Vol. 1, No.4
Summer, 1990



# DIFFERENT TYPES OF ROCKBALLS AND THEIR GENESIS FROM THE KARAJ FORMATION (MIDDLE EOCENE) IN CENTRAL ALBORZ, OF NORTHERN IRAN

S. Feiznia

*Department of Mining Engineering, Faculty of Engineering, University of Tehran, Tehran, Islamic Republic of Iran*

**Abstract**

Several kinds of rockballs have been recognized in Karaj Formation which are formed under different conditions. Field and microscopic studies showed that the most common type is a kind which is called tuffballs. Most of the tuffballs have a core and a coating around the core. The core consists of very fine grained tuff containing radiolaria. The coating of tuffballs consists of medium - grained, crystal, lithic and vitric tuff with a groundmass of partially devitrified glass, containing fossils. During middle Eocene, submarine volcanic eruptions were active, pyroclastic debris poured out and were mixed with marine sediments and planktonic organisms and deposited. Due to accumulation of excessive amounts of sediments on the existing slopes and subsequent slumping, the cores formed and rolled over the soft tuffaceous mud. The pyroclastic debris wrapped around the core, making the tuffballs (like the formation of an avalanche). The tuffballs rolled and finally accumulated down the slope. The second type of rockball is sandy and is called sandballs in this paper. The sandballs may or may not have a core. The core is fine - grained tuff. The coating of the sandballs is lithic sandstone. Sandballs are formed like tuffballs. The other types of rockballs are related to processes of slumping, boudinage formation and spheroidal weathering.

## Introduction

The purpose of this paper is to investigate the various types of spherical bodies found in different parts of the Karaj Formation, which are herein called rockballs. The Karaj Formation consists of a suite of pyroclastic rocks, lava flows and sedimentary rocks or a mixture of these. They are exposed from the east to the west of the Alborz Mountains in the northern part of Iran. The age of the Karaj Formation is Middle Eocene, but in some localities extending into Upper Eocene [9]. The Karaj Formation has a varied thickness in different areas. This implies that the formation has mostly filled previous depressions. The depressions were either the result of regional relief before deposition of the Karaj Formation and after the termination of Early Alpine orogenic event or possibly fault depressions.

**Key words:** Rockballs, Karaj Formation, Central Alborz.

One of the controversal aspects about this formation is whether the volcanic eruptions were submarine or subaerial. It seems that most of the eruptions have been submarine, although restricted subaerial eruptions also existed [2]. The idea that most of the eruptions were submarine is confirmed by the present work.

Rockballs of the Karaj Formation are called «concretions» by some workers (like Vatan and Yasini, [11]) saying that «these concretions are the result of silicification, similar in mechanism to the formation of chert concretions in limestones. Here, silica is precipitated around a nucleous from solution». The present study showed that the process of rockball formation is

