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**PRACTICAL APPLICATION OF THE UNITED NATIONS
FRAMEWORK CLASSIFICATION FOR THE RESERVES/RESOURCES**

**Application of the United Nations Framework Classification
to the Turkish Lignite Deposits
Case Study: Yatagan-Eskihisar Mining Area, Turkey∗**

ABSTRACT

This study attempts to classify some Turkish lignite deposits according to the United Nations
Framework Classification for Reserves/Resources (UNFC). For this purpose, the Turkish Coal
Enterprises' concession areas of the Eskihisar, Yesil Bagcilar and Turgut deposits have been selected,
which all together are named as the Yatagan-Eskihisar Mining Area and Turgut-2 deposit. The study
also provides a short description of the Turkish lignite sector; and the current Turkish classification in
use for reserves and resources. The study shows that the UNFC could easily be adapted to the Turkish
lignite deposits.

1. INTRODUCTION

Mineral resources are available for different purposes and are usually classified in different ways
depending on the different interest and requirements of individual mining companies, mining
houses, investors, governments, international institutes [15]. This wide range of interest in
reserve/resource estimates and their classification underlines the importance of having a uniform
system that is flexible enough to meet all these demands.
The United Nations Framework Classification is the latest effort to introduce a universally
acceptable and internationally applicable scheme for classifying reserve/resource data, and

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represents an advance on conventional systems in three significant ways: Geological assessment, Feasibility assessment and Economic viability [19].

After the introduction of the UNFC worldwide in 1997 the Turkish Coal Enterprises (TKI), the largest lignite producer of Turkey, has applied it to its own lignite deposits and preliminary results have been obtained. In the light of further study it is understood that reclassification is necessary.

The solid fuel reserves/resources of Turkey mainly consist of lignite and some hard coal. The annual lignite and hard coal production is around 65 million tons and 2.2 million tons respectively. The lignite production wass equivalent to 7% of the total world production in 2001.

However, the quality of Turkish lignites is rather low. For instance, 66% of the total resources have a calorific value of between 1000 and 2000 kcal/kg. The characteristics of the lignite produced allow them to be consumed mainly for electricity generation (85%) and on a minor scale (15%) for household and industrial consumption. Despite the increasing annual lignite production resulting from the increasing demand for electricity generation; the high energy consumption rate has caused the share of lignite in total generated electricity to decrease from 42% (1985) to 27% (2001). By 2002, there was a sharp decrease in domestic lignite demand for electricity due to imported natural gas fired power stations.

In this study; after briefly introducing of the classification system used in Turkey, TKI's concession areas of Eskihisar, Yesil Bagcilar, Turgut deposits which are all together named Yatagan-Eskihisar Mining Area and Turgut-2 deposit which is not already in operation are classified according to UN Framework Classification based on three criteria: Geological Assessment, Feasibility Assessment and Economic Viability.

2. CLASSIFICATION OF SOLID FUELS (LIGNITE) RESERVES/RESOURCES IN TURKEY

- In Turkey, there is no unique system for the classification of reserves/resources- solid fuels and mineral commodities. The system currently in widespread use is mainly based on western classification systems such as that of the United States of America.

- There is terminology chaos in the usage of the terms "reserve" and "resource". Most commonly in practice the term "reserve" corresponds to both "reserve" and "resource" for lignites. However, in the official records, a small quantity is classified as "potential resources" that are currently not economic but may possibly be so in future.

- Lignite reserves in Turkey are categorized as proven, probable and possible. The classification is made according to geological assessment.

Proved Reserve: is a reserve that geological assurance has identified in three dimensions, and has the lowest risk for its continuity within these dimensions. A decision to conduct a feasibility study can be made from the information provided by detailed exploration.

Reserve tonnage, densities, grade and mineral contents are estimated from locations such as outcrops, trenches, pits and drill-holes. The locations for inspection, sampling and measurement are so closely spaced and their geological character so well defined that the size, shape and mineral content are well established.

