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## Genesis of the Baery knolls developed in the Northern Caspian Plain

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## ABSTRACT

There are many such forms on the North Caspian lowland, where the author and colleagues conducted detailed geologic and geomorphologic field surveys. On the south, the range of altitudes of Baer knolls (BK) reaches 10–12 m, and the hills have a general southwest orientation. The described landforms are the same BK as those developed along the Volga delta. The sediments composing the BK consist of alternations of clay, silt and sand. They contain a rich complex of brackish water ostracods, detritus and even whole shells, which indicate their subaqueous genesis. During the Late Khvalyn, currents dominated in a large lagoon. Chocolate clay (CC) deposited in it. These currents were not linked to the littoral zone with wave activity, as granular composition of the deposits, their sorting and type of lamination are not peculiar to sediments of a coastal marine zone. They are characteristic of unidirectional currents with frequently changing velocities. Water from the lagoon flowed through the Manych passage into the Black Sea in the Late Khvalyn. Hence, last connection of the Caspian Black and Black Sea was at the end of the Late Khvalynian time (Early Holocene). At first, the water overflowed through the Manych passage (minimal width of 2 km) from the Caspian to the Black Sea; then, it reversed and flowed from the Black Sea to the Caspian Sea. At this time, when the most recent alluvial dam had not yet formed yet in Manych, there was infiltration of *Cerastoderma glaucum* to the Caspian Sea. Discusses the landforms similar to BK, in particular, the long ridges in the south of Western Siberia.

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## 1. Introduction

Interesting forms of a relief, the so-called 'Baery knolls' (BK), are widespread in the Northern Caspian Plain. K. Baer was the first who paid attention to them (Baer, 1856) was the first who paid attention to them. He wrote that they can be compared to gentle waves of the sea. The radial position of BK, converging to the East Manych, the nature of the lithology and stratification of sediments forming the BK suggest that simultaneously with their formation was the water flow towards the lowlands or from it.

Subsequently, many articles have been devoted to these forms and some hypotheses relating to their genesis have been proposed: aeolian (Fedorovich, 1941; Yakubov, 1952; Volkov, 1960; Leontiev and Foteeva, 1965; Belevich, 1979; Kroonenberg et al., 1997; Richards et al., 2014) erosion-accumulative associated with the formation of deltas (Zhukov, 1935; Dorskach, 1949; Pravoslavlev, 1929 et al.), coastal and littoral, due to the action of marine factors (Britzyna, 1955; Nikolaev, 1955; Zhindarev et al., 2001; Svitoch and Klyuvitkina, 2006; Rychagov, 2009), and by the geological

factors (Aristarkhova, 1980; Leonov and Lavrushin, 1995). One of the most detailed publications is a monograph of Svitoch (2014) who summarized all existing views and provided a detailed list of published works on this topic. A sizeable proportion of the published information on the Baer knolls is based on the studies in the Lower Volga and its delta region. That area is noted for occurrence of conspicuous knolls more than 10 m high; besides, there are many outcrops displaying their internal structure.

In the Northern Caspian Plain, BK are present in the form of separate hills or ridges across wide terrains; their relief occurs not only within the Volga delta but also in the adjacent regions surrounding the Volga mouth, and extending over large areas in the Northern Caspian region up to about 0 m (global sea level), where the former Late Khvalynian coastline is situated. Their morphology and lithology are quite different compared with the surrounding relief. Underlying the base of BK in many areas are so-called 'chocolate clays' (CC), and deposits of the BK occur on top of them, often over sharp erosion surfaces, which causes frequent reworking of the CC deposits.

The results of the study of the distribution and character of sediments forming the BK have been published previously in several articles. This paper consists of a review of previously

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published work about BK and causes some new arguments in favor of the fact that similar landforms are in other regions. Widespread hills and ridges (looking very much like BK) are in the southern part of Western Siberia, which could be formed during the overflow of glacial lakes toward Turgay Pass.

## 2. Regional setting

The Northern Caspian Plain occupies a large territory, where common types of terrain present, due to the influence of the sea. A significant part is the Early Khvalynian marine plain. It is complicated by a series of shorelines, formed during the oscillations of the Caspian Sea level which occurred over the entire history of the basin. In Late Quaternary time, there were several transgressive regressive cycles. They are Early Khvalynian, Late Khvalynian and Novocaspian transgressions. Regressions separating, respectively, these transgressions are – Enotaevsky and Mangyshlak. Despite the long study of the Caspian Sea history, there are still many controversial issues of the time and the level amplitude (Varushchenko et al., 1987; Rychagov, 1997; Yanina, 2012; Svitoch, 2014). In this paper the relief of the territory, confined to the Late Khvalynian and Novocaspian marine plains is considering.

