after the death of the organisms and can be preserved in sedimentary rocks for many millions of years, ultimately to be used as fossil fuels.

5. In this paper, we do not consider existing government leasing practices although we realize that the allocative effect of leasing practices merits careful study. We do, however, inferentially consider the wisdom of the kind of property rights created by existing leases, since the kind of property regime dictated by a sovereign under its regulatory power for resources underlying lands in private ownership may be equally desirable for resources underlying public lands.

6. A joule is the unit of energy or work in the International System of Units and is equal to 0.2389 calories or 9.48 x $10^4$ British thermal units.

The sun is not the only source of energy that can be used by man. The earth itself provides energy in the form of elements that can be mined and converted into energy by nuclear fusion or fission and in the form of heat produced naturally within the earth and transmitted to the surface by conduction, convection, and radiation. This last form of energy is commonly termed geothermal energy, and is transmitted naturally to the earth's surface at a rate of about $10^{21}$ joules per year.\(^8\)

Although the solar flux at the earth's surface is 10,000 times the geothermal flux, the influence of solar energy is restricted to the outer few tens of meters of the earth. At greater depths, temperatures within the earth are controlled not by the solar radiation but by the earth's own heat. Temperatures increase with depth in the earth with the average temperature gradient in the upper few kilometers\(^9\) being approximately 30°C per km.\(^{10}\) At the base of the continental crust (25 to 50 km) temperatures range from 200°C to 1,000°C and at the center of the earth temperatures may reach 3,500°C to 4,500°C.\(^{11}\)

The heat of the earth is derived from a combination of several mechanisms: 1) decay of long-lived radioactive elements, particularly uranium, thorium, and potassium; 2) chemical differentiation of the originally homogeneous earth into the present core, mantle, and crust; 3) dissipation of rotational energy as the rate of rotation of the earth decreases with time; and 4) conversion of kinetic energy to heat as the earth was accreted from primordial matter some 4.5 billion years ago. Of these four mechanisms, radioactive decay may well be the most important.\(^{12}\)

Although the amount of heat within the earth is immense, most of this heat is far too deep beneath the earth's surface to be tapped by man even under the most optimistic predictions for improvement in drilling technology. Although drilling has reached 9 km and may someday reach as much as 20 km, the depths from which heat might be extracted economically are unlikely ever to be greater than approximately 10 km. However, the amount of geothermal heat above the surface temperatures (15°C) in this outer 10 km of the earth is approximately $1.25 \times 10^{27}$ joules,\(^{13}\) which is more than 2,000 times the heat represented by the total coal resources of the world.\(^{14}\) Thus, even considering only the outer 10 km of the earth, the potential resource of geothermal energy is truly immense.

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8. Id.
9. One kilometer equals 0.6214 miles.
10. Temperatures in degrees Celsius may be converted to temperatures in degrees Fahrenheit by multiplying by 9/5 and adding 32.
B. Geothermal Resources

It is a big jump, however, from heat in the ground to energy in a form usable to man and at the place where man needs it. For the geothermal heat of the earth to be used by man, it must be extracted from the ground and transmitted to the point of use at costs competitive with alternate sources of energy. To date, four main factors have made the utilization of geothermal resources uneconomical, except locally on a small scale. First, geothermal wells, like oil wells, are expensive to drill and the expense per meter drilled increases exponentially with increasing depth. The high cost of wells drilled under present technology and economic conditions has precluded utilization of geothermal energy from depths greater than 3 km. Second, conversion of geothermal heat to electricity has proved economical only when the reservoir fluid is at least 180°C, and reservoirs at such temperatures have proved to be uncommon at depths less than 3 km.

Third, under current technology, geothermal energy extraction depends on the existence of natural permeability within the geothermal reservoir. The thermal energy in a geothermal reservoir is stored both in solid rock and in water and steam filling pores and fractures within the rock. These fluids serve to transfer heat from the rock to a well and thence to the ground surface. Under present technology and economics, rocks with too few pores or with pores that are not interconnected do not comprise an economical geothermal reservoir, however hot the rocks may be.

A final factor is that hot water and steam cannot be transmitted more than a few kilometers from the wellhead without unacceptable heat losses. Accordingly, geothermal heat either must be used at the production site or must be converted to some form of energy such as electricity that can be transmitted economically to load centers.

In summary, concentrations of geothermal heat which are economically significant at present for the production of electricity occur only where temperatures greater than about 180°C are found in permeable rocks saturated with water or steam at depths less than approximately 3 km. Therefore, under present economic conditions, only a small fraction of the immense amount of heat in the earth’s crust can properly be considered a geothermal resource.

C. Types of Geothermal Systems

Geothermal systems can be grouped into five major categories: 1) hot-water systems; 2) vapor-dominated systems; 3) geopressed systems; 4) hot dry rock; and 5) magma.

1. Hot-Water Systems

Hot-water geothermal systems contain at depth a single fluid phase, water, at temperatures that can be well above the surface boiling point because the weight of overlying fluid increases the boiling point at depth. The
The highest temperature measured to date in a hot-water geothermal system is 388°C, at Cerro Prieto, Baja California, Mexico. As the hot water flows into and up a well (figure 1) it flashes into steam, with the proportion of steam increasing as the mixture approaches the surface. The steam is separated from the water at the wellhead and is directed into a conventional, low-pressure steam turbine that drives a generator. At a separator pressure of 4.5 Kg/cm², the steam fraction ranges from 34 weight percent at a reservoir temperature of 300°C to only 7 percent at a reservoir temperature of 180°C. The remaining 66 to 93 percent of hot water is not used under present technology, and is either discarded or reinjected.

A schematic model of a hot-water geothermal system is shown in figure 2. Water serves as the medium by which heat is transferred from a deep heat source (for example, an igneous intrusion) to the geothermal reservoir, which
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Figure 2

TABLE 1
World Generating Capacity, 1975, in megawatts (electrical)

<table>
<thead>
<tr>
<th>Country</th>
<th>Field</th>
<th>Operating</th>
<th>Under Construction</th>
<th>Vapor-dominated</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>The Geysers</td>
<td>502</td>
<td>216</td>
<td>718</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>Larderello</td>
<td>380.6</td>
<td>380.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monte Amiata</td>
<td>22</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Travale</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>Wairakei</td>
<td>192</td>
<td></td>
<td></td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Kawerau</td>
<td>10</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>Matsukawa</td>
<td>22</td>
<td></td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Otake</td>
<td>13</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Onuma</td>
<td>10</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Onikobe</td>
<td>25</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hatchobaru</td>
<td></td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Takinoue</td>
<td></td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>Pathe</td>
<td>3.5</td>
<td></td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cerro Prieto</td>
<td>75</td>
<td></td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>El Salvador</td>
<td>Ahuachapan</td>
<td></td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>Tiwi</td>
<td></td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Soviet Union</td>
<td>Pauzhetsk</td>
<td>5</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paratunka</td>
<td>0.7</td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>Namafjall</td>
<td>2.5</td>
<td></td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Krafla</td>
<td></td>
<td>55</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>Kizildere</td>
<td>0.5</td>
<td>2.5</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

|              | 1278.8         | 533.5     | 1182.6             | 629.7           |
is located in the upflowing part of a major water convection system. The driving force of this convection system is gravity, effective because of the density difference between the heavier, cold, downward moving, recharge water and the lighter, hot, upward-flowing, geothermal water.

Hot-water systems are used for the generation of electricity at the localities shown in table 1. With the exception of Paratunka in the Soviet Union, these installations all use flash steam at high temperatures. Low-temperature geothermal waters (less than 180°C) are used directly in the heating and air conditioning of buildings,\(^1\) in the heating of hot-houses and soil, and in product processing.\(^1\) In addition, warm geothermal waters are widely used for bathing, recreational, and therapeutic purposes, particularly in central Europe and in Japan.\(^1\) Geothermal waters have potential use in refrigeration and freeze-drying,\(^1\) and production of fresh water by self-desalination of geothermal waters has been proposed for the hot-water geothermal systems of the Imperial Valley in California.\(^2\) Finally, some geothermal waters contain potentially valuable by-products such as potassium, lithium, calcium, and other metals.

Proposals have been made in recent years to generate electricity from geothermal waters less than 180°C using a system whereby the geothermal fluid is passed through a heat exchanger to boil a secondary fluid of lower boiling point such as isobutane or freon.\(^3\) This secondary fluid (as a gas) drives a turbine, is condensed, and then returns to the heat exchanger in a continuously circulating loop (figure 3). The geothermal fluid is not allowed to vaporize, and is returned ultimately to the ground. A generating unit based on this principal and using 81°C intake water has been operated on a pilot basis at Paratunka, Kamchatka in the Soviet Union.\(^4\) Although there has been much recent discussion of this "binary system" for the utilization of geothermal energy, the only feasibility test to date in the non-Communist world is in the Imperial valley of California, where San Diego Gas and

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Electric Company, Magma Power Company, and Magma Energy, Inc. are testing a modified scheme. The results of their tests are not yet public, and the economics of this and other binary system schemes for generating geothermal power are not known. Some published analyses are very optimistic. Other analyses are more cautious, suggesting that under most circumstances direct steam generation would be more economical than a heat-exchanger system.

2. Vapor-Dominated Systems

Vapor-dominated geothermal systems (figure 4) contain both water and steam in the pores and fractures of the rock, with steam having by far the

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greater volume and thus being the hydraulically controlling phase. During production, only steam passes into the well. This steam becomes superheated as it flows up the well and therefore need not be put through a separator before entering a turbine. The condensate from the exhaust steam is either discharged on the surface or reinjected.

Producing vapor-dominated systems are located at Lardello, Monte Amiata, and Travale in Italy, the Geysers in California, and Matsukawa and Onikobe in Japan (table 1). Vapor-dominated geothermal systems are economically attractive, but are uncommon.

Like hot-water systems, vapor-dominated systems are located on the upflowing limbs of major water-circulation systems. Vapor-dominated

26. Id. at 76.
geothermal systems appear to evolve from hot-water systems when net fluid discharge starts to exceed fluid recharge.\(^{27}\) According to one study,\(^{28}\) vapor-dominated reservoirs are unlikely to exist at pressures much greater than about 34 Kg/cm\(^2\) and temperatures much above 240\(^\circ\)C. Temperature and pressure distributions with depth in idealized hot-water and vapor-dominated geothermal systems are shown in figure 5.

![Figure 5](image)

3. **Geopressed Systems**

Geopressed systems are found primarily in rapidly subsiding basins containing young sedimentary rock. Unlike hot-water and vapor-dominated geothermal systems, the fluid found in a geopressed reservoir is not water that circulates from the surface but instead is water trapped in the sediments at the time of deposit. Owing to overlying impermeable shale beds, this water does not escape readily because the sediments are buried. It therefore remains at pressures that can approach the pressure exerted by the overlying rock.\(^{29}\) Although there is no anomalous, deep, heat source as in hot-water and vapor-dominated systems, temperatures in geopressed reservoirs are elevated, due to the trapping of the normal heat flow of the earth by the insulating water-rich geopressed sediments.\(^{30}\)

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27. *Id.* at 91.
Along the Gulf Coast of the United States, extensive drilling for oil has incidentally delimited large reservoirs of geopressed water at temperatures up to 273°C. These reservoirs have not yet been tapped commercially. Proposals have suggested not only the use of the thermal energy, but the combustion of methane contained in the water.

4. **Hot Dry Rock**

Several proposals have been advanced recently for the extraction of heat from hot dry rock, rocks that are hot but lack permeability and naturally circulating fluids. A scheme being tested by Los Alamos Scientific Laboratories involves drilling a hole to temperatures of 200 to 300°C (at perhaps 3-6 km in the western Jemez Mountains, New Mexico). The lower part of the hole is packed off and fractured hydraulically, producing a vertical crack perhaps 1 km in radius. A second drill hole is drilled to intersect the top of the crack. Cold water is pumped down the first hole, heated at depth, and withdrawn through the second hole.

Should extraction of heat from hot dry rock be proved economically feasible, the size of the nation's geothermal resources will be greatly augmented, for even at a normal geothermal gradient (30°C per km) temperatures of 300°C can be reached at 10 Km. However, there are major technical problems to be solved in the hydrofracturing, heat transfer, and crack propagation, and the economics of the proposed systems can only be guessed.

5. **Magma**

Finally, attention has been drawn to the possible extraction of the energy contained in magma (liquid rock). There is no denying that the energy contained even in a modest amount of magma such as that in the lava lake at Kilauea Iki, Hawaii, is immense, but the technical and materials problems attendant with using this energy are formidable. Some effort at Sandia Laboratories in Albuquerque, New Mexico, currently is being directed toward these problems.

D. **Geothermal Resource Potential of the United States**

Estimates of the geothermal resources of the United States differ by as

much as a million times. Although much of the disagreement reflects our lack of precise knowledge about the nature and distribution of geothermal heat in the earth, a greater part of the disagreement is due to varying usage of the term "resource" and varying (or unstated) assumptions. The assumptions that must be specified can be grouped into five categories.

1. **Uses**: Will use of geothermal energy in the United States continue to be concentrated in electrical generation, or will nonelectric uses become important?

2. **Technology**: What technological breakthroughs can be expected? Possible breakthroughs in the next few years include:
   a. Electrical generation from low-temperature hot-water geothermal systems, possibly through the use of heat exchangers and low boiling-point organic fluids.
   b. Improved or radically different drilling technology that might permit low-cost drilling of wells to depths greatly in excess of the present 3 km economic limit.
   c. Techniques of artificially fracturing hot dry rocks to allow economic extraction of the contained heat.
   d. Resolution of scaling and corrosion problems associated with high-salinity brines such as those at the Salton Sea geothermal area.

3. **Economics**: What will be the costs of geothermal power and heat, and what will be the costs of competing energy sources?

4. **Environmental protection**: Will massive extraction of geothermal heat cause environmental problems that will either preclude extraction or make extraction unduly expensive?

5. **Governmental policy**: Will leasing, taxing, regulation, and environmental policy of the government be such to stimulate the growth of the geothermal industry or to hinder it?

Assuming that governmental restrictions do not become excessive, one can predict that the next few years will see a large increase in the use of geothermal energy in the United States, both for the generation of electric power and for direct use in heating, industrial, and agricultural applications. The emerging scarcities of petroleum products, the environmental constraints on emissions from coal combustion, and the environmental delays and unexpectedly high capital costs of nuclear plants all make the relative economics of geothermal energy uses more and more attractive.

A recent study by the U.S. Geological Survey estimated recoverable

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36. For example, Pacific Gas and Electric Company in a recent submission to the California Public Utilities Commission estimated the escalated cost of power from unit No. 14 at The Geysers to be $0.00967 per kilowatt-hour at 70 percent capacity factor, whereas the comparable cost of alternative power, in this case gas-combustion turbine, was $0.01869 per kilowatt-hour. Pacific Gas and Electric Company, Application No. 54201 before the Public Utilities Commission of the State of California, Exhibit J, sheet 1 and Exhibit L, sheet 1 (1973).
geothermal resources of hydrothermal convection systems above 150 °C in the United States (expressed as electrical energy without regard for economic feasibility) to be 46,000 megawatt-centuries.\textsuperscript{37} As part of this study, Papadopulos and others estimated recoverable thermal energy from the geopressed areas of the United States (expressed as electrical energy without regard for economic feasibility) to be 24,380 megawatt-centuries.\textsuperscript{38} An equal amount of electrical energy probably can be derived from combustion of methane dissolved in the geopressed fluids. These figures can be compared with approximately 2,510 megawatt-centuries of electricity generated in the United States in 1974.\textsuperscript{39} White and Williams also estimate the recoverable geothermal resources from hydrothermal convection systems of 90 °C to 150 °C to be 3.5 x 10\textsuperscript{20} joules (for direct use as heat).\textsuperscript{40} This figure can be compared with 17-27 x 10\textsuperscript{20} joules calculated (at 6.15 x 10\textsuperscript{9} joules per barrel of crude oil) from data given by Miller and others for the total economic and subeconomic crude oil resources of the United States.\textsuperscript{41}

\textbf{E. Geothermal Resources of the Imperial Valley}

One of the most promising areas in the United States for the development of geothermal resources is the Imperial Valley of southeastern California. Drilling carried out in the Imperial Valley and in the Mexicali Valley just to the south in Mexico has demonstrated the existence of large quantities of heat in hot-water geothermal systems at depths as shallow as a few hundred meters. Despite extensive exploration and drilling during the past twelve years, though, the only area in this region yet to produce electrical power is Cerro Prieto in Mexico, which currently is producing electricity at a rate of about 75 megawatts (Mw).

The Imperial Valley and the geologically indistinguishable Mexicali Valley lie at the north end of the structural trough occupied by the Gulf of California. This trough marks the point where the East Pacific Rise (part of the worldwide net of spreading ridges) intersects the North America continent.\textsuperscript{42} It is a zone of high heat flow, recent volcanism, and hot springs. The Imperial Valley is underlain by as much as 6.4 km of silt and finegrained sand deposited by the Colorado River as part of its delta.\textsuperscript{43} The geothermal systems of the Imperial Valley occur entirely within these young, deltaic sediments.

\textsuperscript{37} Assessment of Geothermal Resources, supra note 34, at 150.
\textsuperscript{38} Papadopulos, Wallace Jr., Wesselman, & Taylor, Assessment of Onshore Geopressed-Geothermal Resources in the Northern Gulf of Mexico Basin, in Assessment of Geothermal Resources, supra note 34, at 125, 139.
\textsuperscript{40} Assessment of Geothermal Resources, supra note 34, at 150.
\textsuperscript{41} B. Miller et. al., Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States 34 (U.S. Geol. Survey Circ. No. 725, 1975).
\textsuperscript{42} Elders, Rex, Meidav, Robinson, & Biehler, Crustal Spreading in Southern California, 178 Science 15 (1972).
\textsuperscript{43} Biehler, Kovach & Allen, Geophysical Framework of Northern End of Gulf of California Structural Province, in Marine Geology of the Gulf of California—A Symposium
The location of the various geothermal systems of the Imperial Valley can best be shown by a map of near-surface temperature gradients (figure 6).

The geothermal systems appear to be discrete convective cells, with near-surface temperature gradients reflecting the buoyant upwelling of hot water. These areas of high near-surface gradients are also marked by relatively high gravity and relatively low resistivity. Many of these areas have been drilled, and geothermal resources at depth have been proven in several areas at depths of two to three km. At least 14 drill holes in the Salton Sea geothermal field have demonstrated the existence of a geothermal reservoir at temperatures up to 360°C with contained water having up to 250 grams of dissolved salts per liter. Drillholes at the East Mesa anomaly have shown temperatures to

126, 132 (T. van Andel & G. Shor Jr. eds. 1964); Merriam & Bandy, Source of Upper Cenozoic Sediments in Colorado Delta Region, 35 J. SEDIMENTARY PETROLOGY 911 (1965); Muffler & Doe, Composition and Mean Age of Detritus of the Colorado River Delta in the Salton Trough, Southeastern California, 38 J. SEDIMENTARY PETROLOGY 384 (1968).

44. ABSTRACTS WITH PROGRAMS 128 (1972); Meidav & Furgerson, Resistivity Studies of the Imperial Valley Geothermal Area, California, 1 GEOTHERMICS 47 (1972).

exceed 180°C at about 1.5 km. The geothermal systems at Heber and Brawley have also been proven by drilling, but temperatures at the Dunes geothermal system reached a maximum of 103°C at only 290 m and decreased gradually to the maximum drilled depth of 612 m. It is not known whether these geothermal systems are connected at some great depth, or whether extensive production of one system could have a detectable effect on another.

Several theories have been proposed for the origin of the geothermal waters of the Imperial Valley. White and others originally suggested that the hypersaline brines of the Salton Sea geothermal field were pure magmatic water, but later work on the oxygen and hydrogen isotopes of the water and the rocks showed the H\textsubscript{2}O of the brine to consist largely or wholly of locally derived meteoric water. The other geothermal systems of the Imperial Valley, however, appear in great part to derive their water from underflow from the Colorado River. Figure 6 shows the direction of movement of deep ground water as inferred by Dutcher and others.

