REPUBLIC OF TÜRKİYE
MINISTRY OF ENERGY AND
NATURAL RESOURCES

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Critical and Strategic Minerals Report

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PREFACE

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In contemporary society, the swift advancement of technology and industry significantly shapes the way of life of mankind and influences the global economy. The primary element that underpins this transformation is the natural resources found within the Earth's crust, namely minerals.

Critical and strategic minerals significantly contribute to the sustainability, security, and prosperity of contemporary societies. These minerals hold considerable significance in military, economic, and industrial sectors, possessing the capacity to influence both the economic strength and military capabilities of a nation.

In particular, rare earth elements play a significant role in a multitude of contemporary technologies, ranging from guided missile to electronic and magnetic materials, as well as renewable energy solutions such as wind turbines.

The appropriate and sustainable utilization of critical and strategic minerals is of paramount importance for a nation's national security and economic competitiveness. This necessity arises from the fact that the extraction, refinement, and distribution of numerous strategic minerals entail complex and demanding processes.

Each nation identifies its critical and strategic minerals through an assessment of its resources and requirements. In this context, various criteria such as national security, economic growth, technological development and sustainable development are considered. In addition, the industrial structure, technological infrastructure and trade policies of countries are also effective in determining critical and strategic minerals.

Identifying the critical and strategic minerals of our country will facilitate the efficient utilization of our resources, promote investments in research and development as well as

technology, and foster the growth of the domestic industrial ecosystem. This is closely linked to our national interests and the future prosperity of our nation.

This report has been prepared by the Department of Natural Resources to identify the critical and strategic minerals of Republic of Türkiye. I would like to express my gratitude to my colleagues, the Secretariat of Defence Industries, Turkish Statistical Institute, and the Ministry of Industry and Technology for their valuable contributions to the preparation of this report.

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Critical and strategic minerals constitute a fundamental class of commodities essential for the manufacturing processes across numerous industrial sectors. These minerals play an indispensable role in the production of a diverse array of technologies and goods.

Critical and strategic minerals are the basic building blocks for the development of modern technology and industry. They are used in many industrial sectors such as electronics, computers, communications, energy, defense, automotive and aerospace. Without these commodities, many advanced technologies and devices cannot be produced.

Critical and strategic minerals, which play an important role in the energy production and transportation sectors, are needed for the production of many sustainable energy sources, especially renewable energy technologies, solar panels and wind turbines. Critical and strategic minerals are also widely used in electric vehicles and hybrid vehicles.

Critical and strategic minerals play a critical role in the technological development, energy production, defense, health and economic security of modern societies. Effective management of these materials helps countries create a more sustainable and secure future in terms of security, economy and environment. Identifying these materials is also a critical step for countries to understand and effectively utilize their resources.

Leading nations that identify critical and strategic minerals make strategic plans by taking into account their own resources and national interests, and may prioritize different raw materials depending on various factors. As an illustration, raw materials critical for the defense industry, the production of electronic devices, and energy production are among the priorities of the United States. Japan, as a foreign-dependent country, attaches great importance to the security of supply of critical and strategic minerals.

I believe that this report, prepared by the Department of Natural Resources and identifying the critical and strategic minerals of our country, will contribute to the formulation of our country's policies and strategies and projections for the future. I would like to thank those

who carried out and contributed to this valuable work and wish it to be beneficial for our country.

1. Introduction

Mineral commodities are indispensable for economic growth and development. In the defense industry, telecommunication, renewable energy production, transportation, health sector and many similar fields, various minerals are used more and more widely with the developing technology.

Although mineral commodities are formed in different parts of the world, some commodities are relatively more abundant in various regions. As a result, the production of many raw materials is concentrated in a few countries. China dominates the market for rare earth elements, while Chile is the largest copper producer. South Africa and Russia are the largest producers of platinum group elements.

