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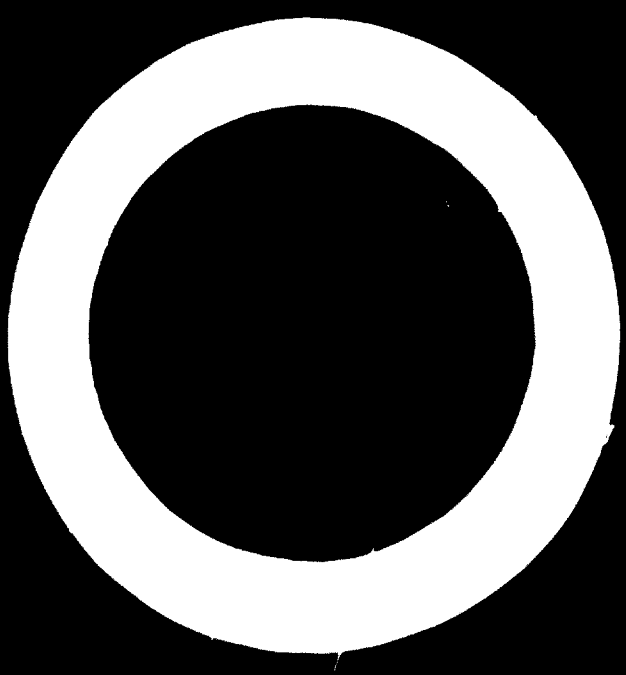
WORLD SULPHUR SUPPLY AND DEMAND

1960-1980

UNITED NATIONS

WORLD SULPHUR SUPPLY AND DEMAND 1960–1980



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Preface

This analysis of world sulphur supply and demand was prepared for UNIDO by M. N. J. Horseman of the British Sulphur Corporation Ltd., London, serving as consultant to the United Nations Industrial Development Organization. The views and opinions expressed in this publication are those of the consultant and do not necessarily reflect the views of the secretariat of UNIDO.

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Reference to tons is to metric tons unless otherwise stated.

Reference to dollars ($) is to United States dollars unless otherwise indicated.

The shillings (s.) and pence (d.) referred to in this text are the former British currency units.

Dates divided by an oblique stroke (e.g. 1960/1961) indicate a crop year or a financial year.

Dates divided by a hyphen (e.g. 1960–1970) indicate the full period involved, including the beginning and end years.

References to "the present decade" relate to the 1960s.

The following abbreviations have been used:

c. and f.	=	cost and freight
f.i.o.	=	free in and out
f.o.b.	=	free on board
f.o.r.	=	free on rail
p.s.i.g.	=	pounds per square inch gauge
S.O.F.	=	sulphur-in-other-forms

INTRODUCTION

The sulphur resources of the world are present in the earth's crust in numerous forms, but their exploitation does not always lead to the production of sulphur in its elemental form. The production of sulphur involves more than just mining and refining ores to yield a product that contains 99.5 per cent S or better; production also involves mining and utilizing the sulphur values in sulphide and sulphate minerals, and the recovery of the sulphur content of hydrocarbons such as oil and natural gas.

Elemental sulphur is present in sulphur ores that were created by volcanic action or ores that are associated with such related phenomena as fumaroles and solfataras; elemental sulphur is present also in deposits associated with sedimentary rocks such as limestone. These occurrences are generally known as native sulphur ore irrespective of the type of host.

Sulphur resources in the form of sulphide minerals include deposits of iron pyrites, cupreous pyrites and pyrrhotites as well as deposits of pyrite and pyrrhotite associated with non-ferrous metal sulphide ores. The sulphur values in non-ferrous metal sulphides may also be realized by the utilization of sulphur dioxide in smelter gases at plants where ores or concentrates are converted into metal.

Occurrences of sulphur in the form of sulphate minerals are represented chiefly by calcium sulphate (gypsum or anhydrite), the output of which is included in world sulphur production. Calcium sulphate is exploited for its sulphur values, for example, as a raw material for the manufacture of sulphuric acid or ammonium sulphate. The same exploitation and use also applies to the synthetic product phospho-gypsum which is produced during the manufacture of phosphoric acid by the acidulation of phosphate rock with sulphuric acid.

Sulphur is also found in association with liquid and gaseous hydrocarbons, most abundantly in coal, and with a few notable exceptions the petroleum crude oils of the world contain significant amounts. Sulphur is present in abundance in world oil reserves represented by oil sands and shales. Reserves of sour natural gas have become increasingly important in recent years as an energy source, and gas sweetening and sulphur recovery operations yield elemental sulphur as a co-product or by-product of pipeline gas. Sulphur associated with coal may be liberated as by-product pyrite which is produced during coal beneficiation, or it may be recovered from combustion gases notably in the form of sulphuric acid produced from hydrogen sulphide.

To distinguish between the various forms in which world production of sulphur is realized, three terms are commonly used to identify the sources and uses of the world's sulphurous raw materials; they are: *brimstone (bright and dark sulphur), pyrite*, and *"sulphur-in-other-forms"*.

Brimstone

The term brimstone which applies solely to sulphur produced in its elemental form, is used to distinguish between elemental sulphur and all other types of sulphur, and to avoid the confusion created by using the word sulphur to designate aggregate production of sulphur in all of its forms. Three methods or types of brimstone production are referred to as: Frasch sulphur process, recovered sulphur production, and native refined sulphur production.

Frasch sulphur and native refined sulphur are produced by exploitation of native sulphur ore, the former being brimstone produced by the Frasch process of hot water injection and liquid sulphur recovery, and the latter, brimstone produced by conventional ore mining techniques followed by treatment in a beneficiation/refining plant. Recovered sulphur production takes place mainly at oil refineries and natural gas plants where desulphurization units provide H_2S streams for sulphur recovery plants which extract the sulphur content in its elemental form.

Pyrite

Included in the pyrite category is the mining of pyritic ores to obtain iron pyrites, cupreous pyrites and pyrrhotites as the main products or the recovery of by-product pyrite and pyrrhotite at operations producing, for example, lead, zinc, or copper concentrates from sulphide ores other than iron sulphides.

Sulphur-in-other-forms (S.O.F.)

Sulphur production involving forms other than brimstone or pyrite is grouped in this general classification and includes native sulphur ore used directly to produce sulphuric acid without prior refining into brimstone. Sulphur-in-other-forms is used to produce sulphuric acid, and such forms can be produced from a variety of sources, in addition to unbeneficiated sulphur ore, such as the following sulphur-containing materials:

(a) SO_2-containing waste gases at zinc, copper, lead or nickel smelters;
(b) Gypsum or anhydrite;
(c) H_2S content of oil refinery or coke-oven gases;
(d) Oil refinery acid sludge;
(e) Spent oxide;
(f) Ferrous sulphate;
(g) Filter cake (residues from the filtration of Frasch or native refined sulphur);

or in a form that does not go through the process of sulphuric acid production such as:

(a) Gypsum or anhydrite used for ammonium sulphate production;
(b) Smelter gas SO_2 used for liquid sulphur dioxide production;
(c) Spent oxide used in pulp manufacture;
(d) Unbeneficiated sulphur ore used in certain agricultural and industrial applications.

To indicate the sum total of sulphur production from these different sources, a further delineation is used which is "sulphur-in-all-forms". For example, aggregate world output of brimstone, plus the sulphur content of pyrite and the sulphur equivalent of sulphur-in-other-forms, is termed the world's sulphur-in-all-forms production to distinguish between total production of a particular type of sulphur and total production of all types.

PART I

Chapter 1

WORLD SULPHUR SUPPLY AND DEMAND 1960–1969

World sulphur supply

Before 1970 world production of sulphur-in-all-forms was approaching 40 million tons annually (see figure 1). For 1969 it was estimated that the aggregate output would have increased by 5.1 per cent on the 1968 level to end the year at 38.9 million tons. Just over half of the world's sulphur is produced in its elemental form—as brimstone—from the Frasch process, and from recovered and native ore mining/refining operations.

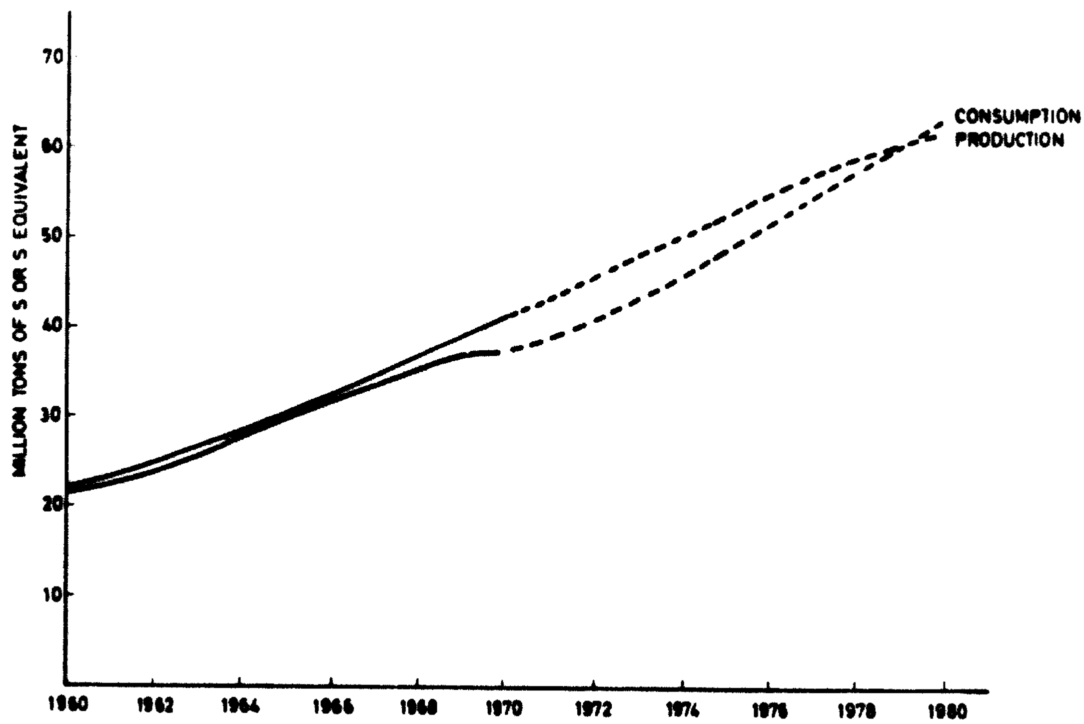

Figure 1. World sulphur-in-all-forms production and consumption

In 1968 brimstone production accounted for approximately 53 per cent of total all-forms production (37.1 million tons) which means that a very substantial proportion of world sulphur supply still materializes in non-elemental forms such as pyrite and the various types of sulphur-in-other-forms. It has been the rapid expansion of brimstone production, however, that has seen the most significant development in the pattern of sulphurous raw material supply during the present decade. Although the 1969 output of brimstone was not expected to exceed 55 per cent of world sulphur-in-all-forms production, it represented no less than two thirds of the net increase of 16.6 million tons of in-all-forms supply since 1960.

Table 1 shows that world brimstone production during the 1960s was expected to more than double or to increase to over 21 million tons, whereas world production of pyrite and sulphur-in-other-forms was expected to increase by 41 per cent and 61 per cent respectively.

TABLE 1. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION (1960, 1968, 1969)

	1960	*1968*	*1969*
Total production[a] (million tons)	**22.3**	**37.1**	**38.9**
Brimstone	10.2	19.8	21.0
Pyrite	8.1	11.0	11.4
Sulphur-in-other-forms	4.0	6.3	6.4
Total production (per cent)	**100.0**	**100.0**	**100.0**
Brimstone	45.7	53.4	54.3
Pyrite	36.3	29.7	29.3
Sulphur-in-other-forms	18.0	16.9	16.4

[a] Totals may not add because of rounding.

Brimstone

At the present time, the principal sources of world brimstone supply are the Frasch sulphur mines in the United States and Mexico, the operations in Poland that use a modified version of the Frasch process, and the recovered sulphur plants associated with natural gas treatment units—notably in Canada, France and the United States. Although production of native refined sulphur was an important factor in the earlier history of the world sulphur industry, it now accounts for only a minimal proportion of total production, and except for the relatively large-scale operations in the USSR, Poland and Japan, the unfavourable economics of sulphur ore mining and refining compared with production of Frasch and recovered sulphur have led to the relative decline of this sphere of activity in the sulphur industry.

During 1969, world brimstone production exceeded 20 million tons for the first time and it was envisaged that the outturn for 1970 would amount to some 21 million tons. The major contribution of Frasch sulphur to total brimstone supply is evident in table 2 which shows that about half the aggregate world output is attributable to mining operations using this method of production. Next, and rapidly increasing in importance, is the production of recovered sulphur, the output of which was nearly 41 per cent of world brimstone production in 1970. Native refined sulphur output is currently steady at some 2.4 million tons/year which represents about 11 per cent of total production in 1969 compared with 12 per cent in the previous year.

TABLE 2. WORLD BRIMSTONE PRODUCTION (1968, 1969)
(Thousand tons S)

		1968	*1969*
Total production/type		**19,859**	**21,042**
Frasch sulphur		9,978	10,050
Recovered sulphur		7,530	8,594
Native refined sulphur		2,351	2,398
Total production/source		**19,859**	**21,042**
Sub-total:	*Major sources*	*16,094*	*16,920*
Frasch	United States	7,574	7,220
	Mexico	1,608	1,650
	Poland	796	1,180
Recovered	United States	1,420	1,530
	Western Canada[a]	3,088	3,660
	France, Lacq	1,608	1,680
Sub-total:	*Other sources*	*3,765*	*4,122*
Recovered	Western Europe	397	438
	Eastern Europe[b]	635	715
	Others	382	571
Native	Eastern Europe[b]	1,675	1,700
	Japan	261	260
	Others	415	438

[a] Provinces of Alberta and British Columbia only.
[b] Including USSR.

Frasch sulphur

In the production of sulphur using the method devised by Herman Frasch in the latter part of the last century, superheated water, under pressure, is injected into sulphur-bearing formations with subsequent recovery of molten sulphur in liquid form. Until the recently successful application of this process to native sulphur deposits in sedimentary rock in Poland and then in the United States in the western part of Texas, Frasch sulphur production had been confined to the exploitation of native sulphur associated with salt dome structures beneath the coastal and off-shore areas of Texas and Louisiana, and to anticlinal structures in the Isthmus of Tehuantepec in Mexico. One of the major hurdles that had to be overcome before the Frasch process could be extended to the mining of sulphur deposits in sedimentary formations was the difficulty of maintaining a reservoir of molten sulphur around the base of the recovery pipes—something that is more readily accomplished in a deposit of dome sulphur overlain by an impermeable cap rock.

World production of Frasch sulphur originates chiefly in the United States where production has been between 7.0 and 7.5 million tons/year since 1966. Two other countries, Mexico and Poland, account for the remaining output which amounted to some 2.8 million tons in 1969. Since early 1968, Mexican production has been comparatively stable at a rate of 1.60–1.65

million tons/year but output in Poland has been accelerating and passed the 1.0 million tons/year mark in 1969.

United States. The established dome operations in the United States Frasch sulphur industry are located in the southeastern part of Texas, southwest of Houston and near Beaumont; in the Mississippi delta area of Louisiana; and off the coast of Louisiana. Two companies, Freeport Sulphur Company and Texas Gulf Sulphur Company, account for a major proportion of United States Frasch sulphur production, the former operating mines solely in Louisiana and owning both the units sited on platforms in the Gulf of Mexico and the latter, as the name implies, based mainly in Texas but with one of its six mines—Bully Camp—in Louisiana. The only other Frasch sulphur producer operating more than one dome on the Gulf coast is Jefferson Lake Sulphur Company; the remaining output comes from five small-scale operations each currently yielding approximately 100,000 tons/year.

The inauguration of production at a large-scale facility in the Rustler Spring area of Culberson County in September 1969 by Duval Corporation has confirmed the emergence of western Texas as a major source of Frasch sulphur, the new mine in the vicinity of Fort Stockton joining the other mines which were already exploiting native sulphur deposits in limestone formations.

Mexico. Frasch sulphur mining is conducted at three locations in the province of Veracruz inland from the port of Coatzacoalcos. While mineralogically similar to the native sulphur occurrences on the United States Gulf coast, the structure of the Mexican deposits is more irregular geologically and the sulphur-bearing structures take the form of anticlines as opposed to the salt plugs in the United States. Formerly run by majority-owned subsidiaries of United States companies, the Mexican Frasch sulphur mines are now operated in two instances by Mexican companies in which a United States interest is held on a minority basis (Azufrera Panamericana S.A. and Cia. Exploradora del Istmo S.A. are 34 per cent owned respectively by Pan American Sulphur Company and Texas Gulf Sulphur Company), and in the third instance the Salinas mine operated by a 100 per cent United States subsidiary—Cia. de Azufre Veracruz—recently sold by the parent company, Gulf Resources and Chemical Corporation, together with the latter's other sulphur interests, to a Mexican company, Inversiones Azufreras S.A.

Poland. Polish production of Frasch or Frasch-type underground molten sulphur from the sedimentary sulphur deposits in the southern part of Poland is carried out by Zjednoczenie Kopalnictwa Surowcow Chemicznych, the Chemical Raw Materials Mining Association, which is also responsible for the production of native refined sulphur. The mines at Jeziorak and Grzybów have been greatly expanded in recent years from the early experimental facilities built to test the feasibility of applying the Frasch process to deposits of native sulphur ore associated with limestone and gypsum-bearing limestone formations.

Recovered sulphur

Nearly 9 million tons of brimstone are produced each year from the treatment of natural gas, oil refinery gases and other industrial gases; such recovered sulphur is second only to Frasch sulphur as the most important single source of world sulphur-in-all-forms supply. The extraction of sulphur in gaseous and liquid hydrocarbons is determined by several considerations related particularly to shipment requirements, end-product quality requirements and controls governing atmospheric pollution by sulphurous gases. In the case of natural gas, the exploitation of a sour crude necessitates the extraction of its H_2S content to comply with product specifications laid down for pipelines and by natural gas consumers. Further gas plant treatment of the H_2S downstream from a desulphurization unit results in the recovery of sulphur in elemental form and this by-product brimstone together with extracted liquified petroleum gases (LPGs) contributes to the valorization of the crude gas. Except when a sour gas plant is so remotely located that it makes marketing and hence the recovery of sulphur uneconomic, and the flaring of desulphurization gases permissible, there is normally a direct correlation between production of sour natural gas and recovered sulphur – to the extent that such brimstone production is often termed involuntary.

The refining of sour crude oil results in the presence of H_2S and organic sulphur compounds in the various refined products, but the quality requirements of the lighter fractions, i.e. down to gas oils and diesel oils, normally necessitate the extraction of sulphur. Most of the original sulphur content of the crude oil, however, remains in the heavier fractions, fuel oils, residual oils, coke and bitumen. Part of the sulphur in the lighter fractions is removed in unrecoverable form but most is recovered either as brimstone or directly as sulphuric acid (see below, sulphur-in-other-forms). The recovery of sulphur from fuel oils and residual oils is only a recent innovation but in the light of public policy in many countries to curb air pollution and specifically SO_2 emissions from power stations and other industrial facilities burning fuel oil, new restrictions on the sulphur content of such oils will lead partly to an increase in recovered sulphur production either in the oil consuming countries or at the sources of production.

In a few instances, recovered sulphur production arises as a result of the carbonization of sulphur-containing coals and the subsequent extraction and treatment of hydrogen sulphide. More commonly practised during the early part of this decade and before, but now restricted to one operation in Finland, is the smelting of pyritic ores and the recovery as brimstone of the labile S-atom of pyrite.

World production of recovered sulphur derives from three principal sources of supply—the sour natural gas treatment plants in the Canadian provinces of Alberta and British Columbia, in the southwestern part of France at Lacq, and the gas plant and refinery based units in the United States. From an anticipated production of recovered sulphur amounting to 8.59 million tons in 1969. these three sources were expected to account for 80 per cent of the total.

Western Canada. The development of the sour natural gas reserves in western Canada started in the mid-1950s and recovered sulphur production began to assume major proportions towards the end of that decade. The output comes at present from almost 40 plants, all but two of which are located in Alberta, with daily brimstone production capacities ranging from 20–2,000 tons. While in many cases the ownership of the natural gas and sulphur recovery plants is shared by more than one company, with the result that the brimstone output is distributed among the participants for shipment against separate sales programmes, one company is usually designated as operator of the facilities in such instances. There are at the moment eight major producers with the following total production capacities:

Operating/producing company	*Total production capacity (thousand tons/year)*
Hudson Bay Oil and Gas Company Ltd.	855
Texas Gulf Sulphur Company	739
Petrogas Processing Ltd.	662
Shell Canada Ltd.	634
Amoco Canada Petroleum Ltd.	605
Gulf Oil Canada Ltd.	418
Canadian Superior Oil Ltd.	335
Jefferson Lake Petrochemicals of Canada Ltd.	265

One of the producers of western Canada, Great Canadian Oil Sands Ltd., operates a sulphur recovery plant at Athabasca which is the first in the world to be associated with the exploitation of tar sands. The balance of Canadian brimstone production originates at other gas processing plants in Alberta and British Columbia, relatively smaller in scale than those above, and at oil refineries in eastern Canada.

France. All but a fraction of French recovered sulphur output is produced by the public sector company, Sté. Nationale des Petroles d'Aquitaine (SNPA) at the world's largest sulphur recovery complex which consists of six individual plants at Lacq and one unit exploiting gas production from the neighbouring St. Faust field. Since the start of production in 1957, SNPA has progressively expanded its production capacity and brimstone output is currently running at a rate of 1.6–1.7 million tons/year.

United States. Production of recovered sulphur from the world's third most important source of supply, the United States, is not connected exclusively with the processing of sour natural gas as it is in western Canada and France, nor is there the same degree of concentration in the recovered sulphur industry of the United States in terms of a limited number of major producers accounting for a sizable proportion of total output from a select group of large-scale plants. Such conditions exist in western Canada and even more so in France where SNPA is the sole significant producer. Nevertheless, for the United States industry with its wider geographical distribution of recovered sulphur facilities and the smaller scale of operations generally at individual locations, it is evident that there are certain key areas of production. The first area includes the oil refinery-based operations in California, the Gulf coast in Texas, the Atlantic coast (in New Jersey, for example) and in the states around the Great Lakes; the second area is the natural gas-based operations in Texas and Wyoming. In all, there are some 130 sulphur recovery plants in the United States deploying a total production capacity of some 3.2 million tons/year, over half of which is based on oil refinery H_2S; the annual output of recovered sulphur in the United States currently amounts to some 1.5 million tons.

Other recovered. The remaining 20 per cent of world recovered sulphur production which is attributable to operations outside those in western Canada, France and the United States derives in a similar fashion from plants attached to oil refineries and sour natural gas treatment facilities, and also from units based on the treatment of oil-associated well-head gas, industrial gases and SO_2 gases from pyritic smelting. The noteworthy sources of supply in Europe, apart from the USSR, are Finland, the Federal Republic of Germany and the German Democratic Republic, and to a lesser extent, the Netherlands and the United Kingdom. Production takes place mainly at oil refineries, but Finnish output is from pyritic smelting and a growing proportion of USSR production and that of the Federal Republic of Germany is connected with the exploitation of indigenous sour natural gas resources.

Large-volume production of recovered sulphur began in the Near East during 1969 with the commissioning of oil refinery units in Kuwait and sour natural gas plants in Iran. Plant capacities installed or under construction indicate that the Near East is scheduled to become a major source of world recovered sulphur production in the next few years and together with additional projects in Saudi Arabia, Iraq and Syria, these Kuwaiti and Iranian operations will make a considerable impact on the future pattern of sulphur supply in the Indian Ocean/South-East Asia area.

Other important centres of the recovered sulphur industry are Japan, where legislation against air pollution and tighter restrictions on the sulphur content of imported fuel oils has stimulated plans for an extensive increase in sulphur recovery capacity at oil refineries, and Central America where output in Mexico and the Netherlands Antilles is also mainly associated with oil refining.

Native refined sulphur

Deposits of native sulphur ore not amenable to mining by the Frasch process are found throughout the world and contain sulphur in elemental form commonly in concentrations up to 35 per cent S, occasionally in grades up to 70 per cent S and even as pure sulphur in some volcanic deposits. Native sulphur ore mining is conducted by conventional opencast or underground methods and the mine output is subjected to a refinery process to separate the sulphur from the gangue material.

With few exceptions, sulphur ore deposits are relatively small and are often inaccessible. The economics of brimstone production as native refined sulphur are influenced principally by ore grades, distances between mines and refining plants, the refining process employed in terms of its recovery efficiency and utilities required, and the distances from production points to market outlets. Because of the comparatively small scale of most native refined sulphur operations, the excessive production costs compared with other sources of brimstone and the high transport costs incurred in moving output from remotely located production points, the exploitation of native sulphur ores, other than by the Frasch process, has not progressed in proportion to the over-all growth of world brimstone supply.

However, the merits of large-scale operations, where possible, are such that native refined sulphur production can be more than economically viable and the size of mining operations in some countries, notably the USSR and Poland, attests to this.

World production of native refined sulphur amounts to some 2.4 million tons/year (equivalent to 11 per cent of total brimstone production), the output arising on a measurable scale from mining and beneficiation plants in only fourteen countries. The leading supply sources are the USSR and Poland where aggregate production was anticipated to be 1.7 million tons (70 per cent of the projected world total of 2.4 million tons) for 1969. In Poland and partly in the USSR, native sulphur mining exploits sulphur mineralization associated with marine Miocene sediments of the Carpathian foredeep which extend from Austria and Czechoslovakia through Poland and into the Ukraine, the ore being located in sulphur-bearing limestone within beds of sulphate rocks.

The occurrences of native sulphur in Japan, which is the third largest producer of native refined sulphur, are of volcanic origin and found in a multiplicity of deposits. The industry's growth has been severely restricted in recent years as escalating production costs rendered the output from some of the mines uncompetitive. The operations that remain are faced with the possibility of competing with a growing volume of recovered sulphur production unless the latter is shipped almost entirely to export markets.

Appreciable quantities of native refined sulphur are also produced in China where ore is mined in Szechwan and adjoining provinces, in Central and South America, particularly in Chile, Bolivia, Argentina and Mexico, and in Italy where since the mid-1960s, production has been centred on the Sicilian deposits—the oldest source of brimstone supply in the world.

Pyrite

The pattern of world pyrite production is dominated by the activities of producers in western and eastern Europe, the USSR and Japan which between them account for about 80 per cent of total output (see table 3).

Almost all the remaining production comes from operations in North America, Morocco, South Africa and four other countries in Asia. In respect of its contribution to sulphur-in-all-forms supply, pyrite represents less than one third of aggregate all-forms production. In 1969 the output was expected to amount to 11.4 million tons S-content out of a total of 38.9 million tons.

TABLE 3. WORLD PYRITE PRODUCTION (1968, 1969)
(Thousand tons S content)

	1968	*1969*
Total production	**10,959**	**11,403**
Economic Commission for Europe (ECE) area	*7,219*	*7,560*
Cyprus	482	485
Germany, Federal Republic of	254	265
Italy	590	600
Norway	310	400
Portugal	270	275
Spain	1,250	1,300
Sweden	225	230
Romania	330	340
USSR	2,700	2,800
Economic Commission for Africa (ECA) area	*408*	*432*
Morocco	127	140
South Africa	237	250
Economic Commission for Asia and the Far East (ECAFE) area	*2,470*	*2,548*
Japan	1,450	1,475
China	575	590
Korea, Democratic People's Republic of	190	200
North America	*833*	*830*
Canada	465	470
United States	368	360
Economic Commission for Latin America (ECLA) area	*29*	*33*

World pyrite production originates either as a primary mine product (irrespective of its grade in relation to commercial or technical requirements concerning quality) or as a concentrate obtained as co-product or by-product from the beneficiation of other ores—usually non-ferrous metal sulphides. Where pyrite is mined as a main product, it is either supplied as crude pyrite, or in the few instances where the crude pyrite fails to conform with commercially or technically acceptable standards, as washed pyrite or concentrate.

The essential difference between the two broad categories of pyrite is that main product pyrite is normally priced and used on an "all values" basis whereas co-product or by-product pyrite is usually sold and used solely for its sulphur content. With the aim of ensuring adequate return on mining and production operations, and reflecting its status as the principal result of such operations, main product pyrite is valued for its sulphur content, as well as that of the iron and non-ferrous metal values that can be recovered from the cinder after the pyrite has been roasted to produce an SO_2 gas stream. On the other hand, co-product or by-product pyrite concentrates represent the tailing of non-ferrous metal sulphide ore which has been beneficiated for its non-ferrous metal content. Thus most, if not all, mining and treatment costs are covered by the main product, e.g. copper, lead, zinc concentrates, enabling the producer to cost the co-product or by-product pyrite at its marginal value. In most cases however the value of the co-product or by-product pyrite is its sulphur content as the tailings residue has virtually no recoverable non-ferrous metal values and the iron content may be rendered of limited worth by the presence of impurities in the form of non-recoverable, non-ferrous metals. In western Europe, for example, by-product pyrite accounts for a significant proportion of pyrite production in countries such as Cyprus, Sweden, and the Federal Republic of Germany in association with the production of copper, lead and zinc concentrates and iron ore whereas pyrite output in Italy, Portugal and Spain arises largely, or even wholly, in the form of a main product. Other notable instances of by-product pyrite production are provided by the operations in the gold mining industry of South Africa and in North America at plants producing copper, lead and zinc concentrates.

ECE area. The pyrite-producing countries in western Europe are so located that they may be classified conveniently according to their regional group, that is, Scandinavia, northwestern Europe, the Iberian peninsula and around the Mediterranean. There are three producers in the Scandinavian area, namely Norway, Sweden and Finland. Norway, as one of the principal exporters of pyrite to western European markets, sells about 70 per cent of its output abroad. The Swedish production derives from the mining operations of only two companies, as it does in Finland, whereas Norwegian production is in the hands of eight companies. In northwestern Europe, pyrite is produced in the Federal Republic of Germany and in France, though in the latter case the output represents only a modest proportion of domestic all-forms production. The pyrite deposits in the southern part of the Iberian peninsula run from the Aljustrel and Louzal areas in Portugal through to the famous Spanish operations near Huelva and are exploited at a production rate of 1.4 million tons S content annually, the balance of the production arising from smaller mines in the Spanish provinces of Sevilla, Murcia and Asturias. Finally, in western Europa there are the producing countries around the Mediterranean—Italy, Cyprus and Greece. Cyprus is distinguished from the other two in that it relies solely on export business for the disposal of its output whereas Greece uses its output captively and Italy imports almost as much pyrite as it produces from indigenous resources.

The main pyrite producers in eastern Europe are Czechoslovakia, Romania and Yugoslavia with a combined output of 0.6 million tons/year S content, accounting for about 75 per cent of the total output of eastern Europe. Particularly important supply sources are the major Czech mine at Neratovice, the Muntii Metalici and Moldova Nua deposits in western and southwestern Romania, and the Yugoslav operations at Trepča and Bor and Maidan-Pek in the northeastern part of Serbia which produce pyrite in association with the beneficiation of mixed sulphide and copper ores respectively. Pyrite output in the USSR is represented by cupreous pyrite, iron pyrite and pyrite concentrates yielded by the differential flotation of sulphide minerals, notably copper ore and zinc blende. Production, which has increased rapidly in recent years and is reportedly nearing the 3.0 million tons/year level, is being shipped to domestic consumers and a range of export markets.

ECA area. Virtually the entire production of pyrite in Africa comes from Morocco and South Africa. In Morocco the product is pyrrhotite, containing some 33 per cent S, which is mined at Kettara about 60 miles from the port of Safi. Iron pyrite occurrences are widespread in South Africa and most of the deposits contain other valuable minerals with the result that output is mainly in by-product form arising from the treatment of tailings and residues from gold and uranium production.

ECAFE area. Apart from the production of 0.7—0.8 million tons/year pyrite in China and the Democratic People's Republic of Korea, the pattern of supply in Asia is dominated by the output of Japan. Pyrite deposits are worked on all four of the main Japanese islands but the most important operations are those in Shikoku and Honshu. The origin and types of deposit vary considerably and include:

(a) Deposits consisting mainly of iron pyrite which may be present in black ore (Kuroko, also containing galena, zinc blende and barytes); in deposits with some pyrrhotite and copper ores; and in bedded deposits as cupriferous pyrite;
(b) Pyrite deposits associated with sulphur ore;
(c) Deposits consisting mainly of pyrrhotite and other metal sulphides.

Japanese production of pyrite and pyrrhotite currently amounts to some 1.5 million tons/year S content which is almost 60 per cent of total output in the ECAFE area and 13 per cent of the world total. The remaining production of pyrite in Asia and Oceania derives mainly from the Philippines, Turkey and Australia, each of which produces less than 100,000 tons/year S content at the present time.

North America. A substantial annual tonnage of pyrite is produced in Canada and the United States but, in view of the large-scale production of brimstone in both countries, pyrite makes only a limited contribution to sulphur-in-all-forms supply—about 11 per cent in Canada and 4 per cent in the United States. In Canada, the two pyrite producers, Noranda and Anaconda, ship all their output to sulphuric acid manufacturers in the United States while the two pyrrhotite producers, International Nickel Company

(INCO) and the Consolidated Mining Company (Cominco) respectively deliver and use roaster gas SO_2 for sulphuric acid production. Only one company operates pyrite production facilities on a significant scale in the United States—Tennessee Copper Corporation, a division of Tennessee Corporation—accounting for about 85 per cent of aggregate production against the captive requirements of its sulphuric acid plants.

ECLA area. Only a minimal level of pyrite production is realized in Latin America, operations being confined to the working of a cupreous pyrite deposit in Cuba and the recovery of pyritic tailings as a 46 per cent S concentrate at a copper refinery in Chile.

Sulphur-in-other-forms

Sulphurous materials in forms other than brimstone or pyrite make a significant contribution to world sulphur-in-all-forms supply. Almost 6.5 million tons/year S equivalent is produced, mainly as sulphuric acid and ammonium sulphate; the 1969 out-turn was forecast to represent some 17 per cent of all-forms production. The exploitation of sulphur-in-other-forms for sulphuric acid manufacture accounts for 90 per cent of world other-forms output, the most intensively used sources being the sulphur dioxide content of non-ferrous metal smelter exit gases, oil refinery acid sludge, gypsum and anhydrite, sulphur ore and hydrogen sulphide.

Non-acid uses of sulphur-in-other-forms are covered chiefly by ammonium sulphate production which is based on the direct reaction between calcium sulphate as gypsum or anhydrite, and ammonia, and carbon dioxide, and the use of smelter gas SO_2 for the manufacture of liquid sulphur dioxide.

As far as the offtake of other-forms for sulphuric acid is concerned, the practice of recovering the SO_2 content of metal smelter waste gases is a well-established one and originates partly as a practical step to meet growing needs for sulphuric acid and partly as a necessity to avoid atmospheric pollution in the vicinity of the smelters. The most abundant source of smelter gas SO_2 is the sulphur content of zinc blende which when roasted yields a gas with a steady SO_2 content in contrast to the lower and fluctuating SO_2 content in gases obtained from the smelting of lead concentrates. In fact, SO_2-bearing lead smelter gases are infrequently used alone as a sulphuric acid plant feed, and a more common approach is to upgrade the SO_2 gases with a stream from an associated zinc smelter. Less frequent use is made of copper smelter gases even though the sulphur content of such concentrates is readily recoverable, and in some producing countries, Finland, Japan and Zambia, for example, it accounts for a major share of the available input for smelter gas acid operations.

Another important source of other-forms for sulphuric acid production is oil refinery acid sludge, which is the dirty residue of sulphuric acid used in alkylation plants. It is decomposed to free SO_2 which is fed to an acid plant for a fresh make and the subsequent production of virgin acid is redelivered to the refinery. The H_2S content of oil refinery and coke oven gas streams are partly utilized for the direct production of sulphuric acid, although in some cases the sulphur content is recovered in elemental form, i.e. as brimstone. Calcium sulphate, in the form of anhydrite or gypsum, spent oxide from the dry purification of coal gas, ferrous sulphate from steel pickling plants, filter cake from Frasch and native refined sulphur filters and unbeneficiated sulphur ore provide the balance of the sulphur-in-other-forms used for acid manufacture.

On a regional basis, the world's production of sulphur-in-other-forms is concentrated in western Europe and in eastern Europe, the USSR, Asia and North America; together, these continental groups realized 97 per cent of total output during 1968 (see table 4). The degree of concentration is even more significant than the percentage figure suggests; from a total of more than 40 producing countries some 83 per cent of the other-forms production is attributable to the seven major producers in Europe plus the USSR, Japan, Canada and the United States.

TABLE 4. WORLD SULPHUR-IN-OTHER-FORMS PRODUCTION (1968, 1969)
(Thousand tons S equivalent)

	1968	*1969*
Total production	**6,258**	**6,421**
Economic Commission for Europe (ECE) area	*3,455*	*3,564*
Belgium	186	185
France	150	150
German Democratic Republic	205	205
Germany, Federal Republic of	276	285
Italy	274	280
Poland	200	210
USSR	1,130	1,175
United Kingdom	499	515
Economic Commission for Africa (ECA) area	*115*	*120*
United Nations Economic and Social Office in Beirut (UNESOB) area	*3*	*3*
Economic Commission for Asia and the Far East (ECAFE) area	*1,231*	*1,243*
India	108	110
Japan	896	900
Australia	128	130
North America	*1,362*	*1,400*
Canada	241	250
United States	1,121	1,150
Economic Commission for Latin America (ECLA) area	*92*	*91*

ECE area. For the most part, the incidence of sulphur-in-other-forms output in the principal producing countries reflects the offtake of sulphurous values for sulphuric acid manufacture. Although the situation reversed in 1968, only in the case of Italy in recent years has the production of other-forms as non-acid products been greater than that for sulphuric acid, a situation which results from the use of a substantial quantity of gypsum/anhydrite in the manufacture of ammonium sulphate. Gypsum and anhydrite also figure prominently in the pattern of sulphur-in-other-forms supply in the United Kingdom, as they are consumed for ammonium sulphate and for sulphuric acid and account for over 70 per cent of other-forms output. Production in Belgium is almost entirely in the form of smelter gas sulphuric acid and also in France and the Federal Republic of Germany, except that the latter two are additionally significant as producers of H_2S-based acid. Operations in eastern Europe and the USSR similarly reflect the extensive use of non-ferrous metal smelter gases for sulphuric acid plant feedstocks and in Poland a particular variation on the pattern of other-forms acid feedstock utilization is the employment of filter cake residues from the native refined sulphur operations.

ECAFE area. To date, Japan has been the only significant source of sulphur-in-other-forms supply in Asia although an emergent smelter gas acid sector in India is beginning to provide a further boost to Asian and, of course, Indian production, the latter being still mainly derived from gypsum-based ammonium sulphate output. Japanese production consists largely of smelter gas sulphuric acid, although the country is also noted as a leading consumer of unrefined sulphur ore for sulphuric acid manufacture.

North America. Sulphur-in-other-forms supply in Canada is based wholly on smelter gases that are required for liquid SO_2 as well as sulphuric acid, but in the United States appreciable tonnages of sulphuric acid are produced from sludge acid and hydrogen sulphide in addition to smelter gas.

Other producers. The remaining share of world sulphur-in-other-forms production is derived from operations in Australia, Africa and Latin America and emerges chiefly from smelter gas acid plants although in the Caribbean this is supplemented notably by the petroleum industry's H_2S-based and sludge acid-based sulphuric acid output.

