INTERNATIONAL LABOUR REVIEW

VOL. XXIII. No. 5. MAY 1931

The Present State of the Lignite Industry in the Various European Countries

The studies on lignite hitherto published by the International Labour Office[1] *deal with the question from the international or at least the European standpoint. They were intended to meet an immediate need, that of supplying information on the value of the various arguments submitted to the Preparatory Technical Conference (Geneva, January 1930) for and against the inclusion of lignite mines in the scope of international regulations on hours of work in coal mines. The investigation made to obtain the necessary facts related solely to points that had been the subject of dispute. It thus left out of account certain important problems which had not given rise to discussion.*

As the lignite question is still of great interest, and forms one of the most difficult parts of the problem of the international regulation of hours of work in coal mines, it has been thought useful to throw more light on the position of each country in this respect by preparing a series of studies setting out in detail the present situation of the industry in each. For this purpose the Governments of the countries concerned were requested to describe the natural, technical, and economic conditions of the lignite industry in their country as a whole and in the different coalfields. On the basis of the replies received it is now possible to present a series of short reports for Austria, Czechoslovakia, France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, Rumania and Yugoslavia.

These reports, which supplement and illustrate the article previously published in the Review, *will appear in sufficient time to supply the delegates to the Fifteenth Session of the International Labour Conference with additional information. They*

[1] *Hours of Work in Coal Mines: Enquiry into the Lignite Industry in Europe.* International Labour Conference, Fourteenth Session, 1930. Report III, Supplement.

"The European Lignite Industry", in *International Labour Review*, Vol. XX, No. 6, Dec. 1930, and Vol. XXIII, No. 1, Jan. 1930.

show how the lignite industry differs from country to country, and therefore how difficult and complex is the problem of the international regulation of hours of work in this industry.

FOLLOWING on the studies already published by the International Labour Office on the international aspect of the lignite industry, the reports given below indicate for each country the importance of the industry and its position in the national economy. So far as the information received allows, they describe in detail the natural, technical, and economic conditions of the industry.

Under the head of natural conditions, they describe the geographical situation of the deposits and their geological properties. The first factor is of both international and national importance : international, because the geographical distribution of the deposits over the Continent explains the absence or presence of lignite in a country, and also determines the number and grouping of the deposits in any country ; national, because the geographical situation affects the economic conditions of production. Lignite, which has a comparatively low calorific value as compared with hard coal, is as a rule consumed on the spot, unless it can be manufactured into briquettes or transported on favourable terms — by water, for instance. When the deposits are scattered over the whole country, it is easier for them to find local markets, at least to the extent of local demand. Proximity to a large centre, in particular, facilitates sales.

When a lignite deposit is situated near a navigable waterway or the sea, its market can be extended into the country or abroad. On the other hand, hard coal becomes a much more serious competitor, for it, too, benefits by these transport facilities. In Greece, where economic activity is concentrated on the coast, the lignite deposits find it difficult to meet the competition of the hard coal arriving at all ports at relatively low prices. In the Danubian countries, the lignite fields have also to compete with foreign coal brought by ship ; the fields lying far from the Danube suffer less from this competition. Thus, the situation of the deposit with respect to the sea or navigable waterway may have opposite effects.

The geological properties of the deposits (age, position, thickness of the seam, etc.) determine how favourable the conditions of working will be. The geologically older lignite deposits give a

product in which carbonisation is more advanced and the calorific value is higher, but as a rule they lie deep (Austria, Czechoslovakia, Hungary, Rumania, Yugoslavia, etc.). The more recent deposits, on the contrary, have a lower calorific value but are nearer the surface and easier to work (Germany, the Netherlands). The position of the deposit, its regularity, the depth and thickness of the seams, their inclination, the nature of the covering ground, are all factors affecting, as will be shown below, the method of working and the output, creating very marked differences between the different lignite-producing countries, and even between different fields of the same country.

What has been said above of the geological conditions may be repeated for the technical conditions, which as a rule are determined by the former. The properties of lignite are to a large extent determined by its age, unless it has been subjected to metamorphic influences that have abruptly modified its primitive characteristics. Recent surface lignites are less compact and more impregnated with moisture than deep-lying lignites, which have been subjected to greater pressure and are more protected against the infiltration of water. These characteristics, which the geologist might place on the same level from the point of view of specific properties, are of variable importance in practice, depending on the possibilities of working and of use. The conditions of working will be discussed below.

As regards the possibilities of use, the calorific value, which is of the highest interest to the consumer, is itself a function of the relative proportions of carbon, volatile substances, and water. Lignite with a low water content can be used in the crude state, while that with a high percentage of moisture must first be dried, either naturally or artificially, with a view to briquetting. The degree of purity of the fuel and its ash content will determine the ease with which it is used. A large proportion of sulphur may reduce its value. The consistence of some lignites, which are too earthy or powdery, prevents them from being used in the crude state, and they have to be made into briquettes, a process yielding a fuel that is easier to transport and has higher calorific value. Some lignites are more suitable for briquetting than others. Some can be briquetted by simple pressure, others require the use of some form of cement, others again have first to be mixed with fat coal. Their chemical properties also determine their fitness for distillation.

The methods of working depend on the natural conditions of the deposit and the properties of the lignite. The depth of the deposit determines whether the working is to be open or underground, two methods that are sometimes combined for a single deposit. The nature of the lignite, and in particular, its consistence, the thickness and inclination of the seams and the nature of the covering ground, determine for each system of working what particular technique and special equipment is to be used for hewing and haulage. Open workings lend themselves to the use of powerful machinery for stripping the seam and hewing. Underground mines differ considerably in the methods of working, with respect to access to the deposit, and the means of hewing, haulage, and removal of the lignite. The position of the deposit with respect to the surface determines whether the seam is to be reached by shafts or by horizontal or inclined adits. The methods of hewing and the equipment used vary with the thickness and inclination of the seam and the nature of the lignite. One seam may be worked by blasting, another by the pillar-and-stall system. One lignite lends itself to mechanical cutting ; another can only be hewed with a pick or drill hammer ; and in yet another mine mechanical cutting is impossible, not owing to the nature of the lignite, but owing to the thinness of the seam. Similarly, the methods of haulage and removal of the lignite vary according as the process used is cage winding in shafts or haulage along inclined or horizontal adits, and according as the product is removed from the pit-head by tubs, wagons, cable-way, etc.

The natural conditions and the properties of the lignite often lead to serious difficulties in working, which increase the cost of production and reduce output : risk of sudden flooding, and risk of fire owing to the spontaneous combustion of carbonaceous shale in the Hungarian fields near Budapest ; risk of spontaneous explosions of fire-damp and coal dust in the Hungarian Pécs field ; risk of shifting sands in certain Czechoslovakian and other mines.

The output per worker depends on all these natural and technical conditions and the methods of working. Moreover, if it is to be estimated more accurately, it should be reckoned not by tonnage extracted, but by calorific value, especially as the relation between output and calorific value varies from mine to mine.

The economic conditions, namely, the production and use of the fuel, are the outcome of the natural and technical conditions. The production of lignite depends on the number and richness of the deposits, the facilities for working, and the size of the markets. According to their production of crude lignite in 1929, the countries studied below may be classed in the following order :

Country	Tons
Germany	174,458,000
Czechoslovakia	22,555,000
Hungary	7,044,000
Yugoslavia	5,242,000
Austria	3,525,000
Rumania	2,675,000
France	1,210,000
Italy	985,000
Netherlands	156,000
Greece	120,000 [1]
Poland	74,000

[1] In 1928 ; figure for 1929 not given.

Lignite in the crude state, dried, or in the form of briquettes, is used for various purposes. It is of great importance for domestic heating. In Germany, 70 per cent. of the total output of lignite briquettes is used for this purpose. In Austria, Hungary, Rumania, Yugoslavia, etc., too, many lignite mines sell a large proportion of their output for such use. A great variety of industries and the railways are customers of the lignite mines, where the use of this fuel is more economical than that of hard coal, on condition, however, that it is technically suitable for the purpose in question. Finally, lignite may be treated in carbonisation works for the manufacture of lignite tar and coke, the latter being most frequently used for the manufacture of briquettes. This industry is of importance only in Czechoslovakia and Germany ; elsewhere, for instance in Hungary and Yugoslavia, it is still in the experimental stage.

Lignite is a product intended primarily for local consumption, and at the outside for national consumption. The amount exported in 1929 formed barely 3 per cent. of the total extracted. But if the lignite industry is considered in relation to the hard-coal industry, it will be seen that it has an important influence on the trade in hard coal. In countries that do not produce hard coal, the presence of lignite considerably reduces the need for importing hard coal ; this is the case, for instance, in Austria, Hungary, Rumania, and Yugoslavia. In countries that produce

both hard coal and lignite in large quantities, such as Germany, the home consumption of lignite frees substantial amounts of hard coal for export.

At present the lignite industry is suffering from very severe depression. Most countries report a decrease in production due to the falling off in demand. As lignite, at least in the crude state, can hardly be stocked, the industry suffers very soon from such a falling off. The present drop in demand dates in most cases from 1929. It is due to the relative mildness of the winter of 1929-1930, which reduced the domestic demand. Since then the lignite industry has been affected by the general depression, and the falling off in demand has become more marked. Finally, certain countries—for instance, Czechoslovakia and Hungary—describe the depression in their industry as still more serious and of longer standing, being due to the loss of markets caused by the political conditions following the war, or to the progress of the lignite industry in neighbouring countries, which has reduced their export market.

Thus the European lignite industry is characterised by an extreme diversity of natural, technical and economic conditions. Each country, and often each field, presents special aspects, the principal features of which are indicated in the following reports.

Austria

Natural Conditions

Lignite deposits are worked in most of the Austrian provinces.

In the Tyrol, there are the Häring-Kirchbichl mines near Wörgl in the Inn valley. In Upper Austria, the Hausruck basin contains several important lignite deposits. Lower Austria has mines at Oberwölbling between Krems and St. Pölten, south of the Danube above Vienna ; south-west of Vienna there are the Hart mines near Gloggnitz, the Grillenberg mines near Berndorf, the Zillingdorf mines near Wiener Neustadt, and the mines to the west of Statzendorf. Styria has several deposits. In Upper Styria there are those of the Mur valley : the Fohnsdorf and Feeberg fields near Judenburg, the Leoben, Parschlug and Göriach fields near Kapfenberg. In Central Styria there are several lignite fields in the Graz district : west of the town there is the Voitsberg-Köflach field in the Kainach valley, north-west the Weiz field, east the Ilz field, south-west the Wies-Eibiswald field. Carinthia has lignite deposits in the valley of the Lavant, a tributary

of the Drave, and in the Sonnberg mountain region east of the valley of the Gurk, another tributary of the Drave.

