

The Beypazari trona deposits¹

A beypazari szódatelep

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(with 9 figures and 1 table)

Abstract

The Beypazari trona deposits are the second largest soda deposits of the world. This industrial mineral has been deposited in Beypazari province of Ankara, and formed in Neogene sequences under evaporative conditions.

The deposits have accumulated in two horizontal disconnected seams and have several beds in the levels which were interbedded with bituminous shale, dolomitic mudstones-limestones, claystones and tuffs/tuffites. The studies have shown that nahcolite, pirrsonite, gaylussite, natron and thermonatrite were the other soda minerals of the deposits. The minerals of the enclosed rocks of the levels generally have been consisted of dolomites, analcime, clinoptilolite, K-feldspar, quartz and clay minerals.

The total reserves were estimated 376 million metric tons and the average grade was 84% trona. The total areas of the upper and lower level were 12.9. and 6.2 km², respectively. The trona deposits have been formed under the conditions which were the results of the volcanic activities during the Middle and Upper Miocene in central Anatolia. The sources of the carbonate and sodium ions were present in unsaturated solutions of the thermal springs and products of the volcanic activities.

Key words: Soda, economic geology, Neogene, Turkey

Introduction

The Beypazari deposits have located in the Neogene basins of central Anatolia and situated 100 km northwest of Ankara (Fig. 1.) The deposits were discovered in region during the drilling workings for the lignite explorations in 1982 (TENEKECI et al., 1983).

In the present study, the investigations of mineralogical, petrographical and geochemical features of the deposits and the explanation of the possible principles of the trona formations are presented.

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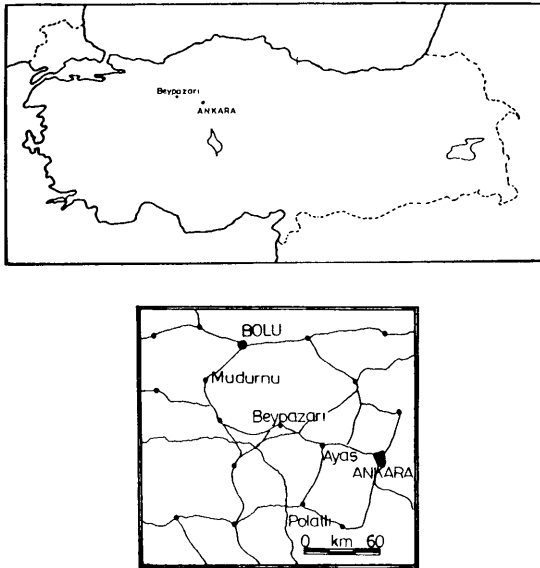


Fig. 1. Location map of Beypazarı district.

Geology

The rocks in the area were Paleozoic metamorphic basement, Mesozoic ophiolite, carbonate and clastic rocks; Paleocene and Eocene clastic sediments (SUNER, 1988; HELVACI et al., 1989) which were overlain by Neogene sediments. Paleozoic complex has included micaschist, amphibolite, phyllite which were cut by granitic batholite. Jurassic and Cretaceous limestones have overlain the basement units; Jurassic limestones have graded into lower Cretaceous limestones which were overlain by upper Cretaceous units (Fig. 2).

Paleocene units have consisted of mainly conglomerate, sandstone, mudstone and volcanoclastics and interbedded with limestones. Eocene rocks were limestones and sandstones. Neogene units from Middle to Late Miocene have consisted of clastics, carbonates and evaporites. In the sequence trona deposits were interbedded with the shale and claystone units as two disconnected seams (SUNER, 1988). All sedimentary rocks have graded into pyroclastics (Fig. 3.).