World sulphur demand

The incidence of world sulphur-in-all-forms consumption emphasizes the degree to which demand emanates from the chemical and fertilizer manufacturing industries in Europe, the USSR and North America since possibly the most prominent feature of the pattern of use is the fact that four out of every five tons of sulphur used throughout the world are consumed in these three areas. From a total of 35.53 million tons S consumed in 1968, the combined consumption of the ECE area countries, the USSR and North America amounted to 27.99 million tons and if certain other developed countries such as those in Oceania and Japan are included in the sub-total,

TABLE 5. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION (1968, 1969)

(Thousand tons S or S equivalent)

	1968				1969			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	**35,532**	**18,766**	**10,508**	**6,258**	**37,374**	**19,972**	**10,960**	**6,421**
ECE area	*16,466*	*6,120*	*6,891*	*3,455*	*17,242*	*6,460*	*7,218*	*3,564*
Western Europe	9,904	4,013	4,131	1,660	10,250	4,234	4.310	1,706
Eastern Europe	2,412	787	960	665	2,567	866	1,018	683
USSR	4,250	1,320	1,800	1,130	4.425	1,360	1,890	1,175
ECA area	*959*	*456*	*388*	*115*	*1,047*	*492*	*435*	*120*
UNESOB area	*60*	*57*	—	*3*	*89*	*86*	-	*3*
ECAFE area	*5,465*	*1,878*	*2,356*	*1,231*	*5,710*	*2,025*	*2,442*	*1,243*
Asia	3,688	1,055	1,581	1,052	3,850	1,145	1,647	1,058
Oceania	836	638	70	128	880	685	65	130
Others	941	185	705	51	980	195	730	55
North America	*11,572*	*9,359*	*851*	*1,362*	*12,181*	*9,921*	*860*	*1,400*
ECLA area	*1,010*	*896*	*22*	*92*	*1,105*	*989*	*25*	*91*
Central America	558	482	15	61	626	547	17	62
South America	452	414	7	31	479	442	8	29

it becomes evident that the other countries in Asia, excluding Japan, Africa and Latin America account for only about 10 per cent of world all-forms consumption (see table 5).

Reflecting the pattern of supply noted earlier, over half of the total sulphur-in-all-forms consumption involves the use of brimstone while about 30 per cent and 20 per cent is used as pyrite and sulphur-in-other-forms respectively. World trade in sulphurous raw materials, however, which is virtually confined to brimstone and pyrite, effects some notable changes in the pattern of sulphur consumption as compared with production in the main continental areas.

ECE area. Sulphur-in-all-forms consumption in Europe and the USSR during 1968 totalled some 16.46 million tons; the breakdown between brimstone, pyrite and other-forms being 37 per cent, 42 per cent and 21 per cent respectively, whereas in the same year the area's importance as a source of pyrite is underlined by the 33 per cent-46 per cent-21 per cent split between brimstone pyrite and sulphur-in-other-forms in the total output of 15.86 million tons. The area's status as a net importer of sulphur results from the contribution to aggregate supply made by brimstone deliveries to western Europe from outside suppliers, notably those in North America and Central America.

Traditionally, pyrite has been singularly the most important source of sulphur in western Europe but brimstone supply from indigenous production is now doubled by the import of more than 2 million tons/year. During 1969 it was expected that, for the first time, brimstone would account for an equitable proportion of all-forms consumption with pyrite. Pyrite consumption predominates mainly in the pyrite-producing countries such as Italy, Spain, Portugal, the Federal Republic of Germany, Norway and Sweden where mining operations are frequently integrated with sulphuric acid plants; the only non-pyrite producer with a significant annual pyrite intake is Belgium. The principal brimstone-consuming countries, accounting for 74 per cent of aggregate western European use in 1968, are France, the United Kingdom, the Federal Republic of Germany, the Netherlands and Belgium, each of which has a major port system and/or inland waterway arteries to industrial areas that have favoured the large volume delivery and transportation of brimstone to consuming plants in acid and non-acid industries.

Both in eastern Europe and the USSR the leading contribution to all-forms consumption is made by pyrite, about 40 per cent in the former and 42 per cent in the latter. Only in Czechoslovakia, Hungary and Poland does brimstone account for a sizable share of all-forms use although the level of brimstone consumption of the USSR is brought into some prominence by virtue of the large pyrite export programme and the consequent reduction of the amount of domestically produced material available for use in the Soviet Union itself.

ECA area. The all-forms sulphur consumption in Africa of 960,000 tons in 1968 constituted 2.7 per cent of the world total, and in contrast to the continent's status as a producer of pyrite, its pattern of sulphur consumption mirrors the availability of imported brimstone which represented about 48 per cent of total use in 1968. For the most part, this brimstone is used in Egypt, South Africa and Tunisia with the balance distributed fairly widely, notably to Algeria and Morocco. The two significant pyrite producing countries, South Africa and Morocco, account for nearly all the material used in Africa, the only supply from continental sources being the modest tonnages shipped into Egypt and Tunisia.

UNESOB area. Aside from a minor quantity of other-forms sulphur produced and consumed in Iraq and Saudi Arabia, the area's sulphur requirements are met by brimstone either imported in the case of Lebanon, for example, or derived from indigenous production as in the case of Kuwait and Saudi Arabia. Currently, the level of sulphur use is not very great but a major expansion is expected in the short term as demand increases commensurately with the growth of fertilizer production in the region.

ECAFE area. In much the same way as in Africa, the availability of sulphur in Asia and Oceania derived from the areas' resources of sulphur-in-pyrites and other-forms is boosted by the import of brimstone. The deliveries of brimstone have so accelerated in recent years that they accounted for 37 per cent of total consumption in 1968 in contrast to 12 per cent of indigenous production during the same year. In terms of the tonnage involved, brimstone consumption in Asia and Oceania amounted to 1.69 million tons of the all-forms total of 4.52 million tons, which represents a major share of the sulphur supply used in India, the Republic of Korea, Australia and New Zealand. Pyrite consumption is confined to the producing countries such as Japan, Australia and the Philippines and the two former together with India are the principal producers and consumers of sulphur-in-other-forms.

China and the Democratic People's Republic of Korea account for about 17 per cent of the sulphur consumed in the ECAFE area as a whole, mainly indigenously-produced pyrite and lesser quantities of brimstone.

North America. Not considering the multiple regional groups of western Europe, eastern Europe and the USSR in the ECE region, North America is the largest sulphur-consuming area in the world, and certainly contains the most important sulphur market—the United States. Aggregate consumption of sulphur-in-all-forms in the United States and Canada exceeds 11.5 million tons/year, and a large measure of this is in the form of brimstone as might be expected from the dominant position held by these two countries in the pattern of world brimstone production. At a combined 9.36 million tons in 1968, North America's share of world brimstone use amounted to half the world total and represented all but 19 per cent of the continent's sulphur-in-all-forms consumption. Although an appreciable call is made on pyrites as a source of sulphur in both Canada and the United States, more than 60 per cent of the remaining 2.21 million tons used during 1968 in forms other than brimstone was as sulphur-in-other-forms; only in Oceania and Latin America, where the tonnages involved are not comparable, does the similar situation occur of pyrite use being less than sulphur-in-other-forms.

ECLA area. Sulphur-in-all-forms consumption in Latin America presently stands at over 1.0 million tons/year a majority of which is used in Central America, particularly in Mexico and Cuba. The pattern of all-forms use, which has been determined largely by the indigenous production of Frasch and native refined sulphur and by the availability of Frasch and recovered sulphur from other sources in the western hemisphere and elsewhere, shows an expectedly strong reliance on brimstone. With only a limited volume of sulphur materializing in various other-forms categories and even less from pyrite, brimstone meets practically 90 per cent of the sulphur requirements of the ECLA area.

Uses of sulphur

The applications and uses of sulphur and sulphur derivatives are so widespread that it is not an exaggeration to say that they help to produce almost everything that is made to eat, to wear or to use. In fact, the amount of sulphur consumed *per capita* is often taken as an index of a country's standard of living. Outstanding among the primary uses of sulphur is the manufacture of sulphuric acid which accounted in 1968 for over 83 per cent of world sulphur-in-all-forms consumption, the balance of world all-forms production being consumed directly for various non-acid uses.

Sulphuric acid, commonly referred to as the "workhorse of chemistry" because more of it is used in chemical processing than any other liquid except water, is used either as a source of sulphur values in finished fertilizer or chemical products or as a chemical tool at different stages of manufacturing. In some applications this twofold distinction is not discernable, the acid used fulfilling both purposes, i.e. producing a sulphur component and providing a process ingredient. The fertilizer industry, for example, uses sulphuric acid in the production of single superphosphate by the acidulation of phosphate rock; the acid acts as a process agent and imparts a substantial sulphur content (14 per cent) to the finished product. Triple superphosphate manufacture similarly requires the use of sulphuric acid, insofar as the latter is needed for the intermediate production of phosphoric acid, but in this case the end-product has only a residual sulphur content (1.5 per cent).

About half the world's output of sulphuric acid is used in the production of fertilizers, the principal applications in this sector being in the manufacture of nitrogenous and phosphate fertilizers such as ammonium sulphate and single superphosphate and also potash fertilizers, such as potassium sulphate, where the latter is not manufactured directly from sulphate salts such as kainite and langbeinite. Sulphuric acid is also used for the production of one of the important fertilizer intermediates, phosphoric acid, which in turn is required for the manufacture of high analysis phosphate and compound fertilizers such as triple superphosphate and mono- and diammonium phosphate, and for the production of complex NPK fertilizers by mixed acid processes.

Outside the fertilizer industry, sulphuric acid is widely used in such chemical sectors as titanium ore processing and pigments production (for paints and enamels, paper, printing inks, fabric coatings and the like), in rayon and nylon production (for tire cords, viscose and acetate textiles, cellophane, photographic film, etc.), in petroleum refining (for alkylation, polymerization, cracking, etc.), in metallurgy (steel pickling and ore leaching) and for a variety of other products and uses including: synthetic detergents, explosives, pharmaceuticals, dyestuffs, insecticides, water treatment, synthetic rubber processing, and production of plastics.

Non-acid uses of sulphur, accounting for less than one fifth of world all-forms consumption, are also multifold and again arise in both the fertilizer and chemical industries. Most of the non-acid offtake uses brimstone but a sizable proportion of pyrite and sulphur-in-other-forms consumption occurs in this way for pulping and bleaching in the pulp and paper industry (mainly in the form of roaster gas SO_2 and spent oxide) for the production of ammonium sulphate from gypsum/anhydrite and for liquid or gaseous sulphur dioxide from pyrite roaster gases or non-ferrous metal smelter waste gases. Brimstone is used also in the pulp and paper industry for sulphite pulping and for bleaching at both sulphite and sulphate (Kraft) pulp operations. In the rayon industry brimstone is used in non-acid form, as well as acid, mainly for the production of carbon disulphide which goes into viscose. Ground and refined brimstone is produced in many grades and has applications in rubber vulcanizing, as a direct application fertilizer and in the manufacture of insecticides and pesticides.

Effects of sulphur supply and price movements in developing countries

In any examination of the effects of fluctuations in sulphur supply and sulphur prices, attention should be centred on trends in brimstone supply and demand. There are several reasons for the importance of brimstone in the context of the world sulphur situation, not the least of which is the fact that it currently accounts for over half of world all-forms consumption. Not only is it the more generally available sulphurous raw material, it is also the form most widely used in international sulphur trade and almost exclusively in intercontinental trade. Pyrite on the other hand is used mainly in the producing countries and only about one fifth of the world's output is consumed outside the suppliers' domestic market (trade taking place largely within continental areas, e.g. between western European countries, from the USSR to western Europe and from Canada to the United States).

The close connexion between domestic production and consumption is also a feature of the supply/demand pattern of sulphur-in-other-forms which normally materializes as a by-product of some other operation and only where there is some immediate use to be made of the sulphur values thus liberated. World pyrite reserves and the availability of sulphur-in-other-forms are such that the incidence of production reflects producer's ability to gear exploitation to some specific purpose—output is scarcely inhibited by any lack of resources but it may be by comparative costs vis-à-vis brimstone or, in the case of other-forms, by a disinclination to put available sulphur values to use.

In short, whereas pyrite and sulphur-in-other-forms production is usually contingent on a particular relationship between production and consumption, brimstone is an international commodity and as such, its supply and its price is governed by the type of factors common to most commodity markets, namely, demand trends in consuming industries, stock changes and the adjustments made to production programmes by individual suppliers to take account of the relative impact of all producers' shipments and sales in various world markets. Concerning short-term to medium-term trends in the world sulphur situation, therefore, it is the changes in brimstone supply and demand that provide the principal dynamic.

Brimstone consumers in the developing countries and their counterpart in the more developed economic systems can be faced with two basic situations in the world sulphur market, either one in which an over-supply position has developed and which is accompanied by a decline in brimstone prices or one in which supply shortages have emerged along with an upward trend in prices. Of course, the effects of these supply and price variations differ between individual countries depending on whether they are brimstone producers and consumers or whether they are solely brimstone consumers relying on imports to meet consumption requirements. Thus the results of brimstone supply and price fluctuations take on different forms depending on the nature of the situation: with an over-supply and resulting low prices, a buyers' market emerges; shortage of supply naturally brings on a sellers' market and high prices.

Brimstone over-supply/low prices

In brimstone-producing countries the emergence of a buyers' market situation of freely-available supply and declining prices may be manifested by an increase in brimstone producers' stocks and, where necessary, some move to cut back production at high cost sources in order to adjust to more competitive sales. The lower prices arising from the need to compete more intensively with other suppliers gives a lower unit return on sales and, more likely than not, lower over-all revenues are generated by the shipment programmes. Producers will be interested in securing long-term sales contracts to stabilize their sales volume in a situation where consumers' purchases are responding to marginal fluctuations in prices and in the absence of contract business, the movement of tonnage at distress spot prices may encourage official action—by Governments or industry authorities—to regulate prices on socio-economic grounds and possibly to restructure the ownership of producing companies to reflect national interests.

Such considerations apply to developing and developed countries alike but for the former the effects on their economic performance may be more critical. By the nature of the definition, developing countries are frequently producers and exporters of commodities (jute, coffee, tea, sugar etc.) and raw materials (oil, natural gas, iron ore, non-ferrous metals or ores, brimstone, phosphate rock etc.) and are therefore dependent on the resultant foreign exchange earnings to cover the import of much needed plant and machinery, consumer durables and other finished goods. The effect of declining world prices for exported commodities and raw materials can thus be extremely unfavourable for the pace of economic and industrial expansion in developing countries. One method of overcoming the dependence on commodity/raw material prices that has been adopted by brimstone producers such as Mexico, Iran and Kuwait has involved the establishment of high analysis fertilizer plants within the domestic chemical industries to process locally available raw materials and to export relatively high value finished products in addition to the lower value basic commodities such as brimstone. This has enhanced the potential of the respective countries' export programmes, it has begun to break the cycle of commodity exports and finished product imports and it has served to expand employment and factor incomes in their domestic chemical industries.

In brimstone-consuming countries, where little, if any, of the requirements are met by domestic production, over-supply in world brimstone markets brings an easier availability against import purchasing programmes. The rate of growth of all-forms consumption is likely to rise under the stimulus of expanding use of cheaper brimstone and the continuance of the fluid supply conditions for any length of time may lead, where feasible, to some transfer of existing pyrite- or even sulphur-in-other-forms-based acid industry demand to brimstone or to some new expansion of brimstone consumption at the expense of use of domestic pyrite resources as has been true (outside the developing world) in the United States, Greece and Australia.

Brimstone shortage/high prices

The opposite situation to the above, caused by the development of a sellers' market as brimstone demand outruns world supply, reverses the picture facing the producers on the one hand and the consumers on the other. Brimstone exporters are able to make substantial increases in sales and if production rates cannot be raised in the short term to meet the scale of the new deliveries, producer stocks will be depleted accordingly. Higher prices and expanded sales will generate improved cash flows, part of which will be earmarked for exploration and development work on new prospects designed to assure long-term supply and for investment programmes in new production facilities that may be warranted by forecasts of near-term sales growth in excess of productive capacity. As an alternative to new plant construction, sources of comparatively high cost brimstone, old Frasch domes, for example, may be re-opened to assist in meeting outstanding demand.

A prolongation or augmentation of activity could be expected also at brimstone operations which are normally orientated to meeting domestic demand as happened recently in the Bolivian native refined sulphur industry. Restricted supply is likely to be accompanied by an increase in spot purchases, since producers will be concentrating on meeting contract tonnages, and speculative offers of brimstone at high prices from other than established sources or suppliers.

The initial effect in brimstone-consuming countries of a tightening of brimstone supply is likely to be an upward trend in delivered prices which is followed by some slackening in demand coupled with a progressive depletion of consumer stocks. Where import programmes are organized through a central agency—the State Trading Corporation in India has been an example—some allocation of imported supplies between consumers may be undertaken and where more stringent controls are needed these can be provided by limits on government allowances of foreign exchange for import purchases. In a severe and prolonged brimstone shortage two remedial courses of action are open; first, the development of alternative sulphurous raw material production in the form of pyrite or sulphur-in-other-forms, and second, the use of alternative processes to minimize or avoid the consumption of sulphur in the fertilizer and chemical industries. In many brimstone-consuming countries plans were announced during the period of restricted brimstone supply in the 1960s, from 1964 to 1968, for the re-evaluation or new exploitation of pyrite resources, notably in India, Australia, Brazil, South Africa, Turkey and the United States, and greater use was made of sulphur-in-other-forms sources for sulphuric acid production. In the field of process technology there was a rash of licence agreements between designers and plant constructors covering the possible use of anhydrite/gypsum for the manufacture of sulphuric acid. Several projects were announced for the eventual employment of these processes but most of them appear to be in abeyance at the present time now that the principal stimulus to their implementation, brimstone shortage and high prices, has disappeared.

More direct steps to counter the effects of a brimstone supply shortfall in consuming countries will include the examination of possibilities for reducing or eliminating the use of sulphur in chemical or fertilizer production or in the manufacturing industry generally. Some of the options presently available are the use of the chloride instead of the sulphate route in titanium dioxide production, the employment of hydrochloric acid for steel pickling instead of sulphuric acid, the manufacture of phosphoric acid from elemental phosphorus (by the so-called thermal process) or by the acidulation of phosphate rock with hydrochloric acid, and the production of complex NPK fertilizers *via* the nitrophosphate route employing nitric acid attack on phosphate rock rather than those based on ammonium phosphates. The most straightforward option that could be available in a situation of brimstone shortage would be to switch from raw material imports to intermediate or finished product imports. In the fertilizer industry, for example,

TABLE 6. WORLD CONSUMPTION OF SULPHUR-IN-ALL-FORMS BY MAIN END-USE SECTORS (1967, 1968)

(Thousand tons S equivalent)

	1967			1968		
	Total all-forms	*Sulphuric acid*	*Non-acid uses*	*Total all-forms*	*Sulphuric acid*	*Non-acid uses*
Total consumption	**33,861**	**28,147**	**5,714**	**35,532**	**29,600**	**5,932**
ECE area	*15,422*	*12,479*	*2,943*	*16,466*	*13,426*	*3,040*
Western Europe	9,187	7,379	1,808	9,804	7,983	1,821
Eastern Europe	2,175	1,800	375	2,412	1,993	419
USSR	4,060	3,300	760	4,250	3,450	800
ECA area	*890*	*799*	*100*	*959*	*856*	*103*
UNESOB area	*47*	*43*	*4*	*60*	*57*	*3*
ECAFE area	*5,227*	*4,460*	*767*	*5,465*	*4,676*	*789*
Asia	3,386	2,771	615	3,688	3,057	631
Oceania	871	844	27	836	798	38
Others	970	845	125	941	821	120
North America	*11,315*	*9,563*	*1,752*	*11,572*	*9,727*	*1,845*
ECLA area	*951*	*803*	*148*	*1,010*	*858*	*152*
Central America	512	473	39	558	518	40
South America	439	330	109	452	340	112

TABLE 7. CONSUMPTION IN DEVELOPED COUNTRIES[a] OF SULPHUR-IN-ALL-FORMS BY MAIN END-USE SECTORS (1967, 1968)

(Thousand tons S equivalent)

	1967			1968		
	Total all-forms	*Sulphuric acid*	*Non-acid uses*	*Total all-forms*	*Sulphuric acid*	*Non-acid uses*
Total consumption	**30,075**	**25,025**	**5,050**	**31,172**	**25,927**	**5,245**
ECE area	*14,146*	*11,363*	*2,783*	*14,924*	*12,064*	*2,860*
Western Europe	8,156	6,473	1,683	8,542	6,860	1,682
Eastern Europe	1,930	1,590	340	2,132	1,754	378
USSR	4,060	3,300	760	4,250	3,450	800
ECA area	*394*	*362*	*32*	*413*	*377*	*36*
UNESOB area	—	—	—	—	—	—
ECAFE area	*4,186*	*3,703*	*483*	*4,228*	*3,724*	*504*
Asia	2,525	2,169	356	2,647	2,271	376
Oceania	871	844	27	836	798	38
Others	790	690	100	745	655	90
North America	*11,315*	*9,563*	*1,752*	*11,572*	*9,727*	*1,845*
ECLA area	*34*	*34*	—	*35*	*35*	—
Central America	34	34	—	35	35	—
South America	—	—	—	—	—	—

[a] See note following table 8 on country classifications.

TABLE 8. CONSUMPTION IN DEVELOPING COUNTRIES[a] OF SULPHUR-IN-ALL-FORMS BY MAIN END-USE SECTORS (1967, 1968)

(Thousand tons S equivalent)

	1967			1968		
	Total all-forms	*Sulphuric acid*	*Non-acid uses*	*Total all-forms*	*Sulphuric acid*	*Non-acid uses*
Total consumption	**3,786**	**3,122**	**664**	**4,360**	**3,673**	**687**
ECE area	*1,276*	*1,116*	*160*	*1,542*	*1,362*	*180*
Western Europe	1,031	906	125	1,262	1,123	139
Eastern Europe	245	210	35	280	239	41
USSR	—	—	—	—	—	—
ECA area	*505*	*437*	*68*	*546*	*479*	*67*
UNESOB area	*47*	*43*	*4*	*60*	*57*	*3*
ECAFE area	*1,041*	*757*	*284*	*1,237*	*952*	*285*
Asia	861	602	259	1,041	786	255
Oceania	—	—	—	—	—	—
Others	180	155	25	196	166	30
North America	—	—	—	—	—	—
ECLA area	*917*	*769*	*148*	*975*	*823*	*152*
Central America	478	439	39	523	483	40
South America	439	330	109	452	340	112

[a] See following note on country classifications.

Country classifications

The following classification of developed/industrialized countries and developing countries is used in tables 7 and 8.

Developed/industrialized countries

ECE area

Austria
Belgium
Bulgaria
Czechoslovakia
Denmark
Finland
France
German Democratic Republic
Germany, Federal Republic of
Hungary
Ireland
Italy
Netherlands
Norway
Poland
Romania
Sweden
Switzerland
USSR
United Kingdom

ECA area

South Africa

ECAFE area

Australia
China
Japan
New Zealand

North America

Canada
United States

ECLA area

Puerto Rico

Developing countries

ECE area

Albania
Cyprus
Greece
Portugal
Spain
Yugoslavia

ECA area

Algeria
Egypt
Libyan Arab Republic
Morocco
Mozambique
Senegal
Southern Rhodesia
Tunisia
Uganda
Zaire
Zambia

UNESOB area

Iraq
Jordan
Kuwait
Lebanon
Saudi Arabia
Syrian Arab Republic

ECAFE area

Burma
India
Indonesia
Iran
Israel
Korea, Democratic People's Republic of
Korea, Republic of
Malaysia
Pakistan
Philippines
Thailand
Turkey

ECLA area

Argentina
Bolivia
Brazil
Chile
Colombia
Cuba
Ecuador
Mexico
Netherlands Antilles
Peru
Trinidad and Tobago
Uruguay
Venezuela

nonavailability of sulphur for high analysis phosphate and compound fertilizer manufacture could be dealt with by the import of phosphoric acid or ammonium phosphates.

It is unlikely that these purchases could be adopted on a spot basis, however, without the importing country suffering grave disadvantages to its short-term economic position. World prices on fertilizers and fertilizer intermediates would be increasing during general raw material shortages so that a premium would be attached to the imported commodity which may create an even wider margin than normal between brimstone and fertilizer product prices. Also, the importing country would have to take account of the domestic cost of lower employment of production capacity, unemployment trends and a downturn in earnings on capital investments in the home chemical industry.

Pattern of sulphur consumption

Just how significant a proportion of world sulphur-in-all-forms consumption is attributable to use in the developed countries as opposed to the developing countries is shown in tables 6, 7 and 8. This summary analysis reveals that in 1968 the industrialized countries, which are primarily those in the ECE area, North America and Oceania, together with South Africa, Japan and China accounted for some 88 per cent of aggregate consumption; of this proportion, about 85 per cent (representing 75 per cent of the worldwide total) represented all-forms consumption in the ECE area and North America alone. The picture changes little when analysing the proportional offtake between developed and developing countries of sulphur-in-all-forms for sulphuric acid production as apposed to non-acid uses, the developing countries accounting for only about 12.5 per cent of the acid-based consumption of sulphur and 11.5 per cent of the non-acid based demand.

Chapter 2

WORLD PRODUCERS OF FRASCH SULPHUR, RECOVERED SULPHUR AND PYRITE

A detailed reference to the world's sources of sulphur supply in the form of Frasch sulphur, recovered sulphur and pyrite is provided by the three following tables which indicate operating companies, mine and plant locations, and rated production capacities — the latter being shown in terms of thousands of metric tons per year sulphur or sulphur equivalent (see tables 9, 10 and 11).

Frasch sulphur mine production capacities are based on realized production over a certain period in the present decade. Since the rate of production at such facilities is governed by the recovery performance in the orebody, and as this changes progressively with the depletion of the reserve and the occurrence of structural movements arising from its evacuation, output capacities are neither pre-determinate nor constant. As an order of magnitude the capacity may be suggested by the size of surface facilities, e.g. mine water heating plants; however, the mine-water rate (gallons of water required to produce a ton of sulphur) fluctuates considerably during the life of a mine.

The quoted capacities of sulphur recovery plants relate to the maximum gas throughput rates for which they have been designed. In effect this means that the capacities of most units are nominal in view of the seasonal fluctuation in energy source sales (plants have to cope with desulphurization streams at peak demand periods and are relatively under-utilized at other times) and, notably at oil refineries, in view of possible inconsistencies in the sulphur content of the crudes processed and variations in the required proportions of the product fractions.

TABLE 9. WORLD FRASCH SULPHUR PRODUCERS

Country and producing company	*Mine*	*Production capacity (thousand tons/year)*
ECONOMIC COMMISSION FOR EUROPE AREA		
Poland		
Zjednoczenie Kopalnictwa Surowcow Chemicznych	Grzybow Jeziorak	1,300

TABLE 9 *(continued)*

Country and producing company	*Mine*	*Production capacity (thousand tons/year)*
NORTH AMERICA		
United States		
Freeport Sulphur Company	Caminada[a] Garden Island Bay, Michigan Grand Ecaille Grand Isle, offshore Louisiana Lake Pelto	4,750
Texas Gulf Sulphur Company	Boling Bully Camp Fannett, Texas Gulf Moss Bluff Spindletop	3,250
Duval Corporation	Rustler Spring Fort Stockton, Texas Orchard Dome, Fort Bend County, Texas	1,950
Jefferson Lake Sulphur Company	Long Point, Illinois Lake Hermitage	525
Atlantic Richfield Company	Fort Stockton, Texas	150
Phelan Sulphur Company	Nash, Texas	100
Mecom Sulphur Company	Chacahoula	100
Allied Chemical Corporation	Sulphur Dome	50
Pan American Petroleum Corporation	High Island, Michigan	50
ECONOMIC COMMISSION FOR LATIN AMERICA AREA		
Central America		
Mexico		
Azufrera Panamericana S.A.	Jaltipan	1,600
Cia. de Azufre Veracruz[b]	Salinas, Veracruz	450
Cia. Exploradora del Istmo S.A.	Nopalapa	100

[a] Operations at this mine were suspended in February 1969.

[b] The parent company, Gulf Resources and Chemical Corporation, has reached an agreement covering the sale of this mine to a Mexican company, Inversiones Azufreras S.A.

TABLE 10. WORLD RECOVERED SULPHUR PLANTS

Country and operating company	*Plant location*	*Production capacity (thousand tons year)*
ECONOMIC COMMISSION FOR EUROPE AREA		
Western Europe		
Austria		
Österreichische Mineralöl-verwaltung A.G.	Schwechat, Vienna	6
Other units (1)	—	1
Belgium		
Sté. Industrielle Belge des Pétroles S.A.	Antwerp	18
Esso Belgium S.A.	Antwerp	
Other units (2)	—	15
Denmark		
Gulf Oil A/S	Stignaes	17
A/S Dansk Shell	Fredericia	6
Finland		
Outokumpu Oy	Kokkola	150
France		
Sté. Nationale des Pétroles d'Aquitaine (SNPA)	Lacq and St. Faust	1,750
Sté. Nobel Hoechst Chimie	Port Jerome	20
Raffinerie de l'Ile de France	Grandpuits	10
Cie. Rhenane de Raffinage	Reichstett-Vendenheim	14
Other units (4)	—	18
Federal Republic of Germany		
BP Benzin und Petroleum A.G.	Dinslaken, Hamburg, Vohburg	23
Deutsche Shell A.G.	Hamburg-Harburg, Godorf, Ingolstadt	53
Esso A.G.	Hamburg-Harburg, Köln, Karlsruhe, Ingolstadt	35
Mobil Oil A.G.	Bremen, Neustadt, lower Bavaria	10
Wintershall A.G.	Weser-Ems	25
Norddeutsche Erdgas Aufbereitungs G.m.b.H.	Voigtei	123
Ruhrgas A.G.	Essen, North Rhine-Westphalia	20
Other units (15)	—	78

TABLE 10 *(continued)*

Country and operating company	*Plant location*	*Production capacity (thousand tons year)*
Italy		
Anic SpA.	Gela, Sicily	50
SARAS (SpA. Raffinerie Sarde)	Sarroch, Sardinia	10
Shell Italiana SpA.	Rho, La Spezia, Rondinella	20
Anic SpA.	Sanazzaro de Burgundi	12
SAROM	Ravenna	11
Other units (7)	—	29
Netherlands		
BP Raffinaderij Nederland N.V.	Europoort, Rotterdam	11
Gulf Oil Raffinaderij N.V.	Europoort, Rotterdam	15
Shell Nederland Raffinaderij N.V.	Pernis	54
Other units (2)	—	11
Norway		
A/S Norske Shell	Sola	9
Other units (1)	—	3
Portugal		
SACOR (Sociedade Anónima Concessionaria da Refinação de Petróleos en Portugal)	Cato Ruixi, Oporto	17
Spain		
CEPSA (Compania Española de Petróleos S.A.)	Algeciras	15
Other units (3)	—	10
Sweden		
Koppertrans Oljeaktiebolag	Skarvik	10
Other units (1)	—	3
Switzerland		
Raffinerie de Cressier S.A.	Cressier	6
United Kingdom		
British Petroleum Co. Ltd.	Llandarcy, Isle of Grain, Belfast, Northern Ireland, Grangemouth, Scotland	56
Conoco Ltd.	South Killingholme	17
Esso Petroleum Co. Ltd.	Fawley	34
Shell U.K. Ltd.	Shell Haven, Stanlow, Teesport	45
Other units (8)	—	28

TABLE 10 *(continued)*

Eastern Europe and USSR

Sulphur recovery capacities at oil refineries, natural gas plants and coke oven gas plants in eastern Europe and the USSR are listed below:

Country	*Production capacity (thousand tons/year)*
Bulgaria	30
Czechoslovakia	50
German Democratic Republic	150
Hungary	20
Poland	30
Romania	20
USSR	600

Country and operating company	*Plant location*	*Production capacity (thousand tons/year)*
ECONOMIC COMMISSION FOR AFRICA AREA		
Egypt		
Suez Oil Manufacturing Company	Suez	28
Other units (1)	—	5
Libyan Arab Republic		
Esso Standard Libya Inc.	Marsa Brega	47
Southern Rhodesia		
Central African Petroleum Refineries (Pty) Ltd.	Umtali	5
South Africa		
Shell and BP South African Petroleum Refineries (Pty) Ltd.	Reunion Rocks	30
Other units (2)	—	11
UNITED NATIONS ECONOMIC AND SOCIAL OFFICE IN BEIRUT AREA		
Kuwait		
Kuwait National Petroleum Company	Shuaiba	191
American Independent Oil Company	Mena Abdulla (Neutral Zone)	109
Saudi Arabia		
Saudi Arabian Fertilizer Company	Dammām	12
Syrian Arab Republic		
General Petroleum Establishment	Homs	33
ECONOMIC COMMISSION FOR ASIA AND THE FAR EAST AREA		
Asia		
India		
Madras Refineries Ltd.	Madras	22

TABLE 10 *(continued)*

Country and operating company	*Plant location*	*Production capacity (thousand tons/year)*
Iran		
Kharg Chemical Company	Kharg Island	198
Shahpur Chemical Company	Bandar Shahpur	503
Other units (3)	—	40
Israel		
Haifa Refineries Ltd.	Haifa	13
Japan		
Daikyo Oil Company Ltd.	Yokkaichi	33
Fuji Oil Company Ltd.	Chiba	30
Idemitsu Kosan Company Ltd.	Chiba, Tokuyama	67
General Sekiyu Seisei KK.	Sakai, south of Osaka	22
Kyushu Oil Company Ltd.	Oita	15
Maruzen Oil Company Ltd.	Shimotsui, Chiba	55
Mitsubishi Petrochemicals Company Ltd.	Mizushima	44
Nippon Petroleum Refining Company Ltd.	Yokohama, Kanagawa, near Tokyo, Negishi	65
Nippon Mining Company Ltd.	Mizushima	40
Showa Yokkaichi Sekiyo Company Ltd.	Yokkaichi	63
Toa Nenryo Kogyo KK	Wakayama, Kawasaki, Shizuoka	76
Showa Oil Company Ltd.	Kawasaki	17
Kansai Oil Company Ltd.	Kansai, Sakai	81
Other units (6)	—	31
Malaysia		
Esso Malaysia Company Ltd.	Port Dickson	5
China		
Aggregate capacity for production of recovered sulphur is estimated at 100,000 tons/year.		
Thailand		
Summit Industrial Corporation	Bangkok	4
Other units (1)	—	2
Oceania		
Australia		
Petroleum Refineries (Australia) Pty. Ltd.	Altona, Adelaide	15
Shell Refining (Australia) Pty. Ltd.	Granville	17
Other units (1)	—	4

TABLE 10 *(continued)*

Country and operating company	*Plant location*	*Production capacity (thousand tons/year)*
NORTH AMERICA		
Canada		
Amerada Hess Corporation	Olds, Alberta	63
Amoco Canada Petroleum Company Ltd.	Bigstone, Alberta; East Crossfield, Alberta	605
Canadian Fina Oil Ltd.	Wildcat Hills, Alberta	47
Canadian Superior Oil Ltd.	Harmattan, Alberta	335
Chevron Standard Ltd.	Nevis, Alberta	54
Great Canadian Oil Sands Ltd.	Athabasca, Alberta	114
Gulf Oil Canada Ltd.	Nevis, Alberta; Pincher Creek, Alberta; Rimbey, Alberta	418
	Other units (5)	48
Hudson Bay Oil and Gas Company Ltd.	Edson, Alberta; Kaybob (No. 1), Alberta; Kaybob (No. 2), Alberta; Lone Pine Creek, Alberta	855
	Other units (4)	42
Imperial Oil Ltd.	Dartmouth, Nova Scotia; Redwater, Alberta; Sarnia, Ontario; Winnipeg, Manitoba	63
Jefferson Lake Petrochemicals of Canada Ltd.	Peace River, British Columbia; Savannah Creek, Alberta	265
Laurentide Chemicals and Sulphur Company	Montreal East, Quebec	50
Mobil Oil Canada Ltd.	Wimborne Field, Alberta	129
Petrogas Processing Ltd.	Crossfield, Alberta	662
Shell Canada Ltd.	Waterton, Alberta; Jumping Pound, Alberta	634
	Other units (5)	99
Texas Gulf Sulphur Company	Okotoks, Alberta; Whitecourt, Alberta	739
Other units (8)	—	83
United States		
Allied Chemical Corporation	Linden, New Jersey; Richmond, California; El Segundo, California	119
American Oil Company	Whiting, Indiana; Yorktown, Virginia; Sugar Creek, Missouri	82
Anlin Company of Illinois	Wood River, Illinois	50
Ashland Oil Inc.	Canton, Ohio; Buffalo, New York	33
Atlantic Richfield Company	Houston, Texas; Philadelphia, Pennsylvania	55
	Other units (2)	11

TABLE 10 *(continued)*

Country and operating company	*Plant location*	*Production capacity (thousand tons year)*
British Petroleum Oil Corporation	Port Arthur, Texas Marcus Hook, Pennsylvania	37
Cities Service Oil Company	Myrtle Springs, Texas Milnesand, New Mexico	130
	Other units (2)	7
Elcor Chemical Corporation	Van Horn, Texas	335
Great Northern Oil Company	Pine Bend, Minnesota	47
Gulf Oil Corporation	Philadelphia, Pennsylvania Port Arthur, Texas	95
	Other units (2)	20
Humble Oil and Refining Company	Bayway, New Jersey Benicia, California	182
	Other units (2)	11
Jefferson Lake Sulphur Company	Manderson, Wyoming	38
Marathon Oil Company	Detroit, Michigan Indian Basin, New Mexico Iraan, Texas	60
Mobil Oil Corporation	Paulsboro, New Jersey Coyanosa, Texas Woodhaven, Michigan	47
Montana Sulphur and Chemical Company	Billings, Montana	34
National Sulphur Company	Fashing, Texas	18
	Other units (5)	24
Olin Mathieson Chemical Corporation	Beaumont, Texas McKamie, Arkansas	67
Pan American Petroleum Corporation	Edgewood, Texas Elk Basin, Wyoming Wood County, Texas Riverton, Wyoming	286
	Other units (5)	35
Phillips Petroleum Company	Crane County, Texas Goldsmith, Texas Martinez, California	137
	Other units (3)	33
Shell Chemical Company	Houston, Texas Martinez, California Bryans Mill, Texas	143
	Other units (2)	22
Signal Oil and Gas Company	Tioga, North Dakota Houston, Texas	87
Stauffer Chemical Company	Baytown, Texas Long Beach, California	194
	Other units (2)	15
Texaco Inc.	Dunbar, Texas Other units (3)	62
Tidewater Oil Company	New Hope, Texas Delaware City, Delaware	189
Trans-Jeff Chemical Corporation	Tilden, Texas	33

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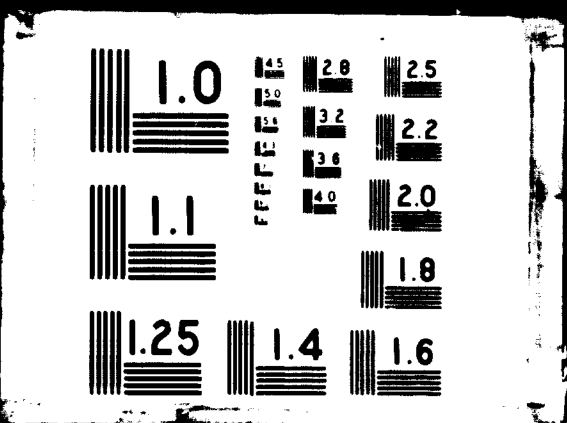

TABLE 10 *(continued)*

Country and operating company	*Plant location*	*Production capacity (thousand tons/year)*
Union Oil Company of California	Oleum, California	
	Wilmington, California	
	Santa Maria, California	122
	Lemont, Illinois	
	Other units (1)	
United States Steel Corporation	Pittsburgh, Pennsylvania	37
Warren Petroleum Corporation	Sulphur Springs, Texas	
	Waddell, Texas	64
	Other units (3)	35
Other units (48)		300
ECONOMIC COMMISSION FOR LATIN AMERICA AREA		
Central America		
Mexico		
Petroleos Mexicanos (PEMEX)	Tampico	
	Poza Rico	88
	Other units (3)	20
Netherlands Antilles		
Esso Standard Oil S.A. Ltd.	Aruba Island	13
Shell Curaçao N.V.	Curaçao Island	40
Puerto Rico		
Two units	Ponce	2
Trinidad and Tobago		
Texaco Trinidad Inc.	Pointe-à-Pierre	12
South America		
Brazil		
Industria Brasileira de Enoxfre S.A.	São Paulo	8
Petróleo Brasileiro S.A. (Petrobras)	Duque de Caxias	10
Colombia		
Empresa Colombiana de Petroleos	Barrancabermeja	10
Other units	—	4
Uruguay		
ANCAP (Administración Nacional de Combustibles, Alcohol y Portland)	Montevideo	2

TABLE 11. WORLD PYRITE PRODUCERS

Country and producing company	*Mine*	*Production capacity (thousand tons/year S equivalent)*
ECONOMIC COMMISSION FOR EUROPE AREA		
Western Europe		
Cyprus		
Cyprus Mines Corporation	Skouriotissa, Mavrovouni, Apliki	300
Hellenic Mining Company Ltd.	Mathiatis, Memi, Kalavasos, Kokkinopezoula	240
Cyprus Sulphur and Copper Company Ltd.	Limni	40
Finland		
Malmikaivos Oy	Luikonlahti	90
Outokumpu Oy	Outokumpu, Otanmäki, Pyhasalmi, Vihanti	250
France		
Soc. Produits Pechiney St. Gobain	Sain-Bel	40
Germany, Federal Republic of		
Sachtleben A. G. für Bergbau und Chemische Industrie	Meggen, Waldsassen	270
Braunschweigische Kohlen-Bergwerke	Treue	10
Greece		
Hellenic Mining Company	Kassándra, Ermióni	100
Italy		
Montedison SpA.	Gavorrano, Niccioleta, Boccheggiano, Fenice Capanne	625
SpA. Miniera di Fragne	Alagna Valsesia	80
Norway		
Bergverkselskapet Nord Norge A/S	Rana	5
A/S Bleikvassli Gruber	Bleikvassli, Mofjell	20
Elkem A/S	Skorovas, Sulitjelma	120
Folldal Verk A/S	Tverfjellet	130
Fosdalens Bergverks AB	Fosdalen	15
A/S Killingdal Grubeselskab Oppredningsverk	Killingdal	15

TABLE 11 *(continued)*

Country and producing company	*Mine*	*Production capacity (thousand tons/year S equivalent)*
Orkla Grube AB	Lokken	110
A/S Vigsnes Kobberverk	Vigsnes	10
Portugal		
Mines d'Aljustrel S.A	Aljustrel	160
Mines et Industrie S.A.	Louzal	120
Spain		
Cia. Española de Minas de Rio Tinto S.A.	Rio Tinto	600
Cia. de Azufre y Cobre de Tharsis, Ltda.	La Zarza; Tharsis	500
Minas de Herrerias S.A.	Herrerias	75
Soc. Francesa de Piritas de Huelva	Lomero-Poyatos	60
San Telmo Ibérica Minera S.A.	San Telmo	45
Electrolisis del Cobre S.A.	Concepción	45
Productos Químicos de Huelva	San Miguel	30
Cobre y Piritas de Cueva de la Mora S.A.	Cueva de la Mora	15
Hijos de Vazquez Lopez SRG	La Joya	15
Real Cia. Asturiana de Minas	Reocin	40
Cia. Andaluza de Piritas S.A.	Aznalcóllar	60
Empresa Eloy Celdran; Minas de Cartes S.A.; Montesoria S.A.; Minas de Cartes	Murcia Province mines	25
Sweden		
Boliden A.B.	Mines in Skellefte district of northern Sweden and in central Sweden notably Bergslagen district	240
Stora Kopparbergs Bergslags A.B.	Falun	25

Eastern Europe and USSR

The mining and beneficiation of pyritic ores in eastern Europe and the USSR is organized by the respective sectors of the state mining and chemical industries in each of the countries and undertaken by the individual combines where the scope of operations may extend to the utilization of the pyrite output as well as its production. Current pyrite production capacities are as follows:

Country	*Production capacity (thousand tons/year S equivalent)*
Bulgaria	90
Czechoslovakia	180
German Democratic Republic	75
Poland[a]	50
Romania	380
Yugoslavia	175
USSR	3,000

[a] The sole remaining pyrite mine in Poland, at Staszcz, was scheduled to be withdrawn from operations in 1969/1970.