The geological characteristics vary considerably from one mine to another. In open workings the thickness of the seams varies from 3 to 20 metres. The average may be said to be between 6 and 10 metres. The thickness of the dead ground covering the deposits is up to one and a half times that of the seams.

In underground workings, the thickness of the seams varies from 1 to 60 metres, though this maximum is found in only one field. The average thickness is about 8 metres. The depth of the pits may be as much as 800 metres.

Technical Conditions

In Austria, the term " lignite " (*Braunkohle*) refers to coal belonging to the Tertiary period. Coals belonging to older geological formations, that is to say, not only those of the Carboniferous period, but also those of Triassic, Liassic, and Cretaceous origin, are classified with hard coal. The real Carboniferous formation occurs in only one place in Austria and is of very little importance. Coal of the Carboniferous period is not worked.

Every variety of lignite is found in Austria, and the calorific value varies from 1,800 to over 5,000 calories.

According to its calorific value and other properties, lignite may be classified as xyloid lignite (*Lignit*), brown lignite (*Braunkohle im engeren Sinne*), and black lignite (*Glanzkohle*).

The xyloid lignites are those with the lowest calorific value ; their colour varies from yellow to light brown. Their ligneous structure is clearly apparent and their water content sometimes exceeds 40 per cent. The dark brown coal in which the ligneous structure is scarcely or not at all apparent is brown lignite. The most valuable lignites, with a calorific value almost equal to that of hard coal, are the black lignites ; they show no trace of ligneous structure ; they have a shiny appearance and often a conchoidal fracture.

Extraction in the strict sense is practically always done by hand. In the process of production as a whole, however, some of the work is done by machinery. In the first place, there are the rock drills and drill hammers used in most large undertakings for boring shot-holes ; they are sometimes worked by compressed air. Furthermore :

(*a*) In open workings, excavators are employed to remove the covering strata and sometimes even to extract the coal ; belt conveyers are employed for the automatic transport of the coal from the work-place to the tubs ; there are also all the other mechanical means of transport that are generally employed.

(*b*) In underground workings, rock-cutting machines, jack hammers and other types of drills are sometimes used.

In 1929 the annual output per worker (underground and surface workers together) was 330.4 tons, and the output per shift per worker was 1.17 tons; the annual output per underground worker was 276.3 tons, and the output per shift per underground worker 1.72 tons.

Economic Conditions

In 1929 the total production of lignite was 3,524,792 tons. The total quantity sold, deducting that used in the mines, was 3,200,076 tons.

Most Austrian lignite is sold in the crude state ; only one mine dries part of its lignite for sale. The amount of dry lignite sold in 1929 was about 200,000 tons. Lignite briquettes are not manufactured in Austria.

The position of the lignite industry is very unfavourable, partly because the conditions of extraction are decidedly more difficult than in the neighbouring countries, and partly because the Austrian industry, unlike that of those countries, is not protected, so that it finds it difficult to meet the competition of foreign coal. This competition reduces the price of lignite to a level that often fails to cover the cost of production.

Czechoslovakia

Natural Conditions

The centre of the Czechoslovakian lignite production is in North Bohemia, west of the Elbe, where there are several lignite fields lying in the depression between the Krušné Hory (Erzgebirge) and the České Stredohori (Böhmisches Mittelgebirge). These fields together form the mining districts of North Bohemia and Karlovy Vary (Karlsbad), which, according to the data for 1929, produce 96 per cent. of the total quantity of lignite extracted in Czechoslovakia. Of this total, 76 per cent. comes from the North Bohemian mining district and 20 per cent. from the Karlovy Vary district. The rest of the Czechoslovak production, amounting to 4 per cent. of the total, is derived from the basin of more recent lignite (*Lignit*) in South Moravia (1 per cent.), the two smaller basins of similar lignite in the south and north-east of Bohemia and another small basin in Silesia (0.4 per cent.), and the lignite (*Braunkohle*) mines of Slovakia, in particular those of Handlová on the upper Nitra River (2.6 per cent.).

As regards their geological age, the two basins of North Bohemia belong to the Upper Oligocene and Lower Miocene. The lignite seams in the North Bohemian mines were formed during geological periods which in that country were accompanied or terminated by volcanic activity. The result is frequent folding and displacement of the seams. The older deposits (Upper Oligocene) are not of much importance, their maximum thickness being only 1 metre. The prosperity of this district is due to the more recent part of the deposit, belonging to the Lower Miocene, which constitutes a single vein of considerable thickness, up to 30 metres, though it often includes strata of dead rock.

The depth of the seam is variable. On the outskirts of the basin and near the displacements of volcanic origin, the seam outcrops ; in the centre of the basin the maximum depth is 400 metres.

The quality of the lignite in this basin depends mainly on the depth of the deposit. The deeper the seam, the better the coal.

The Karlovy Vary basin is situated to the west of the North Bohemian basin, and its lignite deposits belong to the same geological formation (Oligocene and Lower Miocene). It has three seams. The "Josefi" seam consists of three strata separated by layers of clay often some metres thick. The total thickness of the three strata is from 7 to 9 metres. The overlying ground covering the "Josefi" seam consists of a stratum of clay 30 to 50 metres thick, covered by another seam, the "Anežka" seam, which varies in thickness from 5 to 10 metres. After a period of volcanic activity, which in this basin followed the formation of the "Anežka" deposits, the lignitiferous period terminated with the formation of the deposits of more recent lignite in the "Antonín" seam. In the neighbourhood of the town of Falknov this seam reaches a thickness of 20 to 30 metres; near Karlovy Vary it is divided into several strata. More to the east, in the neighbourhood of Cheb (Eger), there is a seam of the same age as the "Antonín" seam which is up to 30 metres thick. The depth of the seams worked in this field varies from outcrops to 130 metres.

The lignite basin of South Moravia forms the north-eastern part of the Vienna basin and belongs to the Upper Tertiary. Its principal seam, varying in thickness from $1^1/_2$ to 4 metres, includes several strata separated by layers of marl. The ground covering the principal seam contains one or two others of insignificant thickness.

In Slovakia the Handlová basin, which is situated on the eastern slope of the banks of the Nitra, belongs to the Middle Miocene. This field consists of two workable seams; the upper is $2^1/_2$ to 4 metres thick, the lower, which lies 40 metres deep and more, is from 1 to 2 metres thick. The deposit lies on the slope of a mountain range and can be reached by adits.

In addition to the above-mentioned basins, there are several lignite fields of the Tertiary formation, small and not very thick, which are scattered throughout Czechoslovakia. The small mines in these fields are for the present of only local importance.

Technical Conditions

The lignite coming from the deep pits in the centre of the North Bohemian basins is almost bituminous in appearance, while that from the outskirts of the field has an earthy appearance. All these lignites are brown. The content of water varies from 15 to 40 per cent., of volatile substances from 50 to 70 per cent., of ash from 3 to 8 per cent. The average calorific value ranges from 3,000 to 5,500 calories.

The lignite extracted in the Handlová basin approaches in quality the bituminous lignite of North Bohemia. The water content is 15 per cent., the ash content 4 per cent. The lignite worked in the South Moravian basins has the appearance of recent lignite, and has a definite vegetable structure, or else an earthy appearance. Its water content varies from 40 to 50 per cent., its ash content is about 15

per cent. Its calorific value is from 2,000 to 2,500 calories. The lignite of the other smaller basins is similar in quality.

The following table, based on the data of the State Statistical Office, shows the number of mines worked in 1927 according to the type of working :

Basin	Open	Underground	Mixed
North Bohemia	25	78	13
Karlovy Vary	9	43	6
South Moravia	—	9	—
Others	1	8	—
Total	35	138	19

The statistics do not indicate how much lignite is obtained from open workings and how much from underground. According to the estimates of specialists, the quantity of lignite obtained from open workings in the North Bohemian mines represents 36.5 per cent. of the total production, in the Karlovy Vary field 23 per cent., and in Czechoslovakia as a whole 33 per cent.

In certain parts of the North Bohemian basin the overlying ground includes shifting sand, which necessitates caution in sinking the pits and extending underground workings.

A considerable proportion of the open mines are provided with excavators worked by steam or electricity, which are used both to strip the seam and to extract the lignite. From the workplace the lignite is transported to the sheds where it is prepared for use and to the loading stations either by cable or by locomotive. In the underground lignite mines mechanical extraction is much less usual than in the Czechoslovak hard-coal mines, the reason lying in the nature of the seams and of the lignite itself. Lignite is usually worked at a less depth than hard coal. The sinking of the shafts is therefore less costly, and to exploit a deposit a larger number of shafts are sunk. On the other hand, the area served by these shafts is smaller than in hard-coal mines and the period during which they can be used is therefore shorter. The result is that the equipment of these pits for mechanical extraction on any great scale is more costly than in hard-coal mines. In 1929 11.7 per cent. of the total production of lignite in Czechoslovakia was extracted by mechanical means. The transport of the lignite from the working face to the shaft, however, is effected in most undertakings by mechanical means : cables, belt conveyors, locomotives. Haulage is effected exclusively by mechanically propelled machinery, mostly driven by steam, though during the last few decades the more important undertakings have preferred electrical machinery worked by current from the great central electrical generating stations.

The output per worker per shift and per year from 1927 to 1929 s shown in the table below. The years 1928 and 1929 were exceptionally prosperous, but in 1930 the situation was much less satisfactory.[1]

[1] The number of workers has been calculated by the method used by the International Labour Office ; the number of shifts worked and lost has been divided by 310.

PRODUCTION OF LIGNITE AND OUTPUT PER WORKER, UNDERGROUND AND OPEN WORKINGS TOGETHER

Region	Year	Production (tons)	Output per worker (tons)	
			Per shift	Per year
North Bohemia basin	1927	15,189,904	1.83	466.3
	1928	15,563,401	1.91	486.1
	1929	17,400,919	1.96	526.6
Karlovy Vary basin	1927	3,718,649	2.18	573.2
	1928	4,105,795	2.25	603.6
	1929	4,260,039	2.39	643.3
All Czechoslovakia	1927	19,620,637	1.82	469.7
	1928	20,451,421	1.89	488.7
	1929	22,560,796	1.94	542.1

Economic Conditions

The production of lignite in the Czechoslovak Republic is shown in the table above.