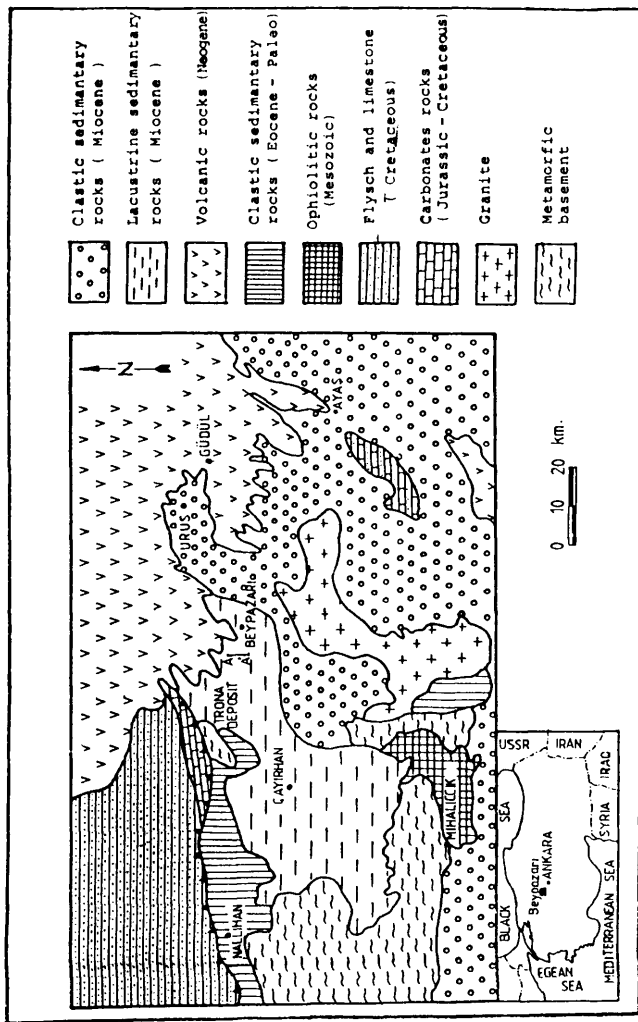


Fig. 2. Simplified geological map of Beypazari basin.

STRATIGRAPHIC SEQUENCE SHOWING TRONA AND PIRRSONITE OCCURENCES IN BEYPAZARI BASIN			
U. SYSTEM SYSTEM PERIOD EPOCH	NAME	LITHOLOGY	EXPLANATIONS
CENEZOIC TERTIARY NEOGENE MIOCENE	K. DOR.	40-80	Claystone , Marl Chert bearing dolomitic limestone
	HIRKA	250-350	Claystone Bituminous Shale Claystone Tuffite Claystone Bituminous shale Marl Tuffite
		250-350	Soda (Trona) Soda (Trona)
		100-150	Bitu. Shale, Clayst., Pirrsonite Limestone , Dolomite
		100	Coal
		100	Bituminous Shale
		100	Coal
		100-150	Conglomerate Volcanic material bearing limestone
	100-150	Conglomerate	
	PALEOGENE EOCENE	CORAKLI	100

Fig. 3. Stratigraphic sequence of the Neogene units of Beypazari basin.

Deposits

Geometry

The trona deposits have been limited by folds in the north and south; and trona levels were affected by these tectonic elements which have caused displacements dominantly in Miocene sediments (Fig. 4). As a result of this tectonic regime, the trona grades in the levels were largely affected laterally and vertically, related to asymmetrical folding which were very common in Beypazari. The grade change in trona were also determined in the lower level of the deposits because of not only the tectonic feature but also the topography of the paleolake.

Because of changing in geochemical conditions of the depositional environments, the change of thickness of the seams in the upper and lower levels have been observed

(Figs. 5–6). The effects of this extensional regime has determined mostly in the northern part of the deposits.

The total thickness has varied from 2.5 m to 32.0 m very sharply in short distance as a result of paleolake topography. The total trona beds were 33 m in two levels and reserves were estimated 376 million metric tons by a number of detailed reserve calculation methods. The average grade was 84% trona. The upper level had approximately 287 million metric tons of trona as total reserves and those of lower level was 89.5 million metric tons. The total area of the upper level was 12.9 km² and those of the lower level was 8.2 km²

Petrography

As a result of optical, XRD, SEM and DTA methods, the features of trona and other observed soda minerals have been determined. Nahcolite (NaHCO₃), pirrsonite (Na₂CO₃·CaCO₃·2H₂O), gaylussite (Na₂CO₃·CaCO₃·5H₂O), natron (Na₂CO₃·10H₂O) and thermonatrite (Na₂CO₃·H₂O) were the determined minerals (SUNER, 1988, 1989, 1990, 1991) (Figs. 7–8).

