THE DEVELOPMENT OF THE SULPHUR INDUSTRY IN TEXAS

APPROVED:

L. W. Newton
Major Professor

G. A. Odam
Minor Professor

L. W. Newton
Director of the Department of History

L. A. Sharp
Chairman of the Graduate Council

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By

Earl Olin Posey, B. S.
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PREFACE

This subject was selected because the author lived near the largest sulphur field in the world, and therefore became intrigued by the peculiarities of Texas sulphur mining.

The scarcity of materials on the historical phase of the sulphur industry is surprising, while there are volumes written on other industries that pale into insignificance when compared to the economic potentialities of this industry. Not only were the sources in the Teachers College Library carefully consulted, but search was made also at the Texas State College for Women Library, Southern Methodist University Library, Dallas City Library, the Library of the Dallas News, The Texas Weekly office, and from publications of the United States Department of Interior and the Texas Sulphur Industries.

The author would like to record here a debt of gratitude to those who so graciously aided in the collection of the materials used, and to those whose kind and helpful guidance made this work a reality.

My efforts on this thesis will be repaid if it inspires someone to write a more complete history of one of our greatest industries.

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CHAPTER I

GENESIS, OCCURRENCE AND METHODS OF PRODUCING SULPHUR

In writing the history of the development of the sulphur industry in Texas, it is the writer's wish to touch upon the interesting place sulphur has held in the world, and especially in the life of man, since the beginning of time. We know from various evidences that sulphur had its place in the life of man long before written records.

The history of sulphur has its imaginative as well as its technical phase. Sulphur is a sort of an Aladdin which has influenced the world for more than four thousand years with its feats of yellow magic.

The story probably began in pre-historic times when those early ancestors of ours who lived so comfortably in their caves and jungles first discovered the wonder worker we call sulphur. You can almost see them now, through the dim mists of the ages, eating sulphur in the springtime to purify their blood, and burning sulphur to cast out evil spirits from their bodies.

Appearing as doctor, warrior, artist, priest, and in a dozen other well-known guises, the yellow magician, sulphur, has held the center of the stage of world progress for nearly forty centuries. From the mystic temples of the Orient to the volcanoes of Sicily, the arsenals of Europe, and the scientific laboratories of the United States sulphur has continued to weave its saffron thread into the fabric of history.

We learn from ancient writings that sulphur was used twenty centuries before the Christian era by pagan priests in weird ceremonials. Its bright, almost ethereal, blue flame and pungent odor gave it an important role in temple sacrifices and purification rites. About the same time, but more practically, it was used as a bleaching agent for linen and cotton. Certain Egyptian paintings about 1600 B. C. clearly contain colors that require sulphur compounds.[1]

In that work of literature, the Odyssey, the great Greek poet tells how Odysseus, after slaying the suitors for his wife's hand, cleansed the air of evil and purified his house by burning sulphur. Thus we trace the use of sulphur as a fumigant back to 1000 B. C. Five hundred years later, during the time of the celebrated Chinese philosopher, Confucius, the Chinese invented gunpowder by compounding sulphur with other substances. When the Roman empire was at the height of its power, the historian Pliny, about 50 B. C., wrote that there were four kinds of sulphur and indicated fourteen medical virtues for this strange, yet vital substance.[2]

Down through the ages sulphur has intrigued and benefited mankind. It was used in the early manufacture of artificial jewelry, imparting a gold-like glint to the cheap jewelry of the Middle Ages. Alchemists (early chemists) struggled to convert base metals into gold with it. Its inflammable nature baffled students of early physics. Its curious odor when burned puzzled scientists who continually debated its properties.[3]

Sulphur is sometimes, indeed, a nuisance. Silver spoons tarnish when used with eggs because the sulphur in the eggs forms a blackish

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[1]George Sarton, Introduction to History of Science, I, 533.

[2]Ibid., 56, and 4,000 Years of Yellow Magic, Freeport Sulphur Company, pp. 1-2.

[3]H. S. Redgrove, Alchemy: Ancient and Modern, pp. 20-22.

silver sulphide over the surface of the spoon. That same sulphur forms an alliance with hydrogen to assault your nose with the horrible odor of rotten eggs (hydrogen sulphide or sulphuretted hydrogen). The pungent, and to some people, scarcely less objectionable odor of cabbage, onions, turnips, and mustard is due to sulphur compounds. Burning matches, because of the burning sulphur they contain, give off a suffocating fume of sulphur dioxide which irritates the throats of people and blacken the surface of metals. Sulphur is found in most of the proteins, these remarkable complex substances which are so important in animal tissues and in many vegetable structures. Human hair contains the exceptionally high proportion of five per cent sulphur.[4]

Sulphur's magic is almost unlimited. With the coming of each new era in history new uses have been found for sulphur. Its singular properties have been recognized by the folk of every age--whether in the ancient world, and in the earliest laboratories of science, or laboring in the so-called Twentieth Century Industrial Revolution and the modern struggle to eliminate disease, aid agriculture, and speed a scientific Utopia.[5]

Sulphur, like oxygen, is most promiscuous in its mating with other elements, and the result is that thousands of sulphur compounds are known and used. Therefore, the history of sulphur is incomplete without a mention of the part the sulphur compounds play in the world today. A

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[3]Compton's *Pictured Encyclopedia*, XIII, 323.

[4]R. H. Ridgway, "Sulphur," *Information Circular No. 6329*, U. S. Bureau of Mines, p. 3.

[5]*4,000 Years of Yellow Magic*, p. 3.

general idea of the importance of the sulphur compounds is given by a brief consideration of that "Grand Old Man of Chemistry," sulphuric acid.

When you get up in the morning and turn on the water for your bath, you use a nickel-plated faucet which required sulphuric acid in its manufacture. Your tub, be it old or new-fashioned, has met sulphuric acid before it became what it is. The water in which you bathe has probably been treated with copper sulphate to clean it of algea. Your bath towel had experience with sulphuric acid before you bought it, and the soap-maker probably found it necessary to use sulphuric acid in the making of your soap. The bristles of your hair-brush have been treated with it, and the back of your brush as well as your comb --if they are celluloid--could not have been produced without it. Your razor, before it reached its present high estate, may have been pickled in sulphuric acid before it was annealed.

As you put your underwear on you may recall that the bleacher and the dyer used sulphuric acid on the thread before it was knit or woven, and upon the fabric afterward. As you button up your outer garments you may be reminded that sulphuric acid was needed in scouring the wool, in making the dye, and in the process of dying the cloth. The button-maker needed some before your buttons were complete. The tanner used it for making the leather of your shoes, and it is also used in the manufacture of shoe polish. The cushion on which you rest your pious knees in devotion has met sulphuric acid often, before it reached its present dignity.

At breakfast your cup and saucer may have come into being without the aid of sulphuric acid, but only provided they are plain white. To produce the constituent of agua regia, which dissolved the gold for gild ornamentation, sulphuric acid may have been used. The silver of your knife and fork may have come from a smelter which had first burned the sulphurous ores and made sulphuric acid of the fumes; while, if they be silver-plated, the process was carried out in a sulphuric acid bath. The farmer who raised wheat of which your biscuits are made probably used acid phosphate on his land to encourage the wheat to grow. Acid phosphate is phosphate rocks treated with sulphuric acid. The paper-maker used some sulphorated aniline blue to tint your morning paper, which contains about twenty per cent of sulphite pulp; and it would be rare ink indeed, that has not come in contact with sulphuric acid, at some point in its history. If you eat buckwheat cakes and syrup for breakfast, the syrup required sulphuric acid in its manufacture, and as for your artificial light, if you get up early enough to need it, you would be driven back to candles if it were not for this product. It is needed in the refining of kerosene and gasoline; and as for your electric light, brought to you by currents of electricity through copper wires, where would the copper industry be without the electrolytic process of refining which requires enormous quantities of sulphuric acid? It would be paralyzed.[6]

We heard during the Great War of the embarrassment of industry from the lack of German dyes. That is nothing compared to the general break-up that would follow a shortage of sulphuric acid. We can neither

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[6]B. L. Clarke, Marvels of Modern Chemistry, pp. 187, 188.

go to war nor live in peace out of its path. You may never see it, and its very remarkable chemical personality, but you certainly cannot get along without it.[7]

The necessity of sulphur to mankind is more forcefully illustrated in the list of manufactured articles that either contain or require it in the process of making. Following is a partial list of the industries and products in which sulphur is employed[8]:

Alcohol	Bleaching agents
Binders	Chemicals
Cements	Elastics
Ebonites	Fertilizers
Fabrics	Food Preservatives
Fire Extinguishers	Gasoline
Fungicides	Glycerine
Glues	Insecticides
Inorganic acids	Leather
Organic acids	Lubricants
Laboratory Reagents	Metallurgy
Livestock Foods	Paints
Medicine	Photography
Moving Picture Films	Rodent Extermination
Petroleum Products	Soda
Poisons	Sugar
Refrigerator Agents	Water Purification
Tires and Rubber Goods	Anibesic
Steel Pickling	Beltings
Textiles	Celluloids
Alum	Dyes
Artificial silk	Explosives

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[7] Ibid., p. 189.

[7] Holland Thompson, The Book Of Texas, p. 126.

[7] J. E. Phillips, The Wonders of Modern Chemistry, pp. 21-27.

[8] D. P. South, Texas Sulphur Industry, A Topical Survey, for Texas Planning Board, 1933, p. 4.

[8] C. J. West, Annual Survey of American Chemistry, New York, VII, 1933, p. 203.

[8] Julia Jones and Laura Holt, "Texas Sulphur: A World Power," in Bunker's Monthly, April, 1928, I, 586.

Fireworks	Paper
Fumigants	Plastics
Glass	Pepsin
Illuminants	Soap
Liquid Fuel	Solvents
Matches	Tanning

Fortunate, indeed, is it to the general welfare that there is such an abundant supply of sulphur, since it is so widely used. And true it is that we have abundant sulphur. Clarke has estimated that it makes up .06 of one per cent of the earth's crust; but a large part of the world reserves cannot be estimated with precision.[9] Sulphur occurs widely and is abundantly distributed in nature in both combined and free state. Hundreds of minerals contain sulphur as one of their essential chemical constituents, but only a few are mined or used for sulphur, and of those few only one is used exclusively for its sulphur. This mineral is native sulphur, or elemental sulphur, and very commonly known as brimstone. (Nevertheless, elemental sulphur furnishes only about thirty-five per cent of the sulphur used in industry--sixty-five per cent comes from pyrites and by-product sources.)[10] A complete list of the localities containing native sulphur would include all the volcanic regions of the world.[11] The waters of the ocean, and various inland seas (Black Sea in particular) contain H_2S in noticeable quantities, and there is free sulphur in marine sediment.[12]

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[9] F. W. Clark, The Data of Geochemistry, U. S. Geol. Survey, 1924, Bulletin No. 770, p. 36.

[9] R. H. Ridgway, "Sulphur," Information Circular 6329, p. 24.

[10] South, op. cit., p. 4.

[11] H. T. Briscoe, General Chemistry for Colleges, pp. 597, 580.

[12] W. H. Twenhofel, Treatise on Sedimentation, pp. 587-591.

more commonly accepted theories, however, assume that the sulphur and the limestone are alteration products of gypsum and were formed as a result of reduction by bituminous matter followed by oxidation.[17]

More commonly sulphur is found in the rocks of volcanic vents or of solfataras. Hydrogen sulphide (H_2S) is a common exhalation from volcanoes, and the reduction of this gas gives volcanic sulphur which is deposited in the tufas or other adjoining porous rocks.[18] The following hypotheses have been proposed to explain the presence of sulphur near volcanoes: the gases, hydrogen sulphide and sulphur dioxide, generated by volcanic action, react to form sulphur; hydrogen sulphide evolved from underground sulphides is oxidized by the oxygen of the air to give sulphur; and, lastly, sulphur may be produced by the weathering of metallic sulphides.[19] Such deposits on a small scale may be seen incrusting fumaroles in the Roaring Mountains or associated with the Sinter deposits of the Mammoth Hot Springs in Yellowstone Park. Such deposits have also been observed at many other places in the western states--at Cupite, Esmualds County, Nevada; at the Rabbit hole Mines in Humboldt County, Nevada; at Sulphur Banks, California; Cove Creeks Mine, Beaver County, Utah; and at Thermopolis, Wyoming. The deposits are often small and consist largely of fissure fillings. They are workable in Hokkaido and in the Island of Kyusher, Japan; in Chile; in the vicinity of Tahe Notorua, New Zealand; and in Nevada and Utah. To this type also belong the deposits of Alaska,

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[17] Texas Gulf Sulphur Co., A Treatise on the Properties and Application of Sulphur, p. 3.

[18] Ridgway, Information Circular No. 6329, p. 3.

[19] Texas Gulf Sulphur Co., A Treatise on the Properties and Application of Sulphur, p. 3.

Ecuador, Iceland, Mexico, and other volcanic regions.[20]

Compounds of sulphur are more abundant in nature than the free element. These include sulphates, the most important of which are gypsum and barite ($BaSO_4$); sulphides of the metals, such as galena (PbS), Cinnabar (HgS) and Zinc blend (ZnS); iron pyrites (FeS_2); and several ores of copper, gold and other metals.[21] The possibilities of most of these minerals as sources of sulphur are very remote because of either low sulphur content or scarcity of the mineral. The most extensive occurrences of sulphur in sulphide form are as pyrite and purrhotite, which are mined chiefly for their sulphur content. Comparatively little sulphur is derived from sulphate, and to date it is not an important source of sulphur. Occurrence of the sulphates is widespread and they have many important commercial applications other than as ores of sulphur.[22]

The principal sources of sulphur in the world today are the United States, Italy, and Japan, with the former in the lead. Other countries producing sulphur, but of minor importance, are Chile, Spain, and the United Kingdom (as a by-product of Chance-Claus process and in the purification of coal gas). Other sources of known production are Austria, Ecuador, France, Norway, Sweden, Turkey, China, Germany, Portugal, Greece, Russia, Netherlands, East Indies, Bolivia, and Argentina. Exploration for sulphur was reported in Costa Rica, Nicaragua, Mexico, and Palestine.[23]

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[20] Briscoe, _op. cit._, p. 597.

[21] _Ibid._, p. 597.

[22] Ridgway, _Information Circular 6329_, p. 5.

[23] R. H. Ridgway and A. W. Mitchell, "Sulphur and Pyrites," _Minerals Yearbook, 1936_, p. 908.

For many years past and until 1913, ninety-five per cent of the world's supply of sulphur was mined and prepared for use in Sicily. Since then, however, the United States has become the largest producer contributing about seventy-six per cent in 1934, of which seventy-one per cent came from Texas.[24]

A brief discussion of the chief methods of sulphur production used in those countries that might be called competitors of the United States--that is to say Texas--will be given. Since the production of sulphur is so dependent on the Frasch process, it will be described in detail. For further information on sulphur production, the reader is referred to J. W. Mellor, A Comprehensive Treatise on Inorganic and Theoretical Chemistry.