The geothermal fluids in the Imperial Valley show a wide range of salinity. The Salton Sea geothermal system appears to be unique in its hypersalinity. Salinities of other geothermal systems are less than 35 grams per liter. The Salton Sea system is also unique in its content of heavy metals in the brine.

Rex concludes that there is 2000-6000 km\textsuperscript{3} of water in storage in the Imperial Valley north of the Mexican border and south of an east-west line through Westmoreland, with 40-70% of this water at temperatures greater than 260°C. Dutcher and others, however, calculate that total usable and

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49. Craig, Isotopic Composition and Origin of the Red Sea and Salton Sea Geothermal Brines, 154 SCIENCE 1544 (1966); Craig, Discussion: Source Fluids for the Salton Sea Geothermal System, 267 AM. J. SCI. 249 (1969); Clayton, Muffler, & White, Oxygen Isotope Study of Calcite and Silicates of the River Ranch No. 1 Well, Salton Sea Geothermal Field, California, 266 AM. J. SCI. 968 (1968); White, supra note 45, at 313-14; Coplen, Isotopic Geochemistry of Water From the Imperial Valley, in COOPERATIVE GEOLOGICAL—GEOPHYSICAL—GEOCHEMICAL INVESTIGATIONS OF GEOTHERMAL RESOURCES IN THE IMPERIAL VALLEY AREA OF CALIFORNIA 113, 114 (1971).

50. Coplen, supra note 49.


52. White, supra note 45; Skinner, White, Rose, & Mays, Sulfides Associated with the Salton Sea Geothermal Brine, 62 ECON. GEOL. 316 (1967); Doe, Hedge, & White, Preliminary Investigation of the Source of Lead and Strontium in Deep Geothermal Brines Underlying the Salton Sea Geothermal Area, 61 ECON. GEOL. 462 (1966).

recoverable water in the Imperial Valley beneath an area slightly larger than that assumed by Rex is only 1360 km$^3$.\textsuperscript{54} Furthermore, Dutcher and others conclude that perhaps only 247 km$^3$ of this water is at temperatures greater than 150°C and thus of significant geothermal potential.\textsuperscript{55}

Much of this discrepancy arises from Rex’s assumption that near-surface geothermal gradients in the Imperial Valley can be extrapolated linearly to a depth of 2134 m.\textsuperscript{56} This extrapolation is suspect from two points of view. The porosity of sediments in the Imperial Valley ranges from 50 percent near the surface to five percent at depth. Inasmuch as the thermal conductivity of rock is three to ten times that of water, decreased porosity will result in increased bulk thermal conductivity and, at constant heat flow, the thermal gradient must decrease. Thus, considering only conduction, temperature gradients in the Imperial Valley should decrease with depth as porosity decreases. Furthermore, any convection (and there can be no doubt that the Imperial Valley thermal anomalies are convective cells) will result in high near-surface gradients over convective cells, whereas the cells themselves will be essentially isothermal.\textsuperscript{57} Some of the discrepancy also resides in the fact that Dutcher and others used specific yield rather than porosity to calculate the amount of recoverable water from the shallower zones of the Imperial Valley.\textsuperscript{58}

The geothermal electric power potential of the Imperial Valley has therefore been the subject of much disagreement. Rex has estimated that 20,000-30,000 Mw electrical capacity could be maintained by the Imperial Valley geothermal resources (excluding the Salton Sea geothermal area), along with the simultaneous production of 6.2 km$^3$ per year of distilled water.\textsuperscript{59} Rex’s calculations are based on the assumption of linear temperature gradient extrapolation (discussed above), plus an assumption that an average well will produce 5.4 x 10$^5$ Kg/hr of steam and water.\textsuperscript{60} Results from the Bureau of Reclamation wells at East Mesa suggest that this estimated flow rate may be too high by an order of magnitude.\textsuperscript{61}

A somewhat lower estimate of the geothermal potential of the Imperial Valley is given by Stanford Research Institute.\textsuperscript{62} Basing their analysis on the

\begin{footnotesize}
\textsuperscript{54} Dutcher, Hardt, & Moyle Jr., supra note 51, at 46.
\textsuperscript{55} Id.
\textsuperscript{56} Rex, supra note 53, at 11.
\textsuperscript{57} White, Characteristics of Geothermal Resources, in Geothermal Energy 69, 72 (fig. 2) (P. Kruger & C. Otte eds. 1973).
\textsuperscript{58} Dutcher, Hardt, & Moyle Jr., supra note 51, at 41.
\textsuperscript{60} R. Rex, Investigation of the Geothermal Potential of the Lower Colorado River Basin (1968).
\end{footnotesize}
report by Dutcher and others, the authors of the SRI report suggest that the maximum electric power capacity from geothermal resources in the Imperial Valley would be 2,000-3,000 Mw. Inasmuch as Dutcher and others specifically excluded the Salton Sea geothermal field from their calculations, the potential of this field must be added to the SRI estimate (not included in it, as done by SRI). Estimates of the geothermal potential of the Salton Sea geothermal field are in the range 850-6,500 megawatts (electrical). Accordingly, the geothermal potential of the Imperial Valley including the Salton Sea geothermal field may be somewhat between 2,850 and 9,500 megawatts (electrical).

An even lower estimate of the geothermal resources of the Imperial Valley is given by White and Williams who list four fields in the Imperial Valley totalling only 1,374 megawatt-centuries (electrical).

F. Environmental Considerations

Possible environmental hazards from the production of a geothermal reservoir have been discussed by Bowen, and are exhaustively considered in the Environmental Impact Statement issued in late 1973 by the Department of the Interior in connection with the leasing of geothermal resources on federal lands. The following summary of environmental considerations is quoted from Muffler:

Considerable attention has been drawn to geothermal resources as an electrical generating mode that can have a relatively small effect on the environment. Geothermal energy does not produce atmospheric particulate pollutants as do fossil-fuel plants, and it has no potential for radioactive pollution. Geothermal modes of generating electricity do share with fossil-fuel and nuclear modes that potential

63. DUTCHER, HARDT, & MOYLE JR., supra note 51.
64. STANFORD RESEARCH INSTITUTE, supra note 62, at 283.
65. Id. at 284.
An estimate of 92,000 megawatts for 20 years presented by Austin, Higgins, & Howard, supra at 7, is based on incorrect calculations. Corrected calculations, using the same methods and assumptions as Austin, Higgins, & Howard, supra at 4-7, give a potential of 6,500 megawatts for 20 years by their total-flow concept.
67. ASSESSMENT OF GEOTHERMAL RESOURCES, supra note 34, at table 16, lists four fields in the Imperial Valley totalling only 1,374 megawatt-centuries (electrical).
70. Radon emissions have been reported recently from several geothermal fields. Stoker & Kruger, Radon in Geothermal Reservoirs, in PROC. SECOND UNITED NATIONS SYMP. ON THE DEV. AND USE OF GEOTHERMAL RESOURCES 1797-1804 (1976).
for thermal pollution; indeed, the amount of waste heat per unit of electricity generated is higher for geothermal than for either nuclear or fossil-fuel modes, owing to the low turbine efficiencies at the low geothermal steam pressures. Geothermal effluents, as well as being warm, commonly are mineralized and thus present a chemical pollution hazard to surface or ground waters. Accordingly, most if not all proposed geothermal developments in the United States plan to dispose of unwanted effluent by reinjection into the geothermal reservoir.

Other insults to the environment that are inherent in geothermal development are in large part controllable at reasonable costs. These include noise (drilling, testing, and production), gaseous emissions (particularly H\textsubscript{2}S), and industrial scars. Intensive geothermal exploitation may cause subsidence, due either to fluid withdrawal\textsuperscript{71} or to thermal contraction of rock as heat is withdrawn. Reinjection of water in fault zones may increase the incidence of earthquakes, by a mechanism similar to that demonstrated for the Rocky Mountain Arsenal well in Colorado.\textsuperscript{72}

Bowen correctly pointed out that "[t]o understand properly the impact of the production of electric power on the environment, it is necessary to evaluate more than just the power plant, whether it is geothermal, nuclear, or fossil fueled; the entire fuel cycle, from mining, processing, transportation, and the disposal of spent wastes must be considered."\textsuperscript{73} When viewed in this light, the environmental impact of geothermal generation does indeed appear to be minor compared with fossil-fuel or nuclear generation. The environmental impact of geothermal generation is restricted to the generating site, whereas much of the environmental impact of other modes of generating takes place at other sites (mines, processing plants, disposal sites) and is commonly neglected in the evaluation of environmental impact of a power plant.

The possible environmental impacts that could result from development of geothermal resources in the Imperial Valley were thoroughly evaluated by the Department of the Interior.\textsuperscript{74} Of particular interest is the section in the Department’s environmental impact statement on land subsidence and induced seismic activity.\textsuperscript{75} The potential adverse effect of subsidence on the irrigation canals, drainage ditches, and tile drains in the Imperial Valley has been recognized by all concerned. Monitoring of land surface movement was begun in 1972 as a cooperative venture among private industry and various federal, state, and local agencies. Reinjection of spent geothermal fluids is

\textsuperscript{71} Hunt, Gravity Changes at Wairakei Geothermal Field, New Zealand, 81 GEOL. SOC. AM. BULL. 529 (1970).
\textsuperscript{72} Healy, Rubey, Griggs, & Raleigh, The Denver Earthquakes, 161 SCIENCE 1301 (1968).
\textsuperscript{73} Bowen, \textit{supra} note 68.
\textsuperscript{74} II DEP'T OF THE INTERIOR, FINAL ENVIRONMENTAL IMPACT STATEMENT FOR THE GEO- THERMAL LEASING PROGRAM v-299-v-445 (1973).
\textsuperscript{75} \textit{Id.} at v-379—v-381.
envisaged as the means of maintaining subsurface fluid pressures and thus preventing subsidence. The success of such a program will depend on achieving a delicate balance between maintaining reservoir pressure on one hand while not significantly cooling the reservoir on the other hand. Reinjection far from the producing area will avoid thermal degradation, but will result in unavoidable subsidence in the producing field. Subsidence probably can be minimized by reinjection throughout the producing field, but at the cost of decline in temperature of produced geothermal fluids. In addition, chemical reaction between spent brines and the rocks into which they are injected could precipitate minerals in the pores of the rock and thus reduce porosity. The magnitude of this effect is unknown, and will be critically dependent on the specific chemistry of fluid and solid.

Successful reinjection of spent brine is clearly the key to the development of the geothermal resources of the Imperial Valley. Neither the economics nor the environmental effect of reinjection is certain, though, and extensive field experimentation probably will be required before feasibility is demonstrated.

III

FEDERAL RIGHTS TO GEOTHERMAL RESOURCES IN PATENTED LANDS

A. The Relevant Statutes

According to a government report, three heat anomalies have been identified under lands in nonfederal ownership in the Imperial Valley. Because most, if not all, of the nonfederal lands in the Imperial Valley trace their title to federal patents, any inquiry concerning rights to geothermal resources underlying nonfederal lands must begin with an examination of these patents.

Federal patents to lands in the Imperial Valley may be classified into three categories. The first category includes patents under statutes permitting transfers from the federal government if the lands are nonmineral in character. Entries under the Homestead Act and Desert Land Act and the grants to a railroad and the state fall within this category. Under these laws


77. Although we have obtained information regarding the principal federal statutes under which the lands in the Imperial Valley have been patented, letter from G.W. Nielsen of Bureau of Land Management, U.S. Dept of the Interior (Jan. 26, 1973), we do not have information concerning the specific federal statutes which apply to lands in which the heat anomalies occur.


81. Act of Mar. 3, 1853, ch. 145, 10 Stat. 244. Sections six and seven of this act granted sections 16 and 36 of each township to California for school purposes, but if those township
a grant may be made only if the land is nonmineral, determined as of the time the right to the land vests. If the land is nonmineral, it is patented without any reservation of minerals, and the federal government has no right to minerals discovered in the land subsequent to the patent.

Sections were not available because of settlement before survey, reservation, or private claims, the state was entitled to select other lands.

Relevant statutes which do not permit grants if the land is mineral in character are as follows:

Homestead: A general provision withdrawing mineral lands from entry and settlement under various homestead acts seems first to have appeared in Revised Statutes § 2302 (derived from Act of June 21, 1866, ch. 127, § 1, 14 Stat 67). This provision now is found in 43 U.S.C. § 201 (1970).


Railroad grant: Act of Mar. 3, 1871, ch. 122, § 9, 16 Stat. 576 (mineral lands are not granted but iron and coal are excepted from the term "mineral"). However, the United States has reserved the minerals under the right-of-way. Cf. United States v. Union Pac. R.R., 353 U.S. 112 (1957).

State school grant: Although the Act of Mar. 3, 1853, ch. 145, 10 Stat. 244, does not seem to except mineral lands explicitly, the act has been construed to except mineral lands. Mining Co. v. Consolidated Mining Co., 102 U.S. 167 (1880); United States v. Sweet, 245 U.S. 563 (1918) (construing the grant to Utah).

It seems clear under any of the acts involved here that, in the absence of fraud or other similar fact, the government cannot assert a right to minerals after the land has been patented as nonmineral. Cf. Shaw v. Kellogg, 170 U.S. 312 (1898); Davis' Administrator v. Weibbold, 139 U.S. 507 (1891); Colorado Coal and Iron Co. v. United States, 123 U.S. 307 (1887). As to whether rights of the grantee can vest, insofar as the issue of mineral character is concerned, before the patent is issued, see Wyoming v. United States, 255 U.S. 489 (1921); as to railroad grants, see Barden v. Northern Pac. R.R., 154 U.S. 288 (1894). The standard for determining the mineral character is that the land must be known when patented to be valuable for minerals. Deffeback v. Hawke, 115 U.S. 392 (1885).

Under these statutes the Department of the Interior does not seem to have authority to make reservations if the lands are determined to be nonmineral at the critical time. Cf. Burke v. Southern Pac. R.R., 234 U.S. 669 (1914).

According to the U.S. Supreme Court, Congress made this distinction between mineral and nonmineral lands simply to establish different methods of disposal. United States v. Sweet, 245 U.S. 563 (1918). However, in a case involving a railroad land grant, the Court delayed the determination of the mineral character of the land until the time of patent rather than at the time of location of the railroad routes because of the possibility of vast mineral riches in the generous land grants to railroads. Barden v. Northern Pac. R.R., 154 U.S. 288, 326-32 (1894). For a history of federal land and mineral disposition policies, see P. Gates, HISTORY OF PUBLIC LAND LAW DEVELOPMENT (1968); B. Hibbard, PUBLIC LAND POLICIES (1965). See also Greene, Promised Land: A Contemporary Critique of Distribution of Public Land by the United States, 5 Ecology L.Q. 707, 709-43 (1976).

In constructing the dichotomy between "mineral and thus no patent" and "nonmineral and thus patent without any reservation," the Court concluded that Congress could not have meant that the patent is retroactively voided because of subsequent discovery of minerals. See Shaw v. Kellogg, 170 U.S. 312 (1898). In Davis' Administrator v. Weibbold, 139 U.S. 507 (1891), the Court reasoned that the dichotomy was necessary to protect the patent holder against prospecting miners. An innovative result could have been reached by reasoning that the intent of Congress was to reserve the minerals but that subsequent mineral explorers or developers would be liable for any injury to the surface estate.


It should not be assumed that all entries are based on this "all or nothing at all" principle. Since 1910 unreserved lands (exclusive of Alaska) which have been withdrawn or classified as
In the second category are those statutes which require a reservation of minerals to the United States without regard to the mineral character of the land at the time of disposition. These statutes include the Stock Raising Homestead Act 86 and the Recreation Act of 1926.87 The Stock Raising Homestead Act reserves "all the coal and other minerals" to the United States. The Recreation Act permits the disposal of public lands to governmental entities for a public purpose and to nonprofit organizations for a recreational or public purpose but with a reservation of "all mineral deposits." 88

The third category consists of exchanges made under the Taylor Grazing Act. 89 Under this Act, the Secretary of the Interior is authorized to make certain exchanges of federal lands for nonfederal lands. Where exchanges are made on the basis of equal value, either party may reserve minerals. 90 Where exchanges are made with a state on the basis of equal acreage, the Secretary is required to reserve all minerals to the United States if the land to be conveyed by the United States is mineral in character. 91 Since information has not been acquired as to whether there has been any reservation of minerals under the Taylor Grazing Act, there will be no discussion of the lands transferred by the United States under this statute. 92

B. Geothermal Resource Rights Under Federal Mineral Reservations

The Stock Raising Homestead Act reserves "all the coal and other minerals" to the United States; 93 the Recreation Act of 1926 reserves "all mineral deposits." 94 The issue is whether geothermal resources are included within these reservations.

1. Stock Raising Homestead Act

a. The Department of the Interior's position

By 1965, the Department of the Interior had concluded that geothermal coal lands may be entered under some other entry law subject to a reservation of coal to the United States. 30 U.S.C. § 83 (1970). Since 1914 lands withdrawn or classified as containing phosphate, nitrate, potash, oil, gas, or asphaltic minerals have been made subject to selection, entry, or purchase with a reservation of such deposits to the United States. 30 U.S.C. § 121 (1970).


88. The patents under the Stock Raising Homestead Act are required by regulation to contain a reservation in the language of the statute, 43 C.F.R. § 2093.5-1 (a) (1975). No similar regulation is found for the Recreation Act of 1926, but the statute would control in any event. See Mall, supra note 86, at 11.


90. Id. § 315g(d).

91. Id. § 315g(c).

92. Although lands may have been patented under other acts, a discussion of those listed above will expose the major issues.


94. Id. § 869-1.
steam is not reserved to the United States under the Stock Raising Homestead Act. It reasoned that "geothermal steam is developed from hot spring systems and . . . the dominant component in these systems is meteoric water;" geothermal steam is "essentially just subterranean water heated to a high temperature." While water is normally classified as a mineral, it differs from other minerals and must be treated differently from a legal standpoint; furthermore, "[w]ater has not been treated as a mineral in the public land laws."

The Department’s analysis is too facile. Its position stands or falls on the characterization of geothermal steam as water. Yet this analysis fails to perceive the functional difference between ordinary percolating water and geothermal steam. Consequently, the cases relied upon by the Department are readily distinguishable. Erickson v. Crookston Waterworks, Power & Light Co. was cited for the proposition that water must be treated differently because it differs from other minerals. Erickson involved the allocative regime for percolating groundwater among competing users. The Minnesota Supreme Court recognized water as a mineral but refused to apply the law governing either hard minerals or oil and gas. The latter products are primarily commodities of commerce, whereas water, although also a commodity of commerce, frequently is essential to the use of land for agriculture and other purposes as well as to the support of human life. The court rejected the absolute ownership doctrine in favor of the reasonable use rule so that water would not be subject to monopoly control. The functional difference between percolating groundwater and other minerals was of critical importance to the Erickson court in adopting a different allocative regime.


96. Id.

97. Id. at 16. The letter opinion states, however, that "[a]ny minerals connected with the geothermal steam would . . . appear to be subject to the mineral reservation." Id. Another exception noted as a possibility is that a patent under the Stock Raising Homestead Act of land which has been withdrawn by the President as a hot spring or a spring with curative properties might not be authorized. For a contrary position by J.H. Loeb, counsel for Signal Oil and Gas Co., see Hearings on H.R. 7334, H.R. 10204, S. 1674 Before the Subcomm. on Mines and Mining of the House Comm. on Interior and Insular Affairs, 89th Cong., 2d Sess., ser. 89-35, at 197 (1966) [hereinafter cited as Hearings on H.R.7334].