In practice, the acceptable error limit is ± 20%.

Probable Reserve: is a reserve that geological assurance has identified in two dimensions by completed prospecting, geological and geophysical studies. Because of the low level geological certainty, probable reserves do not provide a reliable statement on economic viability.

Tonnage and grade are estimated partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geological evidence. The locations for inspection, sampling and measurement are too widely or otherwise inappropriately spaced to outline the reserve or to establish its grade throughout.

In practice, the acceptable error limit is ± 40%.

Possible Reserve: is a reserve whose dimensions geological evidence has not sufficiently determined, but which is expected by partly completed prospecting, geological and geophysical studies. The level of confidence is not sufficient to allow a prefeasibility study to be carried out.

Quantitative estimates are largely based on a broad knowledge of the geological character of the deposit for which there are few, if any, samples or measurements. These estimates are based on an assumed continuity or repetition for which there is geological evidence: this evidence may include comparison with deposits of a similar type.

In practice, the acceptable error limit is ± 50%.

- In addition to these terminologies two others, defined below, are used in practice:

Extractable Reserve: is the tonnage within the proved amount in place that the estimated losses to be occurred during mining operation depending on geological and technical factors are deducted from proved reserve. The percentage of losses varies according to mining methods. In general, 10% for open-pit mines and 25% for underground mines are accepted.

Developed Reserve: is the reserve that belongs to active open pit mines whose overburden had been excavated completely or ready for Dragline operations.

- After estimating reserve/resource quantities based on geological assessment, the economic viability of the deposits is estimated from the mining reports for the active mines and from the feasibility studies for the deposits that will be mined in the near future. Also preliminary evaluation of the economic viability of the deposits is done by application of cut off values from comparable mining operations.

- However there are no generalized, predefined criteria for the cut off values as in the other countries for the depth, thickness, ash and sulphur contents, calorific value etc. The most commonly used criteria are ≥ 1000 kcal/kg for calorific value, ≤0.5 m dilution thickness of intermediate rocks to the coal seam.

- According to the current classification system of Turkey, lignite reserves/resources are categorized as follows (by 2002):

Proved reserves	6 932 Mt
Probable reserves	841 Mt
Possible Reserves	153 Mt
TOTAL RESERVES	7 951 Mt
Potential resources	308 Mt
GENERAL TOTAL	8 259 Mt

- While 75% of this total quantity belongs to public owned companies, the remainder belong to the private sector.

3. UN FRAMEWORK CLASSIFICATION

The United Nations International Resources Framework Classification was developed by the United Nations Economic Commission for Europe Working Party on Coal and distributed worldwide in 1997 [20].

The methodology of classifying resources is based on three stages: Geological Assessment (G), Feasibility Assessment (F) and Economic Viability (E). Each stage is subdivided into consecutive stages (Figure 1). In order to make this system short and easy to understand, each sub-stage is coded by a number. The digits are quoted in the order of EFG. The numbers are used to designate different classes, the lowest number, 1st, is the best, referring to the highest degree of Economic Viability on the E axis and the highest assurance on the F axis and G axis [20].

The class coded as 111 (the shaded block in Figure 1) is of prime interest to investors as it refers to quantities that are economically mineable, have been proved by means of a feasibility study or actual mining and is based on detailed exploration [20].

The most commonly used classes based on the UNFC are as follows [20]:

Code	Term
111	Proved Mineral Reserve
121 and 122	Probable Mineral Reserve
211	Feasibility Mineral Resource
221 and 222	Pre-feasibility Mineral Resource
331	Measured Mineral Resource
332	Indicated Mineral Resource
333	Inferred Mineral Resource

334   Reconnaissance Mineral Resource

Yatagan-Eskihisar Mining Area

The Yatagan-Eskihisar lignite basin is located in the south-eastern part of Turkey between Muğla – Yatagan district, Bagcilar and Turgut villages (Figure 2). The first studies in the basin were initiated in 1956 [8] and the Eskihisar Open Pit Mine covering three deposits – Eskihisar, Yesil Bagcilar and Turgut – has been exploiting since 1979. Production is designed to supply the power generation market (Yatagan Power Station) and households with a capacity of 3,300,000 tons/year and 200,000 tons/year respectively [11].