Sulphur is one of the chief mineral products of Italy. With an annual output of nearly three hundred thousand metric tons, it is the most important sulphur-producing country in Europe and ranks second to the United States in world production. The most important Italian sulphur deposits are found on the island of Sicily, but sulphur also occurs on the mainland in the province of Emilia, the Marches, Campania, Calabria, and Sienna. Sicily has produced sulphur for several hundred years, and estimates indicate that over 28,000,000 tons have been mined and extracted. At the beginning of the twentieth century most of the world's supply of sulphur came from Sicily, which now produces in the neighborhood of fifteen per cent of the world's consumption.[25]

Almost all the Sicilian sulphur is removed by underground methods, much of it in accordance with the best modern practice. However, one may

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[24] Ibid., p. 903.

[25] Ibid. p. 4.

[25] Jones and Holt, op. cit., p. 587.

encounter many plants in which extremely primitive mining methods are used. Here, as has been the practice for many generations, the ore is broken down by hand, loaded into baskets, and carried to the surface by men or by animals. During the past few years the construction of power lines has tended toward a gradual mechanization of the mines.

The ore as mined contains a high proportion of waste material and hence it must be treated in order to recover sulphur in sufficient purity to compete in the world markets.

There are three principal processes of extracting sulphur from the ore: by burning part of the sulphur in mounds called calcarne; by burning part of the sulphur in Gill regenerative kilns; and by means of retorts heated with superheated steam. The last two processes are the most efficient and cause less damage to vegetation in immediate vicinity, since the sulphur gases are not allowed to escape. Constant improvement in the extraction devices has increased the recovery of sulphur from the ore from sixty per cent to ninety per cent. However, one-third of the sulphur is used for fuel except in the steam retort method.[26]

The sulphur deposits of Japan are all of volcanic origin and usually of the volcanic vent type. Since many of these fumeroles are still active, a small quantity of sulphur is recovered by passing the escaping gases through condensers. In the ordinary process, sulphur is charged into retorts, which are then sealed and the sulphur is distilled with heat

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[26]Sir Edward Thorpe, A Dictionary of Applied Chemistry, V., 515-516.

[26]Ridgeway, Information Circular 6329, p. 19.

[26]Texas Gulf Sulphur Co., A Treatise on the Properties and Applications of Sulphur, p. 6.

produced by coal. The molten sulphur recovered in the condensor is moulded in convenient sizes for shipment.[27]

The deposits of sulphur in Chile are in the volcanic districts of that country, being found in Atacama, Antofagasta, Tacna, and Arica. Only a small percentage is exploited, mostly in Tacna and Antofagasta.

The Chilean sulphur deposits are mainly confined to the volcanic peaks of the Andes, where the high altitudes and remoteness from railways retard development. The deposits are usually found at altitudes ranging from thirteen thousand to twenty thousand feet and are difficult to operate because of the rarity of the atmosphere, the cold, and the violence of the prevailing winds.

Underground mining is the most common. The ore is dug out of the mountains, sorted by hand, sacked, and taken to the refinery.

At the refinery, the ore is charged into cast-iron retorts that are heated, and the sulphur is volatilized. An alternative method uses steam to melt the sulphur from the ore, which is charged into a vertical cylinder. The average production of Chile is in the neighborhood of fifteen thousand tons per year.[28]

Sulphur mining on a small scale, including the production of eight

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[27]Thorpe, op. cit., pp. 515-516.

[27]Ridgeway, Information Circular 6329, pp. 20-21.

[27]Texas Gulf Sulphur Co., A Treatise on the Properties and Applications of Sulphur, p. 6.

[28]Ridgway, Information Circular, 6329, p. 20.

[28]Texas Gulf Sulphur Co., A Treatise on the Properties and Applications of Sulphur, p. 6.

hundred and forty tons in California in the early sixties from the Sulphur Bank Mine at Clear Lake, has been carried on in the United States for a long time.[29] Utah has been in and out of the picture as a producer of sulphur,[30] Nevada has made claims about the value of her Humboldt County mines, and has had her production up to twenty-five to fifty tons per day. But the nature of the deposits calls for open pit mining and the resulting expensive method of refining by heat processes,[31] that makes the cost of production too high for the West Coast to be an important competitor with the Gulf Coast. The Toyah deposits in Texas are in the same category with that of the West Coast. Here, also, the method of production is similar to all other open-pit methods for mining. Not until the Louisiana deposit was opened did this country become a factor in the world output.[32] Since that time, Louisiana and Texas have controlled the world market, with Texas gradually taking the lead after 1914.

Louisiana and Texas were made the world's leading producers of sulphur by the Frasch method. There is no doubt that Italy would still be the leader as it was before 1900, but for the ingenious process invented by Herman Frasch. The sulphur deposits on the western border of Louisiana were discovered as early as 1865 in a search for oil, but the mineral lay four hundred and fifty feet below the surface, beneath a bed of quicksand, impregnated with poisonous fumes of hydrogen sulphide. A number of attempts

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[29] "Reopening of Old Sulphur Mines in Nevada Gives Western States Local Source of Sulphur," in Review of the Pacific, March, 1928, p. 16.

[30] Ridgway and Mitchell, "Sulphur and Pyrites," Mineral Yearbook, 1936, p. 904.

[31] Review of the Pacific, p. 16.

[32] Ibid., p. 17.

to sink shafts into the deposit led only to cave-ins and loss of life through inhalation of the deadly gas, until in 1891 a chemist, Herman Frasch, declaring that "if we cannot go to the sulphur, we will make the sulphur come to us," devised the process that now bears his name.[33] It was not until 1913, however, that his method became an assured success.

The Frasch process can be applied only to subterranean sulphur deposits, and differ radically from the recovery of any other type of solid mineral or of sulphur in other parts of the world. Ordinary oil well equipment is used to bore holes to the bottom of the sulphur bearing strata. Concentric pipes varying in size from ten inches to one inch are placed in the holes. A ten inch or an eight inch casing extends to and rests upon the cap rock. Inside this casing, a pipe, of smaller diameter (six inches) passes below the lower end of the casing, through the sulphur-bearing stratum, and rests in the upper portion of the barren anhydrite. A still smaller pipe (three inches) passes through the second so that an annular space exists between the two; it extends nearly to the bottom of the sulphur bearing rock and rests on a collar which seals the annular space between the second and third pipes. Finally, a one inch air pipe, inside of the three inch line, extends to a depth slightly below the casing, and is set in the barren anhydrite, is adequately perforated at two different levels, separated by the annular diaphragm or collar, the upper set of holes permitting the escape of hot water and the lower, the entrance of the molten sulphur.

In "steaming" a well, the hot water, heated to three hundred fifty

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[33] Jones and Holt, op. cit., p. 586.

degrees Fahrenheit, passes down the annular space, inside the six-inch pipe, and is discharged into the porous formation near the foot of the well, through the perforations in that pipe. The region through which the water circulates is raised to a temperature above the melting point of sulphur (250°F.). The liquid sulphur being heavier than water, makes its way downward, forming a pool around the foot of the well, and after entering through the lower perforations rises in the three-inch pipe.

The height to which the sulphur rises in the three inch pipe is the resultant of its specific gravity and the pressure in the system established by the operating pressure of the pumps in the power house, which is necessary to force the hot water into the deposit. The height may be one-half or two-thirds of the depth of the well. Compressed air released at the bottom of the central one-inch pipe, uses and mixes in the sulphur column, the weight of which is reduced by the aerification, thus producing an airlift that raises the liquid to the surface of the ground.

Choice of well location is influenced by existing local characteristics at any point being considered, and will be determined with reference to underground topographical features of the sulphur deposit and the consequent reach of the hot water outward from the well in horizontal and vertical directions. Wells favorably located with respect to all the conditions prevailing pump continuously over long periods, becoming increasingly intermittent in their action as old age advances. Some wells will last a year or more. Others cease to produce in a few weeks, due to destruction of the well equipment by ground movement, or to local denseness of the gangue, which prevents the circulation of hot water and molten sulphur. As extraction of the sulphur proceeds, the integrity of the rock structure is weakened and its subsidence results in a general downward creep of the overlying formations, an inequality of movement in which different strata are involved, finally bending or breaking the pipe so as to put the well out of service.

Subsidence is a disadvantage in mining in so far as it causes the loss of producing wells and failure of equipment. This disadvantage is more than offset by the relatively impervious character of the crushed exhausted sulphur formation. Water circulates through this caved formation with difficulty and the incoming hot water is therefore confined to the porous unexhausted parts of the deposits.

However, this condition of subsidence as a factor in the actual mining operation does not rule at all of the sulphur deposits being mined now. In some cases the barren rock above the sulphur stratum is so thick and of such a character that it is not crushed when the sulphur below is removed. Production costs in mining such deposits are greater than in those where subsidence takes place readily.

In the most successful type of deposit, the gumbo and shale, which lie above and to the sides of the dome, are relatively impervious to water. There is no natural outlet for the great volume of water which is pumped into the deposit. The water is removed at practically the same rate at which it enters by means of "bleed-wells." These wells, located at some distance from the active steaming zone, tap the deposit at lower levels than the producing wells, and remove the water which has cooled in its downward progress through the porous rock formation. The incoming hot water displaces the water from which the useful heat has been removed and the latter is progressively discharged to waste through the bleed wells, there being of course, a certain degree of dilution with the original ground-water.

Deposits which are not entirely enveloped by formations impervious to water may lose a considerable amount of the water pumped in. This condition obviously results in a material increase in the volume of hot water required per ton of sulphur produced over that required in deposits surrounded by the impervious strata.

Although operation costs vary with the richness of the deposit, average figures show that to produce two thousand tons of sulphur it is necessary to heat 8,000,000 gallons of water by burning 4,000 barrels of fuel oil (or gas in the same heat quantity). It is estimated that less than two per cent of the heat put into the ground actually melts the sulphur, the remainder being dissipated, or heating the surrounding rock. To prevent wastage of heat by permitting the melted mineral to run back into the earth, however, a great many wells are usually sunk close together to insure the sulphur reaching a pipe line.[34]

Next to fuel, the greatest expenditure entailed by the Frasch process is for pipe, the labor cost being comparatively small as the operation is almost automatic. All pipes used for the transmission of sulphur are galvanized, to resist corrosive action. A one-inch steam line is laid inside this sulphur discharge line to prevent the sulphur from solidifying. Practically all pipes through which sulphur is conveyed are equipped with such steam lines. Pipe movement due to temperature changes is taken care of by expansion joints.

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[34]Review of the Pacific, p. 18.

The steel derrick, and enough of the drilling equipment to raise pipe, are left as a permanent part of the surface equipment of the sulphur well, for sometimes during the life of a well portions of the piping must be removed for repairs or replacement. When the use of a well is discontinued, the derrick and as much pipe as possible are salvaged. The well is then permanently capped to prevent the escape of water.

Sulphur from the wells is collected at pumping stations. The discharge lines from the wells deliver the sulphur into sumps at these points. A group of wells may discharge at one pumping station. The stations are located close to the area being steamed, usually within a few hundred yards of the most distant tributary well. The sump is dimensioned to suit the operating conditions, number of wells supplying sulphur and so forth. The lining may be of any suitable material, but cast iron has been found to be the most efficient. Steam coils on the bottom and at the sides of the sump are required to keep the sulphur in the liquid state.

When the sumps are reasonably full in the judgment of the operator, centrifugal pumps, either steam or motor driven, force the liquid sulphur through sulphur pipe lines to the vats. These pumps are specially designed for this service, and the moving parts are either submerged in liquid sulphur or are steam jacketed.

Pumping stations are the central points from which actual mining operations are controlled. The valves regulating hot water and air lines, and sulphur discharge lines, are conveniently grouped so that the station operator can adjust them readily. The best conditions for each well are determined by experiment, and are controlled by conveniently placed meters and gauges on air and water lines.

Sulphur from the pumping station is delivered to the vats through well insulated pipe lines, each carrying internally a small pipe in which live steam is flowing for the purpose of keeping the sulphur well heated so that it will move freely with minimum friction. These lines discharge directly on the vats. In fact, a vat is formed by the solidification of this liquid sulphur in a wooden bin. The sulphur is pumped into the bin at a rate which increases the height a few inches per day, the slight vertical increment being a consequense of large horizontal area which provides maximum cooling surface, and involves ample tonnage capacity. As the sulphur solidifies, it gradually builds up into a great block of solid sulphur, bright yellow in color. The wooden vat walls are built up slowly and are kept but a few inches higher than the sulphur. They are tied into the sulphur by means of short planks. When a vat is complete and ready to be shipped, these wooden walls are removed. In a solid state the sulphur, of course, requires no support and a large block will stand indefinitely with its wooden skin peeled off.

Vat dimensions vary, and will naturally be governed by the methods followed and the scope of the operation carried on. Sulphur for shipment is blasted from the face of the vat as required. A vertical block from twelve to twenty feet thick is removed at one time. Holes are drilled back from the face of the vat at suitable intervals apart. Each hole is charged with powder and exploded. Most of the sulphur is thereby broken into pieces of a size suitable for loading. Large pieces are broken with picks to sizes which can be conveniently handled. Locomotive cranes equipped with two-yard clamshell buckets, load the sulphur into railroad cars. Sulphur is loaded at the vats, directly into box cars for all-rail movement, the box cars loaders being set on railway running gear.

At the mines of the Texas Gulf Sulphur Company, permanently placed vats are built up and broken down in rotation. The sulphur currently being shipped has probably been in storage for one to two years. One and one-half million tons of sulphur or more is kept at hand. It is thought to be conservative management to carry such large stocks, because of the necessity of thoroughly cooling the sulphur, as well as the desirability of maintaining at all times a sufficient quantity on the surface to provide against any possibility of a temporary shut-down in production.[35]

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[35] Review of the Pacific, p. 18.

[35] Ridgway, Information Circular, 6329, pp. 9-10.

[35] "Modern Sulphur Mining," Texas Gulf Sulphur Company, pp. 8-17.

[35] Mellor, op. cit., p. 15.

[35] Thorpe, op. cit., pp. 518, 579.

CHAPTER II

THE RECENT HISTORY OF SULPHUR

The recent history of sulphur chronicles the rise of the United States from a position of dependence upon foreign deposits to a place of dominance in world production, so that this country not only supplies its domestic market but furnishes the outside world with exports approximating seven hundred thousand long tons annually. This rise was made possible by the invention of a new and ingenious method of mining, the Frasch hot-water well process, and by the discovery of extensive deposits strategically located near the coast of Louisiana and Texas and near the sources of cheap fuel supply necessary to the unique mining method employed.

During the first few years of the century, the sulphur-consuming industries of the United States were supplied largely with imported brimstone and pyrites, domestic pyrites being of minor importance and domestic sulphur almost negligible. The average annual consumption of sulphur in the first four years of the century amounted to 457,000 long tons. In 1903, the production of sulphur in Louisiana by the Frasch process began on a large scale, and the United States soon became an important factor in the world market.

The thirteen year period, 1904-1916, was characterized by a steady increase in the domestic production of pyrites, by an increase in the imports of pyrites, and by a sudden increase in the production of sulphur. Imports of sulphur decreased while exports increased, resulting in a net annual outflow of six thousand long tons. If this net annual outflow is deducted and proper allowance is made for a total of more than a million tons of brimstone accumulated in stocks during the period, the total sulphur made available in brimstone and pyrites indicates an average annual consumption of about 794,000 long tons of sulphur, exclusive of any utilization of by-product smelter fumes. About 517,000 tons of this sulphur consumed was derived from pyrites.