98. 100 Minn. 481, 111 N.W. 391 (1907).
Having established that water is to be treated differently from minerals, the Department of the Interior cited cases holding that a mineral reservation does not include ordinary groundwater. Of course, these authorities are persuasive only if the Department is correct in contending that a geothermal resource is ordinary water. The only case cited by the Department which may support that critical premise is Hathorn v. Natural Carbonic Gas Co., which applied water allocation law to mineral waters containing carbonic acid gas. However, the problem faced in Hathorn was whether the allocative regime applicable to percolating groundwater used for agriculture and human consumption should apply to mineral waters exploited commercially. In contrast, the problem we face is whether, as a matter of construction, a particular resource falls within the terms of mineral reservations in various federal patents.

b. The Union Oil case

Because of the uncertainty with respect to the scope of the mineral reservations, Congress in 1970 directed the Attorney General to institute proceedings to quiet title of the United States to geothermal resources "in lands the surface of which has passed from Federal ownership but in which the minerals have been reserved to the United States . . . ." One such suit

99. Three cases are mentioned by the Department for the proposition that a mineral reservation does not include water. Fleming Foundation v. Texaco, Inc., 337 S.W.2d 846 (Tex. Civ. App. 1960) (criticized in 49 CALIF. L. REV. 763 (1961)), involved the right to ordinary groundwater under a private reservation of oil, gas, and other minerals. With the help of three constructional aids, the court concluded that water was not included in the reservation. First, the court held that the rule of *ejusdem generis* applied; second, that the deed would be construed against the grantor; and finally, that the meaning of minerals was to be determined according to the "vernacular of the mining and mineral industry, the commercial world and the land owners at the time of the grant . . . ." 337 S.W.2d at 852.

Mack Oil Co. v. Laurence, 389 P.2d 955 (Okla. 1964), is the second case. The court, relying upon Erickson v. Crookston Waterworks, Power & Light Co., 100 Minn. 481, 111 N.W. 391 (1907), held that ordinary groundwater was not included in a private reservation of "all mineral rights."

The third case, Estate of O’Brien v. United States, 8 OIL & GAS REP. 845 (N.D. Tex. 1957), sheds even less light. The results in these cases are not surprising since water ordinarily is necessary for the enjoyment of the surface estate.

In Vogel v. Cobb, 193 Okla. 64, 141 P.2d 276 (1943), the court, while recognizing that water is mineral, held that it was not included in a reservation of specific minerals as well as "other minerals." The court applied the rule of *ejusdem generis* in construing the reservation and reasoned:

The minerals specifically named in the deeds (coal, oil, petroleum, gas and asphalt) are of a species or class which does not include water. The former are valuable minerals of a somewhat similar chemical composition, existing in limited amounts, which are ordinarily extracted from the earth and sold for profit, but which serve no useful function in connection with the use and enjoyment of the surface. Water, on the other hand, is of a quite a different chemical composition, is not ordinarily thought of as valuable, but is necessary to life and the use and enjoyment of the surface.

Id. at 68, 141 P.2d at 280.

100. 194 N.Y. 326, 87 N.E. 504 (1909).

was *United States v. Union Oil Co.*, wherein the United States sought declaratory relief concerning its ownership of the geothermal steam in The Geysers area of California where lands had been patented under the Stock Raising Homestead Act. The matter now is on appeal before the Ninth Circuit Court of Appeals following the district court’s dismissal of the government’s complaint.

In the *Union Oil* case, the government argued that the history of public land disposal demonstrates that Congress provided different methods of disposal for surface estates and mineral resources. Consistent with the above policy, Congress under the Stock Raising Homestead Act “intended to grant only an estate limited to the use reasonably necessary to serve the purpose of the surface ownership.” Because the patentee received only a limited surface estate and the United States retained title to the entire subsurface estate, geothermal resources belong to the United States as part of the subsurface estate. The government further argued that geothermal resources should be included within the reservation because the method of production and the use of geothermal resources are similar to the production and use of oil and gas.

The district court, while acknowledging the constructional preference in favor of the United States, reviewed the history of the Stock Raising Homestead Act and concluded that Congress, rather than giving only a limited surface estate, intended to grant to the patentee the fee title to the land except for the minerals. After establishing the premise that water is not considered to be mineral, the court characterized geothermal steam as superheated water and concluded that geothermal steam is not a mineral. Moreover, the court gave deference to the Department of the Interior’s position that geothermal steam was not within the reservation.

Analysis of the *Union Oil* opinion must begin with the purpose of the Stock Raising Homestead Act, which was to open for homestead entries public land “chiefly valuable for grazing and raising forage crops.”

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104. *Id.* at 17.

105. *Id.* at 20-22.

106. *Id.* at 23-24.


108. *Id.* at 1293-95.

109. *Id.* at 1296-99. The district court, without further elaboration, concluded that section 9 of the Stock Raising Homestead Act referred to minerals which were locatable under the mining laws and geothermal resources which were not locatable. This conclusion was based on the Department of the Interior’s position that a geothermal resource is not a mineral within a mineral reservation or the mining laws.

reserving "all the coal and other minerals." 111 In Skeen v. Lynch, 112 a 1931 case construing the Act, the Tenth Circuit stated in a dictum that it was the purpose of Congress in the use of the phrase "all coal and other minerals" to segregate the two estates, the surface for stock-raising and agricultural purposes from the mineral estate, and to grant the former to entrymen and to reserve all the latter to the United States. 113

However, in State ex rel. State Highway Commission v. Trujillo, 114 the New Mexico Supreme Court disagreed with the "two estates" or "surface only" theory on the ground that the adoption of that theory would lead to the absurd result that the patentee would not be able to use the soil to grow grass, build a stock tank, or take groundwater. The New Mexico court held that materials which do not have exceptional characteristics or value when compared to the surrounding soil, which form a part of the surface, or which cannot be removed without destroying the surface, are not "minerals" within the reservation. 115 Thus, exposed rocks to be used as gravel for road building purposes were held to be excluded from the reservation.

The conflict presented by these two contradictory constructions of the mineral reservations is more apparent than real. The Trujillo court took the "two estate" theory much too literally. The theory permits the patentee to enjoy the use of the surface and of those substances connected with the enjoyment of the surface for stockraising and agricultural pursuits. 116 Moreover, to the extent that the Trujillo court suggested that the reservation includes only those substances which can be removed without destruction of the surface, the court was in error, since that approach would exclude from the reservation coal or other minerals which can be removed economically only by open mining. Finally, the court made no reference to Northern Pacific Railway v. Soderberg, 117 in which the Supreme Court, construing a congressional land grant in another context, held that granite, valuable as a building stone, was a mineral.

Unfortunately, the government's argument in the Union Oil case also appeared to focus upon a false issue, namely, whether, in enacting the Stock Raising Homestead Act, Congress made a horizontal separation of land and created two estates so that a patentee would not have any subsurface rights.

112. 48 F.2d 1044 (10th Cir. 1931).
113. Id. at 1046. The court also had no doubt that oil and gas were reserved under the Act.
114. 82 N.M. 694, 487 P.2d 122 (1971).
116. It should be noted that the statute protects the patentee from subsequent mineral development by compensating him for "damages to the crops or tangible improvements." 43 U.S.C. § 299 (1970). The court did not mention this section in its opinion. The Department of the Interior has seized upon the above provision as indicative of congressional intent that sand and gravel at or near the surface should be within the mineral reservation. United States v. Isbell Constr. Co., 78 I.D. 385 (1971).
117. 188 U.S. 526 (1903).
Although it disposed of this issue correctly, the *Union Oil* court erroneously emphasized what the government had reserved rather than what the government intended to grant. Logically, a determination of one will define the extent of the other. But had the court looked to the purpose as well as the bare words of the Stock Raising Homestead Act, a different conclusion would have been indicated.

c. Congressional intent as a means of construing the reservation

In order to continue with the examination of the Act’s purpose, a constructional aid must be emphasized. While the existing case law does not resolve the status of geothermal resources, the following observations can be made. Since the word “mineral” does not have a precise meaning when used in conveyancing, the courts, where the intent of the parties is not clear, have relied upon rules of construction. The rule concerning private grants construes the instrument strictly against the grantor, but the Supreme Court has on many occasions announced a rule of construction of federal grants in favor of the government. The Court has stated:

> [G]rants for the sovereign should receive a strict construction—a construction which shall support the claim of the government rather than that of the individual. Nothing passes by implication, and unless the language of the grant be clear and explicit as to the property conveyed, that construction will be adopted which favors the sovereign rather than the grantee.

Keeping these principles in mind, we may proceed by analyzing the Stock Raising Homestead Act. There is very little help in the statute’s legislative history. The following statement with reference to the reservation, however, is found in a House report: “The purpose of [the section making the reservation] is to limit the operation of this bill strictly to the surface of the lands described and to reserve to the United States the ownership and right to dispose of all minerals underlying the surface thereof.”

The Stock Raising Homestead Act itself discloses a precise congressional purpose to patent lands the surface of which is . . . chiefly valuable for granting and raising forage crops, do not contain merchantable timber, are not susceptible

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120. Northern Pac. Ry. v. Soderberg, 188 U.S. 526, 534 (1903). *See also* United States v. Union Pac. R.R., 353 U.S. 112 (1957); Shively v. Bowlby, 152 U.S. 1 (1894). The Supreme Court has been quite protective of federal interests in minerals. In United States v. Sweet, 245 U.S. 563 (1918), the Court held that mineral lands were excluded from school land grants even though the statute was silent as to the matter, the Court relying on the general mineral disposal scheme adopted by Congress. In United States v. Union Pac. R.R., *supra*, the Court read into the railroad grant a reservation of minerals in the right-of-way.

of irrigation from any known source of water supply, and are of such character that six hundred and forty acres are reasonably required for the support of a family.\(^{122}\)

A further indication of congressional intent is the provision in the original Act that entitles surface entrymen to compensation for damages to crops and tangible improvements caused by prospecting or mining under the mineral reservation.\(^{123}\) The Open Pit Mining Act of 1949\(^{124}\) later provided for compensation for the value of the land for grazing purposes if damages were caused by strip or open pit mining. The above provisions, intended to accommodate the interests of the surface entrymen, are drafted in terms of crops, tangible improvements which probably are restricted to agricultural improvements,\(^{125}\) and grazing value of the land.\(^{126}\) The agricultural purpose of the Act is thus apparent.

The methodology of resolving the meaning of the reservation urged by Kuntz\(^{127}\) is eminently reasonable. He observes that the cases construing mineral reservations are in conflict because the courts seek to determine an intent regarding each specific substance. He argues that the courts ought to focus instead upon general intent by considering the purposes of the grant or reservation in terms of the manner of enjoyment of the respective interests.

The manner of enjoyment of the mineral estate is through extraction of valuable substances, and the enjoyment of the surface is through retention of such substances as are necessary for the use of the surface, and these respective modes of enjoyment must be considered in arriving at the proper subject matter for each estate.

Applying this intention, the severance should be construed to sever from the surface all substances presently valuable in themselves, apart from the soil, whether their presence is known or not, and all substances which become valuable through development of the arts and sciences, and that nothing presently or prospectively valuable as extracted substances would be intended to be excluded from the mineral estate.\(^{128}\)

\(^{123}\) Id. § 299.
\(^{125}\) Cf. Kinney-Coastal Oil Co. v. Keiffer, 277 U.S. 488, 505 (1928), construing the damage entitlement of the surface entrymen to "crops and improvement" from mining operations under an act similar to the Stock Raising Homestead Act as referring to agricultural improvements by referring to the title of the act and also the use of the term "improvements" with reference to "crops." For a more complete discussion of damage entitlement of the surface entrymen, see Mall, supra note 86, at 15-35.

\(^{126}\) Of course, the extent to which the servient tenement is entitled to compensation under the statute cannot conclusively determine what the mineral interest is, nor does it suggest that the surface ownership is restricted to agricultural uses, but the damage entitlement provision to protect surface entrymen is another factor to consider in determining the purpose of the Stock Raising Homestead Act.

\(^{127}\) Kuntz, supra note 118, at 112.

\(^{128}\) Id. at 112-13. In Acker v. Gunn, 464 S.W.2d 348, 352 (Tex. 1971), the court adopted Professor Kuntz's approach and held that iron ore was not included in a grant of "oil, gas and other minerals" inasmuch as surface mining of iron ore would destroy the surface.
The same approach has been taken by Geraud with respect to federal mineral reservations,\textsuperscript{129} and was adopted in \textit{Skeen v. Lynch}.\textsuperscript{130} Thus, applying this construction of the reservation, geothermal resources—however classified in other contexts—would be included in the reservation since they are not associated with the use of the land for grazing and raising forage crops, especially when the resources have a high mineral content.\textsuperscript{131}

d. \textit{Classification of geothermal resources as “minerals”}

If, however, the \textit{Trujillo} case is the correct statement of the law,\textsuperscript{132} it becomes necessary to determine whether a geothermal resource fits within the term “minerals.” The Supreme Court has noted that ordinary dictionary definitions are of little use in construing mineral reservations.\textsuperscript{133} The scientific division of all matter into the animal, vegetable, or mineral kingdom is equally unhelpful since all lands belong to the mineral kingdom and therefore could not be excepted from the grant without destroying it.\textsuperscript{134} In holding that granite was a mineral excepted from a railroad grant, the Supreme Court concluded that “mineral lands include not merely metalliferous lands, but all such as are chiefly valuable for their deposits of a mineral character, which are useful . . . for purposes of manufacture.”\textsuperscript{135} Another court has adopted the following test from a well-recognized text:

The mineral character of the land is established when it is shown to have upon it or within it such a substance as: (a) Is recognized as a mineral according to its chemical composition, by the standard authorities on the subject, or (b) Is classified as a mineral product in trade or commerce, or (c) Such a substance (other than mere surface which may be used for agricultural purposes) as possesses economic

\textsuperscript{130} 48 F.2d 1044, 1046-47 (10th Cir. 1931).
\textsuperscript{131} In Geothermal Kinetics, Inc. v. Union Oil Co., No. 75314, intended decision at 16 (Sonoma Co. Super. Ct., May 28, 1976), the court was faced with an issue identical to that in \textit{United States v. Union Oil Co.}, namely, whether a private grant of “all minerals” included geothermal resources. The court initially acknowledged that neither the language nor the specific intention of the parties was helpful since the resource was unique and was not contemplated at the time of the grant. Relying upon the general purpose of the grant, the court concluded that the resource was within the mineral grant and was not water which appertained to the surface estate. It reasoned as follows:

As a resource, a geothermal system possesses those characteristics and qualities which have long been considered by the courts as belonging to the owner of the mineral estate. First, the heat itself is a direct product of molten minerals and the fluids and gases produced therefrom. Second, the resource is separate and distinct from the soil, rock and water systems which lie above it. Third, the resource is valuable for its own sake in producing energy and thus far has not been shown to have any significant value for any other purpose. Fourth, the resource is extracted by drilling for it in much the same manner as drilling for oil and gas. Finally, its extraction does not materially interfere with the enjoyment of the surface.

\textsuperscript{132} See text accompanying notes 114-17 supra.
\textsuperscript{133} Northern Pac. Ry. v. Soderberg, 188 U.S. 526, 530 (1903).
\textsuperscript{134} \textit{Id}.
\textsuperscript{135} \textit{Id.} at 536-37.
value for use in trade, manufacture, the sciences, or in the mechanical or ornamental arts.136

Under either test, the term "mineral" includes a substance of mineral character, broadly defined, which is commercially valuable when extracted from the land, but excludes ordinary materials commonly associated with surface use.137

As explained earlier, the value of geothermal resources derives primarily from the heat energy that is converted to work to produce electricity.138 Additionally, in the Imperial Valley the heat energy may make feasible the demineralization of fluid for normal water uses. The internal energy in the hot fluid is as much a physical characteristic of the substance as is the chemical energy stored in oil, coal, or oil shale. If the fluid were most valuable for the extraction of calcium chloride in solution,139 one would not hesitate to characterize the composite of the substance as a mineral just as ore which

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137. One writer has concluded:

[C]ourts have developed a non-scientific definition of minerals, which includes any substance that has sufficient commercial value to be extracted from the earth for its own sake or for its own special purposes. . . . Judicial concern for the surface owner's right to the normal use of his land, including the right to use water, has apparently led the courts to disregard the possibility of water being used for commercial purposes. . . . The application of the commercial value test to any substance claimed to be withheld from a grant by a general mineral reservation would avoid the need to rely upon rules of construction purporting to ascertain an often unformulated intent.

49 CALIF. L. REV. 763, 766-67 (1961). The writer concludes that ordinary percolating groundwater should be classified as mineral where water has commercial value apart from the land, although the surface owner would still have the right to water to the extent needed for use and enjoyment of the land.

138. Olpin, supra note 2, at 141, argues:

Geothermal steam is a source of energy just as fossil fuels such as oil, gas and coal are sources of energy. Any water produced as a byproduct of the geothermal process is likely to be contaminated by mineral solutions which render the water unusable for the purposes of the surface estate. Courts are obliged to take into account considerations such as these, and the answer should not be so mechanical as to yield the result that the surface owner owns geothermal resources simply because the primary component is water.

During congressional hearings in 1966, Congressman Hosmer recognized that geothermal steam has unique properties in that the prime product of geothermal steam is heat energy, and thus is distinguishable from hydroelectric power generation which depends upon the kinetic energy of falling water; however, he expressed doubts as to whether the heat energy could be defined as a mineral. Hearings on H.R. 7334, supra note 97, at 168-69, 183.

139. In Robinson v. Robbins Petroleum Corp., 501 S.W.2d 865 (Tex. 1973), the court faced the issue of whether salt water was reserved under "oil, gas, and all other minerals," and refused to make a distinction between salt water and fresh water since water is never absolutely pure. The court held that water would not be within the reservation but that there was an implied right of use for oil extraction. The court noted, however:

If a mineral in solution or suspension were of such value or character as to justify production of the water for the extraction and use of the mineral content, we would have a different case. The substance extracted might well be the property of the mineral owner, and he might be entitled to use the water for purposes of production of the mineral.

501 S.W.2d at 867.
contains iron would be so classified. Similarly, a fluid containing economically valuable heat energy is so different from ordinary water that it should be classified as a mineral for the purposes of the reservation despite its meteoric origin. Even the Department of the Interior has conceded that water is normally classified as a mineral.\footnote{140}

An alternative argument treats the hot rock itself as the mineral which is within the reservation\footnote{141} and thus the liquid is impliedly reserved because it is necessary to extract the energy from the hot rock.\footnote{142} This approach, although plausible, is unsatisfactory since there is no more reason to select rock as the vital resource for classification purposes than there is to select the fluid. It is the integral system that permits the extraction of valuable heat energy. While it is true that the natural presence of fluid is not essential to the extraction of heat, as demonstrated by the hot dry rock system,\footnote{143} nevertheless, exploitation of the hot dry rock system depends on artificial injection of fluid for heat transmittal, and, consequently, the natural existence of the fluid in hot-water systems does make the resource more valuable.

Thus, the inclusion of geothermal resources within the Stock Raising Homestead Act reservation would not be inconsistent with the Trujillo case, even granting its premise, since such resources possess "exceptional characteristics or value which distinguish them from the surrounding soil" and they do not form a part of the surface nor does their development inevitably destroy the surface. In summary, the case for classifying geothermal resources as minerals within the reservation of the Stock Raising Homestead Act is compelling.

2. Recreation Act of 1926

The Recreation Act of 1926 seems to evince a clear intent to grant a limited interest to those receiving federal lands under its provisions. As originally enacted,\footnote{144} the Act permitted nonmineral land classified as "chief-

\footnote{140. Interior Letters, \textit{supra} note 95.}
\footnote{141. Bjorge, \textit{supra} note 102, at 22, argues that dry hot rock would certainly be considered a mineral and that for the purposes of the reservation it should not make any difference whether or not the resource is a fluid system.}
\footnote{142. In Sun Oil Co. v. Whitaker, 483 S.W.2d 808 (Tex. 1972), which held that an oil and gas lessee had the right to use fresh water for water flooding purposes even though the use of water adversely affected the surface owner, the court stated the rule:}
\begin{quote}
The oil and gas lessee's estate is the dominant estate and the lessee has an implied grant, absent an express provision for payment, of free use of such part and so much of the premises as is reasonably necessary to effectuate the purposes of the lease, having due regard for the rights of the owner of the surface estate. . . .
\end{quote}
\begin{quote}
The implied grant of reasonable use extends to and includes the right to use water from the leased premises in such amount as may be reasonably necessary to carry out the lessee's operations under the lease.
\end{quote}
\footnote{483 S.W.2d at 810-11. \textit{Accord}, Robinson v. Robbins Petroleum Corp., 501 S.W.2d 865 (Tex. 1973) (use of salt water for flooding purposes but limited to use for recovery of oil from the leased premises); Holt v. Southwest Antioch Sand Unit, 292 P.2d 998 (Okla. 1956).
}
\footnote{143. See text accompanying notes 32-33 \textit{supra}.}
\footnote{144. Act of June 14, 1926, ch. 578, 44:2 Stat. 741.}
ly valuable for recreational purposes"145 to be exchanged for other lands owned by a state or to be sold or leased to a state or its political subdivision. The statute originally subjected every transfer to a reservation to the United States of "all mineral deposits" and to a reversion to the United States if the transferred land were not used for park or recreational purposes. A subsequent amendment in 1954146 broadened the purposes for which lands could be transferred to include "any public purpose,"147 and enlarged the class of transferees to include nonprofit associations.

