COAL DEPOSITS IN IRAN*

Geologically, Iran is situated along an orogenic axis which begins at the Bay of Biscay, passes through the Alps, continues towards the east and after crossing Iran and Afghanistan joins the Indonesian archipelago by way of the Himalayas. Thus, the western mountains of Iran are joined to the Carpathians and the eastern ones to the Hindu Kush ranges. Along this orogenic axis the highest mountains in the World are to be found. Most of the metamorphic transformations and movements of the earth, especially those of the early and recent Tertiary periods, took place before their formation, the earliest movement affecting this region having accured during the system formation of the Cambrian time.[1]

Studies carried out by a number of geologists have raised the idea that older strata dating back to the Archian epoch exist in the area.Bedrocks related to the Cambrian period have frequently been observed. It is said that during these periods a large section of Iran was covered by water which dried up only after the Tertiary formation period when the land emerged and volcanic eruptions caused large amounts of magmatic matters to pile up over the sedimentary layers. Rocks of Silurian[2] origin have been seen in shale sediments, sandstone and quartzite beds in Bandar Abbas and the South West region. The system of the Devonian period[3] is very irregular and bears no resemblance to older layers of the Paleozoic era. During the mid-Devonian period a large portion of Iran, excepting the west, was once again submerged and the marine sedimentations of this period gradually turned into carboniferous strata [4] extending all over the country. These strata are composed of multi-layer calcareous shales, clay and coarse conglomerates.

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* By the Research Group on the Heavy Industries.

1. 70 million years.

2.130 million years.

3. 50 million years.

4. 85 million years.

Although no traces of rocks of the Permian period have been found in Iran, the thin limestone beds of the north-west and south-east are attributed to this era. Thick marine calcareous beds have, however, remained from the Triassic[1] period and it is expected that fossil plants will be found in the Alborz region. Comparatively large amounts of Jurassic bedrocks[2] are scattered throughout the country. There is little doubt that, in the first epoch of the Jurassic period, the Fossiliferous Liassic period, some sections of the country consisted of dry lands and sand dunes reaching a height of 100 metres. It is during this epoch that Iran's coal deposits were formed. These coal-bearing Liassic strata are not only found in Iran, but also extend far into the neighbouring territories of Afghanistan and Pakistan. Limestone beds related to the first epoch of the Jurassic period, which have been found along the Persian Gulf littorals, are indicative of the fact that the entire south of Iran was covered by water. During the recent Jurassic epoch, the sea advanced towards the north and gradually submerged the entire country. It appears that this sea was a part of the Pacific Ocean out of which the Alps and the Himalayas emerged. Fossiliferous liassic systems attain a thickness of 4,000 metres, but seem to become thinner towards the south-west.

Layers of the Cretaceous period,[3] also reaching 4,000 metres thick in places, have spread unevenly over the Jurassic beds. The constituent materials of these systems are mainly a mixture of sandstones, clay and coarse conglomerates inside which are scattered impurities like marls and calcareous particles. Unique formations of green beds containing volcanic tuff, quite thick in places, are occasionally observed.

During the early epoch of the Tertiary period, when the sea withdrew, the central Iranian plateau emerged and lake basins were left behind. Massive orogenic movements occured resulting in the emergence of the land from beneath the sea. In the Miocene[4] and Eocene[5] epochs the Alborz ranges were still submerged, but the southern mountain chains had emerged. It was then, in the Miocene epoch, that, as a result of strong earth tremours, the present day contours of Iran were shaped. Now, mountain ranges extend from the west

1. 35 million years.
2. 35 million years.
3. 65 million years.
4. 12 million years.
5. 20 million years.

of the country in two directions. The Alborz constitute the northern mountain belt of Iran and the Zagros surround a major part of central Iran.

Systems of the Pliocene[1] epoch in the north-west of Iran consist of layers of breccia, coarse conglomerates, sandstones, and clay whose formation dates back to the Continental era, spreading over strata of Eocene and Miocene epochs. It is evident that volcanic activities have recurred over a long period of time and that effusive materials like tuff, lava, and magmatic intrusive materials such as igneous dykes, sills and batholiths have caused the formation of specific mineral seams and ore-bodies. With the passage of time strong diastrophisms took place which, together with overthrusts,anticlines, synclines and depressions brought about tectonic changes considered very important from the standpoint of geological economy and the techniques of mining exploration and exploitation.

Coal deposits in Iran have been studied by three different groups. The first group, which consisted of Iranian and foreign engineers, carried out general and mineralogical surveys, in particular visiting several mines and studying the condition of probable coal deposits. A second group were assigned by the Government in 1929 and 1930 to conduct a quick survey of Iranian mines to find out if there were the necessary raw materials for the establishment of a steel mill in the country. The work of this group was unfortunately interrupted by World War II. The third group consisted of engineers and mine explorers who, in 1957, were given the task of completing the latter project. The finding of this group is that all Iran's bituminous coals deposits are related to the Liassic period and the first Rhaetic system whose bedrock formations cover a major part of the country.The main coal bearing areas of Iran are divided into five districts.

1.The North Alborz District.

2.The South Alborz District.

3.The Khorasan District.

4.The Kerman District.

5.The Central District.

The common features of all these districts are their geological epoch, the ground formation and the constituents of their rocks (sandstones and shale on a mixture of the two containing bands and nodules of iron and quart-

1. 6 million years.

zite) and the abundance of fossil plants, the coal bearing strata frequently including lichen. A major portion of the rocks of the Liassic period consist of shale and relatively fine sandstones but the existence of intercalcations like coarse conglomerates, compressed sandstones, and quartzite beds has protected the land from heavy erosion. In superficial geological inspections, these groups usually serve as guide or key beds for detecting formations.

PART I. COAL DEPOSITS IN THE ALBORZ DISTRICT

The Alborz mountain chains, which rise to the sky like a huge wall in the north of Iran, have been fully explored from a geological point of view. Some geologists have come to the conclusion that a major part of Iran's coal deposits are to be found in this region. Another group are of the opinion that beds of calcareous shale extend along the edge of all the mountains and that these have produced outcrops in certain regions. This latter group also believe that coal-bearing layers stretch far below the depression of the Caspian Sea. If a geological map were to be drawn on the basis of this assumption it would show that the reserves of the Alborz district, regardless of their mining possibilities, are far more than had been, or can be, estimated from the conspicuous calcareous layers. The average maximum thickness of the coal seams in this district amounts to 1.5 metres. Some experts say that the coal of this district has coking qualities whilst others think that, because of its varying sulphur and ash content, it does not.

In the following pages we will outline in some detail the regions which are considered to bear good quality coal or in which further studies have been carried out, and we will enumerate various coal fields in the north of Iran giving the results of experiments as to the type of coal, the amount of probable,possible and proven reserves in each field, its geographical situation, and its distance from main roads and major cities. We do not claim that the figures and views we present constitute the best documentation of facts on the subject, but we do believe that they are one of the most comprehensive descriptions of the Iranian deposits ever compiled.

Coal Fields in the North of Iran

If we take an imaginary line starting from Torbat-Jam (in the east of Khorassan), extending through Garmsar and Ghom, continuing on to Bijar and ending in Saghez (Kurdestan), then all the coal fields situated above this line are to be considered as North Iranian coal fields. So far, a total of about 70 coal mining permits have been issued for this region. Some of the mines are exploited just to meet local needs, others are good commercial mines, whilst a few have shut down.

In order to see that the extraction of mineral deposits in Iran is carried out correctly, the Government some time ago established an agency connected to the Plan Organization and known as the General Company for Iranian Mines and Metal Foundries. This company has a monopoly of the exploitation of most of the mines thought to have considerable reserves, including those of the coal fields of Shemshak, Gejereh, Elika, Galandrood, Zirab, Cheshmeh Gol and Golbanoo. To give our readers a fuller picture of these mines we will describe the location and characteristics of each separately.

While exploring and tracing the coal seams in these fields, the mining company came across some good quality coals which they regarded as suitable for use in the steel industry. The coal reserves of these mine fields were, therefore surveyed in co-operation with advisors and engineers of the Iranian Steel Mill Organization. However, in view of numerous extraction problems, some had to be shut down. Some other coal fields have been surveyed partly by supervising engineers of the Ministry of Economy and partly by operating engineers.

The North Iranian coal fields are not evenly distributed throughout the region. In Azarbayjan only a few small and unimportant mine fields have been observed around the cities of Tabriz and Maragheh, but more coal seams are found closer to Tehran. The most important of these stretches from Abyek to the vicinity of Gachsar but there are also numerous seams approaching the surface in a large area called Roodbar of Ghasran. These seams reappear in several places near Lavasanat and Larijan but their continuation appears to have been lost from there up to the region of Damghan and Shahrood.

A similar seam has been found on the northern slopes of the Alborz mountains, forming several coal fields extending from Chaloos up to the neighbourhood of Shahpasand.These include the coal fields of Galandrood,Zirab and Gheshlagh of Gorgan. The seam is discontinued after this area but emerges once again in the district of Torbat Jam and Sarakhs where it forms relatively large fields.

The North Iranian coal mines with permission to operate at the present time are listed in the following table:

Name of Coal Field	Distance by road
1. Saridagh, Tabriz	2 kilometres south-east of Tabriz
2. Chowghan, Maragheh	56 kilometres north of Maragheh
3. Guydargh, Maragheh	36 kilometres south-west of Maragheh
4. Khormazard, Maragheh	9 kilometres north-west of Maragheh
5. Amir Gheslagh, Maragheh	15 kilometres north of Maragheh
6. Shirgi & Sagatloo	20 to 30 kilometres south of Khoy
7. Azadolya, Zanjan	19.5 kilometres south-east of Zanjan
8. Looshan	88 kilometres from Ghazvin
9. Kaman, Ghazvin	54 kilometres north of Ghazvin
10. Ardebilak & Neshamzehbar, Ghazvin	—
11. Lazjerd & Ghahpayeh	25 kilometres north-east of Ghazvin
12. Ziaran, Ghazvin	65 kilometres east of Ghazvin
13. Abyek	54 kilometres east of Ghazvin
14. Hiu	55 to 60 kilometres west of Karaj
15. Fashand, Karaj	42 kilometres from Karaj
16. Sangkhor	40 kilometres from Karaj
17. Ardehe	38 kilometres from Karaj
18. Karaj	—
19. Gajereh	124 kilometres from Tehran
20. Nessae Olya	72 kilometres north of Karaj
21. Nessae Gajereh	126 kilometres north of Tehran
22. Elika	140 kilometres north of Tehran
23. Azadbar, Gachsar	88 kilometres north of Karaj
24. Hasanak, Malekfaliz Valley	63 kilometres north of Karaj
25. Gholghole Cheshmeh	66 kilometres north of Tehran
26. Shemshak	58 kilometres from Tehran
27. Lalan	62 kilometres from Tehran
28. Rooteh	69 kilometres from Tehran
29. Cheshmesar	61 kilometres from Tehran
30. Hashtpar, Roodbar	65 kilometres from Tehran
31. Daryuk & Shidkosh	63 kilometres from Tehran
32. Ardineh, Roodbar	—
33. Golchal, Garmabdar	61 kilometres from Tehran
34. Maryamkhas & Moradchal	67 kilometres from Tehran

35. Khatoon Bargah	65 kilometres from Tehran
36. Yunezar & Divasialar	——
37. Golrood, Lavasanat	65 kilometres from Tehran
38. Shahbolaghi	82 kilometres from Tehran
39. Ab Ask	——
40. Imamzadeh Hashem, Larijan	80 kilometres from Tehran
41. Gandaloo, Larijan	——
42. Bazm, Larijan	——
43. Garnav & Melard	——
44. Shahandasht, Larijan	——
45. Firoozkooh	——
46. Galandrood	256 kilometres from Tehran,65 kms. west of Amol
47. Korrehsang	——
48. Zirab	39 kilometres south of Shahi
49. Gheshlagh, Gorgan	113.5 kilometres from Gorgan and 30 kms. south of Shahpasand
50. Jam	64 kilometres from Semnan
51. Larestan	——
52. Hapan & Salboreh, Damghan	40 kilometres north of Damghan
53. Mansoorkooh, Damghan	29 kilometres north-west of Damghan
54. Taloo, Damghan	31 kilometres from Damghan
55. Ahvanoo, Damghan	24 kilometres from Damghan
56. Ahmadabad, Shahrud	——
57. Pasikhan, Shahrud	17 kilometres south west of Shahrud
58. Dehmolla Shahrud	31 kilometres west of Shahrud
59. Tamesh, Shahrud	——
60. Robat Torogh, Mashad	——
61. Darakhte Toot, Mashad	——
62. Aghanj, Mashad	24 kilometres south of Mashad
63. Noghondar & Dowlatabad	——
64. Dorud Estan	20 kilometres west of Cheshme Gole mine
65. Timang	38 kilometres north of Torbat Jam
66. Torbate Jam Mian	144 kilometres east of Mashad
67. Cheshme Gole	36 kilometres north-east of Torbate Jam
68. Kutah Goosh, Fariman	——
69. Agh Darband	140 kilometres east of Mashad
70. Golbanoo	76 kilometres north-east of Torbat Jam

The reserves of a coal field are estimated either from a geological or from a technical standpoint. From the technical standpoint the possibilities of quarrying by mechanical means are considered and, after the technical reserves of the field have been estimated, calculations are made to find out whether or not quarrying the coal would be economical. Two methods are customarily used in order to estimate geological reserves: The"Profile" method and the "Geological Block" method. In the "Profile" method, geological cuttings are taken from adjacent outcrops and, by calculating the special value of the cutting, the reserves of the field are measured. Obviously this method cannot be employed in districts lacking adjacent outcrops. In the "Geological Block" method,the width and depth of the stratum is guessed from the outcrops and, taking into account the geological condition of the mining area, the volume of existing coal is estimated and converted into tons.