TABLE 11 *(continued)*

Country and producing company	*Mine*	*Production capacity (thousand tons/year S equivalent)*
ECONOMIC COMMISSION FOR AFRICA AREA		
Algeria		
Ste. des Mines de Miliana	Filfila	20
Morocco		
Sté. d'Exploitation de Pyrrhotine de Kettara	Kettara	150
Southern Rhodesia		
Anglo-American Corporation of South Africa Ltd.	Glendale (vicinity of)	25
South Africa		
Western Reefs Exploration and Development Company Ltd.	Klerksdorp	40
Hartebeestfontein Gold Mining Company Ltd.	Hartebeestfontein	
Loraine Gold Mines Ltd.	Virginia	
Rand Leases (Vogelstruisfontein) Gold Mining Company Ltd.	Magaliesburg	
Virginia (OFS) Gold Mining Company Ltd.	Virginia	
Zandpan Gold Mining Company Ltd.	Leslie/Kinross	100
Government Gold Mining Areas (Modderfontein) Consolidated Ltd.	Modderfontein	50
Durban Roodepoort Deep Ltd.	Roodepoort	
Harmony Gold Mining Co. Ltd.	Virginia	50
Buffelsfontein Gold Mining Company Ltd.	Klerksdorp	
West Rand Consolidated Mines Ltd.	Krugersdorp	70
O'okiep Copper Company Ltd.	O'okiep	10
Rooiberg Minerals Development Company Ltd.	Rooiberg	10

Zambia

(The King Edward mine, about 30 miles west of Lusaka was scheduled for re-opening in 1970 to continue the exploitation of a cupreous pyrite.)

ECONOMIC COMMISSION FOR ASIA AND THE FAR EAST AREA		
Asia		
India		
Pyrites and Chemical Development Corporation	Amjore	90

TABLE 11 *(continued)*

Country and producing company	*Mine*	*Production capacity (thousand tons/year S equivalent)*
Japan		
Dowa Mining Company Ltd.	Akagane, Hanaoka, Kosaka, Yanawara	710
Furukawa Mining Company Ltd.	Ani, Iimori, Kune	40
Ishihara Industrial Company Ltd.	Kishu	20
Matsuo Mining Company Ltd.	Matsuo	90
Mitsubishi Metal Mining Company Ltd.	Furutobe, Hosokura, Makimine, Myoho, Osarizawa, Shimokawa, Washiaimori	160
Nicchitsu Mining Company Ltd.	Chichibu	40
Nippon Mining Company Ltd.	Hanawa, Hitachi, Kamikita, Kawayama, Komori, Shakanai, Shirataki, Toyoha, Yoshino	320
Nittetsu Mining Company Ltd.	Abuta	70
Nitto Metal Company Ltd.	Ainai, Oage	30
Otomi Mining Company Ltd.	Oppu, Yatagai	30
Rasa Industries Company Ltd.	Taro	40
Sumitomo Metal Mining Company Ltd.	Besshi, Sazare, Yaso	110
Toho Zinc Company Ltd.	Nan-etsu, Taishu	20
Others	–	80
Philippines		
Atlas Consolidated Mining and Development Corporation	Toledo, Cebu	50
Marinduque Mining and Industrial Corporation	Bagacay	45

China

Pyrite production, in the form of by-product pyrite arising during coal beneficiation or as material arising from the exploitation of mixed sulphide ores is conducted on an extensive scale in China, notably at the mines in the south Chinese provinces of Kwangtung and Hunan and in the central provinces of Hupeh and Anhwei. Current production capacity is estimated at 700,000 tons/year S equivalent.

TABLE 11 *(continued)*

Country and producing company	*Mine*	*Production capacity (thousand tons/year S equivalent)*
Turkey		
Etibank	Küre; Maden	100
Oceania		
Australia		
Mount Morgan Ltd.	Mount Morgan, Queensland	10
Mt. Lyell Mining and Railway Company Ltd.	Mount Lyell, Tasmania	40
Nairne Pyrites Ltd.	Nairne, South Australia	50
Others		
Korea, Democratic People's Republic of		
Current pyrite production capacity in the Democratic People's Republic of Korea is 200,000 tons/year S equivalent.		
North America		
Canada		
Anaconda Company	Brittania Beach, British Columbia	20
Noranda Sales Corporation Ltd.	Noranda, Quebec; Normetal, Quebec; Quemont	160
Cominco Ltd.	Kimberley, British Columbia	100
International Nickel Company of Canada Ltd.	Copper Cliff, Ontario	200
United States		
Bethlehem Steel Company	Cornwall mine, Pennsylvania; Grace mine, Pennsylvania	35
Climax Molybdenum Division, American Metal Climax, Inc.	Lake County, Colorado	10
Commercialores Inc.	York County, South Carolina	10
International Smelting and Refining Company	Park City, Utah; Marysvale, Utah	10
Magma Copper Company	Pinal County, Arizona	10
Tennessee Copper Corporation Division, Tennessee Corporation	Copperhill, Tennessee	350
ECONOMIC COMMISSION FOR LATIN AMERICA AREA		
Central America		
Cuba		
State Mining Company	Coral Nuevo	25
South America		
Chile		
Soc. Minera El Teniente S.A.	Teniente	7

Chapter 3

WORLD SULPHUR SUPPLY 1960–1969

The evolution of world sulphur-in-all-forms supply during the 1960s has been marked by the rapid growth that has taken place in brimstone production. From a total anticipated increase of 16.55 million tons in world all-forms output between 1960 and 1969, incremental production of brimstone was expected to account for about 66 per cent, equivalent to some 10.85 million tons. Thus, compared with the situation at the begining of the decade, brimstone has come to represent a much improved proportion of world all-forms supply and, by the same token, the share of output attributable to pyrite and, to a lesser extent, sulphur-in-other forms has declined (see table 12).

TABLE 12. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION — RAW MATERIAL SOURCES (1960, 1965, 1969)

(Per cent of total output)

	1960	*1965*	*1969*
Total production	**100.0**	**100.0**	**100.0**
Brimstone	45.6	50.2	54.1
Pyrite	36.4	32.3	29.4
Sulphur-in-other-forms	18.0	17.5	16.5

The dominant contribution made by the brimstone producers in the development of world sulphur supply during this decade is well reflected by the rates of growth that have been registered by the component sectors of output. All-forms production in advancing from 22—32 million tons to a projected 38.87 million tons shows an annual increase of 6.4 per cent, whereas brimstone output in reaching an estimated 21.0 million tons by the end of 1969 records a growth rate of 8.4 per cent per year since 1960. This is more than double the rate of growth observed in pyrite production whose running was anticipated at 3.8 per cent per year for the nine-year period between 1960 and 1969, a growth rate comfortably in excess of the 5.4 per cent per year compound increase that was anticipated to take sulphur-in-other-forms production to 6.42 million tons S equivalent by the end of 1969.

Brimstone production

The successful implementation of large-scale brimstone production during the 1960s from new sources of supply and the facilities built in the 1950s to exploit these sources has changed fundamentally the pattern of world brimstone supply and has had a notable effect on the growth of brimstone and, hence, all-forms output during this decade. In 1960 the United States and Mexican Frasch sulphur industries were clearly the principal source of world brimstone supply, and together with the then recently formed operations in Mexico, the United States dome operations accounted for approximately two thirds of global production, and alone for practically half of it. Production of recovered sulphur represented only about a quarter of world brimstone output and native refined sulphur just over 10 per cent. The production of recovered sulphur grew to such an extent, however, that by the end of the 1960s it represented over 40 per cent of the world total brimstone supply, while by comparison, Frasch sulphur declined to account for less than half of the world total. Against the aggregate growth of 8.4 per cent per year in brimstone, recovered sulphur production has risen at a cumulative rate of 13.9 per cent per year and Frasch sulphur output at 5.3 per cent per year. In tonnage terms, out of the additional 10.85 million tons brimstone production in 1969 as compared with 1960, recovered sulphur producers accounted for 5.92 million tons (55 per cent) and Frasch sulphur producers for 3.76 million tons (35 per cent) (see table 13).

TABLE 13. WORLD BRIMSTONE PRODUCTION (1960, 1965, 1969)
(Sources as per cent of total output)

	1960	*1965*	*1969*
Total production	100	100	100
Frasch sulphur	62	51	48
Recovered sulphur	26	35	41
Native refined sulphur	12	14	11

Native refined sulphur production has accounted for a fairly consistent proportion of total brimstone output and the expansion of output that has taken place has been confined to developments in eastern Europe and the USSR. The growth of production was more apparent during 1960–1965 and accounted for the upturn in the proportion of brimstone produced as native refined sulphur shown in 1965.

Frasch sulphur

As the major source of world brimstone supply and the one in which the intensiveness of operations can be most readily adjusted to changes in the world market situation, the progression of aggregate Frasch sulphur output during the 1960s has followed generally the course of world brimstone supply/demand trends and in the two established producing countries the short-term tempo of mining activities has reflected also the interplay of company production programmes. During the period of serious over-production of brimstone in the early 1960s—occasioned by the advent of new tonnage from many sources of supply in Canada, France and Mexico—United States Frasch output was adjusted accordingly and between 1960 and 1963 (despite the growth of Mexican production) world Frasch sulphur production showed a net advance of only 150,000 tons compared with an over-all surge of 2.38 million tons in global brimstone output. The emergence of a brimstone shortage in some parts of the world during 1964 and 1965 coincided with a marked decline in the rate of growth of output in several major brimstone producing countries, one of which was Mexico, and much of the burden in attempting to meet the soaring brimstone demand was carried by the United States Frasch industry which boosted production by 25 per cent between 1963 and 1965; Mexican production advanced by only 21,000 tons during the same period.

Thereafter, Frasch producers played a major role in the development of new production capacity, particularly in the United States where both the leading companies initiated new mining projects as well as expanding and making greater use of existing capacity; United States Frasch output climbed to a record 7.57 million tons in 1968 and Mexican production to a peak of 1.82 million tons a year earlier.

World Frasch supply was augmented in the mid-1960s by the start of large-scale production in Poland, although it was not until 1967 and 1968 that this source of new supply began to exert a significant influence on the pattern of shipments to world markets. During 1969 and in response to the change in brimstone supply from shortage to easier availability, Frasch sulphur production in the United States declined at a rate equivalent to a projected cut-back of 350,000 tons for the year and Mexican output proceeded only marginally above the rate registered in 1968. However, in line with its intention of significantly raising capacity and output at Jeziorak and Grzybów over the period 1968—1972, the Mining Association in Poland expected to achieve a sizable gain in production of underground molten sulphur in 1969/1970.

Recovered sulphur—major sources

The substantial broadening of the base of world brimstone supply achieved first by the growth of sulphur recovery in the United States and the establishment of Frasch sulphur production in Mexico in the mid-1950s and later by the exploitation of sulphur in Frasch and western Canadian sour natural gas, was promoted mainly by an earlier sulphur supply crisis at the time of the Korean War. This led to a world-wide investigation covering exploration for new sources of sulphurous mineral raw materials and work on new process technology to recover sulphur values from the alternative sources that appeared likely to offer commercial success, including the sulphur content of hydrocarbons in gaseous and liquid form.

Discovered in 1951 and brought into production by SNPA in 1957, the gas field at Lacq in southwest France contains a sour crude with an H_2S-content in excess of 15 per cent. The desulphurization and recovery of sulphur from this gas has a major impact on the pattern of brimstone supply in western Europe as production and shipments grew rapidly from 1958 onwards. From a total of 128,000 tons in that year, output rose to 790,000 tons in 1960 and by a further 619,000 tons in the next three years.

In western Canada the development of brimstone production was associated with the boom in natural gas production following the construction of the trans-Canada pipeline and the start of gas exports to the United States through a series of specially constructed pipelines into major energy markets. It was not until natural gas exploitation started in the western area of Alberta that the sour gas-bearing formations were encountered on a substantial scale and that the number and volume of sour gas reserves became significant. Coincidentally with the subsequent growth of pipeline gas output from sour gas reserves in the late 1950s and early 1960s, there was an increase, therefore, in the average H_2S content of the aggregate crude gas output and the basis for a major expansion of by-product brimstone production. The years 1960 to 1963 saw the first stage of the western Canadian sulphur industry's expansion programme completed; the output rose by about 45 per cent per year to a total of 1.3 million tons.

During 1963—1965, however, there was a slackening of the pace of new sulphur recovery plant installation and this, allied to the fact that several operators experienced technical difficulties and were unable to fully utilize available capacity, led to a noticeable diminution of the rate of growth of western Canadian brimstone output. To a certain extent this was also triggered off by lower-than-expected gas sales and delays in the completion of new gas treatment units, with the net effect that recovered sulphur production increased by only 11.4 per cent per year during 1964—1965. Considerably greater progress has been attained since 1965; output all but doubled between 1965 and 1968 and was expected to have shown a further massive increase during 1969.

In the United States the recovery of sulphur at oil refineries and natural gas plants has shown a relatively more uniform rate of growth than that registered in comparable industries in western Canada and France. The rather more limited scale of operations at individual locations and the fact that most producers are either meeting a captive demand or have comparatively assured non-captive outlets for their by-product brimstone have combined to impart some degree of stability to operations.

Taking the 1960—1969 period and the contribution of the major Frasch and recovered sulphur producers to total world brimstone supplies, it can be seen in retrospect that there were several phases in the growth of output, notably:

1960—1962/1963, when Frasch producers commonly were responsive to over-supply conditions while the "involuntary" by-product brimstone suppliers were working up capacity at recently installed facilities;

1962/1963—1966, during which time the rate of growth of output declined appreciably in Canada, Mexico and France while United States Frasch sulphur producers pushed production to over 7.1 million tons;

1967—1968, which saw United States and Mexican Frasch, western Canadian recovered and Polish underground molten sulphur suppliers boosting production to record levels; and finally,

1969, and the return of over-supply conditions after some five years with only the Polish and western Canadian suppliers making noteworthy additions to their output.

Other brimstone sources

Although it has made a less noticeable contribution in terms of quantity than expanded production at the major sources of supply, brimstone output at the other recovered sulphur and native sulphur mining/refining operations in the world has grown at a slightly faster rate during this decade—9.0 per cent per year as against 8.2 per cent.

In the recovered sulphur industry the principal improvements in the growth of output have occurred in eastern Europe, notably in the USSR, Czechoslovakia and the German Democratic Republic; second, in the ECAFE area where Iran, Japan and China have become significant supply sources; and third, in the UNESOB area, where Kuwait is the first of several impending producers to commission sulphur recovery plants. Notwithstanding the gains in recovered sulphur production in several western European countries such as Finland and the Federal Republic of Germany, the continent's net increase in production has amounted only to 70,000 tons in view of the disappearance of pyrite smelting operations in Norway and Spain and the closure of the Swedish recovery plant exploiting a sulphur-rich shale oil deposit at Kvarntorp in 1965.

The native refined sulphur industry has ended the decade with enhanced prominence only in Poland and the USSR, but the up-rating of various mines in the latter country and the establishment of the Piaseczno mine and the Makow mine in Poland moved aggregate world output ahead in 1969 by nearly 1.2 million tons since 1960.

Pyrite production

For most of the 1960s, operations at the main centres of pyrite production have been disadvantageously affected by the mounting volume of new brimstone supply seeking outlets in world markets at comparatively low prices (1965—1968 excepted). The potential for expanded pyrite use has also been curtailed in non-pyrite-producing countries (i.e. the pyrite producers export market) by the growth of sulphur-in-other-forms consumption—

which has increased at a faster annual rate than pyrites consumption with a few notable exceptions; therefore, the pyrite producers have given greater attention to domestic markets as outlets for their production, the exceptions being the leading pyrite exporters, Spain, the USSR and Cyprus.

During the early part of the decade, world pyrite production assumed only marginal changes and both upward and downward fluctuations took place in incidence of output in various continental areas—it increased, for example, in eastern Europe and Asia but in western Europe and North America, where sulphur consumers were responding to brimstone over-supply conditions, production was down by almost 300,000 tons S content in 1963. Over the period 1960—1965 world pyrite output rose by 3.8 per cent per year cumulative but in the areas containing the principal producers, western Europe and eastern Europe, pyrite supply increased by only 1.0 per cent and 2.7 per cent per year respectively. (The 2.7 per cent rate of increase includes factor for growth of USSR production.)

It was not until the second half of the decade, during the period of restricted brimstone supply, that general interest in pyrite was revived sufficiently to promote some acceleration of the output growth rates recorded to 1965 though even from the latter date through the end of 1969 pyrite production only developed at 3.9 per cent per year world-wide and at 2.4 per cent per year in western Europe. Quite the most important feature of the last four years was the major expansion in eastern European output caused primarily by the Soviet Union's enlarged production to meet sizable increases in domestic needs and the requirements of its wide-range export programmes.

While the recently renewed interest in pyrite was certainly stimulated by brimstone supply and price developments post-1964, new projects for the greater utilization of pyrite in the producing countries have been, and will continue to be, promoted by more positive factors, such as the need to capitalize effectively on domestically available resources, and by opportunities to install large-scale pyrite-based sulphuric acid capacity projects located favourably for cinders disposal and acid offtake. Such projects can be directly integrated with mining operations in the pyrite-producing countries or they may reflect the plant operator's acid disposal interest, i.e. located in the acid sales area as soundly as possible in relation to incoming raw materials transportation and outbound shipments of residue for valorization.

Examples of large-scale, pyrite-acid plants directly associated with captive raw material supplies are those operated by A/S Boregaard in Norway (one of its subsidiaries operates the Tverrfjell mine); Boliden A.B. in Sweden; Sachtleben A.G. in the Federal Republic of Germany, Montedison SpA. in Italy, Maroc Chemie in Morocco; the by-product pyrite-acid plants operated by gold mining companies in South Africa, operations of the Tennessee Corporation in the United States and the plant of the Fertilizer Corporation of India at Sindri, Bihar north-west of Calcutta.

Located preferentially to sulphuric acid markets are pyrite-acid units operated by companies such as Farbwerke Hoechst A.G., Farbenfabriken

Bayer A.G. and Ruhrschwefelsäure G.m.b.H. in the Federal Republic of Germany; Produits Chimiques de Limbourg S.A. in Belgium; Albatros Zwavelzuur-en Chemie Fabrieken N.V. in the Netherlands and the project of Interquímica S.A. in Spain.

SULPHUR-IN-OTHER-FORMS PRODUCTION

Although in most instances it arises essentially through by-product operations, world production of sulphur-in-other-forms continued to contribute a substantial minority share of world all-forms production during the 1960s and, reflecting the obvious attractions in certain circumstances and industrial situations of utilizing what would otherwise be waste products, it has shown an annual growth rate of some 5.4 per cent per year cumulative. Thus, output of sulphur-in-other-forms has risen much in line with the growth of world production of sulphur-in-all-forms as a whole, and if the projected proportion of total world all-forms production represented by sulphur-in-other-forms in 1969 (16.5 per cent) was below what it was in 1960 (18.0 per cent), this was due as much to statistical factors relative to the enormous growth of brimstone production as to anything else.

The similarity in the pace of other-forms and all-forms production is not surprising over the medium and long term in the sense that both are linked closely to the over-all development of world sulphur consumption—the former because its production is, *ipso facto*, consumption of sulphur and the latter because its growth is correlated to demand movements over the longer term. In contrast, the incidence of brimstone and pyrite production may reflect a degree of substitution between them as alternative sulphurous raw materials, which leads to different rates of growth between them and all-forms production. In conforming with its basic by-product status, then, sulphur-in-other-forms production is frequently complementary to brimstone and pyrite production and increases in association with the general advance in all-forms production, whereas the progression in brimstone and pyrite production mirrors their competitive status one to the other as well as the expansion of that primary share of all-forms demand which they meet.

On a world-wide basis, there has been a consistent increase in sulphur-in-other-forms production year by year during this decade. Between 1960 and 1965, output rose by 5.9 per cent per year and at an average of 266,000 tons/year S equivalent, and between 1965 and 1969 it expanded by some 4.8 per cent per year representing the new supply of 270,000 tons/year S equivalent on average.

In western Europe where the pattern of all-forms sulphur supply is dominated by the availability of indigenous and imported brimstone and pyrite, there has been only a limited growth of sulphur-in-other-forms production, notably as sulphuric acid in France, the Federal Republic of Germany and Sweden. The expansion of output in eastern Europe has been the primary growth factor in world other-forms production during the 1960s; it has resulted mainly from the advance in the Soviet Union's offtake of by-product sulphur values, but also advances in the German Democratic Republic, Poland and Yugoslavia.

Production in Asia, that is in Japan and India, which account for virtually the entire output, has increased by 6.8 per cent per year since 1960; while of the other countries in the ECAFE area, only Australia and China have had any significant development in other-forms production.

Output of other-forms in Africa and Latin America constitutes about 3.3 per cent of world production, so most of the balance is accounted for by operations in North America where supply has increased by 0.28 million tons since 1960—equivalent to a growth of some 2.5 per cent per year. (For world sulphur-in-all-forms production in thousands of tons, see table 14.)

TABLE 14. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION (1960, 1963, 1965, 1968, 1969)
(Thousand tons S or S equivalent)

	1960	*1963*	*1965*	*1968*	*1969*
TOTAL ALL-FORMS PRODUCTION	**22,819**	**26,118**	**30,862**	**37,076**	**38,866**
Total brimstone production	10,188	12,568	15,221	19,859	21,042
Sub-total: Major sources	*8,298*	*10,138*	*12,189*	*16,094*	*16,920*
Frasch sulphur	*6,290*	*6,441*	*7,816*	*9,978*	*10,050*
United States	5,021	4,960	6,214	7,574	7,220
Mexico	1,269	1,481	1,502	1,608	1,650
Poland	—	—	100	796	1,180
Recovered sulphur	*2,008*	*3,697*	*4,373*	*6,116*	*6,870*
United States	798	986	1,237	1,420	1,530
Western Canada	420	1,302	1,615	3,088	3,660
France, Lacq	790	1,409	1,521	1,608	1,680
Sub-total: Other sources	*1,890*	*2,430*	*3,032*	*3,765*	*4,122*
Recovered sulphur	*667*	*746*	*1,019*	*1,414*	*1,724*
Western Europe	370	306	332	397	438
Eastern Europe[a]	152	220	380	635	715
Others	145	220	307	382	571
Native refined sulphur	*1,223*	*1,684*	*2,013*	*2,351*	*2,398*
Eastern Europe[a]	471	1,091	1,391	1,675	1,700
Japan	247	221	213	261	260
Others	505	372	409	415	438
Total pyrite production	8,126	8,688	9,805	10,959	11,408
Western Europe	3,451	3,269	3,618	3,727	3,975
Eastern Europe[a]	1,928	2,425	2,769	3,492	3,585
Asia	1,102	1,263	1,491	1,632	1,678
North America	732	629	699	833	830
Total other-forms production	4,005	4,857	5,886	6,258	6,421
Western Europe	1,543	1,597	1,560	1,660	1,706
Asia	586	657	779	1,052	1,058
North America	1,119	1,235	1,318	1,362	1,400

[a] Including USSR.

Chapter 4

WORLD SULPHUR DEMAND 1960–1969

In a manner similar to that observed in the previous chapter of this report, the pattern of sulphur-in-all-forms consumption that evolved during the 1960s had as its most conspicuous feature the exceptional growth of brimstone demand, the corollary being the assumption of a much greater share of world sulphur consumption by this material to the detriment, principally, of suppliers of sulphur-in-pyrite.

To place the phenomenal rise in brimstone use during this decade in an historical perspective, it should be recalled that in the 35 years up to 1960 the annual rate of growth of world sulphur demand was 3.9 per cent. The post-war period in the late 1940s saw the rate of demand growth gradually rising, and during the 1950s the cumulative annual rate of expansion rose to some 4.8 per cent. In the present decade the rate of growth of all-forms consumption has climbed to over 6 per cent per year for the ten years as a whole and during several years after 1960, rates in excess of 8 per cent per year were registered. The rapid development of brimstone demand between 1960 and 1969 occasioned an 8.1 per cent per year advance in consumption over the entire ten-year period, and during the brimstone demand boom in the mid-1960s, annual growth rates in consumption of over 10 per cent were recorded.

The consequences of this greatly expanded brimstone requirement are manifestly clear insomuch that out of a projected growth of 15.6 million tons in all-forms consumption between 1960 and 1969, new brimstone supply has accounted for 65 per cent of the total (10.1 million tons) pyrite for 20 per cent (3.1 million tons) and sulphur-in-other-forms for about 15 per cent (2.4 million tons).

Tabulated below in summary form (table 15), the components of the consumption pattern reveal the essential two-stage phasing of the growth of sulphur demand during the 1960s, namely, the initial period up to 1965 when the most noticeable surge in demand lifted all-forms consumption up by 6.8 per cent per year—equivalent to some 8.5 million tons over-all—and from then until the end of the decade when demand, though continuing to rise, was doing so at a slightly less intensive rate with the result that the annual growth of consumption declined marginally to 5.4 per cent per year, equivalent to an increase of 7.1 million tons in the period to the end of the decade. Even more apparent in retrospect was the distribution of the incidence of brimstone consumption growth between 1960—1965 and 1966—1969; in the earlier period the use of brimstone advanced sharply to 16.0 million tons at a rate of more than 10 per cent per year but the expansion slackened appreciably to some 5.6 per cent per year thereafter under the influence of an emerging shortfall between supply and demand. It is interesting to note too that in the last four years of the decade, although the main trends were not in any way reversed, the relative decline in the proportion of world all-forms requirements met by pyrite and sulphur-in-other-forms eased from the rate of decrease noted in 1960—1965 and that conversely, as far as pyrite consumption is concerned, the rate of growth of its use has been higher—5.3 per cent per year as compared with 2.5 per cent per year in 1960—1965.

TABLE 15. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION—RAW MATERIAL SOURCES (1960, 1965, 1969)

(S or S equivalent)

	1960	*1965*	*1969*
Total consumption (million tons)	**21.8**	**30.3**	**37.4**
Brimstone	**9.9**	**16.0**	**20.0**
Pyrite	**7.9**	**9.0**	**11.0**
Sulphur-in-other-forms	**4.0**	**5.3**	**6.4**
Total consumption (per cent)	**100.0**	**100.0**	**100.0**
Brimstone	**45.4**	**52.8**	**53.5**
Pyrite	**36.2**	**29.7**	**29.4**
Sulphur-in-other-forms	**18.4**	**17.5**	**17.1**

BRIMSTONE CONSUMPTION

The stimulus that has enhanced the role of brimstone in meeting an augmented proportion of world all-forms demand in this decade has emerged in three main areas of the world market—North America, predominantly in the United States; western Europe; and eastern Europe including the USSR. Between them, these three continental areas have accounted for 81 per cent of the 10.1 million ton increment in world brimstone consumption since 1960 and much the most important of these has been the expanded offtake in North America representing no less than 44 per cent of the total. In large measure, the channelling of all but one fifth of new world brimstone supply into these markets in the past ten years has been determined by the expansion of their respective fertilizer industries, particularly in the phosphate fertilizer sector for the manufacture of phosphoric acid and high analysis straight and complex P_2O_5 products. The boom, however, in phosphate fertilizer production—again, at its most significant in the United States—took place largely in the mid-1960s in association with the soaring level of brimstone demand in those years, and it is apparent from the substantial growth of the use of brimstone over the whole of the decade that this is attributable almost equally to expansion of the chemical industry consuming sectors. In these three areas, therefore, brimstone demand growth reflects additionally the higher living standards in industrially-advanced countries which sustain the large brimstone and brimstone-based sulphuric acid end-use sectors, particularly pigments, synthetic and man-made fibres, detergents and plastics.

Outside the additional tonnage used in the ECE area and in North America during the present decade, about half the remaining 20 per cent has been consumed in the ECAFE region, principally in the countries of Asia not run on a centrally planned economy basis, and the balance in Latin America and Africa. In most of the consuming countries in these regions a major share of the intake is required for fertilizer production and a broad spectrum of brimstone uses has developed to a significant extent only in Japan, South Africa, Australia, India and Brazil.

Pyrite consumption

The upward trend in pyrite consumption since 1960 has been compounded chiefly of the growth in demand in the world's major producing countries and the three regions within which they are located, that is western Europe, eastern Europe and the USSR, and Japan. The factors governing the measure of pyrite production and consumption in particular situations have been discussed earlier and the distribution of pyrite consumption growth during the 1960s bears witness to the progressively close contact between pyrite producers and the consumers in their respective domestic markets.

All but a very minor proportion of the total increase in world pyrite consumption has taken place in the ECE area, Japan and North America; from an aggregate 3.05 million tons S content gain in use expected in the period ending 1969, these regions and countries accounted for some 93 per cent of the total—western Europe for 30 per cent, eastern Europe and the USSR for 35 per cent, ECAFE (mainly Japan and China) for 24 per cent, and North America for 4 per cent. In inverse relation to the aforementioned trends in brimstone supply and demand, the growth of pyrite consumption has been featured more strongly in the second half of the decade except in eastern Europe and the USSR where pyrite plays a more prominent role in the pattern of sulphur production and consumption than in many western world pyrite markets open to the attractions of competitively priced brimstone. Thus pyrite consumption has continued upwards in a fairly uniform fashion in eastern Europe, whereas in western Europe and North America the 1960–1965 period saw respective fluctuations of plus 0.7 per cent per year and minus 2.4 per cent per year, and in 1965–1969 the growth rates of plus 5.1 per cent and plus 7.6 per cent were registered during the time that pyrite acid plant operators were able to expand the scale of their operations to meet unfulfilled demand for sulphuric acid during the period of restricted brimstone supply.

SULPHUR-IN-OTHER-FORMS CONSUMPTION

The rate of expansion of sulphur-in-other-forms consumption has been governed principally by determinants unrelated to the situation evolving in brimstone and pyrite markets, though this is not to say, *post facto*, that upward and downward movements in prices and supply of the two more important sulphurous raw materials do not stimulate interest in, or give more or less scope for, the utilization of sulphur values in forms other than brimstone or pyrite.

In the last nine to ten years, other-forms consumption, largely in the form of smelter gas sulphuric acid, has risen by just over 5.0 per cent per year from 4.0 to 6.4 million tons S equivalent. There has been little difference in the world-wide distribution of the pattern of growth of consumption as between other-forms on the one hand and brimstone and pyrite on the other, the greater part of the new supply and utilization having arisen in the ECE area, notably in eastern Europe and the USSR, in the ECAFE area, especially in Asia, and in North America (see table 16).

TABLE 16. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION BY AREA (1960, 1963, 1965, 1968, 1969)

(Thousand tons S)

	1960	*1963*	*1965*	*1968*	*1969*
Total all-forms consumption	**21,807**	**25,891**	**30,886**	**35,582**	**37,374**
ECE area	*10,041*	*12,180*	*14,108*	*16,466*	*17,242*
Western Europe	7,023	7,726	8,595	9,804	10,250
Eastern Europe	1,105	1,539	1,838	2,412	2,567
USSR	1,913	2,915	3,675	4,250	4,425
ECA area	*535*	*546*	*708*	*959*	*1,047*
UNESOB area	*13*	*17*	*30*	*60*	*89*
ECAFE area	*3,355*	*4,085*	*4,809*	*5,465*	*5,710*
Asia	2,233	2,625	3,030	3,688	3,850
Oceania	537	630	801	836	880
Others	585	830	978	941	980
North America	*7,359*	*8,392*	*9,926*	*11,572*	*12,181*
ECLA area	*504*	*671*	*755*	*1,010*	*1,105*
Central America	223	318	375	558	625
South America	281	353	380	452	480

Chapter 5

SULPHUR PRICES 1960–1969

During the 1960s the evolution of world sulphur prices has been determined by three principal factors:

(a) The availability of additional brimstone supplies in world markets following the emergence of three new producers (Mexico, France and Canada) within a comparatively short period in the latter half of the previous decade and, coupled with this, the nature of the reaction made by the established suppliers—notably the United States Frasch sulphur industry—to the rearrangement of the pattern of world brimstone production and trade which took place.

(b) The boom in world sulphur demand which occurred during the mid-1960s and the inability of the brimstone suppliers to meet in full the rising level of requirements in many major markets.

(c) The downturn in the rate of demand growth in 1967 and 1968 which coincided with the inaugural arrival of substantial tonnages of Polish sulphur in western world markets.

In association with these fundamental developments, therefore, there have been three distinct phases in the movement of sulphur prices over the course of the present decade. The first of these lasted from 1960 until 1963 during which time brimstone, and subsequently, pyrite prices declined as the degree of competition intensified in major markets between the United States and Mexican Frasch sulphur suppliers and the producers of recovered sulphur in western Canada and France.

Then, from 1964 to 1968, the situation changed rapidly under the influence of the acceleration in world brimstone consumption and, reflecting the progressive establishment of a sellers' market, prices climbed strongly to peak levels in 1967/1968. Thereafter, in the latter part of 1968 and more dramatically in 1969, a new price weakness set in as the competitive interaction of expanded brimstone supplies from both new and established sources and the slowdown in demand growth sent prices tumbling in an unexpectedly short period of time.

Since 1960, much of the attention given to world sulphur prices has focused on the identification of trends in brimstone prices chiefly because over a broad range of world sulphur markets this sulphurous raw material has come to account for the major proportion of all-forms requirements. This has happened partly as a result of brimstone's versatility and cost effectiveness in meeting the requirements of sulphuric acid and non-acid sulphur consumers alike, partly in view of the more favourable economics of transporting a product which is almost 100 per cent elemental sulphur against one, such as pyrite, which commonly has an S content of less than 50 per cent, and partly because potential pyrite consumers, to minimize the sulphur-in-pyrite price, need to be concerned additionally with the valorization of the other mineral constituents of the raw material. Nevertheless, in pyrite-producing countries especially, and in neighbouring markets such as those in Europe, the price of sulphur-in-pyrite remains an important factor in sulphur consumers' evaluation of alternative raw material costs, particularly in relation to sulphuric acid plant investment programmes. For reasons mentioned earlier in this report, little concern will be given to prices of sulphur in forms other than brimstone and pyrite; the exploitation of sulphur-in-other-forms is rarely the result of a decision between one of the three main sulphurous raw material forms and it is likely to be governed rather by the convenient availability of low-cost, by-product sulphur values, by a captive, on-site requirement for sulphur derivatives or by the enforced necessity in populated areas of recovering sulphur values—from non-ferrous metal smelter exit gases, for example.