In this study, information was derived from various reports of the Mineral Research and Exploitation General Directorate and Turkish Coal Enterprises since 1956. In addition field studies were carried out in the mining area by analysing mining reports.

In the following sections some essential factual data concerning the geological and feasibility assessment and economic viability are given by following the Guidelines [19] and Key for Classification[21] documents.

4.1. Geological Assessment

Geology:
Details of the Yatagan-Eskihisar formation stratigraphy are shown in Figure 3. The lignite deposit consists of a unique coal seam which has an average thickness of 11.7 m. The coal seam of the middle miocene age was basically formed by coal and clayey coal. It is quite jointed and laminated and its inclination is relatively low and has uniform thickness. However inclination increases at the boundary of the basin up to 25-30°.

Neogenic deposits including coal seam were settled in a narrow graben area surrounded by high schist and marble basement (Figure 3). This tectonic structure causes slope stability problems at the boundary of the basin. In order to take precautions, detailed geotechnical [14], [17],[18] and geophysical studies [2] were carried out. Results obtained were applied successfully to the opencast mining area.

Geotechnical and geophysical studies carried out during the exploitation period show that faults are frequently repeated (50-100m) with low throw in the directions of NE-SW and NW-SE. Since these normal gravity faults have low throw, they do not seriously affect operations.

Exploration:
The exploration of the deposit on which mining activities are going on was mainly done by drilling. Before starting operation of the mine, 170 drillholes were completed with an average spacing of 250m [9]. In order to increase the reliability of data related to tectonism, stratigraphy, limits of open pit mine, thickness, quality, about 130 drillholes of 50-100m spacing were made during the exploitation period. Thus detailed explorations were carried out in the Eskihisar Mining Area. The dispersion of the drillhole locations, first and last open pit limits are shown in Figure 4.

In Turgut 2 deposit, 6 drillholes with 400-600m spacing were made in TKI's concession area. For this deposit, general exploration was done.

Quality:
The lignite quality is characterized by the following values:

	Eskihisar Mining Area	Turgut-2 Deposit
Average Calorific Value (kcal/kg)	2100	2310
Average Moisture Content (%)	36	–
Average Dry Ash Content (%)	32	32
Average Total Sulphur Content (%)	1.9	–

Hydrogeological Studies:
Before the mining operations, in 1975, hydrogeological studies showed that no water problems would be faced [5]. However, during detailed geotechnical studies carried out in 1990, a small scale hydrogeological study showed the existence of a water problem and to overcome this a drainage channel (shown in Figure 7) was recommended [17]. An unexpected large amount of water flow (75 lt/sec) was faced during exploitation and so water was transferred to a drainage channel via steel pipes [7].

Reserve Estimation:
The Polygon method was used in reserve estimation. In order to increase the reliability of the estimation, a geological coefficient factor ranging from 0.8 to 1.0 was taken. This factor was established depending on drillhole spacing, tectonic structure, drillhole closeness to deposit boundary.

118 million tons of proved reserve, and 106 million tons of extractable lignite were estimated for the Eskihisar Mining Area during the feasibility study [10]. Values for the produced lignite, unmined part of the mine and Turgut-2 deposit are tabulated in Tables 1 and 2.

The reserves were estimated based on the following criteria [10]:
- Intermediate rocks (clay, silt, marl) which have ≤ 0.5 m thickness were included in the coal seam (calorific value= 0, moisture content = average log value were accepted).
- Coal bearing clays which have ≤ 1.0 m thickness were included in coal seam.
- Coal bearing silts which have ≤ 0.8 m thickness were included in coal seam.
- Specific gravity was taken as 1.5 t/m^3.