Trona has shown as series of crystal forms. It was classified in two main groups: The massive tronas and the crystallized tronas having a lot of varieties mostly fibrous and rosette forms (Fig. 7). Calcite, magnesite, dolomite, clay minerals, analcime, clinoptilolite, K-feldspar, quartz were the other observed principal minerals.

Nahcolite, the second most important soda mineral in the deposits, has been observed mostly in the upper level, showing hypidiomorphic texture and lath-like crystal forms.

Geochemistry

Trace element analyses of trona and other soda minerals were carried out using gravimetric, colorimetric and other methods on pure samples. The grade analyses of trona were made by volumetric method and the analyses have shown that it has been subjected to change in short distances within the deposits. The data from experimental studies have been evaluated physicochemically with respect to phase assemblages and discussed possible carbonate phases and depositional principles of this industrial mineral.

The results of trace element analyses have exhibited statistically normal distribution pattern, indicating similar formation and precipitation conditions from the same sources. Trace element content have been studied statistically and correlation and regression relationships have been investigated.

Formation

Trona is an evaporite mineral and has a number of ways of formation. Taking into account of the observed mineral assemblages, a crystallisation path was assumed. The most important point of the chemical structure of the mineral is incongruent melting. The formation of the weins in two levels were largely affected by this property. The other important physicochemical property of the trona is the ability of formation under equilibrium with atmospheric carbon dioxide. Therefore it is logical that trona may be

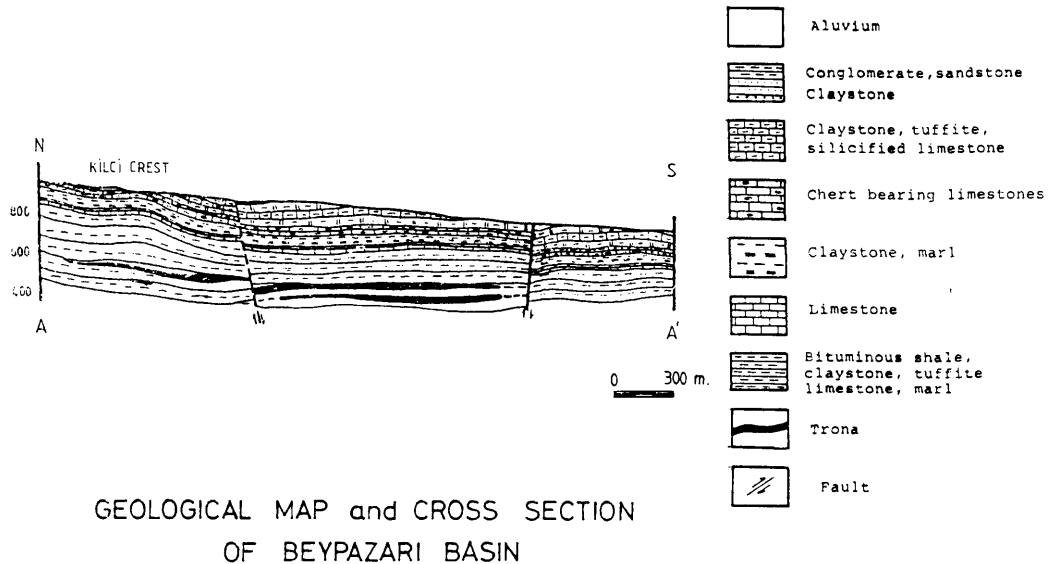


Fig. 4. Generalized geological cross section of Beypazari basin.

precipitated easily under atmospheric conditions, on the surface of paleolake, somewhere in Beypazari Basin.