In the Northern Caspian Plain, the coastline of the maximum stage of the Late Khvalynian Sea crosses the landscape at 0–3 m above global sea level (agsl). From these elevations, the character of the relief on the plain changes (Fig. 1). At first there are extremely flat, low, extended positive forms with a height of about 1 m, a width of 10 m, and a length of about 100 m. They gradually become higher to the southeast, transforming into the shape of the typical BK and reaching heights of 10–12 m, for instance near the settlement of Kharabaly (Fig. 2). There are many BK here; they look like large waves and ridges.

The BK in this region have a general southwest orientation. These landforms are the same BK as those developed along the Volga delta (Badyukova, 2005a). The last large Novocaspian transgression (up to –20/–21 m) after the Mangyshlak regression did not reach this elevation, and that is why the BK were not eroded. So the real relief of the BK can be observed in this area, and not in the Volga delta or adjacent areas. In contrast, southwards from the hypsometrical levels of –20/–21 m and within the Volga delta, the BK are prominently displayed (Fig. 3) because of swamp development in the depressions between the knolls and ridges (so-called ‘*ilmeny*’) during the Novocaspian transgression, and in contemporary times due to flooding in the delta. Dominating ENE winds and erosion of the *ilmeny* banks apparently led to an extending of the depressions, which were drawn out in the same direction. Moreover, sand supplied from the *ilmeny* beaches created aeolian forms between the BK, so separate knolls appear as long ridges (Fig. 4).

The area on the right bank of the Lower Volga from the Nikol'skoye settlement features a slightly undulated steppe surface; gradually it acquires a more distinct hilly topography and farther still BK appear associated with closed depressions (Fig. 1); the landforms are best pronounced between the Kopanovka and Lenino settlements. There is a distinct relationship between morphometric characteristics of the BK: the higher and broader they are, the greater is the distance between them. There are areas, however, where the BK are extremely closely set, while in other regions Baer knolls neighbor on flattened plain areas.

Gradual changes in the morphology of the BK are traceable also east of the Volga where the knolls occur south of Lake Baskunchak. There the flat surface of the Caspian Lowland gives way to an undulating plain with low ridges (1–2 m high) of variable orientation and vast closed depressions in between. The ridges gain in height southwards and become 10 m high or even more near the town of

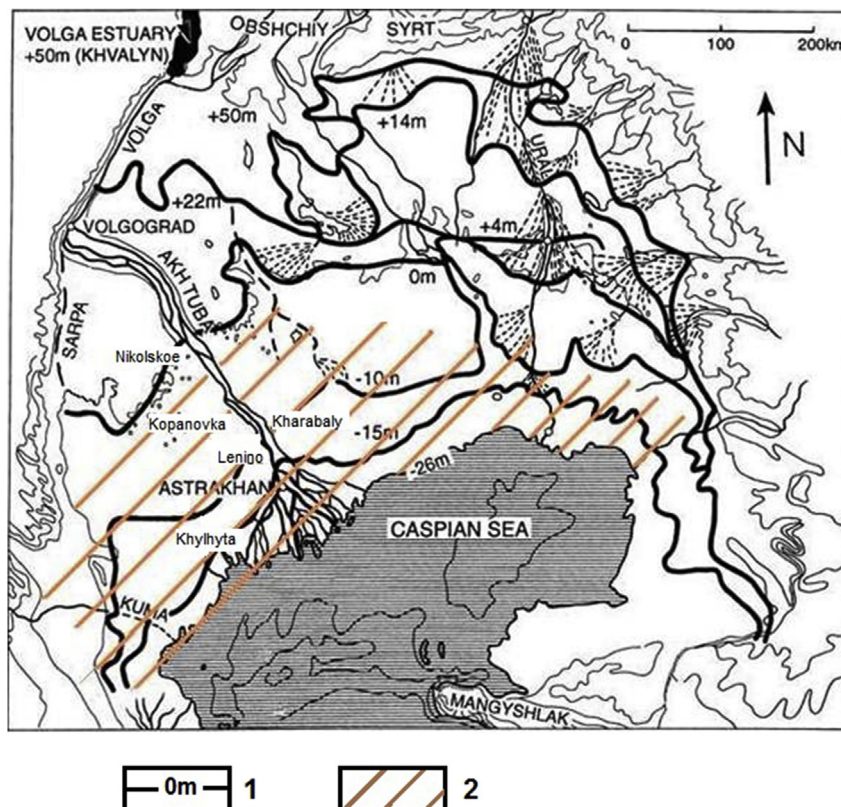


Fig. 1. Region of investigations. 1- coastlines, 2 –areas with BK.

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