When carrying out this study; the reserves of Eskihisar-2 and Y.Bagcilar-2 deposits shown in Figure 7 were included in Eskihisar Open Pit limits and the reserve/resource quantity of Turgut-2 deposit was re-estimated.

Average stripping ratio ("waste material":"extractable lignite") of the Eskihisar Mining Area is 4.1. Stripping ratio curves for the unmined part of the deposits are shown in Figure 5.

Archaeological Studies:

In the studied area; archaeological studies have continued on the ancient city of Stratonikeia since 1967[1]. About four million tons of coal were left as a pillar in this area. Initiation of mining operations in the district resulted in accelerating exposure of the ancient civilisation.

Detail geophysical studies done by TKI [3] in parallel with mining operations are enabling both the exposure and transfer without damage of the buried ancient graves in Stratonikeia and continuity of mining operations. To date about 200 graves have been exposed (Figure 6)[3].

Other Studies, Tests and Analyses:
The following studies, tests and analyses have been carried out for the Eskihisar Mining Area: washability, carbonization, chemical analyses, elementary analyses, mineralogical analyses, physical analyses, ash analyses (including melting and flowing temperatures), grindability test, combustion of coal in boilers and stoves, ASTM Classification [16], uranium analysis [12], briquetting [13], utilization of marl as a raw material of cement [13].

4.2. Feasibility Assessment

As stated before, production is designed to supply the power generation market (Yatagan Power Station) and households with a capacity of 3,300,000 tons/year and 200,000 tons/year respectively. Actual figures of saleable production, average calorific values, sales, overburden removal amount are shown in Table 1. As can be seen from the table, sales to households have decreased since 1995 due to environmental regulations.

The layout scheme (Figure 7) shows the mined-out area, industrial plants and administrative buildings, recultivated dump area and unmined part of the deposit. Dump areas are returned to nature by afforestation; 796,000 trees have been planted on the 294 hectare site since 1991.

Table 1. Actual Production, Sales, Overburden Removal, Quality Values by the Years

| Years | Saleable Production (t) | Ave. Calorific Value (kcal/kg | SALES | | | Overburden Removal (m^3) |
			Power Station (t)	Household (t)	TOTAL* (t)	
1979	58,946			58,946	58,946	798,302
1980	345,506			345,506	345,506	1,461,766
1982	422,246	1,629	207,742	214,504	422,246	2,498,268
1985	4,132,667	2,025	4,007,489	120,728	4,128,217	12,874,932
1990	3,150,260	2,042	2,958,677	154,520	3,113,197	7,991,000
1995	2,291,530	2,101	2,259,530	7,747	2,267,277	10,849,000
2000	3,647,967	2,054	3,619,418	20,667	3,640,085	18,423,662
2002	3,238,911	2,081	3,221,515	10,022	3,231,537	13,896,055
2003**	1,121,411	2,101	1,112,813	3,397	1,116,210	4,203,000
TOPLAM	59858318		56,861,259	2835121	59696380	244,041,584

*Difference between sales total and production figures gives internal consumption
**by 01.07.2003

Equipment in Use:

For overburden removal, dragline (60 yd3)- Excavators (15 yd3) and trucks (85 ston) are in use while excavators (10 yd3) and bottom dump trucks (150 ston) are allocated for coal production and transportation.

Feasibility Study:
Depending on the cash flow analysis, it was determined that the project was feasible. Mining reports also showed the feasibility of the Eskihisar Mining Area[7]. However, there are no prefeasibility and/or feasbility studies for the Turgut-2 deposits.

4.3. Economic Viability

Factors mainly affecting economic viability are the stripping ratio and competing price of other energy sources.
The economic viability of the Eskihisar Open Pit Mine was determined by evaluating actual mining reports. Financial analyses of the mine show that the mine is profitable except for the last three years, 2000, 2001, 2002 due to the transfer pricing policy. As a state owned company, TKI sells its own production to another state owned Electricity Production Company (EUAS). The price of lignite given to the power station is not therefore determined on the competitive market.

