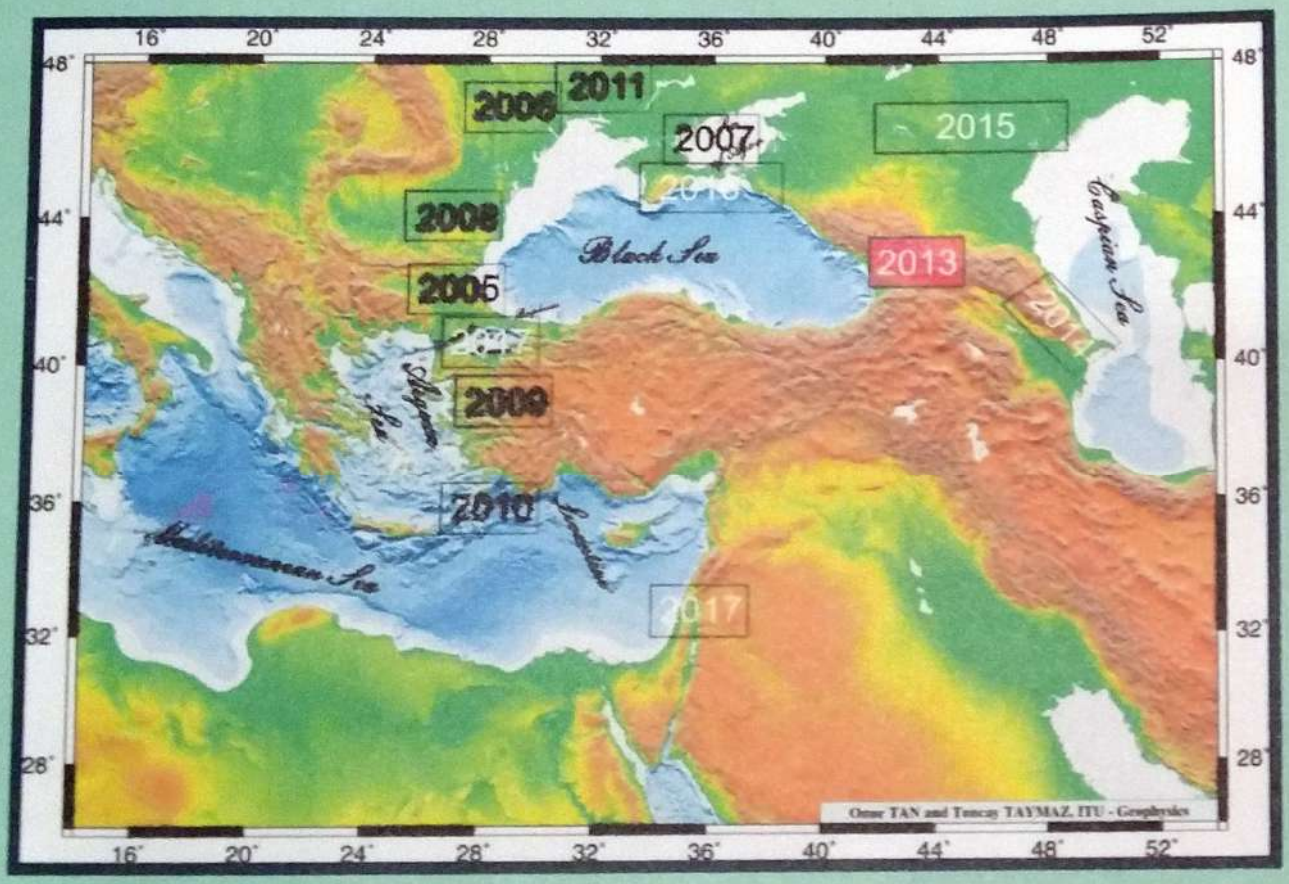
Georgian National Academy of Sciences, Department of Earth Sciences, Tbilisi, Georgia

2-9 October 2016

INTERNATIONAL GEOSCIENCE PROGRAMME



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MORPHOLOGICAL ANALYSIS OF FLAT-BOTTOMED DEPRESSIONS, THE EASTERN AZOV SEA REGION

