PATTERNS OF GEOTHERMAL LEASE ACQUISITION IN THE IMPERIAL VALLEY: 1958-1974

A REPORT PREPARED BY:

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Over the past decade considerable interest has been shown in geothermal resources as a potential energy source in the United States. Much of this interest has centered on the resource in the Imperial Valley. Scientists have studied the resource along numerous dimensions, including extent, properties, and technical aspects.

This research has been furthered by grants and contracts, chiefly from various federal government agencies. In recent years, however, agencies of the State of California, the California Legislature, and the County of Imperial have provided significant support for studies of the geothermal resource. The following report, Patterns of Geothermal Lease Acquisition in the Imperial Valley: 1958-1974, has been made possible by support from two committees of the State Legislature and by the Board of Supervisors of the County of Imperial.

This report makes a specific contribution. Its particular value lies in the historical and analytical consideration of corporate behavior in geothermal development, examining the actions of those companies over time to discover patterns of involvement, investment, and likelihood of further development. Much work has been done in the scientific and technical areas of the geothermal resource; less has been accomplished in the social, political, and economic areas. Patterns of Geothermal Lease Acquisition is a modest but nonetheless important step to redress this imbalance. It is a sound addition to the general understanding of the potential for development of the resource in the Imperial Valley, and the direction such development has, so far, tended to take. It also suggests the technical, economic, and institutional impediments to development which may also obtain in other locations and which therefore should be of especial interest to those concerned with geothermal resource development in other portions of the United States.

Upon completion of their manuscript, the authors requested that I read, review, and comment on their work. I have done so and consider their effort an important and sound piece of research.

James Combs

James Combs, Ph.D.

This report developed from a special research project undertaken by the authors under the general supervision of Dr. Donald Brown, in the Department of Political Science at the University of California, Riverside. The main portion of the study was conducted while the authors were associated with the Center for Social and Behavioral Sciences Research.

Support for the project was made available by the Senate Rules Committee and the Joint Committee on Public Domain of the California State Legislature, and by the Board of Supervisors of the County of Imperial.

Initially designed to cover geothermal lease acquisitions in the County of Imperial during the period 1958-1973, the report was delayed to include an analysis of the impact of Federal Land Lease Sales held in January, 1974. However, the main body of the report, and the maps representing distribution of lease holdings, reflect on the 1958-1973 time period, examining geothermal lease activities through June, 1973. The analysis of Federal Land Lease Sales bids has been included as an addendum following the main body of the text. That addendum applies the findings and conclusions of the basic research to the federal leasing situation and, thus, extends the argument of the paper through 1974.

In addition to the Senate Rules Committee, the Joint Committee on Public Domain, and the County of Imperial, the authors also wish to thank Dr. Michael Reagan, Dean of the College of Social and Behavioral Sciences and Director, Center for Social and Behavioral Science Research, who made available, through the Center, office space and other assistance which greatly facilitated the task of research gathering and analysis; Professor Brown, who was a major influence in directing the authors' interest in this subject; and Dr. James Combs, a member of the faculty at the University of Texas, Dallas, and at the time on the faculty of the Department of Earth Sciences, UCR, who read the manuscript and offered advice and suggestions for improving its contents.

We also thank Stephen K. Holland for his assistance in the preparation of figures and charts for this publication.

We offer this research paper with the hope, and the expectation, that its findings and conclusions will provide a clearer insight into the historical patterns of geothermal development in the Imperial Valley and make available data previously unavailable in this consolidated form. As such, it should be of both interest and use to those individuals, agencies, and firms concerned with geothermal resource development in California.

While the authors gratefully acknowledge their debt to those members of the UCR faculty and staff who have been mentioned above, and to a variety of others who provided various forms of assistance during the preparation of this work, the responsibility for the ideas and conclusions expressed in this paper do not, in any way, necessarily reflect the views of any but the authors.

M. S.
S. McD.
F. V. H.

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IMPERIAL COUNTY

LEASE HOLDER	SYMBOL
UNION OIL COMPANY OF CALIFORNIA	©
STANDARD OIL COMPANY OF CALIFORNIA	A
ATLANTIC OIL COMPANY	+
MAGMA POWER AND MAGMA ENERGY COMPANIES	X
EARTH ENERGY COMPANY	◇
JOSEPH J. O'NEIL PARTNERSHIP	✦
O. B. RESOURCES INTERNATIONAL	X
FLEET OIL COMPANY	Z
R. W. CYPHER (PRIVATE CONCERN)	Y
IMPERIAL THERMAL PRODUCTS	X
SOUTHERN PACIFIC LAND COMPANY	▣
RICHFIELD OIL COMPANY	⊠
ATAN OIL COMPANY	I
OTHER CONCERNS	*

SCALE IN MILES
0.00 4.00

TOWNS:	NO.
HEBER	1
NILAND	2
SEELEY	3
BRAWLEY	4
CALEXICO	5
IMPERIAL	6
EL CENTRO	7
HOLTVILLE	8
DIXIELAND	9
CALIPATRIA	10
WESTMORLAND	11

WATER MAINS:	SYMBOL
EAST HIGHLINE CANAL	EH
WEST SIDE MAIN CANAL	WM
ALL AMERICAN CANAL	AA
CENTRAL MAIN CANAL	CM
MAIN ALL AMERICAN	MA
RIVERS:	
ALAMO RIVER	AR
NEW RIVER	NR

LEASES FOR 1958 TO 1973.

GEOTHERMAL LEASE ACQUISITION
RESEARCH PROJECT. 1973
UNIVERSITY OF CALIFORNIA, RIVERSIDE

SALTON SEA

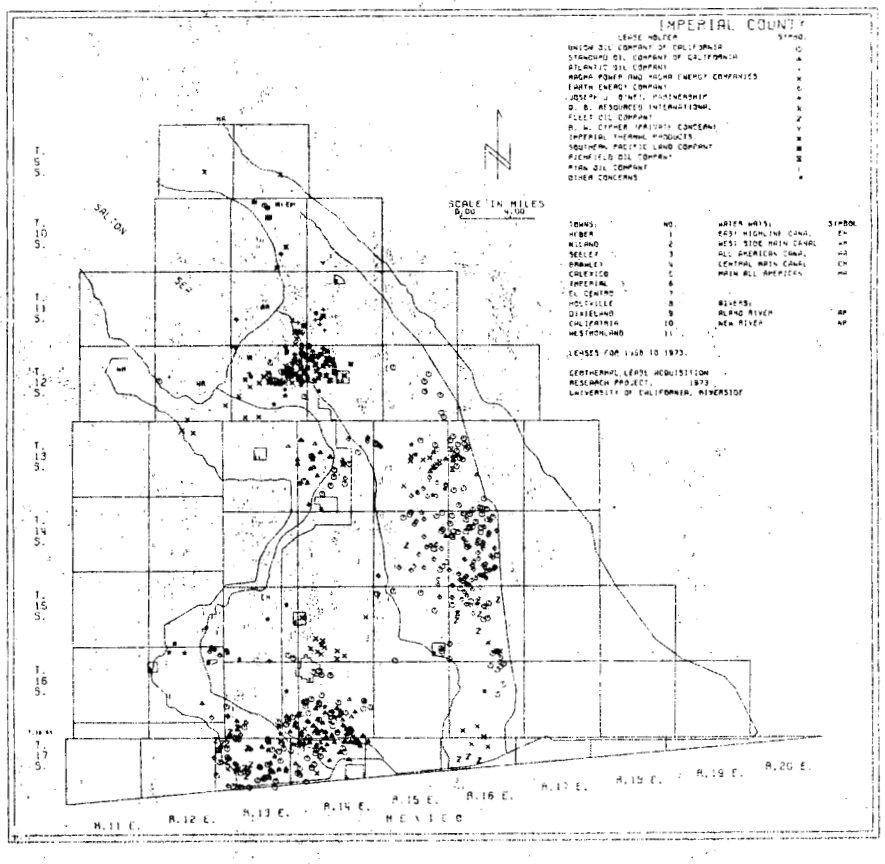
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
T. 15 S.
T. 16 S.
T. 17 S.

R.11 E. R.12 E. R.13 E. R.14 E. R.15 E. R.16 E. R.17 E. R.18 E. R.19 E. R.20 E.

MEXICO

DISCLAIMER

SECTION ONE
EXECUTIVE SUMMARY



1.1 The Concept of Development

Over the past several years much attention has been paid to the geothermal resource known to exist in the Imperial Valley, attention which ultimately focuses on that resource as a potential alternative source of energy. A number of studies have been conducted to determine, among other aspects, the nature and quality of the resource, its extent and energy potential, the possible benefits and problems associated with development, and the impediments, technical and legal, to development.

From such studies, as well as other informed analyses of the Imperial Valley situation, varied explanations for the current state of development have been offered. Divergent predictions about the extent, potential, likelihood, and benefit of geothermal resource development have gained currency among experts and laymen alike. Just as there have been varied explanations, so have there been offered differing rationales for the impediments to development. Since this paper touches more directly on those rationales than on the scientific questions of resource characteristics, it is useful to indicate the two most prevalent types of logics employed to explain the present lack of development in the Imperial Valley. First, many people argue a "limited market" situation in which development has not proceeded faster due to certain limitations in the market for geothermally-produced electricity. Second, other people contend that development has been impeded almost wholly by technological problems associated with generating energy from the form of the resource found in the Imperial Valley. There are, of course, numerous shadings and combinings of these two general rationales, but those variations rest on one or the other of the above positions.

This paper joins those arguments, but it does so based on a theoretical and analytical perspective not previously utilized. It is proposed that development be viewed as a series of relatively discreet steps through which a developer must pass in order to bring the resource to the point of energy production. Specifically, it is held that a developer must, at a minimum, pass through three development states: Initiative, Exploration, and Production. The first refers to those steps necessary to acquire property to search for geothermal resources upon a particular plot of land. The basic document required by a potential developer for this state of activity is a geothermal resource lease. The second state, Exploration, comprises those actions taken to test the resource for potential. A basic document, an exploration drilling permit, is required by both the State of California and the County of Imperial before a developer can engage in this set of activities. The third and final state, Production, involves those steps which a developer must take in order to bring the resource into regular, continuous production and then onto the market. Involvement in these activities requires production permits.

This dynamic concept of development as a process of actions from the securing of land to the placing of the resource product on the market has a number of qualities which recommend it for analytical purposes. First, by close examination of the public record, one can obtain empirical evidence of the behavior being studied. From this one can specify the modal state of affairs in geothermal resource development over a specified period. In the case of this report, that period covers January, 1958, through June, 1973. Second, based upon that same empirical evidence, one can monitor the historical rates of transition from one development state to another and, thus, predict with with greater precision the future direction and speed of development.

1.2 Legal Aspects of Leasing

Land acquisition during the basic period under study, 1958-73, was confined almost wholly to private lands. Before the opening of federal lands for leasing in January, 1974, over 90 per cent of the leased lands in the Imperial Valley were privately owned.

This fact has an an important result for the forms of leases negotiated, leaving the terms and conditions of leases subject to market considerations constrained only by the laws of contract. The parties of the leases have set the tenor of the legal environment within which development will occur.

These leases have assumed the characteristics of mineral leases, thereby restricting the activities in which the lessee can engage upon the leased lands and, at the same time, providing the lessee with exclusive rights to mineral exploitation on that land. This latter point is important, for in a large number of cases the lessee has never taken possession of the land despite leases which have been in effect for up to 10 years. The lease document has served, then, in certain cases as a means of gaining competitive position --- and denying that position to other companies --- for possible future development.

In order to better understand the legal environment established by leasing of private lands, 14 lease documents were selected for content analysis. From a close analysis of these documents, as well as a more cursory examination of other documents on file, several aspects of the legal situation became apparent. First, the early geothermal leases were, on the whole, modified oil and gas leases, amended to include steam, hot water, etc. among the "leased substances." This use of modified oil and gas leases was, no doubt, in large part a function of the relative lack of knowledge about geothermal resources. A clear legal definition of geothermal resources has been slow

to be formulated; it was not until California's Geothermal Resources Act of 1967 that a high degree of legal precision was reached in the definition of the resource. Given the lengthy history of oil and gas leases, then, it was perhaps natural that the early documents were but modifications of oil and gas leases. There is also the possibility, and one which is suggestive when the fifteen-year pattern of lease activity is considered, that many of the companies which filed geothermal leases in the late 1950's and early 1960's were primarily interested in oil and gas potential and only secondarily in the geothermal resource. By the mid-sixties, however, geothermal lease documents began to assume a more standardized and uniform format, likely the result of increased understanding of the resource among the lessees.

Second, several provisions are written into leases which allow the lessee to extend the life of the lease, often indefinitely. Each document includes a primary term specifying the time period for which the lease provisions are to remain in effect. The average primary term for all leases examined was 10 years. Other provisions, especially the production extension provision and the rental fee payment provision, enable the lessee to extend the life of the lease far beyond the primary term at minimum cost. Production extension rights allow the lessee to continue the lease for so long as the resource can be produced. More important is the rental fee payment provision. Although the specific provision in each lease may be termed in different ways, most leases do contain such a rental fee payment provision. The essence of this provision is that the lessee, in the absence of initiating drilling operations within the time specified in the lease, may pay the lessor a rental fee which maintains all rights and obligations of the contract and extends the life of the lease for one year. This option continues in force until the lessee actually

begins marketing the resource or a product of the resource. This provision has certain fundamental ramifications for the process of development. It allows speculators to lease lands for which they have neither the capital nor the intent for actual production; instead, they can secure the rights to certain properties and, at a future time, assign the lease at a profit to another firm which is capable or desirous of reaching a productive stage on that land. It also allows any interested potential developer the means by which he can extend the life of the lease, at minimal cost, until such time as he deems development to be a profitable action.

Third, leases contain unitizations rights, by which the lessee can combine, or unitize, a number of parcels leased separately, and satisfy drilling and lease obligations for all leases by testing on land held under just one of the leases in the "unit."

These various provisions provide developers with the legal mechanisms necessary to control the speed of development --- the transition from one developmental state to the next --- at minimal cost and for such time as the developer wishes to refrain from productive activity. In addition, these provisions, not least the unitization right, allow developers to establish competitive positions with other companies before such time as the developer wishes to engage in production.

1.3 Lease Acquisition Patterns: Two Development Periods

The concept of development utilized in this analysis focuses attention on the questions of the maturity of development: the degree to which activity has progressed into Exploration and Production States of development; the rate of growth and development, or speed with which companies progress through steps within development states as well as between states; and the size and location of leased lands.

The Initiative State is the modal stage of development in the Imperial Valley. Of the 584 leases in the public record for 1958-73, 4.4 per cent have resulted in requests for exploration permits. Of those few leases accompanied by exploration permit requests, only some seven per cent have been further converted to include production permits, and none of these for the purpose of generating electricity. In other words, a mere three-tenths of one per cent of all leases on public record have been advanced to the Production State. This figure may somewhat underestimate the movement from Initiative to Exploration States because exploration permits were not required until 1967. But even when that point is taken into account, only about eight per cent of the leases have accompanying exploration permits.

The rate of conversion from Initiative to Exploration States ranges between one and twenty-three months, but tends to center between six and eighteen months. Recall, however, that this activity is limited to eight per cent of the leases at a maximum.

A more important fact emerges from examination of the rate at which activity increases within any given development state. Since the overwhelming majority of activity locates in the Initiative State, we will only concern ourselves with the rate of growth within that state. Since 1958, two distinct peaks of lease acquisition activity are evident. The first ranged from late 1963 to early 1965. The second began in mid-1969, peaked in 1971, and has been slowing significantly since that time. Between 1965 and 1969, there was minimal new activity.

Although there have been distinct peaks and valleys in the acquisition of leases, over the years 1958-73 some 143,000 acres of land have been transacted in geothermal leases. Some notion of the extensiveness of this leasing

can be gained by noting that this area equals 84 per cent of the privately owned lands located within Known Geothermal Resource Areas in the Imperial Valley. When one recalls that for the period of this study federal lands were not available for leasing, it becomes evident that nearly all potentially productive lands which could be leased have been leased. The area under lease is equivalent to nearly 224 square miles.

1.4 Location and Distribution of Leases

As important as the total size of holdings under lease are factors of the location of those leases in comparison with KGRA's and the distribution of leases among the various companies and individuals involved in leasing activity.

Prior to 1963, only one lease was recorded for land outside the Salton Sea anomaly region. Beginning in 1963, with the start of the first development period, leasing began for lands in three additional areas: Heber, East Mesa, and Brawley. Moreover, new companies emerged as major lessees in this development period, including Standard Oil of California, Fleet Oil Company, Earth Energy Company, and Magma Energy, Inc.

During the 1965-1969 lull in acquisition rates, the pattern of activity reverted to pre-1963 conditions. The majority of activity was confined to the Salton Sea area, with negotiating limited almost wholly to the smaller companies. It must be noted, however, that very few of the leases transacted in the 1963-65 development period were quitclaimed. Those leases formulated in the period of development activity by major companies in new areas were maintained by those companies. The leases were not advanced to Exploration or Production States, but, neither were they terminated.

With the initiation of activities by Standard Oil of California in early 1969 --- during one month alone Standard transacted 35 new leases --- a new development period began. Again, the rate of acquisition of leases increased substantially, with the bulk of the growth due to the involvement of large corporate entities. Besides the renewed activity of Standard and Magma, three other large corporations began, for the first time, to acquire territory: Union Oil Company, Atlantic Oil Company, and Southern Pacific Land Company.

An important distinction between the first and second development periods concerns the areas for which leases were negotiated. In the 1969-73 period, no new areas were involved; that is, during this period, lease activity focused on the same four anomaly regions that were part of the first development period: the Salton Sea area, Heber, East Mesa, and Brawley. Leasing in the second period involved obtaining lands around those which had been secured in the earlier period, leases which, it will be recalled, were not quitclaimed.

The pattern which emerges over time, then, is this: There have been two distinct periods of activity, 1963-65 and 1969-73, with a dormant period between 1965 and 1969; during periods of development, new and large companies became involved in lease acquisition, with their activities accounting for the vast majority of increased leasing; during lull periods (pre-1963 and between the two developments), the limited activity has been confined to smaller companies obtaining land almost wholly confined to the Salton Sea field; during the periods of growth, however, major companies began securing lands in the East Mesa, Heber, Brawley, and Salton Sea areas; at present nearly 85 per cent of private lands located in Known Geothermal Resource Areas are under lease, indicating that leases negotiated in the first period of development were maintained throughout the lull period; and, finally, development activity has been confined to a very large extent to the Initiative State, with a maximum of eight per cent of all leases being extended into the Exploration State.

1.5 Major Leaseholding Companies

Almost 75 per cent of the total privately-owned leased lands are held by four major entities: Standard Oil of California, Union Oil Company, Southern Pacific Land Company, and the two Magma companies, Magma Energy and Magma Power. The remainder of the leases have been filed by more than 15 other firms and individuals.

The behavior of these four major leaseholders offers additional insight into the development patterns in the Imperial Valley. Standard Oil first began securing leases in 1964, the first of the large oil companies to involve itself in geothermal leasing in the Imperial Valley. It has obtained its leases in two separate, relatively short periods of time: in 1964, Standard Oil negotiated 62 per cent of its 124 leases; in 1969, it formalized another 26 per cent of its leases. Its leases have long primary terms, averaging 12 years. Of greater significance is the fact that many of its leases have twenty-year primary terms, and some of these have been amended to 30 years. Its leases are concentrated in the Heber and Brawley areas.

Union Oil Company recorded its first lease in 1969, but it secured the bulk of its 136 leases during the succeeding three years. Union Oil has acquired other, older leases, however, leases originally negotiated by Earth Energy, Inc., a subsidiary of Union Oil. Union Oil's leases tend to have relatively short primary terms, are concentrated in the Heber and Brawley areas, and comprise over 28,000 acres of land. Neither Union Oil nor Standard Oil have advanced to the Production State on any sites, and each company had only moved two leases into the Exploration State at the time data was collected.

The behavior of Standard Oil of California and Union Oil Company typifies the developmental patterns of the large oil companies. They have negotiated

numerous leases, covering geothermal rights for many thousands of acres, and have concentrated their lease acquisitions around one or two geothermal anomalies More importantly, they have moved very few of their leased lands into the Exploration State, but have not quitclaimed any significant percentage of those leases. Their behavior is consistent with that to be expected of a developer interested in securing competitive market position for an unspecified time of future development. Their actions suggest, in other words, a conscious interest in establishing their potential profit position assuming circumstances change in the future such that geothermal resource production is more favorable to their interests and needs. They do not appear overly anxious to further development, however, since they move few leases beyond the Initiative State.

Magma Energy, Inc. and Magma Power Company offer contrasting behavior. Magma (the two companies will be referred to as a single entity hereafter) began acquiring leases as early as 1958, the only major leaseholder whose activities date back that far. It holds 60 leases, covering nearly 21,000 acres, with the largest average lease size of any of the major leaseholders --- about 391 acres per lease. Further, Magma's leases tend to have relatively short primary terms, and the holdings are distributed throughout the anomaly areas rather than being concentrated upon one cr two regions. Magma showed renewed interest in 1971, during which year it contracted 47 per cent of its leases.

Magma is responsible for the majority of Exploration State activity in the Imperial Valley, having secured 22 exploration permits for test wells. These various facts give credence to the general feeling that Magma is the most likely company to move development into the Production State. The short primary terms, large size of individual leases, wide dispersal of holdings, and substantial activity in the Exploration State all suggest that Magma intends to move as rapidly as feasible into the Production State.

The fourth, and largest, leaseholder is Southern Pacific Land Company (SPLC). The company claims to have some 37,000 acres under lease on private lands. SPLC's lease activity is complicated by the number of relationships it has with other companies which have assigned leases to it. Among those companies which have assigned significant numbers of leases to SPLC are Atlantic Oil Company and Imperial Thermal Products, Inc. Three points about SPLC's activities are worth noting: 1) many of its leases are shared with Phillips Petroleum Company and Southern California Edison Company; 2) the majority of SPLC's leases are in the Salton Sea area; and 3) SPLC is the only one of the major leaseholders still securing geothermal leases in sizable quantities.

1.6 Conclusions

As noted near the outset of this summary, two general arguments predominate as explanations for the current state of geothermal development in the Imperial Valley. The one, termed a "limited market" argument, roughly holds that marketing limitations inherent in the resource at the present time preclude development. This argument tends to focus on the geothermal resource alone, often ignoring other related energy market conditions. Ultimately, the "limited market" argument is an applied version of the "lack of technology" argument, the second of the general sets of explanations. This position holds that there is a lack of technology sufficient to meet the problems attendant to the geothermal resource in the Imperial Valley. The resource differs in important ways --- type of substance flashed during drilling, brine content, etc. --- from that being produced at geothermal sites outside the Imperial Valley. Before development in the Imperial Valley will progress, a number of technical problems must be solved, or so this argument runs.

In its applied version, that relating to the market, it is held that technological advances must precede solution of marketing problems, for these technological considerations are the very impediments to production, transmission, and distribution of geothermal energy on the market.

We do not deny that technical problems exist, nor do we deny that market conditions have shaped the form of development. What we do challenge are weaknesses in previous descriptions of development to adequately account for the present characteristics of geothermal activity in the Imperial Valley, as well as tendencies to fail to put the technological and market explanations into perspective.

It must be remembered that two distinct periods of development have marked geothermal leasing activity from 1958-73. The first peaked in 1964, the second in 1971. Neither peak period is associated with changes in the marketability of the resource or significant technological advances which solved problems of production. But other factors dealing with the profit potential did change during the time under study. Specifically, it is noted that many of the leases during the 1964-65 peak activity period were accompanied by oil and gas leases. It is certainly conceivable that the first peak period was, then, the result of searches for oil and gas deposits first, with geothermal searches being merely secondary. One can take this further: the acquisition of geothermal leases during 1964-65, especially by major oil companies, was designed as a hedge against future energy needs only. Very few leases were progressed to the Exploration State. At the same time, very few leases were quitclaimed. The full range of behavior of the companies involved in 1964-65 is consistent with a view that two considerations motivated corporations at this time. First, they were primarily interested in finding oil or gas. Second,

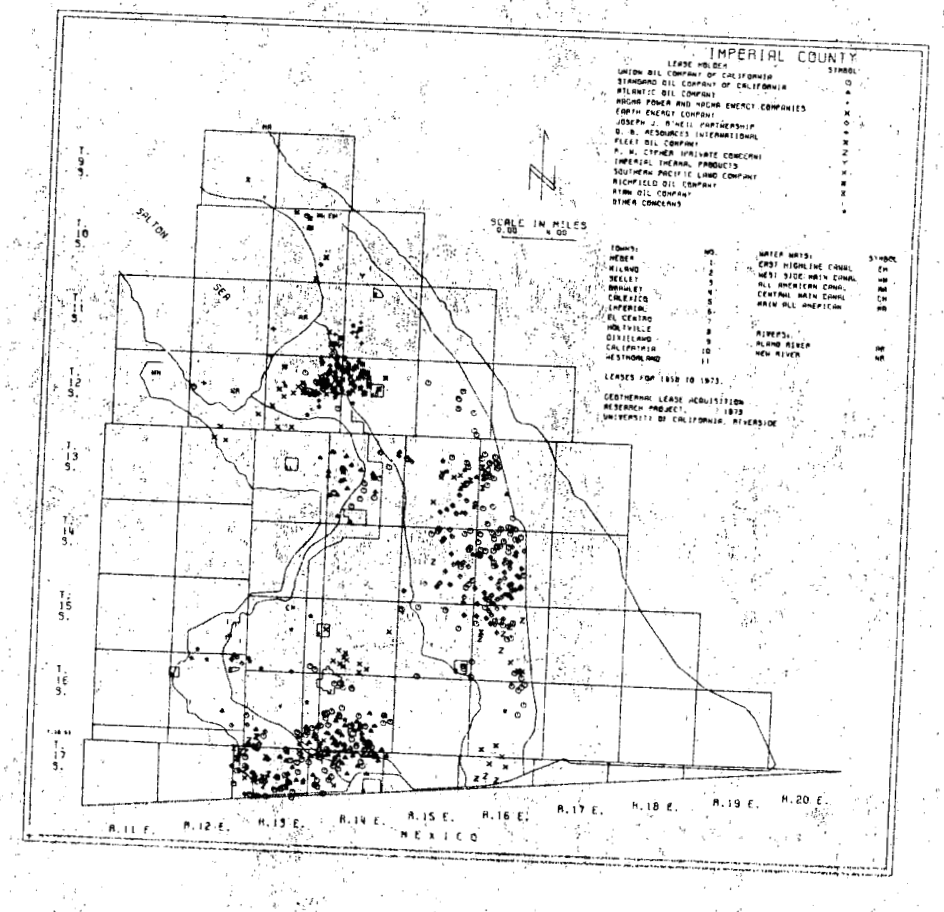
they were interested in establishing initial competitive positions for future development of the geothermal resource, though at an unspecified and relatively distant future time.