The greater part of the lignite extracted is consumed in the crude state after preliminary sorting by size. Only a small proportion of the production of the Karlovy Vary basin, some of which is particularly bituminous, is used for the manufacture of briquettes or treated chemically for the manufacture of tar, light oil, and lignite coke. The marketing of the coke so obtained meets with difficulties, and it is often mixed with the coal used for the manufacture of briquettes.

PRODUCTION OF LIGNITE BRIQUETTES AND COKE, 1927–1929

Product, etc.	1927	1928	1929
Lignite briquettes:			
Number of briquette factories in operation	2	3	5
Lignite made into briquettes (tons)	356,820	410,121	446,665
Lignite coke used for manufacture of briquettes (tons)	—	3,603	11,376
Briquettes produced (tons)	211,770	241,174	256,111
Lignite coke:			
Number of coke ovens in operation	2	2	2
Lignite consumed in the coke ovens (tons)	20,805	18,225	25,372
Products of coke ovens:			
Lignite coke (tons)	5,503	5,450	7,435
Crude tar (tons)	479	462	555
Crude benzol (tons)	102	55	81

Most of the production of lignite and lignite briquettes is consumed in Czechoslovakia. The exports in 1929 were 3,123,000 tons of crude lignite and 152,000 tons of lignite briquettes.

The present situation of the lignite industry in Czechoslovakia is not satisfactory. There was a temporary improvement in 1928 and 1929, but matters became very much worse in 1930. During the first half of 1930 the production of lignite fell by 15.2 per cent. (production in the first half of 1930, 9,330,789 tons ; of 1929, 11,007,014 tons). Exports fell by 26 per cent. (exports in the first half of 1930, 1,214,216 tons ; of 1929, 1,540,800 tons). Since the war the lignite industry has stagnated, not to say definitely dwindled. The 1913 production (23,100,000 tons) has not been attained again. This regression is due, among other things, to the position of the export trade. Before the war, North Bohemia provided the whole of Cisleithania with lignite, whereas now the exports of lignite to Austria are insignificant. Exports to Germany have fallen by one-third compared with the pre-war figures (in 1910, 7.48 million tons ; in 1911, 7.11 million tons ; in 1912, 7.24 million tons ; in 1913, 6.54 million tons). The principal reason for the fall in the exports to Germany is the growth of the lignite industry in Central Germany. The Czech mines, with their underground working, find it difficult to compete with the German mines, most of which have open working and mechanical extraction.

France

Natural and Technical Conditions

The geographical distribution of the French lignite deposits is as follows :

The Fuveau basin (Bouches-du-Rhône), which has the form of a flattened ellipse 75 km. long and 20 km. wide, taking the median width ;

The Manosque basin (Basses-Alpes) between Mount Lure and the Durance, stretching 25 km. from north to south and 10 km. from east to west ;

The Comtat basin, in the Departments of Gard, Ardèche, and Vaucluse ;

Larzac basin (Aveyron) ;

Landes basin (Landes, Gironde) ;

Alpes basin (Isère) ;

Sarladais basin (Dordogne) ;

Aude and Hérault basin ;

Estavar basin (Pyrénées-Orientales).

Only the first two are at present intensively worked.

Eighty-five per cent. of French lignite comes from the Cretaceous basin of Fuveau. The deposit consists of four seams of an average thickness of 2.50 metres. It is worked at an average depth of 450 metres. The lignite extracted is black, shiny, with a conchoidal fracture, and closely resembles hard coal ; it contains only 9 per cent. of

water and has a high calorific value (5,000 calories), with 34 to 39 per cent. of volatile substances and 3 per cent. of sulphur.

Twelve per cent. of French lignite comes from the Oligocene basin of Manosque. The deposit consists of four seams averaging 2.20 metres in thickness and twelve seams 0.50 metre thick. The average depth of the workings is 180 metres. This lignite is of a chocolate brown colour, more earthy than hard coal, and is particularly rich in volatile substances (33 to 45 per cent.); it contains 10 per cent. of water and up to 6 per cent. of sulphur ; its calorific value is hardly more than 4,000 calories.

In the other basins, lignite of different origins are found (Jurassic in Dordogne, Cretaceous and Tertiary in Gard), having different physical properties, more or less compact, with 15 to 30 per cent. of humidity, 2 to 7 per cent. of sulphur, and a calorific value of 3,000 to 5,000 calories.

The Landes coalfield is not yet worked, but under dead ground of 8 to 25 metres of sand there are flattened lumps of lignite 2 to 5 metres thick. This lignite is of mediocre quality (60 per cent. water ; 1,800 calories).

In all these fields, the working is underground. The output per shift per underground worker is 1,550 kg. at Fuveau and 1,252 kg. at Manosque. The output per shift per worker (underground and surface workers together) is 964 kg. at Fuveau and 915 kg. at Manosque.

The special difficulties met with in working the lignite mines are due to falls of roof, drainage problems, and fire. More than 95 per cent. of the extraction is done by machinery. The greater part of the tonnage extracted is obtained underground, three-quarters by electric machinery, and one-quarter by steam. Extraction by compressed-air windlass represents only 1 per cent. of the total national production. This method of extraction is as little used in the lignite industry as in the hard-coal industry.

Of the lignite extracted from stone drifts and adits, half is transported by electric locomotive, quarter by benzol locomotive, and the remaining quarter by man-power.

Economic Conditions

In 1919 the total production of lignite (deducting waste from sorting and cleaning) was 1,200,000 tons. The manufacture of lignite briquettes is not much developed in France. It is carried on only in the Fuveau basin, the output being 6,000 tons.

Similarly, only the Fuveau basin produces for export, and then only a very small amount (5,000 tons).

From the marketing point of view, the small fields have always met with great difficulties. At present, owing to the overstocking of the European market, the Fuveau and Manosque lignites have to meet the competition of imported coal, which arrives in large quantities at low prices in the neighbouring Mediterranean ports.

Germany

Natural Conditions

The German lignite fields are distributed over the whole country, but the centre of the industry is in central Germany. The next most important centre from the economic standpoint is Cologne. For economic purposes the industry is divided into three districts, organised in syndicates.

Geologically, the German lignite deposits belong to the Tertiary formations, principally to the Eocene and Miocene. The seams are horizontal or slightly undulating, and in rarer cases more definitely folded. Their thickness varies from a few centimetres to 100 metres; that of the workable seams averages 4 to 12 metres. In the locally restricted basins of Cologne and Geiseltal, the seams are thicker and may reach 60 to 80 metres.

Whereas in hard-coal mining a deposit comprises a large number of workable seams, in lignite mining there is as a rule only one workable seam, or at most two. For this reason lignite seams cannot be classified, like hard-coal seams, by age and content of volatile substances. Another fundamental difference from hard-coal mining is that the hard-coal seams lie at a comparatively great depth, and are covered by hard rock. The lignite seams do not lie so deep (the maximum depth of the seams worked in Germany may be taken at 100 metres) and are covered by loose ground (sand, gravel, clay, loam).

Technical Conditions

In the crude state the lignite is light brown to dark brown in colour, more rarely black. It is fibrous, ranging in appearance from bark to wood, or earthy and compact. Its consistence is slight. The specific gravity varies from 0.8 to 1.5. Recently extracted lignite contains 50 to 60 per cent. of water, 20 to 35 per cent. of carbon, 8 to 10 per cent. of oxygen and hydrogen, and 5 to 10 per cent. of ash. The calorific value is two-ninths of that of hard coal.

The fossil hydrocarbons contained in the lignite—resins, wax, and asphalte—are together described as "lignite bitumen". Where the content of this crude bitumen is over 10 per cent., the lignite can be subjected to distillation processes. The only lignite that can be used for this purpose is found in the Magdeburg, Anhalt, Halle, Borna, and Meuselwitz-Rositz basins.

The nature of the deposits and the physical and chemical properties of the lignite mean that the miners' conditions of work differ considerably from those of hard-coal miners. The atmosphere is purer in the lignite mines for the following reasons.

Owing to the small depth of the mines, the temperature is not high and the air is fresh. As the lignite is easy to hew and extraction offers no special difficulties, the workings can be high and wide, thus allowing plentiful ventilation without the use of artificial methods. In addition,

the lignite contains no inflammable gases, and the high degree of moisture prevents the formation of coal dust, so that fire-damp and explosions of coal are unknown, and the miners can work with open lamps. The size of the workings also enables them to work standing upright. The danger of falls of lignite is much less than that of falls of hard coal, nor is the miner exposed to falls of rock. [1]

As the thickness of the ground covering the lignite seams is usually comparatively slight, open working is much easier than in hard-coal mines. This system of working has the great advantage over underground working that it makes it possible to get out practically all the lignite. In underground working, about half the fuel is lost. In open working the covering ground is removed, the waste being first collected in dumps and later used to fill in the old workings. This stripping of the seam is effected solely by mechanical excavators, and nearly all the lignite is extracted by this machinery. The types used are bucket or scoop shovels and grab shovels.

The development of open working has followed the improvement of the excavators. The increased size and strength of this machinery has been accompanied by an increase in the size of the trucks for conveying the lignite and waste. First, the larger trucks were used for the lignite ; recently, they have also been used for the waste. The tipping of the trucks formerly used for the waste used to be done by hand ; that of the large modern trucks is done by machinery.

The technique of waste removal has been further developed by the introduction of transportable belt conveyers, which are used to transfer the waste to a dump at a considerable distance from the edge of the excavation. This makes it possible to leave the light rails in position longer without having to shift them as the excavation proceeds. In addition to the saving of labour, this means that the rails are safer against collapse at the edge of the excavation.

Another modern method of disposing of the waste, which means a great economy, is a machine that scoops up the waste, lifts it over the seam that has been stripped to the part that has already been worked out, and uses it to fill this in.

Formerly the shifting of the rails for the excavators and coal trucks in open workings was done by hand. Now this is carried out by special machinery.

These few facts are alone sufficient to show that from the point of view of mechanical equipment modern open workings of lignite have reached a high degree of perfection. On the other hand, it has hitherto been found impracticable to introduce similarly effective rationalisation in underground workings. Here the lignite is won by the so-called "pillar-and-stall" system, which consists in the hewing of the coal by hand in a space of about 4 × 4 metres floor area and 3 to 4 metres in height. The collapse of the walls is prevented by timbering. When all the coal has been won, the timber is removed and

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[1] For further details see the report presented to the International Labour Conference at its Fourteenth Session, Geneva, 1930 : *Hours of Work in Coal Mines : Enquiry into the Lignite Industry in Europe*, pp. 59-60.

the roof and walls fall in. This process is repeated, pillars of coal being left between the different working places for purposes of safety. This method of getting the coal explains the great loss of coal referred to above.