In fact, because of the low stripping ratio (4.1 m3/ton), production costs are quite low. However, in comparison to other fuel sources with the same calorific value base, the established coal price is quite low. Consequently, the mine is in fact profitable.

However, a small deposit in the mining area named Turgut is unecenomic under current mining, economic conditions. This deposit will of necessity be operated as a separate mine because there is a corridor shaped deposit owned by the private sector between the Turgut and Yesil Bagcilar deposits (Figure 4). Paying high expropriation costs to exploit a very small quantity is not economic.

For the Turgut-2 deposit, preliminary economic viability may be estimated from the comparable mining operations. But it is not a reliable statement since it is not based on any prefeasibility and/or feasibility studies.

5. COMPARISION OF CLASSIFICATION RESULTS

Classification of the deposits according to the Turkish Classification System are given in Table 2.

Table 2. Classification of the Deposits According to Turkish Classification System

(1000 t)

	OL*	Deposit	Proved	Probable	Possible	Developed	TOTAL
Eskihisar Mining Area	7200	Eskihisar	36,918 (33,226)	-	-	404	37.322
		Y.Bagcilar	8,107 (7,296)	-	-	-	8.107
	3303	Turgut	1,327 (1,194)	-	-	-	1.327
	Total (in operation)		*46,352 (41,717)*	*-*	*-*	*404 (404)*	*46,756 (42,120)*
	Pillars**		8.266	-	-	-	8.266
Turgut-2	3303	Turgut-2	4,222 (3,800)	-	-	-	4.222
TOTAL			**58,840 (45,517)**			**404 (404)**	**59,244 (45,921)***

* Operating Licence numbers
** Pillars left for ancient city, landslide and Milas highway
*** ( ) Extractable reserve

According to the aforementioned sections of which geological assessment, feasibility assessment and economic viability; the deposits were classified based on the UNFC (Table 3).

Table 3. Classification of the deposits based on UN Framework Classification

(1000 t)

UN FRAMEWORK CLASSIFICATION → ↓	ULUSAL SISTEM	Detail Exploration/ Exploration During Exploitation — Detay Arama/ İşletme Dönemi Aramaları	General Exploration — Genel Arama	Prospecting — Prospeksiyon	Reconnaissance — Ön Arama
Feasibility Study and/or Mining Report	Fizibilite Çalışması ve/veya Madencilik Raporu	1 45,429 (111)* 40,886 (111e)** 2 1,327 (211)*** 3 8,266 (311)****	usually		
Prefeasibility Study	Ön Fizibilite Çalışması	1 (121) 2 (221)	+ (122) + (222)	not relevant	
Geologic Report	Jeolojik Rapor	(1-2) (331)	(1-2) 4,222 (332)*****	(1-2) (333)	(1-2) (334)

Economic Viability Categories:
1: Economic
2: Potentially Economic
1-2: Economic to Potentially Economic (Intrinsically Economic)

* Eskihisar and Y.Bagcilar Deposits
** Exctractable reserve of Eskihisar and Y.Bagcilar deposits
*** Turgut Deposit
**** Pillars left for ancient city, landslide and Milas highway
***** Turgut-2 deposit

Date: July 2003

The Eskihisar and Yesil Bagcilar deposits were classified as "proved mineral reserve" (EFG:111) because in detailed exploration studies have been completed, mining operations are still underway and there is a guaranteed market, i.e. Yatagan Power Station.

Although all detailed exploration and feasibility studies satisfy needs the Turgut deposit was classified as "feasible mineral resource" (EFG:211). Because of high expropriation costs of exploiting a very small quantity it is uneconomic under current conditions.

The quantity belonging to the pillars left for ancient city, landslide and Milas Highway was classified as "EFG:311" which is usually not a relevant part of the UNFC because they will never be operated.

The Turgut-2 deposit was classified as "indicated mineral resource" (EFG:332). Exploration, sampling, testing information from the drillholes are too widely spaced. It has no prefeasibility or feasibility studies. Preliminary economic viability of the deposit may be estimated from comparable mining operations, but it is not a reliable statement.

