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Research Article

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Interpretation of the Gravity Map of Thrace-Ergene Basin by Cellular Neural Network

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Abstract In this study, Cellular Neural Network (CNN) method was applied to the map of gravity anomaly of Marmara Region Thrace-Ergene Basin. The CNN method that is frequently used in electronic engineering is used in Geophysical Engineering to distinguish between regional (effect of deeper structures) and residual (effect of near-surface structures) anomalies. By using the CNN technique and mapping the gravity anomaly maps of the Thrace-Ergene basin, discontinuity boundaries were determined. In this way, it is aimed to reveal many faults in the region. The deep seismic records of the Turkish Petroleum Corporation (TPAO) in this region were compared with the CNN output from the map of gravity anomaly and a good fit was observed.

Keywords Cellular Neural Network (CNN), Thrace-Ergene Basin, Building Boundary Analysis

Introduction

This situation can be observed in the maps of gravity anomalies if the underground geological structures constitute a density difference. For this reason, the determination of the limits of discontinuity has been a very important issue in geophysical studies [1-9]. The boundaries of the geological structure to be searched can be determined as well as information about the parameters of these structures. It is necessary to use appropriate filters according to the geological structure to be searched in geophysical studies. It can be determined that the geological structures to be searched according to the filter techniques to be applied are near-surface or deep-root effects. In this study, Cellular Neural Network (CNN) was used to solve some boundary detection problems in geophysical engineering. It is aimed to determine the locations of the fault lines from the Bouguer anomaly map using CNN. As a land study, the Thrace region Gravity anomaly map obtained by Turkish Petroleum Corporation (TPAO) was handled. These maps have been applied CNN to reveal buried faults there. The toll gate located in Thrace is surrounded by a massive rocky massif in the north, a rodop massif in the west, the Marmara islands and Samanlidag massifs in the south, and a large depression area covering the Sea of Marmara. The width of the north-south of the basin is 120 km. The length of the East West is about 220 km. While the sediment thickness of the basin is 1-2 km on the edges, the thickness is about 6-8 km [10]. The boundaries of the geological structure to be searched can be determined as well as information about the parameters of these structures. Using suitable filters according to geological structure to be sought in geophysical studies Thrace (Ergene) Basin has an important potential in terms of coal and hydrocarbon. For this reason, geological and geophysical studies have been carried out mainly for coal, oil and natural gas exploration studies in the region. The Gravity, Magnetic, deep and shallow seismic studies carried out by the Turkish Petroleum Corporation (TPAO) and Mineral Research and Exploration (MTA) are important work to give some ideas about the tectonics of the region [11-13]. In this study, CNN method was applied to the map of the gravity anomaly of the Thrace (Ergene) basin and a new tectonic map was constructed in the direction of the finds compared with the obtained structural boundaries seismic sections and geological map.

Materials and Methods

Cellular Neural Networks (CNN) are structures made up of cells lined up to form a two-dimensional array. CNN is a method that is used frequently in image processing, requiring preliminary training and enabling certain features of two-dimensional images to be revealed. Contrary to known artificial neural networks, each cell in this neighborhood is connected to the cells in the neighboring neighborhood. Many researchers have worked on the Artificial Neural Network [14-18]. Each cell in these structures is a dynamic input consisting of a linear input unit with a weighted addition, a linear dynamic interface, a symmetrical part-piece linear output unit with respect to the n-piece (generally three-piece) [1]. The r-adjacency of a cell in the cellular artificial neural network (CNN) is defined as follows.

$$N_r(i,j) = \{C(k,l) | \max(|i-k|,|j-l| \le r, \quad 1 \le \mathrm{i} \le \mathrm{M}; 1 \le j \le \mathrm{N} \} \tag{1}$$

(i, j) : the index vector, which determines the position of the cells in the sequence