With the increasing mechanisation of open working, it has become possible to reach ever deeper deposits by this process. In other words, the underground working of lignite is gradually giving way to open working; but this has not affected the importance of those underground mines which still supply fuel for local consumption and employment for local labour.

The principal districts with underground mines are East Germany, Grimma, Kassel, and Westerwald. As, however, the thickness of the ground covering a seam may differ widely within short distances, underground and open working may be found in close proximity. In some cases there is no transition between the two. It may also happen that coal mined underground is transported to the open working and there raised to the surface; or, vice versa, that coal mined in the open is carried to the underground mine and raised to the surface through the shaft. In Central German lignite mining there are about twenty-five mines with mixed underground and open workings.

Owing to the high degree of mechanisation in open mining, the conditions as to output are much more favourable than in underground mining. According to the statistics of the Prussian Ministry of Commerce and Industry for lignite mining in the Halle inspection district west of the Elbe, the saleable output per man-shift (all workers taken together, excluding briquette factories and other ancillary undertakings) was 8.685 tons in open mines and 4.634 tons in underground mines.

Economic Conditions

The production of lignite in Germany in the calendar year 1929 was 174,458,000 tons, of which 15,893,000 tons were mined underground. In other words, 9.1 per cent. of the total production was derived from underground mines and 90.9 per cent. from open mines.

The total number of workers employed in lignite mining in 1929 was 93,986, of whom 12,387 worked in underground mines. Thus 13.1 per cent. of the total number employed worked in underground mines and 86.9 per cent. in surface mines.

The greater proportion of the crude lignite extracted — over 60 per cent. — is worked up in the briquette factories, either in its crude form or dried. More than 20 per cent. of the crude lignite is sold, being dispatched by rail or road to undertakings generating electricity for public use, or else delivered direct to neighbouring large undertakings. The rest is used by carbonisation works, wet briquetting factories, and the mine itself, or issued free of charge to the workers, etc. The deliveries to carbonisation works form only a very small proportion of the total.

As crude lignite has only a very low calorific value, it cannot for economic reasons be dispatched to any great distance. Of all the

lignite dispatched by the East Elbe Lignite Syndicate, for instance, 56.5 per cent. is consumed within a radius of 1 to 50 km. and 27.8 per cent. within 51 to 100 km., so that 84.3 per cent. of the total is used within a radius of 100 km.

The carbonisation of lignite is usually effected in Rolle ovens. Recently, more up-to-date and efficient processes have been introduced (the processes of the *Kohlenveredelungsgesellschaft* and the Lurgi Company, and the Seidenschnur-Pape process). Owing to the low prices obtained for their products, the economic situation of the carbonisation works is very precarious.

Briquetting is the principal use to which lignite is put. In 1929 about 42,000,000 tons of briquettes were produced in Germany, 97.1 per cent. of which were sold. The proportion consumed in the mines was about 2 per cent., and that supplied to the workers about 1 per cent.

Of the briquettes sold, 70 per cent. were used for domestic purposes and 30 per cent. in a great variety of industries. These figures show that industrial consumption is of comparatively slight importance to the manufacturers of lignite briquettes and that their output is absorbed mainly in domestic use.

The German lignite industry is definitely a home industry. The exports of lignite products are so low that they may be regarded as insignificant. The total exports from Central Germany in 1929 were 29,082 tons.

Since the beginning of 1930, the German lignite industry has been suffering from severe depression, which has led to heavily reduced production, much accumulation of stocks of briquettes at the factories, the introduction of short time, the closing down of undertakings, and dismissals of workers. This may be illustrated by the following figures for the Central German lignite mines (area covered by the Central German and East Elbe Syndicate).

The amount extracted in the period January to August 1930 was 62,989,380 tons (January to August 1929 : 77,208,740 tons). Thus in the first eight months of 1930 there was a reduction of 14,219,360 tons, or 18.4 per cent., as compared with the corresponding period of the previous year. The manufacture of briquettes from January to August 1930 was 15,370,315 tons (January to August 1929 : 19,494,682 tons), or a decrease on the previous year of 4,124,367 tons or 21.2 per cent. In spite of this considerable fall in production, there are large stocks of lignite briquettes at the factories. On 20 September 1930 these amounted to 1,460,584 tons.

The number of workers in July 1930 was 13,518 less than in July 1929.

The number of shifts not worked from January to July 1930 was 815,982. The number of mines definitely or temporarily closed down has increased considerably, and threatens to grow even larger.

The factors determining the economic situation of the lignite industry differ appreciably from those affecting the hard-coal industry. Thus in hard-coal mining the lack of markets is due principally to general economic depression. Clearly, the lignite industry also suffers

from the unsatisfactory economic situation of the industries it supplies, but the principal cause of its difficulties is the absence of orders for briquettes for domestic use. There are various reasons for the failure of this market. The winter of 1928-1929 was exceptionally severe, which led to temporary difficulties in the domestic supply of briquettes. Private customers and briquette dealers accordingly laid in large stocks during the summer of 1929. The winter of 1929-1930, unlike the previous winter, was very mild; this fact, together with the large stocks accumulated in the summer, led to a heavy drop in the demand for briquettes for domestic purposes, thus producing the situation mentioned above. The decisive factor in the lignite market is the state of the trade in domestic fuel. The present depression clearly indicates the difference in the factors determining the economic situations of the lignite and the hard-coal industries.

Greece

The lignite industry in Greece is not very much developed, the chief reason being the competition of imported foreign hard coal. The coast line of Greece is much indented, and therefore very long; gulfs and ports are numerous, so that the competition of foreign coal imported by sea is felt everywhere. Furthermore, the industrial centres (the Piraeus, Thrace, Salonika) are near the sea, and it is easy for them to obtain supplies of foreign fuel.

Natural Conditions

The Greek lignite deposits are situated on two nearly parallel lines, one in the north (Macedonia and Thrace), the other in the south (Peloponnesus, Isthmus of Corinth, islands of Chios and Euboea). An attempt was made to work many of these mines during the European war, but since the close of hostilities only about twenty have been worked, being those best situated with respect to the centres of consumption. The best known are those of Koumi, Aliveri, Oropos, Serres, Vevi, Amuntaion, etc.

The Greek deposits are found chiefly in the Upper Tertiary, Miocene and Pliocene formations. All the Upper Tertiary formations have seams of lignite. Most of this lignite appears to have been formed in the sweet or brackish waters of lakes, though it is possible that some of the deposits are of marine formation.

The lignite deposits form fairly regular seams in the surrounding dead ground (marl, conglomerate, loose mud and sand). The seams are sometimes slightly inclined, sometimes very much so, and often folded. So far, the workings have not been very deep, since all the mines are accessible by cross-cuts into the hillside.

The thickness of the lignite seams varies from 1 to 4 metres, except in the Aliveri deposit, where the thickness is 40 metres, the Florina deposits (Vevi and Amuntaion), where it is 8 to 12 metres, and certain other deposits situated far from the sea and not worked.

Technical Conditions

The Greek lignites are brown or blackish brown in colour. Some are powdery, some cohesive. The water content varies from 15 to 25 per cent., that of ash from 8 to 20 per cent., fixed carbon from 30 to 40 per cent., and volatile substances from 30 to 50 per cent. The calorific value in the crude state varies from 2,800 to more than 4,000 calories.

The following table shows the percentage composition and the calorific value (in calories) of various Greek lignites:

Component	Koumi	Aliveri	Oropos	Vevi
Water	5.07	18.79	19.24	28.78
Fixed carbon	32.70	31.54	32.36	22.56
Volatile substances	43.20	38.65	30.74	40.42
Ash	19.03	9.81	17.66	8.24
Calorific value in the crude state	4,971	4,050	4,076	3,847

In Greece, all the lignite workings are underground. They are still worked by cross-cuts in the hillside, which facilitates extraction and drainage. The difficulties arise out of the nature of the ground in which the deposits lie, which is usually loose and friable, and makes timbering and hewing difficult and sometimes dangerous.

The tools used for hewing are simple. Sometimes the lignite can be extracted without explosives; in some mines, on the contrary, drill hammers or rotary rock drills (at Aliveri) are used. Coal-cutting machinery cannot be employed, because the working faces are small on account of the difficulty of propping.

In view of the method of working, extraction is easy and the equipment used not very complicated. There are narrow-gauge railway tracks in the adits, and when the trucks reach the surface they are often drawn by locomotives.

As there is no fire-damp in the mines, they are lighted by lamps with open flames (acetylene). The ventilation is satisfactory, and easily effected and controlled, since the workings are not far from the surface.

The average output per shift per worker (underground and surface workers together) is low, rarely reaching 500 kg. This low output is due chiefly to the difficulty of timbering which prevents the use of cutting machines, and the impossibility of adopting blasting methods, which might produce fires.

Economic Conditions

Before the war, the annual production of lignite in Greece was some thousand tons. As the following table shows, the production began to rise in 1914, owing to the shortage of hard coal, and fell after the war for lack of demand.

Year	Tons	Year	Tons
1914	20,002	1922	132,233
1915	39,745	1923	118,927
1916	116,946	1924	131,109
1917	157,956	1925	142,076
1918	213,488	1926	153,321
1919	182,951	1927	143,346
1920	197,454	1928	120,639
1921	168,576		

All Greek lignite is used in Greece itself. There is no export trade. It is sold in the crude state and used for local purposes in lime kilns, brick kilns, kilns for calcinating magnesite, some gas works (in the Piraeus and Laurium), for domestic use, and for some small steamships.

Plant for the distillation of lignite and the manufacture of briquettes has recently been set up at Aliveri.

The difficulty of developing the lignite industry in Greece is due, as indicated above, to the competition of hard coal imported from abroad. In addition, the cost of production of Greek lignite at the pithead is high owing to the difficulties of underground working; sometimes it reaches as much as 10 shillings per ton. This makes it impossible to sell the lignite in the industrial centres of Greece, when foreign coal is sold, as it is now, at 22 shillings a ton in the Greek ports. The imported coal comes mainly from England, Russia, and Turkey.

Special reference should be made to the important lignite deposits in the Florina district, where the cost of production at the pithead is under 5 shillings a ton, and where plant for distillation and briquette manufacture might profitably be constructed.

Hungary

Natural, Technical and Economic Conditions

The coal deposits in Hungary belong to more recent formations than the Carboniferous. A distinction is made between :

(1) The Liassic coal of the Pécs district in South Hungary : the Pécs, Komló, Szászvár, and Nagymányok basins.