The 1969-73 development period also seems tied to the availability of other energy sources. Recall that in January, 1969, Union Oil Company's Platform A in the Santa Barbara Channel had an oil spill. By February of that year, off-shore oil drilling had been banned, many thought permanently. By April, 1969, a new surge of geothermal lease activity had begun in the Imperial Valley. Finally, this second peak period suddenly declined just prior to the public announcement that the State Lands Commission would hold hearings to reconsider the ban on off-shore oil drilling. Again, leasing activity declined markedly, but very few geothermal leases were quitclaimed In addition, by 1973, nearly 80 per cent of privately owned lands located on potential geothermal areas was under lease.

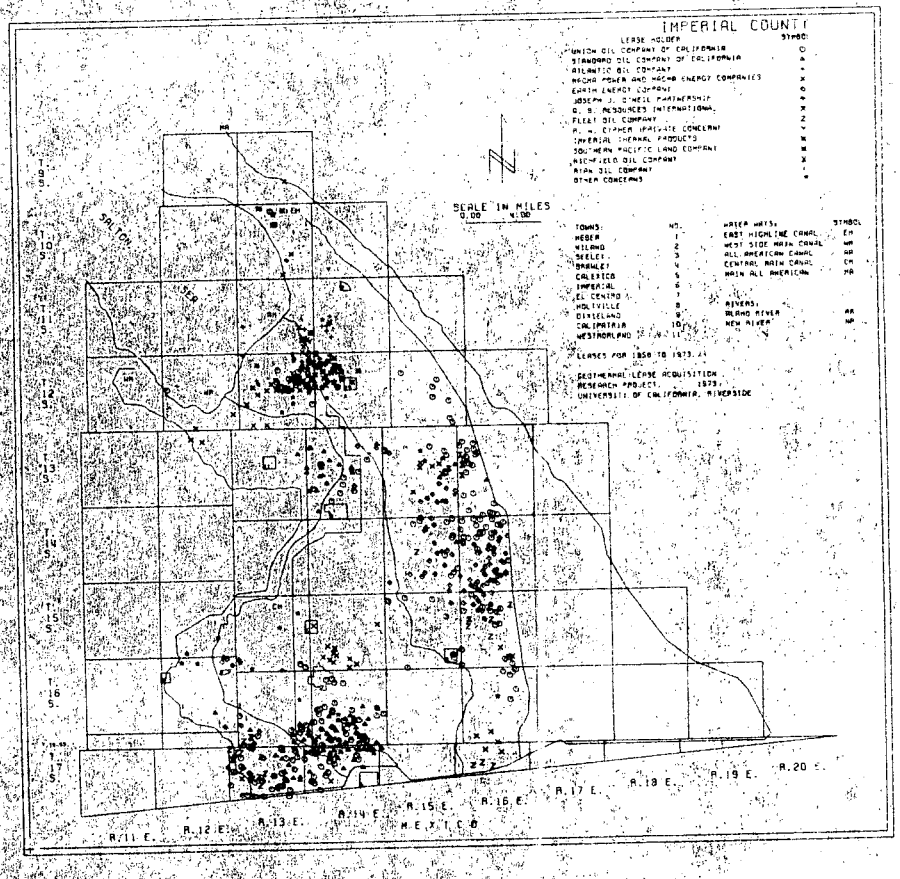
This series of factors suggests that the pattern of geothermal development evidenced in the Imperial Valley is a function of profit potential of geothermal energy, the availability of other energy sources to major oil companies, and distinct historical events. Under the best of conditions, geothermal energy is a marginal profit-maker, substantially below the profit potential of oil. Still, the Imperial Valley has considerable energy potential, and its profit potential may become either absolutely or relatively more favorable. Technological advances, especially if developed at other companies' expense, may make the resource more enticing to major oil companies. This would be an example of raising the absolute profit margin of geothermal resource production. Second, curtailment of availability of other energy sources may make geothermal relatively more profitable.

It is our argument, then, that it is the profit potential of geothermal resources vis other energy sources that has determined the shape of development. In periods of limited availability of other energy sources, geothermal Initiative State activity increases. Further development is checked by the relatively low profit potential of the resource. Major oil companies hold their leases, await technological developments by other, more geothermally-oriented companies, with the anticipation that they will eventually exploit the resource when it is either absolutely or relatively more profitable. In the meantime, they are seeking competitive advantage by securing large areas under lease in areas which the companies expect to be most advantageous once production is reached.

GEOTHERMAL LEASE ACQUISITION: AN ANALYSIS



SECTION TWO
RESEARCH ORGANIZATION



2.1 The Focus

Over the last decade, considerable research has been conducted on the extent, composition and producibility of the geothermal resource in the Imperial Valley. Most of these studies have concerned the geological, geophysical and technological aspects and problems of the resource, though there have been some studies on the economic, political and social issues attendant to potential development of the resource.

The technical and scientific researches have provided considerable information upon which those interested in development --- private industries, governmental bodies and private citizens --- could begin predicting the likely effects of development on the social, political and economic institutions and arrangements in the Imperial Valley. This is not to suggest that these studies have been conclusive; indeed, a major question remains concerning the actual extent of the resource, with current estimates ranging from less than 2,000 to 6,000 megawatts.[1] But despite these problems of conclusive evidence regarding certain facts of the resource, much progress has been made in locating, investigating and understanding the geothermal resource in the Imperial Valley.

There has been less progress in the area of socio-economic analysis and prediction. In part this derives from the lack of technical and scientific precision about the extent and properties of the resource, an imprecision which renders highly tentative any formal predictive models of the impact of future geothermal development on the present institutions and arrangements in the Imperial Valley. In large part, however, predictions about the impact of development have suffered from lack of another type of information --- the pattern of actions of the energy-producing companies and corporations in the Imperial Valley regarding geothermal resources. It is to these actions, to this pattern of actions, that this study addresses itself.

Five general and related questions served as a focus for this research:

1) The extent of development within known geothermal areas in the Imperial Valley;

2) The location of the lands under development within the Imperial Valley;

3) An identification of the major companies involved in developing the resource;

4) Based on the information ascertained through consideration of the above questions, the factors which appear to have influenced the pattern of development; and

5) Based upon consideration of the preceding analysis, prediction of the likelihood of substantial development in the near future.

Geothermal development in the Imperial Valley is a continuing process, a dynamic pattern of exploration and decisions about proceeding with the development process. Because of the dynamic factor, this study focuses on the growth of geothermal development across time in terms of physical location and firms involved, seeking to locate historical patterns and relating these to some aspects of the companies involved and economic characteristics of the development.

It is apparent from the organizing questions of the research that the last two questions, dealing with factors which appear to have shaped the pattern of development and the probability of near-future development of the resource, are the more difficult questions to answer. As will be discussed in the body of the paper, a number of alternative explanations have been offered for some aspects of the developmental pattern and the probability of full development. An attempt is made in this paper to challenge these various explanations, basing our challenges on data derived from this study and certain assumptions about corporate behavior.

2.2 Measures

A specific notion of "development" forms the center of this study. In common usage, development refers to the act of bringing into existence some set of physical or capital objects. We use the term in this common sense, though with a certain increased precision made possible by the nature of energy resource extraction. Specifically, development is not a unitary activity. There are identifiable, discreet elements to the process such that one set of activities, or development "state," must be passed through before further processes can be conducted.

We propose that three such "states" exist --- Initiative, Exploration, and Production --- and that the developer of any subterranean resource must at a minimum:

1) acquire the legal right to explore real property in search of the resource that is sought to be developed;
2) having acquired that legal right, conduct such a search;
3) having found the resource, negotiate the right to develop it. (This is usually acquired at the time when the right of search is acquired; see Section Three.)

This portion of the process of development we term The Initiative State. During the second phase of development, The Exploration State, a developer, having negotiated rights of entry onto property for the purpose of searching for resources, must:

4) secure the permission from various governmental agencies to engage in the construction of the necessary drilling and/or mining equipment for the purpose of testing the resources as to production potential;

5) having secured such permission, determine the production potential of the resource --- i.e. does it exist in profitable quantities, and will the cost of extraction be of such a rate to result in a profitable expenditure of financial resources of the development.

In the final stage of development, The Production State, the developer, having determined that the resource exists on the property in large enough quantities to be profitably extractable must:

6) secure the permission of various governmental agencies to start producing the resource on a regular basis;

7) having met all of the above requisites, place the resource on the market.*

Knowing that a system of requirements is in force and knowing, further, the form of that system, one can precisely define development: underground resource development is conceived as a system of discreet economic, technological, and legal components through which an element must pass prior to becoming incorporated into the set of usable societal resources.

Such a conception forces attention to empirical questions of where, within that system, current activity can be located; that is, one can specify the model state of current development activity. Further, based on empirical evidence, one can note how far along within any given development state activity has progressed. These investigations allow the monitoring of development activity across time and provide the basis for predicting the future direction and speed of development.

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*Two works relevant to this argument about development states and the various federal, state, and local agencies which issue permits and regulate the development are located in Proceedings: National Conference on Geothermal Energy, The University of California, Riverside; August, 1973; see article by Thomas H. Cahraman, and chart prepared by David N. Anderson, both in Volume II.

Empirical data is best obtained from the public record. Two general sets of items were located, collected, and processed:

1) Geothermal lease documents and Special Documents such as amendments, assignments, and quitclaim deeds for the period January, 1958, through June, 1973;

2) Drilling permits from the County of Imperial for the construction of well sites in the Imperial Valley for exploratory as well as production use.

Geothermal lease documents are substantial physical evidence of Initiative State activity, as that state has been defined. Exploration drilling permits, required by law in the State of California and the County of Imperial, are evidence of passage from the Initiative into the Exploration State. Finally, production permits would evidence Production State activity.

While these measures are useful indicators of the extent to which resource development has progressed, they are not without their problems. A full discussion of these measures, their validity and their problems, is contained in Appendix One following the body of this paper. Also contained in that Appendix is a discussion of the collection techniques employed by the researchers.

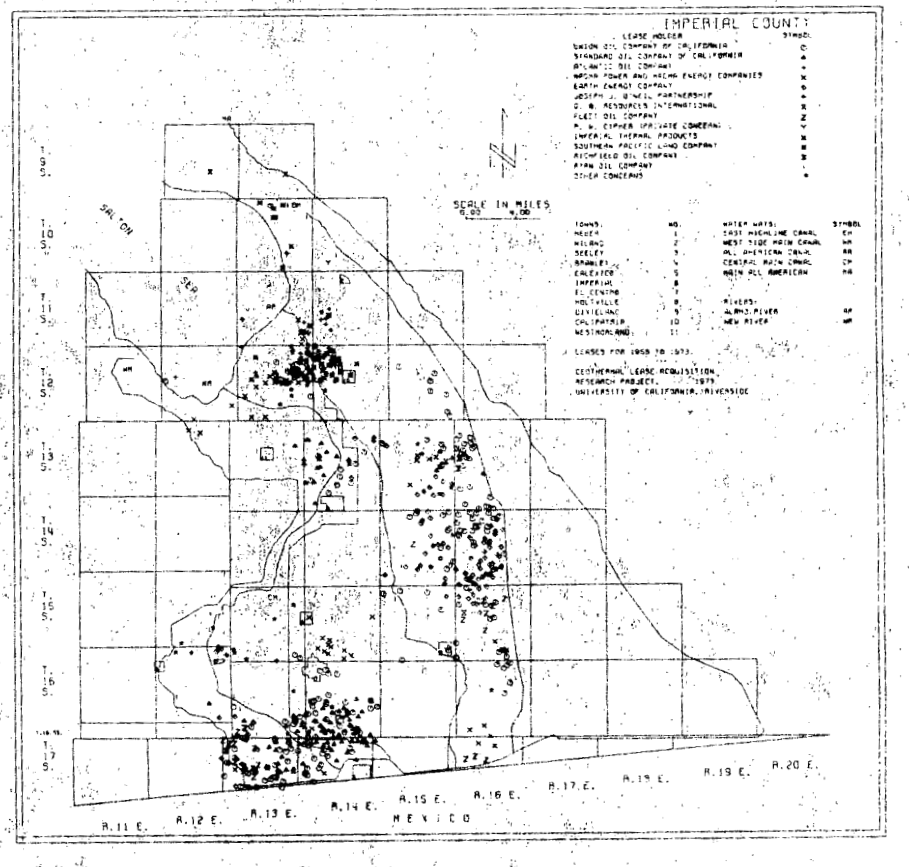
2.3 References

1. Leary, John, "Clean Power Inside the Earth," Environment and the Quality of Life, December 5, 1970.

2. Scott, Stanley and Wood, Samuel, "California's Bright Geothermal Future," Cry California, Winter, 1971-72.

3. Stanford Research Institute, "Meeting California's Energy Requirements, 1975-2000," Menlo Park: Stanford Research Institute, 1973, p. 249.

SECTION THREE
LEGAL ASPECTS



3.1 Legal Aspects

The initial action for any firm interested in geothermal resource development consists of land acquisition, either in the form of legal ownership or through a lease agreement. Certain factors regarding potentially productive geothermal lands in the Imperial Valley must be noted at the outset. First, the amount of acreage is finite, and that land is further restricted to that which is potentially productive, currently estimated at approximately 47 per cent of the total Known Geothermal Resources Areas (KGRA's).[1] This fact establishes a highly competitive situation for companies seeking control, either through ownership or lease, of geothermal lands in the Imperial Valley. KGRA's, a term coined in the Geothermal Steam Act of 1970, are mapped and classified by the United States Geological Survey.[2] Prior to 1970 lands with geothermal potential were located solely by the efforts of those firms interested in development, firms which were almost entirely limited to larger companies and corporations. This fact relates to the second factor of importance, that "wildcatting" has not been a significant activity in the finding or developing of the resource. Wildcatting depends upon having an immediate market for a productive well or site, a condition not obtained in geothermal resource development at the present time. This left exploratory operations under the control of large private firms during the 1950's and 1960's. The very discovery of geothermal resources in the Imperial Valley was in large part an accident stemming from explorations for oil and gas.* Third, and most important for this research, acquisition through the summer of 1973 was confined almost wholly to private lands. Federal lands were not made available for leasing until January 22, 1974.

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*As we shall see, early geothermal leases were modified oil and gas leases. Recently, one firm, Standard Oil of California, returned to using oil and gas leases solely. However, the definition of the "leased substances" make the inclusion of geothermal resources optional.

Analysis of the activity by companies in the federal land lease sales is treated in an addendum to this paper. Only five per cent of the geothermal lands in the Imperial Valley are located on state-owned lands. Leasing activity on private lands, therefore, constitutes over 90 per cent of leasing activity through June, 1973.

This concentration of activity on private lands has subjected lease acquisition patterns to the forces of the marketplace.

Unlike the proposed rules governing leasing of federal lands for geothermal development, there are no restrictions on the acreage of a private lease, no minimum royalty, no set lease term, etc. The parties involved in any leasing agreement are free agents, subject only to laws governing the privity of contract. The terms of the leasing agreement are almost totally up to the parties involved, governed only by their respective motives. The parties set, via the leasing agreement, the legal environment in which development on that particular piece of land takes place.

This is not to suggest, however, that legal restrictions do not shape the leasing activities. There are numerous legal considerations which mold and modify the leasing activities.

Leasing (or hiring) is defined in laws as "a contract by which one gives to another the temporary possession and use of property, other than money, for reward, and the latter agrees to return the same to the former at a future time."[3] Inherent in the concept of leasing is "the granting [of] exclusive possession or control or portion, though use [of the property] be restricted by reservations."[4]

In the case of geothermal resources, the property being leased is real property, but the uses to which the lessee can put the land are limited by the terms of the lease. Lessees are limited to the exploration for and development of geothermal resources. No other action is sanctioned by the leasing agreement. Hence the geothermal leases executed thus far take on the characteristics of a "mineral lease," defined in Black's Law Dictionary as "an instrument permitting the use of land to explore, and then, if mineral is discovered, giving the right to take mineral either for a definite term or so long as it can be produced in paying quantities upon reserved royalty."[5] Thus, under a geothermal lease, although the land covered in any leasing document may be very limited as to its use by the lessee, the possession is still exclusive.

While there is no set language that makes a document a leasing agreement, the courts have been quite explicit in stating that a document is a leasing agreement if: 1) it shows an intention on the part of one party to dispossess himself of certain stated property, and 2) an intention on the part of the other party to enter and hold that property in subordination to the title of the first party.[6] Further, since such a document is also a contract, encompassed in it are all rights and obligations arising under the privity of contract as well as establishing a tenant-landlord relationship.[7]

The law thus establishes two essential criteria for the determination as to whether a given document is or is not a lease: 1) the transfer of exclusive possession of property, and 2) the payment of rent or royalty in the case of a mineral lease.

One particular characteristic of leasing activity in the Imperial Valley must be noted. In a vast majority of cases, lease documents have been executed, leasing agreements have been entered into by a firm and a land owner, yet even though some of the leases have been in force for 10 years, no possession on the

land by the lessee has taken place. The leasing arrangement has served as a means by which a firm maintains the options to exclusive possession of the land covered in the document, despite the company's failure to take possession. As long as one firm holds such an option, no other firm may lease the land for developmental purposes.

This exclusive right (whether exercised or not) of possession of land for geothermal development, being also an exclusive right to development of the energy found on or under the land, confirms our earlier mention of the competitive nature of leasing activities. When the lessee enters into a geothermal lease relationship with a private landowner, it is leasing the exclusive right to take and hold the land covered in the lease for the sole and expressed purpose of exploring for and developing, if possible and profitable, the geothermal energy found thereon. The lessee may not, under the terms of the agreement, take possession of the land and then use it for any other purpose, such as to explore for and develop deposits of bituminous coal. Such would be violation of the lease.

But, the lessor may not grant to any other firm via any method the right to explore for and develop geothermal energy. For under the terms of the mutually binding contract such action would not give the lessee exclusive possession, and would, therefore, be a violation of the lease.

Land acquisition, therefore, forces firms into strict competition. If all the potentially productive land has been leased by the firms involved in the development thus far, any given firm may increase its holdings of potentially productive lands only at the expense of another firm's holding. Similarly, any new firm could become active only at the expense of one or more of the existing firms. Only by expanding its lease holdings onto less potentially productive lands may a firm increase its share of leased lands, and therefore of the resource, without restricting another firm's holdings.

The argument can be made that this will not happen until production is underway. At the present time, with very little exploration occurring and almost no production, those firms that have lease holdings are essentially speculating toward some future development. Unlike the wildcat operation, these larger firms have accumulated land holdings during the past 14 years ostensibly in preparation for a large-scale development of the area's resources, this has not yet occurred.

Further, given the historical patterns of land acquisition in mineral exploitation operations and the basic economic factors governing a firm's activities, a firm interested and involved in geothermal land acquisitions will seek to acquire the most potentially productive land first. This pattern of acquisition derives from two basic factors:

1) The cost of production on any parcel of land is about the same in terms of capital investment in equipment and costs of labor. Thus, firms seeking to maximize their profits will attempt to engage in production on lands with higher potential, for their lower marginal costs will yield larger profits. Only as profits become more assured will firms expand activities onto lands with less productive potential. Theoretically, with the creation of a ready market development will become more profitable and lands of less productive potential will be leased and developed. The development on less productive land will not take place until the marginal cost of production equals the marginal rate of revenue for any given tract of land. Under less favorable conditions it is unprofitable to operate.

2) Firms, in conducting their land acquisition programs, will follow much the same economic logic: they will seek to lease lands that they perceive to be most productive. Only as the outlook for profits becomes more favorable will lands of less productive potential be leased.[8] The two most prevalent

kinds of incentives would be either a ready market for the resource or a sufficiently high return on an investment to warrant taking a risk in investment --- a risk made greater by the absence of a ready market.

As will be discussed more fully later, there have been two distinct periods of major lease acquisition in the Imperial Valley, the first covering roughly the years 1963-65. It must be assumed that companies involved in this period of lease acquisition activity felt sufficient profits could be realized from their investments. Despite the understanding of all companies involved that problems did exist for geothermal production --- certain technical considerations, such as salinity of the brine contained in the resource in the Imperial Valley, and the existence of only one energy producing geothermal site in the United States, at The Geysers in Sonoma, California --- firms do not appear to have been discouraged from investing heavily, from securing numerous leases, in the Imperial Valley in this period. If companies were acting in accord with our theoretical position --- that they would invest initially and most heavily in the most productive areas and then move, over time, to acquire the rights for less productive lands --- then we could monitor the stage of Initiative State activity in which these companies are located. Unfortunately, the present research does not allow classification according to productive potential of lands.

Fourteen lease documents were examined in the content analysis, 12 of which were obtained from the official record of the County of Imperial.[9] The gathering of the document specimens was subjected, therefore, to the same restrictions as the gathering of data for analysis in subsequent sections of this paper. Although there is present on the list of documents examined a good cross section of the companies involved in the development to date, any analysis is limited to the information placed voluntarily in the public record by the parties of a lease agreement. The parties have several options regarding the

content and manner of filing with the County Recorder. First, they may place the entire lease document in the record, as is the practice of Standard Oil of California. Second, they may file a "Short Form of Lease and Agreement," giving such information as the names of the parties involved, the land leased, the length of the primary term, production and unitization rights of the lessee, etc. The amount of information contained on a Short Form Lease varies from firm to firm. Third, the parties may choose to file only a "Memorandum of Lease and Agreement," listing in the public record the names of the parties, the land covered in the lease, the primary term, and very little else.

In the latter two cases, reference is made in the text of the document to the full lease entered into and the terms and conditions of that full lease are incorporated by reference into the Short Form or Memorandum. Thus the existence of a lease agreement is public, but most of the lease information is not available for public inspection.

A process of selected sampling led to the choice of lease documents examined. Such a process assures that each of the various types of leases, and a full overview of common terms and conditions of leases, would be considered.

Given the similarity of technologies involved in oil exploration and geothermal exploration, as well as the similar circumstances that a firm must deal with --- i.e. the rental of land for exploratory and production purposes --- one would expect the great experience of oil and gas leasing to shape the leasing of lands for geothermal energy. Whether the large body of case law surrounding oil and gas leasing applies in whole or in part to geothermal leasing is a question of some doubt and great importance. But since the "procedures of development" are similar, one might logically assume the "procedures of land acquisition" likewise would be similar.

An examination of the leases of earlier years shows this to be true. Initially, geothermal lease documents were modified oil and gas lease documents, amended so as to include steam, hot water, brine, etc., under the definition of "leased substances." (The "leased substances" are those that may be explored for and, if found, developed, on the leased lands.) Later, such documents as those entitled "Mineral, Steam, Oil and Gas Lease" were developed, incorporating the earlier amendments into the test of the document. As activity and interest increased with the 1964 development, the larger firms developed very specific lease documents often covering only geothermal energy. The Imperial Thermal Products Corporation developed a document called "Heat, Fluid and Mineral Lease and Agreement." Such firms as Standard and Magma Energy began using very specialized forms called simply "Lease and Agreement." Standard Oil became so specialized in its leasing document forms as to begin the practice of using two documents to cover one piece of land: one for geothermal energy and one for oil and natural gas.

With this specialization, lease documents assumed a pure-form format such that the more recent documents filed are so complete that only the name of the lessor, the location of the land, and where to send the royalty payments need to be filled into the appropriate blanks before it is ready for signature and filing in the public record.

This is the predominant method used to date, with the terminology and provisions changing little with time. If anything, the companies are coming to use documents more and more similar. Major differences have disappeared slowly over time. The most striking evidence of this is the tremendous similarity of the Sperber-Fleet lease of November, 1963 and the Imperial Irrigation District-Imperial Thermal Products lease of May, 1972, in which both the format and the language of each document are nearly identical.

Such similarity appears to derive from the fact that the interests of the potential developers are so uniform --- given the nature of the industry and that of the resource --- that the document language used to secure and protect these interests was bound to become rather identical as time and experience affected the leasing process.

In the early phases of leasing activity, when either mineral and/or oil and gas leases were used to lease lands for geothermal purposes, the definitions of geothermal resources were not clearly defined. To an extent this lack of clarity in definitions still obtains since there is no scientific name or chemical formula that can be universally attached to all forms of geothermal resources.

Translated, the word "geothermal" means "earth heat." And, indeed, the key phrase that first appeared in lease texts was "the natural heat of the earth." But given the variety of media that can be used for transportation of this natural heat to the surface of the earth for utilization in energy-producing enterprises, such a definition contains much imprecision.

The one aspect that is continually vague in the definitions of geothermal resources, given in the leases, is a differentiation between the liquids found at high temperatures in the depths of the earth and ground water systems. The form lease used by Imperial Thermal Products, for example, defines as among the "leased substances" the following: "formation water, the natural heat of the earth, gases and vapors, brines, liquids and solids, steam, hot water..." and many minerals to be extracted from the leased substances.