The technical reserve of a mining area may be estimated as probable or final. In the first case, probable reserves are estimated by digging opposite trenches. But, when the thickness of the coal seam is found to be sufficient for exploitation, the length of the seam is estimated by digging a trench on one side, making a cautious guess of the other side, and possible reserves are estimated by multiplying the result of this calculation by the approximate depth and length of the seam. The proven reserve can be worked out when all three dimensions, i.e. length, width thickness are distinct. Obviously this computation is possible only when the width and depth of the seam are visible at the end of the tunnels and corridors at the end of the stratum.

For converting volume into weight use has been made of the equation $M=Vd$ in which M is weight, V is volume and d is the density of the coal. The latter varies between I.2 and I.5 depending on the type of coal. The density of various types is as follows:

Brown coal or lignite	1.2
Bituminous coal	1.3
Thin coal	1.35 - 1.4
Anthracite coal	1.5

Coal Fields in Azarbaijan

No rich coal fields are to be found in this province. Just a few seams, which are operated in a primitive way and on a very small scale, have been found in the vicinity of Maragheh, Tabriz and Khoy.

1. The coal mines of Amir Gheshlagh, Maragheh: These mines are situated 15 kilometres north of Maragheh, in a rugged mountainous district. The main seam is, on the average, 60 cms. thick and about 40 cms. deep. Traces of it can be seen up to a distance of 400 metres. Thus, the proven reserve of the field is:

$$400\,m \times 0.6\,m \times 40\,m = 9600\,m^3 = 9600 \times 1.2 = 11{,}520 \text{ tons.}$$

The daily production of these mines is about 3 to 4 tons of coal which is sold at 600-700 rials per ton at the mine head.

2. The coal mines of Choughan, Maragheh: These mines are situated at about 56 kilometres north of Maragheh. The amount of coal extracted is insignificant and the total reserves have been estimated at up to 20,000 tons.

3. The coal mines of Saridagh, Tabriz: These are in the Saridagh mountains, near Baregh village 2 kilometres south of Tabriz on the Tabriz-Ahar road.Non of the seams found so far have yielded rich coal and most are narrow and impure. Three seams, with an average length of 250 metres and an ascertainable depth of 30 metres, have been found. It is possible that further exploration will reveal a greater number containing better quality coal.

4. The coal mines of Shiraki, Sagathe and Khoy: These mines are in three districts.

a) Sudresi, 30 kilometres from Khoy, near Sagathe village.

b) Boyuk Darreh, 20 kilometres from Khoy.

c) Darreh Davood, 21 kilometres from Khoy.

Explorations have not yet been carried out here and it is presumed that no high quality coal is to be found.

Coal Fields around Zanjan

The most important coal-yielding districts around Zanjan are Azadolya and Lushan.

1. The Coal Mines of Azadolya: These are 19.5 kilometres south-east of Zanjan-Bijar road and covering some 18.5 kilometres before reaching the mines. The coal seams are to the east, west and south of Azadolya village. The most important are three seams, traces of which can be found up to a distance of 3 kilometres. However, as yet no measurement of their depth has been carried out and the coal, which is mixed with narrow and impure layers and which has a high sulphur content, is not exploited.

2. *The coal mines of Lushan:* These are 23.5 kilometres from Lushan which is situated at a point 88 kilometres off the Ghazvin-Rasht highway. Their road branches off somewhere near the Lushan cement factory. At present only the outcrops and the coal near the surface is mined. Although the coal is itself of good quality its coking capacity is not so good and it yields no more than 300-400 kilograms of coke per ton. For this reason the main consumers of the coal are the lime kilns in the neighboring cities. However, it is possible that further explorations will yield better quality coking coal at a greater depth.

In 1966 about 90 workers were employed in this field, 45 of whom worked inside the mine pits and the rest on the surface. In the same year the average price of coal, as estimated by the supervising engineers of the Ministry of Economy, was 460 rials per ton.

The Gazvin Coal Fields

1. *The Kaman mines:* These mines are situated in a cold and mountainous region some 36 kilometres west of the Moallem Kalayeh district and some 54 kilometres north of Ghazvin. Low quality coal is extracted on a small scale at widely scattered points.

2. *The Ziaran mines:* These are situated 2 kilometres from Ziaran village, 12 kilometres north of Abyek and include two districts. The first is Khak- Rag in the north and the second Alafabad in the south. Several seams have been found, but the quality is low and there are many breaks. In the year 1963, 1,335 people were working in the mines, extracting small quantities to supply the fuel for nearby brick kilns.

3. *The Abyek mines:*The Abyek district is situated at a point 54 kilometres to the east of Ghazvin on the Ghazvin Karaj road and includes Abyek Pain, Abyek Vasat and Abyek Bala. The coal mines are 5 kilometres north of Abyek Bala, 12 kilometres from the railroad. The thickness of the seams, which are situated on the slopes of the Alborz mountains, is variable and they stretch as far as Karaj. The mines are operated in those districts where wrinkles in the ground make it possible. The most important seams are Mianrag, Khaki, Mianband, Tangrag, Ghalghesmi, Baghun and Ghanbar. Owing to poor exploration full

information regarding their content and quality is not available. What we know is that the average thickness of the seams is about 0.5 metres, that most are coke yielding, and that about 18 tunnels and shafts have been built. Of the coal extracted about $\frac{3}{7}$ is pressed coal dust and Bahmani coal, $\frac{1}{7}$ mixed calcareous (yielding no coke), and $\frac{3}{7}$ coke yielding. The latter is converted into coke in about 58 plants operated in this area. The capacity of each plant is 12 tons and its efficiency 60 per cent.

According to the supervising engineers of the Ministry of Economy, in the year 1965, a total of 151 persons worked in this field, of which 120 worked inside the pit. If we take the daily output of each worker to be 500 kilograms (each digger extracts an average of 2 tons per day, and the total production of the field is about 60 tons per day), and assume 270 working days per year, production amounts to: 270 x 60 = 16,000 tons per year.

In the year 1963, 193 workers extracted 162 kharvars[1] and in 1964, 243 workers extracted 172 kharvars per day. This quantity in kharvars converted into tons per year gives the following figures:

243 x 0.3 x 270 = 19,683 tons in 1964

162 x 0.3 x 270 = 13,122 tons in 1963

In 1966 the supervising engineers of the Ministry of Economy reported production at 200 kharvars i.e. about 60 tons.

The Coal Field of Savojabolagh, Karaj

These mines are continuation of the Abyek seams.

1. The coal mines of Heev: The mines of this area include the four districts of Chal-Darreh, Ayneh Gardan, Eskenan and Chamburak which are 2.7 6, 7.7 and 9.7 kilometres north-west of Heev respectively. Heev is 7 kilometres off the Karaj-Ghazvin highway (45 kilometres from Karaj).

In 1965 it was reported that there are 3 pits in the Chal Darreh district employing a total of 30 workers. In the Ayneh Gardan region there are 3 pits employing 20 workers. At Eskenan 3 layers of coal are extracted, the first containing about 50 per cent dust and per cent Bahmani, the second, 20 centimetres of coke-yielding coal and 10 centimetres, of dust and the third, whose average thickness is 25 centimetres, containing 50 per cent coke-yiel-

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1. A kharvar is a Persian unit of weight equivalent to about 0.3 of a ton.

ding coal. About 20 men are employed in these mines. In the Chamburak district there are 3 pits in which 20 workers are engaged in extraction and tracing.

On the site of the mines there are 56 plants which convert coke-yielding coal (30 per cent of the coal extracted) into coke. The output of the workers is 2 tons of coal per 8 hours of work for each digger. At the site of the mine the coal is sold at the following price:

Bahmani coal: 330 rials per ton.

Calcareous coal (non-coking): 500 rials per ton.

Coke-yielding coal: 930 rials per ton.

A report submitted by the operator of the mines shows that during 1965 altogether 3,500 tons of cold dust and 1,000 tons of mixed coal have been extracted.

2. *The mines of Khoor:* These mines are 4 kilometres from Khoor village, which is situated 7 kilometres north of the Karaj-Ghazvin highway and is at a distance of 40 kilometres from Karaj. The seams contain a great deal of dust and are mostly of the calcareous type (non-coking). In the year 1966,the quantity extracted by a total of 58 workers amounted to 5,670 tons.

3. *Thr mines of Fashand:* These mines are about 42 kilometres from Karaj and 14 kilometres north of the Karaj-Ghazvin highway. Their road brancehes off from Yengi-Imam village, 28 kilometres from Karaj. There are two extractable seams of coal, with an average thickness of 50 and 70 centimetres. The distance between the two is 150 metres. The coal here is of low quality and contains plenty of dust which is used as fuel for the brick kilns. This area covers the three districts of Chenaran, East Fashand and West Fashand. At present very little is mined.

4. *The mines of Ardehe:* These are situated 1 kilometre from Ardehe village,38 kilometres from Karaj and 12 kilometres off the Karaj-Ghazvin highway. There are a few layers of coal whose thickness varies between 0.2 and 0.8 metres and whose upper part is formed by exfoliate layers of the Liassic era and lower part by sandstone strata. The seam of coal stretch up to 3 kilometres and there are plenty of breaks in them. The most important are:

Seam 1, which has an average thickness of 30 centimetres.

Seam 2, which has an average thickness of 20 to 30 centimetres.

Seam 3, (the most important) which has an average thickness of 70 centimetres.

Seam 4, whose thickness varies between 25 and 30 centimetres.

During the years of operation about 4,000 to 5,000 tons were extracted from these mines, of which $\frac{1}{5}$ was mixed coal and the rest pressed dust and Bahmani coals. The legal period of operation expired in 1965, and since then no action has been taken to renew the concession.

Coal Fields Around Gachsar

There are several comparatively good coal fields around Gachsar, the most important of which are described below.

1. *The Gajereh coal field:* This is situated about 9½ kilometres east of Gachsar and 124 kilometres from Tehran on the Chaloos road. Many coal seams have been found the most important of which are as follows:

Seam	Average thickness (cms.)	Distance of seam from preceding seam (metres)
1. Anvari	40	--
2. Ramazani	70	20
3. Main Coke Seam	50	45
4. Khalili	45	40
5. Shahverdi	--	35
6. Noe	70	20
7. Pahn	80	15
8. Molla-Ghasemi	90	16
9. Esmaili	60	35
10. Tighei	40	40

Besides these, there are two narrow seams with an average thickness of 35 centimetres. Between 1958 and 1960, the coal of this area was studied by experts of the steel Mill Organization of Iran and a comprehensive report was drawn up. This report show that the coal of seams 3, 4 and 5 in the western part of the field cannot be converted into coke, whilst seams 1 and 2 may be partly converted into coke. In the Gajereh district the seams are full of faults. Thus, the coal of this field cannot be utilized for the steel mill. However, according to the supervising engineers of the Ministry of Economy, Molla-Ghasemi is not the only seam which can yield coking coal, others, the best of which are the Pahn, Ismaili and Noe seams, are also able to do so.