Differences in political, social, environmental, and other parameters in these countries that influence mineral supply cause sudden fluctuations in market prices as well as supply security problems. In addition, the environmental and health problems caused by mining activities have been attracting more and more attention recently, and these problems are becoming another factor in the possible restrictions in mineral supply. These situations necessitate countries to develop policies on the supply, demand and production of mineral commodities. The Critical and Strategic Minerals study has been prepared to respond to this requirement for our country.

Studies on critical and strategic minerals conducted by developed countries and unions such as the United States of America and the European Union, which are important factors on the supply and demand side of the mining sector, shed light on the determination of the short-medium term natural resource policies of countries. In these studies, the mineral products of countries are analyzed starting from the amount of resources, along with their reserve and production values, and their import and export situations are evaluated. In this way, parameters such as supply risk, economic importance and import dependency for mineral products will be revealed with quantitative data and a fundamental step will be taken in the process of determining natural resource policy.

2. Critical and Strategic Minerals Assessment

In order to identify the critical and strategic minerals of our country, global studies such as those of the European Union, the United States of America and Japan were examined and the methods applied were analyzed. The usage of similar methods in the previous studies is considered important in terms of understanding the evaluations of different countries more clearly.

2.1. Methodology

Critical Minerals: Minerals that are one of the basic inputs of industrial production and carry a high supply risk, where serious economic problems or supply security vulnerability may arise in case of supply disruption or high price increases.

Strategic Minerals: Minerals that are of fundamental importance for national security and economic prosperity and whose supply may be restricted due to internal or external factors.

In the study, first of all, globally important minerals were designated as candidate minerals. Criticality scores were calculated for 37 minerals in this candidate minerals list for which calculation data could be clearly obtained.

A total of 63 candidate minerals were designated to identify critical and strategic minerals for Türkiye (Table 1). While identifying candidate minerals;

- Import-Export Figures
- Herfindahl-Hirschman Index (HHI)
- Previous Studies
- Global Critical and Strategic Mineral Lists have been taken into consideration.

Table 1: Candidate Minerals

Gold	Boron	Phosphate	Tin	Magnesite	Pumice	Tantalum
Aluminum/Bauxite	Mercury	Gallium	Kaolin	Metallic Silicon	Potassium	Tellurium
Antimony	Zinc	Germanium	Limestone	Molybdenum	Rhenium	Titanium
Arsenic	Iron	Graphite	Cobalt	Rare Earth Elements	Rhodium	Thorium
Copper	Diatomite	Silver	Coal	Nickel	Rubidium	Trona
Barite	Natural Stones	Hafnium	Chromium	Niobium	Selenium	Tungsten
Bentonit	Diamond	Indium	Lead	Palladium	Cesium	Uranium
Beryllium	Feldspar	Gypsum	Lithium	Perlite	Scandium	Vanadium
Bismuth	Fluorite	Cadmium	Manganese	Platinum	Strontium	Zirconium

After the identification of candidate minerals, criticality score calculations were performed for 37 minerals among the fundemental minerals for Türkiye in the first stage (Table 2). While determining critical minerals among the candidates, criterias given below are taken into account.

- Global Critical and Strategic Raw Mineral Lists
- Minerals Used in the Renewable Energy Sector
- Foreign Trade Data
- Market Status
- Political Stability

Table 2: Critical Minerals Selected from the Candidates

Critical Minerals		
Aluminum	Fluorite	Lithium
Antimony	Gallium	Manganese
Arsenic	Germanium	Magnesite
Copper	Graphite	Molybdenum
Barite	Silver	Rare Earth Elements
Bentonite	Indium	Nickel
Beryllium	Cadmium	Niobium
Bismuth	Tin	Palladium
Boron and Borate Minerals	Kaolin	Platinum
Mercury	Cobalt	Titanium
Zinc	Coal	Trona
Iron	Chromium	
Feldspar	Lead	

Table 3: Criticality Subcategories Used in the Assessment of Critical and Strategic Minerals