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Introduction

A characteristic feature of the east coast of the Azov Sea is a specific watershed area with flat-bottomed depressions characterizing its relief. Oval shaped with sizes from 0.5x1 km to 5x13 km and depths from 2 to 21 m are typical for this type of closed depression. The highest concentration of depressions is observed in the territory of the Yeisk peninsula. Less commonly, these forms are found to the northeast of Yeisk estuary—the coastal strip from the village of Nikolaevka to the city of Azov. Local names for these forms are: pad', pods, and estuaries. Analysis of the published literature (Safronov, 1973; Kanonnikov, 1977; Kleschenkov, 2010) shows that the problem of the origin of flat-bottomed topography of the eastern Azov is still controversial. None of the hypotheses advanced through the years (paleokarst, karst-suffosion, subsiding loess; lacustrine, eolian, heterogeneous) can find a full confirmation or a final rebuttal. This uncertainty is associated with a lack of geological and geomorphological study of flat-bottomed depressions, and poor factual data on the structure of the depressions. In addition to their origin, it remains unresolved how such depressions will develop in the future: do forms tend to increase or remain stable? The importance of forecasting the development of flat-bottomed depressions is due to the fact that the plots of land belonging to the bottoms of the depressions are usually unsuitable for practical use: on satellite images it is clear that the bottoms of the depressions are not built up and rarely used in agriculture.

Study region and methodology

The present study is an attempt to approach the problem of the depressions from the perspective of morphological analysis. We analyzed numerical data describing the size and shape of the depressions, marked morphological types, analyzed the connection of depressions with the erosion structure network, alluvial and marine terrace levels. The study is based on the use of a digital elevation model (DEM) SRTM-3, which is made up of radar data surveys. DEM was selected due to its greater convenience during morphometric analysis of relief. For the model SRTM-3, the following parameters are given (Farr et al., 2007): Spatial resolution—3 arcseconds (90 meters), the absolute error in the plan—8.8 m, the absolute error in height—6.2 m, the relative error height—8.7 m. Geodetic measurements of the terrain made for individual depressions allowed us to carry out an additional verification of the model used, which showed that the accuracy of the study was slightly above that stated. With the mapping "Global Mapper 11" package, based on the above DEM, we measured 118 identified depressions. The results of the measurements were used to create a depression database, including a set of morphometric parameters for each shape: area, depth, length, width, and azimuth orientation of the long axis. The obtained numerical data were statistically analyzed using the MS Excel program.

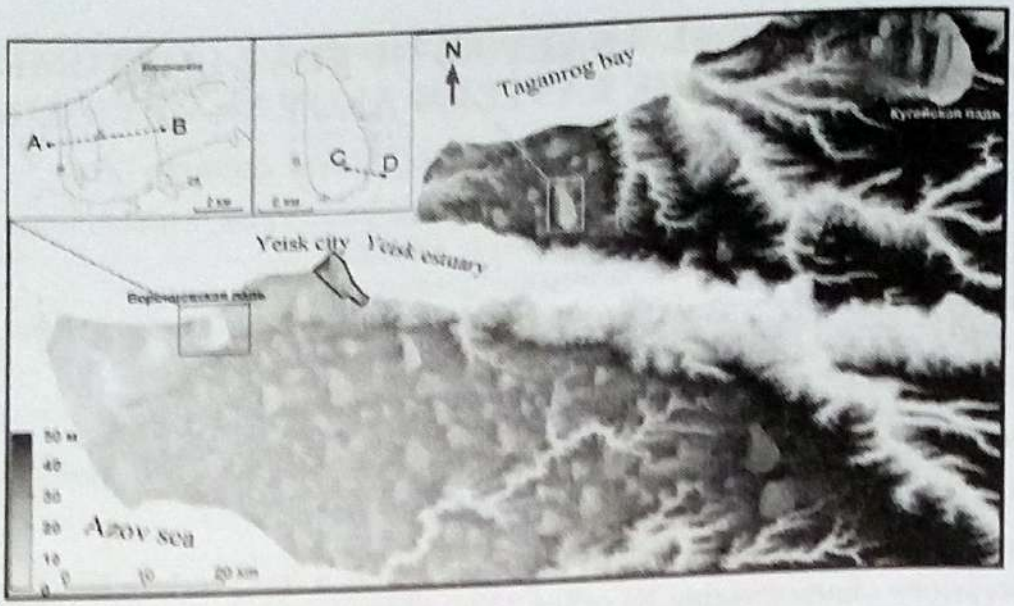

Figure 1. Study area.