According to the above report, the coal of this field is first washed in a heavy liquid. It is then converted into coke in 13 local coke-making plants which have an efficiency of 75 per cent. The coke is used by the government sugar factories. In 1955, about 24,406 tons of coal were extracted, from which 1,885.5 tons of coke were obtained. The coal was sold at 710 rials and the coke at 2,200 rials per ton at the mine site. At the time 65 workers and employees were engaged in this field.

The quantity of coal extracted from these mines during the two-year study by the Steel Mill Organization decreased to a considerable extent.For example, in 1960, the total extracted was 3,190.8 tons. After the mining rights for the coal were given over to the Plan Organization, there was no perceptible rise in this quantity. For instance, in 1961, 3640 tons were extracted, of which 1,789.7 tons was converted into coke, and sold at 2,782 rials per ton at the mine site. In 1963 a total of 3,979 tons, and in 1964, 3,584 tons, of mixed coal was extracted, the price of which, at the mine site, was 200 rials per ton. In the Third Development Plan, the Gajereh coal field attained importance. A budget of 9,775,000 rials was approved for training a technical group for this field of which 4,430,000 was paid by the end of September 1965 (details of relevant expenditures are available in the Plan Organization reports).

2. *The coal mines of Nesa, Gajereh:* These are 2 kilometres west of the government coal field of Gajereh, on the bank of Valayat river, about 12 kilometres from Gachsar and some 126 kilometres from Tehran. In this district, there are thick layers of lime, sand and stone. The seams of coal are embedded in sandstone at a gradient of 40 to 60 degrees and have many wrinkles causing them to disappear under the crust of the earth from place to place. There are 10 parallel seams the thickness of some being over 50 centimetres. It appears that these are the continuation of the coal seams of the Gajereh coal field.

The most important of these seams are the Molla Ghasemi, Pahn and Ramazani, which are approximately 70 centimetres apart from each other.Their average thickness is 60,90 and 60 centimetres respectively. Due to the many faults in the seams only 500 tons of coal are extracted annualy by 10 workers. The price of a ton of this coal on the market in 1961 was 610 rials. If we deduct transport charges to the market, the price at the mine site comes to

304 rials per ton.

3. *The coal mines of Azadbar, Gachsar:* This coal field is about 16 kilometres from Gachsar, in the cold and mountainous district of Azadbar, (west of Gachsar). It has a difficult road which branches off from Shahpoor (1 kilometre from Gachsar) on the Karaj-Chaloos road. Mining here was stopped a long time ago due to bad climate and roads. Its reserves have not yet been determined but the quality of the coal is good. In the first years of operation its annual yield was about 1,500 tons.

4. *The Elika coal field:* This is situated at a distance of 140 kilometres from Tehran via the Karaj-Chaloos road and includes a northern and a southern districts. In the northern district there are 8 long seams situated close to each other in a semi-circular form 9 seams have been found in the southern part which are not so long and which have many faults. The Elika coal reserve has been estimated at about 1.5 million tons. A chemical analysis shows that the coal of this field contains an average of 20 per cent volatile materials and 12 to 20 per cent ashes. Its heat giving power is 6,500 to 7,000 calories.

The Coal Fields of the Rudbar-Ghasran Village Group

This village group, which covers a vast area between Lar and Shemshak, has many outcrops and consists of the following mines:

1. *The coal-mine of Gholgholeh Cheshmeh:* This is about 18.5 kilometres from Fasham and 66 from Tehran and has only 10 kilometres of feeder road.About 60 per cent of its coal can be converted into coke which is made by means of 26 local coke kilns, each having a total capacity of 12 to 14 tons. The efficiency of these kilns is 60 per cent and the time needed for each filling,burning, emptying and cleaning is 10 to 11 days. Filling emptying and repair requires one worker with a daily wage of 100 rials and the fuel used is firewood, whose price at the mine site is 400 rials per kharvar. Production is about 3,000 tons per year for which 5,000 tons of coal is needed.

The coke is used as fuel for the Ghaniabad factory and the sugar factories of Mashad. The coal which cannot be converted is transported to Tehran as mixed coal and sold to the owners of the brick-kilns. This excess amounts to some 3,000 tons per year, part of which is pressed dust and 'Bahmani' and the rest of which is mixed. In 1966 the price of each ton of mixed coal at the mine site was calculated at 750 rials and that of coal dust at 300 rials.

2. *The coal field of Shemshak:* This is 12.5 kilometres from Fasham and 58 kilometres from Tehran, and includes the two districts of Rigju and Fichal. Geologically, it is related to the Lalan and Garmabdar fields all three being situated amongst the layers of the cambrian period of Mehrkool which are separated from formations relating to the Tertiary period of Shemsan mountain (north of Tehran) by the Maygoon Afjeh overthrust.

The most important seams of the Shemshak field are as follows:

The Tolombeh seam - this has an average thickness of 0.4 metres of which about 15 per cent is coal dust, the rest being cokeable its length is about 1,800 metres.

The Jalilabad 1 seam - The average thickness of this seam is 0.5 metres. Its length is calculated at 1 kilometre, this figure being obtained by deducting the length of algal coal along the seam.

The Jalilabad 2 seam - The average thickness of this seam is 1 metre and it consists of 25 centimetres coal lumps; 20 centimetres clay and stone criparities, 40 centimetres lumps, 20 centimetres dust and 20 per cent further lumps.

The Shahrag seam - The thickness of this seam varies between 20 and 100 centimetres and it has an average net coal content of 50 per cent. The apparant length is 1,800 metres so that, if we deduct the algal coal, it will yield about 1,200 metres of utilizable coal. The coal is cokeable and is being mined at present.

The Tuyserkani seam - The average thickness of this seam is 30 centimetres. Besides these, other seams like Darmish, Khake - Khorde, Partavoosi, Anbari, Nassiri and Gougerdi have been found in this field. Their thickness varies between 20 and 50 centimetres and their exploitation continued until 1960 when, as a result of an explosion in which many workers lost their lives, the mines were shut. Although the Ministry of Economy presented various projects to the former operator, he took no action. Even now, all extraction of operation and exploration operations are at a standstill.

Since the resumption of operations in this mine necessitates the existence of sufficient extractable reserves, the engineers of the Ministry of Economy have made estimates of these. The results are as follows:

In the Pichal district, about 500 metres of coal seams have remained intact. If we assume that 30 per cent of this is extractable, the probable reserve of the district would be:

$$500 \times 1.5 \times 200 \times 1.2 \times 0.7 = 126{,}000 \text{ tons.}$$

Length (metres) x Thickness (m) x Depth x Density x Coefficient=Coal Tons
In the Rigju district, which was considered to be the richest district of Shemshak, the greater part of the coal has been extracted. However, a further 750 metres of coal exists and, if we assume that 30 per cent of this seam has already been extracted, its reserve would be:

750 x 1.5 x 90 x 1.2 x 0.7 = 85,000 tons.

Ofcourse, the 1.5 metres average thickness which enters into this calculation shows the total thickness of the existing seams in the district and does not relate to a single seam. A report which describes the quality of the coal of the Tolombeh and Shahrag seams was submitted to the Steel Mill Organization before the explosion. The relevant details are as follows:

Seam	Moisture	Ashes	Volatile	Heating Power
Shahrag	0.4%	10.74%	18.88%	7,000 calories
Tolombeh	0.8%	11.37%	19.58%	7,700 calories

The average composition of the Shemshak coal is as follows:

Water	0.15 to 0.84%
Ashes	4 to 12%
Carbon	70 to 84%
Sulphur	1.14 to 7.86%
Nitrogen	1 to 1. 6%
Hydrogen	4 to 5%
Phosphorus traces	1.54%
Oxygen	1.3 to 4. 8%

The heating value is 6,600 to 8,200 kilo-calories per kilogram.

3. The coal mines of Lalan: These mines, which include the two districts of Kaluk and Jeyshan, are scattered around Lalan village near the Fasham - Lar road. Their distance from Tehran is about 62 kilometres. In the Kaluk district there are 3 major coal seams which are respectively 75 centimetres, 65 centimetres and 1 metre thick. The distance between the first and the second seam varies between 25 and 80 metres. The third seam is approximately 16 metres from the second. In Jeyshan 2 good seams, the Susseyi and the **Kamari**, have been found. They appear to be a continuation of the Kaluk seams. This opinion is strengthened by the fact that although no outcrops are seen between these two districts, the type of coal is the same. Besides, a study of the seams shows that their slip seam is comparatively slight. The coal obtained consists of $\frac{1}{5}$ lumps, $\frac{2}{5}$ mixed 'Bahmani' and $\frac{2}{5}$ pressed ashes. But it should be noted that the coal in these mines is quite good and contains little ash.

In 1966,19 workers were extracting 8 tons per day. Allowing for a year of 200 work days, the total annual extraction of the field may be calculated at 2,400 tons.

4. *The coal mines of Abnik:* These mines are 11 kilometres from Fasham on the Fasham-Lar road, 57 kilometres from Tehran. Operations have ceased since the year 1965, but there are probably considerable reserves.

5. *The coal mines of Garmabdar:* These mines, which include the two districts of Jarband and Goljal, are situated in the vicinity of Garmabdar village 15 kilometres from Fasham-Lar. The former district is 0.2 and the latter 0.4 kilometres from Garmabdar. Their operation permit has, at present, been cancelled but in the eastern part the inhabitants of the area are engaged in coal extraction.

6. *The coal mines of Mariam Khas:* These mines are 20 kilometres from Fasham, and 66 kilometres from Tehran and traces of coal are seen in several places. They have two main seams with an average thickness of 75 centimetres of which at least 1 kilometre is utilizable. Thus, the probable reserve of these two seams is 63,000 tons, i.e. 2x1,000x0.75x35x1.2=63,000 tons.

7. *The coal mines of Mo[illegible] Chahl:* These mines are at a distance of 23 kilometres from Fasham, the most important seam having an average thickness of 40 centimetres and containing algal coal at several points.

8. *The coal mines of Khatoon Bargah:* These are 19 kilometres east of Fasham, by the Fasham-Lar road. Altogether there are 4 seams in the area, stretching north-south, the thickest of which is 1 metre. The seams are:

The Kamari Seam - The thickness of this seam varies between 0.7 and 1.2 metres, of which 35 centimetres is pure coal and the rest impure.

The Aghamoradi Seam - This is situated some 40 to 60 metres from the Kamari seam. It contains 40 centimetres of pure coal but its total thickness, including its impurities, reaches 1.1 metres.

The Tang Seam - This is situated 30 metres above the latter seams.

The Pahne Seam - The average thickness of this seam is 1 metre and the coal is good quality. The extracted coal consists of $\frac{3}{10}$ lumps, $\frac{3}{10}$ mixed

'Bahmani' and $\frac{4}{10}$ pressed dust. In 1966, 24 tons were extracted daily by 53 workers so that, if we assume 300 working days per year, the annual extraction of this field amounts to 7,200 tons.

The Coal Fields of Larijan and Lavassan

The following are the most important mines in this district:

1. *The mines of Gelrud, Lavasanat:* These are 65 kilometres from Tehran and their road, 15 kilometres long, branches off from Rudhen towards the north. The mountains where these mines are situated consist of calcareous formations and in some parts good building stones can be found.

The coal mines of the district are divided into two parts by a hill, one part being in the district of Vastan and the other in Tapyek. In the Vastan section, the thickness of the seams is only about 25 centimetres, but the coal is good and convertible into coke. As the inner layers are made up of calcareous beds coal extraction is easy and in many places no props are needed. Nevertheless, due to poor roads and thinness of the seams, mining stopped some time ago. In the district of Tapyek which is the second part of the Gelrud coal field, we can find the same thin seams with good coking coals. Here too the mines are not operated due to poor roads.