(2) The Cretaceous coal of Bakony (Ajka) in the Transdanubian district.

(3) The Eocene-Oligocene coal of the Transdanubian mountain range : the Tatabánya, Tokod, Dorog, Pilisvörösvár, and Solymár basins. This coal is known as black lignite. Oligocene coal is comparatively rare.

(4) The Miocene coal or lignite of the Salgó-Tarján and Borsod basins in the north of Hungary. These include all the intermediate varieties between black lignite and brown lignite.

(5) The Pliocene lignites of the north and the Transdanubian district.

The total production in 1929 was 7,869 million tons and the total saleable production 7,176 million tons. The output per shift per worker (underground and surface workers together) was 0.83 tons.

The Pécs Liassic Field.

These deposits are found on the southern (Pécs) and northern (Szászvár-Mányok) borders of the Mecsek mountain range, an isolated group south of the Transdanubian plain. There are many folds and faults in the ground and the inclines of the deposits are very irregular. The dead ground is clayey and exerts much pressure. The deposit comprises about thirty workable seams of a thickness of 0.5 to 10 metres. The coal is rich, containing 25 to 30 per cent. of ash, 16 to 22 per cent. of volatile substances, and 2 to 5 per cent. of sulphur. The calorific value is 6,000 calories. It is very friable and yields over 80 per cent. of slack. The deposits are pulverulent, containing fire-damp, and are even liable to explode spontaneously.

To overcome these risks is difficult and costly. The laying out of the workings must be preceded by trial borings and blasting. The maintenance of the haulageways is costly owing to the pressure of the ground. The result of these difficulties is a low output per underground worker, not more than one ton per shift, and a heavy consumption of timber, 0.5 cubic metre per 10 tons extracted.

The depth of the workings varies from 300 to 400 metres.

The high ash content necessitates elaborate cleaning and sorting plant. The region is very hilly and long-distance transport to the surface is necessary. For this reason, over 30 per cent. of the workers are employed at the surface and the output per shift, for underground and surface workers together, hardly exceeds 0.5 ton. This output is lower than that in any other European coalfield, yet the working of these fields combines the risks of hard-coal fields (fire-damp and dust) with the difficulties of lignite working (pressure of the ground and large quantities of subterranean water) and of metal mining (irregular formation of the ground, etc.)

The marketing of the coal of this field is difficult. The railways, which are the principal consumers, use a mixture consisting of one-third of this fuel and two-thirds of Eocene coal (Tatabánya and Dorog mines). The neighbouring railways of Yugoslavia — formerly Hungarian railways with headquarters at Zagreb and Szabadka (Teresianopel) — have ceased buying. The Mines Administration of the First Danube Steam Navigation Company has made a great effort to find new markets by setting up plant for washing slack and a briquette factory, without, however, being able to increase its production above half the capacity of the workings. The result has been a heavy rise in the cost of production. The production in 1929 was 825,434 tons.

The average price per million calories is 4 pengös.

The Eocene Coal Fields.

These are situated in the valleys of the central Transdanubian massif. The deposit consists as a rule of a single seam 5 to 15 metres thick, often interstratified with carbonaceous shale or clay. It rests on very irregular Triassic calcareous formations, much broken up and honeycombed by subterranean watercourses that may at any time flood the workings. The drainage difficulties are great, in particular at Tokod, where the quantity of water drained away sometimes amounts to thirty times the tonnage of coal extracted. The measures to be taken against flooding also include cementing the water-bearing fractures, constructing dams, etc. The lignite seam itself is very irregular, with many faults, broken up into small bands by fractures that tend to convey water and necessitate considerable preliminary work on the dead ground. The latter consists of plastic marl and clay exerting much pressure, which entails a heavy consumption of timber. The strata containing carbonaceous shale are liable to spontaneous combustion, and this risk has to be overcome by hydraulic packing, a process that needs enormous quantities of sand. The purchase of land for the supply of sand, such land being thus withdrawn from agricultural cultivation, the cost of transporting the sand to the piping in the bore-holes and pits, the cost of the underground piping and brattices, the clarification and draining of the muddy water, mean a heavy addition to the cost of production.

The working of this deposit is much more difficult than that of the Bohemian lignite, which often has the same calorific value. The output per shift (underground and surface workers together) is barely one ton, or about half of that in Bohemia, where, owing to the inexhaustible richness of the deposit, the much less costly pillar-and-stall system of working can be used, even though it involves the sacrifice of a fair proportion of the lignite. The consumption of props is from 0.4 to 0.5 cubic metre per 10 tons of coal extracted ; this is higher than in foreign fields, where thicker seams are worked. The depth of the workings varies from 100 to 200 metres.

The lignite obtained burns with a flame ; it contains 10 to 15 per cent. of moisture, 45 per cent. of volatile substances, and 10 to 16 per cent. of ash ; its calorific value is from 4,500 to 5,500 calories. The price per million calories is 3.60 pengös. The Tatabánya coal can be made into briquettes by mixing it with resin and fat coal. The total output of these fields in 1929 was 3.23 million tons, of which 3 million tons were saleable. The output of briquettes was 62,745 tons.

The Salgó-Tarján and Borsod Lignite Fields.

This deposit is situated in the geological basin between the inner border of the Carpathian range and the north-eastern range of the central massif. It comprises several thin seams, of which one to three can be worked. They are separated by bands of clay and sand which are often water-bearing. The basin is traversed by a series of fairly closely associated faults, and the finding of the seams necessitates

much work on the dead ground. As soon as the workings become deeper than about 100 metres, the maintenance costs become heavy owing to creeps in the floor. The lignite is hard and compact. Picks cannot be used for extracting, but cutters and explosives have to be used. The roof of the seams is often liable to collapse.

At Salgó-Tarján the lignite seams have an average calorific value of 4,200 calories, and an average thickness of 0.7 metre. The better-class seams, of up to 5,000 calories, are worked to below 0.5 metre, but this is at the cost of output, which is hardly more than 0.6 ton per shift per worker (underground and surface workers together). The depth of the workings is down to 200 metres. The very irregular deposit is worked in some 30 mines, whose surface plant is much decentralised. About 40 per cent. of the workers are employed at the surface. The annual production is 1.43 million tons.

In the Borsod field the lignite seams have an average calorific value of 3,500 calories, and an average thickness of 1.3 metres. The output is 0.9 tons per shift (underground and surface workers together).

In the seams of average thickness (2 metres), satisfactory output is often interfered with by creeps in the floor and the heavy cost of maintaining the haulage ways. The lignite is hard and fibrous, and not agglomerative like German lignite. The lignite of Saxony, which has about the same calorific value, is worked in the open and its cost of production is much lower than that of Borsod. The annual production of the Borsod field is 1.61 million tons, of which 0.87 million tons are from the workings of two important steel firms (the Rima-Murány-Salgó-Tarján Iron and Steel Company and the State Iron and Steel Works at Diósgyór), and are used in their factories. The remaining tonnage, produced by about 30 mines, is difficult to market, for the hinterland of this field, with its important coal-consuming industries, has been detached from Hungarian territory. The quantity exported is negligible. The production of these mines is hardly 50 per cent. of their capacity. The price per million calories of this lignite is 3 pengös.

The two important firms mentioned above have carried out extensive electrical schemes to find an outlet for their unsaleable products. Their sacrifices are still far from having produced the expected results, for the electrification of the agricultural provinces is making slow progress.

The Salgó-Tarján and Borsod lignite is consumed chiefly by sugar factories and certain other seasonal industries and for domestic heating. In winter the production is 40 to 50 per cent. higher than it is in summer. During that season, therefore, overtime has to be worked in order to make the best use of the available labour.

The Pliocene Lignite Fields.

These are numerous and not much worked. There are only a few mines on the southern border of the central mountain ranges on both sides of the Danube. In 1929 the production was 277,141 tons, of which 135,103 tons were saleable in the crude state ; 58,000 tons were sold after artificial drying.

The average output of these fields is 1.09 tons per shift (underground and surface workers together). The conditions of working are not very favourable considering that the lignite produced has a calorific value of 2,500 calories.

The Ajka Cretaceous Field.

This field, like the Eocene coal fields, suffers from the risk of subterranean water. The lignite, though of older formation, is of lower value. The production is hardly more than 100,000 tons a year. This field, like the Brennberg Miocene field, not yet mentioned, is of only local interest.

The production of Cretaceous, Eocene and Miocene lignite was 6.76 million tons in 1929, of which 6.32 million tons were saleable. The average daily output per worker (underground and surface workers together) in these workings was 0.88 ton. The average calorific value of these lignites is 4,400 calories. The difficulties of exploitation place the Hungarian mines in an unfavourable position both relatively and absolutely, as compared with all the neighbouring producing countries. Polish Upper Silesia, the principal country from which Hungary draws supplies, produces fuel of over 6,000 calories with an average output (underground and surface workers together) of 1.345 tons, which is equivalent to a daily output of 8 million calories. The corresponding figure for England and the Ruhr is 8 to 9 million calories, while in Hungary it is barely 4 million calories for lignite and 3 million calories for Liassic coal. The Hungarian deposits give far less return for the work expended on them. The possibility of using machinery in place of hand labour is very limited in Hungary owing to the great irregularity of the deposits.

The foreign import trade is very active. Total imports rose from 944,958 tons in 1926 to 1,299,200 tons in 1929. Exports, on the contrary, were only 414,626 tons in 1929, of which three-quarters were lignite.

Hungary, therefore, plays no part in international coal policy as a producing country. The Hungarian coal industry is at present suffering from severe depression, the accumulated stocks of Liassic coal amounting to 89,600 tons and of lignite to 230,600 tons. At present the mines are idle two or three days a week.

Italy

Natural Conditions

The Italian lignites are of various geological periods, which in general determine their quality. Ordinarily the common woody and peaty lignite, usually known as xyloid lignite, is found in formations from the Pliocene (the Valdarno basins of Arezzo and Florence and the Torgiano and Spoleto basins in Umbria) to the Quaternary (the Mercure-Basilicata and Calabria basin).

The other lignites, usually known as bituminous (*picee*), are situated in formations from the Miocene (the basins of Magra (Spezia), Grosseto, Pisa and Siena) to the Eocene (basins of Verona and Vicenza, Reggio di Calabria, Sardinia (Gonnesa), and Arsa in Venezia Giulia), and the Triassic (the Upper Tagliamento basin near Monte Dobbis and Cludinico). The products of the last two basins are known as " Liburnian coal " and " Triassic coal ".