SULPHUR PRICES 1960–1963

At the outset of the 1960s, the intention of the United States Frasch sulphur industry to maintain or enlarge its share of the world sulphur market in competition with the recently arrived producers in Mexico and France had been manifest already for some two and a half years in a stable listed price of $25 per long ton f.o.b. Gulf ports for bright sulphur which covered a range of effective f.o.b. price levels to various markets. Canadian recovered sulphur and Mexican Frasch sulphur was priced competitively with material of United States origin in world markets at levels that indicated f.o.b. returns corresponding to $22–$24 and $21–$24 at the respective shipping points of Vancouver, Canada and Coatzacoalcos, Mexico.

The strong competition between United States, Mexican and French brimstone suppliers which had resulted in a weak world brimstone price pattern by 1960 had also caused a substantial fall in European pyrite prices from mid-1957 onwards. In October 1959 the Spanish export price for Rio Tinto crude fines was down to 60 shillings per ton f.o.b. Huelva, basis 48 per cent S. Despite lower pyrite prices, however, the late 1950s saw an appreciable expansion of new brimstone-burning sulphuric acid capacity in western Europe and the substitution of pyrite by brimstone at some established acid operations.

Meanwhile, the price war between brimstone producers in major markets, which stemmed from the policy decisions made in the United States Frasch industry on the posture to be adopted in competitive situations with the newer producers (and the subsequent need for the latter to enter world markets by offering tonnage at discounts on the lower United States prices), continued unabated through the next three years. United States Frasch sulphur continued to be priced nominally at $25 per long ton f.o.b. Gulf ports but with delivered prices incorporating variable discounts and freight contributions.

The price slide in world markets reached its lowest point in 1963 although it carried over into 1964 on the basis of contract business concluded in 1963—the average realized f.o.b. price in the United States at the time had dropped to about $20 per long ton with some returns ranging lower by several dollars where they corresponded with Mexican prices. F.o.b. equivalents for Canadian and French sulphur—priced competitively in delivered terms—reflected the different freight rates to particular markets. In western Europe, Spanish pyrite prices had declined by a further 4s.6d. to 56s.6d. per ton f.o.b. Huelva.

Sulphur prices 1964—1968

The reversal of the six-year downward price trend became officially apparent in February 1964 when the Sulphur Export Corporation (Sulexco) established the United States export price at $22.50 and by end-year this had risen to $27.50 per long ton. The prices of brimstone from the other major producers also began to move upwards in anticipation of significant shortages developing. One supplier in Canada, for example, advanced prices from $18 to $23—$24 f.o.b. Vancouver through 1964 and then later to $31.50 f.o.b., following the Sulexco increase of $4 to $31 per long ton f.o.b. Gulf ports in February 1965, and to $35.20 f.o.b. Vancouver in April 1965 in line with the further rise of $5 (to $36) in the Sulexco price during the same month. In 1965 also, the price of Spanish pyrite rose in January and then again in July to 68s. per ton f.o.b. Huelva.

By 1966 the rise in world brimstone prices was becoming steeper and the contributary causes of the restricted supply pattern that was emerging, primarily under the influence of soaring brimstone demand in the United States during the previous two years, had extended to the levelling off in the pace of production growth which had been maintained at a high rate in Mexico, Canada and France in the late 1950s and early 1960s as the new facilities in these countries stepped up their percentage employment of capacity. In mid-1966 the Sulexco price climbed to $39, the Spanish pyrite price at Huelva to 85s. per ton f.o.b. and quotations for Mexican and Canadian sulphur ranged upwards to $41—$42 f.o.b. at Coatzacoalcos and Vancouver.

As the supply situation in world markets tightened further during 1967, prices on new business rose accordingly and offers of spot tonnages of Canadian and Mexican sulphur advanced beyond $50 per long ton f.o.b. to be followed later in the year by prices on new contracts, these becoming established at $50—$52 per long ton f.o.b.

In January 1968 the posted export price of United States Frasch sulphur was increased to $41 per long ton f.o.b., though this became merely the lower end of an f.o.b. price range which Sulexco had adopted to give different netbacks according to different marketing regions. However, this United States price range, the Canadian quotations in early 1968 of $45–$55 per long ton f.o.b. Vancouver, the $50–$52 per long ton price on Mexican Frasch sulphur and the Spanish pyrite price of 93s. per ton f.o.b. effective January 1968, marked the apogee of the increase in world sulphur export prices during the 1960s, and from the second half of 1968 the price levels began to recede with progressive rapidity.

SULPHUR PRICES 1969

The turn-round in world brimstone markets to a situation of growing over-supply did not become fully evident until early in 1969 so far as world prices were concerned, and only then on a limited tonnage of spot business in the first half of the year in view of the fact that the greater part of 1969 contract shipments had been negotiated during the second half of 1968. Nevertheless, it had been apparent from producer stock increases during 1968 that mounting brimstone production and slower demand growth were combining to end the 1964–1967 period of restricted brimstone supply. The surge in brimstone output during 1968, particularly in the United States and Canada, was combined with a further expansion of very competitively priced Polish sulphur shipments to a wide range of markets outside eastern Europe and, in western Europe, the delivery of over 450,000 tons S content of Russian pyrite. These latter shipments, which had amounted to only 35,000 tons S content in 1961, built up to the point where in 1967 the total stood in excess of 500,000 tons S content. These consignments were priced attractively in c. and f. terms at $12.50–$13.00 per ton product, which, at various consuming points, represented a sizable discount on the delivered price of western European material. At 708,000 tons during 1968, Polish shipments to western world markets were one and a half times the level of those in 1967 resulting in the supply of an additional 450,000 tons brimstone, notably to western Europe which accounted for over 300,000 tons of the incremental tonnage.

In the first half of 1969 the turn-round to a buyers' market from the contrary situation that had been in effect through to 1968 was underlined by the offers of spot tonnage against only modest requirements in a market that was substantially committed for its needs from late 1968 onward. These offers of tonnage, spasmodic at first, originated however, from new suppliers seeking entries or increased sales in already adequately-supplied markets, e.g. western Europe, but as the forward evaluation of potential supply against the potential demand of 1970 began to exert a premature influence on the tone of world markets generally, more suppliers began to seek early assurances of 1970 business or at least the movement of available supplies in 1969. What followed was the duplication by various suppliers of the same tonnage offers to a number of outlets and as the incidence of this increased, a sizable margin opened up between the established and spot or near-term prices for the first half of 1969. Some of the offers of new supplies were backed by extensive production capacity and as the incidence of price competition during mid-1969 became magnified by multiple offers of discounted tonnage, the major suppliers—in anticipation of the substantial over-supply potential that would materialize by 1970—were drawn into the downward price spiral in an attempt to stabilize their prices at levels attractive enough to retain their business.

At the beginning of 1969 the Sulexco export price continued to be determined at $41 per long ton f.o.b. Gulf ports with discounts and freight contributions providing a range of delivered prices in world markets, e.g. $47—$50 in Asia. Prices of Mexican sulphur had been aligned with the posted United States export price, western Canadian sulphur was priced in the range $38—$41 f.o.b. with discounts of $3—$5 per long ton on offers of new supplies while French recovered sulphur was priced competitively in delivered terms, mostly against United States Frasch sulphur. Polish sulphur was offered very competitively world-wide. With the potential short-term surplus of supply appearing ever larger, the established suppliers were either unable or decided not to remain apart from the growing competition in world markets and the downward pressure on prices was recognized by wide-range reductions for the second half of 1969. Thus the Sulexco Gulf coast price for most markets was re-established at $29.50 per long ton f.o.b. with the base price in western Europe at $36 per long ton ex-terminal Rotterdam and offers of Canadian sulphur were priced below $20 per long ton f.o.b. Vancouver. Prices of Mexican sulphur were below those of United States Frasch sulphur in f.o.b. terms and French recovered sulphur in western Europe was in competitive relation to United States supplies and also Polish sulphur—in Europe and in several other markets. Pyrite prices reflected the weakness of the world sulphur market during the second half of 1969 and the Spanish f.o.b. quotations at Huelva were nearly 10 per cent off the first half year price of 93s. per ton.

In retrospect, then, it may be observed that the decade just ended has seen almost a complete cycle in brimstone supply and prices, from over-supply and low prices up to 1963/1964 to stringent short supply and high prices and then back again to the former situation. A comparison of the level of sulphur prices at the outset of the period of restricted supply and its termination shows that prices on the greater part of deliveries, notably in western world markets and including producers' shipments to domestic markets, more than doubled by about $20—$23 per long ton. In spot markets, the increases were more substantial, particularly in respect of western Canadian and Mexican exports which secured advances in excess of $35 per long ton.

Chapter 6

WORLD SULPHUR SUPPLY / DEMAND 1950–1969

World statistics

In the comparatively short period of 20 years since the beginning of the previous decade, the world sulphur industry passed through two intervals of short supply and one of over-supply, and in 1969 embarked on a new phase of over-supply in which prevail all the attendant features associated with a buyers' market in a commodity—an accelerating downward pressure on prices, a growing volume of producer stocks, a rash of multiple offers of tonnage against only modest near term/spot business inquiries and the like. The emergence of periodic supply/demand imbalances in the world sulphur market would not be so remarkable if it were not for the fact that the industry has moved into the four varying supply/price cycles since 1950 without the benefit of an intervening period of stability and in the absence of this, an optimum exploitation of the world's sulphur resources—a relatively distant, if worthy objective—has been even further remote in practice. Without some medium-term stability which would promote a greater assurance on the long-term availability of supplies at economic cost, it remains that the interests of producers and consumers alike are not being served as best they might be.

The limited availability of brimstone at the beginning of the 1950s, which was occasioned by the refusal of the then sole major supply source, the United States Frasch sulphur industry, to match its rate of production to the growing demand in export markets as well as in the United States itself, led to the onset of the first post-war sulphur shortage and also to the establishment of a world rationing programme under the auspices of the International Materials Conference. During this period of restricted supply the sulphuric acid industries in western Europe and in Australia refocussed their attention on pyrite and with that raw material, in Europe, they might have remained but for the fact that prices rose by a wide margin to a plateau of 150s. per ton f.o.b. Huelva where they remained until well after the emergence of a more relaxed brimstone supply pattern in 1957.

The arrival of an easier tone in world brimstone markets from 1953 onward was the result of both supply and demand factors, notably the advent of recovered sulphur supplies on a much larger scale in the United States and the start of shipments from the new Frasch sulphur industry in Mexico and on the other side, the widespread effects of the industrial recession earlier in 1952 which served to depress the level of sulphur demand. Other factors were beginning to make an impression on the situation during the mid-1950s, however, factors that linked back to the stimulus given to the search for new sulphur sources at the time of the shortage in the early 1950s. They included the improvement of process technology covering the beneficiation of native sulphur ores, the recovery of SO_2 from gas streams arising during the roasting of metal sulphides or sulphates, the recovery of sulphur from H_2S present in sour natural gas, oil refinery gas and coal gas streams and the more efficient manufacture of sulphuric acid. More specifically, the major United States Frasch producers were implementing new mine projects and by 1956 the start of large-scale recovered sulphur production was imminent in France.

The response to these developments made by the United States suppliers was to seek an early assurance as to their future share of the market by the downward adjustment of prices and this set off the drastic decline in prices over the period 1957—1963 which was maintained by the intense competition between the established producers and those in Mexico, France, and later, western Canada.

For a time during the late 1950s and early 1960s the commissioning of new brimstone production capacity was carried forward at a rate which insured that the supply capability of the industry, coupled with the expansion of pyrite and other-forms, ran well ahead of demand but at the outset of this decade a noticeable upturn took place in the rate of growth of all-forms and, principally, of brimstone demand. From 1963 onward there was a steep rise in demand that took place at the very time when there was a diminution in the rate of growth of brimstone output in Canada, Mexico and France. Moreover, such was the pace at which demand expanded—registering annual increments of 8—12 per cent—that neither the increased production from other sources, notably the United States Frasch industry, nor the release of stocks could close the margin between supply and demand. In addition, the shortfall in supply from Canada, France and Mexico had not been allowed for and the producers still in full operation were unable to meet both the new demand and the *ad-hoc* inquiries from non-contract consumers of Mexican or Canadian brimstone.

There thus developed in 1964 the second shortage "crisis" and prices began to move upwards from the floor levels reached at the end of the previous six years of over-supply. One of the elements of the early 1960s situation that determined the subsequent trends in demand was simply the attraction, for potential fertilizer manufacturers, especially in the United States, of the greatly improved availability of low-priced brimstone following the introduction of the new Mexican, Canadian and French production capacity. In the United States the interest in sulphur consumption for fertilizer production was boosted by government action to steady the level of commodity prices during the mid-1960s' inflation, and it was not until December 1966 that the

United States domestic brimstone price rose from $27 towards the price of $39 per long ton f.o.b. Gulf ports then posted on United States export business.

In the event, it was the greatly increased use of brimstone in the fertilizer industry between 1963 and 1965 and the massive growth of fertilizer output, to the point of over-supply, that led to a stagnation in sulphur demand during 1967 and 1968. Concurrently, the brimstone producers had been establishing new capacity in an attempt to close the gap between supply and demand. The eventual introduction of this capacity, plus the more intensive call on pyrite and sulphur-in-other-forms resources during the shortage, and later the imports in western world markets of Polish brimstone and Russian pyrite turned the situation around so effectively that the shortage ended in 1968 almost without warning.

With the return of demand growth to more "normal" levels and with the picture of substantial additions to brimstone capacity looming ahead in Poland, the Near East, western Texas, and possibly Japan, the situation in world markets stabilized for only six to nine months in late 1968 and early 1969 before returning very rapidly, via competitive spot and then contract pricing, to the buyers' market from which it had evolved a brief five years before.

Tables 17, 18, 19 and 20 (pp. 66 – 105) indicate: the production by country of sulphur-in-all-forms; production by country of brimstone; consumption by country of sulphur-in-all-forms, raw material sources; and consumption by country of sulphur-in-all-forms by main end-use sectors, at stated years between 1960 and 1969.

TABLE 17. WORLD PRODUCTION OF SULPHUR-IN-ALL-FORMS BY COUNTRY (1960, 1963, 1965, 1968, 1969)

(Thousand tons S or S equivalent)

	1960				1963			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Total production	**22,319**	**10,188**	**8,126**	**4,005**	**26,113**	**12,568**	**8,688**	**4,857**
ECE area total	*9,387*	*1,914*	*5,379*	*2,094*	*11,557*	*3,139*	*5,694*	*2,724*
Western Europe	*6,285*	*1,291*	*3,451*	*1,543*	*6,694*	*1,828*	*3,269*	*1,597*
Austria	76	—	—	76	63	—	—	63
Belgium	178	—	—	178	162	4	—	158
Cyprus	444	—	444	—	441	—	441	—
Denmark	—	—	—	—	—	—	—	—
Finland	159	—	110	49	241	38	106	97
France	1,016	797	119	100	1,639	1,418	108	113
Germany, Federal Republic of	550	84	223	243	528	86	177	265
Greece	74	—	74	—	67	—	67	—
Ireland	13	—	11	2	—	—	—	—
Italy	1,088	149	696	243	978	134	631	213
Netherlands	56	31	—	25	65	35	—	30
Norway	377	72	279	26	352	—	328	24
Portugal	292	13	279	—	279	2	277	—
Spain	1,088	43	1,014	31	1,003	38	928	37
Sweden	256	39	202	15	251	26	206	19
Switzerland	—	—	—	—	—	—	—	—
United Kingdom	618	63	—	555	625	47	—	578
Eastern Europe	*1,009*	*143*	*598*	*268*	*1,353*	*361*	*585*	*407*
Albania	—	—	—	—	—	—	—	—
Bulgaria	70	5	50	15	101	6	55	40
Czechoslovakia	179	—	150	29	161	—	136	25
German Democratic Republic	279	112	47	120	304	120	44	140

Hungary	—	—	—	—	—	—	—	—
Poland	191	26	85	80	403	235	81	87
Romania	120	—	105	15	156	—	131	25
Yugoslavia	170	—	161	9	228	—	138	90
USSR	*2,093*	*480*	*1,330*	*283*	*3,510*	*950*	*1,840*	*720*
ECA area total	*303*	*7*	*241*	*55*	*280*	*7*	*217*	*56*
Algeria	18	—	18	—	18	—	18	—
Egypt	2	2	—	—	2	2	—	—
Libyan Arab Republic	—	—	—	—	—	—	—	—
Morocco	4	—	4	—	7	—	7	—
Mozambique	—	—	—	—	—	—	—	—
South Africa	205	5	200	—	172	5	167	—
Southern Rhodesia	19	—	19	—	25	—	25	—
Senegal	—	—	—	—	—	—	—	—
Tunisia	—	—	—	—	—	—	—	—
Uganda	—	—	—	—	—	—	—	—
Zaire	39	—	—	39	31	—	—	31
Zambia	16	—	—	16	25	—	—	25
UNESOB area total	*2*	—	—	*2*	*2*	—	—	*2*
Iraq	2	—	—	2	2	—	—	2
Jordan	—	—	—	—	—	—	—	—
Kuwait	—	—	—	—	—	—	—	—
Lebanon	—	—	—	—	—	—	—	—
Saudi Arabia	—	—	—	—	—	—	—	—
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	*2,887*	*454*	*1,767*	*666*	*3,350*	*445*	*2,136*	*769*
Asia	*2,589*	*451*	*1,552*	*586*	*2,990*	*440*	*1,893*	*657*
Burma	—	—	—	—	—	—	—	—
China	621	155	466	—	815	167	648	—
India	74	—	—	74	74	—	—	74
Indonesia	—	—	—	—	—	—	—	—

TABLE 17 *(continued)*

	1960				1963			
	Total all-forms	Brimstone	Pyrite	S.O.F.	Total all-forms	Brimstone	Pyrite	S.O.F.
Iran	30	24	—	6	25	21	—	4
Israel	—	—	—	—	—	—	—	—
Japan	1,803	255	1,057	491	1,947	233	1,173	541
Malaysia	—	—	—	—	—	—	—	—
Pakistan	11	—	—	11	12	—	—	12
Philippines	10	—	10	—	29	—	29	—
Republic of Korea	1	—	1	—	—	—	—	
Thailand	—	—	—	—	—	—	—	—
Turkey	39	17	18	4	88	19	43	26
Oceania	*200*	*3*	*117*	*80*	*202*	*5*	*86*	*111*
Australia	200	3	117	80	202	5	86	111
New Zealand	—	—	—	—	—	—	—	—
Others	*98*	—	*98*	—	*158*	—	*157*	*1*
Democratic People's Republic of Korea	98	—	98	—	158	—	157	1
North America	*8,224*	*6,373*	*732*	*1,119*	*9,164*	*7,300*	*629*	*1,235*
Canada	987	458	309	220	1,888	1,354	280	254
United States	7,237	5,915	423	899	7,276	5,946	349	981
ECLA area total	*1,516*	*1,440*	*7*	*69*	*1,760*	*1,677*	*12*	*71*
Central America	*1,393*	*1,354*	—	*39*	*1,634*	*1,585*	*5*	*55*
Cuba	—	—	—	—	5	—	5	—
Mexico	1,337	1,328	—	9	1,563	1,554	—	9
Netherlands Antilles	47	22	—	25	55	24	—	31
Puerto Rico	—	—	—	—	—	—	—	—
Trinidad and Tobago	9	4	—	5	11	7	—	4

	1965				1968			
	Total all-forms	Brimstone	Pyrite	S.O.F.	Total all-forms	Brimstone	Pyrite	S.O.F.
South America	*123*	*86*	*7*	*30*	*126*	*92*	*7*	*27*
Argentina	56	40	—	16	36	24		12
Bolivia	1	1	—	—	8	8	—	—
Brazil	5	5	—	—	5	5	—	—
Chile	47	31	7	9	58	43	7	8
Colombia	10	9	—	1	14	12	—	2
Ecuador	—	—	—	—	—	—	—	—
Peru	4	—	—	4	5	—	—	5
Uruguay	—	—	—	—	—	—	—	—
Venezuela	—	—	—	—	—	—	—	—
Total production	**30,362**	**15,221**	**9,905**	**5,236**	**37,076**	**19,859**	**10,959**	**6,258**
ECE area total	*13,151*	*3,803*	*6,387*	*2,961*	*15,864*	*5,190*	*7,219*	*3,455*
Western Europe	*7,110*	*1,932*	*3,618*	*1,560*	*7,471*	*2,084*	*3,727*	*1,660*
Austria	71	1	—	70	63	3	—	60
Belgium	178	4	—	174	192	6	—	186
Cyprus	474	—	474	—	482	—	482	—
Denmark	6	6	—	—	8	8	—	—
Finland	267	74	85	108	411	125	227	59
France	1,714	1,534	58	122	1,808	1,623	35	150
Germany, Federal Republic of	603	77	274	252	657	127	254	276
Greece	64	—	64	—	84		84	—
Ireland	—	—	—	—	1	—	—	1
Italy	949	103	630	216	958	94	590	274
Netherlands	64	30	—	34	74	39	—	35
Norway	343	—	316	27	350	3	310	37
Portugal	284	3	281	—	274	4	270	—
Spain	1,260	18	1,211	31	1,294	9	1,250	35
Sweden	270	27	225	18	277	4	225	48

TABLE 17 *(continued)*

	1965				*1968*			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Switzerland	—	—	—	—	1	1	—	—
United Kingdom	563	55	—	508	537	38	—	499
Eastern Europe	*1,721*	*571*	*699*	*451*	*2,963*	*1,506*	*792*	*665*
Albania	—	—	—	—	—	—	—	—
Bulgaria	129	10	64	55	180	15	75	90
Czechoslovakia	183	—	151	32	220	30	150	40
German Democratic Republic	329	125	44	160	385	125	55	205
Hungary	—	—	—	—	5	5	—	—
Poland	619	436	95	88	1,601	1,326	75	200
Romania	214	—	188	26	365	5	330	30
Yugoslavia	247	—	157	90	207	—	107	100
USSR	*4,320*	*1,300*	*2,070*	*950*	*5,430*	*1,600*	*2,700*	*1,130*
ECA area total	*349*	*16*	*270*	*63*	*538*	*15*	*408*	*115*
Algeria	27	—	27	—	22	—	22	—
Egypt	3	3	—	—	2	2	—	—
Libyan Arab Republic	—	—	—	—	—	—	—	—
Morocco	46	—	46	—	127	—	127	—
Mozambique	—	—	—	—	—	—	—	—
South Africa	181	13	168	—	286	9	237	40
Southern Rhodesia	29	—	29	—	26	4	22	—
Senegal	—	—	—	—	—	—	—	—
Tunisia	—	—	—	—	—	—	—	—
Uganda	—	—	—	—	—	—	—	—
Zaire	35	—	—	35	43	—	—	43
Zambia	28	—	—	28	32	—	—	32

UNESOB area total	*2*	—	—	*2*	*23*	*20*	—	*3*
Iraq	2	—	—	2	22	20	—	2
Jordan	—	—	—	—	—	—	—	—
Kuwait	—	—	—	—	—	—	—	—
Lebanon	—	—	—	—	—	—	—	—
Saudi Arabia	—	—	—	—	1	—	—	1
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	***3,908***	***560***	***2,436***	***912***	***4,310***	***609***	***2,470***	***1,231***
Asia	***3,494***	***550***	***2,166***	***779***	***3,902***	***598***	***2,207***	***1,097***
Burma	—	—	—	—	—	—	—	—
China	948	259	690	—	840	206	589	45
India	77	—	—	77	108	—	—	108
Indonesia	—	—	—	—	3	3	—	—
Iran	19	19	—	—	21	21	—	—
Israel	—	—	—	—	6	6	—	—
Japan	2,276	150	1,369	657	2,682	336	1,450	896
Malaysia	—	—	—	—	—	—	—	—
Pakistan	13	—	—	13	13	—	—	13
Philippines	49	—	49	—	87	—	87	—
Republic of Korea	—	—	—	—	—	—	—	—
Thailand	—	—	—	—	1	1	—	—
Turkey	112	22	58	32	141	25	81	35
Oceania	*230*	10	*90*	*130*	*212*	*11*	*73*	*128*
Australia	230	10	90	130	212	11	73	128
New Zealand	—	—	—	—	—	—	—	—
Others	*183*	—	*180*	*3*	*196*	—	*190*	*6*
Democratic People's Republic of Korea	183	—	180	3	196	—	190	6
North America	*11,148*	*9,131*	*699*	*1,318*	*14,368*	*12,173*	*833*	*1,362*
Canada	2,259	1,680	328	251	3,885	3,179	465	241
United States	8,889	7,451	371	1,067	10,483	8,994	368	1,121

TABLE 17 *(continued)*

	1965				1968			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
ECLA area total	*1,804*	*1,711*	*13*	*80*	*1,973*	*1,852*	*29*	*92*
Central America	*1,667*	*1,612*	*7*	*48*	*1,803*	*1,720*	*22*	*61*
Cuba	7	—	7	—	22	—	22	—
Mexico	1,593	1,579	—	14	1,729	1,695	—	34
Netherlands Antilles	59	29	—	30	45	22	—	23
Puerto Rico	—	—	—	—	—	—	—	—
Trinidad and Tobago	8	4	—	4	7	3	—	4
South America	*137*	*99*	*6*	*32*	*170*	*132*	*7*	*31*
Argentina	45	28	—	17	44	34	—	10
Bolivia	12	12	—	—	25	25	—	—
Brazil	5	5	—	—	8	8	—	—
Chile	48	35	6	7	48	35	7	6
Colombia	21	19	—	2	33	29	—	4
Ecuador	—	—	—	—	2	—	—	2
Peru	6	—	—	6	9	—	—	9
Uruguay	—	—	—	—	1	1	—	—
Venezuela	—	—	—	—	—	—	—	—

	1969			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total production	**38,866**	**21,042**	**11,403**	**6,421**
ECE area total	*16,897*	*5,773*	*7,560*	*3,564*
Western Europe	*7,859*	*2,178*	*3,975*	*1,706*
Austria	68	3	—	65

Belgium	197	12	—	185
Cyprus	485	—	485	—
Denmark	8	8	—	—
Finland	490	135	295	60
France	1,880	1,695	35	150
Germany, Federal Republic of	700	150	265	285
Greece	90	—	90	—
Ireland	1	—	—	1
Italy	955	75	600	280
Netherlands	82	42	—	40
Norway	444	4	400	40
Portugal	279	4	275	—
Spain	1,338	3	1,300	35
Sweden	286	6	230	50
Switzerland	1	1	—	—
United Kingdom	555	40	—	515
Eastern Europe	*3,413*	*1,945*	*785*	*683*
Albania	—	—	—	—
Bulgaria	192	17	80	95
Czechoslovakia	233	35	155	43
German Democratic Republic	390	125	60	205
Hungary	7	7	—	—
Poland	1,990	1,750	30	210
Romania	380	10	340	30
Yugoslavia	221	1	120	100
USSR	*5,625*	*1,650*	*2,800*	*1,175*
ECA area total	*567*	*15*	*432*	*120*
Algeria	20	—	20	—
Egypt	—	—	—	—
Libyan Arab Republic	—	—	—	—
Morocco	140	—	140	—

TABLE 17 *(continued)*

	1969			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Mozambique	—	—	—	—
South Africa	301	11	250	40
Southern Rhodesia	26	4	22	—
Senegal	—	—	—	—
Tunisia	—	—	—	—
Uganda	—	—	—	—
Zaire	45	—	—	45
Zambia	35	—	—	35
UNESOB area total	*81*	*78*	—	*3*
Iraq	5	3	—	2
Jordan	—	—	—	—
Kuwait	70	70	—	—
Lebanon	—	—	—	—
Saudi Arabia	6	5	—	1
Syrian Arab Republic	—	—	—	—
ECAFE area total	*4,538*	*747*	*2,548*	*1,243*
Asia	*4,111*	*735*	*2,268*	*1,108*
Burma	—	—	—	—
China	876	223	603	50
India	134	4	20	110
Indonesia	3	3	—	—
Iran	80	80	—	—
Israel	6	6	—	—
Japan	2,760	385	1,475	900
Malaysia	1	1	—	—
Pakistan	13	—	—	13

Philippines	90	—	90	—
Republic of Korea	—	—	—	—
Thailand	3	3	—	—
Turkey	145	30	80	35
Oceania	*222*	*12*	*80*	*130*
Australia	22	12	80	130
New Zealand	—	—	—	—
Others	*205*	—	*200*	*5*
Democratic People's	1	1	—	—
Republic of Korea	205	—	200	5
North America	*14,730*	*12,500*	*830*	*1,400*
Canada	4,470	3,750	470	250
United States	10,260	8,750	360	1,150
ECLA area total	*2,053*	*1,929*	*33*	*91*
Central America	*1,854*	*1,767*	*25*	*62*
Cuba	25	—	25	—
Mexico	1,775	1,740	—	35
Netherlands Antilles	46	23	—	23
Puerto Rico	1	1	—	—
Trinidad and Tobago	7	3	—	4
South America	*199*	*162*	*8*	*29*
Argentina	55	45	—	10
Bolivia	30	30	—	—
Brazil	8	8	—	—
Chile	54	40	8	6
Colombia	37	33	—	4
Ecuador	6	5	—	1
Peru	8	—	—	8
Uruguay	1	1	—	—
Venezuela	—	—	—	—

TABLE 18. WORLD PRODUCTION OF BRIMSTONE BY COUNTRY (1960, 1963, 1965, 1968, 1969)

(*Thousand tons S*)

	1960				1963			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*	*Total brimstone*	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
Total production	**10,188**	**6,290**	**2,675**	**1,223**	**12,568**	**6,441**	**4,443**	**1,684**
ECE area total	*1,914*	—	*1,312*	*602*	*3,139*	—	*1,935*	*1,204*
Western Europe	*1,291*	—	*1,160*	*131*	*1,828*		*1,715*	*113*
Austria	—	—	—	—	—	—	—	
Belgium	—	—	—	—	4	—	4	
Cyprus	—	—	—	—	—	—	—	
Denmark	—	—	—	—	—	—	—	—
Finland	—	—	—	—	38	—	38	—
France	797	—	797	—	1,418	—	1,418	—
Germany, Federal Republic of	84	—	84	—	86	—	86	—
Greece	—	—	—	—	—	—	—	—
Ireland	—	—	—	—	—	—	—	—
Italy	149	—	20	129	134	—	21	113
Netherlands	31	—	31	—	35	—	35	—
Norway	72	—	72	—	—	—	—	—
Portugal	13	—	13	—	2	—	2	—
Spain	43	—	41	2	38	—	38	
Sweden	39	—	39	—	26	—	26	—
Switzerland	—	—	—	—	—	—	—	—
United Kingdom	63		63	—	47	—	47	—
Eastern Europe	*143*	—	*112*	*31*	*361*	—	*120*	*241*
Albania	—	—	—	—	—	—	—	—
Bulgaria	5	—	—	5	6	—	—	6
Czechoslovakia	—	—	—	—	—	—	—	—
German Democratic Republic	112	—	112	—	120	—	120	—

Hungary	—	—	—	—	—	—	—	—
Poland	26	—	—	26	235	—	—	235
Romania	—	—	—	—	—	—	—	—
Yugoslavia	—	—	—	—	—	—	—	—
USSR	*480*	—	*40*	*449*	*950*	—	*100*	*850*
ECA area total	*7*	—	*7*	—	*7*	—	*7*	—
Algeria	—	—	—	—	—	—	—	—
Egypt	2	—	2	—	2	—	2	—
Libyan Arab Republic	—	—	—	—	—	—	—	—
Morocco	—	—	—	—	—	—	—	—
Mozambique	—	—	—	—	—	—	—	—
South Africa	5	—	5	—	5	—	5	—
Southern Rhodesia	—	—	—	—	—	—	—	—
Senegal	—	—	—	—	—	—	—	—
Tunisia	—	—	—	—	—	—	—	—
Uganda	—	—	—	—	—	—	—	—
Zaire	—	—	—	—	—	—	—	—
Zambia	—	—	—	—	—	—	—	—
UNESOB area total	—	—	—	—	—	—	—	—
Iraq	—	—	—	—	—	—	—	—
Jordan	—	—	—	—	—	—	—	—
Kuwait	—	—	—	—	—	—	—	—
Lebanon	—	—	—	—	—	—	—	—
Saudi Arabia	—	—	—	—	—	—	—	—
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	*454*	—	*35*	*419*	*445*	—	*38*	*107*
Asia	*451*	—	*32*	*419*	*440*	—	*33*	*407*
Burma	—	—	—	—	—	—	—	—
China	155	—	—	155	167	—	—	167
India	—	—	—	—	—	—	—	—
Indonesia	—	—	—	—	—	—	—	—

TABLE 18 (continued)

	1960				1963			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*	*Total brimstone*	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
Iran	24	—	24	—	21	—	21	—
Israel	—	—	—	—	—	—	—	—
Japan	255	—	8	247	233	—	12	221
Malaysia	—	—	—	—	—	—	—	—
Pakistan	—	—	—	—	—	—	—	—
Philippines	—	—	—	—	—	—	—	—
Republic of Korea	—	—	—	—	—	—	—	—
Thailand	—	—	—	—	—	—	—	—
Turkey	17	—	—	17	19	—	—	19
Oceania	*3*	—	*3*	—	*5*	—	*5*	—
Australia	3	—	3	—	5	—	5	—
New Zealand	—	—	—	—	—	—	—	—
Others	—	—	—	—	—	—	—	—
Democratic People's Republic of Korea	—	—	—	—	—	—	—	—
North America	*6,373*	*5,021*	*1,256*	*96*	*7,300*	*4,960*	*2,340*	—
Canada	458	—	458	—	1,354	—	1,354	—
United States	5,915	5,021	798	96	5,946	4,960	986	—
ECLA area total	*1,440*	*1,269*	*65*	*106*	*1,677*	*1,481*	*123*	*73*
Central America	*1,354*	*1,269*	*60*	*25*	*1,585*	*1,481*	*75*	*29*
Cuba	—	—	—	—	—	—	—	—
Mexico	1,328	1,269	34	25	1,554	1,481	44	29
Netherlands Antilles	22	—	22	—	24	—	24	—
Puerto Rico	—	—	—	—	—	—	—	—
Trinidad and Tobago	4	—	4	—	7	—	7	—

	1965				1968			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*	*Total brimstone*	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
South America	*86*	—	*5*	*81*	*92*	—	*48*	*44*
Argentina	40	—	—	40	24	—	—	24
Bolivia	1	—	—	1	8	—	—	8
Brazil	5	—	5	—	5	—	5	—
Chile	31	—	—	31	43	—	43	—
Colombia	9	—	—	9	12	—	—	12
Ecuador	—	—	—	—	—	—	—	—
Peru	—	—	—	—	—	—	—	—
Uruguay	—	—	—	—	—	—	—	—
Venezuela	—	—	—	—	—	—	—	—
Total production	**15,221**	**7,816**	**5,392**	**2,018**	**19,859**	**9,978**	**7,530**	**2,351**
ECE area total	***3,803***	***100***	***2,233***	***1,470***	***5,190***	***796***	***2,640***	***1,754***
Western Europe	***1,932***	—	***1,853***	***79***	***2,084***	—	***2,005***	***79***
Austria	1	—	1	—	3	—	3	—
Belgium	4	—	4	—	6	—	6	—
Cyprus	—	—	—	—	—	—	—	—
Denmark	6	—	6	—	8	—	8	—
Finland	74	—	74	—	125	—	125	—
France	1,534	—	1,534	—	1,623	—	1,623	—
Germany, Federal Republic of	77	—	77	—	127	—	127	—
Greece	—	—	—	—	—	—	—	—
Ireland	—	—	—	—	—	—	—	—
Italy	103	—	24	79	94	—	15	79
Netherlands	30	—	30	—	39	—	39	—
Norway	—	—	—	—	3	—	3	—
Portugal	3	—	3	—	4	—	4	—
Spain	18	—	18	—	9	—	9	—
Sweden	27	—	27	—	4	—	4	—

TABLE 18 *(continued)*

	1965				*1968*			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*	*Total brimstone*	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
Switzerland	—	—	—	—	1	—	1	—
United Kingdom	55	—	55	—	38	—	38	—
Eastern Europe	*571*	*100*	*130*	*341*	*1,506*	*796*	*185*	*525*
Albania	—	—	—	—	—	—	—	—
Bulgaria	10	—	—	10	15	—	—	15
Czechoslovakia	—	—	—	—	30	—	30	—
German Democratic Republic	125	—	125	—	125	—	125	—
Hungary	—	—	—	—	5	—	5	—
Poland	436	100	5	331	1,326	796	20	510
Romania	—	—	—	—	5	—	5	—
Yugoslavia	—	—	—	—	—	—	—	—
USSR	*1,300*	—	*250*	*1,050*	*1,600*	—	*450*	*1,150*
ECA area total	*16*	—	*16*	—	*15*	—	*15*	—
Algeria	—	—	—	—	—	—	—	—
Egypt	3	—	3	—	2	—	2	
Libyan Arab Republic	—	—	—	—	—	—	—	
Morocco	—	—	—	—	—	—	—	
Mozambique	—	—	—	—	—	—	—	—
South Africa	13	—	13	—	9	—	9	—
Southern Rhodesia	—	—	—	—	4	—	4	—
Senegal	—	—	—	—	—	—	—	—
Tunisia	—	—	—	—	—	—	—	—
Uganda	—	—	—	—	—	—	—	—
Zaire	—	—	—	—	—	—	—	—
Zambia	—	—	—	—	—	—	—	—

UNESOB area total	—	—	—	—	*20*	—	*20*	
Iraq	—	—	—	—	20	—	20	
Jordan	—	—	—	—	20	—	20	
Kuwait	—	—	—	—	—	—	—	—
Lebanon	—	—	—	—	—	—	—	—
Saudi Arabia	—	—	—	—	—	—	—	—
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	*560*	—	*141*	*419*	*609*	—	*166*	*443*
Asia	*550*	—	*131*	*419*	*598*	—	*155*	*443*
Burma	—	—	—	—	—	—	—	—
China	259	—	75	184	206	—	52	154
India	—	—	—	—	—	—	—	—
Indonesia	—	—	—	—	3	—	—	3
Iran	19	—	19	—	21	—	21	—
Israel	—	—	—	—	6	—	6	—
Japan	250	—	37	213	336	—	75	261
Malaysia	—	—	—	—	—	—	—	—
Pakistan	—	—	—	—	—	—	—	—
Philippines	—	—	—	—	—	—	—	—
Republic of Korea	—	—	—	—	—	—	—	—
Thailand	—	—	—	—	1	—	1	—
Turkey	22	—	—	22	25	—	—	25
Oceania	*10*	—	*10*	—	*11*	—	*11*	—
Australia	10	—	10	—	11	—	11	
New Zealand	—	—	—	—	—	—	—	—
Others	—	—	—	—	—	—	—	—
Democratic People's Republic of Korea	—	—	—	—	—	—	—	—
North America	*9,131*	*6,214*	*2,917*	—	*12,173*	*7,574*	*4,599*	
Canada	1,680	—	1,680		3,179	—	3,179	
United States	7,451	6,214	1,237	—	8,994	7,574	1,420	