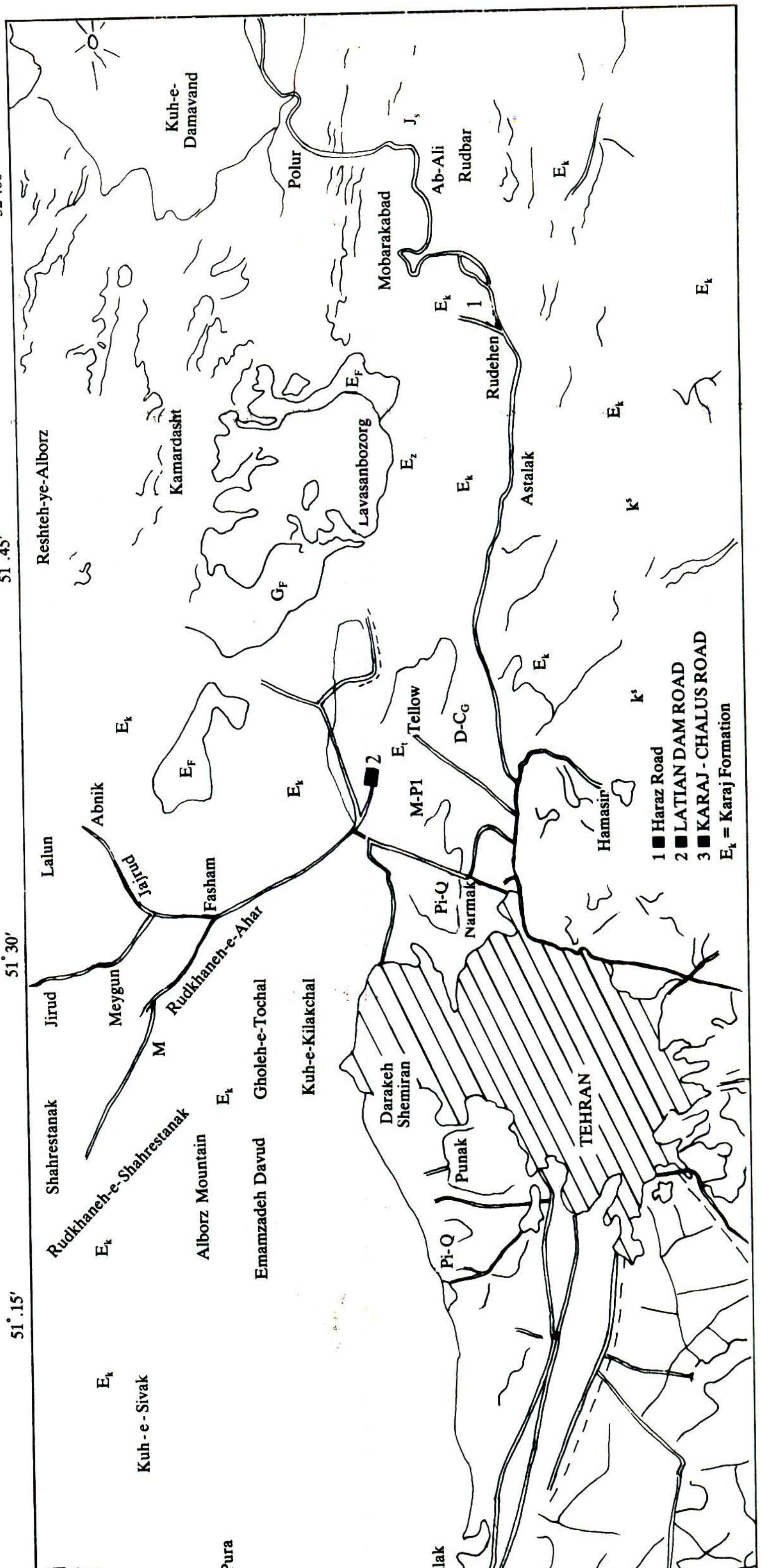


**Fig. 1**- Location map of the sanpled rockballs (after [5]).

not chemical. Darvishzadeh [1] stated, «the rockballs have been erupted with other pyroclastic debris. They were heavy so they fell to the sea floor, rolled and transported away and became rounded and spherical». Most of the rockballs contain a core, so this idea is a simplification of the genesis of rockballs. The goal of the present work has been to distinguish the different rockballs and investigate their genesis with field and laboratory studies.

Types of Rockballs

a) Tuffballs:

The most common type of rockballs are green and white, with diameters of a few centimeters to about one meter and are called tuffballs. Tuffballs are found in the east of Tehran, in roadcuts along Haraz Road (Fig. 1) (just after Rudehen, toward Ab-Ali) and along Latian Dam Road (Fig. 2). [6]