2. *The mines of Bazm, Larijan:* These mines are situated near Poloor village on the Haraz road. There are many earth wrinkles and no more than 2 or 3 seams can be seen. The reserves of these mines are insignificant and they are not being operated at present.

3. *The mines of Emamzadeh Hashem, Larijan:* These mines are 2 kilometres north of Emamzadeh Hashem (80 kilometres from Tehran on the Haraz road). The seams are of various thicknesses and are located among sedimentary rocks which have a gradient of 50 degrees, and which stretch in an east-west direction. In the year 1960, the minimum quantity of coal extracted was 750 tons, but at present there is no mining due to legal obstacles.

The Coal Fields of the Northern Slopes of Alborz Mountains

The most important coal fields of this district are Zirab, Galandarud and Gheshlagh of Gorgan, each one of which will be studied separately.

1. *The coal field of Zirab:* This field occupies the centre of a coal bearing

district of 100 sq. kilometres. It covers the four districts of Karmozd, Kalarijan, Anjir Tangeh and Pak and is situated 1.5 to 8 kilometres from Zirab (39 kms. south of Shahi, on the Shahi-Firoozkooh road). Its distance from Tehran is 210 kilometres and 300 kilometres by railway. As Zirab has access to the railroad, a great many studies have been carried out in the district. When the project of the Iron Foundry in Chamzaman, Ezna, was being considered, the area's coal was studied from a quantitative and qualitative point of view and many explorations were made. The most important of the four sections of this field is Karmozd whose coal was earmarked for the iron-foundry.

The area's stratography begins with stones of the Deronian age such as dark brown shales and small sandstone, among which dark limestone and beds of dolomite are scattered. These stones are covered with a formation of red shakes, quartzites and rocks formed in Tertiary period. The limestone of the carboniferous period appear in the form of layers 200 to 5,000 metres thick and contain numerous fossils. They are separated by formations of stratified clay, sandstone and coarse conglomerate from calcareous coal-bearing beds containing fewer fossils. Siliceous concretions are scattered over the carboniferous limestones. The formations of the Jurrasic period are of considerable thickness consisting of grey shales combined with small and large sandstones alternately covering quartzite beds and coarse conglomerates containing coal seams. Liassic fossils and marl of doggers 400 to 500 metres thick can also be found. There are no traces of the Cretaceous period but it is certain that there are layers related to the Tertiary period.

The Bituminous coal seams of the Zirab district are quite abundant and the most important ones are distributed in the following way.

In a part of the Karmozd district, located between the Pak and Karmozd mines, 28 seams have been found, the thickness of which varies between 10 centimetres and 2 metres.(Tracing operations have been performed up to 8 kilometres south of Karmozd and within 2 kilometres of Kalarijan). This seam has been mapped by means of sample tracing, for which 450 shafts, some 30 metres deep, have been sunk. Several cross-cut exploration corridors were also dug in April 1960 with a total length of about 2,000 metres.Three separate sections have been detected. The upper includes 7 coal seams with a thickness less than 35 centimetres. In the middle section 18 extractable seams have been found and the lower section has three seams. Out of the total number of seams, 13 named "1 to 13" were discovered before the others.

As new seams were struck, they were named after the one below by adding a letter such as A,B etc. Their characteristics are described below.

A-Lower Section.

Seam 1 - This seam is located west of the Karmozd seams, its thickness being 20 to 25 centimetres and its length 3 kilometres. It is situated between two rows of fine grey clay stones.

Seam 1 (A) - This is about 40 to 50 metres above Seam 1. Its average thickness is 25 centimetres and the further it goes towards the west, the greater the impurity of the coal. In the eastern section no exploration shaft has been dug.

Seam 2 - This seam, which is 15 to 20 centimetres thick, stretches all along the length of the Aluch valley. Its lower belt is formed by sand-bearing clay layers part of which are intermingled with tree roots. At a distance of 30 to 50 centimetres above it there is another seam of impure coal which appears at various places and which has an approximate thickness of 10 centimetres.

Seam 2 (A) - This seam, the thickness of which varies, is located about 20 metres above Seam 2. Its maximum thickness in the eastern part of the exploration district is 35 centimetres.

Seam 3 - This seam is located in the upper layer of the lower section and is about 35 centimetres thick. At the eastern part of the exploration area above Seam 3 another coal seam has been discovered. Its thickness is 15 to 25 centimetres and it meets Seam 3 near the Pak seam. It is mined at present.

B-Middle Section.

Seam 4 - This seam is located 14 to 22 metres above Seam 3. Its length in Karmozd valley is 5 kilometres and its width in the Kalarijan vallay is 1.5 kilometres. 91 descending shafts have been dug to examine the composition of the bed and these have shown that, from the standpoint of petrography, seam 4 has a uniform texture and its coal is quite pure. Its upper and lower parts are made up of clay bed formations mixed with fine sand and intermingled with plant roots at some points. However, in the middle it attains a thickness of 45 centimetres of coal. Its quality is good and it has an average coking property. The continuation of this seam is being extracted at the Pak coal field.

Seam 5 - The thickness of this seam varies. In the western part is 20 centimetres and the more it extends to the east, the more impure it becomes,until it finally divides into two small coal layers. But further on these two layers meet and form a single seam with a thickness of 40 centimetres mixed with clay beds.

Seam 5 (A) - This seam is located 20 metres above seam 5 and has a variable texture. On the eastern side it is combined with clay beds but at a point 2 kilometres from the eastern district, it grows into a coal layer with an average thickness of 40 centimetres. After a certain distance it divides into numerous layers and continues to the eastern limits of the exploration area.

Seam 5 (B) - This seam is located 25 metres above seam 5A and has a maximum thickness of 45 centimetres. On the banks of the river Dalilom near the Pak coal field and also in the Anjir - Tangeh district, this increases reaching 80 centimetres in places. Explorations have shown that, after stretching 1,200 metres to the north-west, it is divided up into two layers 25 to 30 centimetres thick and gradually becomes inextractable.

Seam 6 - This seam, 1.2 kilometres long and 50 to 55 centimetres thick, is extractable. In the western section of the exploration area, it reaches 35 centimetres thick and in the eastern section it divides up into two layers which are separated from each other by a clay bed 3 to 8 centimetres thick.

Seam 7 - This seam is formed of impure coal and has an average thickness of 25 centimetres. Its upper part is covered by a sandstone bed and the lower part is made up of clay of low sand content and rests on a layer of sandstone.

Seam 8 - This seam is located some 30 metres above Seam 7. It contains low-grade coal formed of impure layers which gradually thin out as it continues. It is good for fuel.

Seam 9 - This seam is near Laleband village 10-15 metres from Seam 8 but, in the western section it reaches upto 30 metres. By digging numerous shafts for a distance of 3 kilometres and exploration tunnels 1, 2 and 4, this seam has been studied up to a distance of 100 metres. Its thickness in the approximate space between tunnels 1 and 4 reaches 2 metres and averages 1.5 metres. From the standpoint of petrography 5 layers of various kinds of coal are distinguishable, separated from each other by clay and rock beds. In the western part, the thickness of interlining beds suddenly increases to such an extent that the impurities of the coal seam attain a thickness of 2 metres,thus rendering its extraction uneconomical.

Seam 10 and 10 (A) - These two seams are divided up into numerous coal beds each 10 centimetres thick at the beginning and reaching a maximum of 15 centimetres. The interlining and impure layers of these two seams are formed of clay.

Seam 11 - This seam, which rests on a row of sandstone on the western side of Aluch valley, is about 1.7 kilometres long. Its average thickness is 82.5 centimetres. It consists of two coal extractable beds. These two beds are separated from each other by a clay layer having an average thickness of 50 centimetres. The coal layer beneath, whose thickness varies between 60 and 75 centimetres is of lower clay content and therefore considered as pure.However, the upper coal layer, with a thickness of 30 to 35 centimetres, is impure.

Seam 12 - Various parts of this seam have been found between Karmozd and Mamashi in the western section, their total length being 5 kilometres. Like Seam 11 this seam is formed of two coal beds with an intermediate clay layer. This layer becomes thicker in the western section (from 7.5 centimetres to 2.5 metres) so that it would not be possible to extract both layers at the same time. For a distance of 1.5 kilometres, the average thickness of the seam increases from 90 cms. to 1.5 metres. The upper layer, which is of 50 to 60 centimetres thick, is extractable. The eastern part of this seam is covered by a layer of sandstone.

Seam 12 (A) - This seam rests on a hard clay bed combined with sandstone and the coal is mixed with clay 20 to 40 centimetres thick.

Seam 12 (B) - This seam is made up of several coal layers some of which are pure and others of which are mixed with clay,none of them attaining any appreciable thickness.

Seam 12 (C) - This seam consists of 4 coal beds 6 to 14 centimetres thick, interlined with layers of clay and combustible materials, 20 to 35 centimetres thick.

Seam 13 - This seam is over 8 kilometres long, of which 7.5 kilometres, averaging 62.5 centimetres in thickness are located on the southern slopes of the Karmozd mountains and are entirely extractable. The thickness increases from west to east (from 40 to 50 centimetres ultimately reaching 119 centimetres). Layers of clay varying between 1 to 3 centimetres thick and only increasing to 10 centimetres in one place, are also found. Investigations have established the width of the seam up to 3 kilometres, exploration tunnel 5 cuts into it at a depth of 150 metres. In the northern part there is a fault with an approximate length of 500 metres, after which appear several small coal layers. From there seam 12 (A) takes the place of these coal layers and the extraction of coal is shifted over to this new seam.

Seam 13 (B) - The extractable section of this seam follows the Kalarjan river toward the north. For the first 500 metres its thickness is about 60 to 80 centimetres after which a fault with about a length of 1,200 metres appears. Then the first seam emerges again with a thickness of 1 metre and continues for another 1,100 metres. From then on the middle section comes to an end and the upper section begins.

C-Upper Section

Seam 14 - This seam has 2 layers, separated from each other by a layer of clay having an average thickness of 1 metre. The thickness of the coal layer is not more than 40 to 50 centimetres.

Seams 15 and 16 - These two seams have been found on the southern slopes of Kalarjan at a high altitude. They are rather narrow for which reason their operation is not commercial. But it is probable that with further explorations better extractable sections can be discovered.

Out of these seams, numbers 9, 11, and 12 have sufficient coal with good coking capacity, but seams 4 and 13 are of average coking capacity. In order to obtain coke of a uniform nature it is necessary to mix the coal of different seams in proportion to their coking capacity. In this connection coking trials have shown that the most economical way of mixing coals with each other is to use equal quantities of coal from Seams 4 and 13 and equal quantities from Seams 9, 11 and 12. In this formula a margin of error of up to 25 per cent is allowed. This does not in any way complicate the work of coal extraction since the quantitative distribution of the coal reserves of various seams is such as to facilitate the extraction and preparation of coal from the entire reserves of the seams. The cleaning of the coal of this field is quite easy because it is relatively pure and the "magnetite" method can be used.

The coal reserves of this field were, in 1960, estimated as follows:

Seam 4	310,000	tons probable reserves
Seam 9	650,000	tons probable reserves
Seam 13	3,900,000	tons probable reserves
Total	7,650,000	tons probable reserves
Seam 5 (B)	500,000	tons possible reserves
Seam 11	650,000	tons possible reserves

Seam 12 1,950,000 tons possible reserves

Seam 13 (A) 3,700,000 tons possible reserves

In order to extract the coal of this field, Exploration Galleries 1, 2, 3 and 4 have been dug at Laleh-Bank, and 7 and 8 at Karmozd. The technical coal reserves of the latter two galleries alone have been estimated at 6 million tons. The extraction of the coal of Karmozd district was carried out for two years under the direct supervision of a German group of engineers from Demag who were assigned to draw up the Steel Mill Project of Iran. They continued the search along a stretch of 8 kilometres in the western district at a point 3 kilometres from where the seams of coal had outcropped. This place was selected because of the greater thickness of the coal seams, and the greater power and durability and higher quality of the coal as compared with other sections.