- When the Turkish Classification System is compared with UNFC; the main difference comes from the point of view of the economic viability criterion, since the Turkish Classification System is based exclusively on geological assessment.
- Extractable reserve is shown as "111_e" in the UN Framework Classification using the letter "e" as a subscript to mean extractable [4]. There is a difference in the extractable reserve between these two classification systems. Uneconomic quantities were not classified as extractable reserves in Table 3. Since the Turkish Classification System is based on geological assessment, extractable reserves are estimated by deduction of the losses from all proved reserves without evaluating the economic viability of the deposit.
- The term "Exploration during exploitation" was added to the detailed exploration part of the UNFC because condense drilling studies are carried out during exploitation [4].
- While the Turgut-2 deposit was classified as "proved reserve" based on the Turkish Classification System, it was classified as "indicated mineral resource" based on the UNFC. The difference between these two classifications comes mainly from the difference in the level of geological confidence and again economic viability criterion.

6. CONCLUSION AND RECOMMENDATIONS

This study shows that the UNFC can be adapted well to Turkish lignite deposits.

When the Turkish Classification System is compared with UNFC the main difference comes from the point of view of economic viability criterion, since the Turkish Classification System is based exclusively on geological assessment.

The UN Framework Classification provides a guideline in preventing terminology chaos which is one of the important problems for Turkey, particularly for the terms of "reserve" and "resource".

The following benefit was gained by this study:
- All related data were collected from various reports, analysed and put into order in the form of geological assessment, feasibility assessment and economic viability.

- The reserves of Eskihisar-2 and Y.Bagcilar-2 deposits shown in Figure 7, were included in the Eskihisar Open Pit limits.
- A re-estimation of the reserve/resource quantity of Turgut-2 deposit was carried out.
- Consistency of the reserves/resources figures between the operation management (Yatagan-Eskihisar) and TKI Headquarters was provided.
- By this study, an evaluation of the mining area based on "economic viability" was carried out.
- Operation management will carry out its planning studies for the future based on more reliable reserve data.
- This study will be taken as a model and/or guideline for the classification of other basins.

For future studies; the most commonly used cut off values in the reserve/resource estimations should be compiled countrywide and all information derived therefrom should be stored into a shared database for easy updating of the classification due to changes in economic, environmental, legal and mining, technological conditions.

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Figure 1: UN Framework Classification [20]   Figure 2: Locations of the lignite deposits
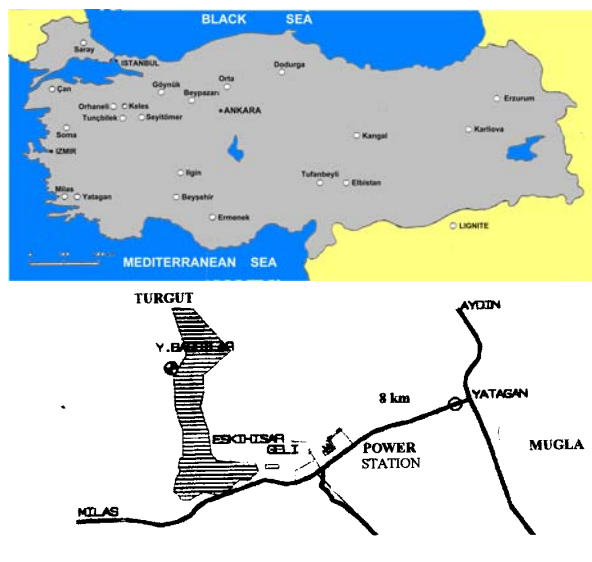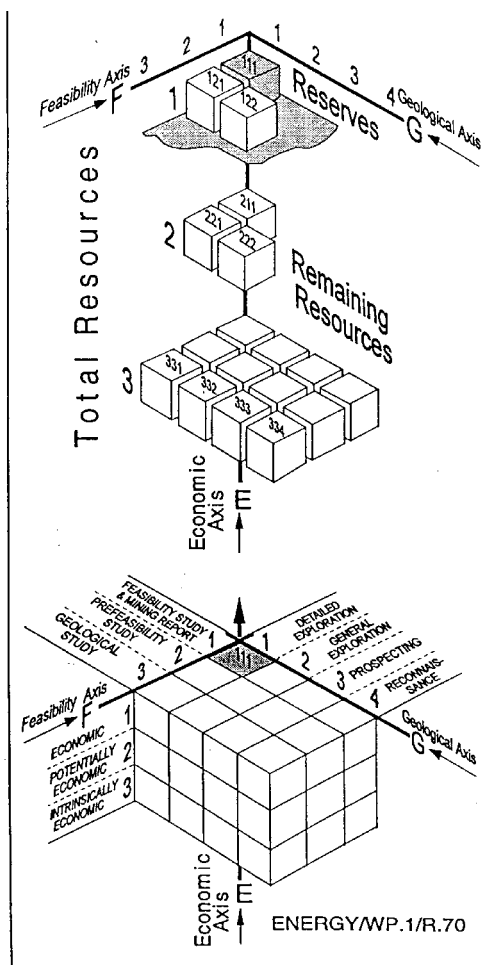
Figure 3: Generalized stratigraphical section [7]