Does this lease give the lessee the right to remove water from natural hot springs, water that otherwise can be utilized for agricultural or domestic purposes? There is no specific prohibition. Further, there is nothing in the lease that differentiates hot ground water from hot water (brine) taken at a depth and thus not from the natural ground water system.

Another lease by Imperial Thermal, this one dated January, 1973 (seven years after the lease cited above), calls for the inclusion of "hot water, steam and thermal energy" among the leased substances covered in the lease. However, in this later lease a section was added that stated definitions. The terms "hot water", "steam" and "thermal energy" are further defined as "natural geothermal water and/or steam, and also the natural heat of the earth and the energy present in, resulting from or created by, or which may be extracted from, the natural heat of the earth or the heat present below the surface of the earth, in whatever form such heat or energy occurs." Again, precision of differentiation is lacking.

Legal definitions, when they were finally set to law were not as vague as the Imperial Thermal phraseology. The State of California, in its Geothermal Resources Act of 1967, took a large step forward in defining geothermal resources as "natural heat of the earth, in whatever form, below the surface of the earth, present in, resulting from or created by, or which may be extracted from such heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, found below the surface of the earth." If the phrase "below the surface of the earth" can be interpreted (as it must) as outside of and excluding those fluids, gases, and other substances associated with the ground water system found in the vicinity of any geothermal development, then considerable clarity has been achieved in the legal definition of geothermal resources.

By way of pointing out the probability that definitions of geothermal energy will continue to be vague, it might be noted here that most of the recent scientific literature on geothermal resources is careful to include dry geothermal heat as among those resources worthy of further research and development efforts. Dry geothermal energy is the natural heat of the earth

in areas where there is no liquid medium to transport the heat to the surface. If and when the technology is developed to utilize such dry heat, participants in that development can look forward to another round of vague definitions, particularly when determining the worth of the resource for royalty calculation purposes.

With these general notes on leases and legal definitions in mind, the 14 selected lease documents were carefully examined along six dimensions:

1) Primary term, or the length of time the lease agreement is in force. By inference, the primary term sets the date at which the agreement automatically expires if: a) the lessee does not exercise its right of quitclaim, and b) the lessee does not exercise one of the several options available to it to extend the life of the lease beyond the stated primary term. We will discuss these various options below.

2) Production extensions, or the right of the lessee to occupy the leased land for as long as it can profitably produce the leased substance(s). By so doing, the lessee extends the natural life of the lease.

3) Royalty Rates.

4) Drilling obligations and penalties, or those requirements of the lease agreement that set forth certain drilling/exploratory activities that the lessee must engage in. Usually this is stated in terms of drilling a well for exploration purposes. Further, the lessee is required to begin this well within a stated period of time, usually one year. Additionally, there are monetary penalties that the lessee must pay to the lessor for failing in these obligations.

5) Production rights, or the rights and/or options that a lease document contains that would allow the lessee to utilize the land for production purposes and the conditions that are attached for such purposes.

6) Unitization rights, or the option of the lessee to unitize the leased lands with other lands and the effect of this action on the terms of obligations of the lease.

Table One summarizes the results of the content analysis of the lease documents examined. It does not show 14 entries due to factors of 1) repetitiveness of lessees and identical lease forms used by the various firms, and 2) the use of brief memoranda of lease and agreement by certain firms, a habit which excludes certain of the information being analyzed from the public record.

Nevertheless, in those cases where the documents contained sufficient information, the similarities were striking enough to enable us to generalize about lease content across companies.

The primary term of the lease documents was noted in each case entered into our data file. Primary terms vary naturally from lease to lease. They range from a low of one year to a high of 99 years. The predominant term length is 10 years. Most firms use this term of length in their leasing agreements. Standard Oil Company of California has used twenty-year terms consistently since first becoming involved in the development in 1964. However, Standard has recently amended most of its existing leases to thirty-year terms.

Primary term length is interesting, but as we shall see, it is less meaningful than first appears, since there are many methods by which the primary term of a lease can be extended, in some cases with no upward limitation.

The production extension is one method by which the primary term can be circumvented and a leasing agreement kept in force. A production extension is simply an extension of the terms of the agreement so long as there shall be production of the leased substances on the land. At the end of the primary

TABLE ONE

LESSEE	TYPE OF DOCUMENT[1]	PRIMARY TERM[2]	PRODUCTION EXTENSIONS	DRILLING OBLIGATIONS[3]	PENALTIES[4]	ROYALTY RATE[5]	PRODUCTION RIGHTS[6]	UNIT RIGHTS[7]
Standard	L	20	yes	w/in 10 yrs	$40.00	10/-	yes	yes
Union	M	5	yes*	-	-	-	yes*	yes*
Imperial	L	3	yes	w/in 1 yr	$720.00	10/12.5	yes	yes
Thermal Fleet	L	10	yes	w/in 1 yr	-	10/12.5	yes	yes
American	L	5	yes	w/in 3 yrs	$1.00/acre	10/12.5	yes	no
Petroleum O'Neill	L	50	no	w/in 1 yr	termination of lease	10/-	yes	yes
Cypher	SF	-	-	w/in 1 yr	$600/acre	-	-	-
Magma**	L	open	yes	w/in 1 yr	open/acre	10/12.5	yes	yes

[1]L = lease; SF = Short Form Lease; M = Memorandum of Lease

[2]Years

[3]Time within which exploration and/or production must begin

[4]Penalties in dollars or dollars per acre to be paid by lessee to lessor if "drilling obligations" are not met.

[5]The royalty rates for geothermal energy and other substances such as soluble minerals of commercial value, expressed in per cent.

[6]Does the lease contain production rights?

[7]Does the lease contain unitization rights?

*Obtained by personal communication with Joseph Wilson, Union Oil Co.

**An example of the form use is the basis for Magma entries, see note 9.

term of a lease, if geothermal energy is still being produced, the lease may, usually at the lessee's option, be extended as long as the lessee considers production worthwhile, that is, profitable. At such time as the land is no longer productive and/or no longer profitable, the lessee may terminate the leasing arrangement. Some documents contain provisions by which the lessor may terminate a lease at the end of the primary term or some stated period of time thereafter. However, the wording of this provision is such that it makes such a decision by the lessor tantamount to the lessor withdrawing his lands from circulation, in that the original lessee exercises the first and last right of refusal to continue a leasing arrangement, exclusive of any other arrangement a land holder may have made. Thus a lessee may, under such circumstances, be forced to pay a higher price to continue leasing, but it always has the option of retaining the lands.

The basic assumption here is that as long as a royalty is paid to the lessor, he will wish to continue the lease agreement.

This assumption has great ramifications in the matter of land use patterns. For if geothermal energy is found in great quantities, once production begins, the lessors will be relatively powerless to stop continued production. A government without the means of controlling development up to and including the production state would find itself in a similar predicament.

Royalty rates stand almost universally 10 per cent of the value of the geothermal energy produced. The only exception noted was a lease between the Imperial Irrigation District (lessor) and R.W. Cypher (lessee) entered into in November, 1960. In addition to the 10 per cent royalty, R.W. Cypher was required to sell to the District, at the prevailing market price all electricity produced by the lessee from the energy produced on the District's lands. Any electrical energy produced in excess of the District's needs could be sold

commercially. It is noteworthy, however, that the lease has since expired and the District has entered into another leasing agreement with Imperial Thermal Products, Inc., which does not contain such a provision.

In those leases that mention and include minerals in solution and/or natural gas and oil in the definition of "leased substances," a royalty of 12.5 per cent of the market value of such substances is written into the lease.

For the purposes of analysis, we define "production rights" as rights and options granted to the lessee in the leasing agreement that would allow it to produce the leased substances in whatever quantities it felt appropriate and to use all land necessary and convenient to such production. All this is predicated, naturally, upon the lessee finding any or all of the leased substances in paying and profitable quantities. If such provisions were not part of the leasing agreement then the agreement would stand as no more than a license to explore the lands, requiring a new agreement to be negotiated if and when the lessee decided the land could be profitably produced.

All leases, without exception, grant these rights. Under the terms of the leases, the lessee has the rights to enter and hold land necessary for production and to utilize whatever other land is required for any and all support operations necessary to maintain production activities. These include: roads, pipelines, storage sheds, disposal ponds, communications lines, structures, and even living quarters if the remote location of the drilling site made such daily traveling to other living accommodations difficult or impossible.[10]

In short, there is nothing in the lease documents preventing a lessee from entering into full-scale development upon determination of the worth of a given piece of leased land.

The cooperative production of a number of different wells within a given natural resource field --- the unitization of a field --- is a common practice within oil and gas production. It is a means by which a limited resource can be better exploited. Even when wells owned and operated by competing firms are unitized, each firm realizes a more usable resource, one whose lifetime is extended by its controlled removal from the earth. These firms realize a benefit of greater certainty about the nature and life of the resource. And although in the past the oil producing firms have attempted to make unitization a solely voluntary act, there have been proposals and provision in some states for mandatory unitization of a field.[11]

Unitization of a field of geothermal energy makes sense in this same context. Further, it makes sense from an environmental-seismic standpoint. It has been argued that uncontrolled geothermal resource exploitation may cause settling of the land, the kind of subsidence that some land areas over large and heavily exploited oil reserves have experienced. This could have disasterous effects on the artificial irrigation system in the Imperial Valley. Since the system is based in large part on the gravitational flow of water within canals, a subsidence phenomenon might conceivably cause the canals to shift position, thus causing the natural gravitational water flow to change radically. Under such conditions the intricate and complex irrigation network would at least be altered and perhaps seriously damaged. The additional concern of seismic disturbances resulting from the change in pressures deep within the earth have caused some to express concern over rapid and uncontrolled development. Certainly mandatory unitization and strict governmental control of production activities would mitigate these kinds of worries.

Still, it is unlikely that these considerations have been the major reason for the leasing documents containing unitization provisions; rather, it is more probable that economic considerations were primary. This conclusion follows from the effects of unitization upon the lessee's obligations within the provisions of the leasing agreement, a point which is best discussed in conjunction with drilling obligations. All the lease documents contain some manner of obligatory provision requiring the lessee to begin exploratory operations within a certain period of time. This period of time is usually one year, though there are instances when it is longer. All lease documents similarly provide for the payment of a penalty in the form of money by the lessee to the lessor if drilling operations have not begun within that period of time.[12] This amount also varies and is listed in Table One under "Penalties" (Column Five). Upon payment of this money, called by various names in the various documents, the lessee extends for one year the provisions of the document spelling out its drilling obligations.

If the land leased is incorporated into a unit by the lessee --- either with other lands held by the lessee or with lands held by other firms --- the drilling obligations of all of the lessees are also unitized. Thus drilling operations on any portion of the unitized lands will satisfy the drilling requirements on all lands within the unit and, therefore, will also satisfy the contractual obligations of the various lessees. The same holds true for production of resources although the various lessors will share in the royalties on a prorate basis.

A firm may obtain a lease of 40 acres, unitize it with nine other such lease holdings, drill an exploratory well on one spot within the 400-acre tract and satisfy the drilling requirements for all ten lease agreements

By this procedure the firm could enter into exploration (as defined in the lease document) without the large-scale expenditure of capital necessary for exploration on each of the ten tracts of land. It should be noted that the correlative nature of geothermal resources, even more so than oil and natural gas resources, may make unitization of production the most efficient utilization of the energy. This becomes very important given the nearly complete immobility of the resource. Unlike crude oil, which can be transported thousands of miles before being consumed, geothermal energy must be consumed within the locality in which it is produced. If used to generate electricity, the power thereby generated can be transported out of the locality, but still only a relatively small distance. Thus, local concerns are paramount in the utilization of the resource, making planned exploitation, rather than unfettered competition, a more reasonable way to utilize geothermal energy.

There is an additional aspect of the lease documents examined that has ramifications for the entire development process. Although it takes various titles in the documents, we shall call it here the "rental fee payment." The rental fee payment is a rent in one important sense: by paying the lessor an annual amount, as specified in the document, the lessee may extend for a one year period its rights and options under the leasing agreement. In addition, the lessee's obligations under the agreement are suspended for the year covered by the rental fee payment.

The amount of this payment varies as does the penalty mentioned above. Most often the two figures are identical. They are shown in Table Two. The payment of the rental fee payment works similarly to the penalty paid to the lessor if drilling is not begun within a stated period of time (see above). But it takes on added dimensions as we shall soon see.

TABLE TWO

Rental Fee Payment Rates on Selected Lease Documents

LESSOR-LESSEE	ACREAGE	RATE/ACRE
Foster Farms, Ryan Oil	1800	$12.00
Wiest,Cypher and Co.	80	7.50
Imperial Irrigation District, Imperial Thermal	547	5.00
Del-Ranch, Imperial Thermal	240	3.00
Campbell, Imperial Thermal	160	2.22
Hiderson, et al, American Petrofine Exploration	640	1.00
Fugate, Standard	80	.50
Sperber, Fleet	68	.50

Roughly, the procedure allowed under this provision runs thus:

1) The provisions of the lease document provide that the lessee begin drilling operations within a stated period of time, usually one year.
2) If this is not done, "Lessee shall pay...to lessor an annual rental in the amount of [X dollars], which shall constitute rental until the next anniversary date" of the lease document.
3) If the lessee continues to make such payments on or before each anniversary date, the lease agreement continues in force for an additional year.
4) This process of rental payments and extended rights and options for the lessee continues "until such time as from the drilling of well or wells...there has been established to the satisfaction of the lessee the existence of sufficient power potential and/or extractable minerals in commercial quantities."
5) If the existence of sufficient power potential is determined, the lessee still exercises the option to "continue to pay...annual rental payments on or before each anniversary date," and continue to do so "until lessee has commenced the actual sale of one or more of the leased substances." Further, the lease agreement remains in force so long as the annual rental payments are paid even though the lessee thereby extends the life of the agreement past the primary term. Only if the lessee fails to make the rental fee payment can it be considered as having defaulted on its obligations under the agreement.

Although the provisions for rental fee payments vary in detail and subtlety with the different leases, the effect is substantially the same. It allows the serious firm, one whose motive involves development to the state

of production, to enter into leasing agreement before economic conditions make production profitable with only a minimum of costs. However, this provision allows the speculator to obtain land with no intention (without mention of means) of productive development and, for similarly minimum costs, hold land from development until such time as he can sell his rights as lessee to another party. There is no doubt that this has taken place. R.W. Cypher, for example, held wide lease holdings at one time. Yet never did Cypher possess the capital, technical expertise or administrative structure necessary to develop those land holdings fully.

There have been other incidents where one firm acted on the behalf of a second firm, such as Atlantic Oil obtaining leases for the Southern Pacific Land Company. More prevalent have been the activities of wholly owned subsidiary firms acting for the parent firm, such as Earth Energy Corporation and Union Oil.

It is the "rental fee" provision that allows a company either to speculate or to acquire land before it is prepared for exploration and/or production. At any time, the lessee may cease any activity that it may be engaged in and, by tendering the rental fee payment to the lessor, still maintain its rights and options of activity under the lease agreement.

This situation is represented in Figure One, with points A, B and C being points in time where decisions about continuing with the development and advancing to the next state are made. Note that Point A, any point in time between the entering into of a lease agreement with a private land owner and the beginning of exploration, a firm may choose to pay the rental fee payment (dotted line) thus returning, in essence, to the point just after the execution of the lease. Similarly, if after exploring the leased lands, the lessee does not wish to begin production, payment of the rental fee payment allows the lessee to "return" to the point just prior --- i.e. just after the completion of the Exploration State.

Figure One
Flow Chart of Lessee's Options in Prevailing Lease Agreements

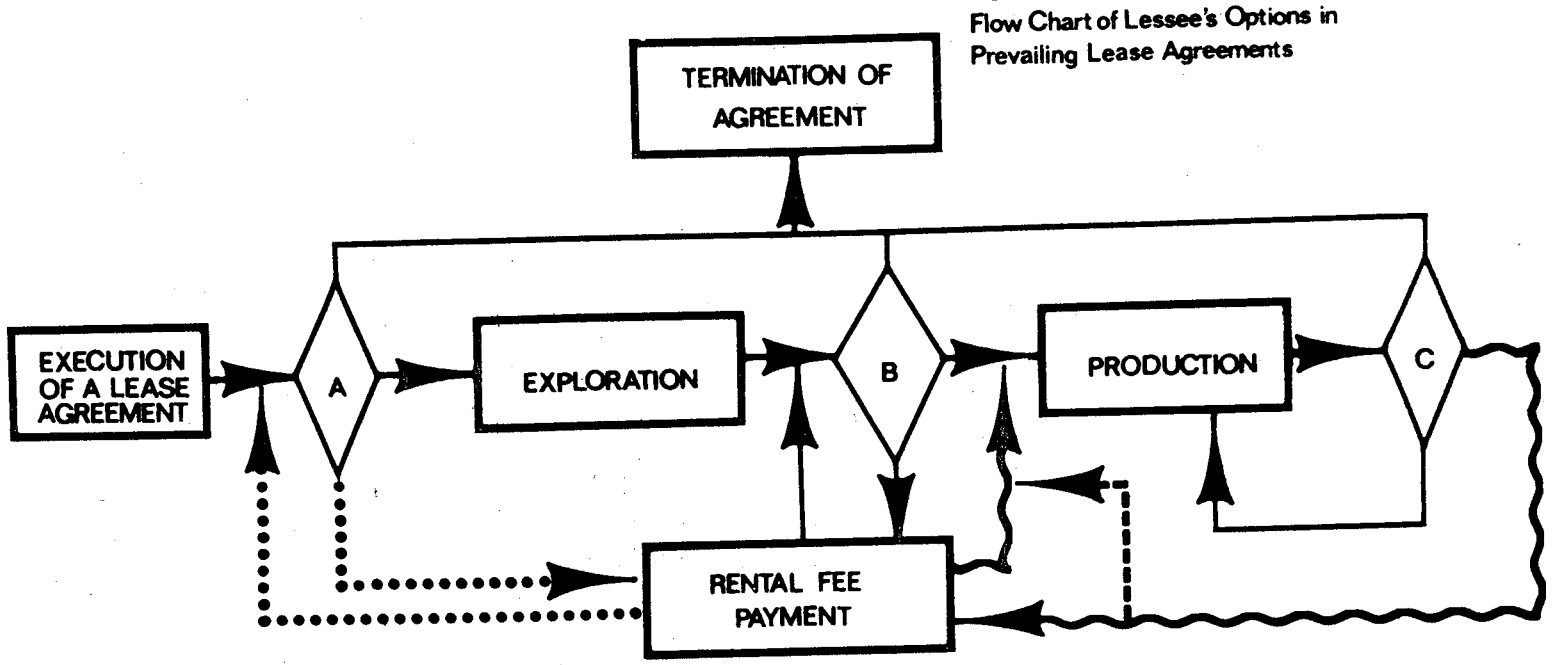
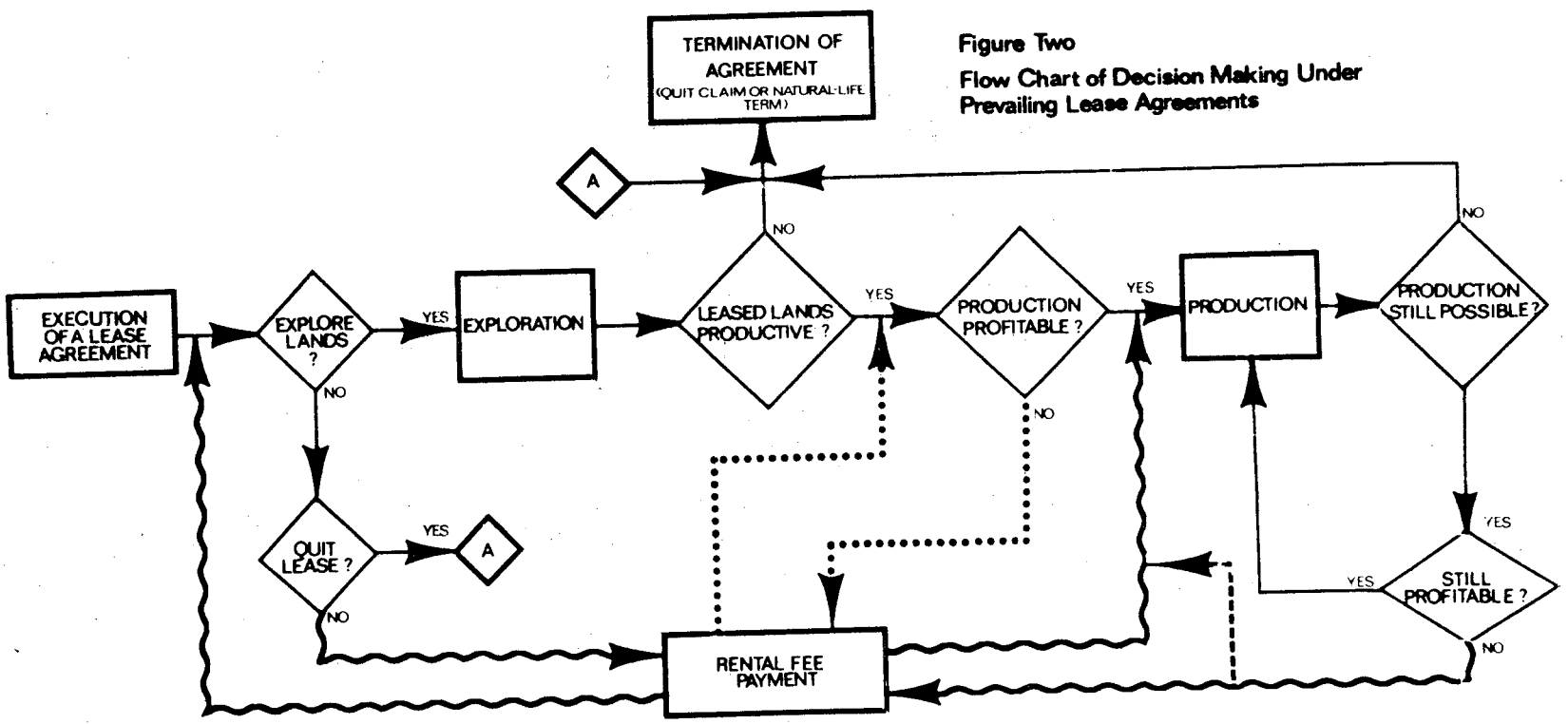


Figure Two
Flow Chart of Decision Making Under Prevailing Lease Agreements



Note further that after the beginning of production, at Point C, the lessee, by making the rental fee payment, can discontinue production while maintaining the lease agreement in force (wavy line). However, if production stops because of factors beyond the effective control of the lessee, such as governmental regulations, effects of the elements, market conditions, strikes, etc., the lease remains in force without the payment of the rental fee payment (broken line).

Figure Two shows a more detailed chart of the decision-making process within the life of a lease. Decisions that need to be made are more complex than is portrayed here, naturally, but we present the basic decision that needs to be made.

The motives of a lessee will govern the factors used in the decision-making process. For example, at Point A, the decision to explore the lands would, for a potential developer, involve such things as the availability of capital for that purpose; other projects to which that capital could be applied; the advisability of exploration at this time because of such external factors as a potential market, etc. A speculator would never seek to explore lands held, unless such expenditure was the only method by which the worth of the land could be proven, thus increasing the attractiveness of his holdings.

If a lessee decides not to explore, he must then decide whether to quit-claim the lease or not.* A potential developer would decide this question based on such factors as the prospects for long term profits realized from development. A speculator would consider short term factors of profit through

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* Quitclaim provisions, common to all leases, allow the lessee to abandon the leased land without further rights or obligations under the lease agreement. In fact, once quitclaimed, the lease ceases to exist as a binding agreement, freeing both the lessee and the lessor of all obligations and rights under the leasing agreement.

assignment of lease rights. Both would quitclaim lease agreements covering non-productive lands. But the potential developer would be more willing to retain land on the basis of geologic data that showed some production potential. If market conditions prevented rapid development, a speculator, unlike a potential developer, would release lands and end leasing agreements, for the longer he waited, the larger his risk would become. As time continues and the amount of funds spent on rental fee payments increases, the pressure to "get out" will increase.

Decisions made after the Exploration State will be made along lines of predictable economic considerations of the productivity of the land and the profit potential for development under current market considerations. If explorations prove the land to be unproductive, the lease is quitclaimed or if past the primary term simply allowed to expire, what might be called "natural life termination". If the land shows production potential, and if current market conditions would allow a profit to be realized from production, production will ensue. If market conditions do not show profit potential for production, then the lessee will revert to the rental fee payment until such time as market conditions change so as to make production profitable or as to make profits forever unrealistic. In this case the lease is released.

Similar considerations are made at various points after production has begun.

We can now easily see how development of the geothermal resources of the Imperial Valley could be stalled at any point for whatever reasons the various lessees feel are compelling. By reverting to the "loop" provided by the existence of the rental fee payment provision, firms may place development in a state of suspended animation.

Thus, we conclude that, while there is nothing within the leasing arrangements utilized by the various firms to obtain land in the Imperial Valley to prevent them from beginning full scale development, the lease documents do contain provisions creating a method by which the firms can forestall development without abrogating the option of development.

3.2 References

1. "Geothermal Resource Investigations, Imperial Valley, California," Developmental Concepts, United States Department of the Interior, Bureau of Reclamation, January, 1972, plate no. 3.

2. The law states that "'known geothermal resource area' means an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary of the Interior, engender a belief in men who are experienced in the matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose." Public Law 91-581, Section 2(e), 30 USC 1001 et seq.

3. California Civil Code, Section 1925.

4. Black's Law Dictionary, "Lease," citing Barnett v. Lincoln, 162 Wash. 613, 299, p. 392.

5. Gorden v. Empire Gas and Fuel Co., 63F2d. 487, 488. (This does not mean, however, that the law treats geothermal energy as a mineral resource. That question is unsettled, and the authors wish to leave no impression that they pretend to make the case one way or the other.)