Trona was formed mostly in the equilibrium with the atmosphere and partly under the pressure of Miocene sediments. The solutions, existing in sediments, under the diagenetic pressure, have been concentrated gradually and resulted in small trona seams and sometimes nahcolite groups. Microorganisms have also contributed to formation partially; extracting carbon dioxide, especially in diagenetic trona accumulations.

The parameters which can affect the formation directly are temperature, Na %, activity of CO_2 , H_2O and HCO_3/CO_3 ratio. The change of these parameters may easily cause a transformation and/or precipitation. Therefore, the determination of the boundaries of the parameters is very important and depending on the positions, trona to nahcolite, trona to thermonatrite conversions are always possible.

As these properties, trona conservation is not a simple procedure, particularly in the basins where tectonic movements are important. In Beypazari, trona has been accumulated in two major levels passing the similar evaporation and precipitation paths from Na-poor solutions in the beginning periods.

In the deposits, there were no various kinds of soda minerals and thick beds which have been formed in the shape of thin accumulations parallel to Miocene sediments and interbedded with them.

This is a typical example of monomineralic deposition. Similarities of trona levels and interbedded sediments have given conclusion that the beds in two levels have been precipitated likely under the similar conditions, which had changed partially and only toward the last period of deposition.

In the early stage of precipitation in Beypazari, Na-poor solutions were responsible for calcite and dolomite formation, which were common in the lower level of the lower trona horizon. As a result of increasing of Na % in solutions in the basin, because of volcanic activity, pirssonite and gaylussite, Ca-Na double carbonates had been formed and deposited very randomly, according to chemical composition of solutions. Depending on changes of HCO_3/CO_3 ratio, thermonatrite and natron have been precipitated very scattered, and mostly from trona as products of alteration. Trona beds have been formed, precipitated and deposited within volcanoclastics. Claystones, sandstones, tuffs, limestones, and bituminous shales have played an important role for protection of resolving tronas, interbedding and alternating with them in the upper and lower horizons. As a result of increasing of the clastic material entry into the basin and ceasing of evaporation conditions, trona deposition has been cut for a period and then it has continued as a result of recurrence of evaporative conditions.

The last cycle of the sedimentation has been subjected generally to the effect of more dilute and cooler undersaturated solutions which were largely responsible for nahcolite deposition, mostly in the SW parts of the basin (Fig. 9).

Conclusion

The Beypazari Trona deposits are the second largest natural sodium carbonate accumulation in the world. They have been deposited in two horizons which consisted of a number of trona beds and interbedded with sedimentary and volcanosedimentary

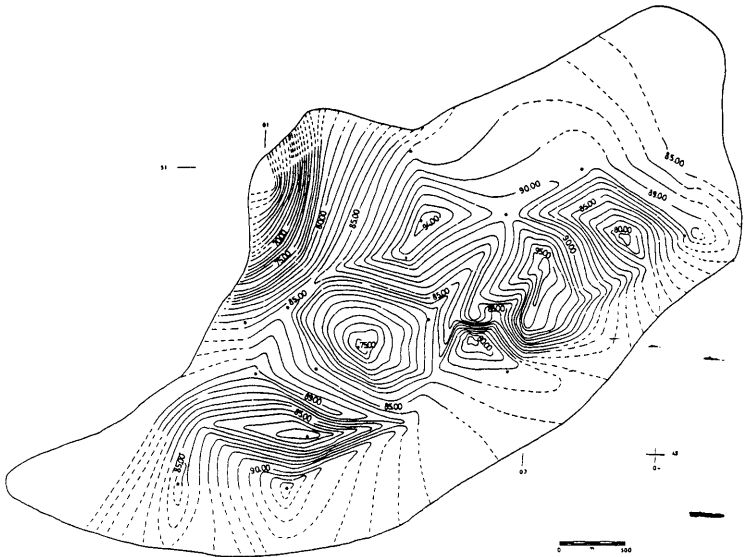


Fig. 5. Isograde map (% of the trona) of upper level of trona deposits.

units. Nahcolite, pirronite, gaylussite, natron and thermonatrite were the other observed carbonate minerals in the deposits.

Based on the features observed and determined, it was thought, that the deposits and rocks were precipitated and deposited mostly in lacustrine and playa-lake environment, partly in a fluvial environment.

