Notes on the Geology and Mineral Resource Potential of Selected Turkish Bauxite Deposits

Alexander Horkel*

2 Text-Figures

Central Taurus Mountains
Amanos Mountains
Seydisehir-Akseki
Bauxite resources
Bauxite deposits
Ayranci
Islahiye
Turkey

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Zu Geologie und Ressourcenpotential ausgewählter türkischer Bauxitlagerstätten

Zusammenfassung


- die kretazischen boehmitischen Bauxitlagerstätten von Seydisehir mit den größten Bauxitvorkommen der Türkei, welche die türkischen Aluminiumindus- trie versorgen,
- die permotriasischen Lagerstätten von diasporitischem Bauxit bei Ayranci, als größten türkischen Produzent von nicht-metallurgischem Bauxit, sowie
- die bisher unerschlossenen Lagerstätten von kretazischem eisenreichem Bauxit bei Islahiye.

Abstract

The Turkish bauxite deposits are basically all karst-type allochthonous or unconformity-type deposits, and occur as pockets or layers in Permo-Triassic to Upper Cretaceous platform carbonates sequences. The main bauxite deposits are located in the Taurus mountains of southern Turkey or in the Amanos mountains near the Syrian border. The deposits with the most interesting economic potential are:

- the Cretaceous boehmitic bauxite deposits of Seydisehir with the largest bauxite mines of Turkey, which supply the Turkish aluminium industry;
- the Permo-Triassic diasporite bauxite deposits of Ayranci, which are the largest Turkish producer of non-metallurgical bauxite; and
- the Cretaceous ferrous bauxite deposits of Islahiye, which are awaiting development.

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Introduction

The geology and mineral resources of the Turkish bauxite deposits were rather unknown in the international literature until a recent summary of the overall mineral potential of Turkey by Yigit (2009). In the past, the state mining corporation Etibank controlled the entire production of bauxite and aluminium through its subsidiary Et Aluminium under the statutory-regulatory political system inherited from the foundation of modern Turkey. Only recently, a liberal mining law and the privatization program of the last decade created an enabling investment climate (Beinhoff et al., 1999), which increasingly attracted foreign investment in the mining sector (Yigit, 2009). Today, Turkey is a world class producer of bora (world no. 3 with a global production share of 20.8%), feldspar (world no. 2 with a global share of 16%), magnesite (global rank no. 3), chromite and peridotite (global rank no. 4), as well as barite, bentonite and kaolin (all global rank no. 9). Turkey is also the world no. 3 lignite producer (WMD, 2009).

Until the promulgation of the liberalized mining law, mineral exploration by the private sector was insignificant, and the mineral exploration and inventory program of Turkey was primarily the task of the Turkish Geological Survey (MTA), often in technical cooperation with state institutions from other countries, such as Austria.

Within the frame of this cooperation, several well-known Austrian geologists, such as (in alphabetical order) A. Egger, T. Gattinger, H. Holzer or W.E. Petrascheck were engaged in mineral exploration and regional geological surveys during the late 1950s and early 1960s. Their work, however, is either unpublished in the archives of the MTA or published only in Turkish, and therefore, they have not yet received the recognition due to their pioneering achievements.

General Geological Background

Main Paleotectonic and Structural Units

The following summary of the overall geological frame of Turkey is based on the recent work of Bozkurt & Oberhansli (2001), Gorur & Tuysuz (2001), Moix et al. (2008) and Yigit (2009).

The complex geology of Turkey is the result of the evolution of the Tethys belt, caused by the convergence of Laurasia and Gondwana. Turkey consists of numerous microterranes, separated from each other by complex suture zones, which represent remnants of Paleo- and Neotethys. In terms of terranes, Turkey consists essentially of the following major tectonic units:

- The Pontide terrane in the north, comprising:
  - Strandja zone and Istanbul-Zonguldak zone, which are part of the southern Laurasian continental margin; and
  - Sakarya zone, a mobile metamorphic belt with Laurasian affinities.