Some of the tuffballs contain no core (Fig. 3) and

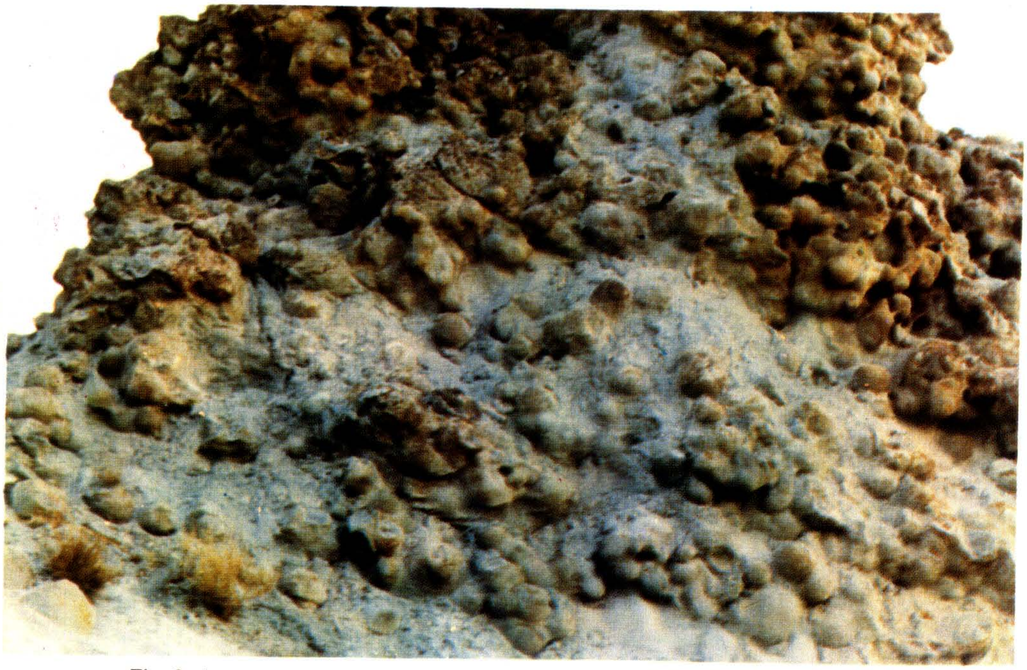

**Fig. 2-** An outcrop of green tuffballs in Latian Dam Road, NE of Tehran, Iran.

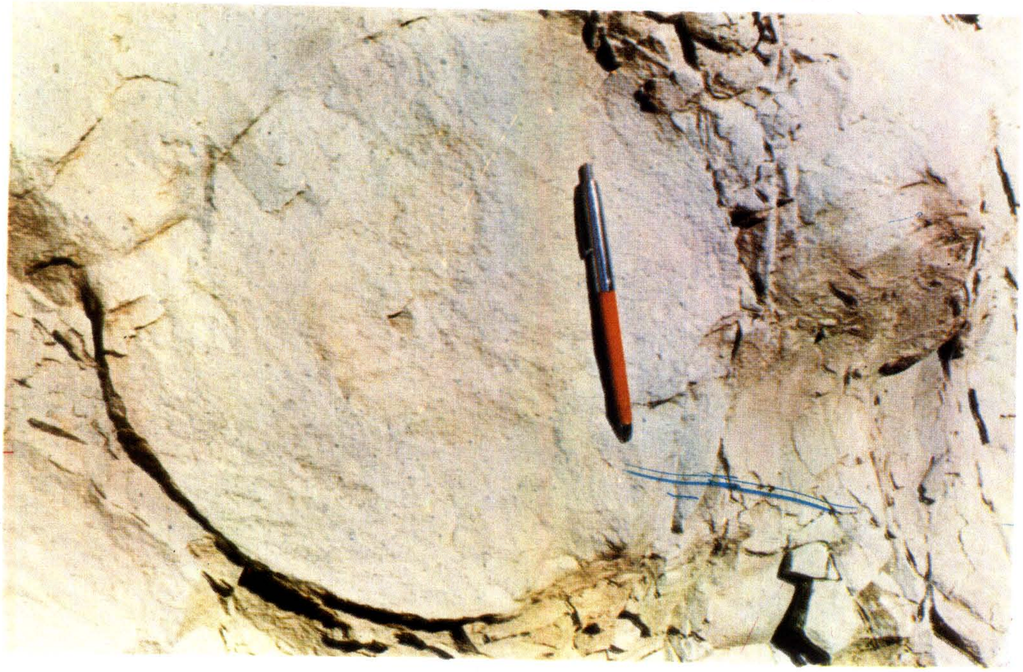

**Fig. 3-** Section of a tuffball with no distinct core, Haraz Road, east of Tehran, Iran.

**Fig. 4-** Section of a tuffball with a core of many angular fragments, Latian Dam Road.

some have a core consisting of many angular fragments (Fig. 4), but most of them have a core consisting of one dark - green fragment and a coating around the core (Fig. 5). In rare cases, the core is extremely altered and is clayey, but the coating is not altered.