$C(i, j)$: I. Line, J. The parameter indicating the location of the cell in the column. Differential equations that characterize the cellular Neural Network can be written as:

$$\frac{dx_{i,j}(t)}{dt} = -S \cdot x_{i,j}(t) + \sum_{(k,l)\in N(i,j)} A_{i,j;k,l} \cdot y_{k,l}(t) + \sum_{(k,l)\in N(i,j)} B_{i,j;k,l} \cdot u_{k,l}(t) + I_{i,j} \tag{2}$$

$$y_{i,j}(t) = f[x_{i,j}(t)] = \frac{1}{2} \cdot (|x_{i,j}(t)+1| - |x_{i,j}(t)-1|) \tag{3}$$

Where:

$A_{i,J}$: Feedback connection weight coefficients

$B_{i,J}$: Input connection weight coefficients

I: The threshold level, which is generally the same for each cell

S: Feedback from state is defined as weight coefficient.

The equation that characterizes the Discrete-Time Cellular Neural Network is expressed as [1] and [17].

$$x_{i,j}(n+1) = \sum_{(k,l)\in N(i,j)} A_{i,j;k,l} \cdot y_{k,l}(n) + \sum_{(k,l)\in N(i,j)} B_{i,j;k,l} \cdot u_{k,l}(n) + I_{i,j} \tag{4}$$

$$y_{i,j}(n) = f[x_{i,j}(n)] = \frac{1}{2} \cdot (|x_{i,j}(n)+1| - |x_{i,j}(n)-1|) \tag{5}$$

In this equation, an iterative filtering is performed from the feedback connection weighting coefficients as well as the classical filtering. Entries of cells here $u_{i,j}$, [-1,1] are real numbers that take values in the range (Figure-1). the outputs of the cells are yi, and j is the outputs that can only be -1 or +1 if stability conditions are provided at the end of a certain period (or cycle). One of the most important features distinguishing CNN from known artificial neural networks is that the feedback weighting coefficients of feedback (a) and input (b) constitute a fixed connection network on the working plane (see for details; [1, 6, 14-19]).

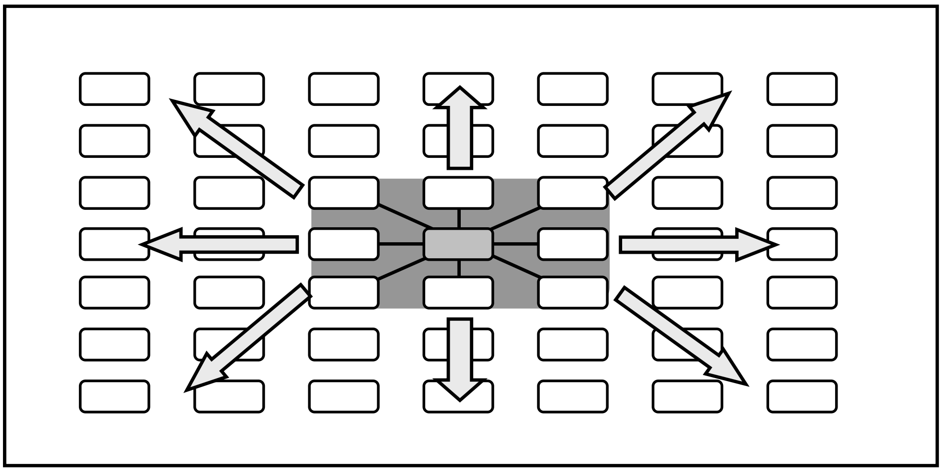

Figure 1: Invariance property in the plane [1]

$$A(i,j;k,l) = A(k-i,l-j) \;\; B(i,j;k,l) = B(k-i,l-j) \qquad (6)$$

Application of CNN Method to Gravity Data in Marmara Region

Topography, Gravite and aerial magnetic data of the Thrace region have been measured by TPAO. The gravity anomaly map prepared by TPAO was used in this study (Figure-2). When the map of gravity anomaly is examined, anomalies from Istanbul region to Edirne show relatively low value. These values correspond to places where the Ergene Basin is located. High gravity values have been measured at sites where intrusive mountains are present, indicating that the density is high. Gravity anomaly values in the Thrace region are decreasing. We can say that this is from the Thrace pit. The Bouguer gravity values in the Thrace Basin range from -5 to 50 mgal. Thick and young sediments with low densities form low gravity anomalies in the center of the Thrace basin. High gravity anomalies are found in the north together with the Istranca Massif and in the south due to outcrops of the Paleozoic basement rocks. These units contain magmatic, metamorphic and ophiolitic rocks in some places [12].