Although the meaning of "any public purpose" is not clear and there are transfers which are subject to the limited reversion, the original purpose of the Act—permitting transfers for recreational purposes coupled with a reversion if used for other purposes—suggests that the inquiry should be directed at what Congress intended the grantee to receive rather than whether geothermal steam is technically a mineral. Discussion of the latter issue is unnecessary here since the status of geothermal steam as a mineral under the Recreation Act can be analyzed along the lines previously suggested in the discussion of the Stock Raising Homestead Act.148

IV
CALIFORNIA'S GEOTHERMAL RESOURCE RIGHTS
UNDER STATE MINERAL RESERVATIONS

California originally provided by statute that the sale of any state lands would be subject to the reservation of "all oil; gas, oil shale, coal, phosphate, sodium, gold, silver, and all other mineral deposits ..."149 In 1947, the statute was amended to make it clear that

145. Id. 44:2 Stat. 741-42.
147. Id. The period of reversion was limited to 25 years. Id. §§ 3-4, 68 Stat. 175. In 1959 the limitation on reversion was repealed so that the reversion is again in perpetuity. Act of Sept. 21, 1959, Pub. L. No. 86-292, § 2, 73 Stat. 571. 43 U.S.C. § 869-3 (1970) provides for a limited reversion of 25 years where the Secretary has approved a transfer or a change in use; but this provision was intended to operate only with respect to outstanding patents so as to permit them to be changed into a more flexible form with a limited reversion similar to the patents issued subsequent to the amendment. H.R. Rep. No. 353, 83d Cong., 1st Sess. 5 (1953). The repeal of the limited reversion operates only with respect to transfers after the 1959 amendment. H.R. Rep. No. 738, 86th Cong., 1st Sess. 3 (1959). Thus, there can be grants with limited reversions outstanding even after the 1959 amendment.
148. See text accompanying notes 93-126 supra.
149. CAL. PUB. RES. CODE § 6401 (West 1956). Certain property is excepted from the required reservation. Id. § 6403; and upon a finding by the State Lands Commission that there are no known deposits of commercially valuable minerals within 500 feet below the surface, the Commission may give up the rights to the use of surface or within the 500 feet subsurface to permit the orderly development of the land. Id. § 6401(b) (West Supp. 1976). The person who acquires from the state the right to extract the resources is liable to the surface owner for damages to the crops or tangible improvements even where the state has not given up the mining easement mentioned in the previous sentence. Id § 6401(a).

The federal government in 1927 reversed its previous policy of withholding mineral lands
mineral deposits reserved to the State shall include all mineral deposits in lands belonging to or which may become the property of the State, including but not limited to oil, gas, oil shale, coal, phosphate, alumina, silica, fossils of all geological ages, sodium, gold, silver, metals and their compounds, alkali, alkali earth, sand, clay, gravel, salts and mineral waters.\textsuperscript{150}

In 1975 the section again was amended and geothermal resources were expressly included in the list of reserved minerals.\textsuperscript{151}

Later amendments cannot affect earlier deeds, unless the original provision is sufficiently ambiguous to accommodate the argument that later amendments are merely declaratory of the original grant. Accordingly, the issue arises whether the term "mineral deposits" or the term "gas" in the original provision includes geothermal resources. The analysis of the meaning of "mineral deposits" would be very similar to the line of reasoning already explored in connection with the federal reservation of minerals with one exception. The discussion of the mineral reservation under the Stock Raising Homestead Act relied in part on the specific purpose of the Act in granting land.\textsuperscript{152} In contrast, the California statute presently under discussion involves a general reservation with respect to any sale of public land.\textsuperscript{153} However, the rule of construction urged by Kuntz—that the general purpose of a reservation ought to control when there is no specific intent with regard to a particular substance—and the previous analysis concerning the characterization of geothermal resources as "minerals" are equally applicable to the California statute and need not be repeated here.\textsuperscript{154}

Geothermal steam, which exists in a gaseous state, arguably is included within the term "gas" as used in the California statute, since that term need not necessarily be restricted to hydrocarbon gas. It has been so held in \textit{Commissioner v. Reich},\textsuperscript{155} which involved the question of whether a taxpayer is entitled to a percentage depletion allowance for geothermal steam under the

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from grants to the states for school purposes and now extends the school land grants to include mineral lands; however, any transfer of such mineral land by the state must contain a reservation to the state of "all the coal and other minerals," the rents and royalties therefrom to be used for the support of common or public schools. 43 U.S.C. § 870 (1970). For a history of the land grants for school purposes, see Colby, \textit{Mining Law in Recent Years} (pt. 2), 36 \textit{CALIF. L. REV.} 355, 373-89 (1948).

\begin{itemize}
\item \textsuperscript{150} CAL. PUB. RES. CODE § 6407 (West 1956).
\item \textsuperscript{151} Id. § 6407 (West Supp. 1976).
\item \textsuperscript{152} See text accompanying notes 122-31 \textit{supra}.
\item \textsuperscript{153} CAL. PUB. RES. CODE § 6403 (West 1956) excepts certain property of the state from the required reservation.
\item \textsuperscript{154} Whether geothermal resource in The Geysers area is included within the reservation under discussion is now before the court in \textit{Pariani v. California}, No. 657-291 (San Fran. Co. Super. Ct.). The plaintiffs' and the defendants' motions for summary judgment were denied by an order entered May 1, 1974.
\item \textsuperscript{155} 52 T.C. 700 (1969), \textit{aff'd}, 454 F.2d 1157 (9th Cir. 1972).
\end{itemize}
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Internal Revenue Code. But whatever the merits of treating steam as "gas" for depletion allowance purposes, this approach does not commend itself as a guide to interpretation of the reservation. If the reservation is interpreted to include geothermal steam within the term "gas," one would have to conclude that the legislature reserved the geothermal resource in the gaseous state, but not in the liquid state. It hardly seems likely that the legislature was playing the game of gas, liquid, or solid.

However, one need not rely upon the term "gas" alone; one can argue that the term "mineral waters," employed in the 1947 amendment, includes geothermal resources in the liquid state. The latter term, however, appears to be as imprecise as the term "mineral." The dictionary defines mineral water as "water naturally or artificially impregnated with mineral salts or gases (as carbon dioxide)." The steam produced in The Geysers area contains noncondensible gases and the steam which is condensed is toxic to fish and wildlife. In the Imperial Valley the mineral content of the geothermal fluid in some anomalies presents the most serious problem for its development. The mineral content is presently of negative value in many prospective developments. Accordingly, it is strange to argue that the geothermal fluid is reserved to the state because of its mineral content. Ultimately, one must recognize that because the value of a geothermal reservoir resides in the entire geophysical system in which the earth’s heat is transmitted to the fluid from the hot rock, the case for the state’s reservation of geothermal resources must depend on the construction of the term "mineral deposit."

156. With respect to land conveyed prior to the 1947 amendment, which made clear that mineral waters were to be included in the reservation of mineral deposits, the later expression of legislative intent with respect to a previously enacted but ambiguous statute may be used in determining the meaning of the earlier act although this interpretation is not binding on the court. See, e.g., California Employment Stabilization Comm’n v. Payne, 31 Cal. 2d 210, 187 P.2d 702 (1947).

157. WEBSTER’S THIRD NEW INTERNATIONAL DICTIONARY (unabr. ed. 1961). The literature on mines and minerals seems not to use this term. The term "mineral waters" might refer to waters from which minerals might be extracted. See CAL. PUB. RES. CODE §§ 6991-6996 (West Supp. 1976), dealing with the method of conferring rights to extract minerals from streams and lakes.


159. See FINAL ENVIRONMENTAL STATEMENT, supra note 158, at V-61.


161. In 1967 the Legislature amended CAL. PUB. RES. CODE § 6805 (West Supp. 1976), which deals with the authority of the State Lands Commission to cancel a permit or a lease, by adding the words "or geothermal resources" after "deposit of minerals." From this amendment it can be argued that the legislature meant to employ the term "minerals" exclusive of geothermal resources. See Plaintiffs’ Memorandum in Support of Motions for Judgment on the Pleadings and
GEOTHERMAL RESOURCE RIGHTS IN THE ABSENCE OF EXPRESS MINERAL RESERVATIONS

An earlier section of this article showed that tracts of land in California's Imperial Valley were patented, some with, and others without, a reservation of mineral rights to the federal government. We have discussed the argument that geothermal resources are included in the express reservations of mineral resources underlying lands patented by the federal government, both on general principles of construction of federal patents and because geothermal resources are analogous to other substances which are included in reservations of "minerals." However, some lands have been patented without an express mineral reservation; in addition, courts may hold that geothermal resources are not included in general mineral reservations. It is therefore necessary to consider what other claims to geothermal resources may be asserted. The remainder of this article proceeds on the assumption that the federal government has no claim to ownership of geothermal resources based on its express mineral reservations. In the following discussion, we will consider (1) whether there is an implied reservation of geothermal resources to the federal government; (2) whether the applicable law should be state law; and (3) whether, in view of the unique properties of geothermal resources, the state should be allowed to assign rights to it free of any existing allocative regime for other resources, in a manner which will allocate the resource most efficiently.

While it is possible to argue that the federal government impliedly reserved geothermal resources, this contention is unlikely to prevail in light of history of federal land disposition and the Geothermal Steam Act of 1970. In the absence of an implied reservation, three alternative approaches are available to define property rights in geothermal resources. First, the patentee can claim that the grant of fee ownership by the federal government transferred all rights to resources above and below the surface on the basis of the ancient doctrine of *cujus est solum, ejus est usque ad coelum et ad inferos.* This claim may be asserted on the basis of federal or state law, whichever may support the claim.

A second approach would characterize geothermal resources as water so...
that the state law defining water rights would apply. We have suggested above, however, that characterization of geothermal resources as water is improper because the value of the resources derives not from their water content but rather from the heat energy which the fluid contains. We will not repeat that argument here.

Finally, one might reject the *a priori* application of any existing allocative regime developed for other resources and instead use the general state power to define property rights in order to provide a regime which takes the unique characteristics of geothermal resources into account. These alternatives are not exhaustive, of course, but they do expose the principal issues which must be faced in examining the rights to geothermal resources underlying lands in private ownership.

**A. An Implied Reservation to the Federal Government**

We are not aware of any previous suggestion that a continuing right to geothermal resources underlying lands previously patented may be implied to the federal government in the absence of an express reservation. This is not surprising when one considers that many of the legal issues, past and present, stemmed from the assumed need to fit geothermal resources into an existing body of law developed at a time when geothermal energy was not a commercially viable energy resource. Thus, prior to the enactment of the Geothermal Steam Act of 1970, disputes arose as to which federal mineral disposition law applied to acquisition of rights to geothermal resources under federal land. Debate continues concerning the proper characterization of geothermal resources as water or mineral for purposes of construing mineral reservations and in applying an allocative regime.

If these problems are examined in the context of the law developed for the allocation of water or traditional minerals, the federal government’s case for a continuing right to geothermal resources is quite weak. If the resources are classified as water, there is no continuing federal right because the federal government has acquiesced in state allocative control over groundwater underlying nonfederal lands and no state has recognized continuing federal ownership of groundwater merely as the patentor. If the resources are given a mineral classification, past decisions have established that there is no continuing right to minerals underlying lands patented as nonmineral. Consequently, the inquiry into whether the federal government has impliedly retained rights to geothermal resources must commence with the argument

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166. See note 2 supra.
167. See text accompanying notes 95-161 supra.
169. See notes 83-84 supra.
that geothermal resources are unique because heat energy can be extracted directly from them.

1. A Unique Characterization for the Resource

While the hot-water system is dependent upon fluid to transmit heat from the hot rocks below, the fluid is functionally different from ordinary water associated with domestic, agricultural, industrial, or recreational uses. The fluid in the Imperial Valley, for example, has such a high salinity that it cannot be used for ordinary water purposes without demineralization, the economic feasibility of which is as yet uncertain.\(^\text{170}\)

Even if the fluid were relatively free of chemical impurities, the presence of the heat energy gives the fluid greater value than that of ordinary water. If the geothermal fluid were valuable primarily for its mineral content,\(^\text{171}\) only the most rigid conceptualism would argue that the chemical presence of \(\text{H}_2\text{O}\) requires the fluid's classification as water for allocative purposes. Heat energy ought to be recognized as a valuable component of the fluid just as much as the mineral in the previous example. The fact that heat energy is harnessed to generate electricity just as ordinary water is used to produce hydroelectric power by no means proves that geothermal resources should be treated as water, any more than oil and gas should be treated as water because their chemical content can produce heat energy which in turn can be converted into electricity.

Similarly, a geothermal resource need not be treated as a mineral within the traditional characterization. The mineral resource to which geothermal resources might be compared is oil and gas, but physically the resources are different. Oil and gas are valuable for their chemical component and can be transported for distant use, whereas geothermal energy must be harnessed for use close to the extractive well. Moreover, unlike oil and gas which are found in discrete pools in finite amounts, a geothermal reservoir may be interconnected with water sources and may have a significantly longer productive life depending upon the extent of natural recharge of the fluid, continuing permeability of the reservoir structure, and the rate of heat depletion.

There is no logic or utility in forcing geothermal resources into traditional water or mineral classifications. Granting the uniqueness of these resources, however, one must still consider whether the government has relinquished the right to them. A cautionary word is in order at this point. Whether the federal government retained any right to geothermal resources is a federal question and probably will be determined pursuant to federal law; nevertheless, it does not follow that the rights of the patentees will be determined by federal law if the federal government has not retained the right,

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170. The Bureau of Reclamation has a pilot plant in the East Mesa of Imperial Valley for desalinization of the fluid extracted from the geothermal reservoir.

171. Minerals were extracted at one time from the geothermal resources in the Imperial Valley. See GEOTHERMAL RESOURCES DEVELOPMENT, supra note 160, at 105-06.
since Congress may have acted against the backdrop of state law. It must be emphasized that our focus at this juncture is on what the government relinquished rather than what the patentee received from the government. It is not necessarily true that the answer to the first issue will determine the answer to the second. For example, while land is in federal ownership, Congress may dictate the nature of water rights appurtenant to that land, but it does not follow that the patentee succeeds to the rights the federal government could have claimed.172 In those jurisdictions adopting the appropriation doctrine, the patentee has no water rights inherent in land ownership. The result may be explainable on the ground that Congress had decided purposefully to relinquish its water rights upon removing the land from the reserved status and has conveyed the land, subject to a determination of the patentee’s rights under state law. Similarly, land in federal ownership may be free from state regulation because of federal supremacy, but the same land when patented to a private party becomes subject to various state regulations which together with the state’s traditional property laws will define the private party’s rights in the land. The importance of this digression will become apparent later in the discussion.

2. Arguments Favoring the Implied Reservation

The inquiry into whether the federal government retains a continuing right to geothermal resources underlying lands previously patented may be approached in either of two ways. One approach seeks to establish a continuing federal interest based on sound social policies and analogies to similar situations, whereas the other seeks only to negate the arguments that the government no longer has any interest. Unfortunately, it is difficult to assert that the federal government continues to own geothermal resources since the Geothermal Steam Act of 1970173 evinces a congressional belief that the federal government no longer has any interest. Consequently, this discussion is necessarily limited to a speculative inquiry as to whether a case could have been made on its behalf.174

172. It has been said that the California Supreme Court, in Lux v. Haggin, 69 Cal. 255, 10 P. 674 (1886), has held that a federal riparian patentee succeeds to federal riparian rights, see TRELEASE, supra note 168, at 29; Note, Federal-State Conflicts Over the Control of Western Waters, 60 COLUM. L. REV. 967, 968-75 (1960), but note the criticism of attempts to talk about federal ownership of water or federal water law in the early days. TRELEASE, supra. There is no doubt that the federal government has reserved water rights with respect to reserved lands, Arizona v. California, 373 U.S. 546 (1963), but if the land should be removed from the reserved status and patented to a private party, it is doubtful that the patentee would succeed to the federal rights.


174. Even if the decision in United States v. Union Oil Co., discussed in text accompanying notes 102-09 supra, should be adverse to the United States, it need not signal the end of the continuing federal claim to geothermal resources. It would be an adjudication that the federal government has no right to the geothermal resource underlying the land in question. It is doubtful that collateral estoppel would apply to preclude the government from asserting rights to geothermal resources in other lands since the issue concerning the rights under a patent is a question of law as opposed to fact.
There are two social reasons for favoring federal retention of rights to geothermal resources. First, if the case for federal retention should fail, inefficiencies will arise wherever the applicable law recognizes a right in the overlying landowner to capture the resource found beneath his land and a geothermal reservoir crosses the boundary lines of land ownership. Under such conditions, the inefficiencies normally associated with common pools could arise, as has been the case with the rule of capture with respect to oil and gas.\(^{177}\) In contrast, if the government has the exclusive right to geothermal resources, those inefficiencies can be avoided since it can manage the resources without necessarily engaging in exploration and development itself, so as to take into account the production interdependencies. Of course, this is not a compelling reason since the states can devise property rules to minimize the inefficiencies stemming from these production interdependencies.\(^{176}\) Another factor that may militate against this efficiency argument is the current federal policy of leasing discrete tracts of federal land without regard to the occurrence of geothermal resources.\(^{177}\) This leasing policy has the effect of assigning a right of capture to the lessee and can give rise to the usual common pool problems unless the lessees voluntarily unitize or the Secretary of the Interior carefully exercises his supervisory authority to minimize the inefficiencies arising from multiple rights to capture through such means as unitization.\(^{178}\)

The second social reason favoring federal retention of the resources is based on distributive considerations. Federal ownership of a newly discovered resource would permit wider distribution of the economic rent from the resource. The Geothermal Steam Act of 1970, which requires competitive leasing\(^{179}\) in known geothermal resource areas\(^{180}\) and royalty payments for all

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The mutuality doctrine has been rejected by the U.S. Supreme Court, Blonder-Tongue Laboratories, Inc. v. University of Illinois Foundation, 402 U.S. 313 (1971), so that the fact that a later action may involve a different party will not prevent the application of the collateral estoppel doctrine if the doctrine otherwise applied. Collateral estoppel applies to prevent a relitigation of an "ultimate fact," Ashe v. Swenson, 397 U.S. 436 (1970), or of "fact, and mixed fact and law," Yates v. United States, 354 U.S. 298 (1957).

175. See S. MCDONALD, PETROLEUM CONSERVATION IN THE UNITED STATES: AN ECONOMIC ANALYSIS (1971); W. LOVEJOY & P. HOMAN, ECONOMIC ASPECTS OF OIL CONSERVATION REGULATION (1967); R. SULLIVAN, CONSERVATION OF OIL AND GAS (1960). See part two of this article for a discussion of the inefficiencies associated with the existing regime for oil and gas.

176. This is discussed in greater detail in part two of this article, in which we suggest an appropriation scheme.


178. It appears that the Secretary may compel participation in a cooperative or unit plan only if the lease so provides. Otherwise, the consent of the lessee is necessary. Geothermal Steam Act of 1970, § 18, 30 U.S.C. § 1017 (1970). The Secretary has prescribed regulations outlining the procedure to be followed and requirements to be met by geothermal leaseholders who wish to unite. 30 C.F.R. § 271 (1976). Under the Act, there will be an incentive to unitize because unitized acreage will not be charged to the lessees in determining the maximum acreage in a given state. 30 U.S.C. §§ 1006, 1017 (1970).