6. Cooperative Building Materials, Inc. v. Robbins and Larkey, (1947), 183, P2d 81; Morris v. Iden, (1913), 138 P 120.

7. Medico-Dental Building Co. of Los Angeles v. Horton and Converse, (1942), 132 P2d 457.

8. Walter Nicholson, Microeconomic Theory: Basic Principles and Extensions, Hinsdale: Pryden Press, 1972, pp. 332-336.

9. The following documents were examined:

A Lease and Agreement between the Imperial Irrigation District, lessor, and Joseph I. O'Neill, Jr., and Ashmun and Hilliard, a partnership, lessee, dated November 29, 1960, found Book 1064 Page 526, Imperial County Official Records (ICOR).

A Short Form of Mineral Lease between Mildred L. Clarke, a widow, lessor, and R.W. Cypher and Co., lessee, dated January 27, 1961, found Book 1096 Page 535, ICOR.

Agreement of Amendment of Mineral Lease between Ed C. Wiest and Dorothy Wiest, lessors, and R.W. Cypher and Co., lessee, dated January 6, 1960, found Book 1067 Page 660, ICOR.

3.2 References (Cont'd)

A Lease and Agreement between H.M. Sperber and Margaret Sperber, lessors, and Fleet Oil Co., lessee, dated November 23, 1963. A copy of this lease was provided to the authors by Mr. and Mrs. Sperber.

A Memorandum of Lease and Agreement between Frank P. Brouchard, et al., lessors, and Fleet Oil Co., lessee, dated December 4, 1963, found Book 1177 Page 1180, ICOR.

A Lease and Agreement between Helen S. Fugate, a widow, lessor, and Standard Oil of California, lessee, dated March 17, 1964, found Book 1193 Page 43, ICOR.

A Heat, Fluid and Mineral Lease and Agreement between Del Ranch, Inc., lessor, and Imperial Thermal Products, Inc., lessee, dated March 1, 1966, found Book 1224 Page 578 ICOR.

A Mineral, Steam, Oil and Gas Lease between Glenn Lindsay Hickerson, et al., lessors, and American Petrofina Exploration Co., lessee, dated April 6, 1966, found Book 1227 Page 20, ICOR.

A Heat, Fluid and Mineral Lease and Agreement between Elizabeth Campbell, lessor, and Imperial Thermal Products, Inc., lessee, dated October 27, 1966, found Book 1237 Page 517, ICOR.

A Memorandum of Lease and Agreement between James Paul Birget, Jr., et al., lessors, and Union Oil of California, lessee, dated May 19, 1970, found Book 1296 Page 1141, ICOR.

A Memorandum of Lease and Agreement between Wiley Corn, lessor, and Atlantic Oil, lessee, dated February 5, 1971, found Book 1306 Page 875, ICOR.

A Geothermal Steam Lease (Short Form) between William H. Heise, lessor, and Magma Power, Inc., lessee, dated October 15, 1971, found Book 1417 Page 927, ICOR.

An Oil and Gas Lease [and Geothermal or It's (sic) By-products] between Foster Feed Farms, lessor, and Ryan Oil Co., lessee, dated May 25, 1972, found Book 1328 Page 655, ICOR. That part of the title in brackets was typed onto what was otherwise a form oil and gas lease.

A lease and Agreement between the Imperial Irrigation District, lessor, and Imperial Thermal Products, lessee, dated January 1, 1973, found Book 1342 Page 647, ICOR.

A Lease and Agreement (sample form for information purposes) provided by Magma Energy, Inc. to the Senate Committee of Interior and Insular Affairs, and reproduced in U.S. Senate, Hearings of the Committee on Interior and Insular Affairs, on S.23 and S.912, 90th Congress, 1st session, 1967, pp. 99-107.

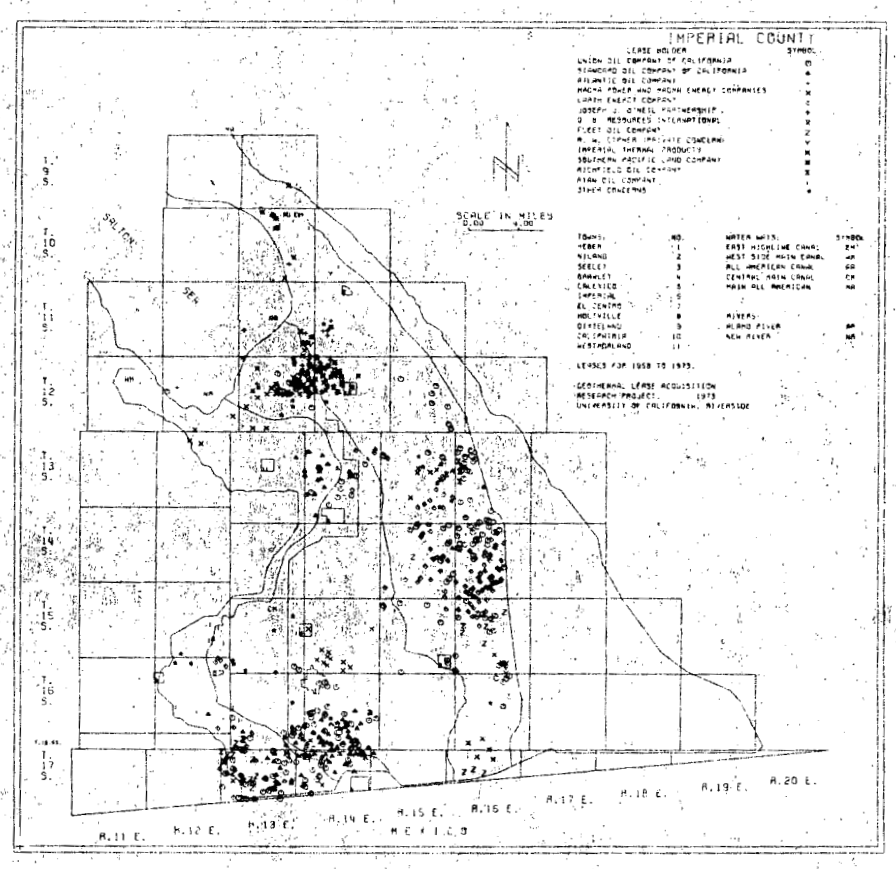
3.2 References (Cont'd)

10. An example of the lease terminology is: "...w/ the right of entry thereon at all times for said purposes, and to construct, use, maintain, erect, repair and replace thereon, and to remove therefrom all roads, pipelines, ditches and lanes, telephone and telegraph lines, utility installations, power lines, poles, tanks, evaporation or settling basins, extraction or processing plants, machinery, equipment, buildings, electric power plants, and equipment for generation and transmission of steam power, and electric power, and for the handling, treatment or storage of lease products, and all structures and facilities related thereto..." Fugate-Standard lease, Paragraph 1.

11. Statement of James Harmon, County Counsel for the County of Imperial, before the Geothermal Resources Board and the California Legislative Joint Committee on Atomic Development and Space, Compendium of Papers, Imperial Valley-Salton Sea Area Geothermal Hearings, October 22-23, 1970, section AA.

12. Standard Oil leases operate a little differently. They provide that drilling is to begin within x years --- x being the term of the lease and that an annual "rental" payment --- specified in the lease --- shall be paid until drilling begins or until the lease is quitclaimed. See Fugate-Standard lease, paragraph 4.

SECTION FOUR
CHARACTERISTICS OF DEVELOPMENT



4.1 Extensiveness of the Development

In the following treatment we will be concerned primarily with measuring the economic and geographic size of the development in the Imperial Valley of geothermal energy as a source of electric power for the State of California. We consider that size in this instance has three dimensions, each measuring an important aspect of economic development:

1) The most important dimension is maturity, the degree to which development has progressed toward a state of full productivity. Using the definition of development outlined in Section Two we will attempt to locate the center of the development in terms of the three states that we know it must pass through in order to reach a production level operation.

2) The second dimension is rate, the speed with which the development has grown during the period under study. This question has two basic components. The first refers to the rapidity of movement from one state to the next and entails measurement of how rapidly exploration permits are filed on leased land and production permits are filed after exploration permits. This component focuses directly on the relationships between states in the development process. The second component concerns the rate at which each developmental state grows over time or how rapidly the frequencies of leases, exploration permits and production permits are accumulating.

3) The third dimension is acreage, or how much land area in the Imperial Valley is encompassed by the geothermal development.

Each of these questions aims at describing one dimension of the scope of geothermal development. Each, as we shall see, will have a bearing on later discussions of the factors that have influenced the growth of the development

of geothermal resource development in the Imperial Valley. Moreover, descriptions of the growth rates in the amounts of acreage will be useful to those who are interested in estimating what economic and social implications development could have for the Imperial Valley.

4.2 Maturity: The Locus of Development

Maturity of development requires identification of the center of activity as indicated by the frequencies of geothermal transactions in each of its states. Recall that we found that two of these states were marked by the presence of a legal document of some form that was legally required of the developer. We concluded that the frequencies of these various documents in the public record would be a measure of the degree to which the development resided in the states marked by the document type.

In Figure Three, the reader will find a bar graph representing the three major states of the system of development (see Section 1.1). Clearly the locus of development is The Initiative State (marked by leasing for private rights). Only 4.4 per cent of the leases apparent in the public record have resulted in subsequent requests for exploration permits and only seven per cent of those have been converted to production permits, and none for the purpose of producing electric power.

It can be argued that Figure Three exaggerates the differences between the states because exploration and production permits were not required by law until 1967. As Figure Four indicates, however, even when one controls for this intervening legal explanation, only eight per cent of the leases are being converted to exploration permits. The relative shift in the percentage size of production permits is equally low. In addition, as we will argue more fully in a later section, the Exploration State activity seems to be principally confined to one company. In short, only two or three companies

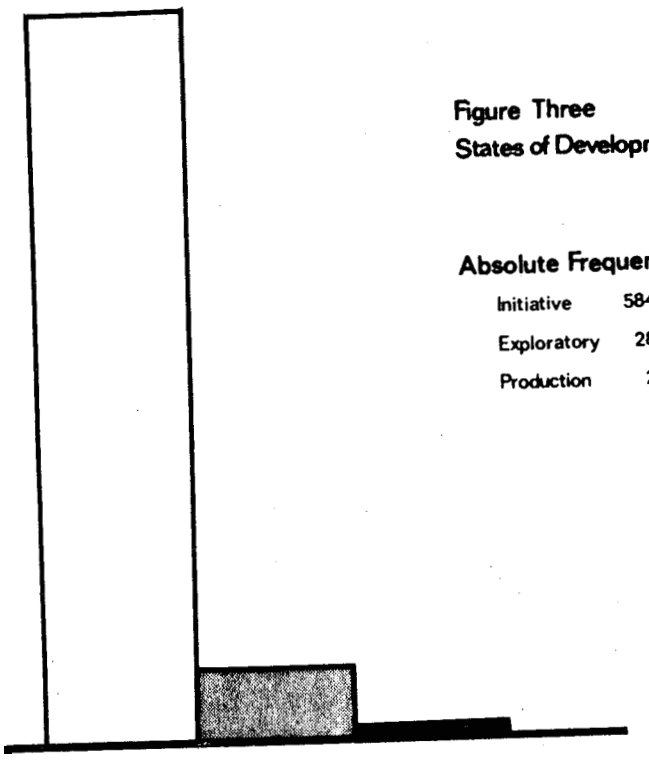


Figure Three
States of Development

Absolute Frequencies

Initiative	584
Exploratory	28
Production	2

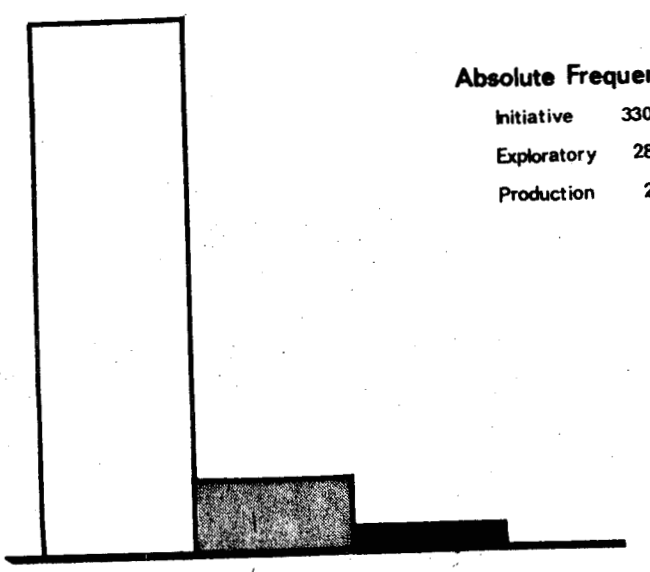


Figure Four
States of Development -- Leases acquired after 1967

Absolute Frequencies

Initiative	330
Exploratory	28
Production	2

have passed from the Initiative State to the Exploration State of the development and only one of those has done so to any appreciable extent.

Where only eight per cent of the leased lands are being explored (evidenced by our data on drilling permits) two conclusions are possible. The first is that the probability of finding "possible" well sites on property leased for the purposes of geothermal development is approximately .08 and, thus, real anomaly property is relatively scarce. The second possible conclusion is that passage from the Initiative to Exploration States has been dampened or stunted by the companies' intentions with regard to development. Full discussion of the relative merits of each alternative explanation will be handled best after consideration of the growth rates in each of the states and for geographic location. It simply should be remembered that a marked assymetry exists between development states in our system.

4.3 Rate

The ideal measure of the rate at which the elements move through our system of development is direct analysis of the dates upon which developers are granted exploration permits for given leased parcels of land in the Imperial Valley. This technique is not usable in this case, because the information collected by the Planning Commission (at least on those documents we have examined) regarding exploration and production drilling for the purposes of geothermal development do not include references to the original leases except for property descriptions. We therefore do not have the information concerning the lease document number, the lessor or date of filing --- the crucial links between the Initiative and later States in our model of development.

A less powerful estimate for the rate at which firms are moving through the development states is the frequency of new elements present in each state for each year of the period under study. This estimate indicates the rate at which activity occurs in each of the states: it does not yield a valid estimate of the rate of conversion from one state to the next. We will argue, however, that where Initiative State frequency estimates at time (t) are highly correlated with Exploration State frequency estimates at time (t+i)*, that a time lag is operating between these two states. This time lag is substantially the rate at which the Initiative State elements convert to Exploration State elements.

Figure Five contains a bar graph of the frequencies of documents in each of the States for the period 1969 through 1973. Ignoring for the moment the year 1969, Exploration State activity lags behind Initiative State activity by one year on the average.** Actually, given the metric that we are using on the x axis (years), we must find that the time between the Initiative State and Exploration State starting points is between one and twenty-three months, with a high probability that it is located between six and eighteen. Adding this to the fact that only eight per cent of leases ever pass to the Exploration State and remembering that only one company accounts for 80 per cent of that passage, we conclude that development is proceeding at an exceedingly slow rate and is not evidencing the type of behavior one associates with a rapid or substantial development process. A fuller explanation of this rate and activity will be presented in Section Six.

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*Where t = any time after 1969; and i = some number of years later which is the case where increases/decreases in Initiative State activity at time (t) correspond with increases/decreases in Exploration State activity at time (t+1).

**This relationship is summarized by the Pearson Product Moment Correlation Coefficient between Initiative State frequency at time (t=i) and Exploration State frequency at time (t=i+1) of r=.997.

Figure Five
States of Development by Year, 1969-73

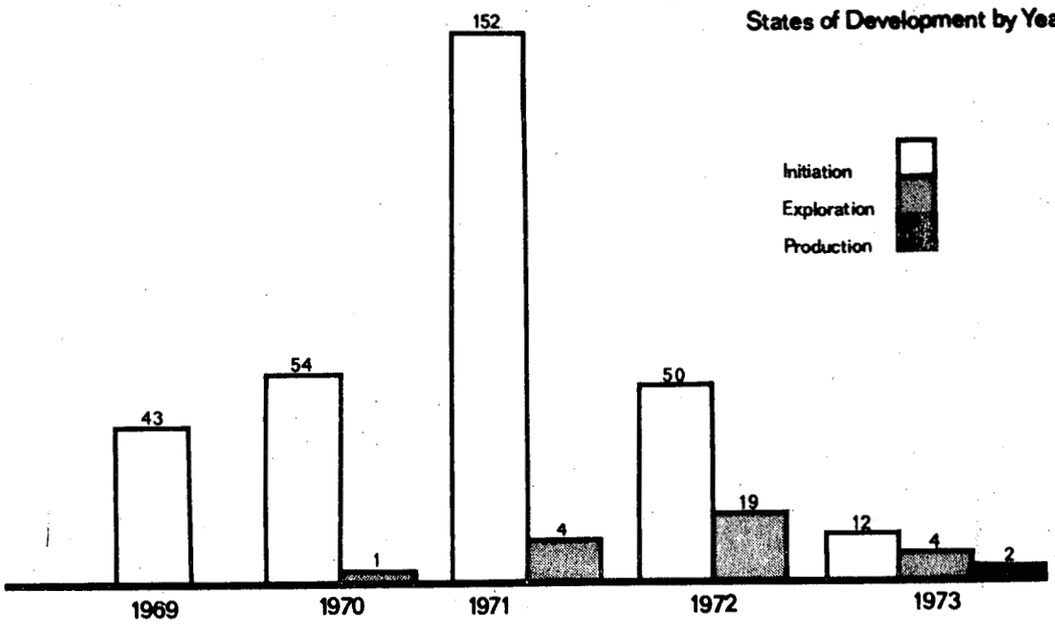
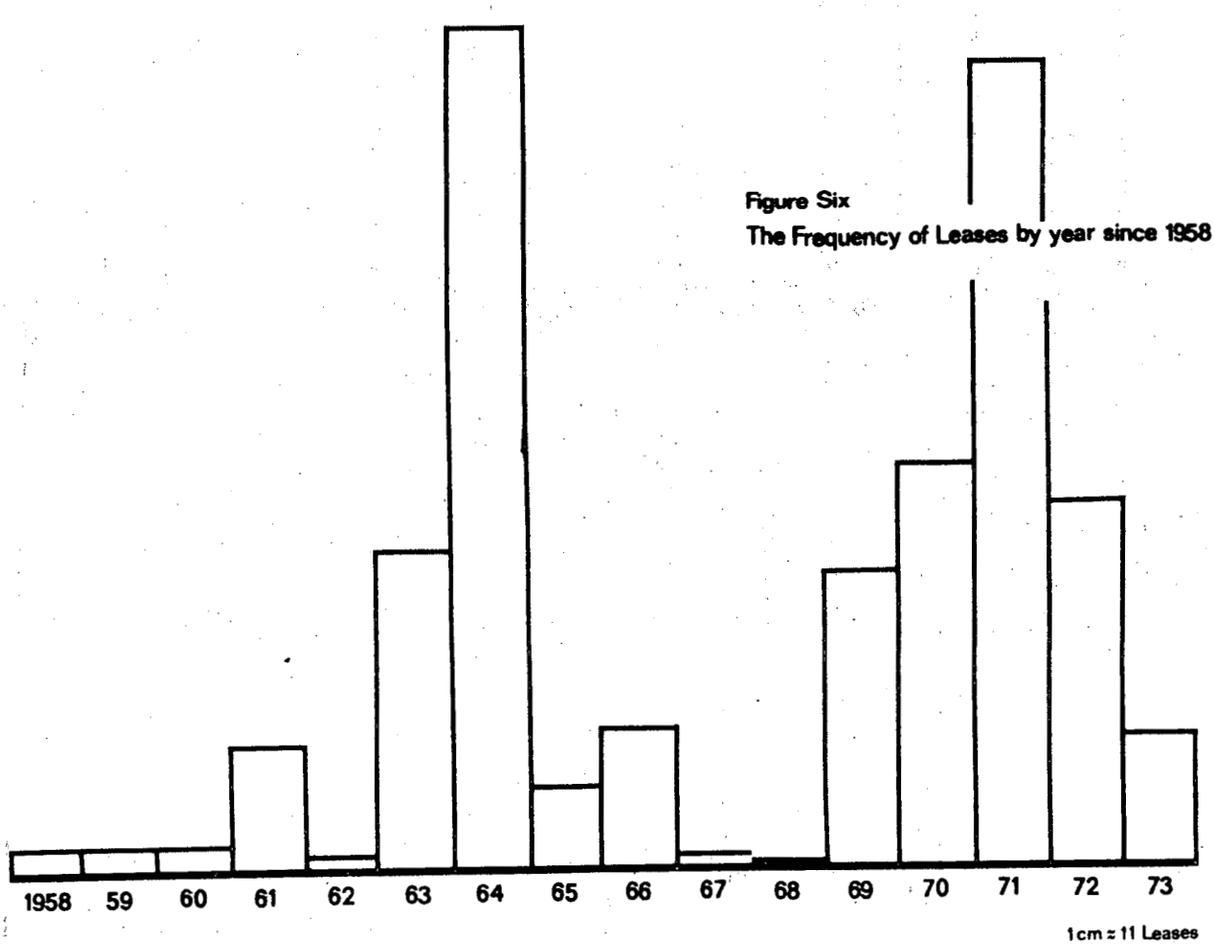


Figure Six
The Frequency of Leases by year since 1958



Additional support for the above conclusion is found in the analysis of the second component of rate, the rapidity of movement within any given developmental state. In considering the growth of each state over time, principle attention will be paid to leasing activities since it is in the Initiative State that most activity has been entered.

There have been 584 leases transacted in the fourteen-year period under study. Figure Six shows the frequency of leases by year since 1959. We had originally thought that, after some point in time, a linear growth equation would describe the increases in the frequencies of leases over the years. As the figure indicates, however, such is not the case. Two distinct peaks occur in the distribution --- one in 1964, the other in 1971. This, we think, indicates that there were two distinct developments. The first began in the late part of 1963 and ended in the early part of 1965. During that time, all of the known geothermal anomalies (KGRA's) were mapped by one company or another. For some reason in 1965, however, the acquisition of leases stopped almost completely. For a four-year period, there was only minimal leasing activity in the Imperial Valley. Then in mid-1969, a new development began. Its beginning was marked by the collection by Standard Oil Company of California of 35 leases with year primary terms during a single month. The momentum continued to grow until late 1971 and has tapered off markedly since.

Development has not been predictably additive with respect to time, evidencing instead two relatively distinct periods of growth. This is an important fact. We will argue in later sections that discreet events in the form of political, environmental and economic occurrences have impinged on the development, thus causing the unsystematic-looking relationship between the frequencies of geothermal leases and time. For the present, the reader should

TABLE THREE**

YEAR	NUMBER OF ACRES	NUMBER OF LEASES	PER CENT OF ACRES	PER CENT OF LEASES	DIFFERENCE IN PER CENT
60	218	2	.16	.30	.14
61	2124	12	1.58	2.25	.67
62	N/A	1	N/A	N/A	N/A
63	17,986	46	13.41	8.63	-4.78
64	38,152	152	28.45	28.51	.06
65	1,431	9	1.06	1.68	.62
66	3,405	15	2.53	2.81	.28
67	2,161	1	2.35	.18	-2.17
68	0000	0	00.00	00.00	00.00
69	4,592	41	3.42	7.69	4.27
70	14,040	52	10.47	9.75	-.72
71	34,632	148	25.63	27.76	2.13
72	13,524	46	10.08	8.63	-1.45
73	1,791	9	1.33	1.68	.35
TOTAL	134,056	534	100.47*	99.87*	-.60

* Cumulated per cent differs from 100 as a function of rounding error.

**Table applies only to 534 leases for which acreage information could be obtained. Twenty-five leases or four per cent of total leases did not contain reference to such information.

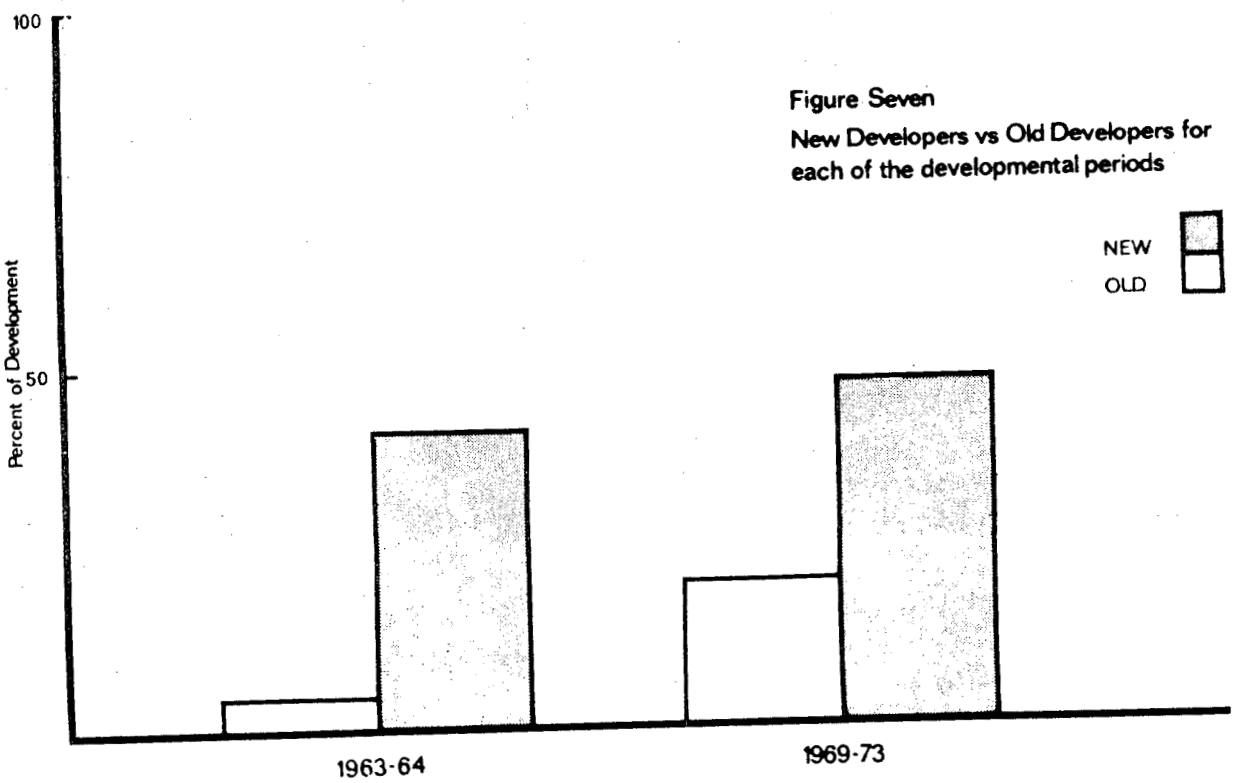


Figure Seven
New Developers vs Old Developers for each of the developmental periods

simply bear in mind the fact that growth rate in the Initiative State has not been constant over time from any relevant point to any other. However, in the last two years, there has been a significant decline in both the Initiative and Exploration States in the development. These facts would seem to indicate that development is tapering off and that geothermal energy, as a source of electric power, is not a likely possibility in the near future, a finding which we consider valid only under certain assumptions (see Section Seven).