Weight (%)	Category	Sub Categories
25	**Supply risk**	depletion time
		reserve concentration
		ore production concentration
		country reserve concentration
		country production concentration
25	**Price risk**	price change
		price volatility
25	**Demand Risk**	mine production change
		domestic demand growth
20	**Recycling Restriction**	stockpiles
		recyclability
5	**Potantial risk**	possibility of usage restrictions

Each of the 12 subcategories was assigned either 0, 1, 2, or 3 points. In the calculation of "reserve density", 3 points are given for minerals with a ratio of a country's reserves to global reserves of more than 90% on a global scale, 2 points for 80-90%, 1 point for 70-80%, and 0 points for densities less than 70%.

For each of the 12 subcategories, scores are combined into a single criticality score using weighting factors. In the assessment of critical and strategic minerals for Türkiye, supply risk, price risk and demand risk each contribute 25% to the total score, while recycling risk and potential risk each contribute 20% and 5% respectively. The weighting between subcategories within each risk category is equivalent. Finally, criticality scores were determined for each of the 37 minerals, with those receiving a score of 16 or higher deemed to be of high importance as critical minerals.

2.1.1. Rating Criterias, Weighting Factors and Data Used for Evaluation

The evaluation of criticality scores is based on data sourced from official reports disseminated by the Ministry of Energy and Natural Resources, its affiliated entities, and relevant international organizations (Table 5). The maximum criticality score, derived through weighted analysis, was established at 35.

2.1.1.1. Depletion Time

The static depletion time is determined separately for each year and is calculated as the ratio of the amount of reserves to global mineral production in the year under consideration.

$$\text{Depletion Time (DT)} = \frac{\text{Reserve (tonnes)}}{\text{Global Production (tonnes)}}$$

2.1.1.2. Reserve Concentration

Reserve Concentration is also determined for each year and is calculated using the reserves of the country with the highest reserves in the year under consideration / global reserves.

$$\text{Reserves Concentration (RC)} = \frac{\text{Reserve of the Top Country (tonnes)}}{\text{Global Reserve (tonnes)}} * 100$$

2.1.1.3. Production Concentration

Production concentration is calculated separately for each year. It is calculated by dividing the production of the country with the highest production in the year under consideration by the global production.

$$\text{Production Concentration (PC)} = \frac{\text{Production of the Top Country (tonnes)}}{\text{Global Production (tonnes)}} * 100$$

2.1.1.4. Country Reserve Concentration

It is obtained by calculating the ratio of the country's reserve of the relevant mineral to the global reserve.

$$\text{Country Reserve Concentration (CRC)} = \frac{\text{Conuntry Reserve}}{\text{Global Reserve}} * 100$$

2.1.1.5. Concentration of Country Ore Production

It is obtained by calculating the ratio of the amount of production of the relevant mineral in the country to the global production amount.

$$\text{Concentration of Country Ore Production (CCOP)} = \frac{\text{Country Ore Production (tonnes)}}{\text{Global Production (tonnes)}} * 100$$

2.1.1.6. Price Change

The price change is evaluated for each year and is calculated as the ratio of the mineral price in the year under consideration to the mineral price in the reference year. In the calculations, 2018 is accepted as the reference year.

$$\text{Price Change (PC)} = \frac{\text{Recent Price } {}^{\$}/_{\text{tonnes}}}{\text{Reference Year Price } {}^{\$}/_{\text{tonnes}}} * 100$$

2.1.1.7. Price Volatility

Price variability calculations are evaluated for each year and are the ratio of the highest price of the mineral in the specified range to the lowest price in the same range. Prices of minerals between 2018 and 2023 are used in price variability changes.

$$\text{Price Volatility (PV)} = \frac{\text{Highest Price } {}^{\$}/_{\text{tonnes}}}{\text{Lowest Price } {}^{\$}/_{\text{tonnes}}} * 100$$