The entry of the United States into the World War marks an important milestone in the expansion of the American sulphur industry. The need for transportation facilities for essential traffic between the United States and Europe resulted in drastic curtailment of bottoms engaged in other traffic. Imports of pyrites from Spain and Portugal at first could not be increased to meet the growing demand. Later, in 1918, imports of pyrites fell off in amount. Therefore, manufacturers turned more and more to domestic brimstone.

At the close of the war many of the industries continued to use sulphur rather than change their plants back to handle pyrites. During the period 1917-1928, inclusive, the average annual production of brimstone in the United States amounted to 1,608,000 long tons, compared with an annual average of 365,000 tons for the period 1904-1916, inclusive. Imports of foreign sulphur during the period were negligible. Exports during the period averaged annually about 449,000 long tons, increasing from 152,736 tons in 1917 to 789,274 tons in 1927, but decreasing thirteen per cent in 1928 to 685,051 tons. Domestic pyrites production decreased from an average annual of 296,000 long tons, 1904-1916, to an average annual of 257,000 tons, 1917-1928, whereas pyrites imports dropped from an average annual of nearly 800,000 long tons for the earlier period to an average of 279,000 tons for the later. Domestic consumption of elemental sulphur exclusive of any utilization of by-product smelter fumes, and pyrites increased during the same time from an average of 794,000 tons to an average of about 1,374,000 tons.[1]

The position of the United States as the major factor in world production of sulphur was maintained in 1929. The year was characterized by record production and shipments, a steadily maintained price, and a reduction of stocks. Exploration by geo-physical methods and by drilling in the Gulf coast region continued, new prospects being investigated and some new discoveries being reported during the year. The consumption of native sulphur and the production and importation of pyrites increased substantially.

Although the depression of 1930 affected most industries adversely, world sulphur production went forward without abatement, surpassing the record total of the preceding year. The United States with an increase of eight per cent accounted for eighty-five per cent; Italy with an increase of eight per cent accounted for eleven per cent; and Japan with a decrease of seven per cent accounted for two per cent of the world production. However, the demand for sulphur declined substantially and stocks were accumulated in the major producing countries.

Spain, Norway, Italy, and Japan were the leaders in the pyrites industry. Increased activity in the production of pyrites was taking place in the United States, Jugoslavia, and Canada. Processes for the recovery of the sulphur content of pyrites, as sulphurous gases or as elemental sulphur, were developed in the hope of utilizing more completely the iron

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[1] R. H. Ridgway, "Sulphur and Pyrites in 1928," Mineral Resources of the United States, 1928, Part II, pp. 53-56.

and sulphur contained in the pyrites. This was done to lessen the cost of producing both products, and continued throughout the depression. Exploration by geophysical methods and by drilling in the Gulf coast region was continued, although the amount of exploration by geophysical methods was less than in immediately preceding years.[2]

The full effect of the industrial crisis was reflected in the sulphur industry in the United States for 1931 and 1932. United States production dropped seventeen per cent in 1931 and fifty-eight per cent in 1932. Italy showed no decrease in production and Japan showed a slight increase. Japan was making every effort to satisfy her home needs and enter the export trade. This she succeeded in doing by a sulphur-wool trade with Australia.

However, the consumption of sulphur was greater than the production under the curtailed program, and resulted in reduced stocks at the principal producing centers. Also plants were relieved of the pressure of production, thus making available equipment and personnal for experimental purposes.[3]

Depression practices in all of the countries of the world were to use home products, develop home industries, and make work for their unemployed. The United States sulphur producers felt the weight of this action from Germany very definitely, by its increased recovery of sulphur from waste coal gases and other by-product sources. Italy, Chile and Australia

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[2] R. H. Ridgway, "Sulphur and Pyrites in 1930," Mineral Resources of the United States, 1930, pp. 117-118.

[3] R. H. Ridgway, "Sulphur and Pyrites in 1931," Mineral Resources of the United States, 1931, pp. 131.

subsidized sulphur production.[4] Thus, by government subsidies or new manufacturing processes Chile, Norway, Sweden, and Australia became factors in sulphur production only during the depression years.[5]

Increased activity in numerous industries, more particularly the various chemical and fertilizer industries, was reflected in the market demand for sulphur during 1933 and 1934. World production of sulphur increased considerably, due principally to the larger output in the United States, where an excess of shipments over production decreased the sulphur stocks held at mines. The United States entrenched itself further in 1933 as the principal world producer of sulphur by a large output from one new property and by the development and equipment of another property where extensive reserves are reported to exist. Both new developments are in Louisiana. Italy maintained a production during 1933 and 1934 that was the largest for that nation since 1914. Japan's production increased sixty-nine per cent from 1931 to 1934. Norway's new Leander treatment of pyrites caused it to remain as a factory in the world sulphur production. Spain's first place as pyrite producer, was furthered by the use of the new Norway process. Germany held down her imports by increased production of by-product sulphur from various industrial gases.[6]

Even though shipments exceeded production for the third consecutive

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[4]South, _op_. _cit_., p. 12.

[5]Ridgway and Mitchell, "Sulphur and Pyrites," _Mineral Yearbook_, 1932-33, Part III, pp. 679, 684, 685.

[5] Ridgway, "Sulphur and Pyrites in 1931," _Mineral Resources of United States_, 1931, pp. 152-153.

[6]Ridgway and Mitchell, "Sulphur and Pyrites," _Mineral Yearbook_, Part III, 1935, pp. 1014, 1023.

year, the sulphur interests in the United States showed losses in favor of pyrites and by-product sulphur.[7]

The United States continued to be the world's largest producer of sulphur in 1935, by a sizeable margin. Italy, in second place, increased its production eight per cent over 1934. Japanese production in 1935 reached a record figure for japan of 138,000 tons. Norwegian output, which comes from the treatment of cupreous pyrites, was about the same as in 1934, or about equalled the installed capacity of the producing plant. Steps are being taken, however, to double the capacity of this plant in the near future. In 1935, Portugal began production of elemental sulphur that was from the pyrites produced at the San Domingos mine. It is believed that Sweden also began production of sulphur from the smelter gases at the Boliden works at Ronskar. The Consolidated Mining & Smelting Co. of Canada, Ltd., is building a plant for the recovery of sulphur from the smelter gases at its smelter at Trail, British Columbia. In Germany the recovery of sulphur from manufactured industrial gases now equals half the indicated domestic consumption. The manufacture of sulphur from native anhydrite has been demonstrated commercially by a pilot plant in England. The process is also deemed applicable to production of sulphur from smelter gases.

Spain, while holding an important place as a sulphur producer, as usual, was the most important source of pyrites in the world; increased output has placed Japan in second place, while Norway dropped to third.

Consumption of both sulphur and pyrites in the United States increased in 1935. In the sulphur industry the year was characterized by

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[7] *Ibid.*, p. 1028.

increased production, slightly increased shipments, decreased exports, and a steady price.[8]

The price of sulphur has been maintained at a fairly uniform level in the United States during its rise as the world's leading sulphur producer. This was possible largely because of the fact that the producers realized that no country has a monoply on sulphur. When the would-be monopolist raises sulphur to a prohibitive price, he has always learned to his sorrow that world requirements not only may be served by any of several nations, but also by any of several raw material sources.

Efforts to stabilize the price of sulphur in which the United States was an interested party began in 1907. In that year an agreement between the Union Sulphur Company of Louisiana, and the Sicilian industry assigned the United States market to the former and the Mediterranean market to the latter, but two new American producers found themselves able to sell sulphur in Sicily more cheaply than it could be produced there. Decreased Sicilian sales of sulphur led to an agreement between the American and Sicilian producers in the spring of 1923. The Sicilian sulphur interest was controlled by a compulsory consortium established by the government in 1905, and charged with the sale and regulation of the production of Sicilian sulphur. To treat with the consortium the American Sulphur Export Company, a voluntary American business organization, was formed.

The agreement, which applied only to unrefined sulphur, assigns North America to the American producers, Italy to the Sicilian producers, and the remainder of the world proportionately between the two, with the provision

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[8]R. H. Ridgway and A. W. Mitchell, "Sulphur and Pyrites," <u>Minerals Yearbook</u>, 1936, pp. 895-896.

that Sicily may sell to any country a maximum of 65,000 tons for the manufacture of sulphuric acid. The agreement permits Sicily to export annually a total of 210,000 tons, including the 65,000 tons for sulphuric acid manufacture. It was to be valid until September 30, 1926, but could be dissolved before that time by not less than six months' notice with the provision that the dissolution may not occur during the sulphur selling season.[9]

The agreement was extended in 1926 and the stability of the foreign market, which had been maintained for several years, was threatened by increased production by the Montecatini interest on the mainland of Italy in 1930. Inasmuch as this production was not included in the Sicilian-American marketing agreement and was therefore free to compete in any market, a controversy between the Sicilian sulphur consortium and the Montecatini interest followed. The Italian Government appointed a board of arbitration, and settled the difficulty for a short time.[10]

The Sicilian Consortium was dissolved in 1932, and its stocks of sulphur was taken over, by the bank of Sicily to avoid depressing the market.[11] Reports indicated, however, that the price was lowered in some foreign markets after the marketing agreement between Sicily and the American exporters was nullified by the dissolution of the consortium. Devaluation of the dollar in 1933 placed American exporters in a relatively favorable competitive position with reference to Sicilian producers. This forced

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[9] Ridgway, Information Circular 6329, p. 17.

[9] H. M. Meyer, "Sulphur and Pyrites in 1923," Mineral Resources of the United States, 1923, Part II, p. 1.

[10] Ridgway, Mineral Resources of the United States., 1930, Part II, p. 117.

[11] Ridgway and Mitchell, Mineral Yearbooks, 1932-33, Part III, p. 669.

the formation late in the year of a Central Sulphur Sales Bureau to handle the sale of all Italian sulphur for both domestic consumption and export.[12] In 1934 the newly organized Central Sulphur Sales Bureau of Italy and the sulphur Export Corporation of American formed a new marketing agreement. The new agreement provides for the allocation of world markets between the two principals, excluding, however, North America and Italy. Both parties are obligated not to sell under the minimum price agreed on.[13]

The average quoted price for sulphur, as reported by the trade journals, was unchanged at $18 per ton f.o.b. mines throughout 1935. This price has been maintained in the United States and throughout the world since 1927.[14]

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[12]Ridgway and Mitchell, "Sulphur and Pyrites," Mineral Yearbook, 1934, Part III, p. 907.

[13]Ridgway and Mitchell, Mineral Yearbooks, 1935, Part III, p. 1014.

[14]See Mineral Yearbooks from 1927 through 1936.

CHAPTER III

TEXAS SULPHUR AREAS

Large accumulations of sulphur are known to exist in two far-distant areas of Texas, one of which is the Toyah Basin in Culberson, Reeves, and Pecos Counties of Trans-Pecos Texas and the other area near the Gulf Coast and the mouth of the Brazos and Colorado rivers in Matagorda, Brazoria, Fort Bend, and Wharton Counties. Also a profitable area has been found in Duval County.[1] The history and development of these areas have been as different as the distance is great between them. Therefore, they merit separate treatment.

The sulphur of the Gulf Coast area occurs in the intrusive plugs or domes of rock salt and anhydrite which have pushed up from below to varying distances from the present surface, through the soft and yielding cenozoic formations. Sulphur can be produced only from the limestone cap, although the sulphur occurs also in the anhydrite. The sulphur in the anhydrite cannot be worked because the rock lacks the requisite porosity. Occasionally it is in a more or less continuous bed, but usually it fills seams, fissures, and cavities, or is disseminated through the porous limestone.[2] The cap rock of the worked sulphur deposits is usually from five hundred to one thousand five hundred feet below the surface, but in many domes it has not yet been found, and in other cases it is still nearer to the surface.[3] Of some two hundred known salt domes on the Texas-Louisiana Gulf Coast only nine to date have produced sulphur in paying

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[1] E. H. Sellards and C. L. Baker, *The Geology of Texas*, II, 613.

[2] *Ibid*.

[3] Lindgren, *op. cit*., p. 382.

quantities. Where a sulphur deposit occurs at not too great a depth, say not more than two thousand feet, it may be possible to work it commercially, if other factors are favorable. Eighty-eight true domes have been drilled into. The safest sampling is done by assaying drill cores, calculating the thickness of the sulphur in each hole, and then extending this to adjacent holes. Naturally the thickness of the sulphur-bearing formation is an important factor. The content is usually expressed in tons per acre, anything less than five thousand tons being probably unprofitable. The extraction, of course, is never complete and probably often less than fifty per cent.[4] The diameter of the salt domes varies in size from one-half mile to two miles or more.[5]

The important producing areas, or domes, on the coast are as follows: Bryan Mound, Big Hill Dome, Hoskins Mound, Big Creek Dome, Palangana Dome, Boling Dome, Long Point Dome, and Clemens Dome. Companies developing, or who have undertaken to develop these domes are: The Texas Gulf Sulphur Company, The Freeport Sulphur Company, The Union Sulphur Company, The Duval-Texas Sulphur Company, Baker and Williams, or the Gulf Coast Sulphur Company, and The Jefferson Lake Oil Company of Louisiana.[6] ~~Each dome shall be treated separately.~~

Bryan Heights salt dome is located in the southern part of Brazoria County, Texas, one mile from the coast and three miles south of Freeport, Texas, about forty miles southwest of Galveston, and sixty miles south of Houston.

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[4]*Ibid.*, p. 384.

[5]*Ibid.*, p. 382.

[6]This information was given to me by Mr. A. G. Wolf, Mining Engineer, for the Texas Gulf Sulphur Company.

Attention was first called to Bryan Mound by S. F. Peckham, in a petroleum report of the Tenth Census, 1880. During the oil excitement of the year 1901, the J. M. Guffey Petroleum Company obtained a number of leases around and on the mound and commenced drilling. The field was considered valuless for oil and was abandoned. Other parties acquired the leases subsequently and attempted to drill for oil, but in each case the operations proved fruitless. During the course of this work the drill is reported to have passed through large deposits of lime and gypsum, showing considerable quantities of sulphur. These materials were encountered between seven hundred and nine hundred feet beneath the surface.

In 1906, a company was incorporated to prospect Bryan Mound for sulphur. It was asserted that sulphur had been found in every one of twenty-seven test holes put down, and that about three hundred acres had been proved to be sulphur-bearing to a workable degree. Difficulties were encountered, however, in obtaining a right to mine under the Frasch process patents then in force.[7] This litigation went on for several years, and it seems that the Frasch method, or a variation of it was used in 1912 at Bryan Mound without the permission of the patent owners. Then, the litigation was dragged along in court until 1919. In March, 1919, the litigation was settled by a decision of the court, that the methods used were to all intents and purposes the same as those covered by the original Frasch patents, which had expired, or were matters of such general knowledge that they were not susceptible of patent, and were therefore open to

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[7] Ridgway, "Sulphur," Information Circular, 6329, p. 13.

the use of all.[8]

As has been previously stated, about 1912, the property passed into the hands of the Freeport Sulphur Company, and a plant was erected at a cost of $200,000. During the early part of December, 1912, sulphur was brought up for a few days, but owing to slight defects in the machinery, work ceased for some months. During 1914 or 1915, work was resumed with a greatly enlarged plant.[9] Bryan Mound was a heavy producer from that time until September 30, 1935, when production was permanently discontinued owing to exhaustion of reserves.[10]

Bryan Mound was one of the structural domes characteristic of the Mississippi embankment which is evidenced on the surface by an actual mound, which rises about twenty-two feet above tide-water. The cap rock, roughly circular in shape, with a diameter of about one mile, contains the valuable deposit of sulphur. The sulphur occurs in pockets and cavities and as streaks impregnating gypsum in a formation including limestone and dolomite in which gypsum predominates. The sulphur-bearing formation has a thickness of about one hundred and fifty feet, and it is overlain by seven hundred to nine hundred feet of gravel "gumbo," and "cap rock." One thousand, one hundred and forty-eight wells had been drilled on this property, of seven hundred eighty acres area in an effort

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[8] P. S. Smith, "Sulphur and Pyrites, in 1919," Mineral Resources of the U. S., II, 536.

