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Research Article

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Calculation of Bingöl Region Iron Ore Reserves Using Cellular Neural Network

A. Muhittin ALBORA

Istanbul University-Cerrahpaşa, Engineering Faculty, Geophysical Department, 34850, Büyükçek-mece, Istanbul, Turkey Email: muhittin@iuc.edu.tr

Abstract In geophysical studies, it is an important issue to determine the building boundaries and to perform separation analysis. In addition to the classical techniques used in geophysical methods, the use of Artificial Intelligence-based image processing techniques is considered attractive. Recently, Cellular Artificial Neural Networks (CNN) method has been used in geophysical studies and very good results have been obtained. The filtering structure of the CNN method provides fast and parallel computation capability for geophysical image processing applications. The behaviour of the CNN method is adjusted by the supervised learning algorithm and is defined by two pattern matrices. For the analysis of data with potential origin, the training phase is first applied to the CNN method, processed into potential origin anomaly maps, and can be analysed sequentially. In this study, the CNN method was applied to the vertical magnetic anomaly map made in the iron mine in the Bingöl region of Turkey. CNN outputs were compared with the boreholes drilled later in the region. As a result, it has been shown that the CNN method is a good method that can be used in solving the problems of both separation and boundary detection.

Keywords Magnetic anomaly map, iron ore, Cellular Neural Network (CNN), Turkey-Bingöl

Introduction

It is an important problem to distinguish between regional and residual anomaly maps and to determine the structure boundaries in potential origin anomaly maps. Many authors have done various studies on this subject. They made the regional and residual distinctions of potential source data using wavelet method analysis [1], [2]. They found regional and residual maps from potential anomaly maps by using wavelet method, which is a new method in revealing the building boundaries and noise analysis method [3], [4], [5], [6]. Cellular Artificial Neural Networks (CNN), a special type of artificial neural networks, were first introduced by Chua and Yang (1988). This puts CNN in a very advantageous position compared to artificial neural networks in the classical sense. In addition to carrying some basic features of artificial neural networks in the known sense, they find a lot of application areas in image processing and image recognition, especially due to their two-dimensional structure [7], [8], [9], [10] and [11] . In this study, the CNN method, which is frequently used in image processing today, was applied to the magnetic anomaly map obtained from the region as a separation method and a very good result was obtained compared to the classical methods. The magnetic anomaly map obtained from the Bingöl mining area has been applied to the separation of the structure boundaries and regional-residual separation, and quite good results have been obtained compared to the classical methods. A good result was obtained when the obtained CNN anomaly maps were correlated with the drilling studies.

Method

Cellular Neural Networks

They are dynamic artificial neural networks that are interconnected and mostly composed of two-dimensional cells. The most important feature that distinguishes CNN from artificial neural networks as we know it is that the connection weight coefficients form an invariant connection network on the studied plane. This puts CNN in a very advantageous position compared to artificial neural networks in the classical sense. In addition to carrying some basic features of artificial neural networks in the known sense, they find a lot of application areas in image processing and image recognition, especially due to their two-dimensional structure. Cellular neural networks are mostly made up of cells arranged to form a two-dimensional array. Contrary to known artificial neural networks, every cell here is in connection with cells in its close neighborhood (Figure 1). The basic function of the CNN method in image processing is to transform any input image into an output image in accordance with the desired purpose. Here, each pixel value is limited to -1 and +1 when the output image is considered in the initial form of the CNN method. However, the input images can also have multiple gray levels, after providing the appropriate voltage values. After any transient initiated or driven by an input image, the CNN-processed image always converges to a steady-state fixed point if it satisfies the necessary conditions. In image processing, the CNN method is generally a non-linear and dynamic processing of a given input image to create the output image.

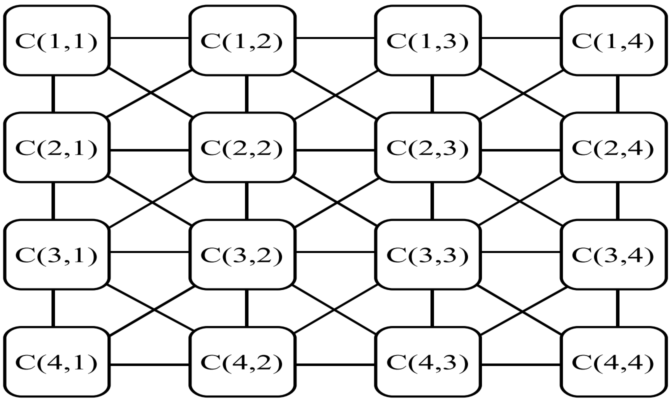

Figure 1: Two-dimensional (4x4) cellular neural network [9]