2.1.1.8. Mine Production Change

The change in mineral production quantities is assessed for each year and calculated as the ratio of mineral production in the year under review to the mineral production in the reference year.

$$\text{Mine Production Change (MPC)} = \frac{\text{Production (tonnes)}}{\text{Production in the Reference Year (tonnes)}} * 100$$

2.1.1.9. Domestic Demand Growth

Domestic demand growth is made for each year. The rate of increase in imports of the relevant mineral compared to the previous year is used in the calculation of domestic demand growth.

$$\text{Domestic Demand Growth (DDG)} = \frac{\text{Import Amount (Tonnes)}}{\text{Import Amount of the Previous Year (Tonnes)}} * 100$$

2.1.1.10. Stockpiles

Stockpile scoring is determined by the status of the stock program for the relevant mineral. With the establishment of stock programs for specific minerals, the risk scores from this assessment decrease.

2.1.1.11. Recyclability

Recyclability is defined as the recovery of end-of-life materials as raw materials by applying various processes. In recyclability calculations, the ratio is determined by dividing the raw material obtained from recycling by the global raw material production and is shown in Table 4.

Table 4: Recyclability Rates

Recyclability Rates (%)	Description
0-10	Very Limited
10-30	Partially Applicable
30-100	Applicable

2.1.1.12. Possibility of Usage Restrictions

Considering the toxicity of minerals in the possibility of restriction of use, future restrictions are evaluated.

Table 5: Rating Rules

Categories	Subcategories	Rating Rules			
		0	1	2	3
Supply risk	depletion time	>150 yıl	100-150 yıl	50-100 yıl	50 yıl>
	reserve concentration	<%70	%70-80	%80-90	%90<
	ore production concentration	<%70	%70-80	%80-90	%90<
	country reserve concentration	>10%	5-10%	2,5-5%	2,5%<
	country production concentration	>10%	5-10%	2,5-5%	2,5%<
Price risk	price change	<%125	%125-150	%150-200	%200<
	price volatility	<%125	%125-150	%150-200	%200<
Demand Risk	mine production change	<%125	%125-150	%150-200	%200<
	domestic demand growth	<105%	105-110%	110-120%	120%<
Recycling Restriction	stockpiles	Complated	Not Complated		
	recyclability	Applicable	Partially Applicable	Very Limited	
Potantial risk	possibility of usage restrictions	Safe	Potentially Harmful	Harmful	

2.1.2. Foreign Trade Data

The average score calculations establish direct relationships between the global and export status of minerals. To develop this network of relationships, foreign trade data were evaluated separately under categories such as raw ore and processed ore/intermediate. In this assessment, import and export values for each mineral were analyzed and scored. Thus, minerals with high import costs (potential foreign dependency risk) stand out with their potential for foreign dependency even though their average scores are low. Export values were also scored, focusing on minerals with high export value and that make a significant contribution to the country's welfare. Although external dependence is relatively low for these

minerals, their high export revenues leave them open to the risk of potential welfare losses. For these minerals, losses due to trade restrictions pose a risk. Export scoring is designed to take this risk into account and emphasizes the importance of minerals for the domestic economy.

In summary, the scoring of foreign trade data is as follows;

- Import and export values were analyzed and scored separately for intermediate/end product and mineral,
- In foreign trade data, data above USD 10 million are taken into account,
- Minerals with a foreign trade volume between USD 10 million and USD 450 million and above were assigned a score between 3.5 and 35 in accordance with the scores obtained from the risk ratings.
- Since imports of a mineral are more important than exports for our country, export scores were calculated as 10% and import scores were calculated as 20% criticality points.

3. Final Score Assessment

The final score valuation was made to bring all the assessments together. Thus, global resources, reserves, price fluctuations, import and export costs and market monopoly were taken into account.