[9] Ridgway, Information Circular, 6329, p. 13.

[10] Ridgway and Mitchell, "Sulphur and Pyrites," Minerals Yearbook, 1936, p. 904.

to deplete completely the sulphur.[11] The large amounts of water necessary for the mining operations were brought in from the Brazos River in a canal.

The character of the formations at this property make it necessary to resort to muddling operations in order to obtain a workable efficiency from the heated mine water. As the sulphur is removed from the foundations, huge cavities remain because the character of the cap rock is such as not to permit any great subsidence of the unconsolidated formations from above into these cavities. As a result, the heated mine water escapes through these channels without circulating through the formations. In order to combat this, mud is dredged at the surface, and put through classifiers and machines for removing lumps and large pieces of materials likely to plug pipes, and the sludge is finally pumped underground. Its filling of open cavities causes a more efficient circulation of the hot mine water.[12]

The original estimate of sulphur at Bryan Mound was 17,000,000 tons. Slightly over 5,000,000 tons were actually mined before the property was abandoned in 1935.[13]

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[11]Lindgren, op. cit., p. 384.

[11]Ridgway, Information Circular 6329, p. 13.

[11]J. A. Udden and E. H. Sellards, Contributions to Geology, 1928, University of Texas Bulletin, No. 2801, pp. 39-43.

[12]Ridgway, Information Circular 6329, p. 13.

[13]Ridgway and Mitchell, "Sulphur and Pyrites," Mineral Yearbook, 1936, p. 904.

[13]William Kennedy, "The Bryan Heights Salt Dome, Brazoria County, Texas," American Association of Petroleum Geologists Bulletin, Vol. IX, Part I, 1925, pp. 613-625.

The Big Hill Sulphur deposit of the Texas Gulf Sulphur Company is located at Gulf, Matagorda County. It lies about midway on the coast line of the county and one mile from the shore of Matagorda Bay; twenty miles southeast of Bay City and eighty miles southwest of Galveston.

The presence of sulphur in this locality was revealed in 1901, by drilling for oil. In 1909 drilling of the dome for sulphur was undertaken; it resulted in the formation of the Gulf Sulphur Company, succeeded by the Texas Gulf Sulphur Company in 1918. Because of the war demands for sulphuric acid and the possible shortage of sulphur, the federal government aided the development and equipment of the property. Construction of the plant was commenced in July, 1918. The first sulphur was brought to the surface March 19, 1919.[14] The plant was thoroughly modern in all its equipment and was planned to produce at least one thousand tons of sulphur a day.

The furnaces are so designed that if one fuel is stopped, gas or oil, the boilers can be kept going by changing to the other fuel instantly. This necessitates keeping a large supply of fuel oil on hand.

As this mine was developed in a practically unsettled part of Texas it was necessary not only to install the mining equipment but also to build a town and the essential adjuncts for the workers. This gave rise to an industrial settlement planned and executed in accordance with the best modern practice.[15] The sulphur is mined by a variation of the Frasch

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[14]Ridgway, Information Circular 6329, p. 9.

[15]Phillip S. Smith, "Sulphur and Pyrites," Mineral Resources of the U. S. 1919, p. 537.

[15]Charles N. Tunnell, "Texas Dominates the World's Sulphur Industry," in Texas Commercial News, August, 1930, p. 10.

process (described in a previous chapter), the basic principle of which is the injection of large volumes of superheated water into the formations for the liquidation of the sulphur. The water for Big Hill was brought in from the Colorado River by a canal twenty-five miles long. This water is treated by the lime-soda process, before heating. The large amount of water pumped into the ground collects in the sulphur formation because of the impervious nature of the material above and below. The cooled water near the edge of the formation is drawn off through bleed wells, and is not used again because of the impurities it has collected. It is washed into the Gulf.

Production, from the Big Hill Dome, started in 1919, and continued until 1932. It began again in 1936, ran for eight months and closed down permanently. For several years this property produced over a million tons of sulphur a year, during which time it was the largest producer in the world.

In the early days of this dome, it was estimated that over 11,000,000 tons of sulphur were available from the deposit. Records show that 7,000,000 tons had been produced at the end of 1928. With four years and eight months of further production, at a yearly average of 1,000,000 tons, there shows a possible recovery of 11,500,000 tons and better from the Big Hill Dome.[16] It would seem from the above figures that accurate estimates, of recoverable sulphur are possible.

Like other sulphur deposits in this district, that at Big Hill occurs in the cap rock overlying a salt dome. The dome has a diameter of about

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[16] Ridgway, Information Circular, 6329, p. 11.

three-quarters of a mile, and before mining began, the highest point rose to an elevation of about forty feet above the surrounding country. The removal of the sulphur has allowed settling underground, and what was formerly a hill is now a noticeable depression. The cap rock which contains the extensive and important deposits is composed of (1) a barren cap of limestone above, (2) the sulphur barren zone chiefly of limestone which grades below into, (3) a thick deposit of anhydrite barren of sulphur.[17]

The sulphur occurs in massive form in layers; as the filling of irregularly shaped cavities which sometimes are several feet in diameter; in little bunches, specks, and veinlets; and in beautiful orthorhombic crystals lining vergs. It varies in thickness from sixty to ninety feet and occurs in a zone immediately below the limestone at depths of eight hundred and seventy to one thousand, two hundred and fifteen feet. The sulphur content of this zone varies from twenty to forty per cent. Unconsolidated muds and sands lie above the limestone cap. The color of the sulphur ranges from a bright canary-yellow in both the crystalline and massive forms to dark brownish and greenish tints in the massive form. It is all extremely pure, and color is no indication of any appreciable percentage of foreign matter.

Hoskins Mound is in the southeast part of Brazoria County, about fourteen miles north east of Bryan Mound and about twenty-five miles west of Galveston.

Between 1900 and 1905, oil prospecting disclosed the presence of rich sulphur strata at Hoskins Mound, the sulphur ranging in depth from

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[17] A. G. Wolf, "Big Hill Salt Dome, Matagorda County, Texas," Geology of Salt Dome Oil Fields, pp. 691-717.

eight hundred to fifteen hundred feet.[18] Several years passed without any development. Then, the Texas Company of Houston began work late in 1921 on the deposit at Hoskins Mound, which had a reserve said to contain more than ten million tons of sulphur.[19]

Not wishing to engage in the sulphur business, the Texas Company entered into an agreement with the Freeport Sulphur Company on March 14, 1922, for the development of the deposit.[20] A plant costing over $2,555,000 was built and production began in 1923. The average production from Hoskins Mound has been nearly three hundred thousand tons annually. At present it is one of the most important producers of sulphur in the world, being surpassed only by the Boling Dome of the Texas Gulf Sulphur Company.[21]

The character of the deposit closely resembles that at Bryan Mound, previously described. Sulphur is produced at Hoskins Mound by a variation of the Frasch process. Mudding operations, similar to those described at Bryan Mound are used to fill the underground cavities. The main source of water supply is Austin Bayou about five miles from the mound. Large reservoirs afford an adequate reserve of water. The water is treated for the removal of scale-forming and corrosive substances.[22]

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[18] Ridgway, Information Circular 6329, p. 14.

[19] H. A. C. Jenison and H. M. Meyer, "Sulphur and Pyrites," Mineral Resources of the U. S., 1921, p. 169.

[20] H. M. Meyer, "Sulphur and Pyrites," Mineral Resources of the U. S., 1932, pp. 1-2.

[21] Ridgway, Information Circular 6329, p. 14.

[22] Ibid.

During the latter part of 1931, improvements were made at the Hoskins mound plant which increased its water heating capacity from 4,800,000 to 6,250,000 gallons per day, or approximately thirty per cent. The improvements include methods of treating the water supply, the use of gases for preheating fuel water, and other alterations to the boiler and existing equipment.[23] This new improvement with the estimate of the reserve raised from 6,000,000 tons[24] to 11,500,000 tons indicates that Hoskins Mound will continue to be a leading producer of sulphur for sometime to come.[25]

Boling Dome is located in the southeastern part of Wharton County, about sixty miles west of Galveston and fifty miles southwest of Houston.[26] Discovery of sulphur here in paying quantities was made in 1927.[27] The dome was located by geophysical methods incident to the search for oil.

The dome is one of the geologic structure characteristic of the Gulf coast region and is probably the largest salt dome ever found, being more than four miles long in a north and south direction and about three miles wide, as determined by geophysical methods. The extensive sulphur deposit is located in a cap rock which overlies a salt plug and is overlain by more than seven hundred feet of unconsolidated sediments and cap rock. Drilling

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[23] Ridgway, "Sulphur and Pyrites," Mineral Resources of the U. S. 1930, II, 120-121.

[24] H. M. Meyer, "Sulphur and Pyrites, Mineral Resources of the U. S., 1923, p. 1.

[25] Ridgway, Mineral Resources of the U. S., 1930, p. 121.

[26] Ridgway, Information Circular 6329, p. 11.

[26] Sellards and Baker, op. cit., p. 613.

[27] Tunnell, op. cit., p. 14.

has determined as closely as possible the extent and approximate outline of the deposit. The reserves are said to be large, the dome being estimated to contain several times as much sulphur as the deposit in the Big Hill Dome at Gulf.

The sulphur is "mined" by the Frasch process, which was developed on similar properties in this region. The large volume of water required for the extraction of sulphur by this method is obtained from the San Bernard River. The pumping plant has a capacity which is actually much in excess of plant requirements to take advantage of the seasonal variation in the supply of water. Ample facilities for storing water have been provided in the form of a reservoir two hundred and sixty-two acres in extent and capable of holding 750,000,000 gallons. Part of the water required for operation is converted into steam, which is then used to run the pumps, generators, etc., to superheat the remaining water required for extraction of the sulphur, and to supply the steam lines used to keep the sulphur in a molten state until it flows into the storage vats.

The power house has ample capacity for mining purposes and in addition is equipped to furnish electricity, both for plant operation and for townsite uses. All water for boiler feed and for the mine is treated in the Cochrane hot-process plant, which has a capacity of 560,000 gallons per hour. Natural gas is ordinarily used, but fuel oil and even lignite may be employed.

The large quantity of water pumped underground to melt the sulphur eventually requires an outlet. The removal of this water is known as bleeding, and the so-called "bleed water" is removed through wells on the edge of the operating area after is has given up the bulk of its heat.

Because of the impurities it has absorbed in passing through the formations the bleed water is unfit for reuse in the plant and can not be discharged into near-by fresh-water streams. It is therefore aerated to remove hydrogen sulphide, treated chemically to remove other impurities, and then conducted through a ditch twenty miles long to tidewater. The plant is connected by rail with the Gulf, Colorado, and Santa Fe Railway near Magnet and with the Galveston, Harrisburg and San Antonio Railway (Southern Pacific) at Newgulf Junction near the station of Boling.

Production of sulphur from this dome was begun by the Texas Gulf Sulphur Company, in the latter part of March, 1929, and by the end of the year probably in excess of 300,000 long tons had been produced. There was a small production in 1928, and 1929 from certain tracts on the dome by the Union Sulphur Company, which erected a small plant and drilled a few wells. Such production came from leases in which the Union Sulphur Company, and the Texas Gulf Sulphur Company each had an interest.[28]

The Texas Gulf Sulphur Company has spent well over $12,000,000 for its plants and equipment at the Boling Dome. In addition it has built a town for its workers.[29] This large expenditure coupled with an estimated reserve of 40,000,000 tons, indicated continuous activity for many years.

Palangana Dome is in the lower Gulf Coast region and is more than one hundred miles west and south of the deposits in the vicinity of Houston. It is six miles from Benavides, in the east central part of Duval County, or about one hundred and ten miles due south of San Antonio, and about

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[28]Ridgway and Mitchell, "Sulphur and Pyrites," Minerals Yearbook, 1934, p. 915.

[29]Tunnell, *op. cit.*, p. 14.

halfway between Laredo, and Corpus Christi.[30]

Palangana has the characteristic structure of a salt dome. The salt cone is approximately circular in outline with a diameter of eleven thousand feet; it has a flat top covered by a cap rock which extends well down the flanks dipping steeply away from the salt core. Unlike most of the other salt domes of the Gulf Coast region, the surficial expression of this dome is a circular ring of low hills surrounding a central basin. The diameter of the floor of the basin is eight thousand feet, and the diameter of the ring of hills, which use fifty to eighty feet above the floor of the basin, is 15,000 feet. The deposit is reported to cover the greater part of 2,000 acres.

Palangana Dome was discovered in 1916 by the Empire Gas and Fuel Company, during a search for oil. In 1923, a shallow test well on top of the dome disclosed considerable sulphur. In 1924, the Texas Gulf Sulphur Company drilled twenty-five test and the Union Sulphur Company three tests. An estimate was made that this property contained between 500,000 and 1,000,000 tons of sulphur. Production was started November, 1928, and at the end of the year approximately two hundred forty tons per day were being produced.[31]

The sulphur is extracted by the Frasch process, and the water necessary for the operation is obtained from wells in the vicinity and requires no treatment. There are no large surface reservoirs, such as are characteristic of similar operations elsewhere, as the nature of the ground will not

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[30] Ridgway, Information Circular 6329, p. 15.

[31] Ridgway, "Sulphur and Pyrites," Mineral Resources of the U. S. 1929, p. 57.

permit storage of water. Tanks were constructed which contained a twenty-four hour supply of water. With a small set-up in boilers and equipment, as compared to the major plants at the other domes, the Duval Texas Sulphur Company continued to produce sulphur at the Palangana Dome until April, 1935, when its operations there were discontinued.[32]

The Long Point Salt Dome in Fort Bend County was discovered after 1924, and has given evidence of containing a valuable deposit of sulphur. The Texas Gulf Sulphur Company has acquired all the sulphur-mining rights of the Gulf Production Company and has been drilling the deposit to determine the extent of the ore body. A sulphur mining plant was moved to this property from Big Creek Dome, preparatory to mine sulphur on a small scale.[33] Production at Long Point was started in March, 1930, but on a much smaller scale than at the other two operations of this company. No shipment was made from the Long Point property until 1935,[34] although it had been in continuous production since 1930, and had produced well over 200,000 tons of sulphur.[35]

The Long Point dome is characteristic of the Gulf Coast Salt Domes and is comparatively new property. No estimate of its reserve is available.

In the Gulf Coast area, between the years 1924 and 1926, the Union Sulphur Company which owned and operated the Louisiana property, on which

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[32]Ridgway, "Sulphur and Pyrites," Mineral Resources in U. S., 1929, p. 178.

[33]Ibid.

[34]Ridgway and Mitchell, "Sulphur and Pyrites," Minerals Yearbook, 1936, p. 903.