4.4 Acreage

The final component of our analysis of the extensiveness of the geothermal development in the Imperial Valley concerns itself with the size of the land area encompassed in the activity. Between 1958 and 1973 there were 142,280 acres of land transacted in geothermal lease agreements. That land area is approximately equal to 223.9 square miles or 6.2 full townships. Map plate #1 shows a point dispersion map of the locations of geothermal leases in the Imperial Valley. Note the neat distribution of lease parcels among the Salton, Brawley, Heber and East Mesa anomalies. This leads to the conclusion that the Imperial Valley has been extensively mapped and leased by the companies involved in the development.

Consistent with our earlier treatments we present in Table Three the frequency of acres, cumulative per cent of acres, frequency of leases and cumulative per cent of leases apparent for the fourteen-year period under study. It should be clear that no systematic or theoretically relevant patterns emerge, a finding which indicates that the mechanisms and events that produced the frequency of acres over time are not different from those that produced the frequencies of leases. Graphic illustration of this is found in Figure Seven.

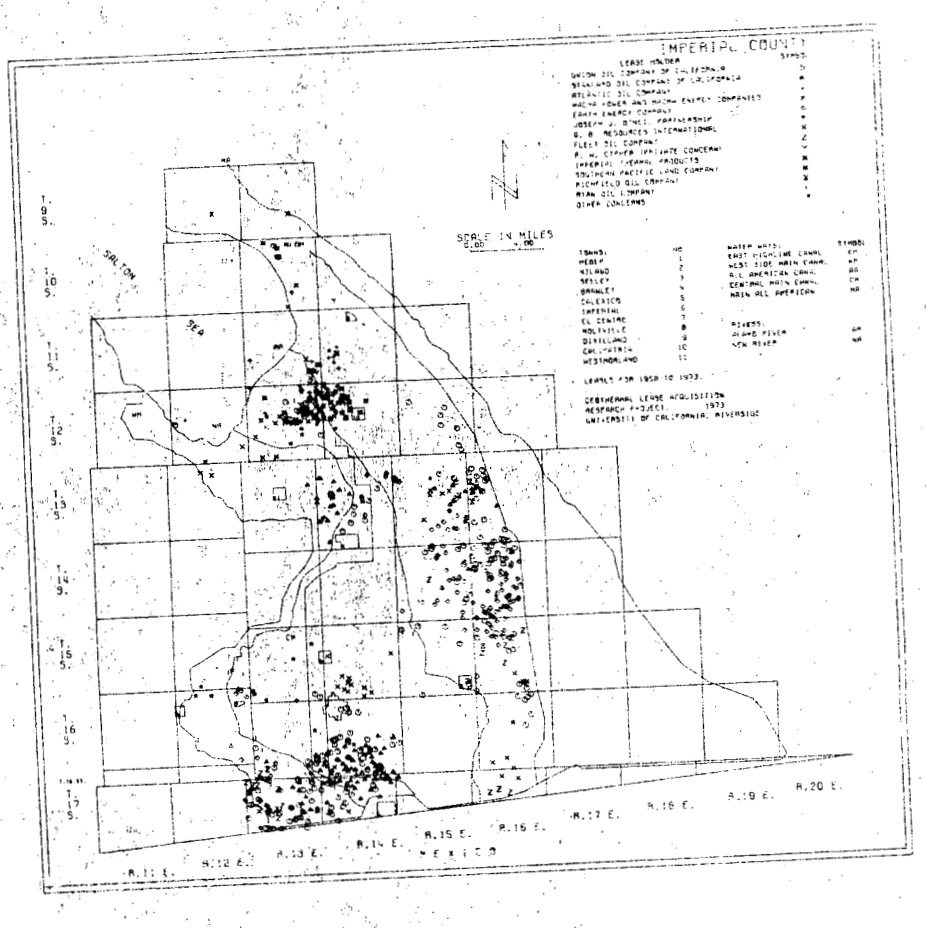
4.5 Summary

We have found that the major proportion of activity has been located within the Initiative State of the development. This, of course, is precisely what would be expected under our theory and definition of development. If we had found, for example, that overall Exploration State activity grossly exceeded that found in the Initiative State, either our theory or our measurement would have contained serious error. We found, however, that Initiative State activity outweighed that in the Exploration State by a factor of 12. In addition, we found that the rate of movement from state to state within our system was predictably slow, averaging from six to eighteen months. An analysis of growth within the states yielded the rather interesting finding that development has not been predictably linear with respect to time and that, indeed, there were actually two developments between 1960 and 1973. Moreover, both of the developments declined markedly after some peak point. Our principle concern, of course, should be the decline of the 1969 development which has all but stopped since its peak in 1971.

Finally, we concluded that the size of the land area encompassed in the geothermal development was by any standards massive and that it was well dispersed among the various KGRA's in the Imperial Valley.

SECTION FIVE

LOCATION OF GEOTHERMAL LEASES



Two map plates have been rendered to display the following information:

1) Map plate #1, with four overlays, plots Initiative State activity in four major chronological phases during the period under study, 1958-1973.

2) Map plate #2, with four overlays, shows lease acquisitions by each of the four major companies examined in Section Six.

5.2 Leasing and Location

In order to establish a base against which we can measure and analyze the location of lease holdings, let us stipulate the conditions under which the distribution of leases would form a random pattern with respect to location of leases and sizes of holdings for each company. Two such conditions can be stipulated: 1) that the probability of leasing any land parcel in the Imperial Valley is equal to the probability of leasing any other parcel; and 2) that for each company involved, the probability of leasing any plot of land is equal to the probability of leasing any other plot of land.

If these two conditions obtained, then a random distribution of leases, both with respect to specific geographical areas and to the company which held the lease, would exist. Such conditions do not, of course, hold. The usefulness of random conditions formulation lies in its setting a base against which actual lease distribution can be compared. To the extent that the first condition is not met, a tendency for clustering of leases around specific geographical areas will result. And, to the extent that the second condition is not met, a measure of each company's assessment of the relative value of the geothermal resource in specific locations will result.

One study indicated that not a great deal was known about the geothermal anomalies that exist on private land.[1] Where one uses exploration drilling as the principle measure of knowledge about the geothermal resource under private land in the Imperial Valley, such a statement is valid. Where, on the other hand, one uses leasing as the principle indicator of knowledge about geothermal potential, rather different statements can be offered. The disparity between measures is not a trivial one, but it derives principally from the different types of knowledge one is seeking.

It is useful to discriminate between knowledge necessary for the generation of electricity using geothermal steam and knowledge necessary to assure that when production of an underground resource becomes a technical and economic reality, one's competitive posture in the market is such that a maximum amount of the fixed available profit is insured. Great care should be taken not to confuse these kinds of knowledge. They have wholly different purposes. In the case of the former, a great deal is yet to be known. In the case of the latter, it will become clear that an abundance of information does exist.

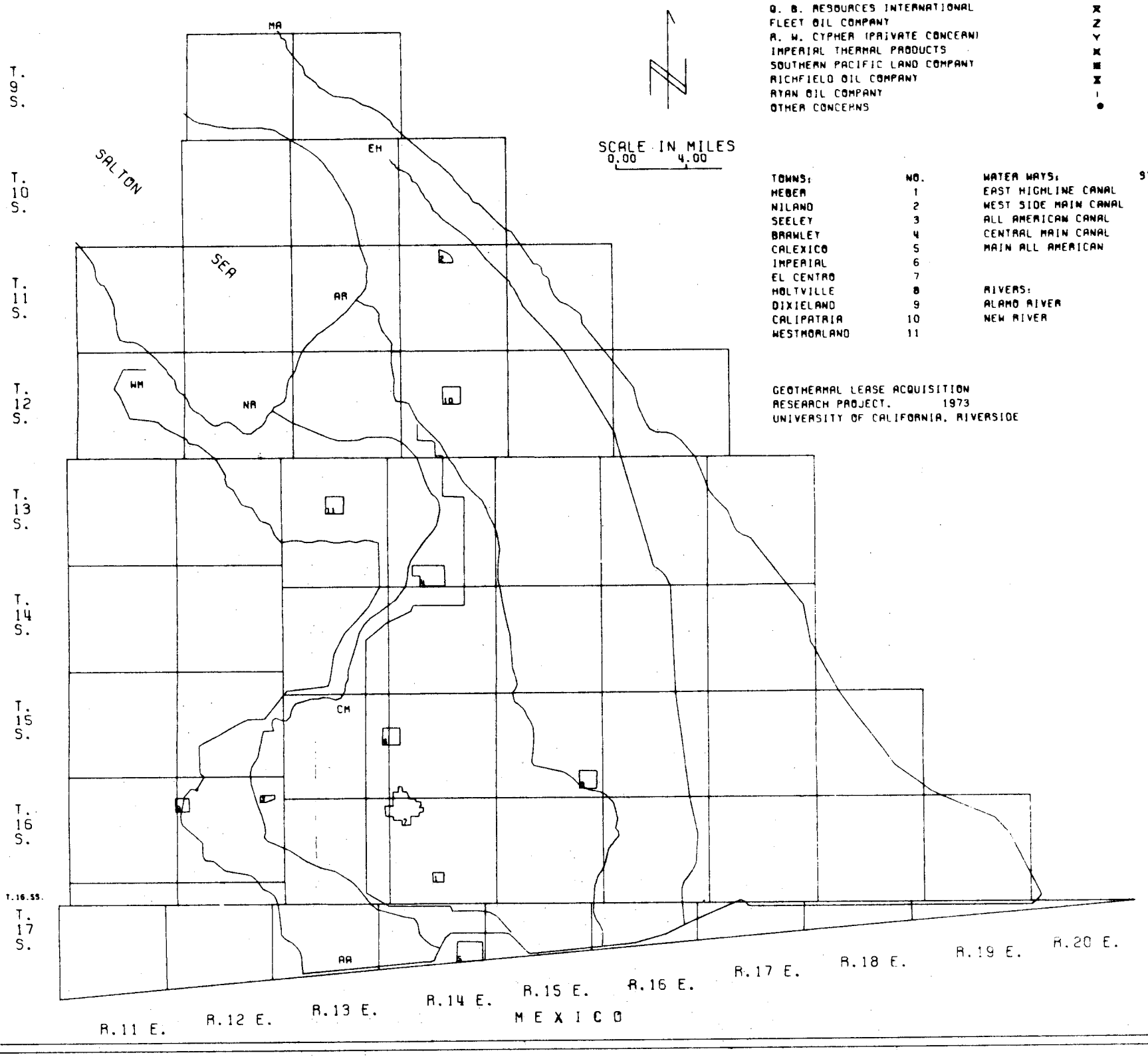
The sheer number of leases in the public record would tend to indicate that, at a minimum, information concerning the location and strength of the geothermal resource under private ownership in the Imperial Valley is widely dispersed. A more telling argument exists, however, in the distribution of leases over the geography of the area. Recall for a moment our discussion of the zero point of clustering of geothermal leases. The assumptions that we made in order to produce this zero point can be related to the absence of information on the part of the lessors. The case in which the probability of every plot of land being leased is equal is substantially the situation

in which no information exists concerning the desirability of any plot of land over any other, in which desirability is a function of the location and strength of the geothermal resource at any point in the Imperial Valley. The second assumption, being essentially the first assumption made for cluster areas, follows the same rules. The extent to which leasing is clustered around geographic points then, is a measure of the amount of knowledge concerning the location and strength of the geothermal resource. Visual evidence of the degree of clustering is apparent in map plate #1. There are specific points of extremely high concentration in leasing over the geography of the Imperial Valley. Less clear is the question of dominance of those clusters by specific companies. Because this phenomenon tends to vary from company to company, discussion of it has been deferred to Section Six. For the present, we think it safe to conclude that companies, at the very least, have fairly complete information on the probable location of the geothermal resource, while confusion exists concerning the relative strength of that resource across areas.

Further evidence for this line of reasoning is offered when we compare the distribution of leases with Known Geothermal Resource Areas. In "Geothermal Resource Investigations: Developmental Concepts," Combs and Randall have plotted those areas which they found to contain great potential for geothermal development.[2] A comparison of their findings with composite map plate #1, a plot of the leasing pattern found from 1958 through 1973, yields the fact that leasing generally tends to occur within the areas shown by Combs and Randall as having geothermal potential. This is especially true for leasing prior to 1971. Only in one area does the pattern not hold.

IMPERIAL COUNTY

LEASE HOLDER	SYMBOL
UNION OIL COMPANY OF CALIFORNIA	⊙
STANDARD OIL COMPANY OF CALIFORNIA	▲
ATLANTIC OIL COMPANY	+
MAGMA POWER AND MAGMA ENERGY COMPANIES	✕
EARTH ENERGY COMPANY	◇
JOSEPH J. O'NEIL PARTNERSHIP	●
G. B. RESOURCES INTERNATIONAL	⊠
FLEET OIL COMPANY	Z
R. W. CYPHER (PRIVATE CONCERN)	Y
IMPERIAL THERMAL PRODUCTS	✕
SOUTHERN PACIFIC LAND COMPANY	■
RICHFIELD OIL COMPANY	⧗
RYAN OIL COMPANY	I
OTHER CONCERNS	●



SCALE IN MILES
0.00 4.00

TOWNS:	NO.
HEBER	1
NILAND	2
SEELEY	3
BRAWLEY	4
CALEXICO	5
IMPERIAL	6
EL CENTRO	7
HOLTVILLE	8
DIXIELAND	9
CALIPATRIA	10
WESTMORLAND	11

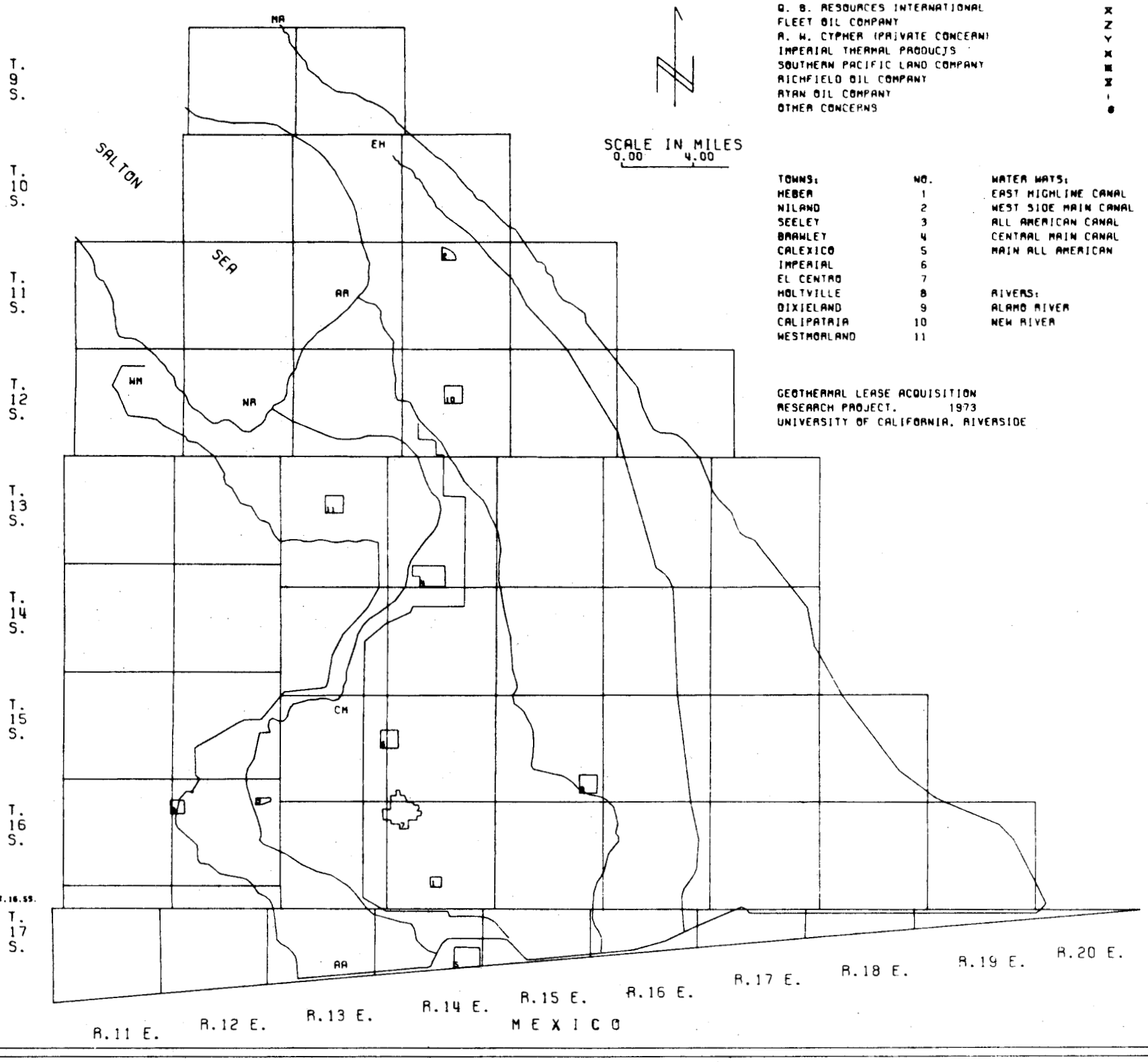
WATER WAYS:	SYMBOL
EAST HIGHLINE CANAL	EM
WEST SIDE MAIN CANAL	WM
ALL AMERICAN CANAL	AA
CENTRAL MAIN CANAL	CM
MAIN ALL AMERICAN	MA
RIVERS:	
ALAMO RIVER	AR
NEW RIVER	NR

GEOTHERMAL LEASE ACQUISITION
RESEARCH PROJECT. 1973
UNIVERSITY OF CALIFORNIA, RIVERSIDE

MAP PLATE #1 – MAJOR PERIODS OF LEASE ACQUISITION, 1958-1973

IMPERIAL COUNTY

LEASE HOLDER	SYMBOL
UNION OIL COMPANY OF CALIFORNIA	⊙
STANDARD OIL COMPANY OF CALIFORNIA	▲
ATLANTIC OIL COMPANY	+
MAGMA POWER AND MAGMA ENERGY COMPANIES	✕
EARTH ENERGY COMPANY	◇
JOSEPH J. O'NEIL PARTNERSHIP	✦
G. B. RESOURCES INTERNATIONAL	✕
FLEET OIL COMPANY	Z
A. W. CYPHER (PRIVATE CONCERN)	Y
IMPERIAL THERMAL PRODUCTS	✕
SOUTHERN PACIFIC LAND COMPANY	■
RICHFIELD OIL COMPANY	⧗
RYAN OIL COMPANY	!
OTHER CONCERNS	●



SCALE IN MILES
0.00 4.00

TOWNS:	NO.
HEBER	1
NILAND	2
SEELEY	3
BRAWLEY	4
CALEXICO	5
IMPERIAL	6
EL CENTRO	7
HOLTVILLE	8
DIXIELAND	9
CALIPATRIA	10
WESTMORLAND	11

WATER WAYS:	SYMBOL
EAST HIGHLINE CANAL	EM
WEST SIDE MAIN CANAL	WM
ALL AMERICAN CANAL	AA
CENTRAL MAIN CANAL	CM
MAIN ALL AMERICAN	MA
RIVERS:	
ALAMO RIVER	AA
NEW RIVER	NA

GEOTHERMAL LEASE ACQUISITION
RESEARCH PROJECT. 1973
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MAP PLATE #2 – LEASE ACQUISITION BY MAJOR COMPANIES, 1958-1973

The final topic in our discussion of the location of geothermal leases within the Imperial Valley is, from an analytical point of view, the most important. We will in the ensuing pages be discussing the growth of the geothermal development over the geography of the Imperial Valley. This will, we believe, shed light on our earlier discussion of the extensiveness of the development within each of the development states.

We concluded earlier that there had been two distinct developments over the period of study; the first occurring in 1963 and 1964, the second occurring between 1969 and 1971. The emergence and disappearance of Initiative State phenomenon at different points in time can be explained, it seems to us, by two different general sets of arguments. The first we term a resource mirage effect. Such explanations declare that to date (any date over the period) no satisfactory geothermal area has been found on private land in the Imperial Valley. It is therefore put forward that growth in Initiative State activity is attributable to the discovery of new areas of possible geothermal potential. Subsequent declines in growth result from the fact that the newly found area is declared to be unsatisfactory for any number of technical or economic reasons. The reason, then, that would be given for lack of development over the period in question would be that no truly productive geothermal property had yet been discovered.

The second set of arguments explain attenuation on the basis of structural and dynamic factors in the energy industry. These explanations argue that satisfactory land, in fact, does exist and has already been discovered in the Imperial Valley. Increased growth in Initiative State activity is explained in this model as attributable to changes in some unspecified parameters in

the energy market, making geothermally produced electricity competitive in terms of profits realized from capital investment in some other energy producing enterprise. Declines in growth of The Initiative State are then produced by changes having the opposite effect on the profit-value of geothermally produced electricity. This explanation would argue that the main reason that geothermal development has not advanced more resides in the fact that not enough profit can be generated therein to make it a worthwhile venture or that capital investments and/or administrative efforts, both valuable and finite resources of the energy industry, are better placed in other activities.

The veracity of these two general models or explanations for the status quo can be easily tested by examining the growth of the development across the geography of the Imperial Valley. This is true because both models imply specific and identifiable outcomes for the character of that growth. The former would require that increased growth in development be related to the discovery of new and possibly profitable land area and would imply that decreases in the rate of growth resulted from the fact that such land was, in fact, not satisfactorily productive. In the case of the second class of explanations, growth in the Initiative State activity would uncorrel with the discovery of new, possibly profitable land area, but it would not necessarily be caused by those discoveries.

In the first class of explanations, increases in land area are a necessary and sufficient condition for the growth of Initiative State activity, a condition which might be termed a trigger effect. In the second class of explanations, growth in Initiative State activity may proceed in the absence of new land area because expansion is predicated on profit margin determinations.

Clearly, these two classes of explanations can be tested by relating development activities in the Initiative State to the distribution of such activity over the geography of the Imperial Valley across time.

Let us, then, examine the growth of the land area over the period under study. This discussion utilizes the graphic presentation contained in map plate #1. Each of these overlays is a photographic reproduction of a plot of the geothermal leases found in the public record during a significant period in the development under study. Map plate #1a contains the leases found for the period 1958 through 1962; map plate #1b presents the first developmental period, 1963-1964; #1c contains the leases found in the subsequent slow period, 1965-1968; and #1d exhibits the second development period, leasing which occurred between 1969 and 1973. The color coding scheme is provided to allow the reader to "track" the movement of the development between those periods. This may be done by allowing all of the overlays to rest on the base map.

Our examination of the growth of geothermal steam leasing begins with the year 1958. We do not argue that significant geothermal development has only occurred since that date. It is likely, however, that developmental activity prior to our analytical period was confined totally to the area around the Salton Sea. Evidence for this assertion can be found in map plate #1a, which shows that during the period 1958 through 1962 only one lease was recorded outside of the Salton anomaly area. The lessor, Joseph I. O'Niel and Partnership, never transacted, in that or later time periods, another lease outside of the Salton anomaly area. Other than that one element, we find no leasing in areas other than the Salton Sea region prior to 1963.

The period between 1958 and 1962 was described in Section Four as a slow period in the geothermal development, with leasing confined to small companies. It will become clear in this section that a pattern is established over these slow periods. For the most part, we find that rapid growth in Initiative State activity is correlated with the appearance of new and powerful corporate interests. Slow periods are characterized by small investments by small companies confined principally to the Salton anomaly area. The period between 1958 and 1962 is such a time.

The next salient time period found in Section Four occurred between the years 1963 and 1964. The marked increase in the amount of Initiative State activity was related, it seems, with two events that occurred simultaneously during that time: three important new areas of geothermal potential were discovered and leased during that period, and, several powerful new companies became involved in the development. Map plate #1b displays this activity.

Beginning early in 1963, Fleet Oil Company, a Long Beach, California based firm, began transacting leases in an area adjacent to the East Highline Canal and west of the present East Mesa anomaly, as well as in an area adjacent to the West Side Main Canal to the extreme southwest of the present Heber anomaly. During the same year, Magma Energy Co., a Nevada based corporation, and Earth Energy Co., a subsidiary of Union Oil Co., also became more active: the former in the Salton anomaly area, the latter in the general area occupied by Fleet Oil Co. In the following year, 1964, Standard Oil Co. of California, became actively involved in the development. This company's leasing efforts were concentrated on what are now called the Brawley and Heber anomalies. They paid only scant attention to the areas mapped by small investors in the Salton region and to areas mapped by Fleet Oil Co.