Results

One of the main features of the flat-bottomed topography of the eastern Azov that attracts attention even at first glance on the DTM (Fig. 1) is a high degree of consistency in the orientation of the long axes of the depressions. 95% of all forms are aligned NNW-SSE (67%) and NS (28%). The remaining 5% were characterized by a NW-SE and NE-SW orientation. Notable is the interposition of depressions: a significant portion of the shapes are built in linear chains of (2-5 depressions), the orientation of which coincides with the orientation of individual depressions. Linear focus (elongation in one direction) of a vast number of shapes may indicate the formation of depressions under conditions of directional flow influence – most likely an aeolian or fluvial agent. Morphology of the depressions is characterized by smooth contours, regular shape (without festooned sides), and elongated ovoid shape with the presence of acute and obtuse rounded ends; the sharp end is always north, and the obtuse end south. In some cases, the depression form tends to be triangular. There are also almost exactly oval depressions with morphologically similar ends. Ideal round shapes do not occur at all. The degree of elongation of the depressions is characterized by the so-called "Elongation ratio": the ratio of length to width. The most common are depressions with values of this coefficient: 1.6-2.2 (55% of all forms), with most of the depressions showing approximately equal proportions, slightly varying in form depending on the size.

The most typical area of eastern Azov depressions is in the range 1-4 km^2; such relatively small forms are in the majority (54%). Most small depressions (<1 km^2) make up 17% of the total number of forms. Mid-sized depressions (5-10 km^2) make up just over 20%. The largest forms, with an area over 10 km^2, amount to a total of ten (8.5%). Of special note is a 'giant' depression, "Kugeyskaya Pad," with an area of 53.9 km^2. Also interesting is the ratio of the area of the depression to its depth. It traces a trend describing the dependence of depth to area: the depth of the depressions ranges from 2 to 21 meters, and the area increases hundreds of times with increasing depth from minimum to maximum. This suggests that the subject forms are only flattened and shallow relative to their size. Ridges within the bottom of the depressions are rarely more than 1-2 meters. The western side of some very large forms ("Kugeyskaya Pad'" and "Vorontsovskaya Pad'") is complicated with trough-ridge relief (amplitude of 3-5 m). It is noteworthy that sub-parallel ridges are oriented along the long axis of the depressions.

Another interesting problem is the relationship between the the distribution of depressions and the alluvial levels and marine terraces developed within the territory. Hypsometrically, there

are two terraced levels traced in the Yeisk peninsula (Fig. 1): the lower one occupies the northwestern tip of the peninsula, and the higher terrace takes up the rest of it. However, according to geological data (Lebedeva, 1972; Velichko et al., 2010) in the study area, there are no fewer than three terraces (the Nogay terrace with Taman fauna; the Platovskaya with Early Tiraspol fauna, and the Voznesenskaya with Late Tiraspol fauna), which suggests a poor expression of terraced ledges. Depressions of various sizes and shapes are not tied to a particular terrace; they are distributed at various levels. This suggests an independent origin for depressions from the processes associated with the formation of terrace deposits (fluvial and coastal processes).

Conclusions

Flat-bottomed depressions act as indoor pools, intercepting part of the surface runoff. This is clearly illustrated by the radial centripetal pattern network of small erosion forms (SEF), i.e., depressions framed by ridges and ravines. These SEFs flowing into the depression to the east and northeast are generally 5-10 times more extended, due to the overall gentle slope in the SW direction. Depressions intercepting the runoff are probably related to the glaring lack of a valley network development on the Yeisk peninsula. Here, there are only two rivers (the Yasen and Albashi), and morphometric parameters of the river valleys do not correspond to the small size of the modern streams. Obviously, the valley of the small rivers, as well as the SEF-shaped relic, in fact formed in the non-modern landscape and climatic conditions. Emphasis is placed on the forced steep turns (up to 90°) of the river and SEF valleys, which, in our opinion, are due to the large rivers crossing the depressions. The totality of these facts gives one reason to believe that the flat-bottomed depressions are more ancient than the erosional network.

Acknowledgments

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