[35]Ridgway and Mitchell, "Sulphur and Pyrites," Minerals Yearbook, 1934, p. 915.

the Frasch process was developed, set up a boiler plant at Damon Mound in the northern end of Brazoria County, and later moved this to Big Creek in Fort Bend County. About three thousand tons of sulphur was produced on these properties before abandonment.[36] Further mention of some of the commercial failures in sulphur production will be made in a later chapter. Domes that are as yet undeveloped will also be mentioned.

The sulphur in Trans-Pecos Texas occurs in the castile formation of anhydrite and gypsum and is found both on the surface and under ground. It is known in appreciable quantity from north of Fort Stockton to the northwest flank of the Guadalupe Mountains in New Mexico, and small amounts have been found in wells drilled in the Permian basin to the east of Pecos River. The deposits can be studied best, however, in an area in eastern Culberson County extending from Delaware Creek, between Delaware and Willow Springs on the north and a line running three miles south of Rustler Springs on the south. There are also some deposits in Reeves County west and northwest of Toyah. In the vicinity of the oil seepage thirteen miles northeast of Fort Stockton, Pecos County, Sulphur occurs in the gypsum at depths between forty and six hundred feet beneath the surface.[37]

The existence of sulphur in this section has been known since 1854, when it was noticed in the bed of the Delaware Creek, by William P. Blake, geologist for an expedition sent out by the United States War Department

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[36]This information was received by correspondence with L. Mims, Vice-President, Freeport Sulphur Company, Houston, Texas.

[37]Sellards and Baker, op. cit., pp. 614-615.

[37]E. L. Porch, Jr., "The Rustler Springs Sulphur Deposits," University of Texas Bulletin, 1722, pp. 13-23.

under the command of Captain John Pope. A sample taken at the Delaware Springs contained eighteen and twenty-eight per cent of free sulphur and samples of water from the springs were found to contain, among other things, considerable sodium sulphide. Among the other important reports that might be mentioned are: Dr. George G. Shumand's under date of September 25, 1855, Dr. Eugene A. Smith's, May 1, 1896, for Science Magazine, and a general summary of the situation up to that time was written by Dr. W. B. Phillips in the University of Texas Mineral Survey Bulletin, number 2, "Report of Progress for 1901; Sulphur, Oil, and Quicksilver in Trans-Pecos Texas." In addition to the above reports there were a number of private reports.[38]

Early in 1916, as a result of war conditions and the increased demand and higher price obtained for sulphur, this well known but neglected sulphur deposit of West Texas attracted the attention of promoters and considerable activity was aroused in their development. Many promotion companies were organized, mainly in the north, and much stock was offered for sale both in northern states and in Texas. Inquiries regarding the deposits and the probability of their commercial development were received by the Bureau of Economic Geology of Texas, in such great numbers that it was deemed desirable to make a study of the deposits.

Dr. Emil Bose and E. L. Porch, Jr., geologist of this Bureau, were sent out early in November, 1916, to make the necessary investigations. After the investigation, Mr. Porch was left in charge of the work. He made a very careful examination and brought the information about the district up to date.[39]

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[38]Porch, op. cit., p. 26.

[39]Ibid., p. 8.

All of the deposits where work was being done or where considerable work had been done in the past, were studied in detail, and all other sulphur occurrences that could be located were visited and examined.

Among the more important developments or prospects studied were: The Johnson Prospect, the Kyle Prospect, the Dot Prospect, the Spann-Welch Holdings, the Holdings and workers of the Michigan Sulphur and Oil Company, the Georgetown Prospect, the Cooksey Prospect, the Stinking Seep Prospect, and prospects on and near the University Lands.[40]

The fact that hydrogen sulphide gas is encountered all over this area, that sulphur is being deposited at the present time from the oxidation of this gas, in solution or otherwise, and that much of the crystallized sulphur, judging by its location, must have been deposited by gases, leads one to believe that this mode of deposition was of considerable, if not of primary, importance in forming this deposit.[41]

The first attempts at mining and extracting the sulphur from any of these deposits were made about 1896 by a Mr. Choteau, of St. Louis, on what is known as the Cooksey property. A vertical extractor, for use of steam, was in use there for some time, and it is reported that two car loads of sulphur were shipped to St. Louis.[42] In 1914 and 1916 most of the prospecting and development work was carried on in the Maverick Springs district. Companies undertaking the development were: The West Texas Sulphur Company, the Toyah Valley Sulphur Company, the Sun Sulphur Company, the United States

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[40] Ibid., pp. 24-55.

[41] Ibid., p. 62.

[42] W. B. Philips, "The Sulphur Situation in Culberson County," Manufacturer's Record, Baltimore, Maryland, December 7, 1916, p. 1451.

Sulphur Company and the Michigan Sulphur and Oil Company. All of these are comprised within an area of five miles south west of Maverick Springs. The American Sulphur Company opened a property near Rustler Springs and produced a small amount of sulphur.[43]

All effort to make sulphur mining pay in this district was unsuccessful. However, we find prospecting still going on there year after year. Jenison and Meyer, in Mineral Resources of the United States, 1921, report the following:

> In western Texas the situation is sulphur fields changed from one of optimism to disappointment. The Texas Sulphur Company of El Paso, Texas, was placed in the hands of a receiver, the Great Southern Sulphur Company of New Orleans, Louisiana, which in 1920 made lavish promises, accomplished little during the year.
>
> It is reported that the Anglo-American Sulphur Company (Ltd.) of London, has purchased one thousand two hundred and eighty acres of patented sulphur and oil lands in eastern Culberson County, Texas. The tract adjoins the property of the Consolidated Sulphur Company of Cleveland, Ohio, in the Rustled Hills district, about twenty miles west of Orla, Texas, on the Santa Fe Railway. The company is reported to have contracted to pay about sixty thousand pounds for the property and to have made a cash payment of ten thousand pounds. An operating company, for the purpose of developing the oil and sulphur resources of the tract, has probably been organized in London by the time of writing.[44]

Evidence of the further progress of this company is not available.

In 1926, it is reported that a car load of sulphur-bearing material was shipped as fertilizer from Culberson County.[45] There is no further mention of production in that vicinity.

The advantages that this sulphur district may have are: (1) it is

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[43] Ibid.

[44] H. A. C. Jenison and H. M. Meyer, "Sulphur and Pyrites in 1921," Mineral Resources of the United States, 1921, p. 169.

[45] C. E. Julihn and H. M. Meyer, "Sulphur and Pyrites in 1926," Mineral Resources of the United States, 1926, p. 297.

seven hundred miles nearer the western points of actual and possible consumption than the deposits at the mouth of the Brazos River; and (2) the initial investment would be comparatively small with respect both to prospecting and development.

There is a considerable amount of sulphur in this district within fifty feet of the surface and it can be mined cheaply. Practically all of the work in mining the sulphur will be by the open-pit and bench system. This system could be used to a depth of fifty feet. It is out of the question to use the Frasch Process, because of the nature of the formations and the deposits. Other underground operations would be very expensive. It must be remembered that it requires a good deal of money to go into the sulphur business and it requires a good deal to stay in it, to be ready to take contracts and to fill them promptly.[46] Also, fuel and water are scarce in that vicinity. There are some sulphur deposits in Culberson and Reeves Counties that are worthy of attention, and can no doubt be made a paying investment by a strong company.[47]

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[46] W. B. Phillips, pp. 1465-1466.

[47] Porch, *op. cit.*, p. 57.

CHAPTER IV

BENEFITS ACCRUING TO BUSINESS AND THE GENERAL PUBLIC, IN TEXAS, FROM THE SULPHUR INDUSTRY

Sulphur has turned out to be one of the most valued friends of the Texas--and the American--farmer, whether he is a cotton planter, a grain grower, or an orchadist, a poultry raiser or a truck gardner. Uses of sulphur on the farm are increasing yearly. One of the most valuable of these uses is in the manufacture of fertilizer, an industry which now consumes more than twenty per cent of all the sulphur produced in this country. This use alone has been of inestimable value to American agriculture. Cotton continues to be of the greatest importance to Texas, and here, too, sulphur plays a significant role. It has been only a few years since agricultural colleges and experiment stations devoted to improving cotton discovered that cottonseed de-linted with sulphuric acid is easier to plant, germinates more rapidly, and produces stronger, healthier plants than seed not so treated. Today Texas is among the States of the South containing cottonseed de-linting stations; the sulphur industry works hand in hand with the cotton farmer. Sulphur has come to the aid of the cotton farmer in waging war against the cotton fleahopper, a tiny insect that has cost Texas farmers many thousands of dollars. Treating cotton plants with sulphur dust stops the fleahopper's damage. The sulphur dusting treatment has increased yield of cotton as much as 361 pounds of seed cotton per acre and has provided a net gain to the farmer of as much as $10.44 per acre.

But it is not only the cotton farmer who enjoys the benefits of sulphur. Grain fields in the West, infested with numerous devastating weeds, are sprayed with sulphuric acid, with the result that the yield of those fields is from fifty to eighty per cent greater than that of unsprayed fields. The orchards of America--notably the citrus groves of the Lower Rio Grande Valley of Texas--are protected from disastrous attack by parasites by sulphur sprays and dusts. On poultry farms sulphur has been used for years in the control of lice, mites, and chiggers, and it has been shown to be of value in fighting diseases that attack poultry. Obviously, the farmers of America have much in common with the sulphur industry of America. To a very great extent, the problems of one are the problems of the other.

Farmers are not, of course, the only class profiting from the use of sulphur. This mineral plays a part in our daily life that is not often recognized by individuals engaged in businesses and professions which do not call for its direct use. The list begins with acids and concludes with water purification, and in between those two there is an amazingly wide diversity of products and industries.[1]

All companies responsible for Texas Sulphur development are likewise responsible for bringing more than mere wealth to the Gulf Coast section of the state. A glimpse at the activities of the Texas Gulf Sulphur Company, the world's largest producer, is only representative of what the several companies have contributed towards making Texas a diversified state with mining and industry keeping balance with farming, ranching,

[1]The information in the foregoing paragraph was taken largely from "Sulphur and Civilization," in Texas Weekly, January 2, 1937, XIII, 4; West, IV, 363, VII, 203,219; and South, p. 4.

lumbering, shipping, manufacturing, and petroleum refining.

At Gulf, a thriving little city of 1,800 population, the Texas Gulf Sulphur Company erected modern homes for employees. Good schools, churches, a hospital, good streets, and all modern conveniences promote the best of living conditions.

Newgulf at the Boling dome, too, has been developed by the Texas Gulf Sulphur Company. Three hundred modern homes equipped with sanitary sewers, electricity, and pure running water are provided for employees. From five hundred to seven hundred workers are employed with a total population of approximately 1,600. Here, too, schools, churches, recreation facilities, and other features have been provided for furthering the education, religion, health, and happiness of members of the industry.[2]

The importance of the Freeport Sulphur Company is reflected in the manner by which the city and its port have developed coincidently with the growth of the industry. Two large mines are operated in the vicinity of the town by the sulphur company, and something like thirty per cent of the world's supply of elemental sulphur is shipped through the port by this company, this tonnage constituting the major portion of the outgoing traffic through the port. The development of the port has been made possible by the assurance of the tonnage contributed annually by the company in the form of taxes.

Therefore the growth of Freeport is traceable to the development of its greatest industry. The Freeport Sulphur Company, since its organization in 1912, has been actively supporting the district program of improving harbor facilities, and the officials of the company are bending every

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[2]Tunnell, _op_. _cit_., p. 16.

effort at the present time to build up industries in the vicinity.[3]

Operations in the Gulf Coast sulphur fields are in every respect characteristic of large scale industry. One is impressed by the magnitude of plants, quality of managerial and labor forces, and quantity and regularity of production.

Huge buildings with smokestacks towering far above the surrounding country may be seen for miles across the level coastal plain, and are made much more conspicuous by the almost complete absence of other developments. Inside these structures are numerous large boilers which heat daily millions of gallons of water and compress similar volumes of air used in steaming the underground sulphur deposits as well as providing heat for all sulphur-transfer lines. The same buildings house electric generators that provide power for drilling, lighting, and to a very limited extent the movement of sulphur. Fuel demands have led to a pipe line extension from considerable distance in order to provide the plants with natural gas which has recently displaced fuel oil. Fuel costs for such a plant may reach $4,000 or $5,000 daily.[4] More than $12,000,000 was invested at Newgulf by its owners in building mining facilities and modern accommodations for employees, while several additional millions of dollars were spent in producing the sulphur reserve before a single ton was shipped to markets.[5]

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[3]C. M. Hammond, "Freeport and Its Sulphur," in Texas Weekly, August 12, 1933, IX, 8.

[4]W. A. Browne, "The Sulphur Industry of the Gulf Coast," in Journal of Geography, XXX, 230-231.

[5]Tunnell, op. cit., p. 16.

Some idea of the sulphur industry's economic value to the state is contained in the following data, acquired from the records of the Texas Gulf Sulphur Company:

Figures for Nine-Year Period, 1925-1934.

Expenditures for labor	$15,300,000
Expenditures for fuel and supplies	29,700,000
Railway freight paid	20,000,000
Taxes to state and subdivisions	10,000,000
Royalties to Land Owners	7,000,000
Total of one company's expenditures flowing directly into Texas channels of trade.	$82,000,000

In addition to the above, it is worth noting that sulphur shipments by ocean going freighters, either coast-wise or foreign, bring into Texas ports many ships which make substantial expenditures for fuel, labor, and other items. The total of such expenditures is not available, but the tonnage of sulphur exported from Texas ports, for selected years, is as follows:[6]

Year	Exports in Tons
1927	848,427
1929	883,121
1931	429,233
1933	514,629
1934	415,147

An analysis of the consolidated purchases by the major sulphur companies of Texas (The Texas Gulf Sulphur Company and the Freeport Sulphur Company) emphasized the economic value of the state's sulphur industry. The analysis is reduced to tonnage actually purchased in an average year, since weight is the only comparable term which may be employed. Dollar terms would be confusing, due to a probable variance in prices paid by the companies, discounts, taken, etc. The analysis follows:

[6]South, *op. cit.*, p. 14.

Purchases of Two Major Texas Sulphur Companies
For an Average Year, In-State and Out-of-State

Item Purchased	Tons Bought In State	Tons Bought Out of State
Automobiles, boats and parts	42	33
Blasting powder, explosives	-	146
Salt Cake	222	66
Commercial fertilizer	130	-
Iron sulphate	-	205
Miscellaneous Chemicals	341	103
Lime	4,254	-
Cement	517	-
Drilling rigs and parts	142	163
Electrical equipment and supplies	35	-
Fuel Oil	1,342	-
Gasoline and lube oils	2,280	-
Ice and food products	1,600	-
Builder's Supplies	425	53
Pipe, iron and steel	-	4,997
Pipe fittings	-	95
Steel plate, bars and rods	7	142
Lubricants	96	7
Lumber	2,097	-
Machinery and repair parts	6	333
Paints and varnishes	134	20
Sand, gravel and shell	2,519	-
Railroad supplies	15	14
Welding gases and black coal	235	90
Miscellaneous	122	113
Fuel gas, MCF	10,000,000	-
Total Tonnage, not including Fuel Gas	16,561	6,580

Local, or intrastate, railroad freight paid by both major companies in a normal year aggregates $2,200,000.[7]

As an employer of labor, the sulphur industry of the state ranks high. Average annual employment of wage earners (not executives, etc.) fluctuates between 1,500 and 2,000 in accordance with conditions in the trade. Average annual payrolls to wage-earners is $2,696,000. All

[7]South, op. cit., pp. 15, 16.

figures are for the two major companies only.[8]

The management and labor force are of comparatively high type. At the head of the business is a corps of efficient, well-trained, and experienced executives and technical staff, including mining, mechanical, and electrical engineers, and chemist stationed in modernly equipped offices, or overseeing the work in the field.