Physicochemical conditions are extremely important in formation of trona deposits. The parameters which control the features of sedimentation, precipitation and protection after deposition of these kind of occurrence are largely dependent on geological and mineralogical properties and geochemical period of the basin.

As a result of the studies it has been concluded that the deposits have been formed physicochemically under the effect of high and continuous Na-feeding from solutions, which have contained likely equal portion of HCO_3 and CO_3 ions, in two separate evaporation periods under the effect of volcanism in the Middle and Late Miocene. The products of the volcanism were the other probable sources for the formation.



Fig. 6. Isopach map of upper level of trona deposits.

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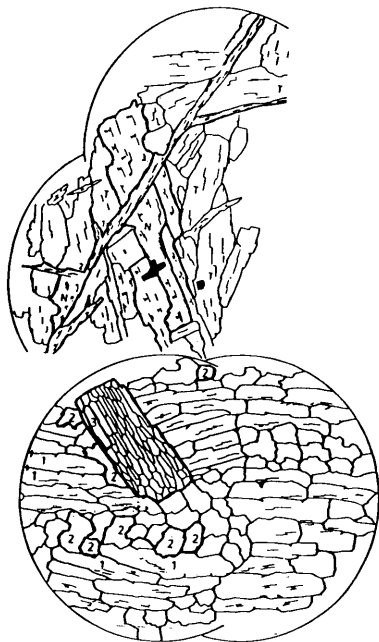


Fig. 7. Trona (T) and nahcolite (N) in thin sections, 6.3 x 10; primary (1), secondary (2), recrystallized (3) tronas.

Table 1. Trace element contents of Beypazari Trona (averages/ppm)

Si 1265.62	Al 263.63	Fe 65.48	Mg 7859.40
Ca 1171.87	K 19.03	Rb 11.50	Cs 631.25
Br 1921.67	B 17.50	As 284.38	F 4875.00
P 71.43	I 1000.00	Ti 3.00	Li 3.00
Ba 575.00	Sr 214.06	Cl 975.00	SO ₄ 8388.88

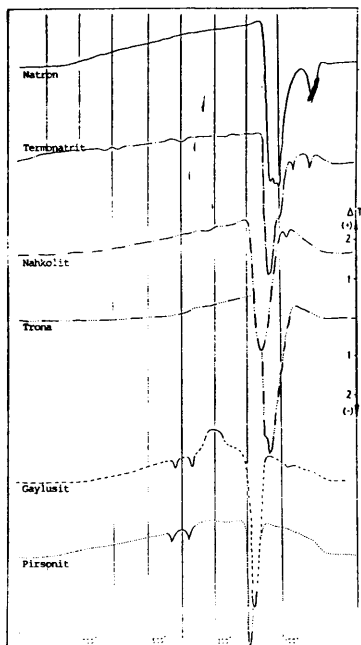


Fig. 8. The DTA curves of the soda minerals observed in the basin.

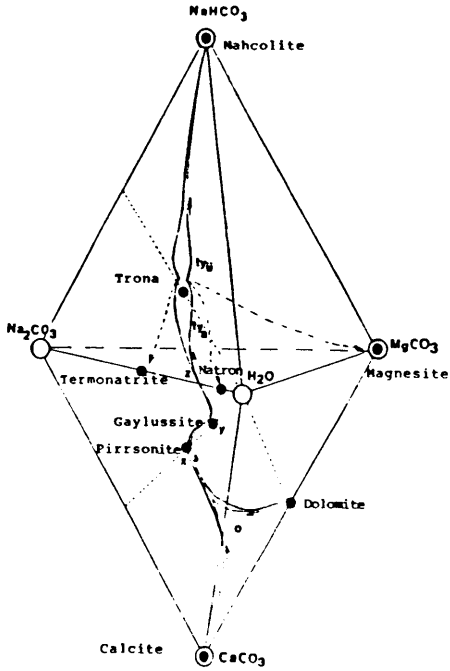


Fig. 9. Evolution of soda and associated carbonate minerals in the Beypazari deposits.