Microscopic studies show that the core is a very fine-grained tuff with a glassy groundmass containing radiolaria (Fig. 6). The groundmass is usually devitrified to silica (quartz and tridymite), sometimes clay minerals (kaolinite and chlorite) and feldspar. Silica has also filled pores and fractures. There are some radiolaria and calcareous fossils (Globigerina or calcitized radiolaria). There is a faint horizontal lamination in this part, with accumulation of greater amounts of silica in some laminae and of clay minerals (especially chlorite) and iron - compounds in the others.

All of the tuffballs have a coating which is homogeneous and shows no distinct lamination. The coating consists of medium grained lithic, crystal and vitric (glass shards) tuff with a glassy groundmass that contains fossils (Fig. 7). Phenocrysts are alkali and plagioclase feldspars and quartz. Some of the quartz grains are rounded and have quartz overgrowth rims, and therefore, they may be detrital in origin. Lithics are mostly volcanic glass devitrified to silica and containing pores filled with silica. Fossils are radiolaria and partly silicified calcareous fossils (Globigerina?). The glassy groundmass is partially devitrified to quartz and chlorite. Devitrification is most intense in the exterior part of the tuffballs. This part is also calcitized and has a greenish color against the pinkish color of the interior (Fig. 3).

The majority of tuffballs are green; but a few are white. This difference is due to the following: in the green type, there is a larger amount of volcanic lithic fragments, more devitrification (to chlorite) of volcanic lithics and of groundmass and more calcitization. In the white ones, there is a larger amount of phenocrysts and glass shards, with lesser amounts of lithics and glassy groundmass. The groundmass is less devitrified and the tuffballs are less calcitized.

Before discussing the process of tuffball formation, a literature review of the occurrances of rockballs will be given. The rockballs mentioned and discussed in the literature are mainly armored mudballs. In this case, mud fragments are separated from a layer of muddy sediments, transported and rolled over sand, granules and pebbles that then coat the mud fragments. This type of rockballs are reported from a variety of environments including beach, intertidal, glacial, lacustrine and even in «fluvial» urban environments [7]. The first rockball reported from a volcaniclastic environment is from the terrestrial volcaniclastics of Mount St. Helens in the U. S. A. [4]. These were called armored mud boulders and have a mean diameter of 25 to 65 centimeters. They have a core of cohesive green tuffaceous mud and a thick coating consisting of