- The Izmir-Ankara-Erzincan suture, resulting from the closure of the northern branch of Neotethys (Vardar Ocean), separates this terrane from the Anatolide-Tauride platform, which consists of the
  - Kirsehir block, a metamorphic basement complex in central Anatolia, which is already part of the Gondwana realm; and the
  - Menderes-Taurus platform, a crystalline basement with Paleozoic to Tertiary sedimentary sequences, which contains characteristic thick Permo-Mesozoic carbonate platforms.

The Bitlis-Zagros suture, caused by the collision of the Arabian platform with Eurasia, separates this terrane from the

- Arabian platform with border folds and ophiolite complexes, which forms a part of the Gondwana continental margin.

These first order paleotectonic units were parts of the Laurasian or Gondwana continental margins, or isolated microterranes within the Neotethys. Age, facies, and faunas of the Istanbul Zone differ markedly from the Gondwana Taurides, and have affinities to Western Europe (Dean et al., 2000); this indicates most probably a location along the margin of Laurasia, while the Anatolide – Tauride microcontinent formed the margin of Gondwana (Tolluoglu & Süm, 1995).

The complex suture systems and ophiolite belts separating the main tectonic units represent remnants of Paleo-tethys and of the numerous branches of Neotethys, which started to open in the early Triassic and closed finally during the late Cretaceous to Paleogene. These subduction processes created magmatic arcs, arc-related sedimentary basins, and large-scale ophiolite obduction. Details of the complex geological evolution of Turkey pose numerous highly interesting aspects awaiting further investigations; they are, however, beyond the scope of this paper.

Major Bauxite Districts

Yigit (2009) provides a summary of the Turkish bauxite deposits, including reserve figures from compilations of government-verified reserves and resources by the geological survey (Ersencen, 1989). The following description is based therefore on Yigit (2009), unless stated otherwise.

Practically all Turkish bauxite deposits are karst-type allochthonous or unconformity-type deposits, and occur as pockets or layers in Permo-Triassic to Upper Cretaceous carbonate sequences. Autochthonous lateritic bauxite is reported only from one deposit.

Except for the Kokasu district in the Laurasian Istanbul-Zonguldak zone on the Black Sea with a relatively small resource potential of low-grade boehmitic bauxite, the main bauxite deposits occur in the Taurus mountain belt of southern Turkey, or in the Amanos mountains between the Taurus range and the Syrian border (Text-Fig. 1). The western Taurus range hosts the bauxite district of Milas-Yatagan, which contains numerous small to medium-sized diaspore-corundum deposits, with a combined total resource potential of about 73 mill. t. This district has currently no significant production.

The central Taurus range contains the most significant bauxite resource, occurring in the districts:

- Yalvac,
- Seydisehir – Akseki – Alanya,
- Ayrancli, and
- Saimbeyli.
The Yalvac district, with a resource of about 29 mill. t ferrous bauxite at 42 % \( \text{Al}_2\text{O}_3 \) has no production, and hosts the only known deposit of autochthonous lateritic bauxite.

The Seydisehir-Akseki-Alanya district is of major economic importance and was investigated in the early 60’s by A. Egger, who produced an unpublished detailed map of the regional geology of the area. The Seydisehir deposits have a total resource of 26.3 mill. t high-alumina boehmitic bauxite at 55–67 % \( \text{Al}_2\text{O}_3 \). Here, the two largest bauxite open pits of Turkey supply the only aluminium smelter of the country.

The Akseki deposits near Seydisehir contain also high-grade boehmitic bauxite with a total resource of 17.5 mill. t at 47–66 % \( \text{Al}_2\text{O}_3 \). This resource occurs in numerous smaller ore bodies, and was not developed in the past, as the Seydisehir deposits are more advantageous in terms of infrastructure and economies of scale. The Alanya deposits contain only about 4.5 mill. t diasporic bauxite at 37–67 % \( \text{Al}_2\text{O}_3 \), and are currently of no economic significance.