As suddenly as it had begun, the 1963-64 development ended. For an unknown reason, new lease acquisitions by Standard Oil, Magma Energy, and Earth Energy companies reduced to a mere trickle in the latter part of 1964, stopping completely in the early part of 1965. This situation remained in effect for four years.

We have described, in effect, one full cycle of the development. It seems to have all of the earmarks of the phenomenon summarized by the first class of explanations mentioned earlier. Increases in activity in this instance are correlated with the discovery of new land areas and the end of development is abrupt and apparently final. Such findings suggest that some insurmountable problems were discovered, and these problems caused termination of development activity. One nagging fact, however, remains unexplained. Few of the leases transacted during the 1963-64 development were quitclaimed or had expiration dates that allowed them to terminate in less than a five-year period. Recall that in Section Three on leasing and legal aspects, we said that failure to develop always resulted in a monetary penalty to the lessor. This means that, at a penalty, the lessors in the 1963-64 development continued to hold the property acquired during the period, long after Initiative State activity had ceased. It seems possible, if not probable, then, that the development was left dormant rather than terminated during the period following 1964.

Map plate #1c is a plot of the leases that were transacted for the years 1965 through 1968. It can readily be seen that leasing during this four-year period was again slow, confined to small companies, and concentrated in the Salton anomaly area. This period is, of course, similar in these respects to the time prior to 1963.

In early 1969, Standard Oil Co. of California amassed 35 leases in a single month. This fact is underrepresented in our map because most of these leases did not contain property descriptions. The few that did, however, were located in the Heber area. This massive acquisition marked the beginning of what we have called the second development (see map plate #1d).

The 1969 development was different from the first along an extremely important dimension. No new land area was involved in this developmental period. Leasing activity took place over exactly the same land area that had been involved in the 1963-64 development. Like the first development period, however, new and powerful corporate investors were introduced to the development. This time, three new companies became active.

The first to appear was Union Oil Company, with its first lease transacted in 1970. Examination of map plate #1d shows that Union Oil has tended to spread its leases evenly over the geothermal anomaly areas in the Imperial Valley. The company holds a large number of leases on each of the anomalies that have previously been described. Moreover, Union Oil's acquisitions from month to month appear to be part of a calculated effort to accomplish precisely this end.

In 1971, leases for Atlantic Oil Company, a Denver, Colorado based firm, and Southern Pacific Land Company (SPLC), a component of the Southern Pacific Railroad complex, began to appear in the public record. The relationship of these two companies --- Atlantic and SPLC --- to one another will be discussed more fully in Section Six. It can be seen in map plate #1d that these two companies have concentrated their efforts almost totally in the Salton anomaly area.

In addition to the appearance of new developers, it can also be seen that the more established interests in the development --- Standard, Magma and various smaller interests --- also became much more active during this period. Their activity, however, does not account for the extreme growth in what we have monitored in development periods. A comparison of leasing activity by new developers in the periods when the Initiative State is growing with the leasing activity of the old developers for the same time periods indicates that the largest amount of growth is attributable to new companies in both developments.

5.3 Summary

Two distinct development periods have occurred since 1958, and they are characterized by certain common aspects of activity. In each period, new and powerful corporate interests have begun acquiring leases. Activity in each period concentrated on the same land area. The similarities, however, break down beyond this point. The 1963-64 development was associated with the discovery of new and potentially useful geothermal resource areas. The 1969-73 development, however, was not. Many of the investors who took part in earlier developments, R.W. Cypher, Fleet Oil Co., and a host of others, were involved in the 1964 development but were not involved in the 1969-73 period.

Let us now consider in more detail the two alternative sets of arguments which could explain the situation of two distinct periods of development. These general arguments have been termed the "mirage effect" explanation and the "profit determination" explanation. In the 1963-64 development period, growth was correlated with the discovery of new land area and the initiation of activity by several new and powerful corporate interests. In the absence

of knowledge concerning the remainder of the period under study, we might be tempted to conclude that the "mirage effect" explanation effectively summarizes the form of the development. Data from the 1965 through 1968 period, however, indicates that while actual leasing stopped, the leases already in effect were not quitclaimed. If the resource had disappeared under close technical scrutiny, developers would not have continued to hold leases for it.

To do so would have been an unnecessary expenditure of finite resources. By maintaining their various leasing agreements and, thus, the option of further development, the companies involved demonstrated an interest in resource development. Their behavior suggests a belief on the part of management of these companies that the resource would prove to be of value at some future date. The decline of Initiative State activity between 1965 and 1969 cannot be attributed to our first set of possible explanations. If it had been shown that the resource did not, in fact, exist, companies would have quitclaimed their leases. Some such quitclaiming did occur during 1965-68, of course, but not on a scale to be expected had the resource been shown not to exist.

Unlike the earlier period, the 1969-73 development was not correlated with the discovery of new and potentially useful resource areas. It took place over the same areas that had been involved in the 1963-64 period. Moreover, most of the leases transacted in the 1963-64 period were still in effect in 1969 (and remain in effect today). Without going into detail in this section on the actual determinants of the growth of Initiative State activity in the geothermal developments, it seems clear that attenuation in the growth of such activity, given our findings in this section, is more likely related to

structural and dynamic characteristics of the electrical energy market in the State of California than to the availability of the geothermal resource in usable quantities in the Imperial Valley.

We set out in this section to describe the distribution of geothermal leases over the geography of the Imperial Valley. The thrust of the treatment has concerned itself with describing, first, the extent and location of and the area involved in the development. We have found that the development has, over time, clustered around specific points in the Imperial Valley and that these points closely correspond to government estimates of the positions of the geothermal anomalies located on private land in the region. We have concluded from these facts that at least enough information concerning the position and strength of the resource has been generated by developers to require them to selectively distribute their lease holdings over the Imperial Valley. We found however, that there seems to be little agreement among the various developers as to the desirability of leasing in specific areas. Common sense, of course, would have argued for the same conclusion since leasing in the amounts that we have described would constitute an absurdity in the absence of some very clear estimates of the location and strength of the resource. We feel however, that the true value of such an assertion is in this instance better tested than assumed.

Secondly, we have examined the growth of the development over the geographic area as that growth relates to our findings with regard to the growth of the development over time. Several interesting findings resulted from this comparison. First, we determined that all of the now Known Geothermal Resource Areas in the Imperial Valley were mapped prior to 1965. Second, we found that the periods in the development have tended to be cyclical in the sense that

periods of rapid growth in Initiative State activity have been correlated with the appearance of new and relatively powerful corporate actors and that coincident to this appearance the "older" powerful corporate actors tend to reactivate their leasing campaigns. Coincident here is meant in the strictest sense of the term; we have not determined that one preceeds the other. Slow periods, on the other hand, are characterized by small and relatively powerless interests leasing small parcels, in and around the Salton anomaly area.

Since all of the geothermal territory was mapped prior to 1965, the 1969 upsurge in leasing activity cannot be related to the discovery of new resource areas. Where this explanation is ruled out, we feel it is extremely likely that the 1969 development was caused by changes in the energy market in California, making geothermally produced steam more competitive with other energy sources. This argument is considered in full in Section Seven.

5.4 References

1. Geothermal Resources Development in California: Imperial Valley Potential, University of California, Riverside, November 15, 1972, Eric Burgess, Staff Consultant, p. 180.

2. "Geothermal Resource Investigations: Imperial Valley, California," op. cit.

6.1 Classification of Companies

In the 15 years which comprise the time period under study, 1958-1973, over 20 companies have engaged in lease acquisition activities in the Imperial Valley. These companies range from relatively small entities with a particular focus on geothermal energy to large, major energy production and utilization corporations. The following lists those lessees active in the Imperial Valley over this time period whose names appear in the public record:

1. American Petrofind Exploration Company
2. Atlantic Oil Company
3. Central California Oil Company
4. Crocker Citizens National Bank
5. Earth Energy, Inc.
6. Fleet Oil Company
7. Geothermal
8. Gulf Oil Company of California
9. Imperial Thermal Products, Inc.
10. Magma Energy, Inc.
11. Magma Power Company
12. Joseph I. O'Neill Partnership
13. Q.B. Resources, Inc.
14. Richfield Oil Company
15. R.W. Cypher and Company
16. Ryan Oil Company
17. Southern Pacific Land Company
18. Standard Oil Company of California (Chevron)
19. Union Oil Company of California
20. V.T.N., Inc.
21. Western Geothermal, Inc.

As apparent from perusal of this list, the companies involved in geothermal leasing activities include a variety of corporate types. There are, in the first place, large oil companies, such as Standard (Chevron) and Union. Their activities in the Imperial Valley appear to be supplementary to their other energy development activities; that is, their interest in geothermal resources seems distinctly secondary and perhaps complementary to their efforts in finding and developing fossil fuel resources. From this perspective it can be argued that

these companies, despite their substantial financial and administrative resources, are not assuming a leading position vis the technological developments necessary for producing electricity from the Imperial Valley's "wet steam" geothermal resource. At least one representative of a major oil company has indicated that his company's policy does not include increased capital commitments to its research and development unit for solution of technical problems currently associated with production of the Imperial Valley's geothermal resource. Rather, it is his company's intention to await such solutions based on either his company's R&D work, at present funding levels, or improvements found by other companies, specifically those more wholly devoted to geothermal development. Such a position is consistent with our earlier findings and conclusions. By committing only those financial resources necessary to maintain leases on KGRA's and relatively minor amounts for internal R&D work, these companies are in a position to begin fairly rapid development and production activity once technical and other problems are overcome. At the same time, their capital investments are enough that they can wait for considerable periods of time before initiating such activity without seriously depleting their financial and administrative resources.

Another category of companies evident from a review of those active in leasing consists of small oil companies, such as Central California Oil Company, Fleet Oil Company, and Ryan Oil Company. These companies do not appear to have the resources necessary to solve technological problems. From public records, corporate records made public, and telephone interviews, it is apparent that these companies are making no R&D commitments to problems associated with geothermal resource development. Both individually and collectively, the lease holdings of these companies are relatively small, and none of the smaller oil companies has applied for exploration permits with the

County of Imperial. It should be noted that in at least two cases, a smaller oil company has acquired and maintained leases for future assignment to larger companies. It is possible, though our research does not conclusively prove this point, that these smaller companies have acquired leases for two reasons: 1) for future assignment to other, larger corporate entities, and 2) for speculative reasons, that is, the acquisition of leases for the purpose of future assignment, at a profit, to other companies.

A third grouping can be described: those companies which are based solely or primarily on geothermal development. These companies may be the most critical group for future development of the resource. Certain of these companies devote all their R&D commitments to technological problems associated with geothermal production. (Technological problems are considered generally to be a major obstacle to development, a point which will be addressed more fully later in this paper.) An example of such R&D efforts is the Magmamax (generating) process developed by Magma Energy. Essentially a binary-fluid power generating system, Magmamax is of considerable importance given the wet-steam resource in the Imperial Valley which is characterized by heavy brine contents. Such a resource, unlike a vapor-dominated system, flashes both hot water and steam when tapped. In the Imperial Valley generally, and the Buttes anomoly particularly, the hot water carries with it a heavy residue of corrosive brines which seriously diminish the generating life of traditional production systems. Magmamax, by utilizing a binary-fluid, heat exchanger process, tends to minimize these technological problems and thus make development a greater possibility.

In addition to the specific technical improvements which have resulted from geothermal-oriented companies' actions, such companies as Magma Power, Magma Energy, and Imperial Thermal Products are looked to by other companies for solutions to other technological problems. Several representatives of major oil companies (who requested that they not be directly quoted) at the National Conference on Geothermal Energy (Palm Springs, California, May, 1973) indicated that their companies were waiting for geothermal-oriented companies to solve the technological problems of geothermal resource production before their companies would commit themselves beyond the Initiative State.

A fourth class of lessees consists of those companies and individuals who are not associated with energy production outside the Imperial Valley. This group includes R.W. Cypher, Joseph I. O'Neil, and Southern Pacific Land Company. Little information could be obtained regarding some of these lessees. Attempts were made to directly contact certain of these companies, but it was discovered that some companies no longer exist and representatives of others indicated no knowledge of their companies lease holdings. From this it appears that most of the companies in this class acted in a speculative manner with regard to geothermal lease acquisition, intending merely to hold leases until such time as they could profitably assign their holdings to other companies more interested in development. This does not, however, appear to be the case for Southern Pacific Land Company. Discussion of SPLC's activities will be considered more fully in Section 6.2.

6.2 Analysis of Major Leaseholders

Rather than providing analysis on all the companies holding geothermal leases in the Imperial Valley, it was decided, for reasons outlined below, to concentrate on the principal leaseholders. In part this decision reflects the

general sense of those who are active in the geothermal field that any increase in activity beyond the Initiative State will result from decisions taken by those firms holding the largest percentages of leases. For geothermal development to progress into productive stages, it will be necessary for large areas to be brought into production at the same time. Smaller companies do not possess the lease acreage, nor do they possess the necessary capital or technological abilities, to foster such large scale activity. On the other hand, four entities --- Standard Oil Company of California (Chevron), Union Oil Company, Magma Power Company and Magma Energy, Inc., and Southern Pacific Land Company --- currently hold title to over 75 per cent of the total private lands under geothermal lease. These companies, each holding relatively large amounts of acreage under lease, are the ones who could, upon moving their activities into the Exploration and Production States, develop the resource in sufficiently large quantities to entice utility companies to commit the requisite financial and administrative resources necessary to production and distribution of electricity based on the resource.

This analysis, then, treats the major leaseholders along dimensions of size of holdings, location of leases, and current state of development of those leases. The companies considered are: Standard Oil Company of California (Chevron), Union Oil Company, Magma Power Company and Magma Energy, Inc., and Southern Pacific Land Company. It should be noted that these analyses are not in any way exhaustive treatments of the companies involved; rather, an effort has been made only to present the information relevant to understanding current lease holdings by these companies in the Imperial Valley and to relate such information generally to known activities of these companies in other areas and other activities. A listing of those major company holdings which have progressed to the Exploration State is contained in Appendix Three.

This discussion utilizes the graphic presentation contained in map plate #2, which is included in Section Five. Each of the four overlays is a photographic reproduction of a plot of the geothermal leases found in the public record for each of the four companies examined in this section. Map plate #2a contains the leases found for Standard Oil Company of California (Chevron); map plate #2b shows the holdings of the Union Oil Company; map plate #2c contains those leases held by Magma Energy, Inc. and Magma Power Company; and map plate #2 shows those leases held by the Southern Pacific Land Company and Atlantic Oil Company.

6.2a Standard Oil Company of California (Chevron)

Standard was the first of the large oil companies to acquire geothermal leases in the Imperial Valley, initiating activity in 1964. During that year, Standard secured approximately 62 per cent of its present total of 124 leases. Following that initial activity, Standard did not complete another lease agreement until 1969, at which time it negotiated rights for another 26 per cent of its total leases. The remaining 12 per cent of Standard's leases have been gathered fairly evenly over the years 1970-73.

Two points need to be stressed. First, there is a five-year gap between two bursts of lease acquisition activity on the part of Standard (1964-69). The reasons for this period of quiescence are not fully known, though some analysis was put forward in Sections 4.2 and 5.2. It is certainly plausible that Standard's lack of activity in the period 1964 to 1969 was based on the state of technological development during those years; that is, Standard's early acquisition of leases may have been halted due to the understanding that technical problems precluded early and rapid development of the resouce.

Second, Standard has not quitclaimed very many leases over the years, and its primary terms on leases are, on the average, longer than any other major oil company's. Standard has negotiated primary terms of 10 years on some 63 per cent of its leases, 20 years on almost 26 per cent, and has, as a mean primary term, a length of 12 years. At this writing, then, except for the few leases which have been quitclaimed, all leases with twenty-year terms remain effective, as do most ten-year leases, without the necessity of Standard engaging in those activities are alluded to in Section 3.1 for extending the life of leases.

From these two sets of facts, Standard's activities are consistent with the argument set out earlier, that the lull in lease acquisition rates between 1965 and 1969 reflect a pattern of delay based on market considerations rather than any failure to prove the resource or its future marketability.

Standard holds the rights to approximately 18,600 acres, with an average lease size of 150 acres. Its holdings are concentrated around the Heber anomaly, with a secondary concentration on the Brawley anomaly (see map plate 2a).

Its activities are primarily restricted to the Initiative State, but from information provided by the County of Imperial Planning Department, Standard has begun, through a subsidiary, Chevron Oil Corporation exploratory drilling procedures on two wells in the Heber area.

6.2b Union Oil Company

Union Oil recorded its first leases in its own name in 1969, during which year it acquired three of its current 136 leases in the Imperial Valley. Over the next three years, it transacted the remainder of its leases. The stipulation that Union's action in 1969 was the first in its own name is important due to the relationships of Union with Earth Energy, Inc. a

subsidiary of Union which is now dissolved. During 1963 and 1964 Earth Energy was quite active in acquiring lease rights for geothermal areas in the Imperial Valley. Prior to its dissolvement, a number of lease assignments involving Earth Energy were completed. Fleet Oil Company assigned numerous leases to Earth Energy which, in turn, assigned many of these leases, as well as those originally transacted by Earth Energy, to Union and to Magma. Certain other Earth Energy leases were quitclaimed. To the extent that these various transactions were placed in the public record, they have been noted in our data. There appear to have been, however, some Earth Energy leases that were not assigned to Union (or, at least, were not recorded) which were assumed by Union upon the dissolution of Earth Energy. Many of these leases, according to Joseph Wilson of Union Oil Company, were then assigned to other companies, particularly Magma Energy. While these transactions, whenever they were placed in the public record, were taken into account in our information gathering, the map plates show Earth Energy leases and Union leases as distinct entities. For purposes of analysis, Earth Energy leases should be considered, in the main, to belong to Union.

Forty per cent of Union's leases have a five-year primary term, 52 per cent a ten-year term, and a mean for all leases of 7.7 years. There is no specific explanation for these relatively short lease terms. It may be that Union, by acquiring its leases during the second period of development activity, expects production to begin within a relatively short time. Or, it may be that Union, by acquiring its leases during the second period of development activity, expects production to begin within a relatively short time. Or, it may be that Union's late entry into lease acquisition activity has forced the company to secure lands which are relatively marginal with regard to production

potential. While both quitclaiming and lease amendment procedures should minimize the effect of acquiring marginal land, it may be that Union did not wish to make full and extensive use of these procedures.

Union holds rights to approximately 28,620 acres (average lease size is 218 acres). This figure incorporates lands under lease originally to Earth Energy but which were later assigned to Union. Union's principal concentration is around the Heber anomaly, with a secondary concentration on the Brawley anomaly (see map plate 2b). Again, according to Joseph Wilson, Union transferred many of its leases in the Buttes area to other companies (presumably including Magma Energy) with the expectation that these other companies were in a better position to overcome the various technical problems associated with the high salinity content of the resource in that area.

Union's activity is wholly confined to the Initiative State except for two sites in the Buttes for which the company has obtained exploratory permits.

6.2c Magma Energy, Inc. and Magma Power Company

These two companies (considered in this analysis as a single entity and referred to as "Magma") are the only large leaseholders in the Imperial Valley whose principal, perhaps sole, corporate focus is on geothermal resource development. Magma is experienced in this activity due to its efforts to help develop The Geysers in the early 1960's.

Magma was the first large leaseholder to begin acquiring leases, with transactions dating from at least 1958. Currently having rights to some 60 leaseholdings, Magma acquired 38 per cent of these leases from 1958-1970. In 1971, however, Magma acquired 47 per cent of its leases. Some of Magma's activities in the early and mid-1960's consisted of co-leasing with Earth Energy. Upon Earth's demise, many of these co-leases were quitclaimed, with the remainder reverting to Magma alone.

It is the case for Magma, as it was for Standard, that leasing activity shows two distinct periods, with minimal lease acquisition during the period 1964 to 1969.

Sixty-six per cent of Magma's leases have primary terms of five years or less, with a mean term period for all leases of 6.8 years, by far the shortest mean primary term length of any of the major leaseholders. This is particularly significant when one realizes that Magma is the one entity which is into the Exploration State in a large way, having some 22 wells requiring exploratory permits. These wells are located on the following anomalies: Salton Sea, thirteen; Heber, five; and Brawley, three.

As seen in map plate 2c, Magma has spread its leases throughout the Imperial Valley anomalies, not concentrating its holdings on one or two specific areas as other companies have. This dispersion of leases, the short primary terms of leases, the number of exploratory wells, and the average size of its holdings --- about 391 acres per lease, considerably larger than any other principal company, and totaling approximately 20,800 acres --- gives credence to the general feeling that Magma is the most likely to move geothermal resource development into the Production State. Magma seems to acquire widely dispersed lands, secures relatively short primary terms, and then moves rapidly to test the potential of the site. If it proves viable, the lease term can be extended through amendment. If it proves unfeasible, then the lease can be quitclaimed or allowed to expire without involving the commitment of large sums of capital on the part of Magma.

6.2d Southern Pacific Land Company

The lease activity of Southern Pacific Land Company (SPLC) offers the most difficult situation to analyze, a situation resulting from SPLC's numerous agreements with other companies regarding both the acquisition and development of geothermal resources. Further, SPLC owns considerable property in the Imperial Valley, some of it directly, other indirectly through such entities as Southern Pacific Transportation Company.

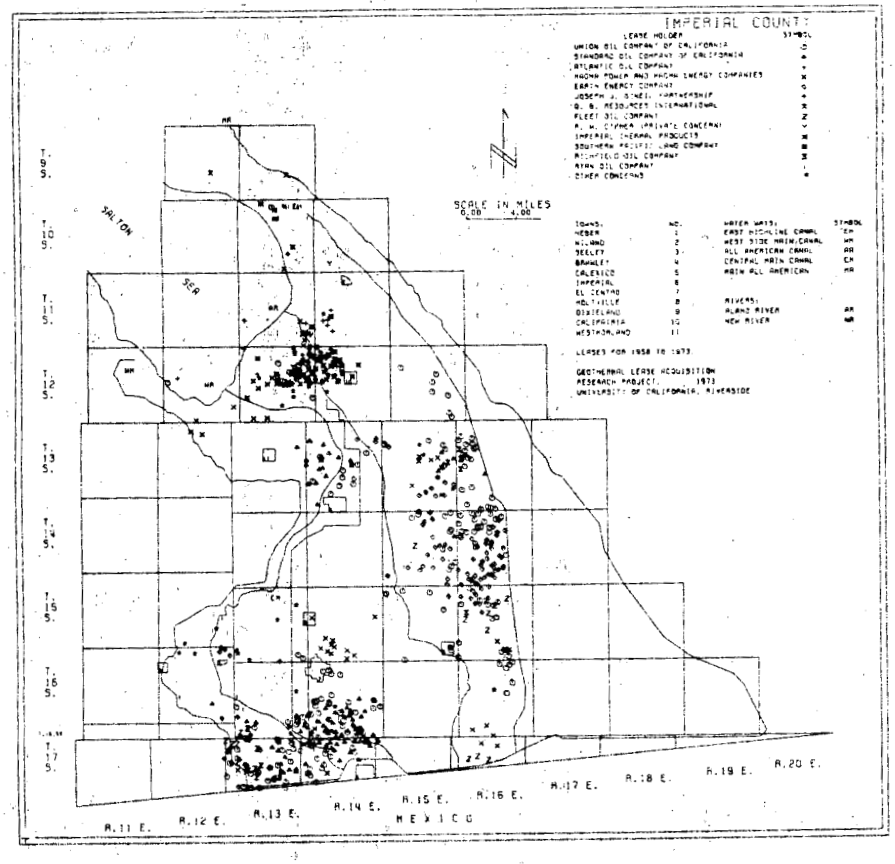
The relationship of SPLC with other companies first came to attention in this study with the finding that many leases held initially by Atlantic Oil Company had been assigned to SPLC. Atlantic has been involved in lease acquisition in the Waterfowl Management Area, through actions taken with the State Lands Commission, holding approximately 3900 acres under geothermal lease and having another 960 acres under application. According to an Atlantic Oil Company executive, an agreement had been reached between Atlantic and SPLC whereby Atlantic would obtain geothermal leases for SPLC since the latter wished to retain a low profile in initial lease acquisition. In a subsequent telephone interview, Carl McCulloch of SPLC indicated that his company was also in the process of obtaining leases then held by Imperial Thermal Products, Inc. The latter's holdings lie primarily in the Salton Sea area, including some 500 acres in the Wister Waterfowl Management Area.

This interview also yielded the information that SPLC currently holds geothermal lease rights on approximately 37,000 acres. This makes SPLC's holdings the largest of any company active in the Imperial Valley. Lands owned by SPLC were not considered to have geothermal potential. Those lands under lease are actually co-leased, with SPLC, Southern California Edison Company, and Phillips Petroleum each having a one-third interest. McCulloch

stated that the three companies felt that by acting with other companies to obtain lands, the resources and expertise of each company could be combined in ways which might promote more rapid development of the resource.

While the situation with SPLC is somewhat unclear, certain facts do stand out. Leases initially obtained by Atlantic and later assigned to SPLC were garnered mostly during 1971, during which year Atlantic obtained 91 per cent of its leases. These leases have a mean primary term of 11 years. Part of the difficulty with addressing SPLC's activities more specifically results from that company's methods of filing transactions in the public record. Either it does not record all activities, or it does so in ways so uncharacteristic that such activities were not uncovered by the researchers. Certainly our data, even allowing for complete transfer of all Atlantic and Imperial Thermal Product leases, does not show 37,000 acres held by SPLC. Two points of particular note can be recognized, however. First, the majority of leases known to be held by SPLC concentrate around the Salton Sea area (see map plate 2d). Second, while the company's actions remain principally within the Initiative State (Phillips Petroleum has drilled three wells for which exploratory permits were required), SPLC is the only company which remains actively involved in the securing of additional leases and geothermal lands.

SECTION SEVEN
FINDINGS AND CONCLUSIONS



7.1 Findings

This study has considered geothermal development in the Imperial Valley in terms of the developmental steps that any corporate speculator must take prior to and during the search for and production of geothermal steam as a source of electricity. From this analysis the following facts have obtained.