The woody lignites have as a rule the following qualities (type: lignite of the Valdarno basin):

Colour : yellow, brown, reddish.
Consistence : ligneous, hard, in certain basins called *piligno*.

Percentage content of :	Maximum	Minimum
Water	44.5 [1]	15
Volatile substances	63	40
Ash	46	6
Calorific value (calories)	5,562	2,878
Fixed carbon (percentage)	38	16

[1] Very variable according to the moisture conditions at the different workplaces, which are partly due to the infiltration of surface water.

The peaty lignites also vary in different basins, for which reason only maximum and minimum figures can be given, with a wide range between them.

Colour : blackish, dull.
Consistence : peaty, friable, cracks on exposure to air.

Percentage content of :	Maximum	Minimum
Water	60	16 [1]
Volatile substances	65	18
Ash	65	8
Calorific value (calories)	5,970	2,260
Fixed carbon (percentage)	45	18

[1] In a few isolated cases, 11 per cent.

The same remark holds for the " bituminous " lignites.

Colour : black and shiny, anthracitic type.
Consistence : compact, uniform.

Percentage content of :	Maximum	Minimum
Water	33	2 [1]
Volatile substances	47 [2]	13
Ash	28.5	5 [3]
Calorific value (calories)	7,480 [4]	3,332 [5]
Fixed carbon (percentage)	65 [6]	30

[1] Upper Tagliamento (Triassic coal); Arsa basin : 1.57 per cent. [2] Arsa : 46.85 per cent. [3] Arsa : 7.2 per cent. [4] Arsa. [5] Murlo (Siena). [6] Upper Tagliamento (Triassic coal).

Technical Conditions

Underground workings are the more usual. As a rule, the instability of the covering ground necessitates a great deal of strong timbering. For hewing, use is made mainly of picks and, to a smaller extent, of

explosives. In some cases mechanical cutters (*tagliatrici*) are used. The transport is effected by shafts and long haulageways equipped with narrow-gauge tracks. This latter method of transport adds heavily to the cost of production of the lignite.

The output per worker varies from 400 to 600 kg. per working day for bituminous lignite, and from about 600 to 1,000 kg. for xyloid lignite. The corresponding annual figures are 100 and 150 tons, the number of effective working days being about 250.

Economic Conditions

Production.

The total production of lignite in Italy was as follows :

Year and variety	Metric tons	Value per ton	Total value
		Lire	Lire
1929 :			
Bituminous lignite	131,145	79.43	10,417,395
Xyloid lignite	650,900	37.35	24,309,416
1928 :			
Bituminous lignite	121,118	77.37	9,370,750
Xyloid lignite	575,915	39.00	22,462,735
Increase in 1929 :			
Bituminous lignite	10,027		1,046,645
Xyloid lignite	74,985		1,846,681
Total	85,012		2,893,326

A comparison of the production in 1925 and 1929 gives the following results :

Variety	Metric tons	
	1925	1929
Xyloid lignite :		
Peaty lignite	147,000	
Woody lignite	623,000	
	770,000	650,900
Bituminous lignite	328,000	131,145

Utilisation of Product ; Present Situation of the Industry.

The Italian lignite industry is at present suffering from depression owing to the fact that the use of hard coal is more economical than that of lignite.

In the xyloid lignite mines of the Valdarno group (the Castelnuovo mines at Arezzo in the Florence district), various plant was installed in 1929 to improve and make better use of the product and effect economies ; but it is difficult to carry on the undertaking owing to the reduced activity of the neighbouring industries and the fall in the local consumption of lignite. In the other mines of this district, at Siena and Casentino (Arezzo), the local demand for brick kilns and other undertakings keeps the mines going to a limited extent.

In 1929 the Florence district produced 482,018 metric tons of xyloid lignite, or 74 per cent. of the total national production, and 81,741 metric tons of bituminous lignite, or 62 per cent. of the total. This result is due to the organised utilisation of lignite in localities that are well situated with respect to the sources of supply.

Next in order of importance for bituminous lignite (Bacu-Abis, Gonnesa) comes the Iglesias district with 24,262 tons of lignite, including 373 tons consumed by the mine, which produces 64.3 per cent. of the total production of the district, and 18 per cent. of the national production. For xyloid lignite the Florence district is followed by that of Rome, with the following production :

Year	Metric tons	Value per ton	Total value
		Lire	Lire
1929	168,882	42.40	7,154,632
1928	177,644	46.47	8,255,500
Decrease in 1929	8,762		1,100,868

The production of lignite in Umbria (xyloid lignite), which is the most important centre of the district, was as follows :

Year	Metric tons	Value per ton	Total value
		Lire	Lire
1929	167,685	42.44	7,116,328
1928	176,410	46.55	8,212,310
Decrease in 1929	8,725		1,095,982

The productive capacity of the principal Umbrian mines (basins of Bevagna, Torgiano, Morgnano and Dunarobba, Piediluco, etc.) may be estimated at about 116,000 tons. Practically all this lignite is used as fuel without transformation.

Concerning the consumption by the mines and the supply of fuel to the workers, the following information is available for Umbria and Valdarno.

In principle it is customary for the persons employed at the lignite mines to receive a free supply of fuel, which they transport for their own benefit to their homes ; these usually lie near the mines. In Umbria the quantity of lignite so supplied is not limited, and the workers may take as much as they like, paying 50 per cent. of the normal price at the pithead. At Poggio d'Avane (Arezzo) in Valdarno they are entitled to 20 tons of fuel a year, but usually they take up to 40 and even 50 tons at a price of 30 lire per ton. The workers' consumption of lignite may be estimated to average 1 per cent. of the total production of the mine.

Work in the lignite mines in the basins mentioned is paid at piece rates. The workers spend 8 hours in the mine and do not leave before the 8 hours are over, even if they have been able to extract enough for a good or average day's pay in less time.

Sometimes there is a general foreman for a particular zone, who gives out the work in the different workplaces at piece rates on his own

account. No deductions are made from this contract price for the cost of transport from the inside to the outside of the mine, or for repairs, the supply of electricity (for traction and lighting), timbering, etc. The workers have only to provide a lamp for their personal use where electric lighting has not been installed.

In the bituminous lignite mines of Verona and Vicenza (Padua district : Motofaggiani, Pulli, etc., mines), the work of hewing and transport is also paid at piece rates, while ordinary repair work, drainage, timbering, etc., is paid by the day. According to the agreement of June 1927 for the Pulli mine — the most important mine in the basin — the hours of work are fixed at 48 a week with 8-hour shifts. The piece rate varies from 32 to 45 lire per ton. Labourers and workers employed on drainage and timbering are paid by the day, receiving an increase of 20 per cent. on their wages for overtime if worked during the day, and 50 per cent. if worked during the night. Several changes have been made in this agreement, but the minima have not been touched.

The production of Liburnian coal in the Trieste (Cave auremiane) and Arsa (Carpano-Vines) basins and of Triassic coal and hard coal in the Upper Tagliamento (Monte Dobbis, Cludinico, Alpe Corona) basin, was as follows :

Variety and year	Metric tons	Value per ton	Total value
		Lire	Lire
Liburnian coal :			
1928	202,433	100.00	20,243,300
1929	113,082	105.00	11,873,610
Increase in 1929	89,351		8,369,690
Triassic coal, hard coal [1] :			
1929	6,683	85.00	568,055
1928	4,363	95.00	414,485
Increase in 1929	2,320		153,570

[1] Some of the coal in these basins (Alpe Corona) resembles anthracite (Carboniferous). The rest (Upper Triassic), owing to its low carbon content, low calorific value, and high ash content, is classed with bituminous lignite. True hard coal, besides differing substantially from this fuel owing to the above-mentioned characteristics, belongs to an older geological period (Permian-Carboniferous).

In a general way, the labour conditions in these mines are similar to those in the Verona-Vicenza basin. In a few cases (Cave di Predil, Province of Udine, in 1928) special agreements on working conditions have been concluded, fixing a 48-hour week, rates of wages varying with the cost-of-living index number, and overtime rates. Piece work is allowed. The workers are given an annual holiday of six days, in addition to the ordinary civil and religious holidays.

In the Arsa basin in the Province of Pola, the agreement of 1928, in force in 1929, fixes a 48-hour week and allows piece work and holidays with pay. Each worker with a family is entitled to a truck-load of coal (nuts) once a quarter for 50 lire, or else an allowance of 0.80 lira per day. For other workers, the allowance is 0.40 lira.

In a general way, without going into detail, it may be observed that most of the workers belong to families that own small rural holdings, and work in the mine when they are not busy with heavy seasonal work in the fields. During the rest of the year the field work is done by women and the older men. This makes it difficult to find skilled labour, but on the other hand it tends to act as a counterweight if there is a surplus of unskilled labour.

Netherlands

Natural Conditions

The only lignite mine in the Netherlands, the " Carisborg " mine, is in the commune of Heerlen, in the centre of the Dutch coal-mining industry. The result of this particular situation is that competition with hard coal is felt much more than in any other lignite field, and that the working expenses are unfavourably affected by the high standard of living and rates of wages in the Dutch coalfield.

The unfavourable geographical situation of this lignite mine in relation to other parts of the Netherlands makes it very difficult for it to compete with the Westphalian and Rhenish lignite fields, which are much better placed from this point of view. In addition, the immediate neighbourhood of these fields makes it practically impossible to find a market in Germany. The situation is slightly more favourable with regard to Belgium and France.

The transport of the briquettes is nearly all by railway, for the different ports of the Meuse and the Rhine that might be suitable are not equipped for the transhipment of lignite briquettes. Moreover, the cost of transport by rail to these ports is too high.

The Dutch lignite belongs to the Tertiary period. A seam of from 4 to 8 metres thick, covered by a layer of sand of an average thickness of 20 metres, can be worked.

Technical Conditions

The lignite extracted varies in colour from dark brown to black. Its water content is 58 per cent. and ash content 7 per cent. Its calorific value is about 1,800 calories.

The workings are open. Both the overlying ground and the lignite are removed mechanically by excavators and transported in trucks drawn by steam locomotives. The ground removed is used in turn to fill in the old workings.

The lignite has to be carefully freed from the sand and clay that are intercalated here and there in the lignite seams.

The work done per shift in stripping the seam is from 30 to 35 cubic metres. The lignite extracted is about 20 tons per shift. Per day, on an average, about 2,000 cubic metres of covering ground are removed and 700 tons of crude lignite extracted.