The diasporic bauxite resource of the Ayranci district amounts to about 4 mill. t high-grade ore at 57.6 % \( \text{Al}_2\text{O}_3 \) (Yigit, 2009), or to 10 mill. t at 53 % \( \text{Al}_2\text{O}_3 \) (Birön & Atak, 1986). Mining started in 2001. Today, the district is the largest Turkish producer of non-metallurgical bauxite (Industrial Minerals, 2009).

The Saimbeyli district contains diasporic bauxite with a total resource potential of about 11 mill. t at 50–52 % \( \text{Al}_2\text{O}_3 \), and has no production.

In the Amanos range near the Syrian border, bauxite occurs in the Islahiye-Payas district. These deposits were already investigated by Petrascheck (1965). Islahiye hosts ferrous Ti-rich bauxite, with a total resource of 96 mill. t at 41 % \( \text{Al}_2\text{O}_3 \), and Payas a resource of 66 mill. t low-grade bauxite at 20 % \( \text{Al}_2\text{O}_3 \). No significant production has taken place so far in this district.

### Geological Frame of the Deposits in the Menderes-Taurus Platform

#### General Geological Frame

The Menderes-Taurus platform consists of several tectonic sub-units with lower Paleozoic to lower Tertiary platform, continental margin, and ocean floor sequences. These subunits are distinct in terms of stratigraphy and metamorphic features, have complex internal structures, and were tectonically juxtaposed during the Senonian to Lutetian. In western Turkey, they include from N to S a blueschist belt, a flysch zone, a major greenschist-facies Palaeozoic–Mesozoic sedimentary zone, and a Precambrian basement with polyphase metamorphism, which is overthrust by Mesozoic carbonate-facies nappes with the bauxites of Milas-Yatagan. These southern nappes pass towards east into the autochthonous, para-autochthonous, and allochthonous units of the Central Taurus and the Anti-Taurus. These units are characterized by thick neritic Permo-Mesozoic carbonate platform facies, and host the bauxite deposits of Seydisehir-Akseki and Ayranci.

During the Senonian subduction, large-scale obduction created ophiolite nappes, which are part of the major ophiolite belt along the tectonic contact of the Arabian plate with the Tethys orogene (Bozkurt & Oberhansli, 2001; Gorur & Tuysuz, 2001).
Following the terminal closure of the sutures in the late Eocene – early Miocene, internal deformation, crustal shortening and nappe tectonics did continue. Crustal consolidation and melting resulted in widespread andesitic to basaltic Neogene–Pleistocene volcanism, with volcanoclastic and fluvial-lacustrine basin sediments. In the final stages of the Neogene tectonic evolution, post-collisional intracontinental convergence and faulting created the extensional Aegean graben systems, as well as the two intracontinental Anatolian transform faults, which are still active today as major seismic zones.

**Geology of the Central Taurides**

The Central Taurides consist of several tectonic units with distinct upper Paleozoic to Tertiary stratigraphy, structure and metamorphism. These units were tectonically superimposed during the Senonian and Lutetian, and most of them extend laterally into the Western and Eastern Taurides (Özgül, 1984).

A single wide platform existed until the end of the Scythian, on which the following units were deposited (from N to S):

- **Bozkir Unit** (ophiolite nappe)
- **Bolkardag Unit**
- **Aladag Unit**
- **Geyik Dag Unit**
- **Antalya Unit**
- **Alanya Unit**

During the Anisian, rifting started to the north and south of the platform. In the south, rifting did not progress far, and the basin was closed before the Rhaetian without forming oceanic crust. A second rifting phase with the formation of oceanic crust occurred between Dogger and Senonian. Rifting and formation of oceanic crust to the north of the platform, characterized by the Bozkir Unit, continued uninterrupted till the Senonian. Compressional tectonics during the Upper Senonian led to the closure of both branches of Tethys. During this event, in the south, the Alanya Unit was emplaced over the Antalya Unit, and in the north, the Bozkir Unit over the Aladag and Bolkardag Units, with the Geyik Dag Unit forming the autochthonous unit at the base.