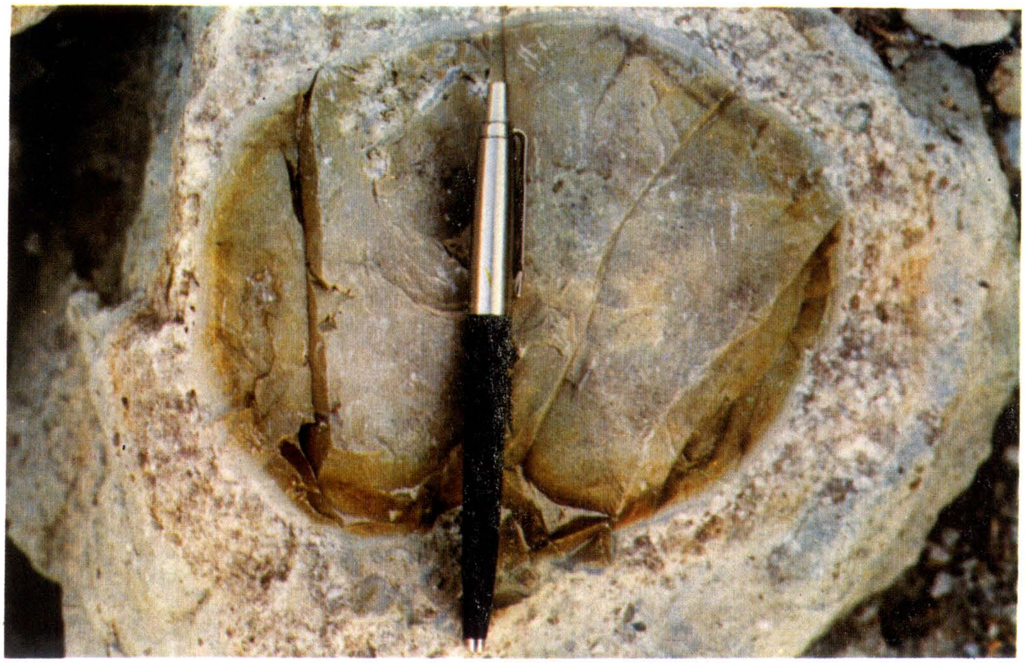

**Fig. 5-** Section of a tuffball with a core and coating, Latian Dam Road.

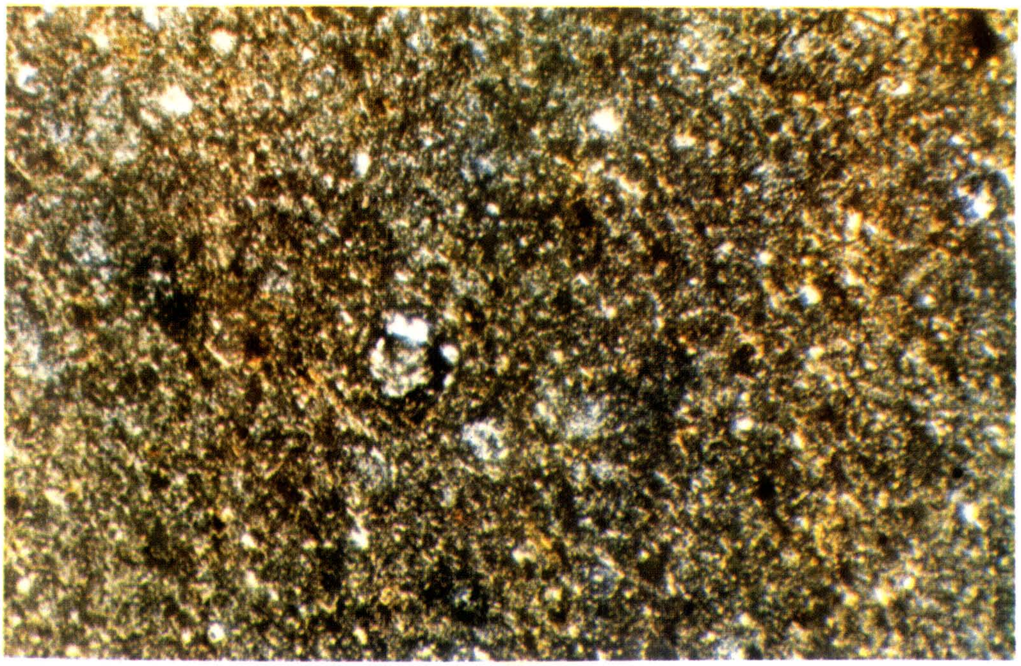

**Fig. 6-** Photomicrograph of the core in the tuffball of Fig. 5; Scale 1 cm = 110 $\mu$, LP.

angular fragments. The cores resulted from the eruptions and transported as a traction load or mudflows by rivers. They were finally coated and rolled at the surface of mudflows and became rounded. Smith [8] says that rolling at the surface of mudflows cannot produce rounded balls, but their roundness is due to the traction process in rivers. After the balls became rounded, they were transported by mudflows.

The process of tuffball formation: During the time of deposition of the Karaj Formation, submarine volcanic eruptions occurred. Fine volcaniclastic particles were mixed with planktonic organisms and deposited. Due to accumulation of excessive amounts of sediments over the existing slopes (unstable slopes) and sluming, fragments were separated from the sediments, making the cores of tuffballs. The slopes were either original relief of the environment, fault scarps and / or slopes around the volcanic vents. Slumping