Next in rank is a host of skilled white laborers, as carpenters and mechanics, who also demand high daily wages. And still further down the list a number of unskilled workmen performing the more menial tasks at a relatively lower wage.[9]

Labor is on the eight hour day basis and operations continue twenty-four hours a day, every day in the year. Contentment among the laborers is suggested by the complete absence of any organized troubles. Working conditions within the industry are remarkably fine. Both major companies have inaugurated old-age retirement pension systems with substantial company contributions. Hospitalization provisions are of the most advanced kind, and at company towns, it seems to have been the policy to provide the best possible in the way of recreational facilities, modern conveniences, etc.[10] The "sulphur towns" are towns of good citizens and good citizenship.

Through its payrolls, purchase of supplies, railroad freight charges, etc., totaling millions of dollars annually, in addition to its large tax

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[8] Ibid., p. 15.

[9] Browne, op. cit., p. 232.

[10] South, op. cit., p. 16.

payments, the sulphur industry has contributed largely to the progress and prosperity of the Gulf Coast area of Texas in which it has operated for many years. It has born an important share of the cost of local government in the counties and school districts where its properties are located.

In the four counties in which the industry operates, (Brazoria, Matagorda, Wharton, and Fort Bend) fine highways, beautiful and commodious school buildings, and numerous other public improvements bear tangible testimony to the developing influence of the industry. Independent school districts of which the sulphur properties constitute a very small part in area, are supported almost exclusively by company taxes.

In the nine years from 1925 to 1934, the Texas Gulf Sulphur Company has paid in labor alone an average of about $1,700,000 each year, while its expenditures for fuel and supplies, which likewise bring widespread benefits to labor, averaged approximately $3,300,000 each year during the period.

Its railway shipments involved freight payments of more than $20,000,000 or an average of nearly $2,500,000 annually. Here again, the contribution to labor and general business was most substantial. Here, also, might be mentioned the cost of the upkeep and operation of the loading facilities at Galveston and Freeport.

During the nine year period taxes which the company paid to the state, and counties in which its mines are located reached the total of almost $10,000,000. While paying this sum in support of local and state governments, it distributed approximately $7,000,000 in royalties to land owners in the same period.[11]

The above figures show in a broad way what the sulphur industry means to Texas. Looking at it on a small scale, we will find many benefits that do not merit a discussion in a paper of this kind.

From the start already made by kindred industries coming to Texas, the acid plants, etc., we can look forward to still more benefits from our sulphur industry. Further mention of the acid plants will be made in a later chapter.

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[11] South, op. cit., p. 14.

CHAPTER V

SULPHUR AND TAXATION

Looking briefly at the origin of the tax measures now levied upon sulphur, it may be said that two of them now relied upon had their beginnings with the Republic and continued down to the present day. These are the ad valorem property tax and the occupation taxes. The occupation tax has in the past, as at present included measures which went afield from the principles of taxing mere occupations. At times it has substantially put into operation sales taxes on corporations, levied under the guise of occupation taxes for want of better constitutional authority.[1]

Another tax levied upon sulphur and which is therefore necessary to be considered here is the franchise tax. This tax was first used to produce revenue in 1894 and has undergone various changes, chiefly upward as to rates and bases. The provision of the law under which franchise tax collections are now made fix the tax to be paid on authorized capital stock, surpluses and undivided profits.[2]

Property taxed at ad valorem rates, in the general terms of the statute, consists of all property, real, personal or mixed,[3] except such as may be specifically exempt by law. Real property, for the purpose of taxation includes land and the improvements thereon, and all mines and

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[1] George Armistead, The Texas Tax Problem, pp. 10-11.

[2] Ibid., p. 16.

[3] Revised Civil Statutes of Texas, 1925, Vol. II, Art. 7145.

mineral under the same.[4] Occupation taxes at present may be considered as falling within two groups: first, taxes imposed for a license to do business, and second, upon gross receipts of business enterprises.[5] That group of occupation taxes based upon gross receipts of the tax payer are commonly called "gross receipts taxes" and "gross production taxes." A gross production tax is collected in Texas on petroleum and sulphur. However, this gross production is practically the same as a severance tax. Armistead says that "the gross production taxes levied on the two products in question are as truly severance taxes as if they bore that name."[6]

Our Constitution provides for the above mentioned taxes and places emphasis on equality and uniformity in all taxation.[7] The rule of uniformity has been rigidly construed several times when brought to judicial test, but the attitude of the courts has been marked by reasonable views. The statutory requirement as to taxable value is true and full value[8] defined in law as "the fair market value in cash . . . at the time of assessment . . . the price which could be obtained therefore, at private sale and not at forced or auction sale."[9] Nevertheless, true value is rarely used as the basis of assessment.[10]

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[4] Ibid., Art. 7146.

[5] Armistead, op. cit., p. 16.

[6] Ibid., p. 18.

[7] Constitution of the State of Texas, Art. VIII, Sec. 1.

[8] Revised Civil Statutes of Texas, 1925, Vol. II, Art. 7174.

[9] Ibid., Art. 7149.

[10] Armistead, op. cit., p. 12.

The gross production phase of the occupation tax has at one time and another been submitted to judicial test both upon the issue of constitutional validity and the further constitutional question of equality and uniformity. The courts have held that they were occupation taxes, and that the application was equal and uniform.[11]

Thus, we find the ad valorem tax, gross production tax, and the franchise tax legally levied upon sulphur production in Texas, and interpreted by the courts as equal and uniform taxation. However, all do not agree in the supposed fairness that exists in sulphur taxation. Let us consider the point of view held by those who are of the opinion that sulphur can be taxed adequately by the ad valorem tax only.

Sulphur is now adequately taxed on an ad valorem basis, because all its lands, power plants, equipment and stocks, and practically all of its investment is physical property which can be and is assessed by the county tax assessors and boards of equalization, the legally constituted authorities for assessing and collecting ad valorem taxes. Sulphur producing lands are assessed at values ranging from $2,000 to $18,000 per acre, which but for their mineral values would be assessed at $2.00 to $10.00 per acre. The productivity of lands is recognized by all tax assessing authorities as a factor in determining values. Sulphur producing lands assessed at $18,000 per acre yield products valued at $10,000 to $15,000 per acre per annum. In addition to the real estate value of $2,000 to $18,000 per acre, all power plants, machinery, buildings, derricks, drilling rigs, pipe lines and other equipment used in the production of sulphur are

[11] Ibid., p. 18.

assessed at their market value. The land values are comparable with farm land assessed at $18.00 per acre that produces crop values of $10.00 to $15.00 per acre. But, unlike other products of the soil, which are not taxed after they are produced and held in storage, every ton of sulphur that is produced is held in storage for a period of one or more years and is again assessed as "goods on hand" on the first day of January each year at its market value.

A group of our legislators maintain that as long as the State retains a state and local ad valorem tax, our natural resource industries should not be burdened with severance or gross receipts taxes in addition to the ad valorem tax.[12] George Howard, in the Texas House of Representatives, urged the House not to adopt a policy of "taking necessary funds from industries and putting them in the hands of politicians,"[13] reminding members of the competitive threats of substitutes for sulphur which can be produced in other states.

Instead of imposing heavy taxes on oil, sulphur and other natural resource producers, said Paris Smith, representative from Matagorda and Brazoria County, the State should "put its arms around them and be darn glad to have them here."[14] Otherwise, he argued the State would be faced with the task of paying pensions to persons more than twenty-five years of age rather than sixty-five.

Jeff Stinson, another representative, counseled the House against

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[12] Freeport Sulphur Company Pamphlet (unpublished).

[13] The Dallas Morning News, March 25, 1937.

[14] Ibid.

an excessive increase in the tax on sulphur, recalling that the State's yield declined several years ago when the rate was raised from fifty-five to seventy-five cents a ton, and said a similar condition might result from boosting the tax to as much as one dollar and fifty cents.[15]

The representatives of the sulphur interest in defense of their attitude against higher taxation point to the fact, that in the face of growing taxation in this country, foreign countries such as Italy, Russia, Japan, and Chile are subsidizing their sulphur industries either through outright bounties or through quota provisions to protect home markets or by bilateral trade agreements to encourage foreign demand.[16] Texas sulphur interests appear not to be so much concerned over the prospects of immediate developments from known resources, as over the possibility of intensive foreign explorations uncovering vast new resources that might destroy entirely the present large, though decreased, export market for the Texas product.[17]

It is further pointed out that in considering the problem of taxing sulphur, we must not forget the fact that sulphur mining is a hazardous occupation. Fortunes have been won, but fortunes also have been lost, and many a lifetime of labor spent in prospecting has been left unpaid.[18] Sulphur has been encountered in some quantity in the cap rocks of most Gulf coast salt domes, but only in a very limited number has it thus been found

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[15] Ibid.

[16] The Dallas Morning News, Centennial Edition, June 7, 1936.

[17] Ibid.

[18] Haas, op. cit., p. 423.

to be present in sufficient quantities, or existent under such conditions, as to justify producing operations. Even the Tax Survey Committee was aware of hazards in the industry:

> It would probably be impossible to ascertain the sums of money that have been spent by the sulphur industry in futile prospecting of cap rock areas, although great expense has been entailed. The actual condition can be determined only by drilling and scientific sampling, followed by investments in plants and machinery needed for converting the mineral from a solid to a liquid form, all of which calls for heavy expenditures in many areas on the chance of finding some that can be commercially operated.[19]

The hazards incident to the exploration and productions of sulphur are great, and the question of determining when the existence of sulphur in one of these cap rocks areas is actually susceptible to commercial development is a highly complicated one.[20] Profits cut down by taxation will tend to lessen exploration and development.

Twenty-two states have only a general property tax, with no special taxation on natural resources provided for. Seventeen states that have special taxes on natural resources levy no other tax on them.[21] The Texas sulphur interests pay not only the three types of state taxes, but to this is added the taxes of all other political subdivisions.[22]

The taxes that other industries pay is used also as an argument for fairness in taxing the sulphur industry.

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19 "Taxation of Natural Resources," Report of the Tax Survey Committee, created by the First Called session of the 42nd Legislature, p. 229.

20 Ibid., p. 229.

21 Hammond, op. cit., p. 8.

21 The Dallas Morning News, Centennial Edition, June 7, 1936.

22 Annual Report of the Comptroller of Public Accounts of the State of Texas, 1935, p. 139.

1. Taxes from Sulphur Industry, 1935

Total assessed value	$42,300,000	
State ad valorem tax @ 62¢		$262,260.00
Severance taxes		994,566.17
Total taxes paid to State (not including county and local taxes)		$1,256,826.17

2. Taxes from Goods and Merchandise

Total assessed value	149,261,399	
State ad valorem tax @ 62¢		925,420.06

3. Taxes from Bank Stocks, Money and Credits

Total assessed value	51,646,175	
State ad valorem tax @ 62¢		320,205.82

4. Taxes from Railroads

Total assessed value	192,102,132	
State ad valorem tax @ 62¢		1,191,033.02

5. Taxes from Live Stock

Total assessed value	80,205,440	
State ad valorem tax @ 62¢		497,273.48

6. Taxes from vehicles, automobiles, carriages, etc.

	77,145,173	
State ad valorem tax @ 62¢		478,299.62

7. Taxes from Pipe Line Companies

Total assessed value	111,126,448	
State ad valorem tax @ 62¢		688,938.68

The sulphur industry, with a valuation of some forty-two million dollars, pays into the state treasury, through both ad valorem and severance taxes, nearly thirty per cent more than the state derives from ad valorem taxes on all the merchandise stocks, materials, and manufactured articles; approximately four times as much as the state gets from taxes on bank stocks, money and credits; slightly more than all taxes from railroads; more than twice the taxes from livestock and farm vehicles, and approximately twice as much as taxes derived from pipeline companies. This seems to them an unfair proportion.

Then, the Texas sulphur companies consider themselves as merely producers of crude sulphur. They liken their position relative to the sulphur industry as not different from the place the cotton farmer occupies in the cotton industry. After the crude sulphur is produced and sold, it is either processed or refined and used in acid manufacture of almost countless industrial, commercial or agricultural commodities. The comparatively small price which the producers of crude sulphur receive, therefore, has no relationship to the price which the ultimate consumer pays for products into which sulphur enters as a constituent part.[23] Sulphur is sold under long term contracts, which provide for reductions but not for increases to be passed on to consumers.

Let us now consider the gross production tax, or severance tax. Those who favor it advance various reasons for their opinions. To make ourselves clear let us take Cooper's definition of a severance tax and apply it to the gross production tax now levied on sulphur:

> A severance tax such as referred to here is a tax deducted or severed from minerals produced; it should have a fixed value in dollars and cents applicable to unit quantities produced rather than to the market value of production. It is a tax on the privilege of producing a given quantity of natural resources, and should be paid equally on all production regardless of whatever its purpose or intended use. It should constitute a first lien by the state on natural resources. It should be paid by the responsible operator and no part should be deducted from any royalty payments or contracts.[24]

This is an exact description of the present gross production (occupa-

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[23] <u>Report of the Tax Survey Committee</u>, p. 230.

[24] L. B. Cooper, <u>The Permanent School Fund of Texas</u>, p. 178.

tion) tax. Justification for the present tax is set forth by our State Tax Commissioner as follows:

It has been but a matter of a few years, comparatively speaking, since conservation of natural resources of wealth first began to appeal to the minds of political economists, legislators and others in authority. Since then what was at first but a growing sentiment has ripened into conviction. The theory that a grant of land carried with it an exclusive title extending from the center of the earth to the dome of the sky has been superseded by a more modern doctrine to the effect that minerals and other elements of natural wealth are properly to be considered as a common heritage. So far as concerns the sovereignty, the old fashioned doctrine of "finders keepers" no longer obtains.

The doctrine itself is gradually but surely widening. Once persuaded that a generous Providence never intended these stores of natural wealth for the benefit of the few, it is but a short step to the conviction that they were destined for the benefit of all. And so firmly has this conviction become rooted that in most American states minerals may not be severed from the soil except upon conditions prescribed by the sovereignty itself. Nor will the sovereignty permit waste of natural wealth, mineral or non-mineral. The owner of a forest for example will not be permitted wantonly to destroy standing timber. Under Conservation laws, the state steps in and declares, "Thou Shalt Not!" Ownership of a tract of land, even though enclosed, does not clothe the owner with authority to hunt, trap or kill the wild game found thereon,--except upon conditions prescribed by the state. Neither may the owner of land abutting on a stream take of its waters except upon authority of the State.

It appears to be generally accepted, that irrespective of the verbiage, or terms, of a grant of land from the sovereignty,,the grantee acquires no rights as against paramount needs of civilization. And particularly is this true of minerals fugitive in character which although severed upon one tract of land, may, due to its fugitive state, be drawn from under adjacent or distant tracts. Nevertheless, the principle extends to all sources of mineral wealth. The courts, both state and federal, while differing at times upon methods are agreed upon the principle involved. In Pennsylvania a per ton charge is imposed upon the privilege of severing anthracite coal. In Minnesota, in addition to an ad valorem tax imposed on ore in place, a severance charge is made against production. In Louisiana the severance tax is imposed against all natural resources including oil, gas, sulphur, salt, coal, lignite. In Texas against oil and sulphur only.