New rifting during the upper Senonian and the lower Triassic in the internal parts of the platform generated oceanic crust between the Geyik Dag and Aladag Units. During the Lutetian, this crust was consumed by subduction underneath the Aladag Unit (Dipsiz Göl ophiolite melange). Related to these events, the Aladag and Bolkardag Units moved tectonically to the south, carrying on their back the Bozkir Unit. The Aladag Unit continued its nappe movement over the Antalya and Alanya Units in the south. Upper Lutetian – upper Eocene and Miocene are characterized by post-tectonic transgressive series. The tectonic structure is summarized schematically in Text-Fig. 2.

The characteristic stratigraphic features of the individual tectonic units are as follows:

- **The autochthonous Geyik Dag Unit** at the base consists of platform-type sediments, starting with lower Paleozoic (Cambrian and Ordovician) dolomites, limestones, and shales, overlain by turbiditic clastics, followed by a transgressive Mesozoic – lower Tertiary series, mostly platform-type carbonates. The transgression at the base of the thick, epicontinental Mesozoic carbonate sequences starts in the various areas at different times during the Triassic or Jurassic. Upper Triassic and lower Liassic are characterized by thick intercalations of terrestrial clastics, and the Jurassic–Cretaceous by neritic and pelagic carbonates.

A regional uplift of the platform in the Cenomanian–Maestrichtian resulted in a stratigraphic break. The major bauxite horizons of Seydisehir-Akseli were deposited in a karst relief on this unconformity. They are overlain by Maestrichtian biostromal limestones, topped by Eocene flysch.

The allochthonous Aladag Unit consists of upper Devonian to upper Cretaceous shelf-type clastics and carbonates, and forms a flat lying nappe over the Lutetian flysch of the Geyik Dag Unit. It has no known bauxite potential.

The Bolkardag Unit forms a rootless nappe over the Lutetian flysch of the Geyik Dag Unit, and comprises Devonian to upper Cretaceous shelf-type clastics and carbonates, which underwent occasionally green-schist facies metamorphism of vertically and laterally varying metamorphic grade.

The sequence starts with Devonian schists and marbles, overlain by lower–middle Carboniferous shale, limestone and quartzite, again unconformably overlain by upper Permian neritic carbonates.

A discordance between upper Permian and Triassic hosts the major bauxite deposits of the Ayranci district. The Triassic starts with limestone, shale and quartzite overlain by upper Triassic reefal limestones. A Liassic basal conglomerate represents the transgressive basis of the Jurassic–Cretaceous neritic carbonate sequence. Turonian bimicrites, indicating the start of deep-sea conditions, overlie

<table>
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<tr>
<th>S</th>
<th>N</th>
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<tbody>
<tr>
<td><strong>Bozkir Unit</strong> (ophiolite nappe)</td>
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<td><strong>Bolkardag Unit</strong></td>
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<td><strong>Aladag Unit</strong></td>
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<td><strong>Antalya Unit</strong></td>
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<td><strong>Alanya Unit</strong></td>
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<tr>
<td><strong>Dipsiz Göl ophiolite melange</strong></td>
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Text-Fig. 2.

Schematic tectonic structure of the Central Taurides.

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older series unconformably. The distinguishing feature of this unit are the frequent sedimentary breaks in the Devo-
nian to upper Cretaceous sequence, especially in the Per-
mian, Triassic, Liassic and Cenoman, which contain all nu-
merous bauxite horizons.

The Bozkır Unit forms an ophiolite nappe with pelagic sediments, spilite, pietra verde tuffs, diabase and ultrama-
fics. The entire facies indicates a continental margin depo-
sitional environment without bauxite potential.

In the south, the Antalya Unit consists of Cambrian–Or-
dovician turbiditic sandstones, transgressively overlain by
upper Permian algal neritic carbonates. Scythian tidal stro-
matalithic and oolithic limestones with small bauxite de-
posits at their base are overlain by variegated limestones
and marls with intercalations of radiolarites, shales, vol-
canics and turbiditic sandstones. Jurassic starts with reef-
al carbonates, and Dogger to Senonian is represented by
radiolarites and pelagic biomicrites.