Economic Conditions

The production in thousands of tons is shown in the following table :

Year	Gross production	Consumption by the mine	Manufacture of briquettes
1926	211	1	210
1927	201	1	200
1928	197	1	196
1929	156	1	155

Practically all the crude lignite is used for the manufacture of briquettes. The sales of lignite briquettes in thousands of tons were as follows :

Year	In the Netherlands	Abroad
1926	49	16
1927	46	16
1928	35	13
1929	31	28

For lack of markets manufacture was stopped from 1 July to 1 October 1930. The prospects are not very encouraging, and at present it is impossible to dispose of the total production.

To sum up, in view of (1) the unfavourable geographical situation, which renders selling difficult, (2) the low calorific value, (3) the unfavourable geological conditions of the deposit (small extent, depth of the overlying ground, thinness of the seam of lignite), (4) the influence of atmospheric conditions on most of the processes, the Dutch lignite finds it difficult to compete with other kinds of coal.

Poland

Natural Conditions

The lignite seams in Poland are in the following districts :

(1) In an area of 60-70 sq. km. in the Warta and Czarna Przemsza river basins in the neighbourhood of Zawiercie (province of Piotrków), along the north-east frontier of the Polish hard-coal field.

(2) Near Ostrowiec and Starachowice (province of Kielce).

(3) In Poznan and Pomerania (provinces of Poznan and Pomorze).

(4) In the neighbourhood of Konin (province of Lódź).

(5) In the neighbourhood of Lódź and Zdunska Wola (province of Lódź).

(6) In the province of Wilno.

(7) In the neighbourhood of Wloclawek and Dobrzyn (province of Warsaw).

(8) In Upper Silesia in the neighbourhood of Knurów (province of Silesia).

(9) In the Sub-Carpathian region near Kolomyja (province of Stanislawów).

(10) In Podolia and Wolhynia in the districts of Zolkiew and Zloczów near Krzemieniec (provinces of Lwów, Tarnopol and Wolyn).

The lignite deposits mentioned under (1) and (2) belong to the Upper Triassic, and the rest to the Tertiary formation.

The deposits are not deep. In several parts of the country, for instance in Poznan, there are from three to eight seams of lignite, constituting a group 9 metres thick. In the other regions the total thickness of the seams is less. The thickness of each seam varies from 0.8 to 2.5 metres.

Technical Conditions

The lignite of Triassic origin is black, bituminous, and resembles hard coal. It contains a high proportion of ash, sulphur, and nitrogen; before drying, its calorific value is 3,800 to 5,000 calories; after drying, 4,700 to 6,000 calories. The water content is about 20 per cent.

The lignite of Tertiary origin contains considerable quantities of vegetable matter. The Poznan lignite in the dry state has a calorific value of about 4,500 calories and contains an insignificant quantity of sulphur, 0.3 to 0.4 per cent. and little ash, 4.5 to 8 per cent. The calorific value of the Pomeranian lignite is lower than that of the Poznan lignite. The proportion of volatile substances is 20 per cent.

All the lignite workings are underground. The difficulties are mostly due to the weakness of the covering strata, and in certain districts (Sub-Carpathian region) to the abundance of water.

The extraction is effected by blasting and the transport by machinery worked by steam or electricity.

The output per worker is 875 kg. per shift, and 235,195 kg. per year.

Economic Conditions

The production in 1929 was 71,069 tons, of which 3,726 tons were consumed by the mines, and the rest was sold in Poland itself. Lignite is not exported from Poland. It is not used for the manufacture of briquettes.

The undeveloped condition of the lignite industry in Poland is due to the abundance of hard coal, which is a better quality fuel. For this reason the working of the lignite deposits is of purely local importance.

Rumania

Rumania has deposits of anthracite, hard coal, and lignite. The anthracite deposits are not large, and have not been worked since 1924. Under the name of hard coal, deposits of coals with a calorific value of 5,000 to 7,600 calories are worked in Transylvania and the

Banat, belonging not only to the Carboniferous, but also to the Permian, Liassic, and Cretaceous formations. As regards lignite, the mining statistics distinguish between brown coal (*carbune brun*) and lignite proper (*lignit*).

Brown Coal. The term "brown coal" covers fuel of the Tertiary period, with a calorific value of 4,000 to 7,500 calories, which, when finely powdered, does not colour a potash solution. This coal can be converted into coke, which is, however, small and friable and has not the necessary resistance for use in metallurgy.

Nearly all this coal is found on the concave side of the Carpathians, in Transylvania and the Banat. It belongs to the four following geological formations : Oligocene, Lower Mediterranean, Upper Mediterranean, and Meotic.

(1) The Oligocene deposits are situated to the north-west of Cluj (Transylvania) in the valleys of the Almash, the Agris, and the Somes. The seams are hardly more than a metre thick. The calorific value of the fuel varies, according to the mine, from 4,300 to 5,800 calories.

(2) The Lower Mediterranean deposit, the principal one in Rumania, lies in the valley of the Jiu (Transylvania) ; it is 48 km. long and 2 to 9 km. wide. This field has twenty-two seams, the chief of which is 10 to 30 metres thick ; five others are over 2 metres thick. The water and ash content is low ; the calorific value ranges from nearly 6,000 calories to over 7,000 calories. This coal is chiefly used by the railways. It is suitable for the manufacture of coke (in particular that of Lupeni) and briquettes. The field produces about 1,800,000 tons a year.

(3) The Upper Mediterranean coal is found in a deposit in the valley of the White Crisis in the region of Brad (Transylvania) and several deposits in the Banat, of which the chief are those in the Almas plain (3,900 to 4,500 calories) and Mehadia (3,500 to 4,150 calories).

(4) The Meotic coal is worked in the Comanesti (Moldavia) basin, which has six seams varying in thickness from 0.50 to 2.50 metres. The calorific value of this coal is 5,530 calories.

The annual production of brown coal is about 2,200,000 tons.

Lignite. Lignite proper is found chiefly on the south and south-east side of the Carpathians. It belongs to the Pliocene period ; the different varieties are distinguished according to their position in this formation : Meotic, Dacian, Levantine.

(1) The Meotic lignite is found in the Capeni-Baraolt (Transylvania) basin. The deposit has four seams. The thickness of the upper seam is 8 metres ; in the mountain zone it is as much as 17 metres, counting the sterile strata it contains. The lignite extracted has a calorific value of 4,000 to 5,000 calories.

(2) The Dacian lignite forms seven basins in the Old Kingdom : the Méhédintzi and Jiu basins (thickness of the seam, 2.50 metres) ; the Courtea de Arges basin (thickness of the seam, 1 metre) ; the Department of Muscel basin (average thickness, 2.50 metres ; calorific value, 3,470 to 4,250 calories) ; the Aninoasa basin (1.80 metres ; 4,970

calories); the Doicesti-Dambovitza basin (3 to 5 metres); and the Ojasca basin (seam containing other strata giving a total thickness of lignite of 1.30 metres; 4,160 calories); and one in Transylvania, the Borsec basin (2 metres; 4,700 to 5,200 calories).

(3) The Levantine lignite forms several deposits, the chief of which is that of Prealea in the valley of the Zmeuris, where there is a seam 2 metres thick. The calorific value of this lignite is low (2,000 calories).

Finally, lignite of inferior quality (2,500 to 3,000 calories, much water, 25 per cent. ash) is found in Bukovina at Carapciu, and in Bessarabia at Imputsita, north of Lake Ialpug.

Most of the brown coal and lignite workings are underground and the seams are reached by shafts or adits. The total production during the last few years is shown in the following table.

TOTAL PRODUCTION OF LIGNITE IN RUMANIA, 1926-1929

(Metric tons)

Year	Brown coal			Lignite of 3,000-4,000 calories [4]	Total
	5,047-7,534 calories [1]	5,000-6,000 calories [2]	4,000-5,000 calories [3]		
1926	1,797,163	149,543	235,349	549,307	2,731,362
1927	1,840,861	181,725	246,076	581,349	2,850,011
1928	1,730,779	261,043	130,622	507,232	2,629,676
1929	1,741,920	361,559	141,338	430,263	2,675,080

[1] Petrosani region, Valley of the Jiu.
[2] Transylvania and the Department of Bacau.
[3] Transylvania and the Banat.
[4] The Banat and the Old Kingdom.

As the production of hard coal in 1929 was 370,947 tons, lignite (brown coal and lignite proper) represented 87.2 per cent. of the solid mineral fuel extracted in Rumania.

The quantity of lignite (all kinds) extracted in 1929 in each of the historical divisions of Rumania was as follows:

Region	Tons
Old Kingdom	538,205
Transylvania	2,120,405
Banat	16,470
Whole country	2,675,080

Yugoslavia

From the administrative point of view, the lignite mines of Yugoslavia are grouped in five mineralogical districts; those of Belgrade,

Serajevo, Zagreb, Ljubljana, and Split, which roughly correspond to Serbia, Bosnia-Herzegovina, Croatia, Slovenia, and Dalmatia respectively.

Belgrade District (Serbia)

In this District there are seven mines, three of them being in the Danube Banovin, three in the Morava Banovin, and one in the Vardar Banovin.

Two of these mines (Kostolac and Klenovnik) are near the Danube. The rest, except the Ivanovo mine, are near railways or are connected with them by industrial lines or cableways.

The following table shows the principal features of the deposits worked and the lignite extracted.

PRINCIPAL FEATURES OF THE LIGNITE WORKED AND EXTRACTED IN THE BELGRADE DISTRICT

Mine	Geographical situation of the deposit (Banovin)	Geological characteristics of the deposit		Properties of the lignite				Annual production (metric tons)
		Age	Thickness of seam or seams (metres)	Colour	Water content (per cent.)	Ash content (per cent.)	Calorific value (calories)	
Kostolac	Danube	Upper Tertiary	15	Yellow	40-45	12-15	2,400-2,800	110,000
Klenovnik	Danube	Upper Tertiary	4-12	Brown	40-45	12-15	2,400-2,800	45,000
Nada-Američ	Danube	Pliocene	1.50	Dark brown	45.1	17	2,007	1,000
Zvezdan	Morava	Upper Tertiary	—	Dark brown	35	15-18	2,800-3,500	7,500
Ivanovo	Morava	Upper Tertiary	2	Dark brown	30-35	10-14	3,000-3,600	4,000-5,000
Jeklov Rudnik	Morava	Upper Tertiary	2	Brown	40	12	2,500	3,000
Kosovo	Vardar	Oligocene	Up to 28	Light brown	40	7-12	2,500-2,800	15,000

It may be added that all these lignites are compact but crack easily on exposure to the air. The workings are underground, and the deposits are usually reached by adits. All the hewing is by hand. The annual production is 186,000 tons. The fuel is consumed in the crude state in the neighbourhood of the mine, production being as a rule entirely for local needs.