In the final score calculation, the following weight values were used;

- Risk Scoring; 70%

- Export Score; 10%

- Import Score; 20%

While making the final scoring within the framework of the above-mentioned weights, trona and boron-like minerals, in which our country is the pioneer in market monopoly, were also taken into consideration on a neutral basis. Thus, minerals with strong reserves were considered as critical minerals with their export values and market shares.

While minerals with an average score between 10 and 16 are classified as important minerals, minerals with an average score of 16 and above are classified as highly important minerals.

Accordingly, foreign trade data were also analyzed in the study as stated in the methodology and scores were made (

Table 6). Focusing on minerals with a value of $10 million and above, each foreign trade data was scored as raw/enriched ore and intermediate/end product.

Table 6: Export/Import Scoring

Export/Import ($)	Score
<10.000.000	0
10.000.000 - 50.000.000	3,5
50.000.000 - 100.000.000	7
100.000.000 - 150.000.00	10,5
150.000.000 - 200.000.000	14
200.000.000 - 250.000.000	17,5
250.000.000 - 300.000.000	21
300.000.000 - 350.000.000	24,5
350.000.000 - 400.000.000	28
400.000.000 - 450.000.000	31,5
>450.000.000	35

Minerals with a criticality score of 16 and above are defined as “Highly Critical Minerals”. These minerals are lithium, silver, titanium, iron, manganese, zinc, copper, aluminum.

Table 7: List of Highly Critical Minerals

Highly Critical Minerals
Lithium
Silver
Titanium
Iron
Manganese
Zinc
Copper
Aluminum

Nineteen minerals with a criticality score between 10 and 16 have been identified as “Significantly Critical Minerals”. These minerals are nickel, rare earths, coal, palladium, cobalt, bismuth, arsenic, molybdenum, gallium, lead, cadmium, indium, germanium, niobium, tin, mercury, antimony, barite and graphite.

Table 8: Significantly Critical Minerals List

Significantly Critical Mineral
Nickel
Rare Earth Elements
Coal
Palladium
Cobalt
Bismuth
Arsenic
Molybdenum
Gallium
Lead
Cadmium
Indium
Germanium
Niobium
Tin
Mercury
Antimony
Barite
Graphite

Minerals with a criticality score of less than 10 are defined as 'Potentially Critical Minerals'. These minerals are beryllium, fluorite, chromium, boron, platinum, magnesite, feldspar, kaolin, trona and bentonite.

Table 9: Potentially Critical Mineral List

Potentially Critical Mineral
Beryllium
Florite
Chromium
Boron
Platinum
Magnesite
Feldspar
Kaolin
Trona
Bentonite

4. Strategic Minerals

A list of strategic minerals was compiled based on the data received from the Presidency of Defense Industries of Türkiye, one of project stakeholders (Table 10). There are 26 strategic minerals, ten of which are both strategic and critical minerals.

Table 10: Strategic Minerals List

Strategic Mineral Name	Area of Use
Hafnium	Turbine engine superalloys
Ytterbium	Laser Applications
Yttrium	Turbine engine superalloys and laser applications
Cobalt	Turbine engine superalloys and steel alloys
Chromium	Steel and other alloys
Lantan	Turbine engine superalloys
Molybdenum	Steel and other alloys
Neodymium	Laser applications
Uranium	Energy source and military applications
Rhenium	Defense Industry Super Alloy Development Projects
Ruthenium	Defense Industry Super Alloy Development Projects
Nickel	Steel and other alloys
Niobium	Turbine engine superalloys and steel alloys
Cerium	Turbine engine superalloys
Tantalum	Turbine engine superalloys
Titanium	Steel and other alloys
Tungsten	Steel and other alloys
Vanadium	Steel and other alloys
Zirconium	Steel and other alloys
Aluminum	Steel and other alloys
Magnesium	Steel and other alloys
Zinc	Steel and other alloys
Silicon	Steel and other alloys
Iron	Steel and other alloys
Manganese	Steel and other alloys
Carbon	Steel and other alloys

** Minerals given in red are both critical and strategic.*

In terms of quantity, aluminum, iron and titanium are the top three strategic minerals. Some of these minerals (rare earth elements, niobium, etc.) are supplied by a relatively small number of producers, even if the quantitative needs are relatively small. This brings high risks from the supply side. Therefore, it is essential to establish emergency stock plans for these mienrals within the framework of 2-3 year needs.