179. Leasing currently is based on bonus bidding, 30 U.S.C. § 1003 (1970), which is discussed in detail in part two of this article.

180. The definition of a known geothermal resource area is found in 30 U.S.C. § 1001(e)
leases,\textsuperscript{181} is itself indicative of congressional sensitivity to distributive problems. For example, Congress could have decided to open the public lands and give the resources to the first appropriator. If patentees were deemed to have the right to capture the resources, windfalls of the type avoided under the Geothermal Steam Act would accrue to them or their successors; the fact that windfalls have been given in the past is no reason to continue the practice.

Interestingly, the recently enacted Federal Land Policy and Management Act of 1976\textsuperscript{182} requires the Secretary of the Interior to reserve all minerals in all future conveyances of lands.\textsuperscript{183} A major exception provides that the Secretary may convey mineral interests owned by the United States to the present or proposed nonfederal surface owner if he finds (1) that there are no known mineral values in the land, or (2) that the reservation of the mineral rights in the United States is interfering with or precluding appropriate nonmineral development of the land and that such development is a more beneficial use of the land than mineral development.\textsuperscript{184}

The transferee of the mineral interests must pay administrative costs, including "costs of conducting an exploratory program to determine the character of the mineral deposits in the land, evaluating the data obtained under the exploratory program to determine the fair market value of the mineral interests to be conveyed, and preparing and issuing the documents of conveyance."\textsuperscript{185} In lieu thereof, the transferee may conduct the exploratory program.\textsuperscript{186} The transferee is also required to pay the fair market value of the interests being conveyed.\textsuperscript{187} These provisions are applicable to geothermal resources.\textsuperscript{188}

These provisions are similar to the recommendations of the Public Land Law Review Commission which believed that reservation to the United States of all mineral interests as a matter of course was "poor policy since reserved interests constitute clouds on title which frequently hinder later shifts of such properties to higher uses."\textsuperscript{189} The Commission, however, was also aware that "[r]eserving valuable mineral interests has the obvious merit of providing

\begin{footnotesize}
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  \item \textsuperscript{181} 30 U.S.C. § 1004(a) (1970), provides that the royalty on geothermal production shall be not less than 10 percent or more than 15 percent of the "amount or value of steam, or any other form of heat or energy derived from production under the lease and sold or utilized by the lessee or reasonably susceptible to sale or utilization by the lessee."
  \item \textsuperscript{182} 30 U.S.C. § 1024 (1970).
  \item \textsuperscript{183} Id. § 209(b)(1).
  \item \textsuperscript{184} Id. § 209(b)(3)(i).
  \item \textsuperscript{185} Id. § 209(b)(3)(ii).
  \item \textsuperscript{186} Id. § 209(b)(2).
  \item \textsuperscript{187} Id. § 209(a)(2).
  \item \textsuperscript{188} Id. § 209(a) removes certain exchanges from the requirement.
  \item \textsuperscript{189} Public Land Law Rev. Comm'n, One Third of the Nation's Land 137 (1970).
\end{enumerate}
\end{footnotesize}
potential revenues and permitting consolidation of mineral interests for potential development" and of forestalling "possible windfalls to surface owners."

While the objective of the Act in removing a burden upon efficient surface use is laudable, it is unfortunate that it is accomplished by means of transfer of the mineral interest to the patentee. As will be explained later, such transfers may interfere with federal or state laws which seek a rational allocative regime for geothermal resources. Moreover, transfer of the mineral interest will permit unforeseen windfalls to accrue to the patentee.

A determination under the Act that there are "no known mineral values in the land" is made in the light of technological and economic conditions. Thus, whichever party owns the mineral interest retains the highly speculative possibility of a windfall in the future, when technological development provides new methods of production or use of subsurface matter, or when economic conditions make production feasible. Aside from paying administrative costs, which may be substantial depending upon the thoroughness with which the exploration is conducted, the transferee of land with "no known mineral values" receives the mineral interest without further cost.

There is an alternative method of accomplishing the Act's objective without the above consequences. The federal government could reserve the minerals as provided in the Act but relinquish its right to use the surface in question for mineral development. When the land in question has "no known mineral values," the negotiated price for the relinquishment, besides the administrative costs, should be somewhere between zero and the difference in the value of the surface with and without the servitude. If the land should contain minerals but the value of mineral development is less than the difference in value of the surface with and without the servitude, the price for the relinquishment should be higher. It should fall within the government's opportunity costs of not being able to develop the minerals, or being able to develop the minerals from neighboring lands but at increased expense, and the difference in value of the surface with and without the servitude. If in the future mineral development should become more valuable than the costs to the surface owner due to mineral development, the parties can negotiate for the transfer of the right to use the surface for mineral development.

190. Id. 191. Id.

192. There is another scheme similar to the one suggested in the text. The government would retain the mineral interest but would assure the surface owner that he would be compensated for harm arising from surface use for mineral activities. This scheme would eliminate the option on the part of the surface owner as to whether he wished to sell an easement. The surface owner also would be unable to assess the opportunity costs for which he would seek compensation in the open market since under this alternative the amount of compensation would be legally determined.

The Public Land Law Review Commission recommended that in all cases compensation be made for affected resources, values, and uses when mineral activity occurred under reserved mineral interests. Public Land Law Rev. Comm'n, supra note 189, at 138.
This alternative scheme has the advantage of permitting the surface owner in some cases to purchase protection at a lesser investment than that required to purchase the mineral interest. A second advantage is that the government retains the possible windfall in the future when a mineral is discovered or becomes valuable enough to be developed. The most important result is that the scheme preserves the flexibility of the government to develop a rational allocative regime for the resource. Because the Act would permit the assignment of the mineral interest to the surface owner, common pool problems with respect to fluid resources can arise in the future when their development becomes socially desirable. By retaining the mineral interest, the government may be able to assign rights to resources, such as geothermal resources, on the basis of an appropriation scheme which may be a more efficient allocative regime for those resources.

The argument for federal retention of geothermal resources can be supported by analogy to navigable waters. Precedent for federal retention of paramount control over a resource where no reservation has been made is found in federal control over navigable waters, despite the fact that the beds of such waters may be transferred to the states. The federal interest in navigable waters is so pervasive that property rights recognized under state law can be subjected to federal control, even to the extent of permitting the federal government to injure state-recognized property interests without compensation. The fact that congressional authority over navigable waters stems from its power to regulate interstate and foreign commerce, rather than from the property clause, does not affect the reality that Congress has plenary power almost as complete as if Congress owned the resource.

Further support for the implied federal reservation of geothermal resources is based on principles developed to limit the common law doctrine of...
cujus est solum. As will be more fully developed later, the cujus est solum doctrine is not absolute or immutable. The bundle of rights relinquished by the government when granting fee title to a tract of land might be limited by important public policies. The cujus est solum doctrine has been rejected in those states that do not recognize rights to groundwater based on overlying landownership. The federal government regulates the navigable airspace pursuant to the Commerce Clause, an instance in which property interests in land have been limited horizontally. The landowner does not have ownership rights in airspace enabling him to prevent or obtain damages for flights over his property on grounds of trespass unless the flights interfere with the owner’s effective use of the land. These are examples of circumstances where government and public interests have superseded competing private claims.

Prior Supreme Court cases holding that the government has no claim to mineral resources discovered after patent without any reservation to the government present more difficult problems. One response to these cases is to note that the Court has at times implied a reservation of minerals to the United States on the basis of the general purpose of the statute in question.

198. See note 164 supra and accompanying text.
199. See text accompanying notes 261-303 infra.
200. See text accompanying notes 265-78 infra.
203. See notes 83-84 supra.
204. United States v. Union Pac. R.R., 353 U.S. 112, 116 (1957). The issue in this case was whether the railroad, which had been granted a “right of way” for the construction of railroad and telegraph lines, had the right to oil and gas within the right of way. The section of the statute under which the patentee received the right of way made no mention of any reservation of mineral interest to the United States, but another provision which granted the railroad alternate sections of public land along the right of way expressly excepted mineral lands from the operation “of this act.” The majority held that exception of mineral lands applied not only to the alternate sections which were to be administratively determined as mineral or nonmineral in character but that it also constituted a reservation of minerals under the right of way. The language of the act was inelegant as a reservation, but the Court explained away this difficulty by noting that a railroad could not be built by skirting mineral lands and that the basic policy of retention of minerals by the United States applied to the right of way just as it did to the disposal of alternate sections.

Compare Mining Co. v. Consolidated Mining Co., 102 U.S. 167 (1880). The statute in question provided that all public lands in California, whether surveyed or unsurveyed, were subject to the preemption laws. However, excepted from the above were “sections sixteen and thirty-six, which shall be, and hereby are, granted to the State for the purposes of public schools in each township;” mineral lands were also excepted; and other exceptions were provided. In concluding that lands which were mineral in character did not pass to the state for school purposes under the above clause, the Court reasoned:

Taking into consideration what is well known to have been the hesitation and difficulty in the minds of Congressmen in dealing with these mineral lands, the manner in which the question was suddenly forced upon them, the uniform reservation of them from survey, from sale, from pre-emption, and above all from grants, whether for railroads, public buildings, or other purposes, and looking to the fact that from all the grants made in this act they are reserved, one of which is
Thus, an explicit reservation has not always been required. Secondly, geothermal resources can be distinguished as unique resources in which the valuable heat energy emanates from the earth, whereas those cases holding that the government has no claim to mineral resources dealt with traditional minerals. The very issue is whether these unique resources merit different treatment.

The Supreme Court ascribed two reasons justifying the result in those cases holding that the government has no claim to mineral resources. First, it would be unfair for the government to reclaim the land upon later discovery of minerals when the patentee had acquired land as nonmineral in character. It is difficult to quarrel with this result. However, the alternative to patentee ownership need not be a reversion of the fee interest to the government upon mineral discovery, for a middle ground exists: namely, that only the minerals were reserved. Yet the Court anticipated this assertion when it stated as its second reason that it would be equally unfair to disrupt the surface use upon later discovery of minerals. However, the Court could adopt a rule that would require the government or its grantee to compensate the surface owner for any damage suffered by him due to geothermal resource exploitation. The Stock Raising Homestead Act, which requires a mineral reservation as a matter of course, provides that upon later mining the surface owner shall be compensated for damages to crops and tangibles and if strip or open pit mining is conducted, compensation shall be made for "any damage that may be caused to the value of the land for grazing." Such legislative policy might provide a basis for the formation of federal common law requiring compensation for grantees under the other statutes. We

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The above cases typify the Court's application of the constructional preference favoring the United States. The Union Pacific case is the more extreme, since a reservation of minerals from the right-of-way was implied by the Court irrespective of the state of knowledge as to the mineral character of the land at the time of disposition.


206. Davis' Administrator v. Weibbold, 139 U.S. 507, 526 (1891). The general rule is that there is an implied easement for a reasonable use of the surface for mining purposes when there is a separation of the surface and the mineral estates. See 2 American Law of Property § 10.6 (A. Casner ed. 1952). Recently, the Texas Supreme Court has held that the mineral lessee has the implied right to use fresh groundwater for water-flooding purposes in the absence of injury to the surface estate. Sun Oil Co. v. Whitaker, 483 S.W.2d 808 (Tex. 1972).


208. 30 U.S.C. § 54 (1970). For a discussion of federal statutes protecting surface entrymen from later mining operations, see Geraud, supra note 129, at 566-80; Mall, supra note 86.

should be reminded that "[a]s to each rule or principle not resting on statute, there must be a first statement." In the alternative, Congress could enact a statute assuring present nonfederal owners compensation for injury caused by removal of geothermal resources, thus eliminating a serious objection which the Court might otherwise entertain.

If the federal government successfully asserts a continuing claim to these resources, fairness dictates the adjustment of existing private geothermal leases. And in those cases where the fluid is interconnected with groundwater to which rights have attached, it would be unfair for the government to assert supervening rights in the geothermal resources.

3. Arguments Against the Implied Reservation

Despite the existence of a plausible case for the implied reservation of geothermal resources to the federal government, there are many counterarguments. First, in other instances where Congress has intended to reserve valuable resources, it has usually expressly declared such policy in the statute. Thus, the adoption of a land disposal scheme in which no reservation to the United States has been made signifies that Congress did not intend to retain rights to resources underlying the patented lands.

Second, every resource is arguably unique. The form in which energy exists is without legal significance; otherwise, title to every resource would be uncertain since there would always be the possibility that a particular resource in the ground might be deemed unique, and the development of any resource would be impeded and costly because of this cloud. Third, the analogy to the navigational servitude is inapposite since it arises from the regulatory power of the government, whereas the argument on behalf of the federal ownership of geothermal resources is based on proprietary claims.

The final argument against an implied reservation is found in § 25 of the Geothermal Steam Act of 1970. It can be argued that the explicit requirement that rights to geothermal resources in lands patented after passage of the Geothermal Steam Act be reserved to the federal government indicated a congressional recognition that geothermal resources were not reserved in lands patented without mineral reservations prior to the Act. Section 25 provides:

As to any land subject to geothermal leasing under section 1002 of this title, all laws which either (a) provide for the disposal of land by patent or other form of conveyance or by grant or by operation of law subject to a reservation of any mineral or (b) prevent or restrict the disposal of such land because of the mineral character of the land,
shall hereafter be deemed to embrace geothermal steam and associated geothermal resources as a substance which either must be reserved or must prevent or restrict the disposal of such land, as the case may be. This section shall not be construed to affect grants, patents, or other forms of conveyances made prior to December 24, 1970.\(^\text{214}\)

At the time of enactment, the effect of clause (a) of section 25 was to require a reservation of geothermal resources under those statutes, such as the Stock Raising Homestead Act,\(^\text{215}\) which provided for a reservation of all minerals as a matter of course, even though the land was not withdrawn, classified, or reported as valuable for minerals. In contrast, clause (b) treated geothermal resources like other minerals in determining whether lands can be disposed of under those laws which prohibit or restrict the grant of mineral lands.\(^\text{216}\)

Under the Geothermal Steam Act of 1970, if a patent is given without reservation, the federal government has no right to geothermal resources upon later discovery.\(^\text{217}\) If that is the result with respect to patents issued after the Geothermal Steam Act of 1970, a similar conclusion probably would be reached with respect to past patents.

It is unfortunate that in enacting the Geothermal Steam Act of 1970 Congress apparently did not inquire into the possible existence of federal claims to geothermal resources in lands which previously were patented. This omission is understandable since the inquiry would have required a radically new perspective regarding a unique resource. Of course, it may not be too late for Congress to reconsider the implications arising from section 25 as to past patents, since section 25 by no means constitutes relinquishment of geothermal resources in the past.\(^\text{218}\)

The recently enacted Federal Land Policy and Management Act of 1976 requires that geothermal resources be reserved in

\(^{214}\) Id.


\(^{216}\) One such law is 30 U.S.C. § 121 (1970) (originally enacted as Act of July 17, 1914, ch. 142, § 1, 38 Stat. 509), which permits disposal of land under nonmineral land laws if a reservation of the deposits is made to the United States even though the land has been withdrawn or classified as a specified mineral land or is valuable for mineral deposits. Even under this law, a person interested in a transfer of such land may disprove the classification as a given mineral land and obtain a patent without reservation. 30 U.S.C. § 122 (1970).

\(^{217}\) See note 83 supra.

\(^{218}\) If the resources were deemed to have been relinquished by the federal government at the time of the patent because they were not expressly reserved, a later congressional expression of intention to reserve such resources would not result in a retransfer of those resources to the federal government. Conversely, if the federal government has always retained the right to those resources, a later congressional expression to the contrary would not result in a loss of those resources. However, the later congressional expression might be used to determine congressional intent at the time of patent as to whether it had contemplated retention of the resources. If Congress were to modify section 25(b) so as to remove any possibility that it might be used to infer past congressional intent, a court faced with the issue of the rights granted under original patent would have to ignore the implications arising from the current language of section 25(b).
patents unless the federal government transfers its right to the surface owner under certain stringent conditions. Thus, if Congress were to reconsider and assert a claim as suggested above, and courts upheld the claim, the impact would be upon patents issued before the 1970 Act. Such an amendment should also provide that the overlying landowner be compensated for any injury to his interest due to geothermal resource exploitation conducted by or with the consent of the government.

B. The Applicable Law Governing Rights to Geothermal Resources: Federal Versus State

If, as seems likely, courts were to determine that the federal government does not retain any right in land patented without express reservation, it becomes necessary to determine who has the right to the geothermal resources underlying patented lands. This involves two major questions: first, does state or federal law govern the rights to geothermal resources; and second, what kind of a property regime exists or should be devised for this unique resource? These questions raise intriguing problems. In the following discussion it will be argued that (1) if the federal government has no claim to geothermal resources underlying nonfederal lands, state law should be applied to define property rights to the resources; (2) state law need not adopt the *cujus est solum* doctrine so as to confer a right upon an overlying landowner to capture the resources; and (3) to achieve an efficient allocation of rights to the resources, the state should adopt a scheme by which it auctions off rights to the resources.219 The first two points are taken up in the major sections below. The final point is discussed in the second part of this study, which includes an analysis of alternative allocation regimes.

We do not dispute that the United States has valid claims to the geothermal resources underlying the lands owned by it; to deny these claims is to reject the efficacy of the Geothermal Steam Act of 1970 by its own force. For instance, given that the federal government would have had the right to the resources in the Imperial Valley had it retained ownership of those lands, the patentees certainly would have succeeded to the federal claims if Congress had expressly so provided, since Congress has the constitutional authority to adopt a dispositive policy for federal property.220 But where Congress has legislated incompletely, the problem to be resolved is whether the property

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219. The states already receive substantial rent from federal leases. Fifty percent of the bonuses, rentals, and royalties from federal geothermal leases is paid to the respective states in which the leases have been issued. The figure is ninety percent for Alaska. Leases in naval petroleum reserves are not included in this arrangement. 30 U.S.C. §§ 181, 191 (1970), as amended by Federal Land Policy and Management Act of 1976, Pub. L. No. 94-579, § 317(a), 90 Stat. 2770.

220. U.S. CONST. art. IV, § 3. Under the Geothermal Steam Act of 1970 the federal government grants "leases" to geothermal resources underlying its land. Congress could provide that the government may convey the resources in fee.
rights of the patentee will be determined by federal common law or by state law.

If a patentee has rights to the geothermal resources underlying his land as a matter of federal law, pursuant to the common law doctrine of *cujus est solum*, a state may be prevented from establishing a regime which rejects rights based on overlying landownership. A state's police power can redefine property rights as long as it does not violate the Fourteenth Amendment or state constitutional provisions prohibiting the taking of property without compensation. Yet if state laws are to be applied initially, a state may have the opportunity to devise property rules to further societal goals. In many cases the legislation dealing with the disposition may be construed to resolve the

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222. The problem at hand is reminiscent of the bygone era when it was hotly disputed whether federal or state law determined water allocation in the West. The debate then centered, though, on a more fundamental issue: whether the control of the federal government over the public domain included proprietary claims to water resources. See, *e.g.*, Bannister, *The Question of Federal Disposition of State Waters in the Priority States*, 28 HARV. L. REV. 270 (1915); Note, *Federal-State Conflicts over the Control of Western Waters*, 60 COLUM. L. REV. 967, 968-75 (1960). The debate has not completely abated. See, *e.g.*, C. MEYERS, A HISTORICAL AND FUNCTIONAL ANALYSIS OF THE APPROPRIATION SYSTEM (Nat'l Water Comm'n Legal Study No. 1, 1971) [hereinafter cited as MEYERS APPROPRIATION SYSTEM STUDY]; F. TRELEASE, FEDERAL-STATE RELATIONS IN WATER LAW (Nat'l Water Comm'n Legal Study No. 5, 1971).

Those states which early adopted the appropriation system have applied state law. When confronted with riparian claims based on asserted federal right, the state courts have pointed to federal legislation as one of the reasons for applying state law. See, *e.g.*, Farm Investment Co. v. Carpenter, 9 Wyo. 110, 61 P. 258 (1900); Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882).