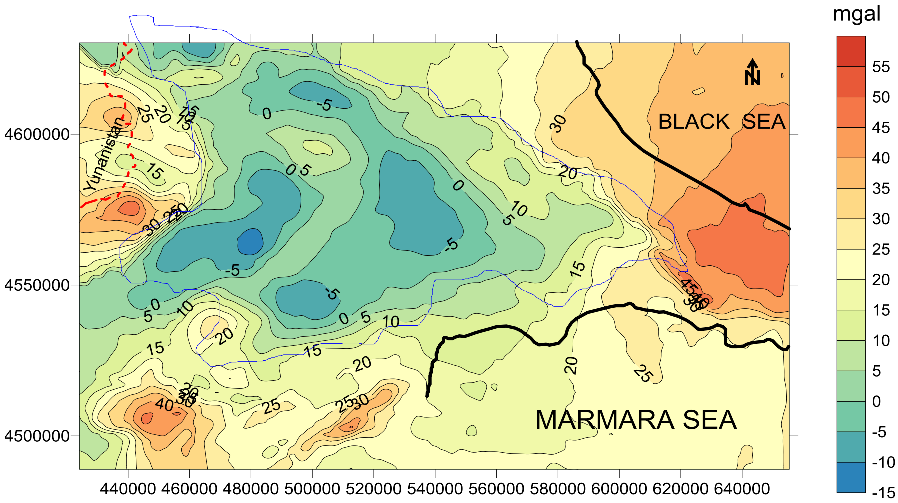

Figure 2: A map of the gravity anomaly of the Thrace (Ergene) region

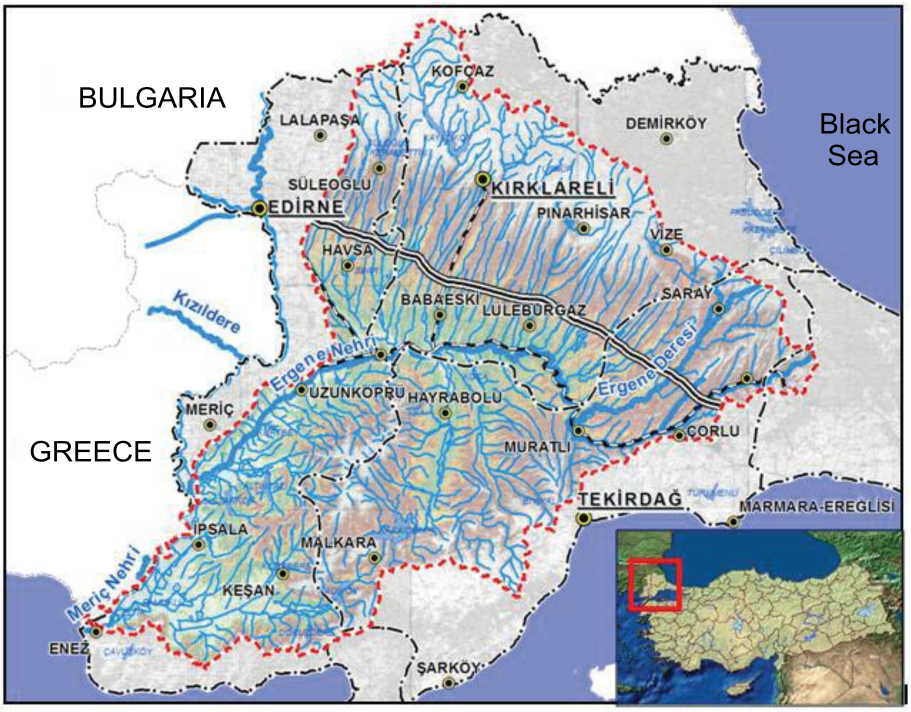

Figure 3: Thrace (Ergene) basin boundaries [12 has been changed and replaced]