In June 1960, Demag submitted its preliminary report to the Steel Mill Organization of Iran. The map they drew of this section clearly shows Galleries 7 and 8 with the vertical and horizontal corridors. Each cross-cut corridor is about one kilometre long and cuts into Seams 11, 12 and 13. This region is situated in the southern part of the eastern and western anticline. The gradient of Boring-in gallery 7, is about 8 degrees, whereas in Gallery 8, it is between 12 and 15 degrees.

In Gallery 7 the axis of the anticline appeared within a short distance. Hence, the direction of the gradient changed so that Seam 13 could not be interested by a cross-cut. It was, therefore, necessary to proceed 80 metres higher up to reach the present profile. With the exception of the main short-cut, a deviation of about 356 metres in Seam 11 and 80 metres in Seam 13 was created and Seams 11 and 13 were traced at a gradient of 220 metres with the result that the total length of the seams amounted to 1,706 metres.

The consulting engineers of Kaizer, who were invited by the government to study the project for the Steel Mill of Iran, went through all the Demag reports, especially the geological maps. In their opinion, Seam 11 in Gallery 7 is extractable for a length of 1300 metres between the existing 2 faults. The floor and roof of this gallery are comparatively good, their average gradient being 8 to 10 per cent. An inspection of the mine shows that about 50 per cent of the material to be taken out of the mine is made up of coal.

Seam 11 in Gallery 8 has a deviation of 330 metres from both sides of the cross-cut and thus shows two parallel seams. Its lower section consists of a coal layer 55 centimetres deep containing clay deposits of 8 centimetres covered by soft clay beds of 1 metre followed by another coal seam 25 centimetres in depth. However, since 1.25 metre slates cover a coal seam 55 centimetres thick, and these slates have to be removed before the coal can be extracted, exploitation seems impracticable.

The depth of Seam 12 in Tunnel 7 is 58 centimetres of which 13 centimetres is stone. Its roof is good but in several places the floor is in bad shape. This renders the work of extraction difficult and also raises the percentage of the stone content of the coal. Seam 12 has been cross-cut a distance of 950 metres from the tunnel gate-top, 10 metres below the floor. The thickness of the seam here decreases to 55 centimetres, 3 centimetres of this containing clay rocks. The roof of this tunnel is quite good, but the floor is in very bad condition. The Kaizer engineers dug the gate-top opposite the cross-cut at a distance of 1,040 metres and found that the seam was 50 centimetres thick and its gradient 6 degrees south.

Seam 12 in Gallery 8 was traced towards the east for a length of 410 metres. The coal of the seam is, on the average, 81 centimetres thick. About 50 per cent of it consists of impurities. The two walls of this tunnel are comparatively good but the eastern terminal of the seam has moved along axis of the synclines so that it is now parallel to the cross-cut. This situation complicates the extraction of the coal and makes it costly.

Seam 13 has been dug at a height of 79 metres above the cross-cut inside Tunnel 7. The coal is 32 centimetres thick and is covered by 34 centimetres of brown coal making the total depth that must be dug 66 centimetres. In the two shafts located at the top of this part, the coal was 43 and 44 centimetres thick, showing that it has decreased at greater depths, probably due to wrinkles in the earth.

In Gallery 8, Seam 13 was cut in two directions, from east to west, to a length of 180 metres. It was found that, if the upheaval of the seam was taken into account, the thickness of the two follow-up seams would be 32 centimetres. In the same way as Seam 12,its eastern follow up bends abruptly to the north and round the anticline axis. The Kaizer engineers were of the opinion that Seam 13 is unextractable because of its thinness and its deviation and transformation in some places.

A limited amount of work has been done on Seam 4, which is situated at a distance of 200 metres from the gate-top of Gallery 8. A short cross-cut intersects the seam and continues for 35 metres to the east, where a shaft with a gradient of 35 degrees has been struck. The coal seam has an average depth of 45 centimetres. The Kaizer engineers think that it is inextractable although the Demag group held the opposite opinion.

Estimate of the Karmozd Coal Reserves

After considering studies made some time ago, the Kaizer engineers came to the conclusion that the extractable coal reserves of Seams 11 and 12 do not exceed 2 million tons; that the thickness of seam 13 is too insignificant for extraction; and that Seam 9, in the eastern part of this district, has a reserve of only 500,000 tons. They are also of the opinion that, from the standpoint of the extraction of coal, Seams 4 and 13, i.e. the last layers to the east of Gallery 8 are unimportant. The extraction of these seams is costly and, judging from Seam 13 in the Galleries 7 and 8, is uneconomical. They also think that Seams 4 and 13, i.e. the last layers in the east of Gallery 8 are unimportant, and that their extraction of the estimated 2.5 million tons of Karmozd coal will be coatly and faced with a great many economic problems. The layers are very thin, and, in most cases, the existence of one or two walls will involve heavy expenses.

The Demag engineers sent many samples from the 500 shafts located in the coal bearing region to Germany for washing and determination of coking value. Since the lower depths of these shafts had already been explored, the engineers had no doubt that they had obtained the samples from pieces excavated from under the oxidised bed. They placed the samples in steel barrels,filled them with water and sealed them before sending them to Germany. In August 1961 Demag submitted its report.

They concluded that the coal obtained from different sections of Zirab could be used in steel-making blow furnaces if the various types were mixed with one another. However, the Kaizer group hold that, from the economic point of view, the extraction of coal from the Karmozd district is unreasonable and would not pay for steel-making blast furnaces, the proportion of coke to coal in 20 milimetre sizes being 55 per cent. According to Demag, Coal Seams 11 and 12 could be mixed with Seam 13 in order to obtain reasonable coke. However the Kaizer group thought that this was not worth while

Characteristics of the Karmozd coal field

Seam	Gallery	Coal			Impure Coal		Overlaying beds		Total Width of seam
		Length of gallery (metres)	Thickness of seam	Weight (%)	Width (cms.)	Weight	Thickness	Weight	
11,Western corridor	7	206	89.45	51.52	12.17	8.82	40.45	39.66	142
11,(Mileh) corridor	7	170	92.18	54.21	5.24	3.88	41.82	41.91	139.24
11,Eastern corridor	8	70	93.29	35.62	11.13	5.36	90.48	58.96	194.90
11,Western corridor	8	260	93.29	35.62	11.13	5.36	90.48	58.96	194.90
12,Western corridor	7	360	58.66	72.33	-	-	13.17	27.67	71.83
12,Eastern corridor	8	410	81.52	52.77	18.97	15.45	28.83	31.78	129.37
13,Farazi	7	79	32	-	-	-	34	-	66
13,Western corridor	8	160	32	-	3	-	10	-	45
13,Farazi	8	50	32	-	3	-	10	-	45
4,Eastern corridor	-	35	41.92	63.20	-	-	14.38	36.88	56.30
4,Mileh corridor	-	50	53.25	57.48	-	-	23.12	45.52	76.37

since the extraction of the coal of Seam 13 is uneconomical, the layers being thinner and poorer than those of other seams.

Continuous activities in the Zirab coal field over a period of two years show that the extractable coal is about 2,500,000 tons. The seams are usually thin (about 65 centimetres deep) and the walls and structure are of a type which renders extraction of the coal difficult and costly. In the opinion of the Kaizer engineers, the coal of this district lacks the constituents necessary for use in a blast furnace. If an electric furnace were to be used transportation charges would be too heavy even though this coal could supply the required carbon.

To summarize in order to produce 600,000 tons of steel per year, 2,000 tons of washed coal per day is needed. However, not only is the ash content of the Karmozd coal high, but also the roof and the floor of the galleries are in an unsatisfactory condition, rendering daily production too low to meet the required figure. Apart from this, adequate transportation, the expansion of the coal field, and the purchase of equipment need a capital investment of about 1,000,000,000 rials. If the relatively low reserve of the field is considered, such a heavy investment is uneconomical but,on the other hand if it is not made, the coal field will in the course of time fall into ruin.

The average chemical composition of the coal of the Zirab district is as follows:

Ashes without foreign matter	2 to 13%
Volatile material in old seams	Less than 30%
Volatile material in younger seams	Over 40%
Resistant Carbon	(Proportion unknown)
Hydrogen	5 to 5.7%
Nitrogen	0.9 to 1.1%
Sulphur	0.7 to 1%
Heating Value	5,685 to 8,200 kilo-calories per kilogram

The coal of this district contains a small amount of ashes and apparently has a coking capacity. The probable reserves have been estimated by Iranian engineers at 10 million tons. Since the extracted coal is used directly as fuel, the ratio of coal lumps to dust is of great importance in the economy of extraction. The average size of over 25 per cent of the products of this coal seam is bigger than 1 inch.

The following table shows the level of production in recent years:

1960	61,344.31 tons
1961	57,002.32 tons
1962	43,753 tons
1963	42,507 tons
1964	231 tons per day
1965	44,604. 6 tons

The supervising engineers of the Ministry of Economy reported that in 1961 the output of each worker was 1.25 tons per day, but in 1964 had become 700 kilograms. However, it is our view that this figure is a guess rather than the result of actual investigation. This is shown by the expenditure data for extraction which in 1960 was 640 rials, that is 2.6 times the cost of extraction at the Gheslagh Gorgan field (240 rials).

The coal of the Zirab field is bought and sold at the railway station. In 1960 its sale price was as follows:

Coal dust	760 rials per ton
Mixed	740 rials per ton
Lumps	66 rials per ton
Handpicked	1,100 rials per ton

The main consumers are the Varamin sugar plants, the Shahi textiles and gunny weaving factories, the Behshahr Chitz Weavers and Rey Cement works. The coal, after being classified, is taken to the sales centre partly by lorry and partly by cables from Karmozd to the railway station.

2. *The Galandrood Coal Region:* The Alborz mountains contain rocks of the Liassic period which are spread over a distance of 60 kilometres in the form of a huge anticline. Several extractable seams appear along both sides of this range. 6 have been discovered at Baharian and 8 at Roudbar and Galandrud. The overall width of these seams is about 40 feet. Since the Liassic ranges are exactly the same as those at Zirab, it is presumed that they are related to those extending along the Mazanderan and Gorgan provinces. But it should not be supposed that coal bearing districts are found exclusively in these areas. Plenty of traces of coal deposits have been found in western Mazanderan, in the Gorgan mountains in the vicinity of Shirgah, in the Babol valley and the Sheikh Mussa and Haraz valley. These display almost the same for-

mation but as yet no geological survey of them has been carried out. The Galandrud coal field is situated 22 kilometres south west of Suldeh, 34 kilometres north-west of Amol and 48 kilometres east of Noshahr on the coastal highway. Its road branches off from Alamdeh 24 kilometres west of Suldeh.The coal beds are shaped like lenses and are spread over a distance of several kilometres. Explorations show that a coal bed 800 metres deep contains numerous coal seams. Above this bed are calcareous layers separated from each other by a layer of coarse conglomerates. Since these calacareous beds have been formed in later geological epochs, they have not greatly affected the coal underneath. Some of the coal layers are covered with masses of clay 20 metres deep in places. These clay layers are more numerous in the southern districts and there is only one piece of land, 10 kilometres west of Galandrud valley, whose clay covering is negligible. The existence of these clay layers has caused many difficulties in tracing, boring experimental shafts,and sounding and has also, in some places, caused the displacement of the coal seams. However, in those districts where the clay does not hamper explorations, the conditions of the seam have, to a certain extent, been ascertained by taking samples from borings. But it has been necessary to make further investigations in order to determine the reserves of the field and the economy of its extraction.

Gehrad Klamer, one of the consultant engineers of the Steel Mill Organization, inspected the Galandrud coal field in 1960 and proposed that 280 soundings over a distance of 300 metres be made and that new maps of the features of this field be prepared. However, later he decided that the expense of digging the pits was not justified by the probable reserves and that exploratory operations should therefore cease. Thus all such operations ended and, after the known seams petred out, exploitation of the field came to a standstill.

During the time that this field was being mined, the coal extracted was usually mixed with impurities. Hence, it was usually necessary to wash the coking coal with a heavy liquid before delivery to the coking furnaces.This washing was expensive and raised the price of the coal considerably.The coal was used by the Chaloos silk-weaving factory.