An CNN cell contains the input, state, and output variables, respectively, um,n , xm,n, and ym,n. The CNN state and discrete time output equations can be written as

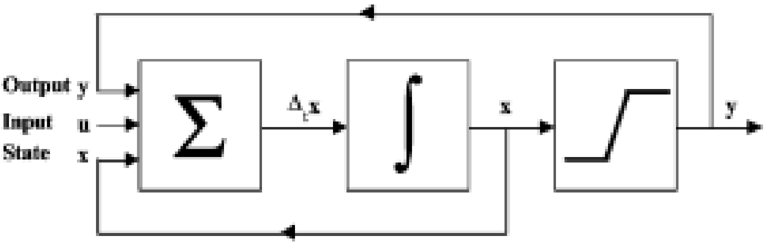

Figure 2: Functional block diagram of a CNN cell

Each cell in these structures:

a) A linear input unit with weighted addition

b) A linear dynamic interface

c) It is a dynamic circuit consisting of a piece-wise linear:pwl output unit symmetric with respect to the origin with n pieces (usually three pieces) (Figure-2).

$$x_{i,j}(n+1)=\sum_{m=-s}^{s}\sum_{n=-s}^{s}A_{m,n}\,y_{i+m,j+n}(n)+\sum_{m=-s}^{s}\sum_{n=-s}^{s}B_{m,n}\,u_{i+m,j+n}(n)+I \qquad (1)$$

$$y_{i,j}(n+1)=f[x_{i,j}(n)]=\frac{1}{2}\left(\left|x_{i,j}(n)+1\right|-\left|x_{i,j}(n)-1\right|\right) \qquad (2)$$

It should be noted that in this equation, besides the classical filtering, an iterative filtering from the A feedback link weight coefficients is also performed. Here, the entries of the cells are real numbers that take values in the range [-1,1]. The outputs of the cells, on the other hand, are outputs that can only take -1 or +1 values if stability conditions are met after a certain period of time (or cycle) [12].

Study Area

As a field study, the reserve research of the iron ore in the Avnik locality of the Bingöl region was carried out. The geological map of the region is given in figure 3.

Stratigraphy of Bitlis Metamorphics in the Region

They form the westernmost extension of the Bitlis massif in the Avnik region. It is composed of two main rock groups with angular unconformity between the Bitlis metamorphics in the Avnik region. The older group was named as the lower group, and the younger units as the upper group. The group called the lower group was cut by the granite masses and then covered by the upper group. [13] who had worked in the Bitlis massif gave the old foundation name to the old rocks (gneiss, leptinite and amphibolite). The sub-community in the Avnik region was formed from this old unit.