TABLE 18 *(continued)*

	1965				1968			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*	*Total brimstone*	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
ECLA area total	*1,711*	*1,502*	*85*	*124*	*1,852*	*1,608*	*90*	*154*
Central America	*1,612*	*1,502*	*80*	*30*	*1,720*	*1,608*	*78*	*34*
Cuba	—	—	—	—	—	—	—	—
Mexico	1,579	1,502	47	30	1,695	1,608	53	34
Netherlands Antilles	29	—	29	—	22	—	22	—
Puerto Rico	—	—	—	—	—	—	—	—
Trinidad and Tobago	4	—	4	—	3	—	3	—
South America	*99*	—	*5*	*94*	*132*	—	*12*	*120*
Argentina	28	—	—	28	34	—	—	34
Bolivia	12	—	—	12	25	—	—	25
Brazil	5	—	5	—	8	—	8	—
Chile	35	—	—	35	35	—	—	35
Colombia	19	—	—	19	29	—	3	26
Ecuador	—	—	—	—	—	—	—	—
Peru	—	—	—	—	—	—	—	—
Uruguay	—	—	—	—	1	—	1	—
Venezuela	—	—	—	—	—	—	—	—

	1969			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
Total production	**21,042**	**10,050**	**8,594**	**2,398**
ECE area total	*5,773*	*1,180*	*2,833*	*1,760*
Western Europe	*2,178*	—	*2,118*	*60*
Austria	3	—	3	—

Belgium	12	—	12	—
Cyprus	—	—	—	—
Denmark	8	—	8	—
Finland	135	—	135	—
France	1,695	—	1,695	—
Germany, Federal Republic of	150	—	150	—
Greece	—	—	—	—
Ireland	—	—	—	—
Italy	75	—	15	60
Netherlands	42	—	42	—
Norway	4	—	4	—
Portugal	4	—	4	—
Spain	3	—	3	—
Sweden	6	—	6	—
Switzerland	1	—	1	—
United Kingdom	40	—	40	—
Eastern Europe	*1,945*	*1,180*	*215*	*550*
Albania	—	—	—	—
Bulgaria	17	—	17	—
Czechoslovakia	35	—	35	—
German Democratic Republic	125	—	125	—
Hungary	7	—	7	—
Poland	1,750	1,180	20	550
Romania	10	—	10	—
Yugoslavia	1	—	1	—
USSR	*1,650*	—	*500*	*1,150*
ECA area total	*15*	—	*15*	—
Algeria	—	—	—	—
Egypt	—	—	—	—
Libyan Arab Republic	—	—	—	—
Morocco	—	—	—	—
Mozambique	—	—	—	—

TABLE 18 *(continued)*

	1969			
	Total brimstone	*Frasch sulphur*	*Recovered sulphur*	*Native sulphur*
South Africa	11	—	11	—
Southern Rhodesia	4	—	4	—
Senegal	—	—	—	—
Tunisia	—	—	—	—
Uganda	—	—	—	—
Zaire	—	—	—	—
Zambia	—	—	—	—
UNESOB area total	*78*	—	*78*	—
Iraq	3	—	3	—
Jordan	—	—	—	—
Kuwait	70	—	70	—
Lebanon	—	—	—	—
Saudi Arabia	5	—	5	—
Syrian Arab Republic	—	—	—	—
ECAFE area total	*747*	—	*289*	*458*
Asia	*735*	—	*277*	*458*
Burma	—	—	—	—
China	223	—	58	165
India	4	—	4	—
Indonesia	3	—	—	3
Iran	80	—	80	—
Israel	6	—	6	—
Japan	385	—	125	260
Malaysia	1	—	1	—
Pakistan	—	—	—	—
Philippines	—	—	—	—

Republic of Korea	—	—	—	—
Thailand	3	—	3	—
Turkey	30	—	—	30
Oceania	*12*	—	*12*	—
Australia	12	—	12	—
New Zealand	—	—	—	—
Others	—	—	—	—
Democratic People's Republic of Korea	—	—	—	—
North America	*12,500*	*7,220*	*5,280*	—
Canada	3,750	—	3,750	—
United States	8.750	7,220	1,530	—
ECLA area total	*1,929*	*1,650*	*99*	*180*
Central America	*1,767*	*1,650*	*87*	*30*
Cuba	—	—	—	—
Mexico	1,740	1,650	60	30
Netherlands Antilles	23	—	23	—
Puerto Rico	1	—	1	—
Trinidad and Tobago	3	—	3	—
South America	*162*	—	*12*	*150*
Argentina	45	—	—	45
Bolivia	30	—	—	30
Brazil	8	—	8	—
Chile	40	—	—	40
Colombia	33	—	3	30
Ecuador	5	—	—	5
Peru	—	—	—	—
Uruguay	1	—	1	—
Venezuela	—	—	—	—

TABLE 19. WORLD CONSUMPTION BY COUNTRY OF SULPHUR-IN-ALL-FORMS — RAW MATERIAL SOURCES (1960, 1963, 1965, 1968, 1969)

(Thousand tons S or S equivalent)

	1960				*1963*			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	21,807	9,873	7,929	4,005	25,891	12,611	8,423	4,857
ECE area total	*10,041*	*2,718*	*5,229*	*2,094*	*12,180*	*3,993*	*5,163*	*2,724*
Western Europe	*7,023*	*2,078*	*3,402*	*1,543*	*7,726*	*2,663*	*3,466*	*1,597*
Austria	152	60	16	76	164	89	12	63
Belgium	529	174	177	178	464	176	130	158
Cyprus	—	—	—	—	—	—	—	—
Denmark	74	7	67	—	80	15	65	—
Finland	192	74	69	49	275	117	61	—
France	863	406	357	100	997	586	298	97
Germany, Federal Republic of	1,351	249	859	243	1,428	343	820	113
Greece	61	13	48	—	58	15	43	265
Ireland	33	19	12	2	52	50	2	—
Italy	1,051	139	669	243	1,233	170	850	—
Netherlands	311	125	161	25	312	168	114	213
Norway	104	32	46	26	102	30	48	30
Portugal	134	13	121	—	165	35	130	24
Spain	476	53	392	31	567	52	478	—
Sweden	355	116	224	15	388	115	254	37
Switzerland	70	53	17	—	71	52	19	19
United Kingdom	1,267	545	167	555	1,370	650	142	—
								578
Eastern Europe	*1,105*	*240*	*597*	*268*	*1,539*	*495*	*637*	*407*
Albania	—	—	—	—	—	—	—	—
Bulgaria	62	5	42	15	93	6	47	40
Czechoslovakia	259	70	160	29	385	150	210	25

German Democratic Republic	350	80	150	120	365	95	130	140
Hungary	65	25	40	—	150	110	40	—
Poland	240	50	110	80	307	120	100	87
Romania	88	3	70	15	105	5	75	25
Yugoslavia	41	7	25	9	134	9	35	90
USSR	*1,913*	*400*	*1,230*	*283*	*2,915*	*835*	*1,360*	*720*
ECA area total	*535*	*214*	*266*	*55*	*546*	*272*	*218*	*56*
Algeria	40	32	8	—	32	29	3	—
Egypt	45	11	34	—	56	26	30	—
Libyan Arab Republic	—	—	—	—	—	—	—	—
Morocco	16	12	4	—	15	10	5	—
Mozambique	—	—	—	—	—	—	—	—
South Africa	303	103	200	—	294	140	154	—
Southern Rhodesia	15	—	15	—	20	—	20	—
Senegal	—	—	—	—	—	—	—	—
Tunisia	59	54	5	—	69	63	6	—
Uganda	2	2	—	—	4	4	—	—
Zaire	39	—	—	39	31	—	—	31
Zambia	16	—	—	16	25	—	—	25
UNESOB area total	*13*	*11*	—	*2*	*17*	*15*	—	*2*
Iraq	7	5	—	2	6	4	—	2
Jordan	—	—	—	—	—	—	—	—
Kuwait	—	—	—	—	—	—	—	—
Lebanon	4	4	—	—	9	9	—	—
Saudi Arabia	2	2	—	—	2	2	—	—
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	*3,355*	*988*	*1,701*	*666*	*4,085*	*1,229*	*2,087*	*769*
Asia	*2,733*	*645*	*1,502*	*586*	*3,310*	*827*	*1,826*	*657*
Burma	1	1	—	—	2	2	—	—
China	532	112	420	—	744	184	560	—
India	242	168	—	74	325	251	—	74

TABLE 19 *(continued)*

	1960				1963			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Indonesia	9	9	—	—	8	8	—	—
Iran	30	24	—	6	26	22	—	4
Israel	46	46	—	—	56	56	—	—
Japan	1,812	255	1,066	491	2,028	254	1,233	541
Malaysia	1	1	—	—	3	3	—	—
Pakistan	21	10	—	11	26	14	—	12
Philippines	12	3	9	—	27	4	23	—
Republic of Korea	5	5	—	—	7	7	—	—
Thailand	2	2	—	—	4	4	—	—
Turkey	20	9	7	4	54	18	10	26
Oceania	*537*	*343*	*114*	*80*	*630*	*398*	*121*	*111*
Australia	412	218	114	80	479	247	121	111
New Zealand	125	125	—	—	151	151	—	—
Others	*85*	—	*85*	—	*145*	*4*	*140*	*1*
Democratic People's Republic of Korea	85	—	85	—	145	4	140	1
North America	*7,359*	*5,516*	*724*	*1,119*	*8,392*	*6,518*	*639*	*1,235*
Canada	902	537	145	220	1,001	630	117	254
United States	6,457	4,979	579	899	7,391	5,888	522	981
ECLA area total	*504*	*426*	*9*	*69*	*671*	*584*	*16*	*71*
Central America	*223*	*184*	—	*39*	*318*	*269*	*5*	*44*
Cuba	25	25	—	—	45	40	5	—
Mexico	103	94	—	9	156	147	—	9
Netherlands Antilles	49	24	—	25	57	26	—	31

	1965 Total all-forms	1965 Brimstone	1965 Pyrite	1965 S.O.F.	1968 Total all-forms	1968 Brimstone	1968 Pyrite	1968 S.O.F.
Puerto Rico	29	29	—		35	35		
Trinidad and Tobago	17	12	—	5	25	21		4
South America	*281*	*242*	*9*	*30*	*353*	*315*	*11*	*27*
Argentina	68	52	—	16	62	50	—	12
Bolivia	1	1	—	—	1	1	—	—
Brazil	115	115	—	—	157	157	—	—
Chile	57	41	7	9	69	54	7	8
Colombia	10	9	—	1	11	9	—	2
Ecuador	—	—	—	—	1	1	—	—
Peru	17	13	—	4	19	14		5
Uruguay	9	9	—	—	11	11	—	—
Venezuela	4	2	2	—	22	18	4	—
Total consumption	**30,336**	**16,034**	**8,966**	**5,336**	**35,532**	**18,766**	**10,508**	**6,258**
ECE area total	*14,108*	*5,377*	*5,770*	*2,961*	*16,466*	*6,120*	*6,891*	*3,455*
Western Europe	*8,595*	*3,504*	*3,531*	*1,560*	*9,804*	*4,013*	*4,131*	*1,660*
Austria	159	78	11	70	181	105	16	60
Belgium	541	257	110	174	637	293	158	186
Cyprus	—	—	—	—	—	—	—	—
Denmark	89	19	70	—	77	14	63	—
Finland	298	134	56	108	363	115	189	59
France	1,200	878	200	122	1,352	1,023	179	150
Germany, Federal Republic of	1,583	472	859	252	1,754	456	1,022	276
Greece	94	37	57	—	309	137	172	—
Ireland	59	57	2	—	115	113	1	1
Italy	1,313	164	933	216	1,482	252	956	274
Netherlands	397	236	127	34	487	398	54	35
Norway	126	52	47	27	177	39	101	37

TABLE 19 *(continued)*

	1965				*1968*			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
Portugal	155	39	116	—	179	25	154	—
Spain	623	44	548	31	774	63	676	35
Sweden	436	155	263	18	464	146	270	48
Switzerland	64	44	20	—	61	43	18	—
United Kingdom	1,458	838	112	508	1,392	791	102	499
Eastern Europe	*1,838*	*598*	*789*	*451*	*2,412*	*787*	*960*	*665*
Albania	—	—	—	—	15	15	—	—
Bulgaria	130	8	67	55	172	12	70	90
Czechoslovakia	452	170	250	32	495	180	275	40
German Democratic Republic	420	110	150	160	515	130	180	205
Hungary	187	140	47	—	230	180	50	—
Poland	328	145	95	88	500	220	80	200
Romania	136	10	100	26	220	15	175	30
Yugoslavia	185	15	80	90	265	35	130	100
USSR	*3,675*	*1,275*	*1,450*	*950*	*4,250*	*1,320*	*1,800*	*1,130*
ECA area total	*708*	*381*	*264*	*63*	*959*	*456*	*388*	*115*
Algeria	40	29	11	—	42	34	8	—
Egypt	85	63	22	—	107	68	39	—
Libyan Arab Republic	—	—	—	—	—	—	—	—
Morocco	54	17	37	—	134	22	112	—
Mozambique	—	—	—	—	3	3	—	—
South Africa	313	138	175	—	413	161	212	40
Southern Rhodesia	26	7	19	—	14	3	11	—
Senegal	—	—	—	—	8	8	—	—
Tunisia	119	119	—	—	154	148	6	—

Uganda	6	6	—	—	5	5	—	—
Zaire	36	1	—	35	44	1	—	43
Zambia	29	1	—	28	35	3	—	32
UNESOB area total	*30*	*28*	—	*2*	*60*	*57*	—	*3*
Iraq	9	7	—	2	8	6	—	2
Jordan	—	—	—	—	—	—	—	—
Kuwait	—	—	—	—	20	20	—	—
Lebanon	19	19	—	—	30	30	—	—
Saudi Arabia	2	2	—	—	2	1	—	1
Syrian Arab Republic	—	—	—	—	—	—	—	—
ECAFE area total	*4,809*	*1,619*	*2,278*	*912*	*5,465*	*1,878*	*2,356*	*1,231*
Asia	*3,840*	*1,046*	*2,015*	*779*	*4,433*	*1,225*	*2,111*	*1,097*
Burma	2	2	—	—	1	1	—	—
China	916	316	600	—	866	281	540	45
India	376	299	—	77	476	368	—	108
Indonesia	8	8	—	—	6	6	—	—
Iran	20	20	—	—	24	24	—	—
Israel	61	61	—	—	69	69	—	—
Japan	2,319	284	1,378	657	2,647	265	1,486	896
Malaysia	3	3	—	—	11	11	—	—
Pakistan	29	16	—	13	29	16	—	13
Philippines	27	4	23	—	94	14	80	—
Republic of Korea	9	9	—	—	113	113	—	—
Thailand	2	2	—	—	27	27	—	—
Turkey	68	22	14	32	70	30	5	35
Oceania	*801*	*568*	*103*	*130*	*836*	*638*	*70*	*128*
Australia	603	370	103	130	664	466	70	128
New Zealand	198	198	—	—	172	172	—	—
Others	*168*	*5*	*160*	*3*	*196*	*15*	*175*	*6*
Democratic People's Republic of Korea	168	5	160	3	196	15	175	6

TABLE 19 *(continued)*

	1965				*1968*			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*	*Total all-forms*	*Brimstone*	*Pyrite*	*S.O.F.*
North America	*9,926*	*7,967*	*641*	*1,318*	*11,572*	*9,359*	*851*	*1,362*
Canada	1,057	642	164	251	1,371	788	342	241
United States	8,869	7,325	477	1,067	10,201	8,571	509	1,121
ECLA area total	*755*	*662*	*13*	*80*	*1,010*	*896*	*22*	*92*
Central America	*375*	*320*	*7*	*48*	*558*	*482*	*15*	*61*
Cuba	[illegible]	55	7	—	160	145	15	—
Mexico	199	185	—	14	286	252	—	34
Netherlands Antilles	54	24	—	30	45	22	—	23
Puerto Rico	35	35	—	—	35	35	—	—
Trinidad and Tobago	25	21	—	4	26	22	—	4
Others	—	—	—	—	6	6	—	—
South America	*380*	*342*	*6*	*32*	*452*	*414*	*7*	*31*
Argentina	81	64	—	17	76	66	—	10
Bolivia	2	2	—	—	3	3	—	—
Brazil	168	168	—	—	204	204	—	—
Chile	59	46	6	7	64	51	7	6
Colombia	12	10	—	2	29	25	—	4
Ecuador	1	1	—	—	2	—	—	2
Peru	21	15	—	6	28	19	—	9
Uruguay	11	11	—	—	11	11	—	—
Venezuela	25	25	—	—	35	35	—	—

	1969			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	**37,374**	**19,973**	**10,980**	**6,421**
ECE area total	*17,242*	*6,460*	*7,218*	*3,564*

Western Europe	*10,250*	*4,234*	*4,310*	*1,706*
Austria	191	110	16	65
Belgium	655	305	165	185
Cyprus	—	—	—	—
Denmark	80	15	65	—
Finland	385	130	195	60
France	1,410	1,075	185	150
Germany, Federal Republic of	1,845	490	1,070	285
Greece	325	150	175	—
Ireland	122	120	1	1
Italy	1,542	277	985	280
Netherlands	505	410	55	40
Norway	195	40	115	40
Portugal	192	27	165	—
Spain	800	65	700	35
Sweden	495	150	295	50
Switzerland	63	45	18	—
United Kingdom	1,445	825	105	515
Eastern Europe	*2,567*	*866*	*1,018*	*683*
Albania	20	20	—	—
Bulgaria	186	16	75	95
Czechoslovakia	526	190	293	43
German Democratic Republic	530	140	185	205
Hungary	245	195	50	—
Poland	535	255	70	210
Romania	240	15	195	30
Yugoslavia	285	35	150	100
USSR	*4,425*	*1,360*	*1,890*	*1,175*
ECA area total	*1,047*	*492*	*435*	*120*
Algeria	46	36	10	—
Egypt	114	72	42	—
Libyan Arab Republic	—	—	—	—

TABLE 19 *(continued)*

	1969			
	Total all-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Morocco	147	25	122	—
Mozambique	3	3	—	—
South Africa	460	178	242	40
Southern Rhodesia	16	3	13	—
Senegal	13	13	—	—
Tunisia	159	153	6	—
Uganda	5	5	—	—
Zaire	46	1	—	45
Zambia	38	3	—	35
UNESOB area total	*89*	*86*	—	*3*
Iraq	10	8	—	2
Jordan	—	—	—	—
Kuwait	33	33	—	—
Lebanon	40	40	—	—
Saudi Arabia	6	5	—	1
Syrian Arab Republic	—	—	—	—
ECAFE area total	*5,710*	*2,025*	*2,442*	*1,243*
Asia	*4,623*	*1,323*	*2,192*	*1,108*
Burma	1	1	—	—
China	907	297	560	50
India	533	403	20	110
Indonesia	8	8	—	—
Iran	27	27	—	—
Israel	81	81	—	—
Japan	2,682	275	1,507	900
Malaysia	14	14	—	—

Pakistan	30	17	—	13
Philippines	111	16	95	—
Republic of Korea	118	118	—	—
Thailand	32	32	—	—
Turkey	79	34	10	35
Oceania	*880*	*685*	*65*	*130*
Australia	696	501	65	130
New Zealand	184	184	—	—
Others	*207*	*17*	*185*	*5*
Democratic People's Republic of Korea	207	17	185	5
North America	*12,181*	*9,921*	*860*	*1,400*
Canada	1,434	838	346	250
United States	10,747	9,083	514	1,150
ECLA area total	*1,105*	*989*	*25*	*91*
Central America	*626*	*547*	*17*	*62*
Cuba	167	150	17	—
Mexico	*342*	307	—	35
Netherlands Antilles	46	23	—	23
Puerto Rico	37	37	—	—
Trinidad and Tobago	27	23	—	4
Others	7	7	—	—
South America	*479*	*442*	*8*	*29*
Argentina	80	70	—	10
Bolivia	4	4	—	—
Brazil	213	213	—	—
Chile	67	53	8	6
Colombia	31	27	—	4
Ecuador	5	4	—	1
Peru	29	21	—	8
Uruguay	12	12	—	—
Venezuela	38	38	—	—

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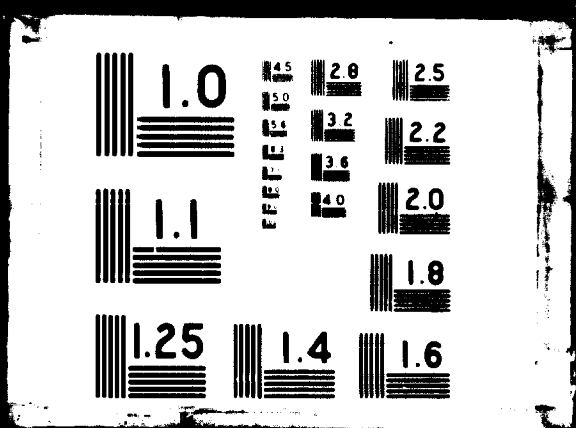

TABLE 20. WORLD CONSUMPTION BY COUNTRY OF SULPHUR-IN-ALL-FORMS BY MAIN END-USE SECTORS (1960, 1963, 1965, 1968, 1969)

(Thousand tons S equivalent)

	1960			*1963*		
	Total consumption	*Sulphuric acid*	*Non-acid uses*	*Total consumption*	*Sulphuric acid*	*Non-acid uses*
Total consumption	**21,807**	**17,631**	**4,176**	**25,891**	20,878	5,013
ECE area total	*10,041*	*8,051*	*1,990*	*12,180*	*9,568*	*2,612*
Western Europe	*7,023*	*5,348*	*1,675*	*7,726*	*5,882*	*1,844*
Austria	152	46	106	164	71	93
Belgium	529	481	48	464	423	41
Cyprus	—	—	—	—	—	—
Denmark	74	70	4	80	77	3
Finland	192	62	130	275	110	165
France	863	690	173	997	800	197
Germany, Federal Republic of	1,351	1,108	243	1,428	1,155	273
Greece	61	48	13	58	43	15
Ireland	33	33	—	52	52	—
Italy	1,051	803	248	1,233	953	280
Netherlands	311	300	11	312	300	12
Norway	104	37	67	102	33	69
Portugal	134	121	13	165	149	16
Spain	476	420	56	567	506	61
Sweden	355	144	211	388	168	220
Switzerland	70	47	23	71	49	22
United Kingdom	1,267	938	329	1,370	993	397
Eastern Europe	*1,105*	*915*	*190*	*1,539*	*1,286*	*253*
Albania	—	—	—	—	—	—
Bulgaria	62	57	5	93	82	11
Czechoslovakia	259	195	64	385	305	80
German Democratic Republic	350	280	70	365	285	80

Hungary	65	57	8	150	135	[illegible]
Poland	240	210	30	307	262	45
Romania	88	80	8	105	93	12
Yugoslavia	41	36	5	134	124	10
USSR	*1,913*	*1,788*	*125*	*2,915*	*2,400*	*515*
ECA area total	*535*	*462*	*73*	*546*	*464*	*82*
Algeria	40	14	26	32	9	23
Egypt	45	36	9	56	40	16
Libyan Arab Republic	—	—	—	—	—	—
Morocco	16	12	4	15	12	3
Mozambique	—	—	—	—	—	—
South Africa	303	279	24	294	265	29
Southern Rhodesia	15	15	—	20	20	—
Senegal	—	—	—	—	—	—
Tunisia	59	51	8	69	60	9
Uganda	2	—	2	4	2	2
Zaire	39	39	—	31	31	—
Zambia	16	16	—	25	25	—
UNESOB area total	*13*	*10*	*3*	*17*	*14*	*3*
Iraq	7	6	1	6	5	1
Jordan	—	—	—	—	—	—
Kuwait	—	—	—	—	—	—
Lebanon	4	2	2	9	7	2
Saudi Arabia	2	2	—	2	2	—
Syrian Arab Republic	—	—	—	—	—	—
ECAFE area total	*3,355*	*2,851*	*504*	*4,085*	*3,463*	*617*
Asia	*2,733*	*2,260*	*473*	*3,310*	*2,734*	*576*
Burma	1	1	—	2	2	—
China	532	490	42	744	671	73
India	242	122	120	325	196	129
Indonesia	9	7	2	8	7	1

TABLE 20 *(continued)*

	1960			1963		
	Total consumption	Sulphuric acid	Non-acid uses	Total consumption	Sulphuric acid	Non-acid uses
Iran	30	28	2	26	24	2
Israel	46	42	4	56	52	4
Japan	1,812	1,544	268	2,028	1,732	296
Malaysia	1	1	—	3	2	1
Pakistan	21	5	16	26	6	20
Philippines	12	9	3	27	23	4
Republic of Korea	5	3	2	7	4	3
Thailand	2	—	2	4	2	2
Turkey	20	8	12	54	13	41
Oceania	*537*	*516*	*21*	*630*	*604*	*26*
Australia	412	396	16	479	460	19
New Zealand	125	120	5	151	144	7
Others	*85*	*75*	*10*	*145*	*130*	*15*
Democratic People's Republic of Korea	85	75	10	145	130	15
North America	*7,359*	*5,859*	*1,500*	*8,392*	*6,811*	*1,581*
Canada	902	541	361	1,001	587	414
United States	6,457	5,318	1,139	7,391	6,224	1,167
ECLA area total	*504*	*398*	*106*	*671*	*553*	*118*
Central America	*223*	*206*	*17*	*318*	*292*	*26*
Cuba	25	25	—	45	42	3
Mexico	103	86	17	156	134	22
Netherlands Antilles	49	49	—	57	57	—
Puerto Rico	29	29	—	35	35	—
Trinidad and Tobago	17	17	—	25	24	1

South America	*281*	*192*	*89*	*353*	*261*	*92*
Argentina	68	46	22	62	37	25
Bolivia	1	1	—	1	1	—
Brazil	115	69	46	157	109	48
Chile	57	49	8	69	61	8
Colombia	10	4	6	11	6	5
Ecuador	—	—	—	1	1	—
Peru	17	13	4	19	15	4
Uruguay	9	7	2	11	10	1
Venezuela	4	3	1	22	21	1

	1965			1968		
	Total consumption	*Sulphuric acid*	*Non-acid uses*	*Total consumption*	*Sulphuric acid*	*Non-acid uses*
Total consumption	**30,336**	**24,866**	**5,470**	**35,532**	**29,600**	**5,932**
ECE area total	*14,108*	*11,263*	*2,845*	*16,466*	*13,426*	*3,040*
Western Europe	*8,595*	*6,765*	*1,830*	*9,804*	*7,983*	*1,821*
Austria	159	68	91	181	90	91
Belgium	541	505	36	637	613	24
Cyprus	—	—	—	—	—	—
Denmark	89	85	4	77	74	3
Finland	298	127	171	363	207	156
France	1,200	981	219	1,352	1,124	228
Germany, Federal Republic of	1,583	1,288	295	1,754	1,470	284
Greece	94	78	16	309	262	47
Ireland	59	59	—	115	115	—
Italy	1,313	1,043	270	1,482	1,167	315
Netherlands	397	385	12	487	475	12
Norway	126	42	84	177	91	86
Portugal	155	140	15	179	158	21
Spain	623	571	52	774	703	71

TABLE 20 *(continued)*

	1965			1968		
	Total consumption	*Sulphuric acid*	*Non-acid uses*	*Total consumption*	*Sulphuric acid*	*Non-acid uses*
Sweden	436	196	240	464	259	205
Switzerland	64	49	15	61	49	12
United Kingdom	1,458	1,148	310	1,392	1,126	266
Eastern Europe	*1,838*	*1,518*	*320*	*2,412*	*1,993*	*419*
Albania	—	—	—	15	14	1
Bulgaria	130	115	15	172	154	18
Czechoslovakia	452	357	95	495	390	105
German Democratic Republic	420	330	90	515	410	105
Hungary	187	157	30	230	190	40
Poland	328	273	55	500	425	75
Romania	136	116	20	220	185	35
Yugoslavia	185	170	15	265	225	40
USSR	*3,675*	*2,980*	*695*	*4,250*	*3,450*	*800*
ECA area total	*708*	*621*	*87*	*959*	*856*	*103*
Algeria	40	17	23	42	14	28
Egypt	85	68	17	107	87	20
Libyan Arab Republic	—	—	—	—	—	—
Morocco	54	51	3	134	131	3
Mozambique	—	—	—	3	3	—
South Africa	313	282	31	413	377	36
Southern Rhodesia	26	26	—	14	14	—
Senegal	—	—	—	8	8	—
Tunisia	119	110	9	154	145	9
Uganda	—	4	2	5	2	3
Zaire	36	35	1	44	43	1
Zambia	29	28	1	35	32	3

UNESOB area total	*30*	*27*	*3*	*60*	*57*	*3*
Iraq	9	8	1	8	7	1
Jordan	—	—	—	—	—	—
Kuwait	—	—	—	20	20	—
Lebanon	19	17	2	30	28	2
Saudi Arabia	2	2	—	2	2	—
Syrian Arab Republic	—	—	—	—	—	—
ECAFE area total	*4,809*	*4,063*	*746*	*5,465*	*4,676*	*789*
Asia	*3,840*	*3,142*	*698*	*4,433*	*3,712*	*721*
Burma	2	2	—	1	1	—
China	916	808	108	866	772	94
India	376	233	143	476	313	163
Indonesia	8	7	1	6	5	1
Iran	20	18	2	24	22	2
Israel	61	57	4	69	66	3
Japan	2,319	1,958	361	2,647	2,271	376
Malaysia	3	2	1	11	9	2
Pakistan	29	8	21	29	8	21
Philippines	27	23	4	94	88	6
Republic of Korea	9	6	3	113	111	2
Thailand	2	—	2	27	24	3
Turkey	68	20	48	70	22	48
Oceania	*801*	*773*	*28*	*836*	*798*	*38*
Australia	603	583	20	664	636	28
New Zealand	198	190	8	172	162	10
Others	*168*	*148*	*20*	*196*	*166*	*30*
Democratic People's Republic of Korea	168	148	20	196	166	30
North America	*9,926*	*8,267*	*1,659*	*11,572*	*9,727*	*1,845*
Canada	1,057	614	443	1,371	892	479
United States	8,869	7,653	1,216	10,201	8,835	1,366

Table 20 (continued)

	1965			1968		
	Total consumption	*Sulphuric acid*	*Non-acid uses*	*Total consumption*	*Sulphuric acid*	*Non-acid uses*
ECLA area total	*755*	*625*	*130*	*1,010*	*858*	*152*
Central America	*375*	*341*	*34*	*558*	*518*	*40*
Cuba	62	57	5	160	153	7
Mexico	199	171	28	286	254	32
Netherlands Antilles	54	54	—	45	45	—
Puerto Rico	35	35	—	35	35	—
Trinidad and Tobago	25	24	1	26	25	1
Others	—	—	—	6	6	—
South America	*380*	*284*	*96*	*452*	*340*	*112*
Argentina	81	56	25	76	48	28
Bolivia	2	2	—	3	2	1
Brazil	168	117	51	204	145	59
Chile	59	50	9	64	53	11
Colombia	12	7	5	29	24	5
Ecuador	1	1	—	2	2	—
Peru	21	17	4	28	23	5
Uruguay	11	10	1	11	9	2
Venezuela	25	24	1	35	34	1

	1969		
	Total consumption	*Sulphuric acid*	*Non-acid uses*
Total consumption	**37,374**	**31,072**	**6,302**
ECE area total	*17,242*	*13,994*	*3,248*

Western Europe	*10,250*	*8,303*	*1,947*
Austria	191	95	96
Belgium	655	628	27
Cyprus	—	—	—
Denmark	80	76	4
Finland	385	219	166
France	1,410	1,170	240
Germany, Federal Republic of	1,845	1,541	304
Greece	325	273	52
Ireland	122	122	—
Italy	1,542	1,212	330
Netherlands	505	490	15
Norway	195	103	92
Portugal	192	169	23
Spain	800	725	75
Sweden	495	280	215
Switzerland	63	51	12
United Kingdom	1,445	1,149	296
Eastern Europe	*2,567*	*2,106*	*461*
Albania	20	18	2
Bulgaria	186	167	19
Czechoslovakia	526	411	115
German Democratic Republic	530	420	110
Hungary	245	200	45
Poland	535	450	85
Romania	240	200	40
Yugoslavia	285	240	45
USSR	*4,425*	*3,585*	*840*
ECA area total	*1,047*	*929*	*118*
Algeria	46	17	29
Egypt	114	92	22
Libyan Arab Republic	—	—	—

TABLE 20 (continued)

	1969		
	Total consumption	*Sulphuric acid*	*Non-acid uses*
Morocco	147	142	5
Mozambique	3	3	—
South Africa	460	416	44
Southern Rhodesia	16	15	1
Senegal	13	13	—
Tunisia	159	149	—
Uganda	5	2	3
Zaire	46	45	1
Zambia	38	35	3
UNESOB area total	*89*	*85*	*4*
Iraq	10	9	1
Jordan	—	—	—
Kuwait	33	33	—
Lebanon	40	37	3
Saudi Arabia	6	6	—
Syrian Arab Republic	—	—	—
ECAFE area total	*5,710*	*4,865*	*845*
Asia	*4,623*	*3,856*	*767*
Burma	1	1	—
China	907	806	101
India	533	355	178
Indonesia	8	6	2
Iran	27	24	3
Israel	81	72	9
Japan	2,682	2,297	385
Malaysia	14	12	2

Pakistan	30	9	21
Philippines	111	103	8
Republic of Korea	118	115	3
Thailand	32	29	3
Turkey	79	27	52
Oceania	*880*	*835*	*45*
Australia	696	663	33
New Zealand	184	172	12
Others	*207*	*174*	*33*
Democratic People's Republic of Korea	207	174	33
North America	*12,181*	*10,259*	*1,922*
Canada	1,434	938	496
United States	10,747	9,321	1,426
ECLA area total	*1,105*	*940*	*165*
Central America	*626*	*579*	*47*
Cuba	167	158	9
Mexico	342	306	36
Netherlands Antilles	46	46	—
Puerto Rico	37	36	1
Trinidad and Tobago	27	26	1
Others	7	7	—
South America	*479*	*361*	*118*
Argentina	80	51	29
Bolivia	4	3	1
Brazil	213	152	61
Chile	67	55	12
Colombia	31	25	6
Ecuador	5	5	—
Peru	29	24	5
Uruguay	12	10	2
Venezuela	38	36	2

PART II

Chapter 7

WORLD SULPHUR SUPPLY 1970 – 1980

World production of sulphur-in-all-forms was predicted to reach 40 million tons S during 1970; present projections of the growth of world sulphur supply during the ensuing decade indicate that this level of output will rise by more than half to exceed 62 million tons S by 1980. To a great extent this advance in world all-forms production will be determined by the maintenance and development of certain key trends that have played a prominent role in governing the evolution of world supply during the decade just ended. In particular, it is expected that by 1980 an even greater proportion of world sulphur output will materialize in elemental form as brimstone from Frasch sulphur and native refined sulphur mining and beneficiation operations and from sulphur recovery units primarily at natural gas plants and oil refineries.

This further development of brimstone supply will reinforce the underlying acceleration in brimstone output which was in evidence throughout the last decade (see chapter 3) and the incremental output during the 1970s will arise most noticeably within the present major supply sources, e.g. the recovered sulphur industries in western Canada and the United States and the United States Frasch sulphur industry. Between 1970 and 1980 operations in these three sectors are expected to account for nearly 45 per cent of the total 15.07 million ton growth in world brimstone production (see table 21). (For world brimstone production by area, see table 22.) However, the major expansion anticipated in brimstone supply will be strongly supported also by new production from facilities introduced during the late 1960s, such as the recovered sulphur plants in the Near East and Japan and the Polish Frasch-type and native sulphur mines. A third component in the supply pattern during the coming decade which is seen to be capable of making a sizable contribution to the improved availability of brimstone is the number of totally new sources scheduled for commissioning before 1980. Included in this category are, for example, the probable emergence of a Frasch-type, underground-molten sulphur producing industry in the USSR akin to that in Poland and the expected start of Frasch sulphur mining in Iraq. Less amenable to quantitative evaluation at the moment but no less likely to be a factor of some significance in augmenting world brimstone supply, is the growth of recovered sulphur production contingent upon the likely implementation of more severe air pollution controls in the latter part of the 1970s.

TABLE 21. WORLD BRIMSTONE PRODUCTION—MAJOR SUPPLY SOURCES BY COUNTRY (1970, 1975, 1980)

(Million tons S)

	1970	*1975*	*1980*
Total production	**22.78**	**31.73**	**37.85**
Frasch sulphur	***9.70***	***12.90***	***15.90***
United States	7.00	8.10	8.90
Mexico	1.30	2.10	2.70
Poland	1.40	2.10	2.70
USSR	–	0.30	1.00
Iraq	– –	0.30	0.60
Recovered sulphur	***10.43***	***15.66***	***18.95***
Western Canada	4.70	7.50	8.00
United States	1.60	2.20	3.10
France (Lacq)	1.70	1.80	1.80
Germany, Federal Republic of	0.20	0.50	0.50
Near East	0.53	1.00	1.60
USSR	0.60	1.00	1.50
Others	1.10	1.66	2.45
Native refined sulphur	***2.65***	***3.17***	***3.00***
Western Europe	0.48	0.52	0.52
Poland	0.80	1.20	1.20
USSR	1.20	1.20	0.80
China	0.17	0.25	0.48

TABLE 22. WORLD BRIMSTONE PRODUCTION BY AREA (1970, 1975, 1980)

(Million tons S)

	1970	*1975*	*1980*
Total production	**22.78**	**31.73**	**37.85**
ECE area	***6.55***	***8.99***	***10.72***
Western Europe	2.34	2.90	3.12
Eastern Europe	2.41	3.59	4.30
USSR	1.80	2.50	3.30
ECA area	***0.02***	***0.05***	***0.05***
UNESOB area	***0.13***	***0.70***	***1.45***
ECAFE area	***1.05***	***1.53***	***2.13***
Asia	0.80	1.11	1.38
Oceania	0.02	0.03	0.03
Others	0.23	0.39	0.72
North America	***13.40***	***17.96***	***20.22***
ECLA area	***1.63***	***2.50***	***3.28***
Central America	1.45	2.25	2.91
South America	0.18	0.25	0.37

Thus, out of an aggregate all-forms production level of some 62 million tons forecast for 1980, brimstone production will represent rather more than 60 per cent of the total compared with 55 per cent in 1970 (see table 23) and, by the same token, over 70 per cent of the expanded volume of world all-forms supply between the present and 1980 will arise as brimstone.

TABLE 23. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION — RAW MATERIAL SOURCES (1970, 1975, 1980)

	1970		*1975*		*1980*	
	Million tons	*Per cent*	*Million tons*	*Per cent*	*Million tons*	*Per cent*
Total production[a]	**41.1**	**100.0**	**52.8**	**100.0**	**62.2**	**100.0**
Brimstone	22.8	55.5	31.7	60.1	37.9	61.0
Pyrite	11.5	28.0	12.8	24.3	14.2	22.8
Sulphur-in-other-forms	6.8	16.5	8.2	15.6	10.1	16.3

[a] Totals may not add because of rounding.

Conversely, it is foreseen that the relative importance of sulphur-in-pyrite supply will show a further decline during the next ten years, and although world output is scheduled to register a modest increase, reflecting primarily the growth of raw material requirements at sulphuric acid plants integrated with mining operations, the proportion of all-forms production attributable to this source will amount to only about 23 per cent in 1980 compared with 28 per cent in 1970 and 36 per cent in 1960.

Little change is anticipated in the incidence of world sulphur supply in forms other than brimstone and pyrite which should maintain a 16 per cent share of total output to end 1980 at a production rate of some 10 million tons S equivalent annually. Nonetheless, the corollary of this projection is that, as with all-forms production, sulphur in other-forms supply will show an increase of approximately 50 per cent on the 1970 level.

BRIMSTONE PRODUCTION

A sustained and substantial growth of recovered sulphur production is expected to be the principal factor influencing the course of world brimstone supply in the next ten years. Over-all, brimstone production will advance from 22.8 million tons in 1970 to 37.9 million tons in 1980 and out of the aggregate increase of some 15.1 million tons in the annual rate of output, recovered sulphur production will represent about 8.5 million tons.