The CNN method is applied to the map of gravity anomaly given in Figure 2 and the CNN output is shown in Figure 5, the relief map of the CNN output is shown. When the CNN output is examined on both maps, we can see clearly the Eskisehir-Thrace Fault Zone which goes towards the Istranca Mountains. This Fault Zone has lost its activity and has not produced earthquakes in recent times.

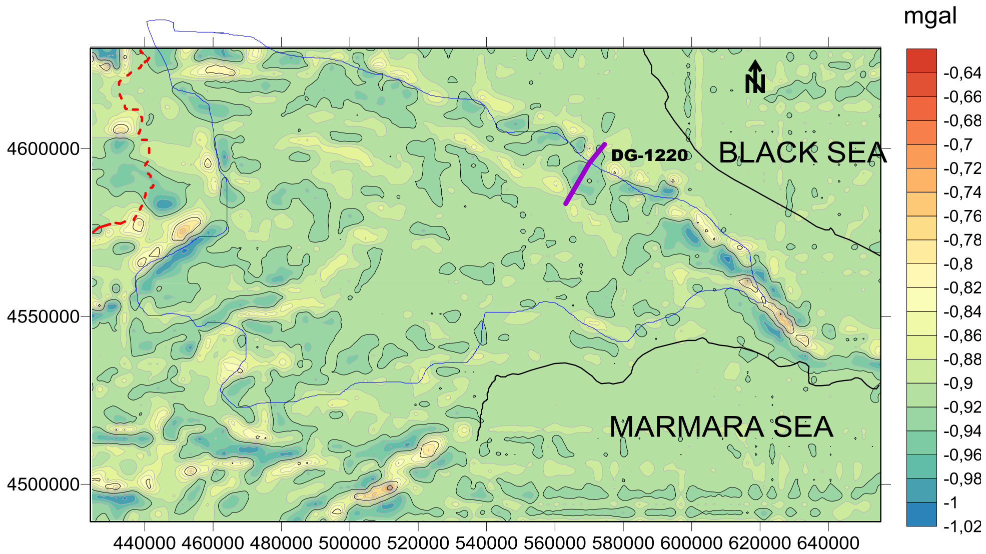

Figure 4: The map obtained after applying CNN to the map of gravity anomaly of the Thrace-Ergene basin. Here, the purple line is the deep seismic (DG-1220) section of the TPAO.