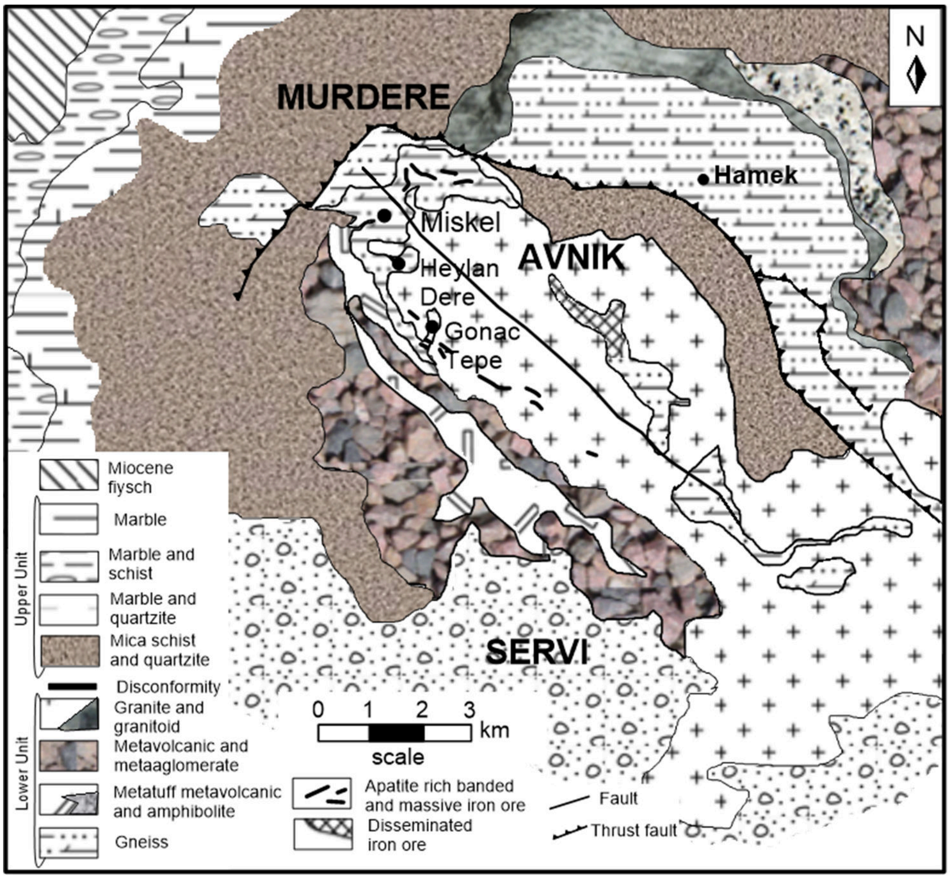

Figure 3: The geology and inventions map of Bingöl iron ore (Avnik region) has been modified from 14.

Sub-Community

The sub-assembly in the Avnik Region is composed of gneiss with lateral and vertical changes, the felsic Sub-assembly in the Avnik region is composed of three rock units that show vertical and lateral transitions with each other and are listed as gneiss, felsic metatuff-metavolcanites and mafic metavolcanics from bottom to top. The lowest unit of the subgroup is gneisses. The gneisses constituting this unit are gray colored and partly augen, biotite, garnet-bearing feldspar-quartz gneisses and green colored structures rich in magnetite and amphibole. The base of the gneiss unit is over 1100 m thick. This unit alternates upwards and passes into the felsic metatuff-metavolcanite unit. Iron deposits are lined up along this transition zone. The uppermost unit of the lower assemblage is the Mafic metavolcanics [14].

Parent Community

The upper assemblage in the Avnik region consists of micaschists and marbles. At the bottom is the micaschist unit. This unit is overlain by a discontinuous quartzite over gray marble.

Structural Geology

The level between the lower and upper assemblage in the Avnik region is an important angular unconformity boundary [15].

The oldest unit of the upper group are the micaschists. General Characteristics of Avnik Apatite Iron Deposits

Avnik iron deposits are massive and lenticular in shape and consist mainly of magnetite and a small amount of apatite and amphibole minerals. The ore type in the form of scattered magnetite zones is encountered in spotted amphibolites and metavolcanics. The most economically important deposits of the study area are located in the transition zone of the gneiss unit and the felsic metatuff-metavolcanic unit and along the section where the rocks of both units are alternated [14].

Gonactepe Locality

The Gönaçtepe deposit consists of large magnetite, apatite and actinolite crystals. As can be seen from the drilling results, they enter the granitoid unit after cutting 5, 10 m thick ores, and these deposits are of no economic importance. As seen in Figure 4, values vary between -24000 nT and 24000 nT on the magnetic map indicated by a. The CNN method was applied to the Total magnetic anomaly map obtained in the Gonançtepe region and the CNN output obtained is shown in Figure 5. In Figure 6, drilling sections of Gonançtepe locality are given. We have 4 drillings (G1, G6, G13, G21) in the region. As can be seen from the drilling pillar sections, there is a thick sediment cover in the region. The ore is near the surface and has outcropped. The purpose of these drillings made in areas with low anomaly values is to determine whether there is ore in deeper regions. Although 2 m high-grade ore was found under the sediment cover in the G1 drilling, it is not significant. When the CNN output is examined, the G1 drilling does not give any anomalies in the region, which shows that our method is successful. In other drillings, the most medium grade ore was found.