Although it now is clear that the United States has a proprietary interest under federal law in the water appertaining to its reserved land, see Arizona v. California, 373 U.S. 546 (1963); Meyers, *The Colorado River*, 19 STAN. L. REV. 1, 65-73 (1966) (discussion of the reserved rights doctrine), the Supreme Court has not decided whether a patentee has ever succeeded to water rights of the United States as its grantee of land, inasmuch as federal statutes have been construed as congressional relinquishment of authority to the states or confirmation of concurrent jurisdiction to allocate water resources.

In California Oregon Power Co. v. Beaver Portland Cement Co., 295 U.S. 142, 163-64 (1935), the Court held that following the act of 1877, if not before, all non-navigable waters then a part of the public domain became *publici juris*, subject to the plenary control of the designated states . . . with the right in each to determine for itself to what extent the rule of appropriation or the common law rule in respect of riparian rights should obtain . . . . The Desert Land Act does not bind or purport to bind the states to any policy. It simply recognizes and gives sanction, in so far as the United States and its future grantees are concerned, to the state and local doctrine of appropriation, and seeks to remove what otherwise might be an impediment to its full and successful operation.

The MEYERS APPROPRIATION SYSTEM STUDY, *supra*, takes the position that under the statutes in question, the federal government had quitclaimed its rights to water when rights were acquired by others under the state law.

F.J. TRELEASE, FEDERAL-STATE RELATIONS IN WATER LAW, *supra*, argues that there has always been silent acquiescence, irrespective of the statutes, that state law would apply to determine water rights in the nonfederal sector, and that water law was the subject of concurrent federal and state jurisdiction.
In analyzing this issue, we commence by discussing three significant United States Supreme Court decisions of recent vintage. The earliest of the three is Hughes v. Washington. The issue was whether "federal or state law controls the ownership of land, called accretion, gradually deposited by the ocean on adjoining upland property conveyed by the United States prior to statehood." Federal law recognized the right to accretion in the littoral owner, whereas the state law placed the ownership of accretion to riparian land occurring subsequent to statehood in the state. Realizing that the extent of a federal grant is a federal question but that a state law may be adopted as the federal rule, the Court chose to apply the federal law because the problem dealt with "waters that lap both the lands of the State and the boundaries of the international sea" which is "too close to the vital interest of the Nation in its own boundaries to allow it be governed by any law but the 'supreme Law of the Land.'" The Court stated that the federal law

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223. The construction of a mineral reservation to the United States under the Stock Raising Homestead Act is such an issue. See text accompanying notes 93-131 supra.


For a more specific treatment relating to lands patented by the United States, see Corker, Where Does the Beach Begin, and to What Extent Is This a Federal Question, 42 WASH. L. REV. 33 (1966); Bade, Title, Points and Lines in Lakes and Streams, 24 MINN. L. REV. 305 (1940).

The problem here should not be confused with the one raised in Erie R.R. Co. v. Tompkins, 304 U.S. 64 (1938), since the problem faced there dealt with diversity cases before the federal courts. In Erie situations, the object is to "secure in the federal courts, in diversity cases, the application of the same substantive law as would control if the suit were brought in the courts of the state where the federal court sits." United States v. Standard Oil Co., 332 U.S. 301, 307 (1947) (distinguishing the Erie problem from the problem in which federal interests present a federal question and require judicial determination as to whether the problem should be resolved by federal common law or state law). The issue raised here is whether the federal common law or state law should be applied. See United States v. Standard Oil Co., supra; Mishkin, supra, at 802-05.


226. 389 U.S. at 290-91.

227. The state constitution, adopted at the time the state was admitted into the Union, provided that the state has ownership of the tideland up to the ordinary high tide. This provision was construed by the Washington Supreme Court as fixing the boundary of state ownership at the ordinary high tide mark at the time the constitution was adopted. Hughes v. State, 67 Wash. 2d 799, 816, 410 P.2d 20, 29 (1966).

228. 389 U.S. at 293.
recognizes the right of accretion in the riparian owner because "[a]ny other rule would leave riparian owners continually in danger of losing the access to water which is often the most valuable feature of their property, and continually vulnerable to harassing litigation challenging the location of the original water lines."^229

The second case, decided only a few years ago, is *Bonelli Cattle Co. v. Arizona.*^230^ The question posed by the Court was whether title to land abandoned by the stream of the Colorado River as a result of a federal rechanneling project vests in the State of Arizona, as owner of the beds under navigable streams within its borders, or in petitioner cattle company, as the owner of land riparian to the river at the time of the rechanneling.^231^

The petitioner's predecessor in interest had received a patent in 1910 from the United States to the disputed tract of land bordering on or near the Colorado River. When Arizona was admitted to the Union in 1912, Arizona succeeded to the title of the federal government to the bed of the Colorado River, a navigable body of water, under the equal footing doctrine.^232^ Subsequent to the issuance of the patent, the Colorado River gradually changed its course, moving eastward over the land in dispute. In 1959 the federal government rechanneled the river, exposing that part of the bed which had been dry land before the river shifted eastward.

There apparently was no dispute as to state ownership of the bed as the river shifted over the land in question. The state supreme court held that, applying state law, the rechanneling was an avulsive change so that the exposed area remained in the ownership of the state. The United States Supreme Court reversed, holding that, because the state's claim was based on the federal equal footing doctrine, federal law must resolve the dispute. The Court reasoned that the purpose of granting ownership of the bed of navigable

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229. *Id.* at 293-94. Although not cited by the Court, the reasoning is reminiscent of that employed in United States v. California, 332 U.S. 19 (1947), in which California's claim of ownership of ocean-submerged lands was rejected.


231. *Id.* at 314-15.

232. The equal footing doctrine is described by the Court as follows:

> When the Original Colonies ratified the Constitution, they succeeded to the Crown's title and interest in the beds of navigable waters within their respective borders. As new States were forged out of the federal territories after the formation of the Union, they were "admitted [with] the same rights, sovereignty and jurisdiction . . . as the original States possess within their respective borders." . . . Accordingly, title to lands beneath navigable waters passed from the Federal Government to the new States, upon their admission to the Union, under the equal-footing doctrine.

414 U.S. at 417-18.

The equal footing doctrine is said to rest upon a constitutional principle. United States v. Utah, 283 U.S. 64, 75 (1931).

In the *Bonelli* case, Arizona also relied upon the Submerged Lands Act, 43 U.S.C. §§ 1301-1315 (1970), in asserting ownership. However, as to beds of internal navigable waters, the Act was construed to convey no more than what the state received under the equal footing doctrine. Thus, the Act did not have independent significance in the case.
rivers to the states under the equal footing doctrine was the recognition of the public importance of navigation and fishery. It concluded that this purpose did not support application of the doctrine to land which is no longer the bed of a navigable body of water. Moreover, if its claim were sustained, the state would receive a windfall of dry land.

Having rejected the state's claim based on equal footing, the Court proceeded to determine the ultimate question of the ownership of the disputed area. For this purpose, the Court applied the federal common law. In the Court's view, federal common law recognized the doctrines of accretion and avulsion, but, in view of the policy reasons underlying the doctrines of accretion and equal footing, the Court awarded the disputed area to the private claimant to further those policies.

The Court distinguished those cases in which state law was applied because they involved the issue whether state law had granted the riparian owner an interest in the riverbed. Otherwise, the interest clearly would be owned by the state under federal law. In other words, if federal law has conveyed an interest in land to the state, whether the state has given up some or all of those rights to another is a question to be decided under state law.

The third and latest case is *Oregon ex rel. State Land Board v. Corvallis Sand and Gravel Co.* The river in this case formerly flowed around a peninsula. During a year of heavy flow, a large volume of the river water

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233. The Court reasoned that the doctrine of accretion is supported by (1) the expectancy of a riparian owner that his land will continue to abut the water; (2) the quality of being riparian may be the land's most valuable feature; and (3) since the riparian owner must suffer the consequences of erosion, he should be compensated by accretions. The equal footing doctrine, on the other hand, stems from public control over navigation and fishery. 414 U.S. at 326.

234. 414 U.S. at 320.

235. The Court thus clarified the ambiguity created by some earlier cases. See, e.g., Brewer-Elliott Oil and Gas Co. v. United States, 260 U.S. 77 (1922). The Court stated in this case:

> In government patents containing no words showing purpose to define riparian rights, the intention to abide the state law is inferred.

> Some States have sought to retain title to the beds of streams by recognizing them as navigable when they are not actually so. It seems to be a convenient method of preserving their control. No one can object to it unless it is sought thereby to conclude one whose right to the bed of the river, granted and vesting before statehood, depends for its validity on non-navigability of the stream in fact. In such a case, navigability *vel non* is not a local question.

260 U.S. at 89.

Justice Stewart, in a lone dissent, argued that the original states derived their sovereign rights directly from the Crown and retained such rights to the extent not surrendered to the federal government. The ownership of the bed of navigable water was one of those rights and thus the states would be free to determine under their own laws the respective ownership of accretions and avulsions. Contrariwise, under the rule stated by the *Bonelli* majority, the later-admitted states are now precluded from applying their laws. Consequently, Justice Stewart concluded that the equal footing doctrine was being emasculated.

flowed across the neck of the peninsula; since that time, the main channel of the river extended across this neck although some water continued to flow in the original river channel. The state brought an action of ejectment against the defendant who, as owner of the area to which the main channel shifted, was removing sand and gravel from this new river bed. The Oregon court, following the *Bonelli* precedent, applied the federal common law and held that the defendant continued as owner of the river bed. The change in the main channel was held to be either an avulsion or within an exception to the doctrine of accretion. The Oregon court rejected the state’s contention that it was the owner of the bed of the newly formed navigable channel. Whether the application of Oregon law would have required a different result is not known since neither party argued that state law was applicable.

Upon review, the majority of the United States Supreme Court held that the equal footing doctrine required the application of federal law to determine state ownership of beds of navigable bodies of water at the time of a state’s admission into the Union. Once established, state ownership is not defeasible by a later application of federal law, and state law controls disposition of the land. The majority also held that federal law does not apply to determine the attributes of ownership of riparian land patented by the federal government, since, under the federal system, property rights are defined by state law “unless some other principle of federal law requires a different result.” The majority expressly overruled the *Bonelli* case, but not the *Hughes* case, noting that, if federal rights were based on the federal patent in *Bonelli*, the holding was erroneous since the “land had long been in private ownership and, hence, ... subject to the general body of state property law.”

Our task now is to determine the import of these cases. The central factors in the dispute are the perceived federal interests and fairness to the private landowner. The federal interest in these cases stems from a state’s

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238. One of the arguments of the state was that the ownership of the bed of the new channel passed to the state by virtue of its sovereignty over navigable waters. 526 P.2d at 474. The court held that sovereign control over navigable water for navigation and other purposes was possible without the ownership of the bed. *Id.* at 477.

239. The majority recognized that there are instances when federal law must still be applied to determine ownership of the bed even after admission of the state into the Union. For example, where a navigable river is an interstate boundary, federal common law applies to resolve disputes arising from changes in the river course. 45 U.S.L.W. at 4108.

240. *Id.* at 4109.

241. Justice Marshall, who wrote the majority opinion in the *Bonelli* case, dissented. *Id.* at 4110. His arguments rested upon (1) stare decisis, (2) the majority’s upsetting the expectancies of federal patentees who relied upon federal common law to establish riparian attributes, (3) the majority’s misreading of early opinions of the Court and (4) the failure to invite the Solicitor General’s opinion as to the impact of the application of state law upon federal interests.

242. *Id.* at 4107.
claim to tidelands and beds of inland navigable bodies of water under the equal footing doctrine. The doctrine is that the states, upon admission to the Union, succeeded to the ownership of beds of navigable bodies of internal water and tideland along the ocean, to the extent not previously conveyed, in order to be placed in equality with the original thirteen states.  

The principle that federal law is to decide such issues as navigability and the high water mark to be used to determine the extent of state ownership at the time of admission has not been affected by the above cases. This is sound because, unless federal law is employed, each state can determine for itself how much submerged land it derives from the federal government. This is an area in which state neutrality in lawmaking is absent; if federal law were not controlling, the supposed equality among the states under the equal footing doctrine could lead to inequality.

Much more difficult is the analysis concerning the proper law to be applied to determine the attributes of ownership, such as the right to accretion. The Corvallis majority concluded without much policy analysis that the Constitution granted beds of inland navigable waters to the states, boundaries to which were fixed as of the time of admission; consequently, the granted land is not defeasible by any federal common law. Because such transfers are constitutional grants, it would appear that riparian federal land would not have any right of accretion under federal law where the

243. The Corvallis majority also argued that the equal footing doctrine would have a perverse application if federal law controlled disputes involving states admitted subsequent to the formation of the Union since the original states would be able to apply their own laws. *Id.* at 4109.

244. *Borax Consolidated, Ltd. v. Los Angeles*, 296 U.S. 10 (1935), applied the federal law to determine the boundary line between the tideland which admittedly passed to the state and upland granted by the federal government to a private party after the state’s admission into the Union. The majority in the Corvallis case distinguished this case. 45 U.S.L.W. at 4108.

Federal test of navigability has been applied in *United States v. Utah*, 283 U.S. 64 (1913); *United States v. Holt State Bank*, 270 U.S. 49 (1926).

245. *Compare* *United States v. Holt State Bank*, 270 U.S. 49 (1926), where the Court saw the necessity of applying a federal test of navigability, when navigability is asserted as the basis of a right arising under the Constitution, in order to have a uniform operation of the Constitution in all states. 270 U.S. at 55-56.

In *Hughes v. Washington*, 389 U.S. 290 (1967), the state had fixed the state ownership of tideland up to the “ordinary high tide” determined as of the time its first constitution was adopted. Whether state law would have operated evenly so that the upland owner would have been entitled to retain ownership up to the fixed line in the event of subsequent reliction of the fast land is not known. *Bonelli Cattle Co. v. Arizona*, 414 U.S. 313 (1973). In *Oregon ex rel. State Land Board v. Corvallis Sand and Gravel Co.*, 45 U.S.L.W. 4105 (1977), if the state law supported the state’s contention that it owned the bed of a new channel by virtue of its sovereignty over navigable rivers, it is a rule that operates only with respect to the state, similar to the state law in the case in the *Hughes* situation. Whether the state would forfeit its ownership of the original bed where the river no longer flows is not known.

246. The majority seized upon a strange case to overrule *Bonelli* and to assert that federal common law cannot defeat the title which the state acquired at the time of its admission. The state in *Corvallis* was asserting title to an area to which it never had title at the time of admission. This was also true in *Bonelli*.
accretion occurs in boundaries fixed at the time of a state’s admission unless
the state law confers such a right. If, on the other hand, the river channel
should gradually move over the riparian federal land, it may well be that
state law would not govern whether the state would own the new riverbed
because federal property is impacted.247

More germane to our inquiry is the situation where riparian lands have
been patented to private parties by the federal government. Under the
previous analysis, it is clear that federal law cannot be applied to accord
riparian landowners a right to accretions to riparian land where the accretion
would divest the state of the ownership of riverbed which it acquired under the
equal footing doctrine. Only the state law may accord such a right. On the
other hand, whether state law can make state ownership of the river bed
ambulatory with a shifting river course when the shift impinges upon
federally patented riparian land should depend upon whether the state law
would adversely affect federal land disposition policy. The majority in
Corvallis, while recognizing the above consideration, in effect concluded,
based on its reading of precedents, that state law applies even if it would
deprive the riparian land of its access to the navigable water.248

Justice Marshall, in dissent, argued that federal grantees of riparian land
expected their patents to be interpreted according to federal law and correctly
understood that boundaries of the patents would shift with the movement of
the water under the federal common law. Justice Marshall is not very
convincing on this point. It is highly doubtful that federal patentees look to
federal common law to determine property attributes of the grant; because
general property attributes, restrictions on their use, modes of transfer,
succession, and other property rights have been determined under the state

247. See, e.g., United States v. Utah, 283 U.S. 64 (1931), where the court, in discussing
the navigability concept, held, “[s]tate laws cannot affect titles vested in the United States.”
Id. at 75. More recently the Court refused to apply the state law in defining the property
interests of the United States on the ground that the later enacted provision was “hostile” to
the United States. In United States v. Little Lake Misere Land Co., 412 U.S. 580 (1973), the
United States purchased and condemned two parcels on separate occasions with a reservation
to the transferor of mineral interests for a term of ten years and so long thereafter as minerals
were produced. Subsequent to the transfer, the state enacted a statute made applicable only to
the United States (there was another statute made applicable to the state) declaring that the
mineral rights would not pass to the United States even though the conditions of the
reservation were not met. The Supreme Court held that the state law did not apply of its own
force since the lands were acquired to further a federal program and the United States was a
party to a contract. On the issue whether the state law should be “borrowed,” the Court held
that state laws which are “hostile” to the interests of the United States, as the statute in
question was, will not be applied. Justice Stewart, concurring in the result, reasoned that the
state law is applicable but that such application would impair the obligation of contract and
would thus be unconstitutional. Justice Rehnquist, also concurring in the result, took the
position that the United States is protected by sovereign immunity against discriminatory
state laws.

248. Because the majority required the application of state law in the Corvallis case and
because the majority overruled the Bonelli case, the effect of the decision is as stated in the
text.
GEOTHERMAL RESOURCES

law, property owners are more likely to look to state law with respect to all attributes of property not expressly mentioned in the patent.²⁴⁹

Although the majority opinion was scant on analysis, it seems clear that state law applies in determining property attributes in lands initially patented by the federal government, unless state law would frustrate discernible congressional policy or unless there was a need for a uniform national policy. In Wallis v. Pan American Petroleum Corp.,²⁵⁰ the Court applied state law with respect to the mode of transfer of a mineral lease issued by the United States. It held:

We focus now on the central question in the case. In deciding whether rules of federal common law should be fashioned, normally the guiding principle is that a significant conflict between some federal policy or interest and the use of state law in the premises must first be specifically shown. It is by no means enough that, as he may assume, Congress could under the Constitution readily enact a complete code of law governing transactions in federal mineral leases among private parties. Whether latent federal power should be exercised to displace state law is primarily a decision for Congress. Even where there is related federal legislation in an area, as is true in this instance, it must be remembered that “Congress acts . . . against the background of the total corpus juris of the states . . . .” Hart & Wechsler, The Federal Courts and the Federal System 435 (1953).

Because we find no significant threat to any identifiable federal policy or interest, we do not press on to consider other questions relevant to invoking federal common law, such as the strength of the state interest in having its own rules govern, cf. United States v. Yazell, 382 U.S. 341, 351-353, . . . the feasibility of creating a judicial substitute, cf. U.A.W. v. Hoosier Cardinal Corp., 383 U.S. 696, 701, . . . and other similar factors.²⁵¹

The above analysis remains unchallenged. Short of having the federal courts develop a complete body of common law of property or having the state law govern all aspects of federal grants, the only rational approach is to apply state law to fill the interstices of federal law when the state interest and the effect of a particular state law do not impinge upon federal land disposal policy or other federal interests.

2. Factors to be Considered

We now seek to determine whether a state property regime for geother-

²⁴⁹. It is interesting to note that after Hughes v. Washington, 389 U.S. 290 (1967), a state court has applied the state law in determining the respective rights of riparian owners adjoining a nonnavigable lake. Bach v. Sarich, 74 Wash. 2d 575, 445 P.2d 648 (1968). In Hay v. Bruno, 344 F. Supp. 286 (D. Ore. 1972), the court found no difficulty in applying state law which approved a customary law of public use of beach area above the high-water mark. The court did not view the law as depriving the riparian owner of the right to exclude the public.


²⁵¹. Id. at 68-69.
mal resources under lands patented to private parties by the federal government would impinge upon federal land disposal policy or any other federal interest. The Hughes case, as previously mentioned, was not overruled by the Corvallis court. In Hughes, the reason given for the application of federal law was the perceived national interest in the boundaries along the ocean. While one might question whether state or private ownership of the accreted land would make any difference to the national interest in the international arena, the Court has on other occasions also found an overriding national interest in the ownership of areas bounding the ocean. By this logic, the allocative regime for geothermal resources underlying nonfederal lands ought to be determined under state law in the absence of a clear intent to transfer a federal interest in the geothermal resource to the patentee. International implications would arise from geothermal development in the Imperial Valley only if there were a common reservoir underlying lands in both the United States and Mexico. Even in this situation, the United States would be free to negotiate a treaty with Mexico allocating the reservoir without any embarrassment by a state allocative regime within the United States. This is because the treaty would override state-recognized rights to the extent that the reservoir crosses an international boundary.