The balance of the addition to world brimstone supply will derive mainly from Frasch sulphur operations and mines employing modified Frasch process technology, e.g. the "underground molten" sulphur facilities in Poland. World output of Frasch sulphur, notwithstanding the larger expansion of recovered sulphur production, is expected to show the sizable gain of 6.2 million tons S by 1980 which will bring the annual rate of output up to nearly 16 million tons.

Only a limited progression is anticipated in world production of native refined sulphur which will rise by an estimated 0.35 million tons S to 3 million tons. In part, the continued operation of open-cast sulphur mines and associated refining units will be adversely affected by the improved availability of relatively lower cost recovered sulphur supplies, although exploitation of native sulphur deposits using non-Frasch techniques will be maintained and expanded at certain locations, such as Makow in Poland, where economies of scale are generated by favourable operating circumstances.

As seen from table 24, the impact of the growth of recovered sulphur production will be evident particularly during the short term to 1975 when almost 60 per cent of the additional 8.95 million tons brimstone to be produced in the latter year will derive from sulphur recovery units.

TABLE 24. WORLD BRIMSTONE PRODUCTION—RAW MATERIAL SOURCES (1970, 1975, 1980)
(Million tons S)

	1970	*1975*	*1980*
Total production	**22.78**	**31.73**	**37.85**
Frasch sulphur	9.70	12.90	15.90
Recovered sulphur	10.43	15.66	18.95
Native refined sulphur	2.65	3.17	3.00

During the second half of the decade it is anticipated that the pace of recovered sulphur output will slacken appreciably and it is in this period from 1975 to 1980 that a more diverse pattern of brimstone production growth is expected. While the volume of new recovered sulphur supply subsides from that experienced in the years to 1975, the growth of Frasch sulphur production will result in almost the same expansion of output as in the earlier five years and world production of native refined sulphur is expected to record a decline from 3.17 to some 3 million tons.

By 1980, therefore, the continued and favourable evaluation of by-product recovered sulphur cost patterns at natural gas plants and oil refineries, coupled with such restraints as may have emerged more specifically governing the sulphur content of fuels such as residual oil, will have dictated a further increase in the share of world brimstone supply attributable to such by-product operations and a complementary decline in the proportion of world output derived from primary producing sources. In this respect the trend in 1970—1980 of greater dependence on recovered sulphur in meeting world brimstone requirements is an extension of the development noted during the 1960s (see chapter 3) when recovered sulphur supply accelerated to account for an ever increasing share of total brimstone output. By 1980 supplies of recovered sulphur will represent half the world's production of sulphur in elemental form compared with only a quarter in 1960.

Frasch sulphur production 1970 – 1980

The broad advance foreseen in world Frasch sulphur production to 1980 will be occasioned mainly by the growth of output at established production centres in the United States and the Mexican Gulf coast, and by the raising of production levels at recently commissioned facilities in the western Texas area of the United States and in Poland. Additionally, it is believed that Frasch mining of sulphur on a commercial scale will be introduced in the USSR and Iraq during the decade thereby widening the distribution of production capacity which for many years during the recent development of the world sulphur industry had been located only in the United States and Mexico.

The total production of Frasch sulphur for 1970 was estimated at 9.7 million tons and by 1980 is seen at an annual out-turn of 15.9 million tons. (See table 21.) Much the most notable contribution to the 6.2 million ton expansion in output during the next ten years is expected to come from producers in the United States and Mexico despite the fact that in the light of the continued situation of brimstone over-supply in world markets, the primary producers will maintain some restraint on output to match the latter to sales volume and to minimize an excessive build-up of stocks. In Poland, the USSR and Iraq, it is anticipated that Frasch sulphur production will amount to 4.3 million tons in 1980, about 2.9 million tons more than in 1970; as yet, this type of operation is being undertaken only in Poland.

United States. The start of brimstone production at the Duval Corporation's new mine in Culberson country in western Texas during the last few months of 1969 added a nominal 1.5 million tons per year to United States Frasch sulphur production capacity. This operation apart, it is expected that improvements in United States Frasch sulphur production levels will be attained without major addition of new facilities to presently available capacity, a substantial proportion of which (e.g. Freeport Sulphur Company's 0.5 million tons/year Caminada mine) has been taken out of operation since the beginning of 1969.

Mexico. The expansion of Frasch sulphur production to 2.7 million tons by 1980 will be accompanied by the introduction of a new mine to work the Texistipec dome by Cia. Exploradora del Istmo (CEDI) in 1971. Reserve capacity is now represented by the shut-down mine of the Gulf Sulphur Corporation at the Salinas dome, Veracruz, and until this is reactivated and the new CEDI operation is brought on-stream, production will be confined to the Azufrera Panamericana and CEDI facilities at Jaltipan and Nopalapa respectively.

Poland. The progressive implementation of enlarged production programmes at Grzybów and Jeziorak is expected to result in major expansion of output of underground molten sulphur through the mid-1970s and thereafter—subject to the developments scheduled in Iraq (see below)—to the consideration of installing a third commercial-scale Frasch mine.

USSR. Current plans provide for the recovery of native sulphur by Frasch-type operation at a number of locations in the vicinity of sedimentary deposits which at more accessible depths are, or could be, also worked by conventional mining and beneficiation operations. The introduction of large-scale underground molten sulphur facilities is expected to be underway by 1975 and in the following five years such operations will assume greater importance with the anticipated coincidental phasing out of some of the native refined capacity.

Iraq. Under a bilateral agreement with Poland, construction work is reported to have begun at the Mishraq dome in northern Iraq. Polish engineers are building a Frasch-type plant which, according to preliminary reports, may have an initial production capacity of 0.3–0.5 million tons/year and a possible start-up date between 1973 and 1974.

Recovered sulphur production 1970–1980

The dominant factor in the forecast massive growth of recovered sulphur production, and indeed the principal determinant of the evolution of all-forms supply in western world markets as a whole, is the continuing increase of by- and co-product brimstone output at gas plants and oil refineries in western Canada. By 1980 it is predicted that world output of recovered sulphur will amount to some 19 million tons, of which, on conservative estimates, western Canadian output will account for about 42 per cent. Other major additions to recovered sulphur production amounting to between 0.9 and 1.5 million tons/year in each case, are expected in the United States, the Near East, and the USSR, while slightly less extensive growth in production will be effected in the Federal Republic of Germany and Japan.

Western Canada. Current indications are that recovered sulphur production growth will rise sharply in the first half of the decade and thereafter increase at a more moderate rate. The expansion of brimstone production, which is determined primarily by the volume growth of natural gas sales to the United States and domestic markets but also by the H_2S-content of the gas input to desulphurization units (the average H_2S content has been rising steadily since exploitation started on the sour gas fields and it is continuing to increase slowly), will be most noticeable during the period 1970–1973. The most significant batch of capacity expansions is scheduled in 1971 when total new plant installations or additions to existing operations will exceed a rated 2.0 million tons/year. Of particular note are the next phase at Kaybob, Alberta, where Chevron Standard is to operate a 916,000 tons/year plant, the Aquitaine/Banff Oil project at Ram River, Northwest Territories (630,000 tons/year), and the Shell Canada 443,000 tons/year expansion at its Waterton, Alberta facility.

Apart from the concomitant growth of sulphur recovery capacity/production and natural gas treatment/shipments the second half of the decade will possibly see renewed interest in sulphur recovery associated with the treatment of tar sands—one such plant (Great Canadian Oil Sands) is already in operation and others are at the evaluation and planning stages.

United States. Recovery of brimstone from sour gas streams at natural gas plants and oil refineries is expected to show a strong upward trend during the coming decade and the current projection of United States recovered sulphur production in 1980—3.1 million tons—indicates that the annual level of output will be double that at present. Moreover, the acceleration in production is likely to be more rapid as the decade proceeds, this being attributable to the increasing incidence of fuel oil desulphurization. Plans are already in hand for the possible establishment of centralized desulphurization and sulphur recovery plants, notably on the United States eastern coast, which will process imported residual oils. The timing of the introduction of such operations, however, and their ultimate scale will be as much dependent on developments at the source of supply, e.g. the Caribbean oil fields, as on the requirements of air pollution controls in the United States.

Western Europe. The principal source of recovered sulphur supply in western Europe, Sté. Nationale des Petroles d'Aquitaine (SNPA) facility at Lacq in southwestern France, is expected to make only a minor contribution to the growth of the region's output—production at Lacq is expected to stabilize at around 1.8 million tons/year. The development of sour natural gas reserves in the Federal Republic of Germany and the resultant boost to recovered sulphur production will account for the greater part of the increased output in western Europe. A production level of around 0.5 million tons is expected by 1975 at which time installed capacity will amount to nearly 1 million tons/year.

Elsewhere in western Europe recovery of sulphur at oil refineries is expected to advance slowly as the intake of sweet crudes in the European oil import pattern is expected to remain substantial.

Near East. Production of recovered sulphur at the plants brought on-stream during 1969 in Kuwait and Iran coupled with the output from additional units to be completed in Iraq (Kirkūk) and Saudi Arabia (Dammām/Abqaiq) should raise production to some 1 million tons/year by 1975. At the beginning of 1970 total installed capacity for sulphur recovery at gas plants and oil refineries amounted to approximately 1.15 million tons/year and this is expected to expand by over half in the next five years.

Others. It is foreseen that production of recovered sulphur at all sources other than those specifically identified in table 21 will increase by about 1.4 million tons between 1970 and 1980, and that a sizable proportion of the expanded volume of supply will materialize from operations in two main areas—Japan and Latin America. The installation of sulphur recovery capacity at oil refineries in Japan is being implemented progressively despite the expected growing procurement of sulphur-free crudes during the 1970s. The construction programme is essentially associated with the erection of fuel oil desulphurization plants and it is eventually intended to deploy a total brimstone production capacity of more than 1 million tons/year. In Latin America also, the expansion of sulphur recovery capacity will be geared prominently to the growing need to desulphurize fuel oils, notably in Venezuela where a total of 160,000 tons/year capacity based on residual oil treatment will have been commissioned by Creole Petroleum Corporation and Shell de Venezuela Limited by 1971.

Native refined sulphur production 1970–1980

World production of native refined sulphur, which was estimated to be 2.65 million tons in 1970, is not scheduled to make a measurable impact on the over-all growth of brimstone supply to 1980. Indeed, this sector of operation is expected to continue to account for a diminishing proportion of world brimstone output and between 1975 and 1980 it is anticipated that there will be an absolute decline in production.

Only two projects are being progressed at the present time and it is not envisaged that further new exploitation will be undertaken during the decade. The projects are those of SNPA at Pomezia in Italy and Benguet Consolidated Inc. in the Philippines—respective nominal capacities are 100,000 and 300,000 tons/year. The fact that native refined sulphur output in the Western Hemisphere is expected to show a net increase of only 40,000 tons/year by 1975 and to remain stable thereafter reflects the anticipation that in Sicily and Japan there will be a decline in production offsetting the output from the new sources of supply.

The most significant gain in native refined sulphur production in the centrally planned economy countries should be occasioned by the increasing intensity of operations at Makow in Poland. The scale of mining and beneficiation plans at this location is such that there will be a steady growth of output into the mid-1970s despite the exhaustion and closure of the Piaseczno mine on the opposite bank of the river Wisla (Vistula). Production of native refined sulphur in China is also seen to be destined for further expansion reflecting the fact that this is the principal source of domestic brimstone supply. In the USSR it is foreseen that there will be a downturn in production of native sulphur after 1975 as Frasch-type mines are established in areas where deposits are too deep to be reached by conventional open pit mining methods.

Pyrite production

In a like manner to the course of events during the 1960s, the potential for increased world production of pyrite in the period 1970–1980 will be diminished by the availability of a mounting volume of new brimstone supply and, as symptomatic of the continued swing to brimstone consumption at the expense of the use of pyrite, it is expected that in pyrite-producing countries the output will be even more oriented to captive outlets than has been the case to date. (For world pyrite production by area, see table 25.)

TABLE 25. WORLD PYRITE PRODUCTION BY AREA (1970, 1975, 1980)
(Million tons S content)

	1970	*1975*	*1980*
Total production	**11.58**	**12.83**	**14.19**
ECE area	*7.80*	*8.64*	*9.52*
Western Europe	3.98	4.04	4.23
Eastern Europe	0.82	1.10	1.29
USSR	3.00	3.50	4.00
ECA area	*0.43*	*0.49*	*0.50*
UNESOB area	—	—	—
ECAFE area	*2.46*	*2.63*	*2.92*
Asia	1.58	1.50	1.37
Oceania	0.05	0.15	0.20
Others	0.83	0.98	1.35
North America	*0.80*	*0.92*	*1.10*
ECLA area	*0.04*	*0.15*	*0.15*
Central America	0.03	0.04	0.04
South America	0.01	0.11	0.11

Total world pyrite production by 1980 is estimated at some 14.2 million tons S content (all pyrite figures are quoted in terms of sulphur content and not as gross/product weight) which indicates that output will advance by some 2.7 million tons on the 11.5 million ton outturn that was projected for 1970. The most interesting feature of the supply pattern expected to evolve during the 1970s is the pronounced regional aspect of the growth of output. Of the total increase in annual production by the end of the decade—2.66 million tons—some 75 per cent will represent expanded production in eastern Europe, the USSR and other centrally planned economy countries whereas in the Western Hemisphere, predicted to account for 60 per cent of world output in 1970, it is forecast that production will increase by only 0.66 million tons. The diversity in growth rates is thus substantial with world pyrite production of centrally planned economy countries expanding by a cumulative 3.6 per cent per year and Western Hemisphere output by 0.9 per cent per year.

As between the first and second five-year periods, it is not forseen that there will be much variation in the rising output trend, the indication being that in both halves of the decade the annual world production rate will increase by 1.3—1.4 million tons.

ECE area. From the foregoing it will be recognized, therefore, that the bulk of the increase in world pyrite output will be generated by the producing countries in the ECE area currently accounting for over two thirds of global production.

The USSR, the world's largest single source of supply, will make a major addition to its rate of pyrite output which by 1980 should have risen by one third to 4.0 million tons/year. While remaining the most important sulphurous raw material in the USSR in terms of tonnage, the production of pyrite will not be as significant as might have been anticipated earlier now that there will be a much expanded volume of brimstone supply emerging in the mid-1970s following the uprated exploitation of sour natural gas deposits.

In eastern Europe the 0.47 million tons/year gain in pyrite production by 1980 will be derived from improved output rates in three countries—Bulgaria, Romania and Yugoslavia. In Poland, the sole remaining operation is in process of being phased out and it is not believed that production in Czechoslovakia will extend into the medium-term future.

Western European pyrite supply from indigenous sources is indicated at some 4.25 million tons/year in 1980 and the growth of output between then and now will accrue mainly from the expansion of output in Spain. Less substantial increases in output are foreseen in Sweden, Portugal, the Federal Republic of Germany and Italy but in each case, as in Spain, the principal stimulus to greater production will be provided by the expansion of sulphuric acid operations integrated with pyritic ore mining and beneficiation.

ECAFE area. After Europe and the USSR, the pyrite producing countries in the ECAFE area are expected to make the most noteworthy contribution to the growth of world pyrite output. This will be occasioned largely by the advance of production in China and the Democratic People's Republic of Korea where in both instances the recovery of sulphur values in pyrite provides the dominant proportion of all-forms sulphur supply.

In Australia there will be a significant resurgence of output associated with the start of sulphuric acid production by Northwest Acid Pty. in Tasmania. The consumption of pyrite output generated by both the participating companies in the venture should boost pyrite production to 0.15 million tons/year by 1975.

The growth of ECAFE area output will be restricted to less than + 0.5 million tons/year by 1980 as a result of the recession expected to take place in production in Asia, that is in Japan and possibly also in the Philippines. In Japan it is anticipated that pyrite output will decline appreciably in conjunction with the second-stage penetration of the market by domestic supplies of recovered sulphur. In the initial stages of Japanese refinery sulphur availability, the expectation is that the home market recovered sulphur requirements will be commensurate with the drop in native refined sulphur output but from the mid-1970s it is forseen that recovered sulphur will be used for sulphuric acid manufacture and that the demand for and, thus, the production of pyrite will be affected accordingly.

Others. About 18 per cent of the expanded rate of pyrite production at the end of the 1970s decade will be represented by the growth of output outside the ECE and ECAFE areas, namely in Africa, North America and Latin America. It will be predominantly in North America that production increases materialize and specifically at the established operations in Canada and the United States where the exploitation of pyrite for sulphuric acid production is well entrenched behind a favourable cost structure, e.g. in Tennessee.

In Latin America the only development of note in the pattern of pyrite supply is expected to be provided by the start of pyrite recovery in Brazil. In the state of Santa Catarina, pyrite arises as a by-product of coal production and it is proposed to recover this sulphur resource from 1972–1973 onward for the purpose of sulphuric acid manufacture in a large-scale integrated project.

The modest rise in pyrite production in Africa reflects chiefly the continued growth of by-product pyrite recovery and utilization at gold mines in South Africa. Notwithstanding the improved availability of brimstone from world suppliers in South Africa, both recently and in the future the impact of these supplies is unlikely to make inroads into the market in the interior of the country in view of the excessive transportation costs that would be incurred. Moreover, in the Transvaal and the Orange Free State, the by-product status of the pyrite output further enhances its attractiveness as a relatively low cost source of sulphur.

Sulphur-in-other-forms production

On the basis of current estimates, it is indicated that the rate of growth of world sulphur-in-other-forms production in the next ten years will be approximately 4.1 per cent per year cumulative—rather more than midway between the expected annual growth rates of 2.1 per cent and 5.2 per cent for world pyrite and brimstone output respectively. In consequence, sulphur-in-other-forms supply will rise from the estimated 6.79 million tons S for 1970 to pass 10 million tons/year S by 1980[1]. Being very much in line with the rate of growth of world sulphur-in-all-forms production between 1970 and 1980 (see tables 26, 27 and 28) (4.2 per cent per year), no change is predicted in the proportion of world all-forms supply—just over 16 per cent—represented by these other sources of sulphur. This projected similarity in the tempo of sulphur-in-other-forms and sulphur-in-all-forms supply growth as noted earlier (see chapter 3) is not to be unexpected in view of the closer relation between production and consumption than in the case of brimstone and pyrite. That is to say that the evolution of other-forms and all-forms production is more readily determined by demand trends—other forms in view of the automatic correlation between production and consumption and all-forms because of the broad identity in supply and demand over the medium term.

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[1] All figures quoted in terms of the sulphur-equivalent content of aggregate sulphuric acid or non-acid production based on sulphur sources other than brimstone or pyrite (see Introduction).

TABLE 26. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION 1970—RAW MATERIAL SOURCES
(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total production	**41.10**	**22.78**	**11.58**	**6.79**
ECE area	*17.98*	*6.55*	*7.80*	*3.63*
Western Europe	7.93	2.34	3.98	1.61
Eastern Europe	4.01	2.41	0.82	0.78
USSR	6.04	1.80	3.00	1.24
ECA area	*0.58*	*0.02*	*0.43*	*0.13*
UNESOB area	*0.13*	*0.13*	—	—
ECAFE area	*5.00*	*1.05*	*2.46*	*1.49*
Asia	3.68	0.80	1.58	1.30
Oceania	0.19	0.02	0.05	0.12
Others	1.13	0.23	0.83	0.07
North America	*15.65*	*13.40*	*0.80*	*1.45*
ECLA area	*1.76*	*1.63*	*0.04*	*0.09*
Central America	1.54	1.45	0.03	0.06
South America	0.22	0.18	0.01	0.03

TABLE 27. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION 1975—RAW MATERIAL SOURCES
(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total production	**52.80**	**31.78**	**12.88**	**8.24**
ECE area	*21.91*	*8.99*	*8.64*	*4.28*
Western Europe	8.46	2.90	4.04	1.52
Eastern Europe	5.82	3.59	1.10	1.13
USSR	7.63	2.50	3.50	1.63
ECA area	*0.70*	*0.05*	*0.49*	*0.16*
UNESOB area	*0.71*	*0.70*	—	*0.01*
ECAFE area	*6.15*	*1.53*	*2.63*	*1.99*
Asia	4.30	1.11	1.50	1.69
Oceania	0.34	0.03	0.15	0.16
Others	1.51	0.39	0.98	0.14
North America	*20.58*	*17.96*	*0.92*	*1.70*
ECLA area	*2.75*	*2.50*	*0.15*	*0.10*
Central America	2.36	2.25	0.04	0.07
South America	0.39	0.25	0.11	0.03

TABLE 28. WORLD SULPHUR-IN-ALL-FORMS PRODUCTION 1980 – RAW MATERIAL SOURCES
(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total production	**62.18**	**37.85**	**14.19**	**10.14**
ECE area	*25.57*	*10.72*	*9.52*	*5.33*
Western Europe	9.04	3.12	4.23	1.69
Eastern Europe	7.13	4.30	1.29	1.54
USSR	9.40	3.30	4.00	2.10
ECA area	*0.75*	*0.05*	*0.50*	*0.20*
UNESOB area	*1.46*	*1.45*		*0.01*
ECAFE area	*7.55*	*2.13*	*2.92*	*2.50*
Asia	4.75	1.38	1.37	2.00
Oceania	0.43	0.03	0.20	0.20
Others	2.37	0.72	1.35	0.30
North America	*23.32*	*20.22*	*1.10*	*2.00*
ECLA area	*3.53*	*3.28*	*0.15*	*0.10*
Central America	3.02	2.91	0.04	0.07
South America	0.51	0.37	0.11	0.03

ECE area. Over half the world's sulphur-in-other-forms output derives from facilities in the ECE area and this situation is expected to be maintained through to 1980 (see table 29). The region's rate of output is expected to increase from some 3.6 million to some 5.3 million tons/year and it is foreseen that this will be almost completely due to the growth of supply in eastern Europe and the USSR.

The near stagnation in western Europe's output of other-forms between 1970 and 1980 is generally taken to reflect the already significant volume of supply—in 1970 this will represent almost a quarter of the world total—and the easy availability of brimstone and pyrite, but more specifically it mirrors the net reduction in output through 1975. Although a number of sources and uses of other forms, notably smelter-gas-based sulphuric acid, will continue to advance in the next five years, it is expected that this incremental supply will be outweighed by the receding output in other sectors, e.g. anhydrite-based or gypsum-based ammonium sulphate production, and the manufacture of sulphuric acid from spent oxide, ferrous sulphate and directly from hydrogen sulphide. Though these amendments to the pattern of other-forms supply in western Europe may continue past 1975, it is anticipated that the rate of output in the second five-year period will resume an upward course—equivalent to an annual growth of some 2.2 per cent cumulative.

TABLE 29. WORLD SULPHUR-IN-OTHER-FORMS PRODUCTION BY AREA (1970, 1975, 1980)
(Million tons S equivalent)

	1970	*1975*	*1980*
Total production	**6.79**	**8.24**	**10.14**
ECE area	*3.63*	*4.28*	*5.33*
Western Europe	1.61	1.52	1.69
Eastern Europe	0.78	1.13	1.54
USSR	1.24	1.63	2.10
ECA area	*0.13*	*0.16*	*0.20*
UNESOB area		*0.01*	*0.01*
ECAFE area	*1.49*	*1.99*	*2.50*
Asia	1.30	1.69	2.00
Oceania	0.12	0.16	0.20
Others	0.07	0.14	0.30
North America	*1.45*	*1.70*	*2.00*
ECLA area	*0.09*	*0.10*	*0.10*
Central America	0.06	0.07	0.07
South America	0.03	0.03	0.03

It is the expansion of sulphur-in-other-forms production in eastern Europe and the USSR, however, that will be most strongly featured in the ECE area up to 1980, being responsible for 90 per cent of the advance in the region's over-all output. It is projected that the larger volume growth will arise in the USSR to reflect primarily a substantial expansion in the utilization of SO_2 in non-ferrous metal smelter waste gases, but that, at 1.54 million tons in 1980, the growth of output in eastern Europe will have been only marginally less substantial. The major producing country then, as now, will be Poland which has its main production sectors yielding sulphuric acid based on smelter gases, anhydrite and by-product filter cake from native sulphur refining. The other leading contribution to eastern European other-forms output growth will be made in Yugoslavia where it will be largely restricted to the expansion of sulphuric acid at metallurgical gas-based units.

ECAFE area. The ECAFE countries are expected to account for a quarter of world other-forms output by 1980 and to have augmented production by 5.3 per cent per year cumulative (+ 1.01 million tons/year) to 2.5 million tons/year. About 70 per cent of the incremental tonnage will be coming from countries in Asia with Japan playing the major role in lifting the volume of output. Particularly significant in the development of this sector of sulphur supply in Japan is the surge in smelter gas acid output that is expected following the expansion of imports of non-ferrous metal concentrates in 1972, notably from Bougainville Island in the Soloman Islands where a major copper project is now under construction.

North America. Production of sulphur-in-other-forms in Canada and the United States will take a one-fifth share of the world total in 1980, a comparable proportion to the offtake expected in 1970. In the short term the growth of output should be mainly determined by supply developments in the United States where new production will appear at sulphuric acid plants based on smelter gases and oil refinery acid sludge. In Canada, the growth of output will be more exclusively based on smelter gases; a major project due for completion in the near future is that at Hoyle, Ontario, where a subsidiary of Texas Gulf Sulphur Company will bring into production a 195,000 tons/year acid plant adjoining a new zinc smelter.

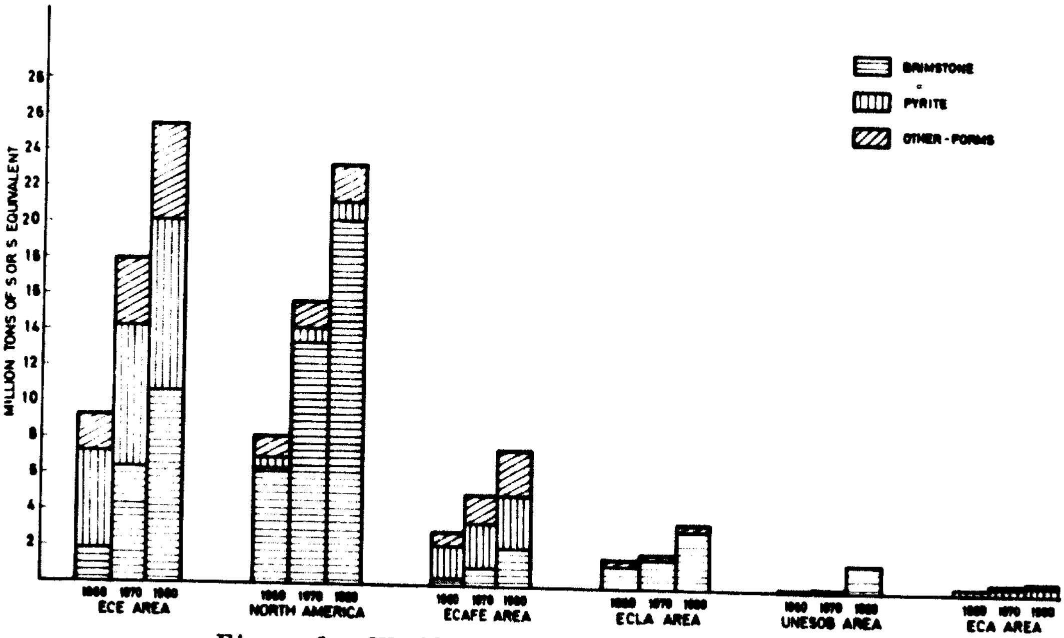

Figure 2. World sulphur-in-all-forms production

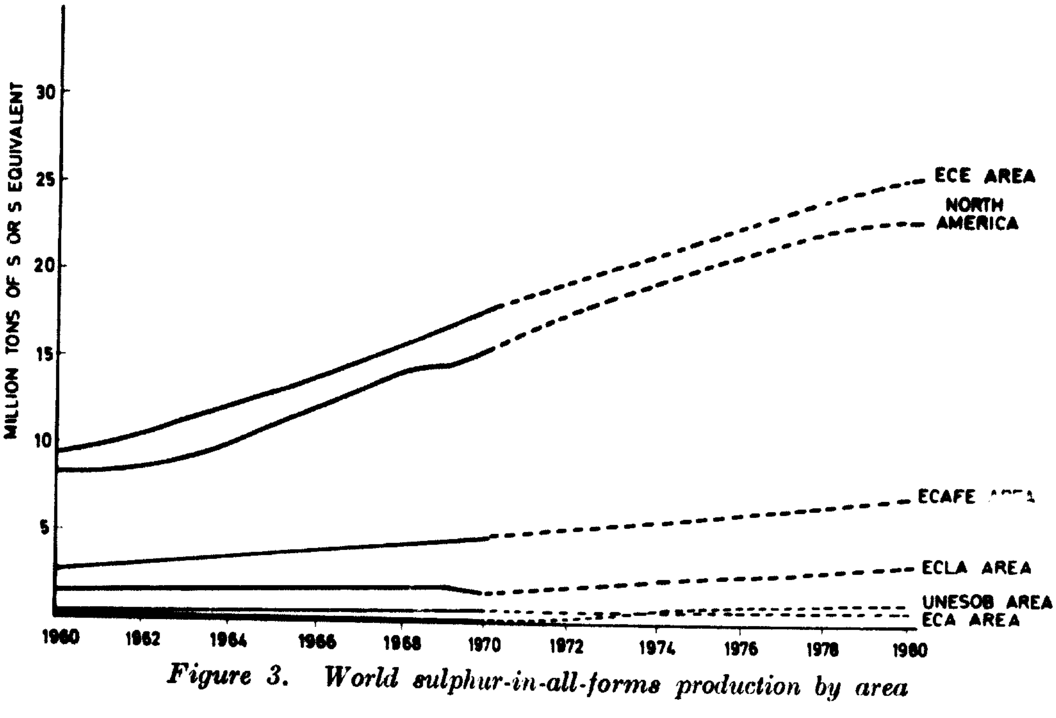

Figure 3. World sulphur-in-all-forms production by area

Figures 2, 3 and 4 indicate world all-forms production (brimstone, pyrite and other-forms); all-forms production by area; and all-forms production by raw material sources for 1960, 1970 and 1980.

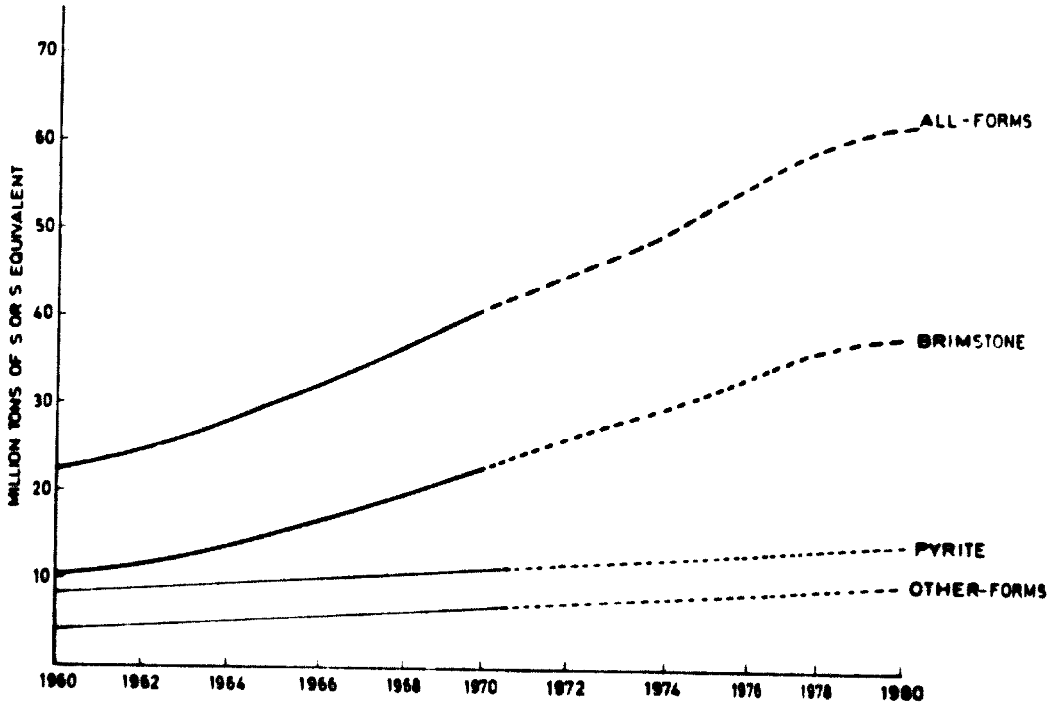

Figure 4. World sulphur-in-all-forms production by raw material sources

Chapter 8

WORLD SULPHUR DEMAND 1970–1980

In the current decade, world consumption of sulphur-in-all-forms is expected to increase by over two thirds to reach a total of 63.7 million tons S by the end of 1980. This expansion in world sulphur use represents a growth of about 5.3 per cent per year which broadly conforms to the long-term (1949–1969) trend of demand growth of 5.2 per cent per year.

The most striking feature of the forecast demand pattern in the next ten years is the way in which the growth of sulphur requirements will be massively fulfilled by expanded brimstone consumption. Of a total growth

TABLE 30. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION—RAW MATERIAL SOURCES (1970, 1975, 1980)[a]

	1970	*1975*	*1980*
Total consumption (million tons)	**37.91**	**49.30**	**63.72**
Brimstone	20.21	28.86	40.27
Pyrite	10.91	12.20	13.31
Sulphur-in-other-forms	6.79	8.24	10.14
Total consumption (per cent)	**100.00**	**100.00**	**100.00**
Brimstone	53.30	58.50	63.20
Pyrite	28.80	24.80	20.90
Sulphur-in-other-forms	17.90	16.70	15.90
	1970–1975	*1975–1980*	*1970–1980*
Increase (million tons S)	*11.39*	*14.42*	*25.81*
Brimstone	8.65	11.41	20.06
Pyrite	1.29	1.11	2.40
Sulphur-in-other-forms	1.45	1.90	3.35
Growth rate (per cent/year)	*5.4*	*5.3*	*5.3*
Brimstone	7.4	6.9	7.1
Pyrite	2.3	1.8	2.0
Sulphur-in-other-forms	4.0	4.2	4.1

[a] The anticipated increments in all-forms and sulphurous raw materials demand indicated by the above projections, together with the resultant cumulative rates of growth over the two halves of the decade and the whole of the period 1970–1980 are indicated by this table.

in the annual all-forms offtake of 25.81 million tons, no less an increment than 20.06 million tons will be taken up by brimstone consumption. The doubling of brimstone demand, though an extension of the trend in the 1960s which was re-aligning the pattern of sulphur demand to lay greater emphasis on brimstone consumption (see chapter 4), represents a further fundamental modification of the current incidence of sulphurous raw material use, as table 30 shows.

Brimstone consumption

As a result of the sustained and accelerating growth of world brimstone consumption up to 1980, about 63 per cent of world all-forms use will be represented by this raw material compared with 53 per cent in 1970 and 45 per cent in 1960. In the short term to 1975 a faster rate of brimstone demand growth is anticipated than in the medium term — 7.4 per cent per year up to the middle of the decade compared with 7.1 per cent over the entire ten years and 6.9 per cent during 1975—1980. The extent of the tonnage growth in annual output however will be more apparent in the second half of the decade. (For world brimstone consumption by area, see table 31.)

TABLE 31. WORLD BRIMSTONE CONSUMPTION BY AREA (1970, 1975, 1980)
(Million tons S)

	1970	*1975*	*1980*
Total consumption	**20.21**	**28.86**	**40.27**
ECE area	*6.82*	*10.16*	*14.52*
Western Europe	4.54	6.37	8.82
Eastern Europe	1.11	2.09	3.10
USSR	1.17	1.70	2.60
ECA area	*0.53*	*0.90*	*1.60*
UNESOB area	*0.08*	*0.14*	*0.29*
ECAFE area	*2.46*	*4.32*	*6.66*
Asia	1.49	2.89	4.19
Oceania	0.72	0.90	1.50
Others	0.25	0.53	0.97
North America	*9.20*	*11.50*	*14.10*
ECLA area	*1.12*	*1.84*	*3.10*
Central America	0.67	1.07	1.67
South America	0.45	0.77	1.43

Short-term trends to 1975

The principal areas of new demand growth in the short term will be the ECE area, Asia and North America: together these three regions will account for some 7 million tons (81 per cent) of the 8.65 million ton expansion in the annual rate of world brimstone consumption. In conformity with its position as the major world sulphur market, the largest increase in demand, 2.3 million tons, is scheduled in North America while consumption in the world's leading brimstone importing region, western Europe, will record an increase of only 0.5 million tons less. Additions to demand levels in eastern Europe and the USSR are seen to reflect the greatly expanded volume of supply and intra-regional trade of recent years while the virtual doubling of Asian consumption from 1.49 million tons/year to 2.89 million tons/year indicates the scope of new captive use requirements, e.g. at Bandar Shahpur in Iran and in Japan and the progressive development of import requirements in such markets as India and the Republic of Korea. About 0.72 million tons more brimstone will be in demand in the ECLA area by 1975 and it may be reckoned that over half the needs will emerge in Central America, notably Mexico, where the Fertilizantes Fosfatados Mexicanos S.A. sulphuric acid plant at Coatzacoalcos has not, at the time of writing, drawn in more than a limited proportion of its total requirements at capacity.

Medium-term trends to 1980

In the second half of the decade, the volume of new brimstone demand in certain areas will remain much the same as in 1970—1975, for example in eastern Europe, Asia, and North America, whereas in other regions there will be a considerable advance in the rate of growth of consumption. Among the latter category are Oceania, where brimstone demand should be reasserted strongly following the absorption of new pyrite-based sulphuric acid output in the mid-1970s and western Europe where the loss of sulphur-in-other-forms output coupled with the projected relative decline in pyrite availability should be of compensatory benefit to brimstone suppliers.

PYRITE CONSUMPTION

World pyrite consumption will rise to an estimated 13.31 million tons/year in 1980 following the maintenance of a 2 per cent per year growth line through the decade. Thus the annual rate of use will increase by a margin of 2.4 million tons/year and in view of the limited scale of this advance during a period when the yearly offtake of sulphur-in-all-forms is expected to grow by 25.8 million tons/year, world pyrite consumption as a proportion of total sulphur-in-all-forms consumption will decrease from about 29 per cent to almost 20 per cent.

For world pyrite consumption as predicted by area (1970, 1975, 1980) see table 32.

Short-term trends to 1975

The rate of growth of world pyrite consumption is likely to be higher in the short term than over the whole of the decade—some 2.3 per cent per year up to 1975 and less than 2 per cent per year in the subsequent five years.

TABLE 32. WORLD PYRITE CONSUMPTION BY AREA (1970, 1975, 1980)
(Million tons S content)

	1970	*1975*	*1980*
Total consumption	**10.91**	**12.20**	**13.31**
ECE area	*7.35*	*8.21*	*8.92*
Western Europe	4.51	4.57	4.57
Eastern Europe	0.77	1.09	1.20
USSR	2.07	2.55	3.15
ECA area	*0.43*	*0.49*	*0.50*
UNESOB area	—	—	—
ECAFE area	*2.30*	*2.47*	*2.65*
Asia	1.54	1.47	1.35
Oceania	0.05	0.14	0.20
Others	0.71	0.86	1.10
North America	*0.80*	*0.90*	*1.10*
ECLA area	*0.03*	*0.13*	*0.14*
Central America	0.02	0.03	0.04
South America	0.01	0.10	0.10

To an extent, this derives from the relative impact of the growth of brimstone consumption which is scheduled for a major expansion in the second half of the decade but it also reflects the stabilization or stagnation expected in pyrite production and consumption from the mid-1970s in certain areas of the world market, notably western Europe and Asia.