5. Results

Türkiye Critical and Strategic Mineral Report was developed through an evaluation of the relevant factors namely, mineral supply risk, price risk, demand risk, recycling status and environmental risks, as well as mineral production and foreign trade data on a national and global scale.

Total criticality score assessments were performed for 37 minerals and 8 of them having criticality score of 16 and above were identified as "Highly Critical Minerals". According to this, **Lithium, silver, titanium, iron, manganese, zinc, copper and aluminum** are in the "**Highly Critical Minerals"** list. Additionally**,** minerals having criticality scores between 10-16 namely Nickel, rare earths, coal, palladium, cobalt, bismuth, arsenic, molybdenum, gallium, lead, cadmium, indium, germanium, niobium, tin, mercury, antimony, barite and graphite were classified as "Significantly Critical Minerals". The remaining minerals with a criticality score of less than 10 are beryllium, fluorite, chromium, boron, platinum, magnesite, feldspar, kaolin, trona and bentonite. Those ten minerals are in the "Potentially Critical Minerals" list.

Tablo 11: Critical Mineral List

Mineral
Lithium
Silver
Titanium
Iron
Manganese
Zinc
Copper
Aluminum
Nickel
Rare Earth Elements
Coal
Palladium
Cobalt
Bismuth
Arsenic
Molybdenum
Gallium
Lead
Cadmium
Indium
Germanium

Niobium
Tin
Mercury
Antimony
Barite
Graphite
Beryllium
Florite
Chromium
Boron
Platinum
Magnesite
Feldspar
Kaolin
Trona
Bentonite

All 37 minerals are deemed critical for Türkiye; however, it is evident that their classifications of criticality vary. For these minerals, future changes in many parameters such as reserve increase, new technology invention, production increase, developments in supply chains, foreign trade situation and price will affect their criticality score.

As an illustration, graphite, which was not very substantial 10 years ago, has become mineral that all countries work on for stock and production planning.

For this reason, the 37 minerals mentioned above are considered critical with the current conditions, but they are divided into different categories according to their criticality scores. In the future, situations such as a decrease in production, price increase or foreign trade deficit in any mineral with a low criticality score will lead to a change the criticality. This necessitates that the criticality scores of these minerals should be updated at regular intervals.

This report is a projection for Türkiye in terms of critical minerals required for green energy transformation, advanced technology applications and defense industry development. It was also revealed that a comprehensive road map containing supply chain security, inventory planning, ore export standards, production planning and the necessary incentive mechanisms for the adoption of these plans by the private sector should be developed.

Preparations have commenced on the "Critical Minerals Strategy Plan," which will address all pertinent issues for the year 2025.

Strategic minerals, in addition to the characteristics of critical minerals, also have a key role in the defense industry. While the demand for strategic minerals may be much lower, their absence or disruptions in the supply chain can quickly lead to security vulnerabilities.

Among the identified 26 strategic minerals, 10 (cobalt, chromium, molybdenum, titanium, nickel, niobium, aluminum, zinc, iron, manganese) have been designated as both critical and strategic minerals. Within the scope of collaborations with the Presidency of Defense Industries, strategic mineral consumption and needs of defense industry companies have been examined.

The production methods for many of the strategic minerals differ significantly from those of critical minerals. Strategic minerals are often obtained as by-products in the production of other raw materials or through secondary production from mine tailings and waste.

The low supply level of strategic minerals, the limited production methods, and their dependence on the production of other minerals necessitate more detailed planning.

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T.C. ENERJİ VE TABİİ
KAYNAKLAR BAKANLIĞI