At first blush it might appear that a levy of a severance tax in addition to ad valorem taxes means double taxation. As a matter of fact there is no relation between the two. One is a tax upon the value of property acquired and held under the protection of the sovereignty. The other is a charge for the privilege of taking and thus depleting the state's economic wealth. This charge we impose in the form of a tax although precisely stated, it is not in fact a tax but rather a transaction; the state conveying whatever claim it may have, or contend to have, against the mineral in place. Manifestly unless imposed at the point and at the time of severance there would be no way of determining either the value or the volume of the substance involved. Severed from the soil they partake of a distinct and separate being both commercially and as a taxable entity. That they possess value is an established fact. They are here today yet may be gone tomorrow. Certainly the more we draw upon them in the present the less remains for the future.

In fixing the charge for severance, the State should of course be governed by the rule of reason, keeping in mind fluctuating elements usually attendant upon hazardous enterprises. A given rate today may be the equivalent of five per cent of net earnings. Tomorrow the same rate may be the equivalent of ten or twenty per cent. If means could be devised whereby differences in cost of production could be taken into account the charge might be made to bear more uniformly.[25]

With the growth of opinion and conviction as stated above the state has turned definitely toward the severance tax. This is further explained by the increasing urgent need of tax revenues to meet the state's increasing costs in recent years, plus the notoriety given the sulphur industry by its spectacular development and its dominance in the world's markets.[26]

A levy of 2 per cent of value of production existed prior to 1930.[27] In that year it was increased to fifty-five cents (55¢) a ton,[28] and the next year raised to seventy-five cents (75¢) a ton.[29] The present rate is one dollar and three cents ($1.03) a ton having been boosted from seventy-five cents last fall by the omnibus tax bill.[30]

Considerable attention has been given by the state legislature to increased severance taxes on all natural resources in the last two years.

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[25]Twentieth and Twenty-First Annual Report of the State Tax Commissioner for Texas, 1929-1930, pp. 15-16.

[26]The Dallas Morning News, Centennial Edition, June 7, 1936.

[27]Revised Civil Statutes of Texas, 1925, Vol. II, Article 7066.

[28]Geo. H. Sheppard, Gross Receipt Tax Law of 1930, p. 11.

[29]Ibid.

[30]The Dallas Morning News, March 23, 1937.

It was suggested by Governor J. V. Allred that the sulphur taxes levied by Texas and Louisiana should be equalized. He noted reports that a sulphur company had announced its intentions of moving to Texas because Louisiana had increased its production tax to two dollars a ton.[31] "Those companies held the threat of Louisiana over us," he said, "and now they are trying to hold Texas as a threat over Louisiana. It seems to me it would be a fine thing to equalize the taxes between the two states."[32]

John B. Bell, of the House, urging a two dollar rate, contended that sulphur companies had escaped proper taxation long enough while making about 100 per cent annually on their investment. He made the claim that one company invested $6,300,000 in Texas about twenty years ago and had realized a profit of $120,000,000 in that short period of years.[33]

Harry M. Graves, a staunch advocate of a higher tax on sulphur in the House, predicated his demand for a higher tax by a review of the financial set-up of the corporations operating mines in Texas. He stated that the companies make such great profits, amounting to $10 a ton, that they could bear a two dollar tax and never know it. He further reviewed the sulphur situation in Texas by showing that in 1936 Texas produced 1,732,290 tons, while Louisiana, its main competitor, produced only 336,000 tons. He thus sought to dispel the idea that the Texas tax must be kept low to prevent competition from other states. As he viewed it, there is no basis for the threat of importation of sulphur, as Italy,

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[31]National Tax Association Bulletin, Dec. 1926, Vol. XXII, No. 3, P. 1.

[32]The Dallas Morning News, Sept. 22, 1936.

[33]The Dallas Morning News, March 23, 1937.

ranking next to the United States in sulphur reserves, produced 365,536 tons in 1935, compared with 1,632,590 tons in this nation.[34]

J. Franklin Spears, senator from the San Antonio district and a former representative, has contended for the two dollar a ton tax for several years. His arguments for the increased tax is the contention that Texas has a virtual monopoly of the world's sulphur. He quoted approvingly the following estimate of sulphur supply:

> The sulphur reserves of Texas are reasonably estimated at 80,000,000 tons; Louisiana 3 to 4 million tons, and according to the University of Texas, in 1928, the world's reserves exclusive of the above were at that time estimated by Mansfield (an eminent authority upon the subject) to be, on a conservative estimate, 30 million tons and, once liberal estimate, 37 million tons. (Contributions to Geology, 1928, University of Texas Bulletin).[35]

After Mr. Spears has established to his own satisfaction that Texas has a world monopoly and without a doubt a national monopoly on sulphur, he compares the taxes paid from other sources with that paid by the sulphur industries, using the State Comptroller's Report for 1934. It is found that $78,946,868 is directly derived from taxation. $30,656,059, about 45 per cent, comes from the gasoline tax; $22,187,027, about 28 per cent, from the state ad valorem tax, and the next largest item is the gross receipt tax of $8,843,706, of which amount $945,200 is sulphur production tax, paid by the three Texas producers, namely, Texas Gulf Sulphur Company, Freeport Sulphur Company, and Duval Sulphur Company. "A small franchise tax, in addition to the above named amount of production tax, represents the State's only participation in this billion

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[34] Ibid.

[35] J. Franklin Spears, "The Truth About the Sulphur Industry." (An unpublished manuscript)

dollar industry," argues Mr. Spears.

The statement was previously made, in Mr. Spears' paper, that practically the entire state ad valorem tax has been remitted to the counties wherein most of the sulphur properties are located, therefore, the State receives little if any revenue from that source.

The conclusion is drawn from the above figures that the sulphur producing industry paid a little over 8/10 of one per cent of the total revenue received by the state, a relatively insignificant sum. From 1923 through 1934, as reported in Gross Receipts Tax Reports to the State Comptroller, 18,935,885 tons of sulphur were subject to tax in the amount of $6,455,474.90. The average price of sulphur during this period was $16.80 per ton, and the value of the 18,935,885 tons of sulphur subject to tax was $318,133,868. The amount $6,455,474 paid as taxes is about 2/10 of 1 per cent of the total value of the sulphur subject to taxation. The average net profit made on sulphur during the period from 1923 through 1934 was $8.88 per ton, or a total net profit of $168,150,658. The tax paid is less than 4/10 of one per cent of the net profit.[36]

The report of the Tax Survey Committee shows that the sulphur industries made a net profit of 34.69 per cent in 1931. The year of 1931 was a dull year for all industries, and the sulphur industry has shown definite increases in production and in profits since that time. Should the state hesitate to demand a higher tax from its natural resources, when profits this great are made? What will happen if the tax is raised higher

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[36] J. Franklin Spears, "The Truth About the Sulphur Industry." (The above figures were verified by the Tax Survey Report, page 231.)

Mineral Yearbooks for 1931, 1932, 1933, 1934, 1935.

However, the $2.00 per ton proposal was trimmed down to $1.28 before it was finally passed by the House and sent to the Senate.[40] The Senate has been very deliberative this session and has not adopted as yet a tax program. For the past month Senate arguments have centered around an increased natural resource tax versus a sales tax as the best source of revenue for old age pensions and for the general fund.

The original pending plan is a joint resolution by L. J. Sulak proposing a constitutional amendment directing the legislature to levy a two per cent sales tax to pay pensions to all more than sixty-five years of age regardless of financial condition. Clint Small's substitute had to do with those who would receive the pension and also placed a two per cent maximum feature to the resolution. A. M. Aiken Jr's. amendment to the Small plan strikes out the sales tax and substitutes a natural resource impost of six per cent on crude oil, ten per cent on natural gas, ten per cent on sulphur and ten per cent on carbon black, with seventy-five per cent of the income allotted to old age pensions and twenty-five per cent to the school fund.[41] Joe Hill offered a substitute for the Aiken amendment, with very few changes except a graduated scale and a minimum tax of $1.75 a ton, at the mine, on sulphur.

General views held in regard to taxing sulphur are shown by opinions given in the Senate. Aiken argued for the adoption of his natural resource plan to displace the Small sales tax amendment, contending that the state should get tax money from the resources before they are exhausted.

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[40] The Dallas Morning News, March 23, 1937.

[41] The Dallas Morning News, April 14, 1937.

Spears' position is that the natural resources should be taxed before exhaustion and placed beyond taxation; and a sales tax if needed could come later. He favored the Aiken amendment, arguing that the people should be allowed to vote on taxing natural resources as well as a sales tax. Grady Woodruff favored a natural resource tax but with the proceeds to go into a permanent fund instead of current appropriations, so its income would be of benefit to those living after the exhaustion of the resources as well as a proportionate share to be used at present.[42] This seems to be a very fair position to take about a severance tax, and it fits exactly with Cooper's idea, provided, a large share of the severance tax would go to the permanent school fund.[43]

That sentiment is growing in favor of a sales tax for Texas, was shown when the Aiken amendment was tabled by a vote of 17 to 12 in the Senate.[44] What will be done with the House bill increasing the tax on sulphur is yet to be decided.

Special taxation of natural resources is provided for in the constitutions of nine states and in the statutes of sixteen additional states. In some of the states where the provisions are specifically set out in the constitution, the organic document prescribes the method of assessment as a part of the general property tax; in others, it permits the taxation of natural resources in addition to the general property tax; in one, it is provided that no additional tax or license shall be

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[42] Ibid.

[43] Cooper, op. cit., p.182.

[44] The Dallas Morning News, April 16, 1937.

imposed upon oil or gas leases by reason of the presence of oil or gas therein or production therefrom and that no severance tax shall be levied by any political subdivision of the state.[45]

In Texas and Arkansas the severance tax is in addition to all other taxes. In Louisiana and Oklahoma the severance tax is accepted in lieu of all other taxes on the producing properties.[46] It appears that taxing agencies generally are turning definitely to the severance tax for a part of their revenue.

From the various views presented, we see that no one opposes the severance tax in its entirety. The sulphur interests favor a reasonable severance tax policy,--one that does not single out that industry and leave other natural resources untaxed. Under the present system, our natural resource industries regard themselves at continual war with all tax units. It is the opinion of many that if all are to share the benefits of natural resources, then the natural resources industries should be relieved of the burden of ad valorem taxes, local and state, and pay only a state severance tax. This conclusion is arrived at because of the impossibility of exact appraisal on the mineral property.

If only the severance tax were levied against the sulphur and other natural resource industries, the fear of erecting plants in lean fields would be minimized. The producers could seek out and prospect in new fields, knowing that the ad valorem spectre would not be hovering over them. Also, mines could be worked to greater completeness, which is greater

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[45] Armistead, op. cit., p. 136.

[46] Ibid., p. 145.

conservation of our resources. The sulphur producers cannot tarry on land that is valued at $20,000 per acre and pay the multiple *ad valorem* taxes on the land and mining equipment for the last few tons of sulphur that might exist in an almost depleted deposit.

CHAPTER VI

THE FUTURE OF THE TEXAS SULPHUR INDUSTRY

Mineral deposits are among the most highly prized treasures of any state or nation. They are the basic resources through which states achieve industrial greatness and through which they are able to maintain their supremacy. With them the foundations are laid for a rich industrial evolution; without them no state can hope for a sustained industrial and commercial advance. Indeed, the cultural complex of a nation is, to a very high degree, mirrored in the per capita consumption of minerals, both as to quantity and variety.[1] The extensive use of minerals, among which sulphur ranks high, clearly differentiates the complexity of the highly developed nations of today from the simplicity of long ago.[2]

Sulphur and other minerals differ from some of the great groups of resources in that they are not only exhaustible but are also not reproducible. Worn-out soils may be rejuvenated, forests regrown, reservoirs refilled by rains; only in the mineral world does nature rarely replace. Man can have no part in their formation, only in their exhaustion. No substitutes are available on a large scale. Substitution of one mineral for another is possible and of common occurrence. But if the mineral is exhausted before the substitution is made, the results are decreased efficiency and an upward revision of cost.

The great discoveries in the sulphur world may well be, therefore,

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[1] W. H. Haas, "Our Mineral Treasures," Our Natural Resources and Their Conservation.... p. 409.

[2] Jones and Holt, op. cit., p. 586.

not so much in the location of larger and richer deposits, as in the invention of means of greater efficiency in using what has already been found. A further important point about the future of the sulphur industry is price and profit stability. As profit is the only motive, except with government subsidies, for bringing sulphur into use, any change in one or more factors of production makes it impossible for the sulphur miner to work any deposits but the richest. If there was less competition in the industry and a stabilized market, the sulphur domes and areas could be worked to a greater degree of completeness. That there are many undeveloped sulphur areas is true; yet most statistics do not tell the full story. There can be no certainty or definiteness as to the amount or the length of time such reserves will be sufficient for industry. It is an easy matter, relatively, to determine the cubic contents of a sulphur deposit and to estimate by analysis the amount of sulphur available. But the answer to the question, can the sulphur area be worked profitably in our present state or knowledge and equipment, has so many unknowns and variables that the conclusion can be little more than mere personal opinions even of those most capable of judging.[3]

Therefore, in looking at the future of the sulphur industry in Texas, let us turn our attention to the following phases: the Texas reserve; substitutes for sulphur in industry; sources of sulphur outside of Texas; and getting the most good from the Texas reserve.

The reserves of sulphur in sight on the Gulf Coast salt domes amount to some ninety million tons definitely available and five million tons

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[3]Haas, op. cit., p. 423.

ultimately available in considerable part. The present world consumption of sulphur is about two million tons per year, of which the Texas-Louisiana salt domes produce about 70 per cent. The reserves in sight will suffice for some fifty years of production at the present rate.

The undiscovered reserve cannot be estimated, although shrewd guesses can be made in regard to maximum and minimum limits. Twenty of the coastal group of domes may be classified at once as improbable prospects for sulphur on account of the excessive depth of the cap rock. Nine domes are impossible as sulphur prospects under the present conditions, as the depth to the top of the cap is slightly greater than the maximum depth at which sulphur can be mined commercially at present. But it is possible that those domes will become commercial prospects before another quarter of a century. Eight domes known to have thick limestone caps close to the surface have not been drilled sufficiently to be judged. Old wells on several of them are reported to have shown evidences of sulphur. There are some twenty domes newly discovered by the seismograph about which very little is known. How many domes may yet be discovered is, of course, unknown. It seems probable that in southeastern Texas all the domes have been discovered which come close enough to the surface to be possible sulphur prospects. There is a distinct possibility that domes possible as sulphur prospects will be discovered in South Texas. From the eight domes that are known to be distinctly possible prospects, one or possibly two may prove to be sulphur deposits of the first class with a reserve of five or ten million tons each, and two or more may have small deposits with an aggregate reserve of some ten million tons probably not commercially minable at present.