First, considered in these terms, there has been substantial development activity in the Imperial Valley during the years under study, 1958-1973. A number of large corporations including Union Oil, Standard Oil of California, and Southern Pacific Land Corporation, are involved in leasing over 140,000 acres of private land. Moreover, the leased lands are advantageously distributed among the known geothermal anomalies in the area.

Second, it is apparent that the rate of passage from one state or stage to another within the system of development for any lease is extremely slow. Moreover, the proportion of leases that have passed beyond the Initiative State is, at most, eight per cent of all leases filed.

Third, while four corporate entities hold over 70 per cent of private lands under lease, the actual developmental activity --- exploration and production drilling --- is undertaken normally by just one of those entities --- Magma Power and Magma Energy. That company, though it is the smallest of the four in terms of financial resources, accounts for approximately 80 per cent of the actual developmental activity over the period in question.

Fourth, two distinct periods of leasing activity have occurred: the one between 1963 and 1965, the other from 1969 through 1973. Further, the second development period appears to be coming to an end. There was a steady decline in the number of leases negotiated per month since mid-1972, and this was accompanied by a drop in the number of exploration permits taken out in later months.

7.2 Conclusions

Experience tells us that there are basically three questions asked by interested citizens and policy-makers concerning the geothermal development in the Imperial Valley. First, what is the status of the development or, how far along is it? Second, why is the situation thus described the way it is or, what is causing the development to be in its current condition? And finally, what, if anything, might be done to further hasten or retard the growth of the development in the future. We think that the findings of this study shed new light on the above three questions. In presenting our answers to the above questions we will also consider the answers that are suggested by other perspectives, arguing that their conclusions are at least partially invalidated by our research.

7.2a Present State of Geothermal Development in the Imperial Valley

Many estimates and conclusions about the present state of development focus directly on current and planned production sites for electricity based on the geothermal resource. From such a perspective, of course, development appears virtually nil at present, with only modest expectation that it will become substantial in the next several years. There are no production stations in operation in the Imperial Valley and, at the time of this writing, none are planned for the next five years. A test well is being worked by Magma, in partnership with Standard Oil of California and San Diego Gas and Electric. Yet even here one has cause for pessimism, since there is no apparent discussion of extending this test well to include a test network or of future tests should this one fail. From this perspective, then, one would argue that no development is occurring and that, instead, the Imperial Valley situation is

best characterized as speculative leasing and testing.

The findings of this paper, based on a different perspective, counter this argument. Considering development in terms of the basic financial and legal activities which must undergird, must preceed, production work, a different argument emerges; that is, prior to reaching conclusions about the likelihood of development and its current state, one must consider the necessary leasing of lands and building of corporate competitive postures in the energy market. Certain facts need to be recalled. First, over 80 per cent of private lands located in Known Geothermal Resource Areas is currently under geothermal lease. The majority of that land is held by several large energy and transportation corporations. Other lands --- the amount of which we do not know --- are owned outright by some of these corporate entities. Second, the leases require payment of rent in lieu of royalties when the lessees do not place the leased lands under development. Despite this cost, many leases have been maintained for 10 years and more as of this writing. Third, the large corporations typically do not involve themselves with development activities beyond the securing of leased lands, with their minimal developmental work normally done in coordination with Magma.

These facts, and this perspective, suggest that something far more complex than speculative activity characterizes the situation in the Imperial Valley. It appears that several corporate entities have secured the necessary competitive positions and are waiting only for other events to hasten development. Precisely what those events are is, of course, the crucial question, and we will address it in the following sub-section. For the moment, it is important to realize that several corporations have established competitive market positions: the resource has been extensively mapped, choice sites

have been negotiated, and leasing has been on a large scale. The remaining action, the construction of resource extraction and generation sites, is the only activity left before full production is a reality. Why, then, given these other factors has that final action not been forthcoming?

7.2b Impediments to Development

Two general types of arguments are current for explaining the absence of development. First, people contend that technological problems associated with extraction and electrical generation preclude development at this time. Second, others argue that the energy market damps the impulse of developers. There are, of course, many variants to these explanations, but the above are, we believe, fair statements of the crux of each argument.

On the surface, either of these arguments, or some combination of them, does seem to explain nicely the situation in the Imperial Valley. But let us consider each more closely, taking the technological statement first. There is a certain circularity, as well as an ignoring of contradicting facts, to the notion that technological problems preclude development. This is not to suggest that technical considerations and difficulties do not need to be solved; rather, we contend that the absence of technological solutions can not adequately explain the lack of development in the Imperial Valley. Technological problems can be categorized in two classes: those for which scientific theories do not exist which would allow resolution of the problem, and those for which it is the lack of application of theory, not the absence of theory itself, which leaves such problems unresolved. If one were to propose the building of an instrument to propel an object faster than the speed of light, one would need first to develop a theory which would account for such speed and then seek application according to that newly formulated theory. In the case of geothermal

resource extraction and production, however, many facts argue that adequate theory exists for the solution of technical problems. There is first the situation that many geothermal production plants exist around the world, not the least important of which is that at Cerro Prieto. One may contend that the resource at the Mexican site is drier and less brine-ridden. But how much drier? How much less brine-laden? And, more importantly, to what extent is the technology employed at that site not applicable to the Imperial Valley conditions? There is a certain tautological nature to the technological argument. Scientific theories exist which could provide the basis for technical solutions. These solutions will require testing, however, at sites in the Imperial Valley to properly prove technology. Yet, to contend that one cannot begin testing until technical solutions exist is to bring one back to the beginning of the circle: no solutions without testing and no testing without solutions.

One can argue likewise regarding the market explanation. No corporation is likely to invest large amounts of capital for production and energy generation in the absence of assured abilities to transmit and market the resource. Such obstacles for other energy resources have historically been solved by changing the product such that a market does exist. But, we are told, that process does not apply to geothermal resources because the necessary technology is lacking. The market argument is, then, an applied version of the technology argument.

Our findings suggest a different analysis of the present conditions of development and a somewhat altered notion of those factors contributory to that situation. Recall that we found that the development had not been stable over time. During the periods 1963-64 and 1969-73 the development moved much

faster than it had during other periods. The peak in the second developmental period, 1971, was also associated with increases in all states in the development. To begin to isolate the factors that are currently holding down development, we will first isolate the factors that might be associated with these fluctuations.

Our basic question in this regard is what events led to corporate investment in the research and development of the geothermal resource in 1963, then to minimal capital commitments in years 1965-1969, and finally to a reallocation of funds beginning in 1969. Was it a burst of technology, the presence of a market, an increase in the availability of the resource? In fact it was none of these. As we shall see both of these developmental periods have as their basis the profit potential or lack thereof of the geothermal resource.

We see that the 1963-64 development was marked by the appearance of three new corporate interests and the discovery of new geothermal territory. We might be tempted, therefore, to argue that increased availability of the resource resulted in the development. Such an argument ignores one major fact: the new geothermal territory (Brawley and Heber anomalies) was discovered in the latter part of 1963 --- in the middle of the developmental period --- by a relative latecomer to the development. Thus, while the discovery of the new areas could not have hurt the development, they certainly did not start it. But why else would the 1963-64 development have occurred? More importantly, why did it stop? The standard answers are, again, either that a lack of technology or an absence of markets foreclosed development. But, we know that the availability of market did not change prior to the 1963 development, nor do we know of any windfall technological advances. There was, however, something that we as researchers made note of at the time but did not systematically

study in our data gathering. In the 1963-64 period there were a number of leases found in the Hall of Records of Imperial County which were accompanied by Oil and Gas leases. It is possible, therefore, that developers systematically and routinely secured the rights to both resources at the time that the documents were initiated. This suggests the possibility that the geothermal development of 1963-64 was a minor and secondary activity on the part of developers, an adjunct to the dominant interests in oil and gas. It is impossible to tell which resource was the central focus of attention during the development, but common sense suggests that it was probably oil. If that is true, then developers really had no intention of developing the geothermal resource at that time. They did have the intention of developing it at some future date, we will argue, because they did not on the whole allow the leases to expire or cause them to be quitclaimed. Why did the development stop? If one assumes that the 1963-64 geothermal activity was secondary to developers' interests in oil and gas, then the cessation of geothermal activity following 1964 most likely resulted from one of two factors. First, developers may have found insufficient oil or gas deposits, thus making further activity in the Imperial Valley senseless. Second, developers may have determined that other areas, including off-shore oil drilling, to offer greater potential. In that case, whether oil or gas deposits existed in the Imperial Valley or not, corporations would cease activities if other areas offered greater potential.

Does a similar explanation obtain for the second period of development, that which began in 1969? We do not think so. First, relatively fewer oil and gas leases can be found for the second development period. Second, a set of events occurred very closely in time to the development which might very well have made geothermal seem more profitable to developers.

There are basically three interrelated phenomena which seem to have

contributed to this situation. First, in 1968 the Department of Interior, in conjunction with the University of California, began a study of the geothermal potential of the federal land within the Imperial Valley. This no doubt improved the general visibility of the resource at the time. More than that, however, it was research that ultimately might lower the cost of producing the resource by improving the basic technology. Second, in January, 1969, Union Oil's platform A located in the Santa Barbara Channel had an accidental oil spill, a spill of greater magnitude than had ever been experienced in the United States. Third, by February, all new drilling and exploration off the coast of California had been banned, many thought permanently.

It is coincidence perhaps that the geothermal development in the Imperial Valley started anew in the fourth month of 1969, exactly two months after the incident off the Santa Barbara coast occurred. If it is coincidence, then it must also be coincidence that geothermal development began to decline rather markedly just prior to the announcement by the State Lands Commission that it would hold hearings to re-examine the desirability of offshore drilling.

There are several reasons why off-shore drilling and geothermal development should be related, reasons which minimize the "coincidence" notion outlined above. First, both energy sources constitute profit alternatives to large energy corporations. Second, they both require research and development funds in the form of exploration for the resource and in developing the technology to extract it. Energy corporations have a limited amount of capital for research and development. If we take these three facts together it makes good sense that the geothermal development and the development of off-shore oil should be related. We should also note other facts: 1) off-shore oil is known to be much more profitable than geothermal steam, 2) off-shore oil suddenly became unavailable two months before the second geothermal development in the Imperial Valley

started, and 3) the geothermal development began to decline just prior to the re-opening of offshore drilling. All these factors combine to provide a logical explanation for the form of the geothermal development in the Imperial Valley.

Remember that there were no real changes in the technology, or the availability of the resource, or the market in 1969 --- at least none that we have discovered. The development was not, therefore, triggered by technology or markets or resource availability. Our explanation argues that the development was triggered by historical factors related to the whole of the energy industry.

Development, then, resulted from various historical events. But, as stated repeatedly, development has not progressed, to any appreciable degree, into exploratory or productive phases. The reason for this is tied closely to the problem of profit potential. We found that the largest concerns involved in the geothermal development held close to 70 per cent of all the leased territory and that, as a rule, they did not undertake development beyond that point. This is clear indication that they are waiting for something to happen. But what?

The clear answer to the above question is that they are waiting for someone to improve the present profit conditions, one element of which is technological advances. Geothermal development is, under the best of situations, a marginal profit maker.* Any investment in improving the present technology can only subtract from that overall possible margin of profit. So they must wait. When we argue that the cost of improving technology is a principal drawback, we are describing a situation in which cost is prohibitive due to the small

*Four to five per cent, according to Ben Nakayama, University of California, Riverside.

profit margins. Where major concerns can turn their money around at a higher rate in other areas and in other energy sources, they are losing money if they focus on resources.

We are arguing, then, that the larger concerns are doing the minimum amount of developmental work necessary to produce a workable competitive posture should the geothermal resource become more profitable than it presently is. The major burden of research and technological improvement is being carried by the smaller specialty companies whose major corporate interest is the geothermal resource.

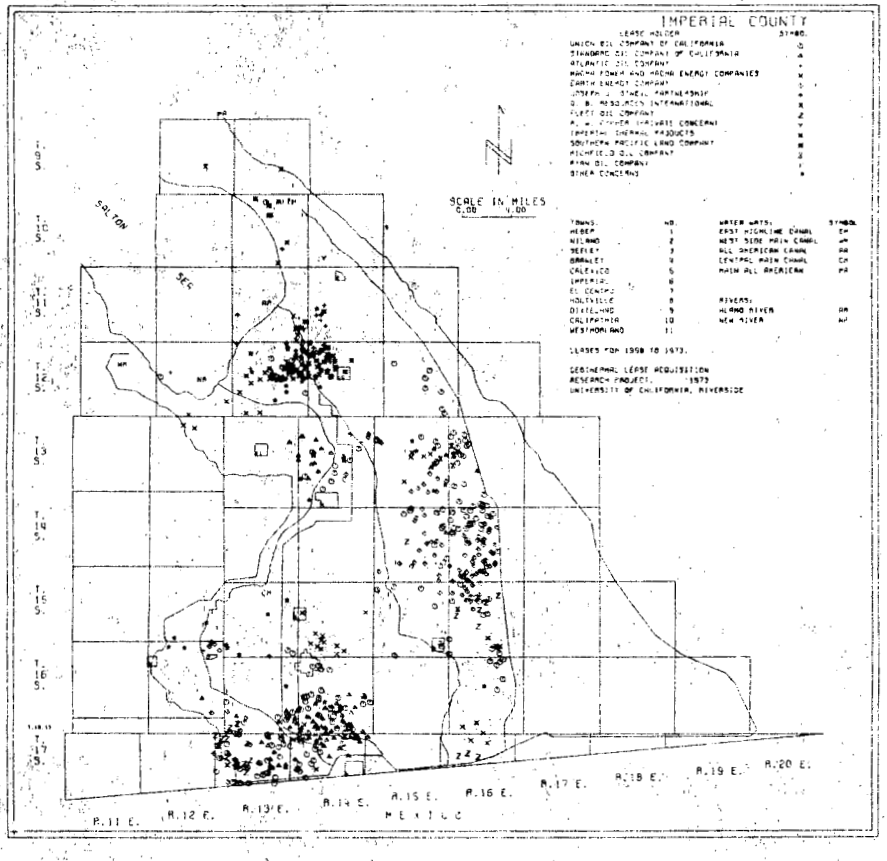
7.2c The Future Assuming the Continuation of the Present State of Affairs

If the present state of affairs continues we can expect very little in the way of geothermal development beyond the leasing state until these specialty companies solve the problems that will decrease the present costs involved in producing electricity with generators turned by geothermal steam. Notice that we did not say that small companies must make geothermal steam profitable. It already is profitable; it is simply not profitable enough.

How fast these companies move will, we think, be a direct function of how much capital they have. The more they can invest in exploration drilling and pilot electrical generation sites, the closer we will be to full scale geothermal development in the Imperial Valley. The less they invest in such endeavors the closer we move to complete corporate stalemate and ultimate decline of the development. It is at present impossible to tell how far away such technology might be.

ADDENDUM

FEDERAL LAND LEASE SALES:
ANALYSIS IN TERMS OF LEASE ACQUISITION PATTERNS



A.1 Federal Land Lease Sales

A predominant theme of company executives heard throughout the course of this study has been that federal lands would have to be opened in the Imperial Valley before geothermal development could go forward. The large oil company geothermal interests were particularly vehement on this point. On first appraisal, the contention appears to have some validity, but when the realities of the situation were examined, this contention appears less tenable.

According to Bureau of Land Management figures, within the six KGRA's in the Imperial Valley, there are 247,595 acres of land. Only 31 per cent of this land is federally owned (78,173 acres) while 69 per cent is privately owned (169,422 acres). Of this privately owned land within the KGRA's, 84 per cent (142,688 acres) is currently under geothermal lease. Approximately 75 per cent (107,016 acres) of all leased private lands are controlled by the four major developing companies: Standard Oil Company of California, Union Oil Company, Magma, and Southern Pacific Land Company. This amounts to their controlling 63 per cent of all available privately-owned land within the KGRA's. With 84 per cent of KGRA private land under lease, undoubtedly the properties with the best geothermal potential within the KGRA's have been taken. This may well account for the seeming decline in leasing activity during the last year (with the exception of SPLC and, to some degree, Magma). Rather, the major activity seems to be trading leases through assignments to consolidate lease blocs or potential geothermal fields. It is precisely this point, that geothermal energy must be developed in fields, not unlike oil fields, that makes the need for federal leases prior to development questionable.

Federal lands within the Imperial Valley lie east of the Highline Canal. As can be seen from the maps, most of the anomalies and, hence, the geothermally

leased fields are not contiguous with federal lands that could be leased. In the majority of cases, then, fields on federal land and fields on private lands would have to be developed independently of each other, since the resource cannot be piped long distances as can oil, with their own generation facilities and to a lesser degree their own transmission facilities. If, as some companies contend, the federal land has much greater geothermal potential, why then do these same companies continue to hold their leases on private lands and in some cases continue to acquire them?

Whether this stated need for federal lands in the Imperial Valley prior to any geothermal development was real or whether it was a tactic for procrastination can be seen in light of the patterns of bidding on leases of federal lands for geothermal development.

On January 22, 1974, the Bureau of Land Management held at auction the sale of leases of federal lands for geothermal exploration and development. We need not consider the legal aspects of these leases in great detail, but certain points do require discussion.

Generally, a lease of federal lands is more stringent in its terms than a lease of private lands (see Section Three). The federal government, has by law set the terms of the leasing arrangement; there is no process of negotiation. Leases are sold at auction to the highest bidder with the government reserving the right to reject an inadequate bid.[1]

We have observed in the main body of this paper that the majority of firms involved in the Imperial Valley geothermal development are either small speculators or large firms waiting for the profit conditions of geothermal production to become more favorable.* We have also observed that the leasing of federal lands is not a process controlled by the firms, but rather by the

*Magma Power being the only observable exception. See Section Seven.

federal government. Given these findings we might expect the behavior of the firms involved in the leasing of federal lands to be even more conservative than in the private lands development.

An example will help illustrate. Firms in the Imperial Valley have at once minimized their risks and maximized their future profit potential through use of infinite extension provisions of their leasing documents (see Section Three). In the leasing of federal lands, any firm wishing involvement enters the "game" with the rules predetermined. The rules are not detrimental to the interests of the firm, but they do differ from those obtaining for private lands. Unlike private lands in the Imperial Valley, there is no provision that allows for an indefinite period of time between the acquisition of a tract of federal land and the exploration of that land for resources and production of those resources.

Thus, by specifications set by the lessor --- the federal government --- instead of the lessee --- the firms --- the firm is placed in a position of greater risk, since it has only a set period of time to explore and develop the land it has leased, regardless of the cost of exploration or the marketability of the resource produced.

The general question to ask is: Does the pattern of the leasing of federal lands shed any light on the validity of the conclusions reached in the main project?

While we would expect the firms to behave more cautiously in the leasing of federal geothermal lands, the basic objective, development of the resource at a profit, would not change. By examining in detail the behavior of the firms involved in the bidding for federal KGRA lands, focusing primarily on amounts bid and locations of lands bid for, we may be able to confirm some of our conclusions made in the main paper.

Bids were taken on 33 tracts of land in four areas of the State of California. Twelve tracts in The Geysers area,* three tracts in the Crowley Lake area, four tracts in the Mono Lake area, and finally, 14 tracts in the East Mesa area of Imperial County, due east of the area we have been studying in this project.

If we begin by looking only at what lands were bid upon, we begin to see the pattern we predicted. Bids were submitted for all 12 tracts available in The Geysers area. Similarly, each of the three Crowley Lake tracts were covered by bids. No bids were received for the Mono Lake units and, of fourteen units in the East Mesa, only five were bid upon. Obviously, the main area of interest is in The Geysers and Crowley Lake KGRA's. An examination of the amounts bid on the various units within each of these KGRA's shows the great concentration of interest in The Geysers area.

Let us examine the bidding on the 12 units in The Geysers KGRA. There were 42 bids on those tracts; no bid was uncontested. A total of $10,716,631.46 was bid on this land by 15 firms and individuals (only four individuals submitted bids). Table A-1 shows the bidding, acres and number of bids on The Geysers land.

An examination of the winning bids shows just how much capital the companies involved were willing to devote to lease purchases. Table A-2 gives this data.

Shell Oil Company was willing to spend $1,367.52 per acre of land in The Geysers area. Recall that Shell Oil Company has not a single lease on private lands in the Imperial Valley, at least none in the public record. In fact, of the 11 firms involved in bidding for leases of federal land in

*The site of the only commercial geothermal development in the United States that is currently productive.

TABLE A-1 --- GEYSERS KGRA BIDDING

UNIT	TOTAL BID	ACRES	# BIDS	AVERAGE BID	AVERAGE BID/ACRE
1	$ 5,865,436.20	2,340	7	837,919.46	358.09
2	3,162,094.05	1,534	6	527,015.68	343.56
3	42,957.00	175	4	10,739.25	61.37
4	79,435.49	101	3	26,478.50	262.16
5	91,424.47	169	3	30,474.82	180.32
6	14,739.99	2,396	3	4,913.33	2.05
7	498,408.68	626	2	249,204.34	398.09
8	132,645.00	250	2	66,322.50	265.29
9	325,001.60	160	3	108,333.87	677.09
10	400,856.52	222	4	100,214.13	451.42
11	27,638.10	45	2	13,819.05	307.09
12	75,994.36	737	3	25,331.45	34.37
TOTALS	$10,716,631.46	8,755	42	255,157.89*	349.73**

*The following formula was used in this calculation:

$$\text{Average bid} = \frac{\text{Total amount bid on unit(s)}}{\text{Total number of bids on unit(s)}}$$

**The following formula was used in this calculation:

$$\text{Average bid per acre} = \frac{\text{Average bid}}{\left(\frac{\text{Total acreage in unit(s)}}{\text{Number of units}}\right)}$$

TABLE A-2 --- GEYSERS KGRA WINNING BIDS

UNIT	COMPANY	ACRES	BID	BID/ACRE
1	Shell	2,340	$3,200,000.00	$1,367.52
2	Shell	1,534	1,300,000.00	847.46
3	Thermogenics	175	22,050.00	126.00
4	Union	101	48,314.36	478.36
5	Union	169	80,842.84	478.36
6	Union	2,396	12,243.86	5.11
7	Union	626	318,120.68	508.18
8	Signal	250	75,600.00	302.40
9	Occidental	160	163,360.00	1,021.00
10	Occidental	220	226,662.00	1,021.00
11	Union	45	22,868.10	508.18
12	Signal	735	56,666.00	76.89

The Geysers area, only one, Union Oil, has been involved in the leasing of private lands in Imperial County for geothermal development.

Since no bids were submitted for the 8,320 acres available for lease in the Mono Lake area, we need examine only the Crowley Lake and East Mesa regions.

In Crowley Lake, three units were open for bidding. Tables A-3 and A-4 give the appropriate information for Crowley Lake bids.

In the East Mesa only five bids were placed for the 14 tracts of land available for lease. Each bid was on a different tract, hence, each bid was uncontested. Furthermore, only two firms were involved: Republic Geothermal and Magma Power Company. Table A-5 shows this.

Comparison of information regarding all areas open for bid shows that the firms involved were excessively interested in the land of The Geysers KGRA, with only small companies interested in other areas.

Table A-6 gives a picture of the distribution of bidding activity through the four areas.

Seventy-four per cent of the bids received by the Bureau of Land Management were for lands in The Geysers KGRA. A total of $12,499,494.60 was bid for geothermal leases in the entire state. A total of $10,716,631.46 (86 per cent) was bid for land in The Geysers KGRA, $1,129,729.32 (9 per cent) was bid for land in the Crowley Lake KGRA, and just $653,133.82 (5 per cent) in the East Mesa KGRA. If we rank order all units available for bid by the total average bid per acre made on each we get the results listed in Table A-7.

Nine of the ten highest valued properties, as determined by the bidding behavior of the firms, are in The Geysers area. Nine of ten of the highest single bids per acre were on lands in The Geysers. By all accounts, primary interest was in The Geysers area. Minimal interest was shown in East Mesa.

TABLE A-3 --- CROWLEY KGRA BIDDING

UNIT	TOTAL BIDS	ACRES	#BIDS	AVERAGE BID	AVERAGE BID/ACRE
1	$ 27,539.36	1,815.08	2	$ 13,769.68	7.59
2	133,145.63	1,895.21	3	44,381.88	23.42
3	969,044.33	1,772.70	5	193,808.87	109.33
TOTALS	$1,129,729.32	5,482.99	10	$112,972.94	61.82

TABLE A-4 --- CROWLEY KGRA WINNING BIDS

UNIT	COMPANY	ACRE	BID	BID/ACRE
1	Chevron	1,815.08	18,459.36	10.17
2	Getty Oil/	1,895.21	98,592.00	52.02
3	Mono Power Republic	1,772.70	515,767.07	290.95

TABLE A-5 --- EAST MESA KGRA BIDDING

UNIT	COMPANY	ACRE	BID	BID/ACRE
3	Magma	1,867.60	$ 4,203.00	2.25
8	Magma	1,437.12	3,235.50	2.25
9	Republic	2,549.09	432,810.01	169.79
11	Republic	1,596.19	208,925.31	130.89
12	Magma	1,760.00	3,960.00	2.25
TOTALS		9,210.00	653,133.82	70.92

Average bid/unit = $130,626.77

TABLE A-6

BIDDING BY KNOWN GEOTHERMAL RESOURCE AREA

COMPANY	NUMBER OF BIDS IN:				TOTAL COMPANY BIDS
	GEYSERS	CROWLEY LAKE	MONO LAKE	EAST MESA	
California Geothermal	2				2
Cecil Folmar	1				1
Chevron Corporation	1	3			4
Dow Chemical Company	1				1
Edward Towne	3				3
Geothermal Resource International	1	3			4
Getty Oil-Mono Power		2			2
Magma Power Company				3	3
Michael Belzer	1				1
Natomas Company	1				1
Northern California Power Agency	2				2
Occidental Petroleum Corp.	2				2
Republic Geothermal		1		2	3
Ronald Shoen	1				1
Signal Oil Company	8				8
Shell Oil Company	2				2
Thermogenics	4				4
Union Oil Company	12	1			13
TOTALS	42	10	0	5	57
% TOTAL NUMBER OF BIDS	73.7%	17.5%	0%	8.8%	100.00%

TABLE A-7

AVERAGE BID PER ACRE IN RANK ORDER

KGRA/UNIT	AVERAGE BID/UNIT
Geysers #9	677.09
Geysers #10	451.45
Geysers #7	398.09
Geysers #1	358.09
Geysers #2	343.56
Geysers #11	307.09
Geysers #8	265.29
Geysers #4	262.16
Geysers #5	180.32
East Mesa #9	169.79
East Mesa #11	130.89
Crowley Lake #3	109.33
Geysers #3	61.37
Geysers #12	34.37
Crowley Lake #2	23.42
Crowley Lake #1	7.59
East Mesa #3	2.25
East Mesa #8	2.25
East Mesa #12	2.25
Geysers #6	2.05

What accounts for this pattern of behavior? A well-known student of the subject has made the argument that organizations will seek, through a variety of methods, to reduce uncertainty.[2] In the face of uncertainty, the outcome of any action or policy is less predictable. Hence, the greater certainty of environment, technologies, etc., the greater the predictability of the outcome.