Of the 2.4 million tons/year increase in world pyrite demand expected by 1980, 1.3 million tons/year will have been achieved by 1975 thereby raising aggregate consumption to 12.2 million tons/year. It is anticipated that two thirds of world demand growth to be registered between 1970 and 1975 will materialize in the ECE area, predominantly in eastern Europe and the USSR. In the latter two regions, where apart from the USSR the growth will be centred in Romania and Yugoslavia, pyrite consumption will rise by an estimated 0.8 million tons/year and will represent the bulk of the expansion in pyrite consumption in the ECE area. Only a modest net advance is foreseen in western European pyrite demand and this will develop mainly in Spain, Sweden, the Federal Republic of Germany and Italy.

Outside the ECE area the remaining 0.43 million tons/year incremental pyrite use projected for mid-decade will be distributed fairly evenly throughout other demand areas. In the ECAFE area, where the most substantial rise in consumption (+ 0.17 million tons/year) will occur following the establishment of new pyrite-based sulphuric acid capacity in Tasmania and the further development of pyrite resources in China and in the Democratic People's Republic of Korea, the margin of demand growth will be depressed by the expected decline in pyrite consumption in Asia—particularly in Japan where the next five years is expected to see a start to the disappearance of a number of small pyrite-based sulphuric acid operations.

Medium-term trends to 1980

As indicated earlier, with the world's sulphur-using industries taking an ever increasing proportion of their requirements in elemental form during the latter half of the decade, a more restricted rate of growth of pyrite demand is seen in the medium term, 1975—1980. The acceleration of brimstone consumption in western Europe, Africa and Oceania coupled with the decline in output of pyrite expected in some eastern European and Asian countries suggests that improvements in the rate of pyrite consumption after 1975 will take place mainly in the USSR, China, the Democratic People's Republic of Korea and North America. Additions to pyrite consumption are expected in eastern Europe and Oceania but the progression of demand is not expected to match that registered in the first half of the decade. In western Europe, the level of demand is expected to stabilize at just under 4.6 million tons/year while in Asia a more substantial recession than that during 1970—1975 is expected to develop in the pyrite industry.

SULPHUR-IN-OTHER-FORMS CONSUMPTION

The world development of production/consumption of sulphur-in-other-forms in the 1970s is not expected to result in any major departures from the growth rates or patterns of supply in various areas of the world that evolved during the 1960s. Just over 15 per cent of world all-forms sulphur demand will continue to be satisfied by alternative sources to brimstone and pyrite and this sector of the sulphur supply and demand will maintain a steady growth of about 4 per cent per year cumulative to 1980 although the period from 1975—1980 is likely to witness a fractionally more rapid expansion of demand than the first five years of the decade. Of the total 3.35 million tons/year expansion in the level of demand by 1980, some 1.9 million tons/year, or 57 per cent, will represent the growth of consumption after 1975. (For world sulphur-in-other-forms consumption by area—1970, 1975, 1980—see table 33.)

However, the incidence of other-forms sulphur consumption is expected to undergo some modification in respect of the sources from which the utilized sulphur values appear, i.e. smelter waste gases, sludge acid, anhydrite, by-product gypsum, coke oven gas H_2S, spent oxide, ferrous sulphate and stack gas SO_2.

TABLE 33. WORLD SULPHUR-IN-OTHER-FORMS CONSUMPTION BY AREA (1970, 1975, 1980)
(Million tons S equivalent)

	1970	*1975*	*1980*
Total consumption	**6.79**	**8.24**	**10.14**
ECE area	*3.63*	*4.28*	*5.33*
Western Europe	1.61	1.52	1.69
Eastern Europe	0.78	1.13	1.54
USSR	1.24	1.63	2.10
ECA area	*0.13*	*0.16*	*0.20*
UNESOB area	—	*0.01*	*0.01*
ECAFE area	*1.49*	*1.99*	*2.50*
Asia	1.30	1.69	2.00
Oceania	0.12	0.16	0.20
Others	0.07	0.14	0.30
North America	*1.45*	*1.70*	*2.00*
ECLA area	*0.09*	*0.10*	*0.10*
Central America	0.06	0.07	0.07
South America	0.03	0.03	0.03

Sulphuric acid production based on sulphur-in-other-forms is expected to reflect the increasing importance of the exploitation of non-ferrous metal smelter waste gases and especially in the United States, the regeneration of oil refinery acid sludges in fresh acid makes. A number of proposals for new acid projects based on gypsum or anhydrite are still being considered but in the light of the anticipated continuation of an easy brimstone supply situation well into the latter half of the decade, it is not expected that there will be any major realization of new capacity such as might have been suggested by the widespread interest in these raw materials during the late 1960s period of brimstone shortage. Any operations that are implemented are likely to be either associated with co-product cement plants, or second, based on by-product gypsum from phosphoric acid operations, or third, located in areas where the delivered cost of brimstone is unacceptably high and where per long ton acid costs would be lower using locally-available gypsum/ anhydrite.

The growing emphasis on the main smelter gas and sludge acid sectors of other-forms sulphuric acid production is also expected to be served by the gradual decline in consumption of certain other-forms sources such as coke oven gas hydrogen sulphide, spent oxide and ferrous sulphate.

Consumption of sulphur-in-other-forms for non-acid purposes will be affected by the decline anticipated in the direct production of ammonium sulphate from gypsum or anhydrite. Small-scale output has ceased in Belgium and operations are being run down in the United Kingdom, probably to be followed by the withdrawal of other facilities in western Europe.

One totally new source of other-forms sulphur which has been projected for introduction in the 1970s is stack gas SO_2 recovery and utilization for sulphuric acid manufacture. Several processes are currently being evaluated in commercial scale units as well as pilot plants, with much of this work being undertaken in the United States. This acid-linked technology provides a flexible alternative to the recovery of sulphur as brimstone from power plant waste gases which, under the provisions of more stringent air pollution legislation, will have to be processed prior to discharge to ensure minimal stack gas SO_2 emissions. Once SO_2 removal has been effected it is expected that the subsequent choice between by-product brimstone or sulphuric acid production will be partly determined by the cost parameters developed from current research and partly by the direct comparison of brimstone and sulphuric acid delivery costs to consuming plants.

Short-term trends to 1975

The world-wide pattern of sulphur-in-other-forms consumption growth will be dominated by developments in the ECE and ECAFE areas which together will account for some 80 per cent of the projected 1.45 million ton growth in the annual rate of use by 1975. As noted earlier (see chapter 7, sulphur-in-other-forms production) the key factor in these two regions is the growth of by-product sulphuric acid production in eastern Europe (in Poland and Yugoslavia), the USSR and Asia (in Japan and, to a lesser extent, in India and Turkey). Much of the balance of the increase in annual world all-forms output to 1975 (+ 0.35 million tons/year) will emerge in North America (+ 0.25 million tons/year).

Medium-term trends to 1980

Variations on the regional incidence of other-forms consumption growth recorded in 1970—1975 are expected to be most noticeable in the ECE area and in North America. A progressive expansion in the volume of demand may be looked for in eastern Europe and the USSR while in western Europe it is projected that other-forms consumption will resume an upward course once the withdrawals of acid and non-acid capacity cease to counterbalance the growth of smelter gas acid production. From the mid-1970s onward it is expected that United States consumption of other-forms will be supplemented by the recovery of stack gas SO_2 as sulphuric acid, and that this innovation will be significant in raising the rate of North American consumption a further 0.3 million tons/year by 1980.

World sulphur-in-all-forms consumption as predicated by area is indicated for 1970 in table 34, for 1975 in table 35, and for 1980 in table 36.

TABLE 34. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION BY AREA, 1970—RAW MATERIAL SOURCES

(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	**37.91**	**20.21**	**10.91**	**6.79**
ECE area	*17.80*	*6.82*	*7.35*	*3.63*
Western Europe	10.66	4.54	4.51	1.61
Eastern Europe	2.66	1.11	0.77	0.78
USSR	4.48	1.17	2.07	1.24
ECA area	*1.09*	*0.53*	*0.43*	*0.13*
UNESOB area	*0.08*	*0.08*	—	—
ECAFE area	*6.25*	*2.46*	*2.30*	*1.49*
Asia	4.33	1.49	1.54	1.30
Oceania	0.89	0.72	0.05	0.12
Others	1.03	0.25	0.71	0.07
North America	*11.45*	*9.20*	*0.80*	*1.45*
ECLA area	*1.24*	*1.12*	*0.03*	*0.09*
Central America	0.75	0.67	0.02	0.06
South America	0.49	0.45	0.01	0.03

TABLE 35. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION BY AREA, 1975—RAW MATERIAL SOURCES

(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	**49.30**	**28.86**	**12.20**	**8.24**
ECE area	*22.65*	*10.16*	*8.21*	*4.28*
Western Europe	12.46	6.37	4.57	1.52
Eastern Europe	4.31	2.09	1.09	1.13
USSR	5.88	1.70	2.55	1.63
ECA area	*1.55*	*0.90*	*0.49*	*0.16*
UNESOB area	*0.15*	*0.14*	—	*0.01*
ECAFE area	*8.78*	*4.32*	*2.47*	*1.99*
Asia	6.05	2.89	1.47	1.69
Oceania	1.20	0.90	0.14	0.16
Others	1.53	0.53	0.86	0.14
North America	*14.10*	*11.50*	*0.90*	*1.70*
ECLA area	*2.07*	*1.84*	*0.13*	*0.10*
Central America	1.17	1.07	0.03	0.07
South America	0.90	0.77	0.10	0.03

TABLE 36. WORLD SULPHUR-IN-ALL-FORMS CONSUMPTION BY AREA, 1980 – RAW MATERIAL SOURCES

(Million tons S or S equivalent)

	All-forms	*Brimstone*	*Pyrite*	*S.O.F.*
Total consumption	**68.72**	**40.27**	**18.31**	**10.14**
ECE area	*28.77*	*14.52*	*8.92*	*5.33*
Western Europe	15.08	8.82	4.57	1.69
Eastern Europe	5.84	3.10	1.20	1.54
USSR	7.85	2.60	3.15	2.10
ECA area	*2.30*	*1.60*	*0.50*	*0.20*
UNESOB area	*0.30*	*0.29*	—	*0.01*
ECAFE area	*11.81*	*6.66*	*2.65*	*2.50*
Asia	7.54	4.19	1.35	2.00
Oceania	1.90	1.50	0.20	0.20
Others	2.37	0.97	1.10	0.30
North America	*17.20*	*14.10*	*1.10*	*2.00*
ECLA area	*3.34*	*3.10*	*0.14*	*0.10*
Central America	1.78	1.67	0.04	0.07
South America	1.56	1.43	0.10	0.03

The following figures (5, 6 and 7) present the world all-forms consumption (brimstone, pyrite and other-forms); all-forms consumption by area; and all-forms consumption by raw material sources for 1960, 1970 and 1980.

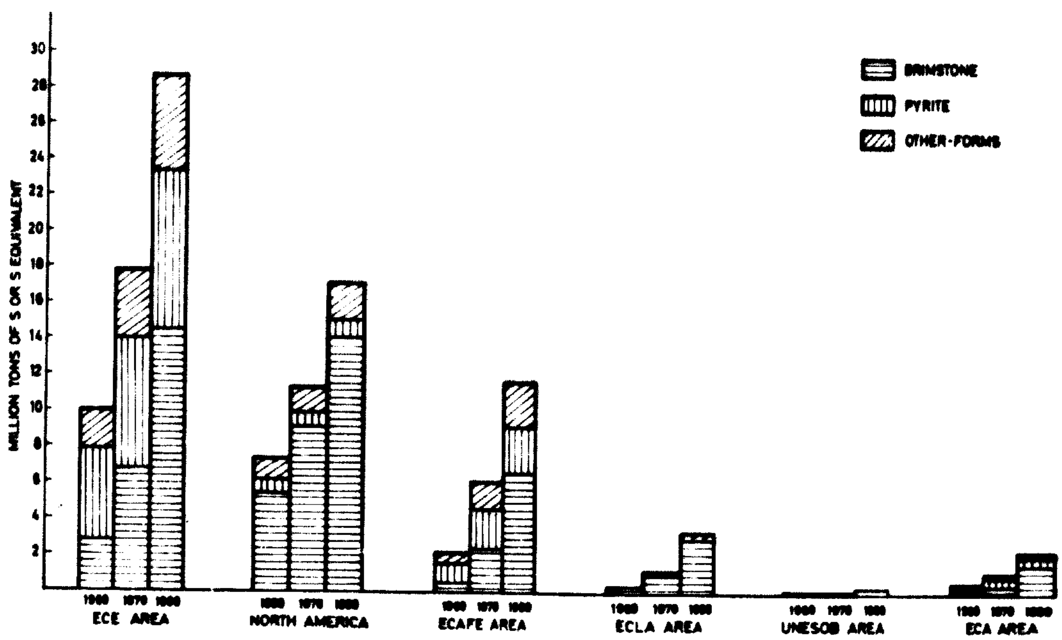

Figure 5. World sulphur-in-all-forms consumption

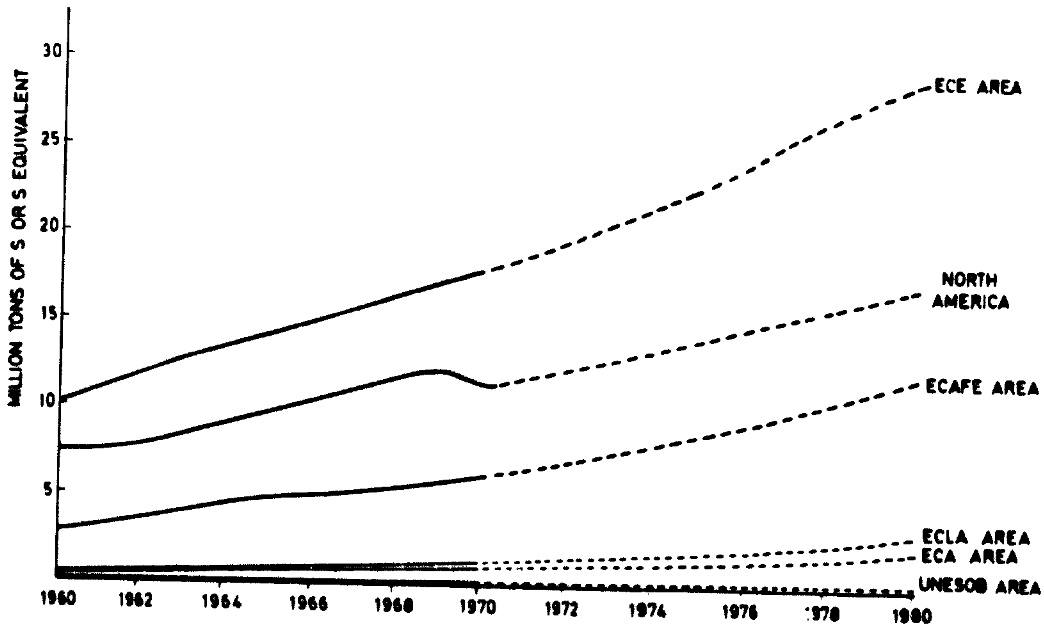

Figure 6. World sulphur-in-all-forms consumption by area

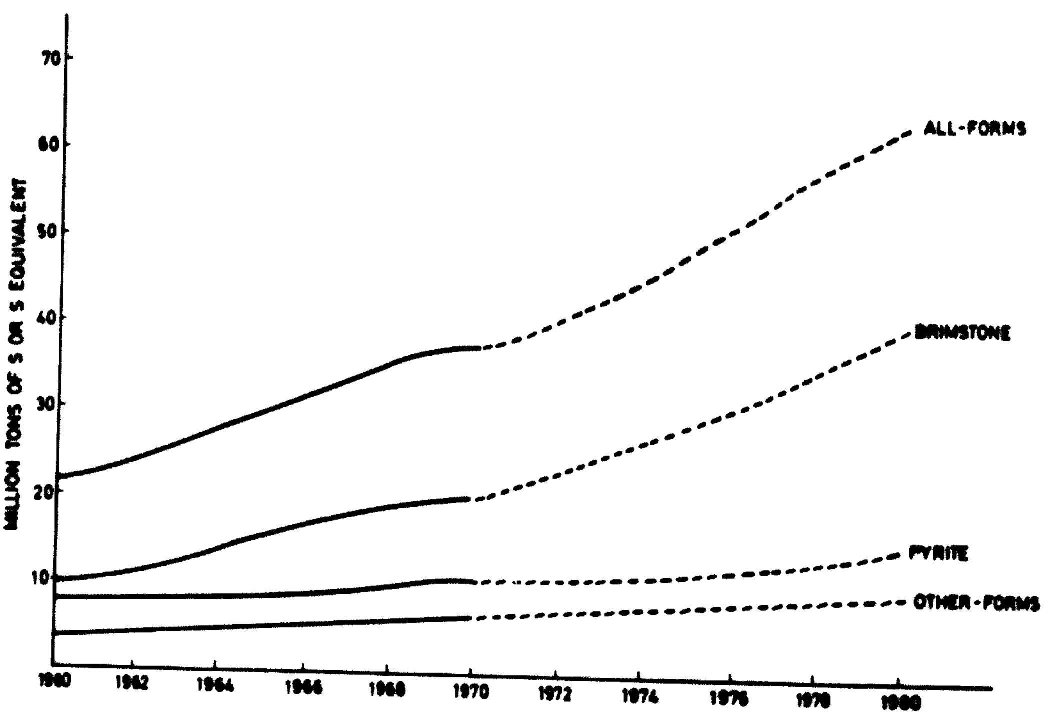

Figure 7. World sulphur-in-all-forms consumption by raw material sources

Chapter 9

WORLD SULPHUR PRICE TRENDS 1970–1980

The precipitate decline that occurred in brimstone prices during 1969 represented a significant commentary on world suppliers' expectations of a weak tone in world sulphur markets during the early part of the 1970s. In 1969 itself, the collapse of brimstone prices did not reflect the physical volume of surplus supplies, which was limited, but rather the anticipation that in the short term there would be a continuing excess of supply over demand and the realization that early assurances to safeguard forward delivery programmes would be desirable.

In the short term, therefore, it is expected that the pressure on world sulphur prices, and notably brimstone prices, will remain and that in the context of an uninterrupted over-supply situation, the evolution of brimstone prices will be determined principally by two factors:

(a) The cost structure established for by-product sulphur recovery, primarily at natural gas plants, and the consequent relationship between by-product sulphur production costs and those at primary supply sources, e.g. Frasch mines and native sulphur operations; and

(b) The extent to which the exerting of freight advantages brings about a regionalization of brimstone trade patterns and removes some consistency to f.o.b. quotations of suppliers.

By-product sulphur costs

The world sulphur industry's expectation of the continuing growth of recovered sulphur production and the unquestioned fact that these supplies will make the major contribution to the growth of world sulphur-in-all-forms supply in the 1970s makes the evaluation of future price trends rest primarily on the method of determining the cost of sulphur recovery from sour natural gas. Extraction costs, that is the cost of desulphurization and sulphur recovery from H_2S, vary widely and are dependent on the analysis of the sour gas, particularly in respect of H_2S, CO_2 and gas liquids. It may be held by the plant operator or sulphur supplier that the cost of H_2S extraction can be attributed solely to the cost of producing the natural gas primary product, which is then priced accordingly. Thereafter the actual cost of sulphur recovery allowing for steam credits and re-allocation of fixed costs, becomes exceedingly low and virtually a nominal charge.

In the first half of 1970 the average ex-gas plant price of recovered sulphur in western Canada receded to less than $11—$12 per long ton with some sales netting less than $7 f.o.r. Alberta plant. Thus the price policy in this area of the world industry becomes of unparalleled significance particularly when the involuntary nature of the operations and the mounting volume of brimstone stocks in the near term is unlikely to assist in promoting a uniform price policy.

Regional markets and freight advantages

The recent downward trend in brimstone producers net realizations and f.o.b. prices has once again emphasized the incidence of freight cost in delivered prices in the various world markets. To take an outstanding example, the lowest bid (first half of 1970) in a brimstone tender for India came from a Canadian supplier's offer at a Vancouver f.o.b. of less than $14.50 per long ton which, at the current level of freights—admittedly high—would approximately equal the rate per bulk carrier lifting (22—30,000 long tons) to the destination involved.

In the light of the excessive volume of new brimstone supply entering world markets and the competitive pressures that will arise, suppliers are expected to exercise their market positions in freight-favourable outlets by the acceptance of regional f.o.b. prices. Simply, this implies the nearer the market, the less the freight cost and the higher the f.o.b. netback obtained compared with that secured by another supplier not so favourably located. In other words a consistent level of f.o.b. prices is not expected generally to be a feature of the major brimstone suppliers' price policies in the short term. It is anticipated, moreover, that the practice of quoting prices on a delivered basis will gain wider acceptance.

So far as the pattern of world brimstone trade is concerned, it is anticipated that Canadian recovered sulphur will be priced with a view to maintaining and securing a substantial share of major regional markets in the Pacific Ocean area, in western Europe and in the adjoining United States market. In southeastern Asia and Oceania, Canadian suppliers will be encountering tonnage from the Near East which has a potentially more favourable freight rate into the area. Nevertheless, it is not expected that the lower end of the export price range on an f.o.b. Vancouver basis will decline below $12 per long ton. At the lower end of the price range, the Canadian suppliers competitive ability in western Europe vis-à-vis the delivery of Polish and French sulphur will depend greatly on the transportation costs incurred and, in relation to the substantial United States and also Mexican shipment programme to western Europe, on the ability to deliver liquid sulphur.

United States Frasch sulphur shipments are expected to remain geared to the domestic market and western Europe and marginally towards Latin America. Currently established at approximately $27—$28 per long ton

c. and f. western Europe, which implies an f.o.b. United States Gulf of just over $20 per long ton, the price of United States Frasch sulphur is not expected to recede further.

The expansion of indigenous requirements is expected to take a growing proportion of Mexican Frasch sulphur shipments which in the two principal export markets (United States and western Europe) will continue to be priced competitively with United States Frasch sulphur. Exports of French recovered sulphur will be increasingly directed to nearby markets in western Europe where strong freight advantages will be exercised in competitive delivered pricing with other suppliers.

Concerning Polish sulphur, the operation of bilateral trade agreements secures a market presence for this material at the most competitive prices established by other suppliers. This has been evident in southeastern Asia and reliance on this mode of operation may be accentuated through the medium term. The export surplus of Japanese recovered sulphur is not expected to be substantial in that most of the output will be directed to the domestic market; however in the medium term the country's trading expertise and credit facilities are likely to find export outlets for brimstone above ruling market prices in countries such as the Republic of Korea and possibly China. For brimstone export prices, United States Frasch sulphur (bright), dollars per long ton f.o.b. Gulf port, see figure 8.

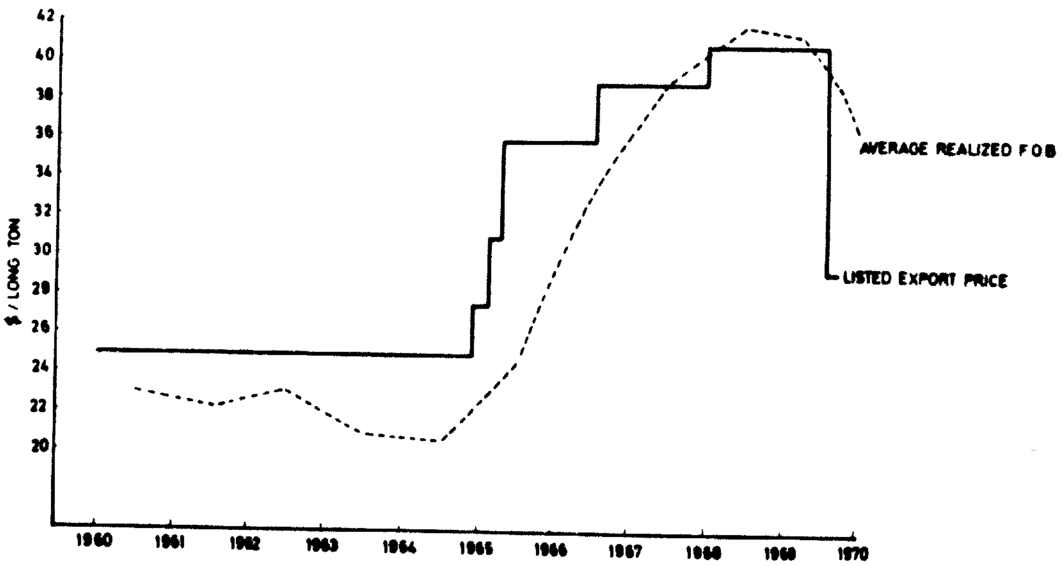

Figure 8. Brimstone export prices

Chapter 10

SULPHUR FREIGHTS

The following five tables (37, 38, 39, 40 and 41) show single voyage, open-market freight rates reported for full cargoes of brimstone in bulk in tramp vessels between the five loading ranges or ports indicated and various discharging zones. All freight rates are shown on net f.i.o. charter party terms, commonly for vessel deadweight cargo capacities in the range 10—15,000 tons or the alternative norm for the particular traffic.

The indications for 1969 are based on national rates prevailing as of 31 December. In all other years the rates are averages for the twelve months or the sole fixtures reported.

TABLE 37. FREIGHT RATES FOR SOLID SULPHUR IN BULK: LOADING RANGE/PORT — UNITED STATES GULF (1960 – 1969)
($/long ton, f.i.o. terms)

Discharging zones	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*+	*1969*+
Northwestern Europe	5.10[a]	5.05[a]	*	4.85[a]	4.80[a]	4.90[a]	4.45[a]	4.05[a]	4.25[a]	7.00
Southern Europe	—	—	—	*	6.50[a]	9.25[a]	5.95	*	7.15[a]	8.05
North Africa: Mediterranean	—	—	—	12.50	6.85[a]	8.15[a]	*	*	*	7.95
South Africa	*	*	*	*	*	*	9.60	8.90	*	9.40
India: West Coast	*	*	*	*	*	*	*	{ 15.50[a]	{ 15.65[a]	13.80
East Coast	*	*	*	*	*	*	*			13.45
Southeastern Asia	*	*	*	*	*	13.00	10.75	13.85[a]	*	15.00
Oceania: West Coast Australia	*	*	*	8.90[a]	*	*	{ 14.50[a]	11.25[a]	11.25	14.00
East Coast Australia	*	*	*	*	11.00	*		11.25[a]	—	12.95
New Zealand	*	—	*	*	*	*	9.80[a]	9.40[a]	9.00	12.70
Latin America: Caribbean	*	*	*	*	—	*	*	5.60	6.50	6.75
Atlantic	5.40[a]	7.55[a]	*	6.50[a]	8.15[a]	9.10[a]	6.75[a]	*	*	9.75

Explanation of symbols: + Option to load at United States Gulf and/or Mexican Gulf port; — No traffic; * No open market figures reported.
[a] Average for the year.

TABLE 38. FREIGHT RATES FOR SOLID SULPHUR IN BULK: LOADING RANGE/PORT — COATZACOALCOS (1960 — 1969)

($/long ton, f.i.o. terms)

Discharging zones	*1960*	*1961*	*1962*	*1963*+	*1964*	*1965*	*1966*	*1967*	*1968*+	*1969*+
Northwestern Europe	*	*	*	+	5.00[a]	*	4.40	*	+	+
Southern Europe	—	*	—	—	6.50	—	—	—	—	—
North Africa: Mediterranean	*	*	*	—	6.85	*	8.50	6.15	*	—
South Africa	*	*	*	*	*	*	*	*	—	—
India: West Coast	*	*	—	—	—	—	12.75	{ 15.50	{ +	—
East Coast	*	*	—	—	—	—	*			—
Southeastern Asia	—	—	—	*	*	*	10.75	13.87	—	—
Oceania: West Coast Australia	*	*	*	+	*	*	{ 11.15[a]	12.00	+	{ +
East Coast Australia	*	*	*	*	*	*		10.45	*	
New Zealand	*	*	*	*	*	*	9.95	*	—	—
Latin America: Caribbean	—	—	*	*	*	*	—	—	—	—
Atlantic	*	—	*	+	*	8.85	*	—	—	—

Explanation of symbols: + Option to load at Mexican Gulf and/or United States Gulf port. Freight rates in respect of relevant discharging zones shown in table 37; — No traffic; * No open market figures reported.

[a] Average for the year.

TABLE 39. FREIGHT RATES FOR SOLID SULPHUR IN BULK: LOADING RANGE/PORT—VANCOUVER (1960–1969)

($/long ton, f.i.o. terms)

Discharging zones	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*
Northwestern Europe	—	—	*	—	*	9.00	*	—	5.50	9.90
Southern Europe	—	—	—	—	9.05[a]	*	9.50	8.50	*	—
North Africa: Mediterranean	—	—	—	—	8.00	—	—	—	—	—
South Africa	—	—	—	*	*	13.40	10.10	*	*	12.25
India: West Coast	—	—	*	11.00[a]	*	*	*	{ 11.65[a] (West and East Coast)	{ 12.00[a] (West and East Coast)	15.25
East Coast	—	—	*	*	*	12.90	*			13.90
Southeastern Asia		*	*	6.70[a]	*	8.15	*	8.85[a]	*	11.60
Oceania: West Coast Australia	—	*	*	*	*	*	9.15	8.70[a]	9.25	12.30
East Coast Australia	—	*	*	*	*	*	*	6.85[a]	8.15[a]	11.25
New Zealand	—	—	—	*	*	*	9.05	7.75[a]	*	11.00
Latin America: Caribbean	—	—	—	*	*	*	—	—	—	—
Atlantic	—	—	—	—	*	*	—	10.50	9.45[a]	8.70

Explanation of symbols: — No traffic; * No open market figures reported.

[a] Average for the year.

TABLE 40. FREIGHT RATES FOR SOLID SULPHUR IN BULK: LOADING RANGE/PORT – BAYONNE (1960 – 1969)

($/long ton, f.i.o. terms)

Discharging zones	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*
Northwestern Europe	2.60	2.70	*	2.50	2.55[a]	*	*	*	*	2.40
Southern Europe	—	*	*	6.80[a]	7.00	*	*	*	6.00	4.55
North Africa: Mediterranean	*	*	*	*	*	*	*	*	*	4.50
South Africa	—	—	—	*	*	*	—	*	*	—
India: West Coast	—	*	—	—	—	—	—	13.80	*	—
East Coast	—	*	—	—	—	—	—		*	—
Southeastern Asia	—	—	*	*	*	*	*	—	*	15.20
Oceania: West Coast Australia	—	*	*	12.60	—	—	—	*	*	—
East Coast Australia	—	*	*	*	—	—	—	*	*	—
New Zealand	—	—	—	—	—	—	—	—	—	—
Latin America: Caribbean	—	—	—	—	—	—	—	—	—	—
Atlantic	—	—	*	*	—	—	—	*	*	6.85

Explanation of symbols: – No traffic; * No open market figures reported.

[a] Average for the year.

TABLE 41. FREIGHT RATES FOR SOLID SULPHUR IN BULK: LOADING RANGE/PORT—GDÁNSK (1960—1969)

($/long ton, f.i.o. terms)

Discharging zones	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*
Northwestern Europe	—	—	—	—	—	*	—	*	*	3.20
Southern Europe	—	—	—	—	—	—	*	*	6.80[a]	6.30
North Africa: Mediterranean	—	—	—	—	—	—	—	5.50	5.80[a]	6.25
South Africa	—	—	—	—	—	—	—	10.20	10.60[a]	—
India: West Coast	—	—	—	—	—	—	12.20	*	10.50 (bracketed over both lines)	15.75
East Coast	—	—	—	—	—	—	*	10.45[a]		15.00
Southeastern Asia	—	—	—	—	—	—	—	—	*	—
Oceania: West Coast Australia	—	—	—	—	—	—	—	—	11.60[a]	12.50
East Coast Australia	—	—	—	—	—	—	—	—	*	—
New Zealand	—	—	—	—	—	—	—	—	—	—
Latin America: Caribbean	—	—	—	—	—	—	—	9.00	8.60[a]	6.75
Atlantic	—	—	—	—	—	—	—	11.50	8.50	7.75

Explanation of symbols: — No traffic; * No open market figures reported.

[a] Average for the year.

Chapter 11

LIQUID SULPHUR TRANSPORTATION

Only during the last ten years has the seaborne transportation of elemental sulphur in its solid form been augmented by the commercial development of freighting systems for the shipment of liquid sulphur. The movement of liquid sulphur however still accounts for a modest proportion of international brimstone trade which remains primarily geared to the customary method of solid sulphur transportation even though most of the world's brimstone output is initially produced as a liquid (e.g. at Frasch mines and sulphur recovery plants) and even though its use frequently involves its transformation back to a liquid (e.g. prior to combustion at a sulphuric acid plant for the preparation of sulphur dioxide).

The early investigations into the feasibility of transporting sulphur in molten form were conducted in the United States after the Second World War. Following a favourable outcome, the major brimstone producers and consumers in the United States domestic market reorganized handling, freighting and storage facilities in the late 1950s to permit the introduction of liquid sulphur transportation. The subsequent expansion of this mode of shipment proceeded very rapidly in the 1960s, and at the present time all but a minor share of brimstone deliveries by road, rail, barge and coastal tanker traffic in the United States is undertaken in liquid form.

In the first half of the last decade this practice was extended to sulphur deliveries in western Europe with the establishment of specialized tank terminals by Mexican, French and United States brimstone suppliers and the initiation of liquid sulphur shipments to the United Kingdom, France, the Federal Republic of Germany, the Netherlands, Belgium and Ireland.

Thus the present pattern of seaborne liquid sulphur transportation is confined to delivery into two major market areas—the United States and western Europe. In the former, the traffic covers not only coastal tanker shipments from the United States primary shipping points on the Gulf of Mexico to regional terminals on the United States Atlantic Coast, but also the liquid deliveries from Mexico to the United States. In western Europe liquid sulphur movements are those at the end of the Atlantic eastbound trade from the United States and Mexico and the shipments from Bayonne in southwest France to terminals in northern France, the United Kingdom and the Netherlands.

In addition the world-wide movement of liquid sulphur embraces the shipment of substantial tonnages within producers domestic markets, notably in the United States, Mexico, France, Poland, and in smaller quantities (commonly by road tanker) from oil refineries in many countries to consumers such as sulphuric acid manufacturers which may take a proportion of their brimstone requirements from local sources of supply.

ADVANTAGES OF LIQUID SULPHUR TRANSPORTATION

The advantages in moving sulphur in molten rather than in solid form materialize at all stages of shipment programmes between producers and consumers and are evident in such aspects as product and quality control, vessel loading and discharging, safety, stock control, elimination of losses and corrosion of exposed buildings, reduction of labour costs during in-plant handling and the avoidance of remelting prior to sulphur-burning in, for example, a sulphuric acid plant. Though there are numerous factors in favour of liquid as opposed to bulk sulphur transportation, the fact that world sulphur export shipments are still primarily undertaken with the product in solid form reflects the sizable capital investments required to establish facilities for liquid sulphur traffic, notably, tank storage and handling facilities and suitable vessel, barge or surface transportation units.

Product and quality control

Significant advantages in product and quality control accrue from shipping sulphur in liquid form since the provision of closed storage and handling facilities allow for improved avoidance of contamination and moisture contact. The possibility of contamination with foreign substances, which might lead to ash build-up in the product, is minimized by the use of specialized equipment solely for liquid sulphur; the absence of moisture inside storage tanks and lines eliminates chances of contamination and corrosion resulting from the formation of sulphuric acid.

Vessel loading and discharging

As with any other liquid cargo, handling rates generally show a measurable improvement over solid cargo loading and discharging rates. This is particularly the case at ports of discharge—where receivers need no extensive quayside installations such as transporter bridges or grab cranes, hoppers and conveyers—in that once connexion is achieved between the tanker and a land line to storage, the unloading proceeds using vessel pumps as in a normal tanker arrangement. This operation can be run continuously with no loss of time, for example, as may be the case with inter-hatch crane movements in discharging solid cargoes.

Safety

Though the installation of liquid sulphur facilities requires the establishment of suitable safety precautions, particularly against combustion and the presence of explosive vapours, these dangers are not severe and the shipment of liquid as opposed to solid sulphur does avoid the danger in the latter traffic of dust explosions and fires. ("Dark" liquid sulphur provides a hazard in that it may generate dangerous amounts of hydrogen sulphide.)

Stock control

For the receiver, taking sulphur in liquid form makes better allowance for the continuous measurement of stocks and this can enhance the planning efficiency of purchasing and usage programmes. The basic advantage here is the elimination of inaccurate stock surveys which may more readily arise in the examination of dry bulk sulphur inventories than with the measurement of tank tonnages of liquid sulphur.

Losses and corrosion

The handling of liquid sulphur circumvents wind losses which may arise during the loading and discharging of solid sulphur. Such losses may amount to 0.5 per cent or more of a particular consignment and, apart from the obvious waste, the distribution of airborne sulphur dust occasioned by bulk sulphur handling may be disadvantageous in that it leads to the corrosion of exposed buildings and equipment.

Labour costs

Labour costs for handling liquid sulphur show a significant reduction compared with costs associated with solid sulphur movements. This arises partly because of the prospects for automated control offered by liquid sulphur handling systems and partly because of the inherent simplicity of liquid sulphur operations. At off-loading points once routine line preparation is complete, the operation mainly comprises the connexion of discharge lines to the tanker, barge or rail/road tanker, initiation of pumping or gravity feed and supervision of storage tank replenishment. Solid sulphur handling, however, requires a full range of stevedoring functions from crane operation through quayside discharge, conveyor routing and store reception.

No remelting

The most striking innovation presented by the adoption of liquid sulphur transportation is that it permits users of sulphur who have to burn the product during processing, e.g. producers of sulphuric acid or liquid sulphur dioxide, to forgo the employment of sulphur melters and the operating and maintenance costs incurred by the use of such units. Moreover in the sense that the sulphur producers output, from a Frasch mine for example, does not have to be solidified prior to shipment, liquid sulphur transportation has streamlined the industry's operations on an "all-liquid" basis from production right through to consumer use. Given that the greater part of world brimstone output is destined to be melted and burned to sulphur dioxide, the attractions to producers and consumers alike of practical and economical transportation systems that allow all-through liquid sulphur shipments are obvious.

Handling and storage facilities

The facilities required at liquid sulphur discharging points are so arranged that it is possible to describe them under a threefold classification: first, the quayside installations, second, the handling facilities linking the quayside with on-shore storage and, third, the storage installation itself plus infrastructure and utilities.

The primary consideration at all stages of a liquid sulphur transportation system is to maintain product stability. Under proper operating conditions, liquid sulphur is a fluid, non-corrosive material with acceptable handling qualities given the appropriate facilities and control devices. The most important factor is the maintenance of the temperature of molten sulphur in the range 240° F (116° C) to 320° F (160° C); below this range sulphur solidifies and above the range it becomes excessively viscous. Thus all handling and storage facilities must be provided with heating equipment and, for maximum benefit, insulation.