As regards composition, a sample of the coal was tested in 1960 and the results are recorded in the table below. They show that the coal has coking capacity.

Sample	No.81	No.82	No.83	No.84	No.85
Moisture (%)	18	16	25	18	16
Ashes (%)	26.97	25.84	27.66	44.13	32.28
Volatile Materials (%)	29.85	27.47	27.97	22.95	25.30
Heating Power(calories) (in each kilo)	5,923	6,253	6,000	4,490	5,600
Coking Capacity	+	-	+	-	+

3. *The Coal Field of Gheshlagh, Gorgan:* This field is situated 113.5 kilometres from Shahrud, near the Gorgan-Shahrud road. Its subsidiary road branches off at about 30 kilometres from the Shahpasand-Shahrud road. It is, from the standpoint of quality and reserves, one of the largest and most important fields in Iran. It is operated by the Mashad Cement Co. which has been able to exploit its reserves in the best possible manner.

The seams which generally extend for several kilometres and in places rise are scattered over the districts of Daghooz and Meliar and contain good quality coal which has coking capacity. Even in those seams containing impurities, good quality coal can be found.

with a capacity of six tons. After the coke has been burned for 48 hours in these furnaces, it yields a substance called semi-coke which is consumed by the Mashad Cement factory. Part of the coal and coke is sold to the Shahrud and Shirdan sugar factories, lime and brick-making kilns and the tobacco dehydrating hot-chambers of Gonbad Ghaboose, Gorgan and Sari.

During recent years the following amounts of coal have been extracted from this field:

1959	18,951 tons
1960	27,751.6 tons
1961	32,523.6 tons
1962	40,020 tons
1963	42,705 tons
1964	47,391 tons
1965	67,430.3 tons

In 1965, about 32 workers were engaged in this coal field, out of which about 125 were engaged in extracting coal from the mines, and the rest in the installations on the mine site.

The Coal Fields between Shahrud and Damghan

In this district there are a few comparatively good fields. We will describe the most important ones.

1. The coal fields of Mansur-Kuh, Damghan: This field is situated on the slopes of the Alborz mountains, 5 kilometres south-west of Ahvanoo village, 24 kilometres north-west of Damghan. Its most important seam extends over a distance of 3 kilometres and has an approximately perpendicular slope. The average depth sometimes reaches 1 metre. Among the other major seams of this field is the Suseyi, which is about 40 centimetres deep, and the middle seam which is an average of 60 centimetres deep.

2. The coal fields of Talu, Damghan: These are situated to the north-east of Damghan, in the Talu mountains. Their road branches off at a point 14 kilometres from the Damghan-Shahrud highway. Traces of the main seam of these mines, known as the "big seam", have been detected for a distance of 1,500 metres. It has a depth of 0.6 metres and a gradient of 45 degrees.The type of coal is quite good, contains only a small quantity of ashes and has coking capacity (about 50 per cent of the coal). Among the other coal seams we might mention the Licheyi and the Tang which are, on the average, 0.5 metres deep.

In 1959 and 60 about 3 to 4 thousand tons of coal was extracted and sold at 300 rials per ton at the mine site.However, this quantity has decreased in recent years. In 1965 only 1,500 tons of coal was mined. In 1952 the final reserve of this coal field was estimated at 112,500 tons but this does not appear to be an accurate figure.

3. The coal mines of Parikan, Shahrud: These mines are situated about 17 kilometres south-west of Shahrud. Their road branches off 10 kilometres from the Shahrud-Damghan highway. Production is about 2 to 3 thousand tons annually and coal is sold at 300 rials per ton at the mine site.In 1965 about 20 workers were engaged on the mine site.

4. The coal mines of Demollah, Shahrud: These mines are situated 10 kilometres from Shahrud and 21 kilometres from the Shahrud-Damghan highway. Many faults and wrinkles render the seams short and for this reason extracting installations soon close down because the seam is exhausted. The layers of coal average 0.5 metres in depth but in places they reach 30 and 80 centimetres and occasionally 1 metre.In 1965 about 20 workers were engaged on the coal field, each extracting about 10 tons of coal per day. If we assume that each worked 300 days per year the annual production of the mine is 3,000 tons.

The Coal Fields of Khorassan

In this province several good fields are being exploited.
1. The Cheshmegol coal field: This field is situated 36 kilometres north-east of Torbate-Jam, 3 kilometres from Cheshmegol village near the Afghanistan border. Geological studies have shown that, like those of all the coal-bearing districts of Iran, its seams are formed of calcareous clay fossils and first formations of Europe. Coarse conglomerates and out thrust rocks are indicative of violent volcanic eruptions which have caused many cleavages in the earths crust. A great batolite slate has penetrated the Liassic coal-bearing bed and has caused many changes in the gradient and continuity of the layers. Numerous siliceous layers containing coal combined with volcanic materials are found. The coal seams are usually lense-shaped and appear succesively. Two large ones occur between the Liassic strata and between these are grains of coarse conglomerate which are also the main producers of crystalline rocks and white nodules of quartzite. Towards the south the Liassic beds are displaced by the siliceous materials which have penetrated the fine sandstones. These stones, due to the existence of materials containing carbon, have acquired a dark or brackish colour.

Here there are some volcanic rocks apparently formed by eruptions of the Liassic period. The magnatic intrusive materials which have poured onto the Liassic strata have changed the constitutent structure of the earth's crust and combined with pre-Jurassic movements have produced many ups and downs in the formation. Thus, the gradient of the coal seams, descending into the depths of the valley, is more than that of the surrounding land.

Plant fossils show that the coal seams have been brought from another area by torrents. Due to the high pressure existing inside the seams, extracted coals are crushed.The ash content is variable. The lower seams produce less than the upper ones and have more volatile materials. Hence, the greater the depth of the coal-seam, the less its coking capacity. Each seam is about 5 to 8 metres deep in the middle, gradually thinning out and gradually disappearing into other coal beds. The average thickness of the seams is about 2 metres and their average length is 1 kilometre.

The coal near the surface has been almost exhausted thus extraction now takes place at a depth of 100 to 200 metres and involves heavy expenditure. In 1960 a new coal-bearing bed with considerable reserves was discovered.

The coal of these seams is of reasonable quality and has a good coking capacity. The average amounts of foreign matter and the heating value of the coal are as follows:

Ashes	17-18%
Moisture	2%
Volatile Materials	14-16%
Heating Power	5,700 kilo-calories per kilogram.

During 1960, 61 and 62, 50 to 60, and sometimes 80 tons of coal were extracted daily. Yearly production is therefore about 18 to 19 thousand tons. In 1965, the joint production of the Cheshmegol and Golbanu fields was 18,893.6 tons. Most of the coal is consumed by government factories in the neighbouring cities or by brick kilns.

The buildings, health and technical installations of the field are comparatively well equipped and ensure the requirements of the 150 people employed on the mine site.

2. *The mines of Timang:* These are situated 20 kilometres west of the Cheshmegol field and 38 kilometres north of Torbate-Jam. They are connected to markets and neighbouring towns from two sides. The major seams are located in a coal bed whose maximum depth is 20 metres. The most important seam has an approximate depth of 50 centimetres. The mine is no longer exploited since its known reserves are slight and discovery of new seams would involve unnecessary expenditure.

3. *The coal field of Aghdarband, Sarakhs:* This field is considered to be one of the best of the privately owned fields of Iran. It is located on comparatively high mountains near Kashfrood on the Afghanistan border. The coal seams, like those of Cheshmegol, are lense shaped and follow each other successively. They vary between 0.5 metres and 5 metres in thickness. In 1961 visible reserves were estimated at 40,000 tons and probable reserves at 500,000 tons.

Part of the coal extracted is converted into coke by 11 coke- producing furnaces each having a production capacity of 4,000 tons every 48 hours. The rest is converted into briquettes by sets with a production capacity of 30 tons every 18 hours. The annual capacity of coke production is 5,000 tons and that of briquette production 2,000 tons. In 1960 a total of 21,740 tons of coal was extracted, from which 4,000 tons of coal and 2,000 tons of briquettes were obtained, the rest being sold as mixed coal. The mine operator reports that, in 1961, 13,828 tons of coal were extracted and its various products sold at the following prices.

Mixed coal	692.4 rials per ton
Furnace coal (semi-dust)	560 rials per ton
Lump coal	1,177 rials per ton
Coking coal	2,000 rials per ton
Briquette	1,100 rials per ton

In subsequent years, coal production was as follows:

1962	12,505 tons
1963	10,904.5 tons
1964	9,832.5 tons
	6,712.5 tons

The decrease in production is due to a fall in the consumption of coal in Khorasan brought about by a reduction in the price of fuel oil by the National Iranian Oil Company. At the suggestion of the Ministry of Economy,the NIOC offered a reward of 120 rials for the production of each ton of coal sold at this field so that the sale price of coal could compete with the sale price of fuel oil. This has, nevertheless, failed to encourage the production of coal. The number of workers in this field, 200 in 1960,gradually fell to about 50 to 55 in recent years.

4. *The Golbanu Coal Field:* This field is situated 40 kilometres east of the Cheshmegol field, near the Afghanistan border. It is connected to the markets by way of both the Sarakhs-Mashad and the Cheshmegol-Torbate-Jam roads. The coal bed covers a distance of 28 kilometres and contains plenty of seams. These, like others in Khorasan, are lense shaped. Some meet at their extremities and form a continuous mass. They obtain a maximum thickness of 3 metres. Since the field is some distance from consumption centres it is not, despite its high quality reserves, well exploited.

PART II. THE COAL DEPOSITS OF THE CENTRAL REGIONS OF IRAN

The Coal of the Kerman Region

Most experts are of the opinion that one of the most extensive coal deposits of Iran lies in this region. Geographically, the relevant seams are situated between 30.15 and 30.35 degrees north and 57.5 and 56.25 degrees east. The lower and middle sections of the Jurassic calcareous clay sedimentations of the Kerman district are coal bearing and contain four ranges each of which has a varying number of lense-shaped coal layers with different thicknesses. The ranges are known as 'A', 'B', 'C' and 'D'. Range D contains the most coal since it is situated in Dogger sedimentations found all over the Kerman region.

There are 9 coal-bearing districts in the region. In the south-west, Dehrood, Neyzar, Darrod Kuh and Darbid Khoon; in the north-east, Ghomrood Eshkeli; the syncline of Kerman and its two closed extremities, i.e. Toghrajeh and Babnizoo. In the middle north-east section no coal has been found between Ghomrood and Eshkeli, but it may be that it is covered by marine sedimentations of the Tertiary period.

65 kilometres of road connect Kerman with the Hejdak mines and from there it is possible to go to all the coal-bearing areas by means of temporary roads. Temporary roads also been built from Rikabad (between the Kerman-Zirand road) and Dashte-Khak as well as from Riz and Tokhrajeh. In order to transport the requirements of the Steel Mill of Iran which is being contructed 40 kilometres from Isfahan, the railway is being extended from Isfahan to Yazd, Bafgh and Kerman.

As we have already mentioned, the coal deposits of Kerman consists of four ranges. Their specifications are as follows:

(a) Range'A' is 500 metres wide and contains a group of coal seams.

(b) Range'B' is 300 metres wide and contains extractable coal in some places.

(c) Range'C' is 400 metres wide and is extractable in places where the depth is suitable.

(d) Range'D' is 400 metres wide and is all extractable.

The major mines of this district are described below.

1. *The Toghrajeh Section:* This is situated on the north-west syncline of Kerman and is separated from Dehrood to the south by a series of breaks and faults and from Ghomrood to the north-east by a large fault.

The total length of the seam is 13.5 kilometres,but it is divided by two faults into southern, eastern and central districts whose length are 4.53, and 3 kilometres respectively. The orogenic structure of the district is,in-fact, very complex. The end section of the syncline in front of Tangol Ravar has been so distorted that, if the faults run into each other in the downward gradient, mining operations will prove to be extremely complicated.