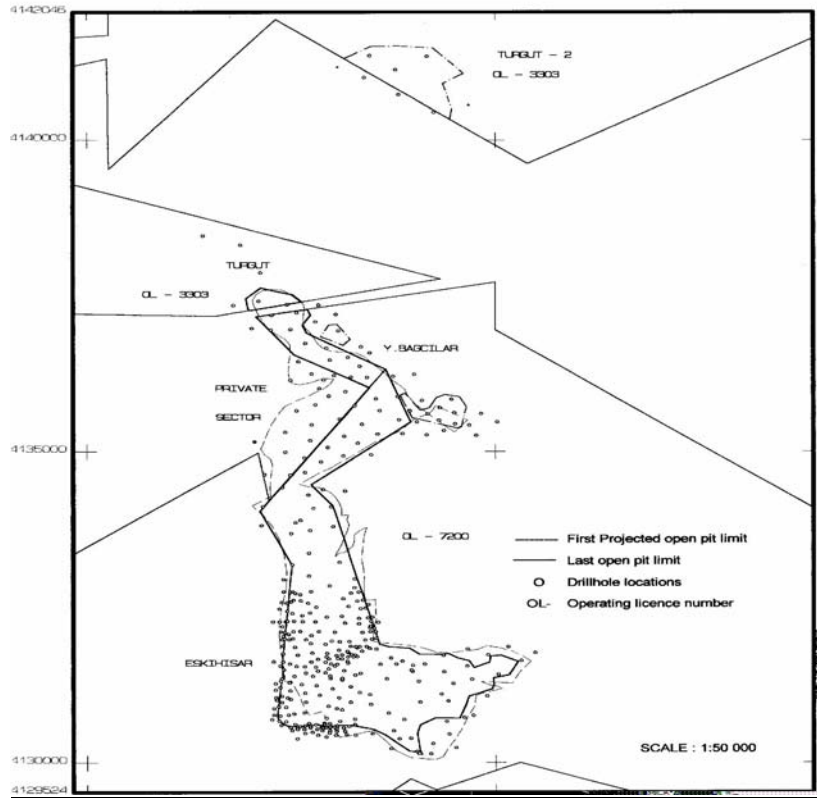|		FORMATION	LITHOLOGY	MAX. THICKNESS (m)	DEFINITION
CENOZOIC	MUGLA GROUP	Yatagan		~ 50	SANDSTONE (with conglomerate lenses)
		Sekkoy		~ 60	LIMESTONE and CONGLOMERATE
				~ 25	CLAY, CLAYEY SILT
				~ 90	CLAYSTONE, LIMESTONE, MARL(above) COMPACT MARL(below)
				~ 20	LIGNITE
		Turgut		>180	CLAY, SILT
Meso.				?	MARBLE
Palae				?	SCHIST