Quayside

No particular provisions govern the type of berthing point for a liquid sulphur tanker except that the economics of on-shore handling and pipeline cost are maximized if the distance between the berth and the storage tanks is as short as possible. As long as the berth provides an adequate water depth at all tides or, if it is on non-tidal water, access gates to a lock basin are of adequate dimension, there should be no immediate preference for any particular type of tie-up point for example, dolphins, jetties or piers, harbour walls and the like. Special considerations may arise however where it is proposed to establish liquid sulphur discharging facilities at quays also used for dry bulk cargo movements. Such quays are frequently covered by rail tracks and overhead piping systems may be ruled out by the presence of rail mounted cranes travelling the length of the quays.

Connexion gantries linking shore lines to tank outlet points aboard the tanker are commonly of the swivel-jointed type allowing uninterrupted operation at all phases of the tide between high and low water and at all stages of vessel displacement during cargo discharge. Flexible hose connexions have found some application but swivel joints have the advantages that they can be almost completely steam jacketed.

Unloading is accomplished by using pumping systems on board the vessel as is normal procedure in tanker operations, though auxiliary/booster pumps may provide at on-shore points to supplement the primary pumping system if the need arises.

Handling to storage

Pipelines with inside diameter measurements commensurate with throughput requirements serve as the link between quayside discharging points and tank storage units. The corrosion of handling (and storage) equipment for liquid sulphur is of little consequence provided installation and maintenance is satisfactory. Such corrosion results from moisture contact and the consequent presence of sulphuric acid; this contamination risk is virtually eliminated by molten sulphur operations. From this point of view, equipment of mild steel construction has proved adequate. Alternatively, galvanized iron and alloy steel, aluminium or other corrosion resistant pipe may be used.

To maintain the elevated temperature of liquid sulphur, lines carrying the product are heated—normally with steam. Steam heating may be effected by steam jacketing, a steam "gut" line (small steam pipe inside a larger line) or by steam tracing. The provision of pipeline insulation will assist in optimizing utilities consumption by maintaining temperature control and minimizing heating requirements. Insulating material may be either loose-fill or pre-formed, such as rock wool inside an aluminium sheet cover, or bonded fibreglass surrounded by a cylindrical aluminium cover.

General practice in operating liquid sulphur handling systems is to keep lines continuously heated and full of sulphur even when not in use. It is difficult to regain operating fluidity once lines are allowed to cool; and if pipes are allowed to drain, any traces of sulphur remaining may be affected by atmospheric oxygen and moisture to form sulphuric acid with resulting serious corrosion.

Molten sulphur lines between quayside and storage are commonly constructed with expansion loops to guard against the effects of product expansion in the event of a malfunction in the line heating system, boosting the sulphur temperature above the normal level.

On-site steam supplies for line and storage tank treating may be generated by specially built boiler facilities or delivered from adjoining sources, e.g. another steam producing/consuming plant. Obviously, capital costs of liquid sulphur storage and handling facilities are advantageously affected if no allowance has to be made for the special construction of steam generation equipment. At most storage operations steam is used at pressures between 35 and 70 p.s.i.g.

Storage

Storage of liquid sulphur in anything other than minimal quantities requires the deployment of welded steel tanks. Occasionally small quantities of liquid sulphur (road or rail tank car lots, for example) are stored in concrete pits which can be designed to employ various types of lining such as unlined steel, brick-lined steel or brick-lined acid-proof cement.

The installation of liquid sulphur storage tanks, depending on the firmness of the ground surface on which they stand, may well need to be preceded by extensive foundation preparation, and even piling, in view of the high specific gravity of the product (1.78). Tanks are normally built with externally insulated walls and roofs, notwithstanding the fact that in uninsulated tanks, sulphur in contact with outer walls solidifies and takes on insulating properties itself. The principal operating disadvantages attending the use of uninsulated tanks are corrosion (solidifying sulphur contracts leaving a small air space between it and the tank wall in which moisture condenses and sulphuric acid forms) and formation of pyrophoric iron sulphide (which brings overheating and fire risk).* As with pipelines, tank insulation materials commonly consist of rock wool or fibreglass surrounded by aluminium sheeting. Internal steam coils, normally on the base and sides of the tanks, are provided to maintain the required product temperature.

Apart from basic components, all tanks are equipped with the requisite loading indicators and meters, alarm systems, foam and other safety lines discharging pumps and loading points for whatever type of onward transportation system is in use.

Temperature and safety factors

All handling and storage facilities designed and installed for liquid sulphur should take account of two main hazards—fire and evolution of H_2S from dark sulphurs. Liquid sulphur is inflammable and its vapours may be explosive. Shipping and storage operations are conducted below 300° F, which is well below the flash point, but if ignited, molten sulphur will burn in air to yield sulphur dioxide. Dark sulphurs contain more hydrocarbons than bright sulphurs possibly up to 0.3 per cent C as hydrocarbon, and in extended storage some of the hydrocarbon may react with sulphur to form hydrogen sulphide. Thus adequate venting should be provided to avoid accumulations of this gas.

During shipment and storage, molten sulphur is generally kept at temperatures between 260° and 270° F (126°—133° C). In addition to problems of viscosity encountered at temperatures above 300°—320° F (149°—160° C— applies to bright or pure sulphur; dark sulphur containing 0.3 per cent or more carbon does not become so viscous at elevated temperatures but the sulphur-hydrocarbon reaction proceeds rapidly to evolve H_2S) the organic matter in Frasch sulphur will form sulphur-containing asphalt-like compounds and carbon-sulphur solids which can foul pumps and sulphur burners.

CAPITAL AND OPERATING COSTS

In the tables at the end of this chapter (tables 42 to 51) data are presented on the investment and running costs that would be incurred in the construction and operation of various sizes of terminals capable of handling liquid sulphur. Before giving further consideration to these capital and operating costs it will be necessary to consider the options available in respect of the form in which the sulphur will be shipped, stored, handled and redelivered, and certain factors that determine the size and scope of the facilities installed at a liquid sulphur terminal.

Types of terminals

The establishment and operation of a liquid sulphur terminal need not mean that the terminal is confined solely to the handling and storage of liquid sulphur. It depends in each case on what operating requirements are envisaged at the time of construction, i.e. will the terminal be geared solely to incoming deliveries in liquid form, is its sole purpose to redeliver liquid sulphur or is it desirable to have some flexibility to redeliver both liquid and solid sulphur.

Assuming the basic objective is to be able to make sulphur redeliveries from the terminal either wholly or partly in liquid form, there are a number of options available in the make-up of the terminal facilities. So far as the material form of the sulphur is concerned, the delivery and redelivery possibilities are as follows:

Into terminal	*From terminal*
1. Liquid sulphur	1a—Liquid sulphur 1b—Liquid and solid sulphur
2. Solid sulphur	2a—Liquid sulphur 2b—Solid and liquid sulphur
3. Liquid and solid sulphur	3a—Liquid sulphur 3b—Liquid and solid sulphur

For the development of capital and operating cost data, the types of terminal operation examined in detail are 1a and 2b. Though all the other types of facility could be described as liquid sulphur terminals their operation, with the exception of 3b, is believed to be less practical and not as cost effective as 1a and 2b; 1b can be overlooked on the grounds that it would be cheaper to establish an all-through solid sulphur operation in conjunction with liquid melters at the terminal (i.e. option 2b) rather than employ liquid sulphur tanker capacity to ship sulphur that would ultimately be delivered to consumers in solid form. Also, rather than vat liquid sulphur and install expensive reclaiming equipment, it would be easier to handle the proportion of the throughput to be delivered as solid in conventional covered storage following incoming shipment in this form. Terminal operation 2a can be eliminated on grounds of limited flexibility to meet all consumer requirements, and 3a for the same reason. Terminal type 3b is a combined version of 1a and an all-solid sulphur terminal. In the future, given the complex arrangements for liquid sulphur as opposed to solid sulphur transportation it is possible that 2b may be seen to be a more acceptable alternative to type 3b.

Terminal sizes

On the basis of the range of vessel sizes that may be involved in delivering liquid or solid sulphur to a terminal, it is possible to identify an associated range of tank or solid storage capacities to cover all contingencies. The latter relate basically to one factor—at what rate will deliveries be made from the terminal during the interval between incoming shipments. To ensure, first, that full vessel cargoes can be completely discharged on arrival, and second, that there is always sufficient product in the terminal to meet extra demand arising between incoming shipments, it is necessary to provide the terminal with an increased margin of storage capacity over and above vessel or cargo size.

There is no general consensus on the optimum size of storage for a given cargo/shipment pattern but a reasonable upper margin would be 50 per cent on vessel deadweight cargo capacity. The closer the tempo of redeliveries from a terminal relates to the frequency of shipments into the terminal, the smaller the margin on incoming vessel size that needs to be allowed for in-storage capacity. However, extra storage capacity is not merely extra cost as it can be valuable insurance against any interruption of the shipment programme into the terminal.

Table 42 shows possible levels of storage capacity at 5,000 long ton intervals for liquid or solid sulphur related to incoming vessel size—the margins on cargo sizes being indicated in table 43.

Rates of throughput

An obviously significant factor in determining the cost effectiveness of terminal operations is the intensiveness with which the storage capacity is employed. Operating costs per ton of available capacity per year are reduced as the rate of turnover or throughput increases. It is generally held that a minimum of four throughputs per year is required to pay off capital costs on any terminal within a reasonable time period and this rate is commonly the one at which most handling charges are fixed in the bulk liquids storage industry where storage capacity is leased rather than owned.

In the subsequent analysis of capital and operating costs, four throughputs per year has been taken as the mean level of operation, though improved capacity employment is entirely feasible. An indication of the range of annual turnover at various sizes of terminal capacity and throughput rates per year is given in table 44.

Solid and liquid sulphur redeliveries

In the case of the terminal type 2b receiving solid sulphur and effecting redeliveries in solid and liquid form, it is necessary to define the liquid-solid redistribution pattern in order to assess what melter and buffer storage capacities would be required for the outbound proportion as liquid sulphur.

At various terminal sizes and four throughput volumes the pattern of redeliveries within the range of 20 per cent liquid/80 per cent solid—60 per cent liquid/40 per cent solid is shown in table 45. The range could be extended more in favour of liquid, e.g. to 60 per cent, 70 per cent or greater as required.

The outline organization of a terminal receiving solid sulphur and redelivering part of the input as liquid is shown in table 46. The proportions redelivered as liquid sulphur have been confined to 20 per cent, 40 per cent and 60 per cent to reduce the length of the analysis. Indicated melter capacities and storage tank capacities associated with the liquid sulphur redelivery programme are shown also. In view of the high cost of small-scale liquid sulphur storage tanks on a cost per long ton basis the lower limit on tank size has been set at 2,200 long tons.

Capital costs

Table 47 gives the capital costs for a liquid sulphur terminal in the capacity range 15—60,000 long tons. Also indicated are a number of alternatives on tank sizes—the principle adopted being that the fewer the tanks, with due regard to operating flexibility, the lower the capital cost. For example, for 50,000 long tons of tankage one deploys a maximum of 2×20,000 long ton units and 1×10,000 long ton units rather than, say, 5×10,000 long ton units. Storage tank capacities are determined by the number of plates and the width of the plating used in building the tank walls and by the diameter of the tank base. Invariably the completed unit will have a capacity either marginally smaller or larger than the nominal capacity required.

The costs, other than those for the tanks, are those within battery limits. One item that has been excluded, so as to put the capital cost data on a uniform basis regardless of location, is a boiler house to provide steam for the tank and line heating system. There may be scope for arranging the location of a terminal so that it is alongside steam generating facilities, e.g. at a bulk liquid chemical or oil storage facility, in which case it may be possible to avoid the special construction of a boiler house.

Table 48 shows the capital costs for sulphur terminal redelivering liquid and solid sulphur on the basis of solid sulphur deliveries. It is assumed in advance of any melting operation that solid sulphur storage has to be provided sufficient to cope with the entire volume of incoming solid deliveries. The excessive capital expenditure in melters and storage tanks for liquid redeliveries of less than 48,000 long tons/year is considered unjustified and no quotations are provided for such operations. Tank capacities for the outbound proportion of deliveries in liquid form have been standardized at 2,000 long ton intervals from 4,000 long tons upwards.

Table 49 provides a summary indication of capital costs quoted in table 48.

Operating costs

Table 50 shows the operating costs applying to the use of various sizes of "all-liquid" sulphur terminals and table 51 the operating costs on solid/liquid sulphur terminal.

Costs: Summary

It should be stressed, in conclusion, that the cost data in the following tables relate to "packaged" terminal installations. That is, capital costs cover items that would be needed regardless of location, i.e. surface components within "battery limits". Depending on the selected site, however, it may be necessary to add cost allowances for tank piling, the installation of steam generating equipment, fuel oil storage and the like. No provision has been made for capital expenditure on utilities or site preparation and the cost of land has also been excluded.

Using the operating cost data presented in tables 50 and 51, it is possible to cost the movement of sulphur through a terminal provided the operating costs are reduced to a "per long-ton capacity installed" basis and then divided by the number of throughputs expected per year. For example, a 40,000 long-ton capacity "all-liquid" terminal has an indicated annual operating cost of $267,000 when the tank deployment is two 15,000 long-ton tanks and one 10,000 long-ton tank. Actual tank capacities will total 39,450 tons and this indicates cost per ton installed capacity of $6.77 per year. Assuming four throughputs are achieved in a particular year, the operating cost per ton of sulphur will be approximately $1.70; this cost will, of course, decline as the number of throughputs per year increases. Table 52 lists the ocean-going, liquid sulphur tankers in service in 1969.

TABLE 42. STORAGE CAPACITY OPTIONS RELATED TO CARGO SIZE
(Long tons)

Cargo size	*Storage capacity options*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*
15,000	15,000	20,000	25,000	—	—
20,000	20,000	25,000	30,000	—	—
25,000	25,000	30,000	35,000	40,000	—
30,000	30,000	35,000	40,000	45,000	—
35,000	35,000	40,000	45,000	50,000	55,000
40,000	40,000	45,000	50,000	55,000	60,000

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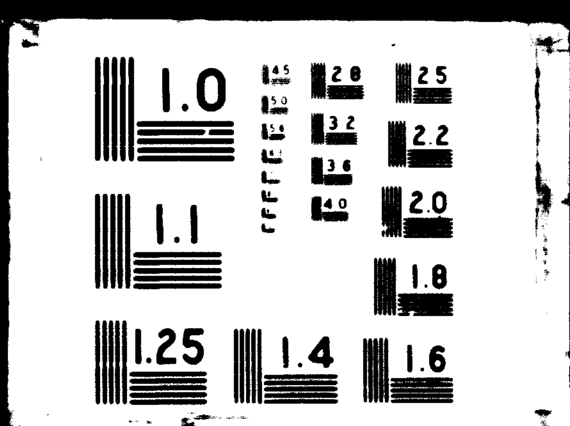

TABLE 43. STORAGE CAPACITY MARGINS ON CARGO SIZES

(Thousand long tons)

Cargo sizes	Storage capacity options (1)		(2)		(3)		(4)		(5)	
	Thousand long tons	Per cent	Thousand long tons	Per cent	Thousand long tons	Per cent	Thousand long tons	Per cent	Thousand long tons	Per cent
15	15	(—)	20	(33)	25	(60)	—		—	
20	20	(—)	25	(25)	30	(50)	—		—	
25	25	(—)	30	(20)	35	(40)	40	(60)	—	
30	30	(—)	35	(17)	40	(33)	45	(50)	—	
35	35	(—)	40	(14)	45	(29)	50	(43)	55	(57)
40	40	(—)	45	(13)	50	(25)	55	(38)	60	(50)

TABLE 44. TERMINAL CAPACITY AT ANNUAL THROUGHPUTS
(Thousand long tons per year)

Terminal capacity	Rates of throughput				
	3×	4×	5×	6×	8×
15	45	60	75	90	120
20	60	80	100	120	160
25	75	100	125	150	200
30	90	120	150	180	240
35	105	140	175	210	280
40	120	160	200	240	320
45	135	180	225	270	360
50	150	200	250	300	400
55	165	220	275	330	440
60	180	240	300	360	480

TABLE 45. TERMINAL SHIPMENT PATTERN:
SOLID SULPHUR DELIVERIES AND SOLID AND LIQUID SULPHUR REDELIVERIES
(Thousand long tons per year)

Terminal capacity	Four throughput volume	Liquid/solid distribution				
		(A) Proportion transformed/redelivered as liquid				
		20%	30%	40%	50%	60%
15	60	12	18	24	30	36
20	80	16	24	32	40	48
25	100	20	30	40	50	60
30	120	24	36	48	60	72
35	140	28	42	56	70	84
40	160	32	48	64	80	96
45	180	36	54	72	90	108
50	200	40	60	80	100	120
55	220	44	66	88	110	132
60	240	48	72	96	120	144
		(B) Balance as solid sulphur redeliveries				
		80%	70%	60%	50%	40%
	60	48	42	36	30	24
	80	64	56	48	40	32
	100	80	70	60	50	40
	120	96	84	72	60	48
	140	112	98	84	70	56
	160	128	112	96	30	64
	180	144	126	108	90	72
	200	160	140	120	100	80
	220	176	154	132	110	88
	240	192	168	144	120	96

TABLE 46. SOLID SULPHUR DELIVERIES AND SOLID AND LIQUID SULPHUR REDELIVERIES — MELTER CAPACITIES AND TANK STORAGE FOR OUT-BOUND PROPORTION AS LIQUID SULPHUR

Primary solid sulphur storage (thousand long tons)	*Four throughput volume (thousand long tons/year)*	*Proportion redelivered as liquid sulphur*			*Melter capacities[a] (long tons/day)*			*Possible liquid sulphur tank storage (thousand long tons)*		
		(a) 20%	(b) 40%	(c) 60%	(a)	(b)	(c)	(a)	(b)	(c)
15	60	12	24	36	40	75	110	—	—	—
20	80	16	32	48	50	100	150	—	—	2,200
25	100	20	40	60	65	125	185	—	—	2,800
30	120	24	48	72	75	150	220	—	2,200	3,200
35	140	28	56	84	85	170	255	—	2,600	3,800
40	160	32	64	96	100	195	295	—	2,800	4,400
45	180	36	72	108	110	220	330	—	3,200	4,800
50	200	40	80	120	125	245	365	—	3,600	5,600
55	220	44	88	132	135	270	400	—	4,000	6,000
60	240	48	96	144	150	295	440	2,200	4,400	6,400

[a] Representative selection of total melter capacities to cover these daily requirements as follows (in long tons day)

50	150	250	350	500
100	200	300	400	

TABLE 47. LIQUID SULPHUR TERMINAL: CAPITAL COSTS

Nominal total capacity (thousand long tons)		Nominal tank options (thousand long tons)	Actual total[a] tank capacity (tons)	Tank cost[b] (thousand $)	Cost of piping[c] valves etc. (thousand $)	Total capital cost (thousand $)
15		1×10, 1×5	14,790	235	145	430
20		2×10	19,500	300	150	450
25		1×15, 1×10	24,600	325	165	490
30	(a)	2×15	29,700	350	175	525
	(b)	3×10	29,250	450	225	675
35	(a)	2×10, 1×15	34,350	475	240	715
	(b)	2×15, 1×5	34,740	485	245	730
40	(a)	2×20	43,200	380	190	570
	(b)	2×15, 1×10	39,450	500	250	750
45	(a)	1×25, 1×20	46,700	395	200	595
	(b)	3×15	44,550	525	265	790
50	(a)	2×25	50,200	410	205	615
	(b)	2×20, 1×10	52,950	530	265	795
55	(a)	2×20, 1×15	58,050	555	280	835
	(b)	1×30, 1×25	54,300	420	210	630
60	(a)	3×20	64,800	570	285	855
	(b)	2×30	58,400	430	215	645

Note: Cost data relate to 1969 prices and construction/operating conditions in developed countries.

[a] Actual tank capacity based on standard units 40 ft high with varying diameters. The capacities are quoted for liquid sulphur at a specific gravity of 1.8 — tank volumes in terms of water tonnage/m³ are commensurately smaller.
[b] Cost of tanks excludes piling.
[c] Costs include all on-site lines, valves, meters etc. but not delivery or discharge lines beyond battery limits.

TABLE 48. SOLID AND LIQUID SULPHUR TERMINAL: CAPITAL COSTS

Primary solid sulphur storage (thousand tons)	*Solid storage[a] capital cost (thousand dollars)*	*Melter capacity[b,c] on 4 throughputs (long tons/day)*			*Melter capital cost (thousand dollars)*			*Secondary liquid[d] sulphur storage (thousand long tons)*			*Liquid storage capital cost (thousand dollars)*		
		(a) 20%	(b) 40%	(c) 60%	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
15	180	50	100	150	25	45	70	—	—	—	—	—	—
20	240	50	100	150	25	45	70	—	—	4	—	—	190
25	300	100	150	200	45	70	85	—	—	4	—	—	190
30	355	100	150	250	45	70	105	—	4	4	—	190	190
35	415	100	200	300	45	85	120	—	4	4	—	190	190
40	475	100	200	300	45	85	120	—	4	6	—	190	205
45	540	150	250	350	70	105	155	—	4	6	—	190	205
50	595	150	250	400	70	105	170	—	4	6	—	190	205
55	655	150	300	400	70	120	170	—	4	6	—	190	205
60	715	150	300	500	70	120	210	4	6	8	190	205	220

Note: Cost data relate to 1960 prices and construction/operating conditions in developed countries.

[a] Includes foundation cost, structural cost and cost of handling facilities such as conveyors and the like.

[b] Melter capacities are nominal and represent appropriate adjustments to capacities shown in table 46. Size of melter unit relates to proportion of annual solid sulphur intake at four throughputs redelivered as liquid sulphur (20, 40 or 60 per cent.)

[c] Units deployed to meet large capacity requirements as follows

total long tons/day	*units and capacity*
350	1 × 200, 1 × 150
400	2 × 200
500	2 × 250

[d] No data shown for small-scale liquid storage operations considered uneconomic.

TABLE 49. SOLID AND LIQUID SULPHUR TERMINAL: TOTAL CAPITAL COSTS

Primary solid sulphur storage (thousand tons)	*Four throughputs per year and proportions redelivered as liquid sulphur (thousand dollars)*		
	(a) 20%	*(b) 40%*	*(c) 60%*
15	—	—	—
20	—	—	500
25	—	—	575
30	—	615	650
35	—	690	725
40	—	750	800
45	—	835	900
50	—	890	970
55	—	965	1,030
60	975	1,040	1,145

TABLE 50. LIQUID SULPHUR TERMINAL: OPERATING COSTS

Nominal total[a] capacity (thousand long tons)	*Actual total[b] tank capacity (tons)*	*Operating costs (thousand dollars)*			*Total operating costs (thousand dollars per year)*
		Fixed[c]	*Variable[d]*	*Steam*	
25	24,600	72	48	59	179
30	*(a)* 29,700	88	48	71	207
	(b) 29,250	113	48	70	231
35	*(a)* 34,350	119	48	82	249
	(b) 34,740	121	48	83	252
40	*(a)* 43,200	95	48	103	246
	(b) 39,450	125	48	94	267
45	*(a)* 46,700	99	48	112	259
	(b) 44,550	132	48	106	286
50	*(a)* 50,200	103	60	119	282
	(b) 52,950	133	60	126	319
55	*(a)* 58,050	139	60	138	337
	(b) 54,300	105	60	129	294
60	*(a)* 64,800	143	60	154	357
	(b) 58,400	108	60	139	307

Note: Cost data relate to 1969 prices and construction/operating conditions in developed countries.

[a] Range of terminal sizes reduced from 15 – 60,000 long-ton range shown in table 47.
[b] Tank deployments as in table 47.
[c] Fixed costs include depreciation, capital charges, maintenance and insurance.
[d] Variable costs include labour and supervision.

TABLE 51. SOLID AND LIQUID SULPHUR TERMINAL: OPERATING COSTS
(Thousand dollars per year)

Primary solid storage capacity (thousand tons)	Solid storage fixed costs[a]	Melter fixed costs[a] (a)	Melter fixed costs[a] (b)	Melter fixed costs[a] (c)	Melter steam costs (a)	Melter steam costs (b)	Melter steam costs (c)
15	30	—	—	—	—	—	—
20	35	—	—	12	—	—	22
25	45	—	—	14	—	—	29
30	50	—	12	18	—	22	36
35	60	—	14	20	—	29	44
40	70	—	14	20	—	29	44
45	80	—	18	26	—	36	51
50	85	—	18	29	—	36	58
55	95	—	20	28	—	44	58
60	105	12	20	35	22	44	73

Primary solid storage capacity (thousand tons)	Liquid storage fixed costs[a] (a)	Liquid storage fixed costs[a] (b)	Liquid storage fixed costs[a] (c)	Liquid storage steam costs (a)	Liquid storage steam costs (b)	Liquid storage steam costs (c)	Labour costs	Total operating costs (a)	Total operating costs (b)	Total operating costs (c)
15	—	—	—	—	—	—	72	—	—	—
20	—	—	32	—	—	10	72	—	—	183
25	—	—	32	—	—	10	96	—	—	226
30	—	32	32	—	10	10	96	—	222	242
35	—	32	32	—	10	10	96	—	241	262
40	—	32	34	—	10	14	108	—	263	290
45	—	32	34	—	10	14	108	—	284	313
50	—	32	34	—	10	14	108	—	289	328
55	—	32	34	—	10	14	120	—	321	349
60	32	34	36	10	14	19	120	301	337	388

Note: Cost data relate to 1969 prices and construction/operating conditions in developed countries.
[a] Fixed costs include depreciation, capital charges, maintenance and insurance.

TABLE 52. OCEAN-GOING LIQUID SULPHUR TANKERS IN SERVICE, 1969

Name of ship	*Dead weight (long tons)*	*Over-all length (ft)*	*Beam (ft)*	*Draft (ft)*	*Principals*
Louisiana Brimstone	25,000	612	80	33	Freeport Sulphur Company
Louisiana Sulphur	16,400	523	68	30	Freeport Sulphur Company
Marine Floridan	23,580	612	80	31.5	Texas Gulf Sulphur Company
Marine Texan	20,065	604	79	31.5	Texas Gulf Sulphur Company
Texas Gulf Sulphur I	9,520	442	57	26	Texas Gulf Sulphur Company
Pochteca	16,200	523	68	30	Texas Gulf Sulphur Company
Naess Louisiana	26,500	620	85	33	Sulphur Export Corporation (Sulexco)
Naess Texas	26,500	620	85	33	Sulphur Export Corporation (Sulexco)
Harry C. Webb	21,900	550	84	31	Pan American Sulphur Company
Harold H. Jacquet	18,800	560	75	31	Pan American Sulphur Company
Etude	16,000	523	68	30	Pan American Sulphur Company
Presidente Andre Blanchard	12,200	479	63	28.5	Sté. Nationale des Pétroles d'Aquitaine
Marine Duval	24,410	612	80	32.6	Duval Corporation

Chapter 12

SUMMARY

The outset of the 1970s presents an opportune moment to take stock of both the broad developments that marked the evolution of the world sulphur situation during the previous decade and to make a summary assessment of the supply and demand trends that are expected to influence prominently the course of events in the next ten years.

1960–1969 IN RETROSPECT

In the 1960s there were three distinct phases in the progress of the world sulphur industry's operations—the first phase lasted from 1960 to 1963, the second from 1964 to 1968 and the third was confined to 1969 (but has been extended, of course, into the new decade). In both the first and third stages of the industry's history in this period the situation in world markets was characterized by freely-available supply, by the relatively low level of prices and by the build-up of brimstone producers' stocks. In general terms, world sulphur demand was adequately covered, and to a greater or lesser extent in the various regional and continental areas buyers' market conditions prevailed. During the middle period of the decade, however, the situation was quite the reverse and from 1964 the industry witnessed the progressive emergence of a sulphur shortage occasioned by the increasingly limited availability of brimstone, the principal sulphurous raw material. The advent of this period of restricted sulphur supply was accompanied by rising prices and the depletion of world brimstone stocks and, in due course, the widening gulf between world requirements and supplies became manifest in rationing programmes, the pro-rata allocation of supplies by the producers and in the stimulus given to the construction of new production capacity, the search for new sulphur sources and the evaluation of substitutes for sulphur in certain fertilizer and non-fertilizer manufacturing or processing operations.

The causes of the fundamental changes, notably in the sphere of brimstone production and consumption, which were brought about in the world sulphur supply/demand balance, first in 1963–1964 and then in 1968–1969, are not difficult to discern. The changeover from adequate supply to shortage initiated in 1963 and progressively evident from 1964 onward was occasioned by a rapid increase in the rate of growth of world sulphur demand. This boom in sulphur requirements had been anticipated in the mid-1960s but its arrival was earlier than expected and it shortly became apparent that world producers were unable, over the near term, to meet the surging level of requirements in several major markets, notwithstanding the availability of sizable producer stocks of brimstone built up during the over-supply period of the late 1950s and early 1960s. The other major turning point in the decade was reached in 1968 when, for the second year in succession, the rate of growth of sulphur demand (particularly the growth of brimstone requirements) subsided from the unusually high rates registered between 1964 and 1966. This decline in the rate of demand growth also coincided with a significant upturn in the availability of brimstone, particularly from Canada and Poland so that the margin by which demand had been exceeding supply was closed effectively from both sides of the production/consumption equation. The turn-round in the situation signalled in late 1968 became reality in 1969 as world brimstone prices collapsed to reflect the expectation that the industry was embarking on an extended period of excess of supply over demand.

SUPPLY AND DEMAND DEVELOPMENTS IN THE 1970s

Comparative analysis of the world sulphur supply and demand projections for the coming decade detailed in earlier sections of the report (see chapters 7 and 8) suggests that the recently arrived supply surplus will be maintained through 1975 and into the late 1970s. On a cumulative basis, the annual excess of brimstone supply over demand will have promoted a massive increase in the stocks of brimstone producers by 1977—1978 so that although by the end of the decade the forecasts show that a deficit situation will have arisen, the accumulated volume of stocks will be such as to cover the postulated shortfall in output for some time. An indication of the growth prospects in this respect was the increase of 3.6 million tons in producer stocks in 1968—1969 which boosted the world total to 7.1 million tons; the latter is not far short of the total recorded in 1963.

Given the increasingly important role which it is foreseen that the world's production and consumption of brimstone will play in the development of sulphur-in-all-forms supply and demand, it is expected that to an enhanced degree in the 1970s the dynamic factor in determining the world sulphur situation will be relation between brimstone supply and demand. The growing orientation of world pyrite output to captive outlets in the form of the producing countries' domestic markets coupled with the identity between sulphur-in-other-forms production and consumption affirms the likelihood that world supply and demand of sulphur in forms other than brimstone will remain in approximate balance.

The following tabulations show the basic balances in world sulphur-in-all-forms and world brimstone supply and demand that are expected to evolve in 1970, 1975 and 1980 (see table 53).

TABLE 53. WORLD PRODUCTION AND CONSUMPTION OF SULPHUR-IN-ALL-FORMS AND BRIMSTONE (1970, 1975, 1980)

(Million tons S)

	1970	*1975*	*1980*
Sulphur-in-all-forms			
Production	41.1	52.8	62.2
Consumption	37.9	49.3	63.7
Surplus (deficit)	3.2	3.5	(1.5)
Brimstone			
Production	22.8	31.7	37.9
Consumption	20.2	28.9	40.3
Surplus (deficit)	2.6	2.8	(2.4)

More detailed supply and demand statistics with balance indications are presented at the end of this chapter.

Supply and demand balance to 1975

The salient feature of the projected supply and demand balance to 1975 is the anticipation that on a global basis the situation will remain much the same as it is at present. The balance between all-forms supply and demand is expected to show a surplus output of some 3.5 million tons compared with the estimated 3.2 million tons of 1970, the corollary being almost identical growth rates for supply and demand of 5.2 per cent and 5.4 per cent per year over the five years. The same condition will apply to the relationship between brimstone supply and demand where respective growth rates of 6.8 per cent and 7.4 per cent per year to 1975 will slightly advance the margin of excess supply in the latter year to 2.8 million tons as against 2.6 million tons in 1970.

The anticipated growth in world brimstone consumption during the short term is substantial and to match this the critical factors in the attainment of the forecast output rate in 1975 (31.7 million tons) will be the growth of recovered sulphur production in western Canada, the United States and Mexican Frasch sulphur production and the availability of increased tonnages of Polish sulphur in western world markets. The areas from which these incremental supplies originate will remain, of course, in surplus (see table 54) as will the UNESOB area which will have a sizable brimstone export availability exceeding 0.5 million tons/year in 1975. The degree to which these surpluses are required may be judged from the growth of brimstone import requirements in areas such as western Europe (+ 1.3 million tons/year) and Asia (+ 1.1 million tons/year) and domestic demand in the areas with a supply surplus such as North America (+2.3 million tons/year and eastern Europe (+ 1.0 million tons/year).

New sources of brimstone supply are expected to make a measurable contribution to meeting expanded requirements; in the ECE area for example nearly 15 per cent of western Europe's additional demand could be met by

Table 54. Balance of world brimstone supply and demand (1970, 1975, 1980)

(Million tons S)

	Production			Consumption			Surplus (deficit)		
	1970	*1975*	*1980*	*1970*	*1975*	*1980*	*1970*	*1975*	*1980*
World total[a]	**22.8**	**31.7**	**37.9**	**20.2**	**28.9**	**40.3**	**2.6**	**2.8**	**(2.4)**
ECE area	*6.6*	*9.0*	*10.7*	*6.8*	*10.2*	*14.5*	*(0.2)*	*(1.2)*	*(3.8)*
Western Europe	2.3	2.9	3.1	4.5	6.4	8.8	(2.2)	(3.5)	(5.7)
Eastern Europe	2.4	3.6	4.3	1.1	2.1	3.1	1.3	1.5	1.2
USSR	1.8	2.5	3.3	1.2	1.7	2.6	0.6	0.8	0.7
ECA area	—	*0.1*	*0.1*	*0.5*	*0.9*	*1.6*	*(0.5)*	*(0.8)*	*(1.5)*
UNESOB area	*0.1*	*0.7*	*1.5*	*0.1*	*0.1*	*0.3*	—	*0.6*	*1.2*
ECAFE area	*1.1*	*1.5*	*2.1*	*2.5*	*4.3*	*6.7*	*(1.4)*	*(2.8)*	*(4.6)*
Asia	0.8	1.1	1.4	1.5	2.9	4.2	(0.7)	(1.8)	(2.8)
Oceania	—	—	—	0.7	0.9	1.3	(0.7)	(0.9)	(1.5)
Others	0.2	0.4	0.7	0.3	0.5	1.0	(0.1)	(0.1)	(0.3)
North America	*13.4*	*18.0*	*20.2*	*9.2*	*11.5*	*14.1*	*4.2*	*6.5*	*6.1*
ECLA area	*1.6*	*2.5*	*3.3*	*1.1*	*1.8*	*3.1*	*0.5*	*0.7*	*0.2*
Central America	1.5	2.3	2.9	0.7	1.1	1.7	0.8	1.2	1.2
South America	0.2	0.3	0.4	0.5	0.8	1.4	(0.3)	(0.5)	(1.0)

[a] Totals may not add due to rounding.

TABLE 55. BALANCE OF WORLD SULPHUR-IN-ALL-FORMS SUPPLY AND DEMAND (1970, 1975, 1980)

(Million tons S or S equivalent)

	Production			*Consumption*			*Surplus (deficit)*		
	1970	*1975*	*1980*	*1970*	*1975*	*1980*	*1970*	*1975*	*1980*
World total[a]	**41.1**	**52.8**	**62.2**	**37.9**	**49.3**	**63.7**	**3.2**	**3.5**	**(1.5)**
ECE area	*18.0*	*21.9*	*25.6*	*17.8*	*22.7*	*28.8*	*0.2*	*(0.8)*	*(3.2)*
Western Europe	7.9	8.5	9.0	10.7	12.5	15.1	(2.8)	(4.0)	(6.1)
Eastern Europe	4.0	5.8	7.1	2.7	4.3	5.8	1.3	1.5	1.3
USSR	6.0	7.6	9.4	4.5	5.9	7.9	1.5	1.7	1.5
ECA area	*0.6*	*0.7*	*0.8*	*1.1*	*1.6*	*2.3*	*(0.5)*	*(0.9)*	*(1.5)*
UNESOB area	*0.1*	*0.7*	*1.5*	*0.1*	*0.2*	*0.3*	—	*0.5*	*1.2*
ECAFE area	*5.0*	*6.2*	*7.6*	*6.3*	*8.8*	*11.8*	*(1.3)*	*(2.6)*	*(4.2)*
Asia	3.7	4.3	4.8	4.3	6.1	7.5	(0.6)	(1.8)	(2.7)
Oceania	0.2	0.3	0.4	0.9	1.2	1.9	(0.7)	(0.9)	(1.5)
Others	1.1	1.5	2.4	1.0	1.5	2.4	0.1	—	—
North America	*15.7*	*20.6*	*23.3*	*11.5*	*14.1*	*17.2*	*4.2*	*6.5*	*6.1*
ECLA area	*1.8*	*2.8*	*3.5*	*1.2*	*2.1*	*3.3*	*0.6*	*0.7*	*0.2*
Central America	1.5	2.4	3.0	0.8	1.2	1.8	0.7	1.2	1.2
South America	0.2	0.4	0.5	0.5	0.9	1.6	(0.3)	(0.5)	(1.1)

[a] Totals may not add due to rounding.

production from the growing recovered sulphur industry in the Federal Republic of Germany and the native sulphur mine in Italy. Output from the new Polish native sulphur mine and possible Frasch-type operations in the Soviet Union would be equivalent to 40 per cent and 60 per cent of the demand growth in eastern Europe and the USSR respectively. The brimstone surplus to captive requirements in the Near East recovered sulphur industry will be emerging from the UNESOB area and from Iran at a rate of some 0.5 - 0.6 million tons/year by 1975 and will be moving into deficit regions such as the ECA and ECAFE areas.

Supply and demand balance to 1980

By the end of the 1970s it is envisaged that there will be a modest shortfall in world sulphur-in-all-forms demand of the order of 2—2.5 per cent corresponding in tonnage terms to some 1.5 million tons (see table 55). With world pyrite production exceeding consumption, the shortfall in world brimstone requirements will be rather more apparent than the margin suggested by the all-forms data—about 2.4 million tons representing some 6 per cent of the estimated consumption level in 1980.

Reading the present forecast, the crucial aspect of the projections is undoubtedly the anticipated decline in the rate of growth of brimstone output—the 6.8 per cent per year rate scheduled for 1970—1975 is expected to be depressed to some 5.2 per cent per year for the decade. Although a downward adjustment of a similar nature is expected in the rate of growth of world brimstone consumption, it is unlikely to be as significant—7.1 per cent per year for 1970—1980 compared with 7.4 per cent per year for 1970—1975. In the sense that the forward projections of world sulphur demand are based on growth prospects in individual and regional markets and of major end use products, it is possible to accord a more determinate status in that part of the analysis and to conclude that the supply projections are inherently the more sensitive element in the forecast.

Thus, the apparent deficit in world sulphur-in-all-forms supply in 1980 must be evaluated in the light of the degree to which production levels can undergo fairly rapid adjustment in the short term. It is considered that the brimstone supply forecast is subject to several indeterminate factors related mainly to recovered sulphur output in Canada and the United States and to Frasch sulphur production in the United States and Mexico. In the case of recovered sulphur, the critical aspects are the timing and extent of energy demand trends and pollution controls and, in the Frasch sulphur industry, the phasing of the restrictions on output which are expected to be undertaken to align production levels with sales volumes and to avoid excessive stock accumulations.

Nonetheless it is believed that the margin by which any one of these "sensitive" components of the supply pattern is possibly conservative would be insufficient to disturb the basic projection of a modest shortfall in brimstone supply in the late 1970s.

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