Shafts dug into ranges 'A', 'B' and 'C' have shown that they contain no extractable coal. Range 'D' has been explored and operated much more. Three tunnels have been dug in Tangol Ravar, Tunnels 1 and 2 at an altitude of 2,500 metres and Tunnel 3 at an altitude of 2,555 metres. At present a further Tunnel 4 is being dug at an altitude of 3,360 metres. The average gradient of the layers in Range 'D' varies between 17 and 32 degrees and the lower we go, the more frequent are the outcrops. The depth of each layer is shown in Table 1.

Table I

No. of	Extractable Depth			Depth of Coal Masses		
Layer	Min.	Max.	Average	Min.	Max.	Average
2	110	260	202	95	235	18
3	90	155	122	65	130	95
4	80	140	101	55	135	82
5	65	90	74	50	75	57
6	60	85	89	60	80	67

Layers 3,4,5 and 6 are situated very close to each other, the distance between layers 3 and 4 along a line perpendicular to the surface being 55 to 70 centimetres and that between layers 5 and 6 being about 1 metre.The closeness of the layers means that the cleaning of the mining site is difficult. Details of their structure have not yet been mapped out and, at present,some of the wells are ruined and others are flooded with water. Of all the layers of 'D' series in the southern section, only 2 and 3 attain a depth which makes extraction worth-while. In the central section Layers 2,3 and 5, and in the eastern section, Layers 2 are exploitable. The depths of extractable layers are shown in Table 2.

Table 2

No. of Layer	Southern section						Central section						Eastern section					
	Overall thickness			Coal mass thick.			Overall thickness			Coal mass thick.			Over all thickness			Coal mass thick.		
	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.
2	180	210	195	160	200	180	150	160	210	75	220	180	192	351	248	175	257	208
5	98	145	118	60	67	620	105	200	150	60	111	80	-	-	-	-	-	-
5	-	-	-	-	-	-	112	166	133	50	110	83	-	-	-	-	-	-

Layer	Thickness (metres)	Computed Area of field 2 (sq.m.)	Mass volume (ton/cu.m.)	Constant coefficient of layer	Reduced coefficient of exploitation	Deposits (1,000 tons)
1	2	3	4	5	6	7
		Southern section above 2370 m.				
2	1.8	$\frac{250,000}{\sin 55°}$	1.5	0.8	0.9	600
3	0.62	$\frac{250,000}{\sin 55°}$	1.5	0.5	0.9	130
						Total 730
		Central section a) above 2500 m.				
2	1.8	$\frac{770,000}{\sin 50°}$	1.5	0.8	0.9	1940
3	0.8		1.5	0.7	0.9	760
5	0.83		1.5	0.2	1.9	220
						Total 2920
		b) Between 2370 and 2500 m.				
2	1.8	$\frac{1,040,000}{\sin 40°}$	1.5	0.8	0.9	2400
3	0.8			0.7	0.9	920
5	0.83			0.2	0.9	270
						Total 3590
		Eastern section a) Over 2500 m.				
2	2.08	$\frac{380,000}{\sin 75°}$	1.5	0.7	0.9	780
		b) Between 2500 and 2370 m.				
2	2.08		1.5	0.7	0.9	800
						Total 1580
						Grand total 8920

Table 3 contains approximate data on the probable deposits of the Toghrajeh district. The calculation has been made despite the lack of geological maps and the fact that most of the layers are covered with marine sediments.

A summary of the general characteristics of the district which affect coal extraction follows.

1. Extraction is made difficult by large and small faults and wrinkles.
2. The layers are largely frail and unstable (except for Layer 2 which is resistant).
3. The closeness of the layers has affected the estimate of the production potential of the field which is 450 thousand tons of coal annually. French experts of IRSID, who were invited to Iran after the Demag and Kaizer experts to advise on the projected steel mill and on coal and iron reserves, think that coal reserves above Tunnel 4 should be around 1,300 million tons.

The Steel Mill Organization decided to drill Gallery No. 4 to secure its coke requirements and IRSID proposed the following conditions for its operation:

a) The maximum quantity of coal to be extracted in 24 hours: 4,000 to 6,000 tons.
b) Number of people to be employed at the field: 1,200.
c) Air to be consumed by each worker in one second: 50 litres.
d) Maximum speed of air circulation in the gallery: 400 to 500 metres per second.

The existence of numerous faults in this section is probably due to the fact that the concentration of thrusts during the Jurassic era has been much greater in the centre of the syncline than in other areas. In the course of drilling the left side of Tunnel 1, two large faults were observed within an area 700 metres square. One of these is clearly visible on the surface.In an attempt to distinguish the stratification of layers, a 2,370 metre long corridor was bored at an altitude of 2,500 metres. Unfortunately this ran into a fault and, from that point onwards, the layers could not be distinguished and thus the exact gradient and reserves of the coal cannot be ascertained. This section contains an abundance of the methane gas which has also been detected on other coal fields in Kerman. (Hejdak, Darbidkhoon).

The determination of the characteristics of this district, and greater efficiency in mining require the following operations:

a) The corridor should be extended to a height of 2,370 metres and, after reaching the fault, short cuts or descending shafts should be dug to discover the condition of the layers.

b) The geometric situation of the syncline,the deposition of the layers in an open horizon, and the orogenic condition of the northern side of the section should be verified.

c) As the methane gas in Gallery 4 is rather dense,the amount of air required by every worker is estimated to exceed 50 litres per second. Soviet experts are of the opinion that the air supply for every worker should be raised to 100 litres per second and, under present conditions, Gallery 4, which is 3.5 metres long, should be bored with smaller cuttings.

2. *The Dehrood district:* Dehrood is situated below the Toghrajeh region beyond the area of large faults and to the south-west of the Kerman syncline. D - layers extend for 9 kilometres from the north-west to the south east.The seam outcrops 2,150 and 3,340 metres from ground-level. These layers have been detected by means of drilling 21 shafts 250 metres apart from each other. In the north-western section, where the layers are covered with marine sediments, 3 other shafts have been sunk.

Table 4 shows the specifications of the seam.

Only layers 2,3 and 5 of 'D' Series are thick enough to justify economic exploitation. The depth of Layers 2 varies between 142 and 255 centimetres, its average being 180 centimetres. Seam 3 is 77 to 127 centimetres thick, and Seam 580 to 370 centimetres thick. The gradient of the layers varies between 65 and 85 degrees and averages 75 degrees. An estimate of the reserves of the coal-field is given in the following table.

Table 4

Seam	Thickness (metres)	Computed Area (sq. m.)	Mass Volume (ton/cu.m.)	Constant Coefficient of seam	Coefficient of Exploitation	Coal Reserves (1000 tons)
2	1.2	1,500,000 / 75 north to south	1.5	0.7	0.9	2,620
3	0.65	1,500,000 / 75 north to south	1.5	0.3	0.9	400
3	1.15	1,500,000 / 75 north to south	1.5	0.35	0.9	540
					Total	3,560

From the information available the following conclusions can be drawn:

a) In all the layers there is an inconsistency but this applies particularly to Seams 3 and 5.

b) The coal bearing region lies in a straight line and there are no faults.

c) Probable reserves can be reached by boring a horizontal tunnel with and upward gradient of 150 metres. Even better, probable reserves can be reached by dividing this 150 metres into two sections each having a perpendicular length of 75 metres. This would allow for an annual production of 170,000 tons of coal, or 210,000 tons of mineral matters. The quantity extracted per square metre for every seam will be as follows:

Seam No. 2:	0.9 x 0.7 x 1.5 x 1.8	1.7 tons per square metre.
Seam No. 3:	0.9 x 0.3 x 1.5 x 0.65	0.36 tons per square metre.
Seam No. 5:	0.9 x 0.35 x 1.5 x 1.15	2.51 tons per square metre.
Total:		2.51 tons per square metre.

If this section is opened up by means of a horizontal tunnel, the extracted coal can easily be carried to the Zarand plain through which the railway will pass. There is also ample space on which to build housing quarters and work shops. The only shortcomings of this method is that the coal output from the mine will be less than if a vertical shaft is bored connecting the pit to the Dashte Khak plain. Detailed technical and economic estimates are necessary to find out which of these methods is most advantageous.

3. *The Neyzar section:* This is a continuation of the Dehrood district and is situated south of Dehrood and south-west of the Kerman syncline. D Series extends for 6 kilometres from the north-west to the south east and is located at an altitude of 2,350 metres starting from Dehrood and continuing to the village of Sarsiah. After this point we do not know the altitude since geological maps are not available. A number of wells, drilled 250 metres, and occassionaly, 500 metres from each other, distinguish the condition of series D.

Series A, B, and C in this section have not yet been exploited. Out of the 19 experimental wells and shafts which have been sunk in this area, only 11 have produced any iformation on the structure and formation of the seams, the others have collapsed. Seam 2, whose overall thickness varies between 146 and 260 centimetres, and whose mean thickness is 169 centimetres, is exploitable. Seam 3's overall thickness is 105 to 170 centimetres and its average thickness is 70 to 80 centimetres. Seam 5, which was tapped at three points,

Table 5

Charactristics of the Darrehgol Section

Well or Shaft No.	Extractable thickness (metre)	Seam No.	No. of wells extractable (≥ 0.8)	Constant coefficient of thickness	Average extractable thickness
1	0.3	2	19	19:21	2.06
2	2	2	19	0.9	2.06
3	1.5	2	19	0.9	2.06
4	1.5	2	19	0.9	2.06
5	2	2	19	0.9	2.06
6	2	2	19	0.9	2.06
7	2.5	2	19	0.9	2.06
8	2.5	2	19	0.9	2.06
9	2	2	19	0.9	2.06
10	2.5	2	19	0.9	2.06
11	2.5	2	19	0.9	2.06
12	2	2	19	0.9	2.06
13	3	2	19	0.9	2.06
14	3	2	19	0.9	2.06
15	2	2	19	0.9	2.06
16	1	2	19	0.9	2.06
17	2	2	19	0.9	2.06
18	2	2	19	0.9	2.06
19	2	2	19	0.9	2.06
20	1.5	2	19	0.9	2.06
21	0.5	2	19	0.9	2.06

has an overall thickness of 100 to 156 centimetres and an average thickness of 60 to 87 centimetres. Seam 4 has been opened in four places and has proved too thin to warrant economic exploitation. Seam 6 has not been explored at all.

4. *The Darrehgor Section:* This is located some 8 kilometres beyond Neyzar. Mining operations have already begun. Layers of Series D appear in many places over an area of 12 square kilometres and stretch from north-west to south east over a flat, shallow plain. Exploratory wells and shafts have been bored into Seam 2,500 metres apart. The overall thickness of the bed is 1 to 3 metres and that of the Seam in half the wells has been found to be 0.4 to 0.5 metres.

This seam stretches all along the section and has a gradient of 70 degrees inclining towards the south-west. No ground fault has been found. Since the topography of the seam has not yet been studied no definite estimate of its reserves can be given. However, if we take the height of the valley to be 100 metres, less than the elevation of Gallery No.1, then the reserves would be roughly 7.4 million tons. If there are other extractable reserves in Series D this figure would be considerably greater.

From an operational point of view this is considered to be a first class section and it imperative that the necessary surveys are carried out to estimate the reserves and the topography of the seams.

5. *The Darbid Khoon Section:* This is situated on the southern shores of Pahlavi, south-west of the Kerman syncline. Outcrops of Layers B and D stretch from north to south and halfway along change their direction, continuing from east to west. Layer B appears at at an altitude of 2,500 to 2,800 metres above sea level and, Layer D 2,200 to 2,800 metres above sea level. 5 deviation tunnels have been dug into Layer D 400 to 600 metres apart,and by means of these, the seam has been examined for 8 kilometres of its length. Seam 2 of Layer D has an average thickness of 1.67 metres and a gradient of 65 degrees. The seams of Layer B have been identified along 8 kilometres of its length by 17 borings or exploration shafts dug at intervals of 250 or 500 metres. There is some information available on 16 of the borings. Of all the seams of Layer D, 5 and 7 are of extractable thickness.

Seam 7: General thickness: 83-400 cms. Average thickness: 184 cms.
Seam 7: Mean thickness: 63-385 cms. Average mean thickness 17 cms.
Seam 5: General thickness: 75-203 cms. Average thickness: 170 cms.