The Alanya Unit consists of three metamorphic nappes
without bauxite potential.

The thin but laterally continuous Dipsiz Gölü ophiolite mel-
gale of ultramafites and pillow lavas with intercalated Cretaceous – lower Eocene pelagic limestones and shales
overlies the Lutetian flysch of the Geyik Dag Unit and un-
derlies the Aladag Unit. It has no known bauxite potential.

### General Genetic Concept

Öztürk et al. (2002) analyze the genesis of the Seydisehir
deposits in detail, including the overall tectonic and sedi-
mentary environment for the general genesis of the Cre-
taceous Turkish bauxite deposits. Similar genetic concepts
are possibly applicable to a certain extent to the other
Turkish karst bauxites.

The platform limestone sequence which hosts the Seydis-
ehir bauxite deposits developed at a passive oceanic mar-
gin. The humid, warm Cretaceous climate led to extensive
tropical vegetation with thick, acidic, humic soils. The clo-
sure of the Tethys Ocean caused local uplifts of this pas-
seive margin, with karstification and bauxite formation in
the incipient bauxite or bauxitic soil were transported as
detrital phases or in suspension, and accumulated in fault-
controlled depressions or sinkholes. Marine transgres-
sions into the foreland basin and nappe emplacement dur-
ing the latest Cretaceous followed the bauxite deposition.

The sources of Al, Fe, and Ti in the Cretaceous bauxites
were probably parent aluco-silicate host rocks, most likely
argilaceous sedimentary rocks or mica-rich granites and/
or gneisses. Characteristic textures, such as intercalations
of bauxite and calcareous conglomerate, reworked baux-
itic material, or lenses of graded beds in the bauxites in-
dicate the abrupt accumulation of the bauxitic material.
Such high-energy, mass-flow depositional conditions were
probably triggered by tectonic activities, which is indi-
cated by the predominant accumulation in fault-bounded
depressions, and by the abrupt nature of the deposition.

Öztürk et al. (2002) propose three stages for the genesis of the Cretaceous bauxites of Seydisehir.

- During stage 1, Al, Fe, and Ti were dissolved from the aluco-silicate parent rocks under extremely acid-
ic weathering conditions. This process resulted in the
accumulation of a bauxitic soil (bauxite minerals, Fe and
ti oxides, and clay minerals) on the limestone surface.

- In stage 2, the bauxitic soils were transported by mass movements to fault-controlled basins and karst de-
pressions, where they accumulated as relatively thick bauxite ores by clastic deposition. The erosion of the
bauxitic soils was promoted by rapid uplift due to ac-
tive tectonics.

- During stage 3, the ore was upgraded by in situ leaching and desilification under the conditions of a well-devel-
oped karst drainage system. According to the mine-eral paragenesis, the redox conditions fluctuated several
times during deposition and diagenesis.

A paleogeographic reconstruction of the Tethys Ocean
in the Taurus mountains during the Santonian indicates a
passive-margin setting. The shallow-marine platform envi-
ronment was presumably marked by fault-controlled de-
pressions and highs. Within this passive margin, the Al,
Fe, Ti, and Mn oxides were fractionated and mobilized by
tropical weathering from thick acidic soils. Mn and Si were
transported to the sea, while Al hydroxides and Fe were
mostly trapped on land, primarily as insoluble hydroxides.

The relatively rapid sea-level changes were probably relat-
ed to tectonic activities, since the oxygen isotopes of the
host limestones indicate that the paleoclimates did appar-
ently not vary much from pre-bauxite to post-bauxite time
(Öztürk et al., 2002). A regression exposing the limestone
surface probably resulted from faulting related to the clo-
sure of Tethys with local uplift of the passive margin, which
cased karstification and bauxite accumulation on the
limestone surface. Subsequent transgressions submerged
the Seydisehir bauxite deposits, followed by nappe em-
placement and the deposition of bioclastic limestones on
the nappe ramp during the latest Cretaceous.