Of the twenty domes recently discovered, and of the fifteen domes previously discovered yet to be explored, two-thirds will probably be condemned by the first drilling. From the remaining ones, the guess may be made that two contain commercial deposits, each with a reserve of five to ten million tons, and three or more contain small deposits not commercial at present with an aggregate reserve of from five to ten million tons. There is also the distinct possibility of the discovery of another extremely rich sulphur dome such as Boling, with a reserve of fifty or more million tons. The shrewd guess may be made, therefore, that the undiscovered sulphur reserve amounts to at least twenty and possibly to ninety million tons available under present conditions of production and some ten to thirty million tons available ultimately. The probability seems to be better that the figures of the maximum estimate are too low by fifty per cent than that the figures for the minimum estimate are too low by twenty-five per cent.

These estimated reserves afford about ninety years supply of sulphur at approximately the present rate of production. The chances seem greater that these estimates are too conservative than that they are too liberal.[4] The above estimate does not include the sulphur reserves in Reeves and Culberson Counties, which reserve will be of importance under proper economic conditions.[5]

A fairly accurate appraisal of the technological trends in the sulphuric acid industry may be gleaned from a study of developments in industries accounting for the much greater part of sulphuric acid consump-

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[4]Udden and Sellards, op. cit., pp. 44-46.

[5]See pages 45-49 above.

Quoting from Chemical and Metallurgical Engineering, for January, 1931:

Among the most powerful competing influences are those that will be encountered in fertilizers and fertilizer raw materials. As a fertilizer raw material of present importance and even greater future consequence, nitric acid is a remarkable example of this tendency. Where a few years ago all of this material was made by potting Chile nitrate with sulphuric acid, now the bulk is produced by the oxidation of ammonia.--While nitric acid production has almost eliminated sulphuric acid from its own raw material requirements, it is simultaneously bidding for sulphuric acid markets in other fields.--As a component of fertilizer raw materials, sulphuric acid suffers a severe disadvantage. It serves only as a raw carrier or means of making some other material available, and has itself little or no fertilizer value. Nitric acid, on the other hand, answers the demand for nitrate in fertilizer and at the same time serves to increase the availability of other materials. Phosphoric acid has the same advantage, and it has been used for the production of so-called triple superphosphate rock. When the acid used is itself a fertilizer material, instead of being only a carrier, as in sulphuric acid, demands for concentrated and complete fertilizers are often more easily met.[6]

In the phosphate industry, two processes are being developed--one for making phosphoric acid, and the other for making acid phosphate fertilizer --which will not require the use of sulphuric acid as heretofore.

All told, in the fertilizer industry--whcih in 1930 consumed 38.2 per cent of the country's sulphuric acid production--the prospects for sulphuric acid are far from encouraging. Refiners of petroleum in 1930 used 19.4 per cent of the sulphuric acid produced in the United States. It ranks as the second largest consumer of the acid. Here, however, the situation is potentially worse for sulphuric acid than in the fertilizer field. Quoting again from Chemical and Metallurgical Engineering:

Possible loss of sulphuric acid markets is more imminent in the petroleum industry (than in the fertilizer industry). Traditional practice in refining gasoline has been to reduce the sulphur content to 0.1 per cent by an acid treatment which also removes gum-forming compounds. It is

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[6] "Three-Cornered Competitive Battle Centers About Sulphuric Acid," Chemical and Metallurgical Engineering, Vol. XXXVIII, pp. 35-36.

estimated that this procedure costs the industry, over the expenses of adequate refining, an excess of $50,000,000 per year in loss of product, reduction in anti-knock properties, and acid. Recent work indicates that such stringent reduction in sulphur is neither necessary nor desirable,--and the possible decrease in acid consumption is large. Should hydrogenation make wide-spread gains, the probable loss is even greater, for this process eliminates the sulphur as H_2S and makes acid necessary only for the removal of gum-forming constituents. Indeed, petroleum hydrogenation may actually turn the tables and make the refining industry a large H_2SO_4 producer with acid to sell. Based on petroleum consumption at the 1929 rate, 173,000,000 short tons, and assuming an average value of $\frac{1}{2}$ per cent sulphur, there would become available from this source approximately 865,000 tons of sulphur, equivalent to 4,200,000 tons of 50 deg. acid, or slightly more than half the entire sulphuric acid production from all sources.[7]

In 1930 chemical manufacturers make a market for 10.7 per cent of the sulphuric acid produced in the United States. Here, again, improved processes and the increasing use of substitutes are cutting deeply into the sulphuric acid market. According to Chemical and Metallurgical Engineering,

Acetic acid is a good example. Here direct processes, which remove the acid from pyroligneous liquor without the intermediate calcium acetate step, have eliminated the use of sulphuric acid by a large part of the industry. Synthetic processes have further reduced H_2SO_4 consumption. Hydrochloric acid is an example. The old salt and sulphuric method gave way to the salt and niter cake process which in turn yielded to the production of HCl as a by-product of organic synthesis, and by the combustion of chlorine and hydrogen.[8]

Iron, steel and other metallurgical operations in the past have used great quantities of sulphuric acid (in 1930 consumption was 8.7 per cent of the whole) principally for pickling. New methods, either independent of acid, or returning a large part of the acid used, already have cut deeply into the market. The assumption that greater inroads will be made is supported by the statement that the Titanium Pigment Company of St. Louis is now successfully and profitably treating ferrous sulphate into

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[7] Ibid., p. 36.

[8] Ibid.

sulphuric acid and a residue cinder of iron oxide.

State laws against pollution of streams have forced more and more steel plants to neutralize their wastes, and the new process makes this profitable. It is significant that it also makes it possible for many plants to make part of their own sulphuric acid which, in this country, has heretofore been manufactured only from pyrites of free sulphur.[9]

Summing up its analysis of the future for sulphuric acid, the authority quoted concludes:

There are many possible and probable points of attach upon the uses for sulphuric acid. As a basic and extremely well-known material, sulphuric acid may expect to become with increasing frequency the butt of cost reducing programs.[10]

Development in the United States, no doubt, is paralleled in foreign countries where the people count more closely the elements of cost than do we.

Conditions confronting the sulphuric acid industry (since it takes 75 per cent of the production of all sulphur, whether of brimstone, pyritic or by-product form) constitute a major factor in any determination of the future prosperity of the world brimstone industry, of which the Texas industry is so large a part. Competition among the brimstone, pyrites and by-product industries, both for the business of sulphuric acid manufacturers and others, completes the picture.

In 1930, the world sulphur industry's peak year, world consumption of sulphur drew upon the competing forms of raw materials as follows:

Pyrites	48 per cent
Brimstone	35 per cent
By-product sulphur	17 per cent

For comparison, the figures for 1913:

Pyrites	70 per cent
Brimstone	26 per cent
By-product sulphur	4 per cent

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[9] *Ibid.*, p. 506.

[10] Ibid., p. 36.

The most conspicuous gain, of course, was that made by by-product sulphur. It appears improbable that this form of sulphur will make comparably large gains in future years; but, upon the other hand, it is certain that it will become an increasingly important factor in the world sulphur industry. In this connection, it is well again to read what the editors of Chemical and Metallurgical Engineering have to say:

Estimates place the present (1930) recovery of by-product, metallurgical SO_2 at from 10 to 40 per cent of the total of that economically suitable for H_2SO_4. Legislation, actual or impending, may be expected to demand increasing recovery as time goes on.--One authority anticipates that the Middle West, the Tennessee region and the Idaho-Montana district are the future producers of cheap sulphuric acid and that they will doubtless become important fertilizer centers. Another believes the Southwest should be added to this list.[11]

However, legislation is not the only factor simulating the recovery of sulphur by chemical and metallurgical processes. In other countries, such as Germany and England, where neither brimstone nor pyrites are available in sufficient quantities to effect independence of foreign sources of supply, by-product sulphur is being southt for its own worth. Chemical Age, of London, editorially utters this significant observation:

Another raw material of the chemical industry is facing a crisis. Most chemical processes depend at one stage or another upon acids; sulphuric acid is the most easily procured of the acids, and the cheapest. Thirty per cent of the output of sulphuric acid in Britain was formerly used for the manufacture of sulphate ammonia.

Today, in spite of strenuous efforts, no satisfactory method has been found for the use of ample supply of sulphur contained in coal. Nevertheless, gypsum now supplies the necessary radicale without the interposition of the acid maker, and Mr. Appleby is able to say that sulphate of ammonia is as often as not made without sulphuric acid. Cost of sulphur prohibits the general use of sulphur for making sulphuric acid in England and in many continental countries, and gasworks oxide, sulphurous ores and so forth are primarily used.

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[11] Ibid., p. 37.

Closer to home, in Canada, similar efforts are directed to increasing the production of by-product sulphur. An Associated Press dispatch, dated Trail, B. C., April 14, 1935, carries this significant item:

> Authority has been recently received by the Consolidated Mining and Smelting Company of Canada, Ltd., to proceed with construction of a sulphur recovery plant to extract sulphur dioxide from the zinc plant gases, officials announced today. The plant, costing approximately $2,500,000 will increase the production of sulphuric acid and will also produce elemental sulphur for the market. Construction will start immediately.

And at home, the same trend is observed. Howard Carswell, eminent financial writer, in the New York World Telegram for June 28, 1935, writes:

> A new process which it hopes will prove more economical and efficient in the recovery of by-product sulphur from waste smelter gases has been developed by the American Smelting Company and will be tried out on a semi-commercial basis within a few months, it was learned today. An appropriation has been set aside for the building of a small semi-commercial plant at the Company's Garfield smelter near Salt Lake City. Initial production will amount to only two tons or more daily. Whether the by-product will be issued in the form of sulphuric acid, liquified sulphur dioxide gas or, more importantly, elemental sulphur, has not yet been decided.

The facts are that sulphuric acid produced from smelter and stack gases is so cheap that it not only becomes an important factor in the market, but acts as an effective brake upon any possible recurrence of price manipulations such as that so unsuccessfully attempted by French interest when they came into control of what was then Sicily's almost absolute monopoly upon brimstone production. By-product sulphur is the great threat in the world's sulphur industry.

Between 1913 and 1930 producers of pyrites suffered a substantial loss in what had been their share of the world's sulphur market. This loss of 22 per cent was transferred as gain, 9 per cent to the brimstone producers and 13 per cent to by-product producers.

The pyrite producers are now making tremendous efforts to recover all or part of their lost markets. By-product sulphur, in view of the conditions and circumstances which characterize its production, is immune to attack. In other words, all gains recorded by producers of pyrites will be at the expense of the brimstone miners. And they are making gains.

In the United States, the production of pyrites has evidenced consistent increases. According to the Bureau of Mines, production has mounted through the past four years:

Year	Long Tons Produced	Value
1932	189,703	$ 489,570
1933	284,311	769,942
1934	432,524	1,216,363
1935	506,215	1,569,672

Tennessee was the largest producing state, others being California, Colorado, Missouri, Montana, New York, Virginia and Wisconsin.

In Australia, the government is discouraging importation and paying a bonus of thirty-six shillings per ton for all sulphur, or its equivalent in pyrites, domestically produced. Production was initiated in 1934 and reached 15,000 tons; production in prospect for 1935 exceeds 35,000 tons.

Canada, where tremendous reserves of pyrites are known to exist, has build the first plant using the Freeman flash-roasting process for recovering iron and sulphur dioxide from iron pyrites. Production will be used by Canadian paper mills which now constitute the major market for American brimstone producers.

In Finland the government operates its own pyrite mines and sells to domestic paper mills at about cost price. Production in 1935 is estimated to equal domestic requirement and leave over for export about 8,000 tons. In Germany, besides stepping up production of by-production sulphur, every means are being used to stimulate production from pyrites. In Greece a large new deposit of pyrites has been discovered. Norway's Orkla mines are producing sulphur from copper-bearing pyrites by the Lenander process. Formerly an importer, Norway now supplies its domestic requirements and has become an export factor. Production in 1934 was about 70,000 tons and plans are to increase production within a few years to 200,000 tons annually. Figures are not available for 1935. Portugal produces the equivalent of 100,000 tons of sulphur each year. It meets its own needs and exports a small surplus. Spain is increasing its exports from pyrites. Sweden, using a process similar to that employed in Norway, now produces about 30,000 tons of sulphur annually. Current reports have it that production will be stepped up to meet domestic needs and compete for the export trade in Scandinavian countries. Production is from metallic sulphides.

The total new production for 1934 and 1935 specifically cited in foregoing paragraphs amounts to more than 375,000 tons of sulphur per annum. Increase for which definite figures are not cited undoubtedly would exceed the specific total.

The inescapable conclusion, therefore, is that pyrites, slowly but surely, are recapturing from brimstone the markets lost subsequent to 1913; and processes being perfected indicate the rate of recovery will be considerably accelerated with the years.[12]

In the light of present information, it appears certain that the Texas industry faces a contraction rather than an expansion of its exports. It

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[12]The above information was taken largely from South, pp. 6-11. See also Ridgway and Mitchell, "Sulphur and Pyrites," Mineral Yearbook 1936, pp. 895-914, and Chemical and Metallurgical Engineering, Vol. XXXVIII, pp. 24-27, 28-31, 35-38, 498-503.

is equally obvious that the Texas industry sells its products in a highly competitive market, where prices are controlled by products of related industries, the by-product and pyrite groups, rather than by the Texas industry or the world industry of brimstone, of which it is a part. Thus the price of sulphur is governed by supply and demand.

To stabilize production in Texas, to insure maintenance of future production at the stabilized level, and to bring to the state the greatest benefits from possession of a basic resource it would appear that a co-ordinate effort could be made to locate in Texas, where Texas sulphur would be the raw material most economically available to them, units of those industries which, both in the United States and abroad, furnish the greatest market for brimstone. Reference is made here, of course, to acid manufactures, and the paper industry.[13]

At present there are only four acid plants in Texas, whose combined output does not satisfy the needs of this state.[14] Further development could be encouraged by the commercial position Texas occupies due to the proximity of its sulphur producing region to the low-cost water transportation of the Gulf of Mexico.[15]

The future possibilities of the sulphur industry is expressed by the Centennial Edition of <u>The Dallas Morning News</u>:

> The location of a larger number of sulphuric acid plants in the State would be the first step toward this development in the great fabric of

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[13] South, *op. cit.*, p. 17.

[13] *The Dallas Morning News*, Centennial Edition, June 7, 1936.

[14] Johnson, *op. cit.*, p. 108.

[15] *Ibid.*

general industry which sulphur is in position to bring about.

As a matter of fact, the great significance of the sulphur deposits to Texas is found in the history of the development of manufacturing industry in this country in recent years. This history revolves largely around the fact that manufacturing is "going commercial." The old purely mechanical processes are giving way to new processes in which the chemical process is predominant. Texas has a boundless supply of raw materials for encouragement of the chemical industries--its forest products, textiles, petroleum and gas, coal and lignite, salt, lime, sulphur and others.

All of these offer advantages to Texas in its program of future industrial development, but sulphur offers a peculiar advantage in that it enters so largely into the manufacture of the products of all of these raw materials. Only a small percentage of sulphur ever arrives in the hands of the individual consumer's product. Its consumer is the manufacturer, and Texas needing more manufacturers will need its sulphur supply and find it of primary usefulness in the era of industrial development ahead.

Sulphur ranks third among the raw mineral products of the state on basis of value. Its role in the future economic development of the state can not be calculated, but it is destined to be large if Texas goes forward from its centennial year according to the hopes of its citizens.[16]

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[16] *The Dallas Morning News*, Centennial Edition, June 7, 1936.

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