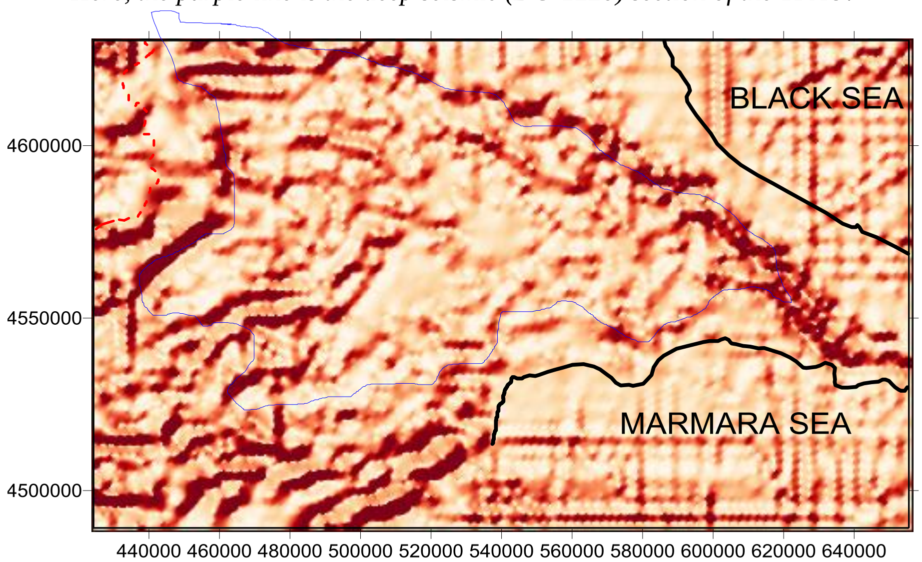

Figure 5: The relief map of the CNN map obtained from the map of gravity anomaly of the Thrace-Ergene basin.

Stratigraphy of the Thrace-Ergene Region

The Palaeozoic-Upper Cretaceous time-varying stratigraphy of a Tertiary Basin, which is rapidly sedimented and rapidly stored starting from Eocene, is given in Figure 6. At the top of the base rocks is the Gazi village formation, which consists of dark gray colored shales containing sandstone, siltstone and tuff. Later, Kesan formation consisting of sandstone, Sogucak formation consisting of limestones, Ceylan Formation consisting of tuff, shale, sandstone and clayey limestone is located. Oligocene sediments, green gray shales, marls and tuffs are composed of Mezardere Formation. Then the Osmancık Formation consisting of sandstones and shales and the gray green claystone, sandstone, conglomerate and tuff Danismen Formation are under this [12]. The stratigraphic structure of the region is organized by the generalized Stratigraphic Section (MTA and TPAO studies [12]).