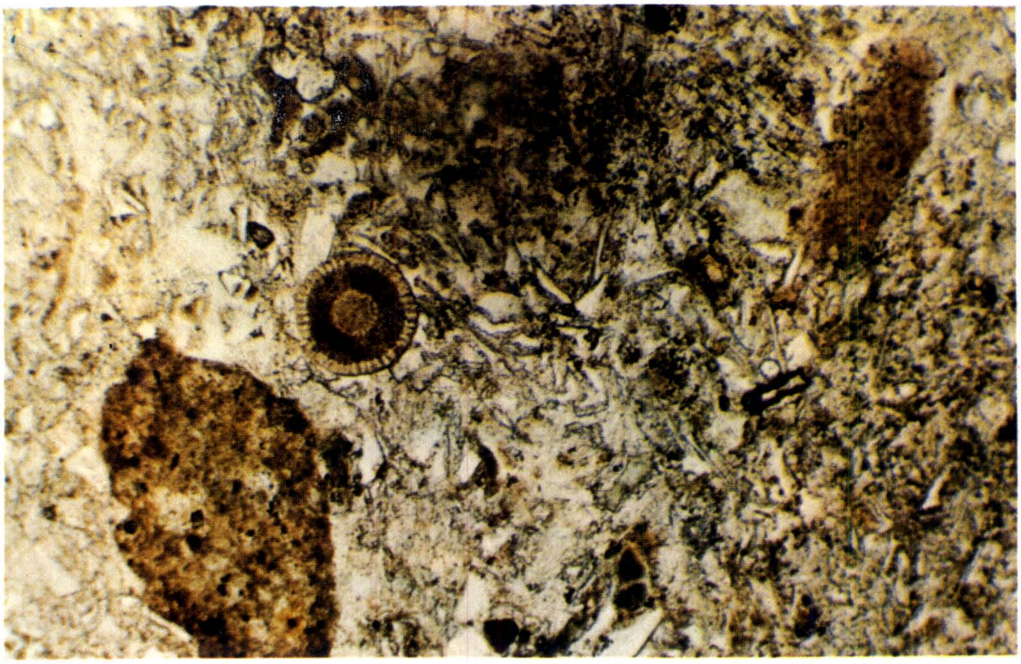

**Fig. 7-** Photomicrograph of the coating in the tuffball of Fig. 5; Scale 1 cm = 100 $\mu$, LN.

structures are present in the Karaj Formation and will be discussed later. The depositional environment has been under periodic volcanic and tectonic activities (the environment was probably broken by faults and volcanic material poured out from these fractures). Therefore, a suitable environment existed for the accumulation of pyroclastic debris and suitable slopes existed for the formation and movement of cores. The cores were rolled over soft tuffaceous sediments and were coated with these sediments (like the formation of an avalanche). The tuffballs rolled, became rounded and finally accumulated down the slope.therefore,the mechanism of tuffball formation is somewhat similar to that of armored mud boulders of Mount St. Helens, but in the case of the Karaj Formation, the volcanic eruptions have been mostly submarine and slumping was effective.

In many thin sections, the particles of coating have penetrated into the core (Fig. 8) showing that at the time of coating, the core was still unconsolidated. In very rare cases, the core is highly altered. In such situations, the core may have originated from outside of the sedimentary basin. The exterior parts of the tuffballs are fresh and unoxidized, this evidence confirms the idea of their formation inside the sedimentary basin. The calcitization of the external part of tuffballs indicate diagenetic processes after their formation.

b) Sandballs:

The other type of rockball is sandy and is called sandballs. They can be seen in the west of Tehran, Karaj - Chalus Road, south of the first tunnel (Figs. 1 and 9). Sandballs are usually calcitized, some have a core, and others do not have any core. The core consists of fine sand to silt size broken quartz and feldspar and some organic remains. The core has a horizontal lamination. Due to calcilizations, the percentage of pyroclastic particles has decreased, but the core has probably been a fine - grained tuff. The coarse-grained coating consists of quartz, kaolinitized alkali feldspar, plagioclase, opaque minerals and rock fragments (mostly metamorphic) (Fig. 10). A few quartz grains have silica overgrowth rims. Some chlorite matrix is present. It seems that the rock is a lithic arenite to lithic wacke according to Dott [3] classification. The sandy sediments then underwent diagenetic processes such as compaction, cementation and calatization. Therefore, the main difference between tuffballs and sandballs is in their coating; the coating of tuffballs consists of pyroclastic debris but the coating of sandballs is terrigeneous sand.