Sarajevo District (Bosnia-Herzegovina)

In Bosnia-Herzegovina a distinction is made between three kinds of mineral fuel according to their chemical, physical and mineralogical properties: (*a*) hard coal, (*b*) brown coal, (*c*) lignite.

Hard coal properly so called of the Carboniferous age is not to be found, but certain coals of the Lower Eocene, owing to their chemical properties and their high calorific value of over 6,000 calories, are classed as hard coal.

In this survey lignite is taken to mean coal of the Pliocene age of pronounced ligneous structure, and brown coal to mean all other Tertiary coal.

Natural Conditions

In the territory of Bosnia-Herzegovina, brown coal is worked in the following mines :

Central Bosnian basin (Zenica-Sarajevo) (Zenica, Kakanj, and Breza),
Banja Luka basin (Banja Luka, Lauś),
Kotor-Varoš basin (Maslovare),
Ugljevik-Priboj basin (Ugljevik),
Kamengrad-Sanski Most basin (Suhača),
Livno basin (Tušnica near Livno),
Mostar basin (Mostar),
Lješljani-Cernica basin (near Dobrljin),
Rogatica basin (Kikavica near Rogatica),
Drvar basin (Drvar),
Teslić basin (Teslić).

Lignite is worked in the Tuzla, Kreka, and Bukinje basins.

All the above basins, except that of Livno, are situated in river valleys where there are at present means of communication which have contributed very much to the opening of the mines. Along these lines of communication various industries have sprung up in the neighbourhood of the mines, which, together with the railways, are the principal consumers of brown coal.

The mines that are not directly situated on the main railway are usually connected with it by industrial lines.

According to their geological age and stratigraphical position all the brown-coal fields mentioned belong to the Oligocene and Miocene formations of the Tertiary period.

Most of the present workings in the mines mentioned above are near outcrops of the deposits, and are not more than 275 metres deep. At first the working was effected by way of cuttings, but by degrees the development of the mines led to underground working. At present the average depth of the workings in most mines is between 60 and 150 metres, except in the Ugljevik mine, where the workings are open.

The thickness of the brown-coal seams varies from 1.5 to 8 metres, while in the Mostar basin it is as much as 16 metres. The whole of the

seams are not pure lignite, but they include strata of sterile ground, representing 20 to 40 per cent. of the total thickness, and in exceptional cases up to 50 per cent.

The deposits of lignite in the Tuzla basin are 12 to 19 metres thick, but intercalated strata of clay reduce this thickness by 10 to 15 per cent.

Technical Conditions

The brown coal worked in the above mines has the following properties :

It is brown in colour, resinous and shiny, and very hard, with a conchoidal fracture. (These characteristics are especially strongly marked in the Central Bosnian basin, which yields 50 per cent. of the total production of that district.) The coke content varies from 40 to 60 per cent., and the content of valatile substances from 30 to 45 per cent. The ash content varies with the place of origin and also with the size of the lumps obtained by mechanical preparation ; thus the larger lumps of the brown coal from the Central Bosnian basin contain 12 to 18 per cent. of ash, and the smaller lumps 15 to 20 per cent. In the other basins the ash content differs from the above figures by 2 or 3 per cent. The calorific value varies from 4,000 to 6,000 calories, averaging 4,500 calories. The water content is up to 4 per cent., and in exceptional cases, for certain mines of inferior qualify, 5 per cent.

The lignite worked in the Pliocene deposits near Tuzla Kreka and Bukinje has the following properties :

It is dark in colour, ligneous in structure, fibrous, and breaks up into large pieces. It contains 36 to 48 per cent. of solid matter (coke) and 32 to 38 per cent. of volatile substances. The ash content is up to 10 and even 25 per cent. The calorific value varies from 3,200 to 4,500 calories, the water content is 18 to 30 per cent., and sulphur content 0.5 to 1.3 per cent.

The working is chiefly underground, by shafts or adits according to the inclination of the deposits, except in the Ugljevik basin, where open working predominates. The tectonic displacements which have produced faults in the deposits, and the presence of intercalated strata of clay, have led to difficulties in working and in the installation of machinery. For this reason most of the working is by hand, except in certain mines, where pneumatic drills are used. The methods of hewing depend on the nature of the ground and the thickness of the seam, but the system is always that of pillar-and-stall working, except in the Mostar mine and to some extent at Zenica and Kreka, where hydraulic packing is used.

The deposits in the Central Bosnian mines and the Mostar mine give off methane (CH_4) as the mine deepens, particularly in the neighbourhood of faults, but this gas does not cause serious difficulties for the working of the mine.

The output per worker per shift of 8 hours is 3 to 4 tons, and in some mines up to 6 tons; the average output for all miners is between 1 and 1.5 tons. The average output per shift of 8 hours for all workers employed in the mines was 0.698 tons in 1929 and 0.749 tons in the first half of 1930. The average annual output per worker was 197.20 tons.

Economic Conditions

In 1929 the total production of hard coal was 37,906 tons, of brown coal 908,463 tons, and of lignite 387,518 tons. During the first half of 1930 the production of hard coal was 24,958 tons, of brown coal 525,091 tons, and of lignite 170,028 tons.

In all the mines the crude product undergoes various processes before use. In those of the Central Bosnian basin the coal is washed, thus being freed from clay, and is then sorted according to the needs of the market. In the other mines the sorting is done in the dry state and the coal is classed according to the indications given by consumers. The coalfields mentioned have no plant for briquette manufacture or carbonisation, but this installation is at present under consideration.

In Bosnia and Herzegovina the coal is consumed chiefly by the railways and industry (30 per cent. and 40 per cent. respectively). The rest is used for heating and for the needs of the mines themselves.

This coal is not exported owing to its low calorific value and the distance it has to be transported. On the other hand the better qualities of English, German, Czech, and Russian coal are sold on the Yugoslav market, particularly along the coast and in the Danube region.

The consumption of brown coal is on the whole permanent and regular, except for a temporary falling off in 1929-1930 due to a mild winter. Lignite, which is not so much used by the railways and industry, does not find so ready a sale. The result is that the lignite mines hardly work more than fifteen to eighteen days a month.

Zagreb District (Croatia)

The Zagreb district (Save Banovin) has fourteen lignite mines; the majority—about ten—are in the Varaždin district north of the Save, and the rest in the valley of this river. Nearly all these mines are near railways, with which they are connected by private lines.

All the deposits worked belong to the Lower Pliocene. The lignite extracted is compact but cracks easily on exposure to the air. Its colour varies from brown to dark brown. In all the mines the working is underground, the deposits usually being reached by adits. Hewing is by hand, by the pillar-and-stall method of working. The following table gives the principal features of each mine and its product.

PRINCIPAL FEATURES OF THE LIGNITE WORKED AND EXTRACTED IN THE ZAGREB DISTRICT

Mine	Thickness of the seam or seams (metres)	Properties of the lignite			Output per worker per day (kg.)	Annual production (metric tons)
		Water content [1] (per cent.)	Ash content (per cent.)	Calorific value [1] (calories)		
Ladanje Dolnje	1.30	20	9.60	3,560	610	35,000
Ivanec	—	34	6.7	3,760	570	70,000
Konjščina	6	15	12.20	2,800	400	50,000
Maretić	4	17	10	3,860	280	1,000
Pitomaća	—	15	8	4,480	470	38,500
Glogovac	3	15	12	3,820	450	24,600
Lepavina	0.80-2.50	14	11	4,490	310	38,500
Gojlo	—	14	7.70	4,000	450	5,500
Poklonica	—	24	12	4,700	320	47,000
Bregi	Up to 1.30	14	12	4,600	380	20,000
Poščeno	4	17	10	3,620	510	21,500
Donjara	1.20	14	12	4,300	320	2,500
Sutinsko	—	18	12	3,370	540	5,000
Rešetari	1.60	18	10	3,870	440	200

[1] These data relate to lignite dried by air. When the lignite leaves the mine its water content varies from 35 to 50 per cent. and its calorific value from 2,000 to 3,000 calories.

The annual production of lignite in this district is about 360,000 tons. The lignite is consumed in the crude state in the neighbourhood of the mines. In the present situation of the industry, production cannot be increased owing to the impossibility of finding a market.

Ljubljana District (Slovenia)

The Ljubljana district (Drave Banovin) has two lignite mines, the State mine of "Velenje", and the "Globoko" mine near Brežica.

The Velenje mine in the valley of the Sales is served by the station of Velenje on the Celje-Dravograd railway. The deposit belongs to the Pliocene formation and forms a pocket about 7 km. long and 3.5 km. wide. The thickness of the seam is from 10 to 100 metres.

The lignite varies in colour from brown to dark brown. It is compact, but on exposure to the air cracks to a depth of 1 cm. It contains 35 to 40 per cent. of water, 9 to 10 per cent. of ash, and its calorific value is from 2,500 to 3,000 calories.

The working is underground. The mine is reached by three shafts, 156, 90, and 190 metres deep, the first being used for extracting the lignite and the other two for ventilation. Hewing used to be by hand, but for some time machinery has also been used. The lignite is removed by double-deck cages. The output per worker per shift was from about 1 to 1.38 tons before the introduction of mechanical cutting.

The use of this process is very recent, so that sufficient data for calculating the present output are not available.

The total production in 1929 was 168,419 tons.

The lignite is used in the crude state in the district itself. So far, attempts at distillation have not yielded satisfactory results. As in most of the other basins, production is limited to meeting local needs.

The lignite of the Globoko mine is very similar to that of Velenje. It has 45 per cent. of water and 4.55 to 8.50 per cent. of ash, and its calorific value varies from 2,000 to 3,000 calories. Owing to the present depression, the mine has been closed down.

Split District (Dalmatia)

The Split district has one lignite mine near Sinj on the railway line from Sinj to Split.

The deposit belongs to the Upper Neocene. The thickness of the seam varies from 10 to 15 metres.

The lignite extracted is compact and dark brown in colour. The water content is 34.70 per cent, the ash content 8.61 per cent., and the calorific value 3,000 calories. The working are partly open and partly underground reached by a cross-cut in the hillside. The hewing is done by hand. The annual production is about a thousand tons.

In Yugoslavia the only unemployment among miners is that due to brief interruptions of the work (seven or eight days a month). It should be added that owing to the fact that the workers are not really miners by profession, so to speak, but are also engaged in agriculture, they have other resources than their wages.