Throughout the entire Alpine region, bauxite deposits in
passive-margin sequences are quite common. According
to the model of Öztürk et al. (2002), bauxite deposition
and the fractionation of Mn, Fe, and Al, plus the separation
of Fe and Mn occurred primarily on land, when the tropical
climate and extensive vegetation during the Cenomanian
and Santonian caused thick acidic humic soils. Acid rain
from volcanic activities could have affected the pH value
of the soils, but no volcanics were observed in the strati-
graphic succession with the bauxite deposits. Öztürk et
al. (2002) favour therefore a dominant climatic control for
the acidification of the soil, and cite carbon and sulphur
isotope compositions as key evidence for the importance
of organic matter and bacterial processes for the acidic
environments and for mobilizing Al.

The regional Alpine paleo-environments, which promo-
ted the formation of the bauxite deposits probably reflect
global geological processes. Extensive oceanic volcanism
and tectonics, high sea-level stands, and widespread oce-
anic anoxia characterized the Late Cretaceous. Globally
extensive anoxia may also have contributed to the redu-
cing conditions during transgression and early diagenesis.

This genetic concept of Öztürk et al. (2002) concurs with
the genetic concepts of Petrascheck (1989) for some
southern European allochthonous karst-type bauxite de-
posits, and with observations of the author, however, with-
out pretension that these concepts are valid everywhere.
However, the consideration of these paleogeographic and
genetic factors can be of valuable assistance when deciding on exploration strategies, or assessing deposits.

According to Petrascheck (1989), several Mediterranean karst bauxites reveal common features of fluvial transport and sedimentation. They are in general allochthonous, originate from neighbouring silicate rocks, and their trace element spectra reflect the petrology of the rocks of origin. The bauxites are sometimes transported over considerable distances. Petrascheck (1989) mentions in certain cases transports over 30 km, which occurred either as slow fluvial transport, mainly as suspended mud, but there is also evidence for transport in rapidly flowing water. Petrascheck (1989) considers it unlikely, that the sediment load of the rivers was trapped in the depressions and sinkholes of a karst plateau. Instead, sporadic marine fossils in the bauxites point to coastal environments for the deposition of bauxitic muds in depressions of slightly karstified coastal plains in lagoonal or estuarine environments, i.e. embryonic karsts. Later tectonic uplift and post-bauxitic karstification created mature karsts.

The depth of these sinkholes and depressions, and therefore the thickness of the ore bodies was controlled by the groundwater table during the time of deposition. The ore bodies are therefore thicker in the more elevated parts, than near the former seashore, and their thickness increases with the distance from the former shoreline. The horizontal shape of the ore bodies is influenced by the direction of drainage and by the structural control of the karst features.

Petrascheck (1989) observed also a relationship between the transport distance and the quality of the bauxites. In several bauxite districts, the Al₂O₃ content decreases and the SiO₂ content increases with the direction of the flow of the river system; the corresponding decrease of the Eh/pH ratio favoured the precipitation of diaspor.

The autochthonous unit is overlain by allochthonous serpentinitized ultramafics, and Permian limestone and dolomites, probably obducted on the autochthonous basement during the Oligocene. Post-tectonic Miocene and Pliocene sediments terminate the stratigraphic sequence.

Detailed exploration of the Seydisehir deposits by ETI Aluminium established a reserve of Boehmitic bauxite of 25.8 mill. t at 57–58 % Al₂O₃, of which 6 mill. tons have already been mined (Öztürk et al., 2002). The Akseki deposits contain also Boehmitic bauxite with a total resource of 17.5 mill. t at 47–66 % Al₂O₃ (Yigit, 2009), but with smaller individual ore bodies. This could be caused by deeper erosional levels for the Akseki deposits, or possibly by the fact, that the larger Seydisehir ore bodies were further inland from the Cretaceous seashore, and had therefore deeper hydrographical levels during bauxite deposition.