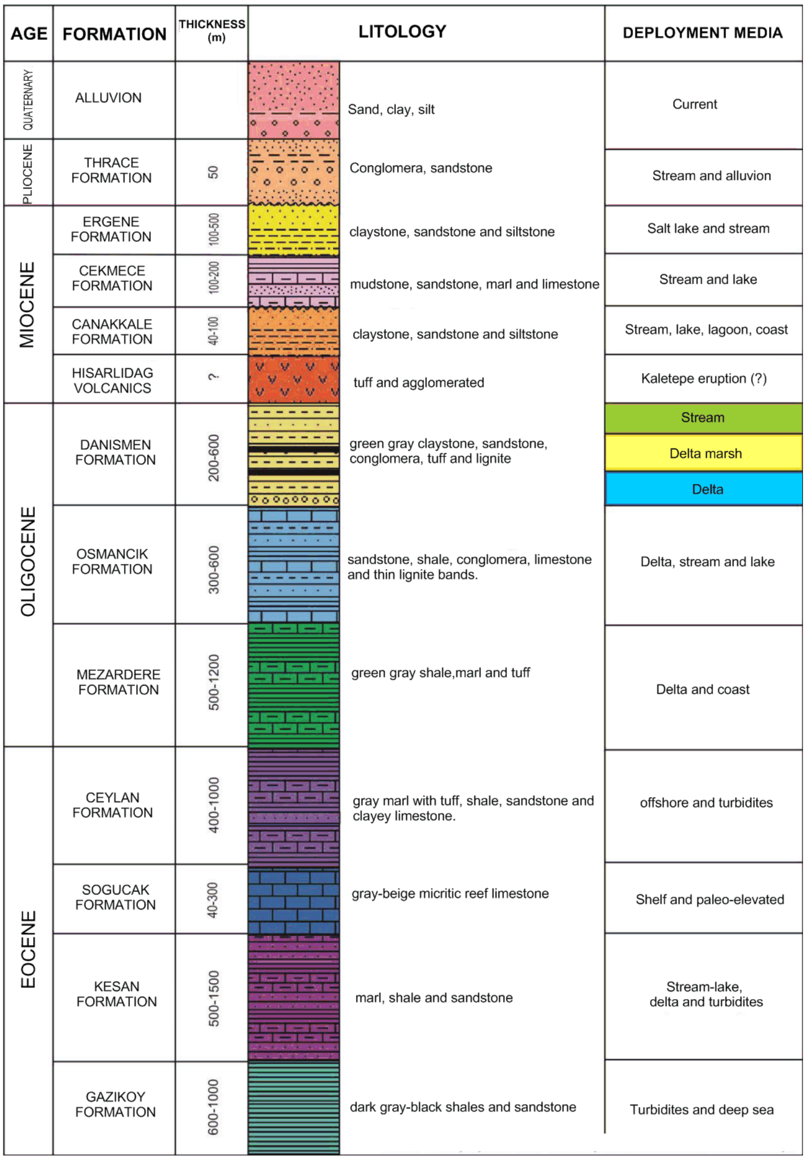

Figure 6: Generalized Stratigraphic Section of the Thrace-Ergene Basin [12 has been changed and replaced]

Conclusion

In this article, the CNN method was applied to the map of Thrace-Ergene region Gravity anomaly. With CNN, successful results were obtained in determining the discontinuity limits. In addition, many studies have been done on the separation of regional and residual anomaly maps using CNN [1], [17], [20] and [21]. It is seen from all these studies that CNN is very successful in solving many problems in Geophysical Engineering. As it is known, gravite anomaly effects can be observed in gravite method if there are density differences laterally. Fault structures cause a discontinuity and thus make it possible to create gravity anomaly. When the map of the location of the ergene basin is examined, it is seen that the ergene class also affects the basin (Figure 3). In this study, CNN is applied to the map of Gravite anomaly of Thrace-Ergene basin (Figure-2) and it is aimed to determine the locations of the faults that cause discontinuity in the region. After applying the CNN gravity anomaly map, the relief anomaly map given in Figure 5 was obtained with the exit map given in Figure 4. When these results are examined, it is seen that the Thrace Eskisehir Fault Zone (TEFZ) comes from the northern part of the Istanbul Bosphorus and extends towards the Kirklareli region. Kirklareli region and the northern side of the Canakkale region have been identified with discontinuity boundaries, which can be said to have originated from faults. This is also evident from the deep seismic records of the TPAO region (Figure 7).

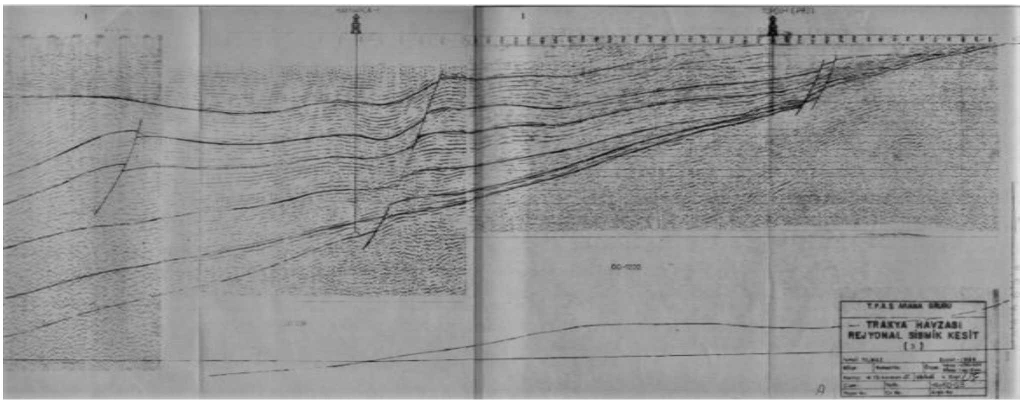

Figure 7: Deep seismic section of TPAO in Thrace-Ergene Reservoir (DG-1220)

Many deep seismic studies have been carried out in order to search oil, natural gas and coal in the Ergene basin and fault lines in the region have been shown. The deep seismic section of the DG-1220 deep seismic section where the TPAO is taken and shown in Figure 7 with the purple line over the map of gravity anomaly given in Figure 4. It is seen that the location of the fault lines detected by CNN and the data obtained from the deep seismic sections of TPAO provide a complete overlap. This proves that the CNN method has achieved quite successful results in boundary detection.

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