Seam 5: Mean thickness: 75-140 cms. Average mean thickness 115 cms.
Gallery No. 1, which has a length of 445 metres, has opened up the seam of Layer B. There are two ways in which Layer D can be opened.

1) By a 2.8 kilometre gallery stretching from Darbid Khoon to Layer B at an altitude of 2,250 metres and breaking into Layer D by means of short-cuts.
2) By digging Layer D in the middle of the coal field, from Ghomrood, at an altitude of 2,200 metres.

The choice between these two ways depends on economic and financial factors and on transportation difficulties.

Table 6

Seam	Average thickness (metres)	Computed Area (sq.m.)	Density (Ton/cu.m.)	Coefficient of seam stability	Coefficient of exploitation	Reserves (1000 tons)
		Layer B				
7	1.76	$\frac{3,150,000}{\sin 65°}$	1.5	1.0	0.9	8,200
5	1.15	$\frac{3,150,000}{\sin 65°}$	1.5	0.7	0.9	3,700
						Totol: 11,900
		Layer D				
2	1.67	$\frac{2,040,000}{\sin 65°}$	1.5	1.5	0.9	3,800
				Total for both layers		15,700

If the road be continued from Ghomrood, and other seams are found in Layer D, further coal reserves can be worked. In this case the annual extraction will reach:

Layer B: 350,000 tons of coal and 450,000 tons of mineral lumps.
Layer D: 135,000 tons of coal and 165,000 tons of mineral lumps.

The coal bearing deposits of this section belong to District B and are not cohesive. Their carbon content is 92 to 93 per cent which indicates that the coal is of lower potential. However, if the coal is concentrated, its sulphur content is 0.65 to 0.98 per cent. Some traces of phosphorus can be found in the seams of District D.

6. The Bab-Nizoo Section: This is situated at the end of Kerman syncline, where four layers of coal, A, B, C, and D have been detected. Of these Layers B and D are worthy of attention. Layer D extends for a distance of about

Table 7

Boring No.	Thickness of seams (metres) 8	7	6	5	3
1	0.40	0.95	-	-	-
2	1.21	1.10	-	0.38	
3	-	1.30	-	0.65	-
4	-	1.20	-	0.5	-
5	-	0.2	-	-	-
6	1	1.2	-	1	-
7	-	1.20	-	0.55	0.50
8	-	2	-	0.65	-
9	0.6	1.1	-	1	-
10	-	1.20	0.8	1	1.00
11	-	2	1	-	-
12	-	1.2	-	1.2	-
13	2	0.3	1	0.5	-
14	-	-	-	-	-
15	1.20	1	-	-	-
16	0.8	1.3	-	0.8	-
17	1	1	-	1	-
18	1	1	-	-	-
19	1	0.8	-	-	-
No. of shafts with extractable thickness 0.8 m.	8		Unextractable seam	6	Unextractable seam
Stability Coefficient of thickness	$0.4 = \frac{8}{19}$	$0.85 = \frac{16}{19}$	Unextractable seam	$0.3 = \frac{6}{19}$	Unextractable seam
Mean thicknesses extractable	1.15	1.22	Unextractable seam	1.0	Unextractable seam

9 kilometres. The distance between the layers is about 1 kilometre. Layer B outcrops at an altitude of 2,200 to 2,750 metres and Layer D at an altitude of 2,280 to 2,650 metres. The coal deposits belong to District D and the coal has excellent cohesive properties. It contains 26.5 per cent volatile materials, 0.7 per cent sulphur, 17-20 per cent ashes and 0.08 per cent phosphorus. Thus it is of a high quality and, if other extractable seams are found, will be adequate for industrial and commercial use.

The geological surveys indicate that there are no extractable seams from Chenar Lukhanuk to Gardaneh. However, the continuation of Seams 5 and 8 yields extractable seams in places. Of the seams of Layer D, only 2 and 5 are extractable.

Their details are as follows:

Seam 2: General thickness: 102-600 cms. Average thickness: 255 cms.

Seam 2: Mean thickness: 51-600 cms. Average mean thickness: 216 cms.

Seam 5: General thickness: 108-358 cms. Average thickness: 200 cms.

Seam 5: Mean thickness: 8-283 cms. Average mean thickness: 148 cms.

The gradient of the seam is 50 to 90 degrees, the mean being 70 degrees.

Gallery 1, which has been dug at an altitude of 2,440 metres, stretches from north to south. Since the seams are displaced and intermingled so that their total thickness and composition cannot be easily calculated. An estimate of the reserves of this section is given in Table 8.

The productive potential of the seams of Layer D is as follows:

Seam 2: $0.9 \times 0.75 \times 1.5 \times 2.16 = 1,2$

Seam 5: $0.9 \times 0.\ 4 \times 1.5 \times 1.48 = 0.8$

Total: 2.9 tons per square metre.

The annual extraction from Layer D is:

$$300 \times 3 \times \frac{100}{\sin 70°} \times 2.9 = 280,000 \text{ tons of coal}$$

$$= 370,000 \text{ tons of mineral lumps.}$$

The annual extraction from Layer B is :

$$300 \times 3 \times \frac{100}{\sin 70°} \times 1.83 = 170,000 \text{ tons of coal}$$

$$= 230,000 \text{ tons of mineral lumps.}$$

7. *The Hejdak section:* This is situated at the south-east extremity of the Kerman syncline and stretches towards the Babnizoo section. In the north it meets the Eshkali section near Bidoo village. It has been divided into two parts by a large fault which passes by Hejdak village. Ranges B,C and D are

Table 8

Seam	Thickness (metres)	Computed Area (sq. m.)	Density (ton/cu.m.)	Coefficient of seam stability	Coefficient of Exploitation	Reserves (1000 tons)
			Layer D			
2	2.16	$\frac{2,380,000}{\sin 70°}$	1.5	1.75	0.9	5,550
5	1.48	$\frac{2,380,000}{\sin 70°}$	1.5	0.4	0.9	2,010
Tótal for Layer D.						7,560
			Layer B			
8	1,150.75	$\frac{980,000}{\sin 70°}$	1.5	0.4	0.9	490
7	1,220.75	$\frac{980,000}{\sin 70°}$	1.5	0.85	0.9	1,100
5			1.5	0.3	0.9	320
Total for Layer B						1,910
Total for both Layers						9,470

Production Potential of Seams in Layer B.

Seam 8	0.9 x 0.4 x 1.5 x 0.75 x 1.15 = 0.47
Seam 7	0.9 x 0.85 x 1.5 x 0.75 x 1.22 = 1.05
Seam 5	0.9 x 3 x 1.5 x 0.75 x 1 = 0.31
Total	1.83 tons per sq. metre.

found in this section. Some of the seams of Range C were worked for a short time but since the quality of the coal is inferior, operations have ceased.

Range D contains an extractable seam No.2, whose thickness varies between 2 and 13 metres and averages 3 metres. Seam 1, with a thickness of 0.4 to 0.7 metres, and Seam 'Zero", with a thickness of 0.3 metres, are also exploitable. Galleries 2 and 4 have been bored into this range and Seam 2 and parts of Seam 1 are being extracted. The gradient of the seams, is, on the average, 7 degrees.Gallery 2 has been dug at an altitude of 1,990 metres and Gallery 460 metres lower down. The extraction of Seam 2 has begun and its reserves are calculated as follows:

$$0.75 \times 0.3 \times \frac{600,000}{\sin 70^\circ} \times 15 \times 0.9 = 1,900,000 \text{ tons.}$$

If the extraction of the coal were begun at an altitude of 1,830 metres, annual production would be as follows:

$$0.75 \times 0.3 \times \frac{100}{\sin 70^\circ} \times 2 \times 1.5 \times 300 = 210,000 \text{ tons, i.e. } 270,000 \text{ tons of ore.}$$

The ash content of the coal is less than that of Tangal-Ravar, being about 10 to 20 per cent. It phosphorus content is also lower but it contains a great deal of sulphur which, when unconcentrated,constitutes 7 per cent of the total content, and when concentrated constitutes 3 per cent of the total content.

8. *The Eshkeli section:* This is situated on the southern edge of the north-east corner of the Kerman Syncline and extends to the borders of the Hejdak district. Seams of Range D have been found over a distance of 6.5 kilometres. 2 kilometres of this section have been cut by two galleries 100 metres apart and 90 metres above the other. Each gallery is 2,000 metres long.Short cuts, 100 metres apart, cross the seams. In each 300 metre space between Galleries 1 and 2, sloping galleries and ventilation shafts 70 to 110 metres long have been dug from Gallery 2 to the surface.

The major extractable seam is 1 to 9.6 metres thick (average 3 metres) but for a quarter of its length is too thin to work.Where the seams of Range D emerge, at a height of 2,400 metres, probable deposits are as follows:

$$3 \times 0.75 \times \frac{1,980,000}{\sin 75^\circ} \times 1.5 \times 0.8 \times 0.9 = 5,100,000 \text{ (thousand tons).}$$

The annual production of coal in this section is estimated as follows:

$$3 \times 0.75 \times \frac{100}{\sin 75^\circ} \times 2 \times 1.5 \times 300 = 210,000 \text{ tons of ore.}$$

The sulphur content of unconcentrated coal is 1.5 to 3 per cent but decreases with concentration.

9. *The Ghomrood section:* This section is situated north-east of the Kerman

syncline and borders on the Togharjeh section. It extends for 5 kilometres. Seams have been detected by means of 6 borings and several shafts. Three borings have given no positive results due to the great thickness of the marine sedimentations and the shafts have collapsed in three of the borings.

Conclusion

Every year a certain quantity of coal is required for the Steel Mill of Iran. The annual production capacity of the mill, which is being built in Esfahan, will be 550,000 tons of cast-iron or steel.This amount requires about 1,100,000 tons of coal annually. In the opinion of foreign specialists, especially the Kaizer engineers, the coal of the northern districts of Iran, i.e. that of the coal fields of Karmozd, Zirab etc., is unsuitable for this purpose since its reserves are doubtful. Hence there remains only the coal of the Kerman district whose reserves are being estimated by experts.

The coking coal reserve of Range D has been estimated at 36.3 million tons, and the power-producing coal of Range B at 13.8 million tons. The reserves are in 7 districts, as shown in Table 9.

Table 9
Coal Reserves in 1,000 tons

District	Range D	Range B	Total
Toghrajeh	8920	–	8920
Dehrood	3560	–	3560
Darrehgar	7400	–	7400
Darbid Khoon	3800	11800	15700
Bab Nizoo	7560	1900	9470
Eshkeli	3200	–	3200
Hejdak	1900	–	1900
Total	36340	13810	50150

Coals in Range D are cohesive and are suitable for coking as the component particles which cause their cohesion are 52 to 90 per cent in some seams and the ash content is high before concentration, sometimes reaching 10to 52 per cent. The sulphur content is variable. In Hejdak it is 7 per cent, which is too high and in the Toghrajeh section it is 1.2 per cent. After concentration in District 1 it falls to 3 per cent and in District 2 to 1 per cent. This means that, at the time of coking, all the coals should be concentrated so that, with the present production method, we can obtain the coke required for the Steel Mill.

The annual coke-extraction will amount to about 2.7 million tons, i.e. 2 million tons from the seams of Range D and 680 million tons from the seams of Range B.

Table 10 shows the amount of extraction distributed by the 7 districts of the Kerman field.

Table 10

District	Range D	Range B	Total
Toghrajeh	600	-	600
Dehrud	230	-	230
Darrehgar	300	-	300
Darbid Khoon	165	450	615
Bab Nizoo	370	230	600
Eshkeli	170	-	170
Hejdak	170	-	170
Total	2205	680	2685

On the basis of this table we can conclude that the three districts of Toghrajeh, Babnizoo and Darrehgar can yield 1,270,000 tons of ore and that this can meet about nine-tenths of the coking requirements.

In conclusion we might point out that this report does not deal with economic problems such as the cost of mining, the distance from the coal field to the mill and the place of consumption, the costs of construction of the workers dwellings, the creation of communications and roads, the transportation of coal from the galleries to the railways and the differences between costs of production and the price of coal. Instead we have confined our discussion to the amount of the coal reserve and the geological condition of each district.