Figure 4: Locations of drillholes

Figure 5. Stripping ratio curves of unmined part of Eskihisar Mine.
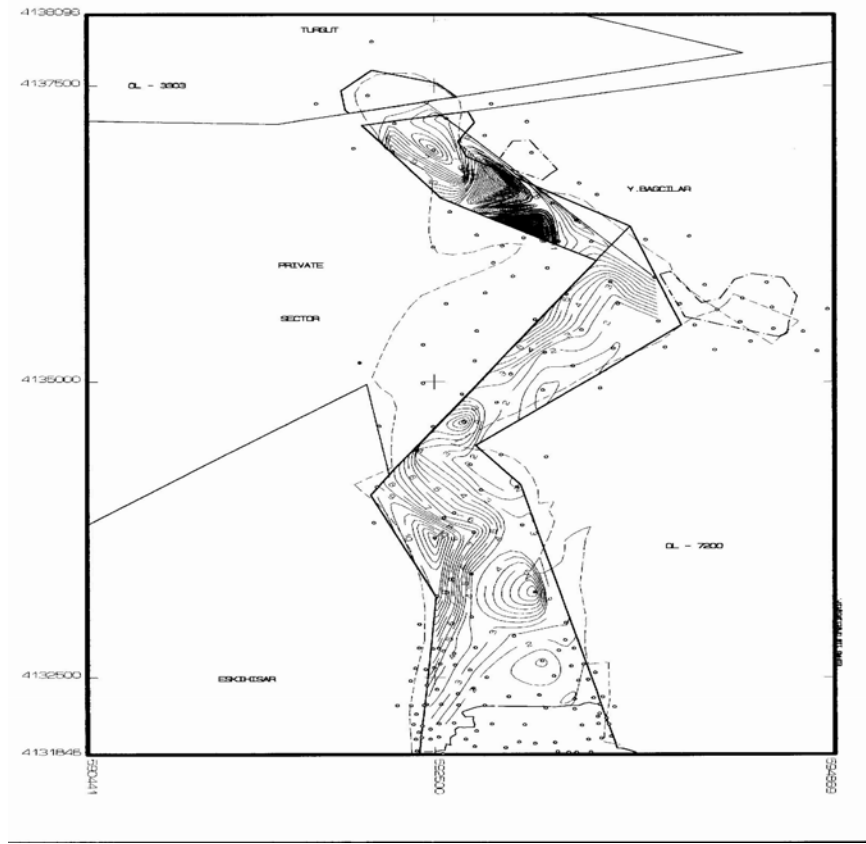

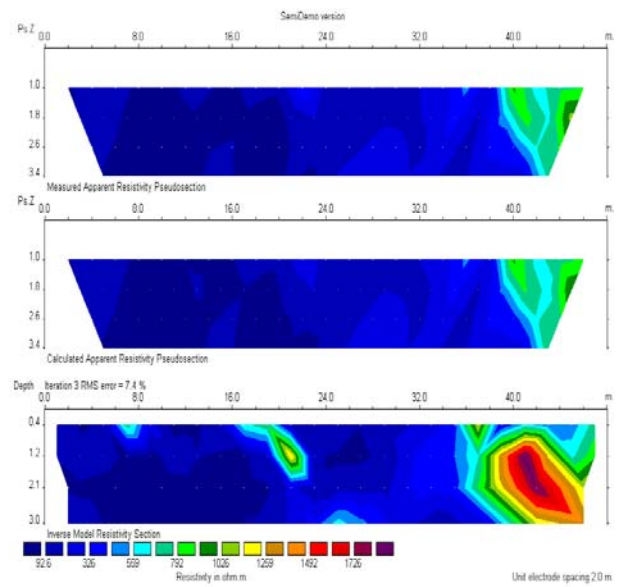Figure 6: Determining locations of ancient graves by geophysical studies

Figure 7: Layout of Eskihisar Mining Area