The process of sandball formation is like tuffballs and in this case, the cores were formed and rolled over the soft sandy sediments.

c) Other kinds of rockballs:

There are other rounded bodies in the Karaj

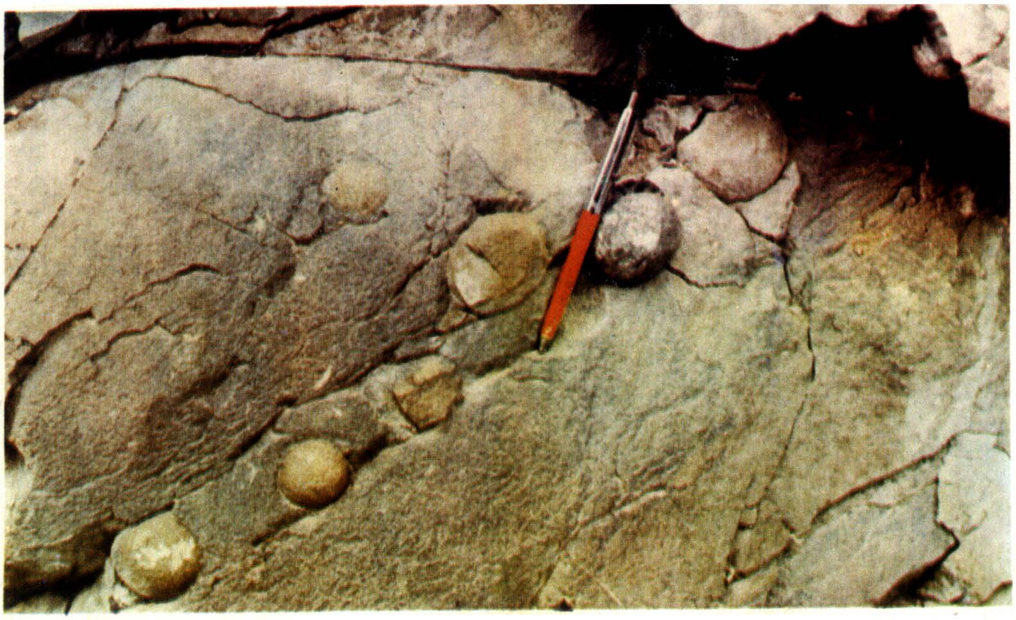

**Fig. 8**- Sandballs in Karaj Formation, Karaj - Chalus Road, before the first Tunnel.

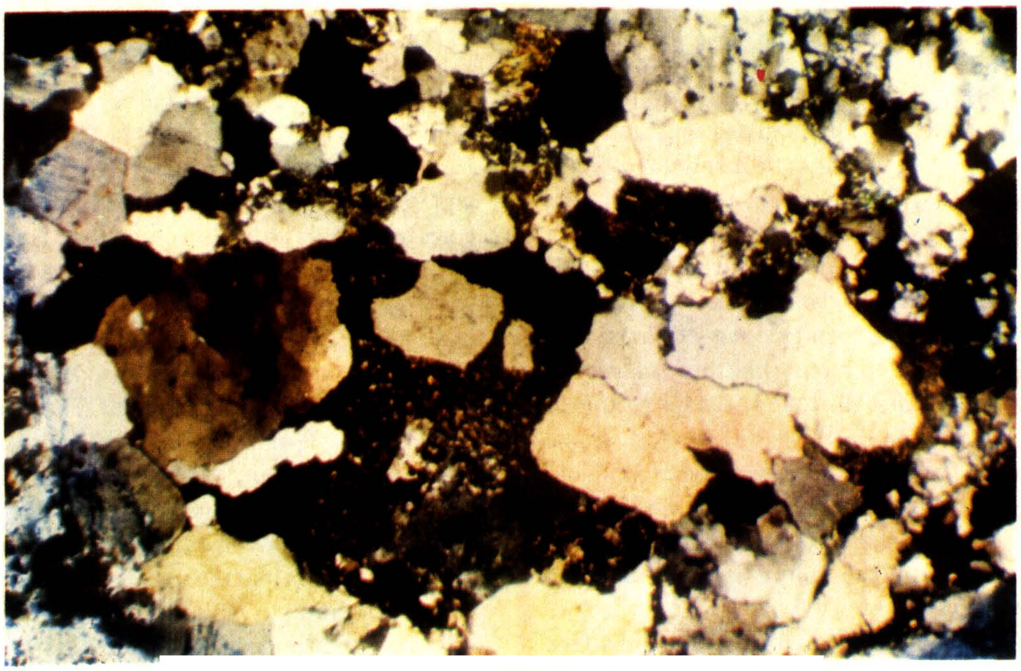

**Fig. 9**- Microphotograph of a sandball. Scale 1 cm = 300$\mu$, LP.

Formation which are different from the described rockballs. These rounded bodies are related to slumping, boudinage and sphereoidal weathering.