No other national interest in the allocative regime for geothermal resources located under nonfederal lands appears. We assumed at the outset of this discussion that there is no federal proprietary interest in the resources, and at the time the lands were granted, rights to geothermal resources probably were not a significant consideration. In addition, the need for national uniformity in this matter is absent.

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252. The national interest appears to be based on international implications. How that national interest is affected in a land dispute between a state and a private party is difficult to comprehend. The state would have the ownership of the shore between the low-water mark and the high-water mark. United States v. California, 389 U.S. 290 (1967). Justice Marshall also found difficulty with this rationale for distinguishing the Hughes case. Oregon ex rel. State Land Board v. Corvallis Sand and Gravel Co., 45 U.S.L.W. 4105, 4110 n.1 (1977).


254. Cf. Hinderlider v. La Plata River and Cherry Creek Ditch Co., 304 U.S. 92 (1938) (interstate compact entered into between two states overriding water rights recognized under the law of the state, a party to the compact).

255. In Reconstruction Finance Corp. v. Beaver County, 328 U.S. 204 (1946), the Court held that state law would be applied to determine the meaning of real property in a federal statute permitting local taxation of "real property" of the Reconstruction Finance Corporation. The Court noted that Congress could not have intended uniformity when the tax burden may differ because of differing rates in various localities and that there were means of achieving uniformity had Congress so desired. The Court also reasoned:

We think the congressional purpose can best be accomplished by application of settled state rules as to what constitutes "real property" so long as it is plain, as it is here, that the state rules do not effect a discrimination against the Government, or patently run counter to the terms of the Act. Concepts of real property are deeply rooted in state traditions, customs, habits, and laws. Local tax administration is geared to those concepts. To permit the States to tax, and yet to require them to alter their long-standing practice of assessments and collections, would create the
It is arguable, though, that state law may "impair the efficacy of the grants or the use and enjoyment of the property by the grantee" and thereby impinge upon a significant federal policy. The difficulty with this argument is that it must assume the very fact in question. One can analyze whether the efficacy of the grant or the use and enjoyment of the property will be impaired only after determining the extent or the incidents of ownership that have been conveyed to the patentee. That is, of course, the very issue in question.

However, the further argument can be pressed that Congress in making the grant intended its patentee to derive some benefit from the land. In one sense this is true. If Congress intended to grant the land to its patentee, a state law which rejects any right of the patentee in the land would frustrate congressional policy and would not be adopted as the federal rule. This extreme case, however, is not the troublesome one. The application to federally patented lands of local rules, whether regulatory measures or property definitions, occurs commonly without serious challenge. The argument that a zoning law, which affects the use and enjoyment of patented land, does not determine what the patentee received from the government but only how the land is used seems ultimately unconvincing, since zoning laws define the extent of actual property rights. Moreover, if regulatory measures are unsatisfactory examples, one might cite local property rules dealing with nuisance, lateral support, and a myriad of other issues. The toleration of these local rules when applied to federally patented land implies that a test which turns on whether the local rule impairs the efficacy of the grant can be meaningful only when the claim is that a discernible congressional policy has been impaired.

Incidents and usufructs of land traditionally have been determined under state law, and properly so, because the federal courts should not be burdened with the development of a federal common law where the federal interest is minimal at best. If a federal common law for the initial entitlement to

kind of confusion and resultant hampering of local tax machinery which we are certain Congress did not intend.

Id. at 210.

256. The quoted language appears in Packer v. Bird, 137 U.S. 661 (1891), in which the Court stated:

The courts of the United States will construe the grants of the general government without reference to the rules of construction adopted by the States for their grants; but whatever incidents or rights attach to the ownership of property conveyed by the government will be determined by the States, subject to the condition that their rules do not impair the efficacy of the grants or the use and enjoyment of the property by the grantee.

Id. at 669.

257. Justice Stewart has observed, "Surely it must be conceded as a general proposition that the law of real property is, under our Constitution, left to the individual States to develop and administer." Hughes v. Washington, 389 U.S. 290, 295 (1967).

In referring to Congress' power to dispose of federal lands under U.S. Const. art. IV, § 3, cl. 2, Professor Hart has remarked:
Grants pursuant to the exercise of this power are the foundation of a large proportion of the land titles in the country. Conceivably, Congress might have attempted to impose conditions on these grants governing the rights and power of
Geothermal resources were to be developed, the courts would be faced not only with issues of initial entitlement but also with those of adjustment of the conflicting claims to a common resource. Moreover, there would be needless litigation to determine whether state law could apply in any given situation, as, for example, to compel unitization or to direct the use of resources for any given purpose. At the same time, the state is better able to coordinate the allocative regime for geothermal resources with the regimes for related resources and also with the residual law of the state. Further, if an effective allocative regime should require administrative supervision, federal courts would be unable to institute such a system.

Geothermal resources are unique and their economic potential is only now beginning to be realized. The lack of settled rules should not prevent the application of state law even though the state law is unclear or still to be developed. Even if state law were to declare state ownership of the grantees and subsequent holders. But as the Supreme Court has read the legislation it provided instead that the interests of the grantees should be assimilated into the general mass of property interests in the state, and subject thereafter to the governance of the general land law of the states.


Wechsler, *The Political Safeguards of Federalism: The Role of the States in the Composition and Selection of the National Government*, 54 Colum. L. Rev. 543, 544-45 (1954), analyzing federalism, would place the burden on those who argue that state law should be displaced by a federal common law; see also Comment, *The Federal Common Law*, 82 Harv. L. Rev. 1512 (1969).

In Mason v. United States, 260 U.S. 545 (1923), the Court applied the state law on damages for the wrongful taking of oil by private parties from federal lands. The Court characterized the entire cause of action as local. 258.

The Court in United States v. Oregon, 295 U.S. 1 (1935), stated that the settled and reasonable rules of construction of the state may afford a guide to determining the scope of federal patents. If the rules of construction include ownership attributes, it is not clear why the rule of construction of the state must be settled and cannot be a developing or an emerging law. If the issue pertains to incidents of ownership and if the incidents are unclear either under federal or state law, there would not be a frustration of federal policy to apply the state law since the very ambiguity of the situation indicates the lack of any clear federal policy.

If a state law changes a property rule, an issue concerning deprivation of property without due process of law may, of course, arise. Justice Stewart, in Hughes v. Washington, 389 U.S. 290, 294 (1967), would have decided the case on that ground. This assumes that the existing property rule is clear.

It is for this reason that the Court in Bonelli Cattle Co. v. Arizona was wide of the mark when it stated, "Finally, recognition of the State's claim to the subject land would raise a serious constitutional issue as to whether the State's assertion of title is a taking without compensation, a question which we find unnecessary to decide on our view of the case." 414 U.S. 313, 331 (1973). If state law were adopted, the private party had no property interest; if federal common law were applicable, the state claim evaporates. Thus, where the existence of a property interest is in question and that question brings into play the issue of federal or state law applicability, a choice of state law cannot result in a taking.

Compare, however, Oregon ex rel. State Land Board v. Corvallis Sand and Gravel Co., 45 U.S.L.W. 4105 (1977), in which the Court would permit the application of state law which might result in the state acquiring ownership of the bed of a navigable river after the main channel of the river has shifted to a location over previous fast land owned by a private party.

If the above argument that state law should be applied to determine the allocative regime for geothermal resources is unpersuasive, another line of analysis is available. However, we are not very enamored by it. The fluid in a hot-water geothermal system is "water" for
resource, denying rights in the overlying landowners in order to fashion an efficient property regime, as has been done in several states in adopting the appropriation system for water resources, no frustration of federal policy would occur.

The above analysis urging the application of state law to define geothermal rights was based on the absence of express congressional intent to grant a specific right to geothermal resources and of any Congressional policy that might be frustrated. The Federal Land Policy and Management Act of 1976, however, contemplates that in the future a federal interest in geothermal resources may be conveyed specifically to surface owners. Where such specific intent appears, the transferee would succeed to federal rights. It is unfortunate that the transfers of mineral interests designed to remove an impediment to nonmineral use of the property might interfere with state law which seeks a rational allocative regime for geothermal resources. As suggested earlier, Congress could protect nonmineral uses of the property without conveying the geothermal resources underlying the patented land. Therefore, Congress should amend the Act, as suggested earlier, to take into account its impact upon allocative regimes for resources.

C. The Cujus Est Solum Doctrine: An Analysis

Before alternative property regimes for geothermal resources can be considered, it is necessary to determine whether a state has the desired flexibility to create new property rules without running afoul of the constitutional protection against the taking of property without compensation. Undoubtedly, a property regime that rejects the overlying landowner's rights to the resources will be subject to attack based on the *cujus est solum* doctrine. purposes of the Desert Land Act, 43 U.S.C. § 322 (1970), and related federal statutes which the Supreme Court has construed to permit the states to apply their own allocative regimes with respect to lands patented by the federal government. California Oregon Power Co. v. Beaver Portland Cement Co., 295 U.S. 142 (1935). Moreover, because the hot fluid may be interrelated with ground water, these acts ought to be interpreted to include geothermal resources so that one governmental entity may coordinate the allocation of these resources. It is, of course, not untoward to classify geothermal resources as water for the purposes of these acts and to adopt an allocative regime which differs from water since a unique resource need not have a universal classification regardless of what the issue is. A characterization is useful only in light of the issue to be resolved.

The reason that we do not forcefully urge this argument is that the previous argument for the application of state law is much tidier, for it recognizes geothermal resources as the unique resources that they are.

260. See text immediately preceding, accompanying, and following notes 192-93 *supra* and text accompanying and following note 218 *supra*.
261. CAL. CIV. CODE § 829 (West 1954), provides that "[t]he owner of land in fee has the right to the surface and to everything permanently situated beneath or above it." CAL. CIV. CODE § 659 (West Supp. 1976), defines land as the material of the earth, whatever may be the ingredients of which it is composed, whether soil, rock, or other substance, and includes free or occupied space for an indefinite distance upwards as well as downwards, subject to limitations upon the use of airspace imposed, and rights in the use of airspace granted, by law.
Consequently, we now give thorough consideration to that doctrine in order to demonstrate that a state need not be inhibited thereby.

1. Judicial and Legislative Relaxation of the Doctrine

That the *cujus est solum* maxim has not been, and need not be, rigidly applied is demonstrated by the fact that it is totally rejected in many states in connection with allocative regimes for percolating groundwater. The strict application of the maxim to percolating groundwater is associated with the English absolute ownership doctrine which recognizes the right of the overlying landowner to take as much water as he needs regardless of the adverse effect upon other overlying landowners. Whether, under this doctrine, the overlying landowner is deemed to be the owner of the corpus of water in his land or he is held to have a usufructuary right is unimportant, since he may treat the water which he captures as a product for his own use or for sale.

When percolating water forms a “common pool” for the overlying owners, the absolute ownership rule may lead to gross inefficiencies in the use of the resource. Consequently, the rule has been modified in many jurisdictions. The reasonable use and correlative rights doctrines modified the English rule in an attempt to adjust conflicts among users, but the modified rights are based upon overlying landownership. In contrast, many states have totally rejected the proposition that landownership includes the right to percolating water underlying the land.

One of the earlier cases in which the common law right or its derivative was rejected was *Yeo v. Tweedy*. That case concerned the validity of a statute which declared an artesian basin with definable boundaries to be “public waters and to belong to the public, and subject to appropriation for beneficial uses.” The plaintiff argued that he had a vested right as an overlying owner to “absolute ownership and dominion over such portion of the underlying waters as he could capture” or to the “right to reasonable use of waters correlative with similar rights of other owners.” Although the statute was declared invalid on a technical ground, the court emphatically

Section 829 has appeared since 1872 but section 659 was amended in 1963 to remove the reference to solid materials and to add the language dealing with space. Section 829, if it is a statement of the *cujus* doctrine, has not been honored literally. See *Katz v. Walkinshaw*, 141 Cal. 138, 70 P. 663 (1902), rehearing, 141 Cal. 116, 74 P. 766 (1903); *Niles Sand & Gravel Co. v. Alameda County Water Dist.*, 37 Cal. App. 3d 924, 112 Cal. Rptr. 846 (1974); *Krieger & Banks, Ground Water Basin Management*, 50 CALIF. L. REV. 56, 72-73 (1962). Moreover, it is arguable that the above provisions do not apply to migratory resources that are not permanently situated.

265. 34 N.M. 611, 285 P. 970 (1930).
266. *Id.* at 613, 286 P. at 971 (invalidating 1927 N.M. Laws, ch. 182, § 1).
267. The statute was repaired and the issue was again litigated; however, in the
stated that the rule of appropriation had always been the law of the state and that, although an earlier statute had generally adopted the common law, the English common law was deemed controlling only so far as it was suitable to the conditions in the state. In view of the arid conditions existing in the state, the court believed that the appropriation doctrine was desirable in order to protect the investments of earlier users.

Similarly, the Utah Supreme Court adopted the appropriation doctrine with respect to percolating groundwater, in effect overruling the prior law which recognized rights based on overlying landownership. The rationale for adopting the appropriation doctrine was to permit a better allocative scheme by giving security to water uses and also to coordinate the use of interconnected water supplies since the appropriative system already applied to other bodies of water.

In several states the legislature has changed the traditional rules by statute. For example, in South Dakota a groundwater allocation system based on overlying landownership was abrogated by a statute which established an appropriation system under administrative supervision. Existing uses were protected, but the absolute ownership doctrine could not be used to justify increased future extraction. The constitutionality of the statute was sustained as an exercise of the police power in furtherance of the general welfare.

The subsequent case, State ex rel. Bliss v. Dory, 55 N.M. 12, 225 P.2d 1007 (1950), an overlying landowner asserted that rights to percolating groundwater based on land ownership had vested in him because the federal government, as the original owner of the land, had transferred such rights with the patent. The New Mexico Supreme Court relied upon California Oregon Power Co. v. Beaver Portland Cement Co., 295 U.S. 142 (1935), to support its conclusion that the federal government had permitted New Mexico to apply its water laws to federally patented lands.

268. Wrathall v. Johnson, 86 Utah 50, 40 P.2d 755 (1935); Justesen v. Olsen, 86 Utah 158, 40 P.2d 802 (1935). The appropriation doctrine is not applied to all percolating water in Utah since a distinction seems to be made between flowing and nonflowing percolating water. Even with respect to the latter, it is subject to appropriation if not necessary to sustain plant life or if it does not affect the land. Riordan v. Westwood, 115 Utah 215, 203 P.2d 922 (1949). In other words, percolating groundwater that is not subject to appropriation is that "which by [its] presence in the soil confer[s] a natural benefit on the land which will be destroyed by the waters being appropriated." McNaughton v. Eaton, 121 Utah 394, 402, 242 P.2d 570, 573 (1952).

269. Justesen v. Olsen, 86 Utah 158, 40 P.2d 802 (1935). Although the court purported to construe a statute in applying the appropriation doctrine to percolating water, it might be said that the court did so despite the statute since its interpretation was rather strained. See Wrathall v. Johnson, 86 Utah 50, 40 P.2d 755 (1935).

Idaho has also adopted the appropriation doctrine. Hinton v. Little, 50 Idaho 371, 296 P. 582 (1931).

270. In Knight v. Grimes, 80 S.D. 517, 127 N.W.2d 708 (1964), the court recognized that the statute resulted in an "invasion of a pre-existing right or interest" but sustained its constitutionality after a general discussion of the scope of police power regulating property rights. The court offered no policy justification other than to conclude:

Being convinced that the legislature was justified in believing that the public welfare requires conservation and preservation of the water supply of the state, that it is not required that irreparable damage be done before action can be taken to conserve and preserve, and that it has not been shown that the regulations adopted are unreasonable or arbitrary, the order of the trial court dismissing such action is affirmed.
effect of the absolute ownership doctrine had been to leave the overlying landowner insecure with respect to current as well as future uses and the appropriation statute therefore benefitted overlying landowners by protecting their established uses. However, a landowner whose need arose after the basin had been fully appropriated would be completely precluded from a share in the groundwater.

In North Dakota the underground water allocation regime based on overlying landownership was converted by statute to the appropriation system. The statute was sustained on the ground that the right to water is usufructuary and, therefore, there was no taking of the corpus of the water. The court also stressed the fact that "the water resources of the State [should] be put to beneficial use to the fullest extent of which they are capable . . . ."272

Arizona, which has been experiencing a severe groundwater overdraft, enacted a statute prohibiting new wells in critical groundwater basins. This statute radically modified the reasonable use system because, under its provisions, irrigation uses commencing after designation of the critical groundwater area may be prohibited. A due process and equal protection attack levelled at the statute was rejected by the Arizona Supreme Court on two grounds. First, the statute was necessary to preserve a vital resource from destruction. Second, the statutory classification was reasonable where irrigation of new acreage would force existing farms to be taken out of production.273


Kansas also has statutorily changed from absolute ownership doctrine to the appropriation system, but it has protected existing uses and has conferred a right to damages to the overlying owners for injury stemming from the abolition of the absolute ownership right. The statute has been sustained in Williams v. City of Wichita, 190 Kan. 317, 374 P.2d 578 (1962), appeal dismissed, 375 U.S. 7, rehearing denied, 375 U.S. 936 (1963).


In a California case, Niles Sand & Gravel Co. v. Alameda County Water Dist., 37 Cal. App. 3d 924, 112 Cal. Rptr. 846 (1974), involving a different factual situation, the court denied compensation to an overlying landowner who was unable to extract sand and gravel from his land because of flooding due to artificial recharge operations by a public water district. The artificial recharge had raised the water level in the ground water basin, which previously had been lowered by excessive pumping by water users, but the raised level was still below that which existed in the state of nature. The court denied a claim for inverse condemnation, relying upon the police power as an alternative ground for the decision. While the court's reasoning was opaque and its conclusion debatable, the fact remains that the court permitted a public water district to exercise the police power to utilize the subsurface area of private land for water storage, despite injury to the landowner.
The above cases demonstrate that the *cujus est solum* maxim does not express an immutable principle. In many states, courts or legislatures have taken the initiative to repudiate rights to percolating groundwater based on overlying landownership. The reasons for initially adopting or later shifting to the appropriation system appear to have been twofold: first, to institute a regime of property rights which improves the efficiency of resource allocation, and second, to permit a greater access to a resource by discarding a system which restricts rights to the resource to overlying landowners. The usual conceptual approach has been to declare the resource to be the property of the state or the public. But as Trelease has concluded, the concept of state or public ownership is not a necessary condition for the legislature to exercise its power to fashion a property regime. That concept has been useful, however, in rejecting landowners' claims to the subsurface resource based on the *cujus est solum* doctrine. In fact, two states have, by incorporating geothermal resources into their groundwater appropriation system, rejected claims to the resources based on overlying landownership.

2. Application of the Doctrine to Airspace

It will be instructive to examine the application of the *cujus est solum* maxim to claims of ownership upwards from the surface of the land. With the advent of aviation, it was inevitable that the maxim would become the focal point of debate. Apparently there were some who believed that the maxim would apply absolutely, so that short of a constitutional amendment landowners would be able to prevent trespass of space over their land regardless of

274. See Wrathall v. Johnson, 86 Utah 50, 40 P.2d 755 (1935); Yeo v. Tweedy, 34 N.M. 611, 286 P. 970 (1930).

275. MEYERS APPROPRIATION SYSTEM STUDY, supra note 221, at 8-9, describes this development with respect to surface water as follows:

As we have seen, the early appropriation cases involved the contention that the riparian land limitation rule should be applied in the West, but the contention was rejected for the very good reason that the gold and silver mines were not located on riparian land or even within the watershed. Irrigated agriculture faced the same conditions. Federal land disposition policies favored farms of 160 acres in the shape of squares conforming to the U.S. Survey. Thus, most farms were not located on the stream containing necessary irrigation water. The policy of promoting development of this back land was so strong that, not only was the riparian land restriction eliminated from Western law but eminent domain power was granted to private citizens by some states to allow acquisition of rights-of-way for canals from stream to backlands.