The bauxite consists mostly of boehmite and hematite, with minor anatase and smectite. Kaolinite fills well-developed joints in the bauxite. The structure is pisolithic, with colloform hematite, and boehmite pisoliths and ooids of widely variable sizes. High-grade bauxite consists of a boehmite groundmass with disseminated and colloform hematite grains. The average quality of the bauxites is in the following ranges:

- Mineralogy: Boehmite bauxite (alumina minerals: + 90 % boehmite)
- Al₂O₃: typically around 55–57 %
- Total SiO₂: typically 5–6 %
- Fe₂O₃: typical in the range of 15–20 %
- TiO₂: 2–3 %
- Loss on ignition: 12–15 %

**Ayranci Diasporite Bauxite Deposits**

The Ayranci deposits occur in the Central Taurus, which consists in this region of the Bozkir, Aladag and Bolkardag Units (Demirtasli et al., 1984). The Bolkar Group of the Bolkardag Unit is a thick limestone sequence with intercalated shales and dolomites, and hosts the main bauxite deposits. It consists of the following four formations with generally conformable contacts:

- Dedeköy Formation (Permian): Thick-bedded, partly dolomitic recrystallized limestones with intercalated micaeous slates, deposited under stable shelf conditions and with an epizonal metamorphic overprint. An unconformity at the top of this formation caused a structurally controlled karst relief, where the major bauxite ore bodies were deposited.
- Gerdekesyayla Formation (Lower–Middle Triassic): Thin-bedded shales and limestones grading upwards into thick-bedded dolomitic limestones with shale and marl intercalations, deposited on an open marine shelf.
- Berendi Formation (Upper Triassic): Thick carbonate sequence with basal thick-bedded dolomites grading into medium to thick bedded limestones with bauxite pockets, indicative of a shallow marine stable carbonate platform.
- Üctepler Formation (Jurassic–Cretaceous): Medium-bedded, partly oolitic and dolomitic limestones, in
which bauxite pockets are common; overlain by thick bedded dolomites, reeval limestones and pelagic limestones, deposited on a shallow marine stable carbonate shelf, which changed into an open marine and deep pelagic sedimentary environment.

The bauxites indicate local subaerial exposures during sedimentation, and occur as numerous elongated, lenticular bodies of varying dimensions in a paleokarst on Permian limestones with structurally controlled sub-parallel alignments (Dedeköy Formation). Numerous limestone intercalations and small ridges in the massive bauxite reflect the old karst relief. The structural control was apparently rejuvenated during subsequent tectonic deformation phases, leading to an overprint of the bauxite-bearing paleokarst by sub-recent karst development. White, micritic limestones, partly cellular and with unclear fossil relics overlie the bauxite unconformably.

The bauxite forms a hard, massive, compact ore of fine grained diaspore with mm-sized, dark, lenticular to subrounded pisolithic grains, occasionally with a fine grained bauxite core of hematite or Ti-minerals. Specularitic hematite coats occasionally joints. The mineralogy comprises diaspore and hematite with minor goethite. Kaolinite and quartz are the silica minerals. TiO$_2$ occurs as anatase. Birön & Atak (1986) state a total resource of 10 mill. t at 53 % Al$_2$O$_3$.

The quality distribution in the individual bauxite lenses is characterized by internal primary structures, and by thin secondary near-surface zones of supergene enrichment, where SiO$_2$ was leached. In terms of grade – grain size distribution, SiO$_2$ tends to be enriched in general in the fine fractions. The average quality of the bauxite is in the following order of magnitude:

<table>
<thead>
<tr>
<th>Mineralogy</th>
<th>Content</th>
</tr>
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<tbody>
<tr>
<td>Diaspore (alumina minerals: + 90 % diaspore)</td>
<td></td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>typically around 53 %</td>
</tr>
<tr>
<td>Total SiO$_2$</td>
<td>typically 6–7 %</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>15–30 %</td>
</tr>
<tr>
<td>TiO$_2$</td>
<td>2–5 %</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>10–12 %</td>
</tr>
</tbody>
</table>

References


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