In The Geysers, there exists a proven source of geothermal energy; one that can be readily retrieved and for which there is a ready market. Uncertainty over the nature of the resource is less, and therefore the hesitation of firms interested in geothermal development in entering The Geysers area is less.

The certainty of resource productivity and of resource marketability does not exist in the Imperial Valley.[3] When a firm interested in entering into geothermal resource development sees this state of affairs, it will, lacking the ability or inclincation to make an independent assessment of the potential production, restrict its acquisitions to areas of proven potential and market. In The Geysers there exists an electrical generating corporation ---Pacific Gas and Electric, Inc. --- that is currently purchasing geothermal steam from Union Oil in several drilling and electrical generation operations. Presumably, since PG&E plans expansion of its facilities in The Geysers area, a market exists for any geothermal steam generated in the area.

In the Imperial Valley, no ready customer exists. Indeed, with the exception of the tentative activities of San Diego Gas and Electric Company with Magma Energy in experimentation with the Magmamax heat transfer process, no large electrical utility company has expressed interest in geothermal

energy in the Imperial Valley. Southern California Edison's plans for a desert-sited nuclear power plant continue. Indeed, Edison's projected power generation plans for the next 15 years include no geothermal facilities.[4]

We can conclude, therefore, that our prediction of relative inactivity in further development activity in the Imperial Valley, unless some firm assumes the risks involved and "proves" the resource, have been supported by our analysis of the federal land lease sales of January 22, 1974. And, given the pressure that was at one time placed on the Department of Interior to release these lands for leasing, it seems safe to say that most of the firms which have involved themselves in The Geysers have little interest in the Imperial Valley.

A.2 References

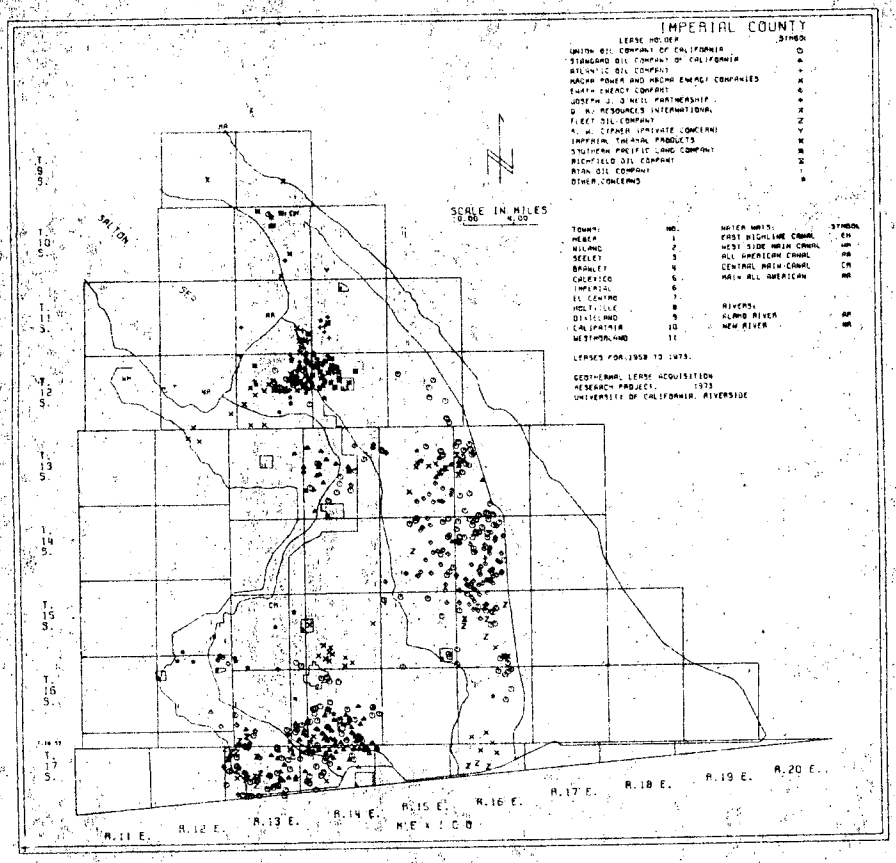
1. 43 CRF 3200 et seq. and 30 USC 1001(e) for regulations and federal statutes concerning federal lands and geothermal energy.

2. Thompson, James, Organizations in Action, New York, McGraw-Hill, 1967.

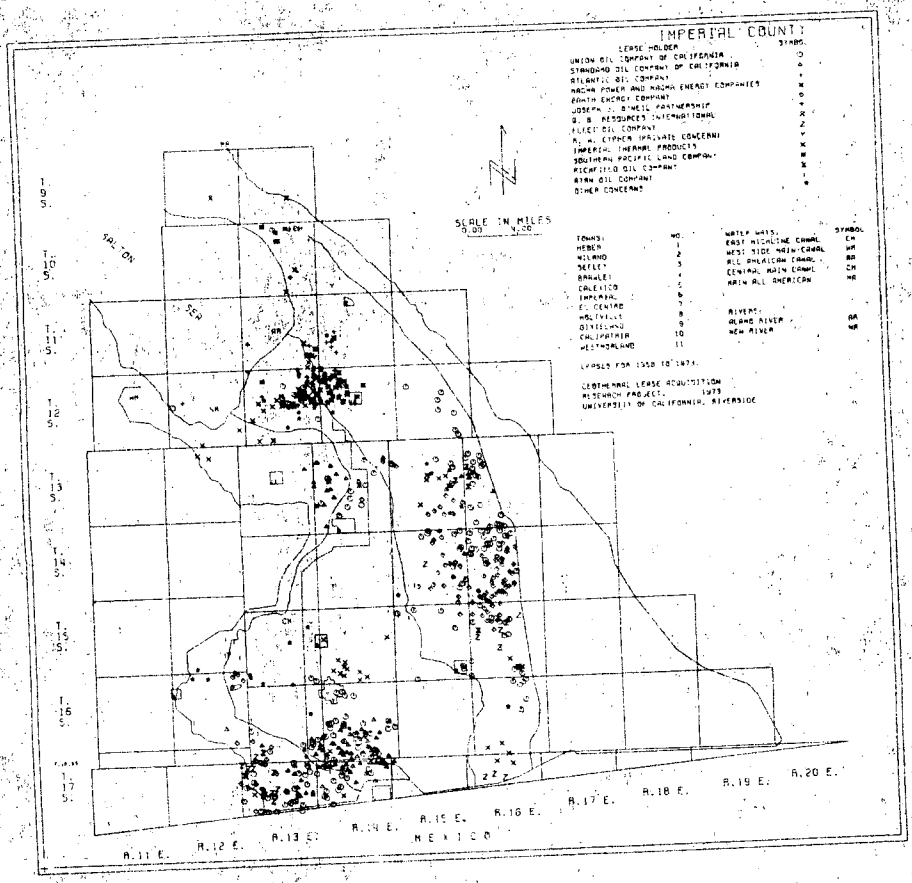
3. Testimony before United States Senate Committee on Interior and Insular Affairs, Hearings on Senate Resolution 45, 92nd Congress, 2nd Session, Government Printing Office, Washington, D.C., 1972, pp. 17-18, 21, 36, 42, 43, 82, 84 et seq., 190. See also: University of Alaska, Assessment of Geothermal Energy Resources (Hickle Report), Department of the Interior, 1972, p. 7.

4. Interview with Mr. Thomas Speers of Southern California Edison, September 12, 1973.

APPENDICES


IMPERIAL COUNTY
LEASE HOLDER
SMITH OIL COMPANY OF CALIFORNIA
STANDARD OIL COMPANY OF CALIFORNIA
ATLANTIC OIL COMPANY
MAGMA POWER AND MAGMA ENERGY COMPANIES
EARTH ENERGY COMPANY
JOSEPH J. O'NEIL PARTNERSHIP
G. A. RESOURCES INTERNATIONAL
FLEET OIL COMPANY
K. W. CIPHER (PRIVATE CONCERN)
IMPERIAL THERMAL PRODUCTS
SOUTHERN PACIFIC LAND COMPANY
RICHFIELD OIL COMPANY
RIAN OIL COMPANY
OTHER CONCERNS
SCALE IN MILES
0.00 4.00
SALTON SEA
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
T. 15 S.
T. 16 S.
T. 17 S.
R. 11 E.
R. 12 E.
R. 13 E.
R. 14 E.
R. 15 E.
R. 16 E.
R. 17 E.
R. 18 E.
R. 19 E.
R. 20 E.
MEXICO

APPENDIX ONE
RESEARCH METHODOLOGY



The Measures

The measures used in this study are extremely useful indicators of the extent to which resource development has reached certain stages. But, they are not without their problems. The following paragraphs are addressed to these problems, and the ways in which they may or may not affect the outcomes and conclusions of this analysis. We begin by discussing the methodological issues involved in their use. We then follow with the methods that were used to control the problem where possible.

The first and most serious problem that vitiates the validity of archival analysis is that of selective deposit. This occurs when archival data are selectively deposited in the storage medium. The storage medium in this case is the public record of the County of Imperial, California. The problem of selective deposit occurs for that part of the data which deals with the leasing of private property for geothermal development because companies may or may not exercise the option of entering a newly consummated agreement in the public record. Recording is not required by law, and we, therefore, cannot assume that all such agreements are in the public record. Lease filing, however, has been recognized as a reasonable and common business practice where the ownership of large amounts of money or property might be contested in a civil action. In short, there is a great deal in the way of impetus for companies to engage in the practice.

An examination of the documents on file for references to leases that could not be located in the record indicated that only one company did not routinely file its leases in the record of the County of Imperial. It is not known at present whether Magma Energy routinely files its leases in the State of Nevada --- its state of incorporation --- or whether it does not file its leases in any record.

While this may affect the reliability of our data, knowledge that one company does not routinely record its leases in the Imperial County public record is useful in that sense that we can now, at least, be certain of the answers to several critical questions. We know, for instance, that all of our estimates of the land amounts and locations involved in the development are downbiased by the per cent of leases not filed by the Magma Energy Company. We can therefore assume that we have underestimated the size of the development. In addition, when comparing the relative strength of each of the companies involved, we must qualify any comparison of Magma Energy and any other company with respect to statements concerning the relative sizes of geothermal holdings. Unfortunately, we do not know the size of our error. We will assume, however, given Magma's relative economic strength (it is a relatively small and financially powerless member of the energy industry), that our estimates, while below those of the true values of the variables involved are not far enough off to significantly disrupt our findings.

This problem does not extend to the data on Exploration or Production drilling since permits to engage in both activities are required by law. Where this is the case and where financial rewards in later time periods are predicated on meeting early legal obligations we expect compliance with rules that require the permits and thus no measurement error attributable to selective deposit.

A second problem usually mentioned in this context is that of selective survival. Where the public record is the unit of analysis and where the relevant time frame is relatively recent --- since 1958 --- there should be little problem in this regard. For this reason we are not inclined to worry much about it.

A far more serious problem is that of selective retrieval. It is created by the need to search out and select the data in question. The

problem is present in any research but is quite a bit more serious in archival analysis primarily because the archive represents an information source of monumental size. Where the source is large and complicated the probability of making an error in coding some characteristic of it increases. In certain situations this problem is minimized by the fact that relative estimates of population parameters will suffice. In such instances, the researcher may appropriately use random sampling of the events to be coded. This allows the researcher to reduce the probability of biased estimates of parameters to zero when the number of events sampled is large. That is, the samples of occurrences that he derives from the population of possible occurrences will represent their relative distribution in that population. This is the case only where relative estimates of the population parameters will provide the information in question.

Where one is required to estimate the exact distribution of occurrences in a fixed population, random selection is clearly not indicated as a method of insuring against sampling bias. In fact, there is no sure way of guarding against such bias where estimates of the exact population parameters are required. Needless to say, we are in precisely this position. We have undertaken to estimate the exact number of leases, acres and companies and their locations of potential drilling sites that are involved in geothermal development in the Imperial Valley. To say that there is no sure cure for a given disease is not to say that one should not try to minimize its effects, however. We have attempted to reduce our problem by adopting a set of sampling techniques that allows for maximum exposure of the researcher to the archive and for checking and rechecking of the file for the period in question. This is only a stopgap measure and will not insure that some peculiar set of lease titles or companies did not completely elude the attention of the

researchers. Where the number of researchers involved was relatively high (4) and the number of times that the archive was visited was also high (3) we feel that the probability of a systematic miss is relatively low.

The final problem apparent with the measures chosen for this analysis is that of instrument decay. This occurs when the measuring instrument changes during the course of its use by the researcher. We have little reason to believe that the system of record keeping used by the County of Imperial changed very much during the period of study. The greatest possible change during that time was the introduction of micro-fiche information storage in 1962. Nor is it very likely that companies changed their tendency to file geothermal documents. These factors remain relative unknowns, however.

In summary, it would seem that there are many problems involved in using the kinds of measures that we have chosen for this research. The problems are not suggested by the measures, however, but by the difficulty of the questions addressed by them. Where the problems mentioned in the foregoing discussion have impinged on the findings of this research, we will endeavor to point it out.

Collection Methods

The data described in this study were collected at two points in time. The first collection was conducted in the summer of 1972, with a follow-up, in the summer of 1973. The form of the data, the focus of the study and the resultant data gathering techniques did not change during the interim.

The data for the study was gathered from the Hall of Records and the Planning Commission of the County of Imperial, California. The public record of that county for the period January 1960 through July 1972 was examined in search of documents relating to the geothermal development. That task was accomplished by undertaking the following routine:

The record of Imperial county is structured such that all documents are filed and indexed in sequential order by date of filing and cross-referenced with the surname of the actor(s) requesting that the document be recorded. It was possible, therefore, to collect the data in at least two ways. First, the researchers might have scanned the public record by date of filing for the fourteen-year period mentioned above. Second, they might have simply examined the alphabetical listing of requestees for the dates mentioned looking for likely companies. Union Oil, for example, which is known to have large holdings in The Geysers Project in Northern California. For reasons that will soon become obvious, the first, more meticulous course of action was taken. Recall that one of the principal interests of the research was to identify the companies that were involved in the development. Would it make sense under those conditions for us to allow our predispositions, however valid, to determine the sample of companies that would be collected? Obviously not, such a consideration would lead to a rather biased sample; in this case it would lead to the set of companies that was involved in The Geysers and the Imperial Valley. No provision would be made for those companies that are restricted to either one.

Typically, the data gathering went as follows:

Each researcher scanned successive sections of the time-file index, noting the micro-fiche document or book identification numbers of all leases, amendments to recorded documents, assignments of rights or quitclaimed deeds that were apparent for each section of the file. (The structure of the public record made this routine necessary because there was nothing in the index indicating the kind or extent of the rights involved in the document transaction. All the researchers knew after examining the index was that the document

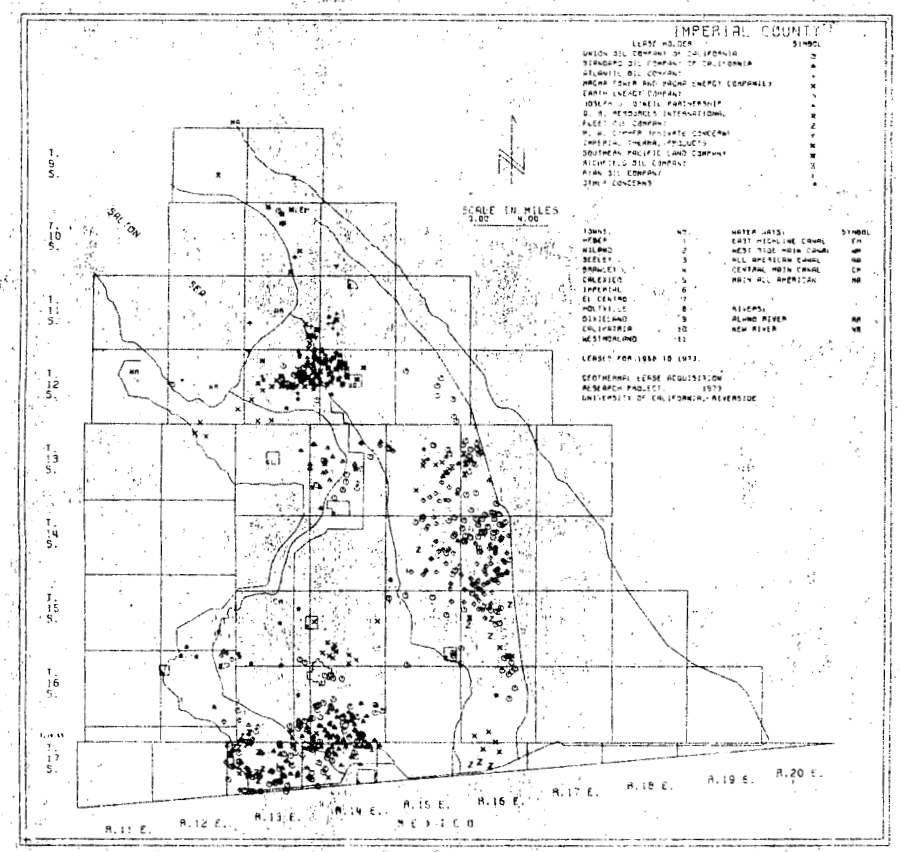
number referred to a possible geothermal document.) Upon acquiring approximately 10 such numbers from the file, the researcher --- using the document numbers acquired in the time file scan --- perused the documents themselves to determine if they referred to geothermal rights. If this was found to be the case, the researcher made note of the date of filing, book and page of record, actors mentioned in the document to include lessor and lessee, relevant land descriptions including the sizes and locations, the specific title of the documents, the term of years that the agreement would be in effect and any special considerations apparent in the documents. If, upon examination the document was found not to relate to the geothermal development, as many were, the researchers simply went on without making note of it, or the data it contained.

This procedure was followed for a three-week period in the summer of 1972 (original data set) and for one additional week in the summer of 1973 (the follow-up).

The follow-up was made necessary by two related but different problems. First, a preliminary analysis of the data revealed trends in lease acquisition that did not obey the growth models expected by the researchers. Second, missing data for some of the variables was well beyond what would be expected by chance alone. Both problems subtracted from our confidence in the reliability of our estimates of the leasing parameters and both suggested that a second data collection was necessary: the first, to extend the time series in both directions; the second to reexamine the cases found in the preceeding search. Both were successfully completed in the summer follow-up.

APPENDIX TWO

METHODOLOGICAL NOTE ON THE MAPS

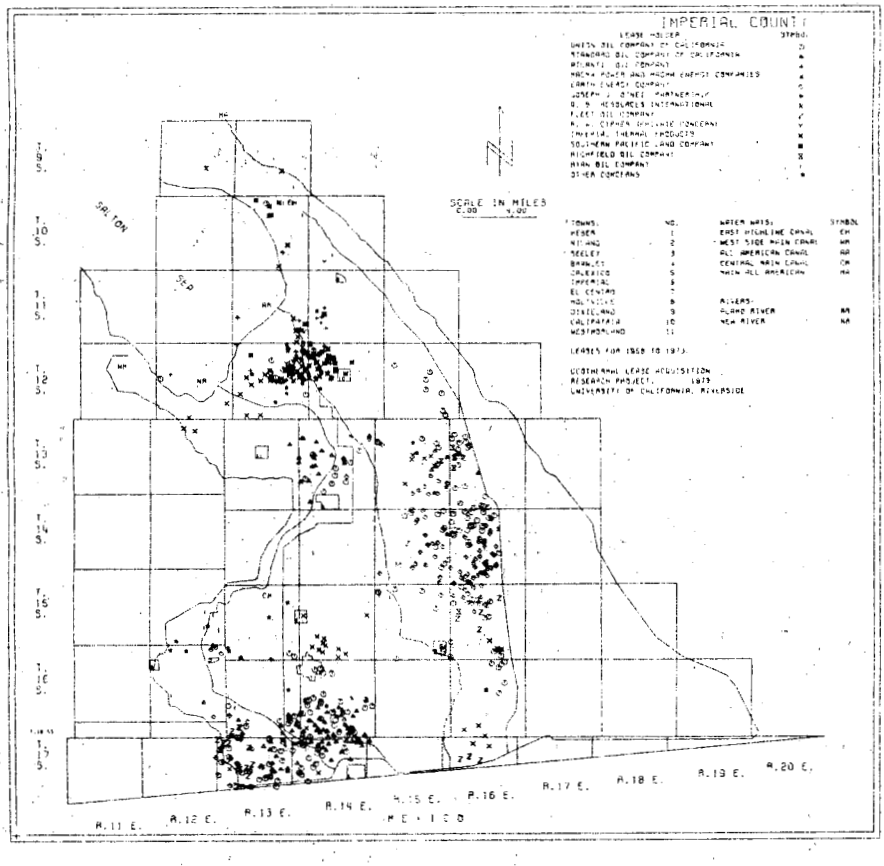


The maps used in Section Five were drawn by a computer at the University of California, Riverside. This technology was chosen over its traditional counterpart for two reasons. First, the essential value of map presentation in this instance resides in the ease with which it allows the reader to become immediately familiar with the relationship between the geothermal development and the geography of the Imperial Valley. A basic problem exists, however, in the fact that we are not geographers. We therefore, cannot be expected to present the data on location with any degree of accuracy. (Accuracy, it should be clear is rather a crucial component of this kind of presentation.) We have turned to the computer in this instance because it provides the accuracy that we lack. We can present many recombinations of the same data in time series, for instance, without appreciable loss of perspective, resultant to coding error. Also, the rapidity with which this can be done is increased to an absolute maximum.

The second, and perhaps more important, value of computer plotting in this instance resides in the fact that information storage and retrieval capabilities of large data processing units like the 360 Mod 50 make the addition, storage and retrieval of map information a mere data processing task (digitizing or keypunching). This characteristic is extremely useful where map information, as in highway engineering or land use planning, must be continuously updated. The value of this method lies in the fact that each of the data sets involved is stored independently of each of the others and thus may be added or subtracted from any of our maps without significant cost in terms of man hours or machine time. It is possible therefore to continuously add new social, geographic, legal, economic or ecologic variables as the situation and the analysis demands. In essence, the technique that we have used allows for further analysis of the data that we have collected

by anyone who cares to understand the logic of our data set construction and has a computer plotter. All we require in return is that subsequent additions to the data set be submitted in condensed form to the archive at the University of California, Riverside for use by planning agencies in the County of Imperial and the State of California. We should point out, in addition, that we are presently in the process of changing the metric of the map. The maps used in this analysis reflect its purpose. They were constructed in an effort to describe the frequencies and locations of the elements of the geothermal development that is being conducted by a number of companies in the Imperial Valley of California. We have, in our haste, ignored pertinent information. The next set of maps to be constructed from this data set will consist of a set of polygons that define the physical map area of each of the leases in the file; in effect, its exact location within the Imperial Valley.

APPENDIX THREE
EXPLORATORY DRILLING SITES



Below are listed the locations of those well sites where exploratory drilling has been initiated by the four companies examined in Section Six.

Standard Oil Company of California (Chevron)

Nowlin Partnership #1	Township 16S Range 14E
Nowlin Partnership #2	Township 16S Range 14E

Union Oil Company

River Ranch	Township 11S Range 13E
J.J. Elmore #1	Township 11S Range 13E

Magma Energy, Inc. and Magma Power Company

Magmamax #1	Township 11S Range 13E
Dearborne #1	Township 12S Range 12E
Woolsey #1	Township 11S Range 13E
Sharp #1	Township 16S Range 16E
Willey #1	Township 12S Range 13E
Heise #1	Township 12S Range 12E
Holtz #1	Township 17S Range 14E
Veysey #1	Township 13S Range 14E
Veysey #2	Township 13S Range 14E
Holtz #2	Township 17S Range 14E
Elmore #2	Township 11S Range 13E
McKelvey #2	Township 11S Range 13E
Elmore #3	Township 11S Range 13E
McKelvey #1	Township 11S Range 13E
Woolsey #2	Township 11S Range 13E
Magmamax #2	Township 11S Range 13E
Magmamax #3	Township 11S Range 13E

Magma Energy, Inc. and Magma Power Company (Cont'd)

Magmamax #4	Township 11S Range 13E
Bonanza #1	No location
Casey Well #1	Township 13S Range 14E
Sharp Well #2	Township 16S Range 16E
Fed-Rite Well #1	Township 17S Range 13E

Southern Pacific Land Company

Sinclair #1	Township 12S Range 13E
Sinclair #2	Township 12S Range 13E
Sinclair #3	Township 12S Range 13E