277. In Wrathall v. Johnson, 86 Utah 50, 40 P.2d 755 (1935), the Utah Supreme Court held that a statute providing that

"[t]he water of all streams and other sources in this State . . . is hereby declared to be the property of the public" does not vest in the state title or ownership of the water as a proprietor. It is a community right available to all upon compliance with the law by which that which was once common to all may be brought within the domain of private right to use, or under certain circumstances private and exclusive possession and ownership.

*Id.* at 100-01, 40 P.2d at 777.

278. The states are Montana, MONT. REV. CODES ANN. § 89-867(1) (Supp. 1975), and Wyoming, WYO. STAT. ANN. § 41-121 (Supp. 1975).
altitude. In the earlier development of the law, a variety of positions emerged. At least one court held that a landowner has ownership rights to space only to the extent that the space is used for the enjoyment of land. Many courts adopted the view that ownership extends to that which is capable of being possessed. Another view, described as the “zone” theory, refused to recognize trespass in the legislatively prescribed navigable airspace in the absence of any interference with land use. The Restatement of Torts, at one time, described the nonliability for passage in the space as a privilege. None of the above views carried the cujus est solum to its logical extreme.

The landmark case was United States v. Causby, in which a landowner sought compensation under the Fifth Amendment for interference with the enjoyment of his land caused by United States aircraft making frequent

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279. See Kingsley & Mangham, The Correlative Interests of the Landowner and the Airman, 3 J. Air L. 374, 376 (1932) (the authors do not subscribe to the absolute application of the maxim).

280. A very comprehensive discussion of ownership of space is found in R. Wright, The Law of Airspace (1968). Chapter V of the book is devoted to the problem of aviation and airspace ownership. The books and articles dealing with this subject are too numerous to list or to read for the limited purpose of this article, but some which have proved helpful are Anderson, Some Aspects of Airspace Trespass, 27 J. Air L. & Com. 341 (1960); Sweeney, Adjusting the Conflicting Interests of Landowner and Aviator in Anglo-American Law, 3 J. Air L. 329, 531 (1932). A very detailed historical treatment of the maxim is found in Klein, Cujus Est Solum Ejus Est . . . Quousque Tandem? 26 J. Air L. & Com. 237 (1959).


282. Delta Air Corp. v. Kersey, 193 Ga. 862, 20 S.E.2d 245 (1942); Thrasher v. City of Atlanta, 178 Ga. 514, 529, 173 S.E. 817, 825 (1934) (“The legal title can hardly extend above an altitude representing the reasonable possibility of man’s occupation and dominion, although as respects the realms beyond this the owner of the land may complain of any use tending to diminish the free enjoyment of the soil beneath.”); Swetland v. Curtiss Airports Corp., 55 F.2d 201 (6th Cir. 1932).


284. Restatement of Torts § 194 (1934). The current Restatement rejects the notion of ownership of unlimited airspace and provides that there is trespass by aircraft flight only if the flight enters into the immediate reaches of the air space next to the land, and it interferes substantially with the other’s use and enjoyment of his land. Restatement (Second) of Torts § 159 (1965). This is an attempt to state the rule as developed in United States v. Causby, 328 U.S. 256 (1946). The Restatement notes in Comment m that there may be liability based on nuisance even though there is no trespass in the “immediate reaches” of the airspace.

285. 328 U.S. 256 (1946). The Court held that there was a taking of property for which just compensation must be paid when the frequent overhead flights were so low that the noise and glare of lights caused substantial interference with the enjoyment of their residence and chicken farming. The decision below was reversed because the lower court failed to determine whether the taking was permanent or temporary. Recent cases differ as to whether the flights must be overhead. Compare Avery v. United States, 330 F.2d 640 (Cl. Cir. 1964); Batten v. United States, 306 F.2d 580 (10th Cir. 1962) (denying recovery where flight not overhead), with Alevizos v. Metro. Airports Comm’n, 298 Minn. 491, 216 N.W.2d 651 (1974); Martin v. Port of Seattle, 64 Wash. 2d 309, 391 P.2d 540 (1964); Thornburg v. Port of Portland, 233 Ore. 178, 376 P.2d 100 (1962) (whether flight overhead is immaterial). Many state constitutions, unlike the Fifth Amendment of the U.S. Constitution, extend the requirement of compensation to the damaging as well as to the taking of the property, and this is one of the factors which accounts for the different results in the above cases.
flights at low altitudes. While holding that there was a taking of property in the case, the Supreme Court stated:

It is ancient doctrine that at common law ownership of the land extended to the periphery of the universe—*Cujus est solum ejus est usque ad coelum*. But that doctrine has no place in the modern world. The air is public highway, as Congress has declared. Were that not true, every transcontinental flight would subject the operator to countless trespass suits. Common sense revolts at the idea. To recognize such private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim.\(^{286}\)

The Court defined the extent of ownership as follows:

We have said that the airspace is a public highway. Yet it is obvious that if the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere. . . . The landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land. . . . The fact that he does not occupy it in a physical sense—by the erection of buildings and the like—is not material.\(^{287}\)

The subsequent development of the law of airspace ownership has been traced elsewhere.\(^{288}\) What is important to note here is that at some altitude, where there is no substantial interference with his land use or enjoyment, the landowner has no property interest\(^{289}\) which would permit him to realize the economic rent of the space resource.

Inasmuch as the airspace cases have been decided under several legal theories, it is important to refine the rationale utilized by the courts in allocating this resource. To begin with, there is no *a priori* principle by which to allocate airspace. Some have argued that airspace has no value to the landowner beyond its usefulness in protecting his enjoyment of land.\(^{290}\) This reasoning is erroneous. If property rights are recognized, they may be valuable, especially near an airport where it might be necessary to have a fixed flight pattern. Value may also exist even far removed from any airport if

286. 328 U.S. at 260-61.
287. Id. at 264.
289. See Anderson, *supra* note 280, at 358-59. See also *Wright, supra* note 280, at 208, where he summarizes the cases as follows:

The effect of this is to say that a landowner has a paramount right to exercise the prerogatives of ownership in all of the airspace which he can effectively possess, although his rights are also extended to an additional buffer area to permit and enhance the enjoyment of what is possessed.

290. See *Wright, supra* note 280, at 208, wherein the author, referring to the "privilege of flight" or "air easement" notion, states:

Thus, the practical effect of these provisions, just as it was the practical effect of the maxim, is to constrict the landowner's rights within the boundaries of reason, or to put it another way, within the boundaries of value. Airspace is only valuable if he can use it, possess it, or sell it, or unless it contributes essentially to such use, possession or purchase.
desirable flight paths are scarce. And if flight paths are scarce, there is no reason why airspace could not be condemned as land is condemned for highways. Consequently, an analysis proceeding from the premise that a landowner does not own the space above because it has no value is unsound.

The true explanation seems to be that the courts have balanced the expectations of landowners and the social desirability of free passage in the airspace. Until the invention of airplanes, the economic value of the upper airspace was unimaginable. The reasonable expectation being protected is that with respect to surface-related uses. In fact, in most of the litigated cases, the landowners generally have been interested in protecting their enjoyment of the land rather than in capturing the economic value of airspace as such. Furthermore, recognition of property rights in the airspace may result in transactional costs greater than are socially desirable to protect those rights.291

The application of this analysis to geothermal resources is obvious. Until the recent activity concerning geothermal resources, most landowners had no expectation of capturing the resources' value.292 Therefore, if the incidents of landownership should be held to include property rights to the resources, the landowner would receive a windfall. The fact that windfalls of other resources have been granted in the past does not mean that windfalls should continue to be dispensed. Moreover, an allocative regime resting upon overlying landownership may be, as we argue, an extremely inefficient one.

3. Application of the Doctrine to Navigable Waters

We wish to discuss briefly one other area of the law in which the conflict between public or governmental rights and private rights has been resolved in favor of the public. Prima facie under English law the King owned the bed of bodies of water subject to tidal flows, and the public had the right to navigate and fish in those waters.293 The riparian owner, however, had a right of access to such water and he had a right to compensation when the government interfered with his access.294 This body of law was adopted in the United States with the modification, adapted to differing conditions within this country, that navigable bodies of water included those which were navigable in fact, regardless of tidal influences.295 The beds of the navigable bodies of

291. The transactional costs involved in making the transfer payments, such as litigation and court costs (the latter being principally social costs), could be greater than the loss suffered by the landowner in many cases. Consequently, it would be socially inefficient to require compensation.

292. In some areas, the hot springs and hot water have been used for recreational and health resorts and for space heating. See text accompanying notes 16-20 supra.

293. See discussion of the English common law in Shively v. Bowlby, 152 U.S. 1, 11-14 (1894); Gould, Law of Waters 8-9, 34-42, 100 (3d ed. 1900). However, a prescriptive public right to navigation in nontidal rivers might be recognized in England. Gould, at 115-16. Thus, in England, the ownership of the bed was determinative of the existence of public rights except for prescription.


295. The Daniel Ball, 77 U.S. (10 Wall.) 557 (1870) (construed statute referring to "navigable waters" as applicable to waters navigable in fact); The Genesee Chief, 53 U.S. (12 How.) 443 (1851) (admiralty jurisdiction of federal government extended to waters navigable in fact).
water, unless previously disposed of by the federal government, passed to the states upon admission to the Union or to the private riparian owners according to state law. However, the federal government’s power to regulate interstate and foreign commerce permits it to regulate navigation. This power to regulate has had important consequences. It has been held to include not only the traditional police power, but also has been held to impose a “servitude” upon the navigable waters so that the Constitution does not require the federal government to pay compensation for injury to or destruction of uses of either the bed or the water. The servitude even permits the federal government to allocate the resource for purposes unrelated to navigation.

While the development of the servitude doctrine has been criticized in some quarters and Congress has ameliorated its impact by legislation, the federal government was building a reservoir principally for power and flood control purposes. The Supreme Court has practically indicated that it will not review a determination by the Congress that a project serves a navigational purpose. One might question whether it is necessary that navigational interests be served for the servitude to operate. See United States v. Appalachian Electric Power Co., 311 U.S. 377 (1940), on the servitude doctrine remains to be explored. A related issue is whether the servitude is coextensive with the regulatory powers of Congress—that is, whether the servitude extends to the non-navigable reaches of a navigable river, as urged by the federal government in several cases. The Supreme Court has avoided the issue so far. United States v. Grand River Dam Authority, 363 U.S. 229 (1960); United States v. Gerlach Live Stock Co., 339 U.S. 725 (1950).

300. E.g., United States v. Twin City Power Co., 350 U.S. 222 (1956) (the federal government was building a reservoir principally for power and flood control purposes). The Supreme Court has practically indicated that it will not review a determination by the Congress that a project serves a navigational purpose. One might question whether it is necessary that navigational interests be served for the servitude to operate. See United States v. Appalachian Electric Power Co., 311 U.S. 377, 426-27 (1940) (Court stated that the federal regulatory power is as broad as the needs of commerce). See also Barker, Sections 9 and 10 of the Rivers and Harbors Act of 1899: Potent Tools for Environmental Protection, 6 Ecology L.Q. 109, 137-38 (1976), in which the author discusses the Appalachian case in conjunction with the federal government’s authority to regulate navigable waters for purposes other than navigation.

301. See Morreale, supra note 299, at 76-77, arguing, the thought occurs that a good deal of the difficulty lies in the manner in which the navigation servitude has been permitted to grow from a rule securing free and unhindered passage on navigable waterways to its present scope. The process seems less the result of studied consideration than of confusion between the national power and non-compensability.

302. 33 U.S.C. § 595(a) (1970). There appears to be no question that Congress has directed...
the constitutional development does illustrate the allocation of these resources between the private and public sectors. The analogy of the navigation servitude to an allocative regime for geothermal resources, although distinguishable, is persuasive. The navigation servitude may be distinguished on the ground that although there is a long common law history of a public right to navigation and fishery on navigable bodies of water, there is no such history with respect to geothermal resources. On the other hand, servitude law persuasively illustrates that, as constitutional law has developed, asserted private rights have not been sustained in the face of government control and use, even when such government use is unrelated to public rights of navigation and fishery. This has proved true even where investments have been made in reliance on those private rights.303

4. Application of the Doctrine to Geothermal Resources

In conclusion, we have discovered that the *cujus est solum* maxim serves as a starting point for examining property rights to resources above or below the surface of the land. While reliance on this ancient maxim undoubtedly will simplify the allocation of geothermal resources, review of the appropriation and navigable airspace cases304 demonstrates that courts have not been content with a mechanical application of the doctrine. From the appropriation cases, we learn that the courts developed, or permitted legislatures to develop, a property system which would permit efficient allocation of water resources by giving security to prior investments. But adoption of the appropriative system rests on additional considerations. The appropriative system for surface waters has been justified on the ground that the water of natural watercourses ought to be made available to lands not riparian to the river.305 In rejecting the common law doctrine, the courts have not been that the right to compensation for taking of the whole of the fast lands includes the value arising from its access to or use with navigable waters. The above statute does not appear to operate when there is no taking of fast lands. H.R. REP. NO. 1665, 91st Cong., 2d Sess. 30-31 (1970); H.R. REP. NO. 1782, 91st Cong., 2d Sess. 23 (1970). Thus, where the water level is raised, the person adversely affected by loss of water power would not be entitled to compensation where there is no taking of his fast land.

303. The "fairness" of upsetting private investments in navigable waters has been justified on the basis of notice that expectancies should not be formed. See Michelman, *Property, Utility, and Fairness: Comments on the Ethical Foundations of "Just Compensation" Law*, 80 Harv. L. Rev. 1165, 1239 (1967). A windfall from the allocation of geothermal resources to the private sector would fit into the same pattern.

304. Although the cases dealing with navigable airspace and navigable bodies of water dealt with the public right, it would seem that the policy-making organ of the government can act to preclude any further public use or to divert the resource to other uses. In the absence of a constitutional provision conferring a direct right to the public, the legislative body ought to be able to allocate public resources among competing uses. See Sax, *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, 68 Mich. L. Rev. 471, 478-91 (1970). Moreover, there would appear to be no valid reason why the government cannot exact a charge for the use of such resources if it so decided. In short, to recognize a public right is to recognize the plenary jurisdiction of the government.

troubled by distributional consequences where the frustration of expectations results at most in future opportunity losses.\textsuperscript{306}

In the navigable airspace cases, the need for efficient allocation of resources probably exerted a strong influence on the courts. Since surface landowners had not developed expectations of an unrestricted right to use and control navigable airspace, and since the use of airspace for air flights produced greater benefits for society than costs imposed on landowners below, the courts were perfectly justified in devising a property regime that rejected rights based on the \textit{cujus} doctrine.

The same result might be achieved by assigning to a surface owner the exclusive right to the navigable airspace above his property and then permitting the transfer of rights thereto by purchase or condemnation, but this would entail transactional costs and by definition would bring about an initial windfall to the surface landowner. In adjusting conflicting claims, the courts have reached a reasonable accommodation by protecting the landowner only to the extent that overflights cause injury to surface uses, a solution which promotes efficiency and distributive equity.\textsuperscript{307}

The purpose of the above discussion has been to establish the position that a state may proceed to allocate geothermal resource rights with a clean slate. Of course, it might still be argued that the resources are to be treated as water or gas and, consequently, that the existing property regimes for those resources are applicable. We reject that proposition here, as we have before, on the ground that geothermal resources are sufficiently unique to warrant emancipation from the bonds of limited classifications.

5. \textit{The Role of Overlying Landownership in Government Leasing Practices}

Finally, we would like to dispose of one issue which, if unexplained, presents a seeming incongruity in the discussion that follows. Many states have enacted laws governing the exploitation of geothermal resources underlying lands owned by the state. The method adopted is invariably a leasing scheme.\textsuperscript{308} Implicit in such leasing laws is an assertion of the state's right to exploit the resources. Because the leasing laws apply only to lands owned by the state or in which the resources are reserved to the state, one might conclude that the right to exploit the resources derives from overlying landownership. If the state claims ownership of the resources based on overlying landownership, one could reasonably assert that the state must recognize similar rights to the resources in private overlying landowners. At issue here is not only a possible difference in the allocative regimes, but more importantly to the landowners, a difference in the distribution of income from

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\textsuperscript{306} \textit{E.g.}, In re Hood River, 114 Ore. 112, 227 P. 1065 (1924). Of course, if the purchase price of the land reflected the common law rights, the loss from destruction of those rights is a real loss to the investor.

\textsuperscript{307} \textit{See Michelman, supra} note 303, at 1218-24.

\textsuperscript{308} \textit{E.g.}, \textsc{Alaska Stat.} § 38.05.181 (Supp. 1975); \textsc{Cal. Pub. Res. Code} § 6902 \textit{et seq.} (West Supp. 1976); \textsc{Idaho Code} § 47-1601 \textit{et seq.} (Supp. 1976); \textsc{N.M. Stat. Ann.} § 7-15-5 (Supp. 1973).
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the resources. The fundamental issue is whether the state may exploit the resources on the apparent basis of its overlying landownership, while adopting in the private sector an allocative regime which rejects rights based on overlying landownership.

Analogies under existing law in support of this discrimination are not easy to find. State constitutional or statutory provisions proclaiming public ownership of water are inapposite since we know of no state which has attempted, pursuant to such provisions, to capture the rent from the use of water in the same way that a state leases its lands for geothermal resource exploitation.309 These provisions have been adopted in recognition of the overriding public interest in water resources and the consequent need to promote an efficient allocative regime unencumbered by common law notions.310 However, in those states adopting an appropriation system for water resources, it has not been uncommon for the state to reserve the use of those resources, otherwise available for appropriation by private parties, for on-site recreational or other public uses. This in effect appropriates water to permit the derivation of public benefits from it.

Similarly, if the state should reject overlying rights to geothermal resources in the private sector and adopt an appropriation system, and if the state should persist in leasing its lands for geothermal resource exploitation, state leasing may be considered an appropriation of the resources under state land or a reservation for public benefit. In the one case, public benefit is direct in the sense that the use constitutes the public benefit, while in the other, the benefit is indirect since the rent from the geothermal resources must be spent to provide public benefits. However, the directness of public benefit in the two situations ought not to be of sufficient legal importance to validate one and not the other. In other words, one may view state leasing of geothermal resources under its land as state appropriation for a public benefit within the totality of the allocative regime.

On the other hand, if one were to insist that the basic property rights in the public and private lands are different because state geothermal leasing laws are based on a state ownership concept, one should note that there are many differences in the property rules applicable to public and private lands. For example, state property might be immune from claims based on adverse possession, whereas private property might not.311 The extent to which an execution may be levied upon public and private property may differ.312

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309. In permit states, the fee that is charged to obtain an appropriative right is designed to defray the costs of administration and bears no relationship to the value of water. E.g., CAL. WATER CODE §§ 1525-1533 (West 1971).
Ultimately, the question boils down to whether the state may give itself a favored position in devising an allocative regime. We find some difficulty in answering in the negative when property rights to geothermal resources are by assumption not fixed as yet. The way in which the state favors itself with revenues from resource exploitation is very similar to the means by which public benefits are derived from nonrecognition of private ownership in the navigable airspace or from state reservation of water from private appropriation. In each case, the absence of settled ownership expectations and the public benefits to be derived from state ownership justify nonrecognition of private ownership of the resource.

In conclusion, we can do no more than make the bald assertion that it is unlikely that the problem alluded to here will prevent the state, by rejecting the *cujus est solum* maxim, from determining rights to resources underlying private lands or will result in a violation of the Equal Protection Clause. However, later in this study we recommend the adoption of the appropriation system as an allocative regime for geothermal resources. There is no reason for not applying this regime to resources underlying lands owned by the state. If this is done, the seeming difference in the nature of state and private property rights will be eliminated.

[The second part of this article will appear in the next issue of *Ecology Law Quarterly.*]