The process of slumping in Karaj Formation was suggested by Dedual [2] in the west of Tehran, north of Karaj Dam. In the present study, this phenomenon was observed in the east of Tehran, along Haraz Road (after Rudehen) and in the west of Tehran, along Karaj - Chalus Road (in fourth kilometer north of Karaj). In the advanced stages of slumping, the deformed parts can be separated and become rounded [6].

In south part of Karaj Dam wall, in the tuff layer below monzonitic sill, boudinage phenomenon is

**Fig. 10-** Slumping structure in Jajroud Road. after Rudehen.

reported by Dedual [2] (although Vatan and Ayanian, [10] think of this phenomenon as a slumping structure). In the present work, boudinage was observed in Karaj - Chalus Road, south of the first tunnel. Therefore there are rounded bodies which formation is due to progress of boudinage formation.

In some regions, spheroidal weathering has caused the formation of spherical weathered layers within the fine - grained sediments, especially shales. The general outline of the center of these layers are rounded. This phenomenon can be seen in the east of Tehran, along Haraz Road and in the west of Tehran, along Karaj - Chalus Road.

## Conclusion

The rockballs of the Karaj Formation are varied in type and genesis. The majority of rockballs have cores which are mainly formed from the mixing and deposition of fine pyroclastic debris and planktonic organisms over the existing slopes, slumping and fragmentation of sediments. The cores rolled over the slopes and pyroclastic debris, sand and other sediments which existed in the region, became attached to the core. Then the rockballs rolled and accumulated down the slope.

## Acknowledgement

I am grateful to Dr. K. Seyed - Emami, the professor of Mining Engineering Department, University of Tehran, for informative discussion and for reading the preliminary draft of the manuscript. I thank Mr. A. Moridi, graduate student of the Teacher's Training University, for collecting some of the samples, taking some of the pictures and discussing certain ideas.

## References

1. Darvishzadeh, A., The principles of volcanology, University of Tehran Pub. no. 1793, 2nd edition, P. 299 (1986) (in Persian).
2. Dedual E., Geology of middle and lower part of Karaj - Valley, central Alborz, Iran, Geol. Inst., E. T. H. Univ. Zurich, n. s. No. 79, P. 45 - 75 (1947) (in German).
3. Dott, R. H., Wacke, graywacke and matrix, what approach to immature sandstone classification? *Jour. Sed. Petrology*, v. **34**, P. 625 - 632 (1964).
4. Fritz, W. J. and Harrison, S., Giant armored mud boulder from the 1982 Mount St. Helens mudflows, *Jour. Sed. Petrology*, v. **53**, No. 1, P. 131 - 133 (1983).
5. Haghipour, A., Taraz, H. and Vahdati - Daneshmand, F., Geological quadrangle map of Iran No. F5. Tehran, Geol. survey of Iran (1986).
6. Moridi A. A., 1990, Aresearch about different types of rounded rocks from the Karaj Formations, Unpublished research work of

the graduate Sedinentary rocks course, under Supervision of Feiznia Geology Department, Teacher's Training University, 18 P. (in Persian).

7. Ojakanjas, R. W. and Thompson, J. A., Modern armored mud balls in an urban environment, *Jour. Sed. Petrology*, V. **47**, P. 1630 - 1633 (1977).

8. Smith, G. A., Giant armored mud boulder from the 1982 Mount St. Helens mudflows - Discussion, *Jour. Sed. Petrology*, V. **53**, No. 4, P. 1355 (1983).

9. Stocklin, J. and A. Setudehnia, International Lexicon of Stratigraphy, volume III, part 9b, Iran P. 128 - 132 (1972).

10. Vatan, A. and Ayanian. P., Sedimentological observations of Green Series in Alborz (Iran), C. R. S. G. F., part 10 (1962) (in French).

11. Vatan, A. and Yasini, I. Geology of Alborz Mountain around Tehran, University of Tehran, Faculty of Engineering Pub. No. 14, P. 36 - 63 (1969) (in Persian).