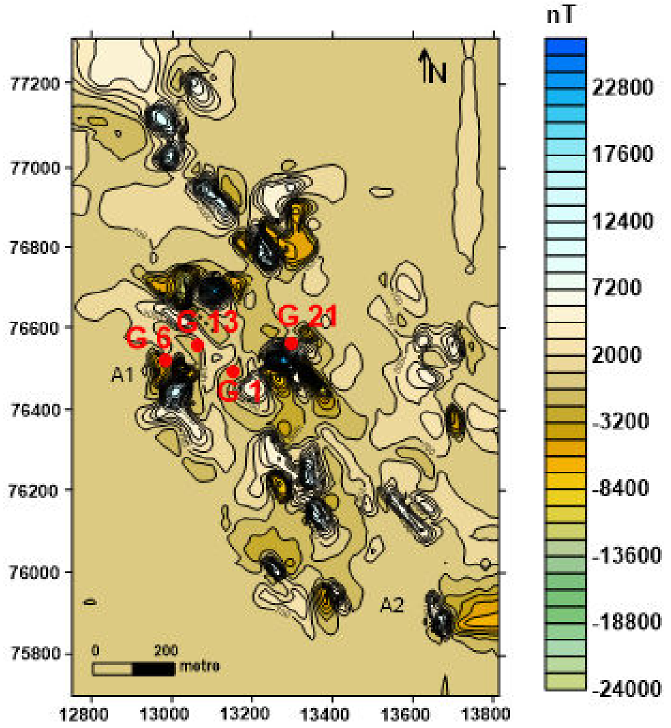

Figure 4: Obtained total magnetic anomaly map of Gonançtepe locally

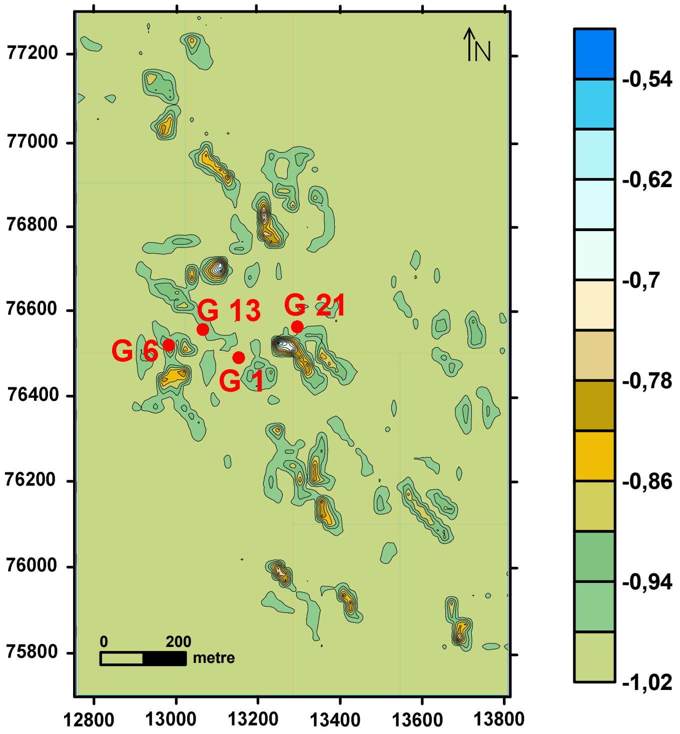

Figure 5: CNN output of the total magnetic anomaly map of the Gonançtepe location

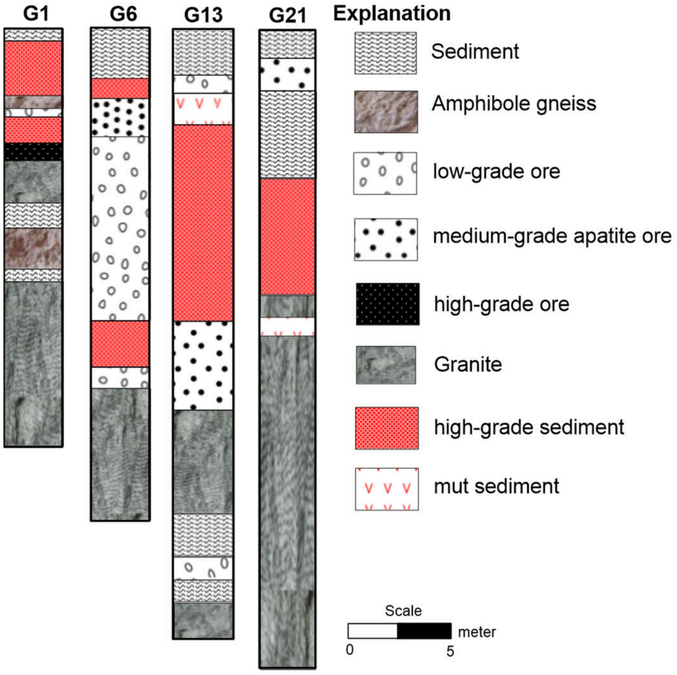

Figure 6: Drilling data of Gonançtepe location (taken from MTA)

Conclusion

In order to distinguish between regional and residual anomalies and to determine the structure boundaries, it is aimed to use a new method, CNN, by combining Cellular Artificial Neural Network (CNN) and Wavelet methods, which have been used recently in Geophysical Engineering. As a field study, the total magnetic anomaly map made by the Mine Investigation Assignment (MTA) on the iron ore of the Avnik region in the Bingol Region was used. CNN method was applied to the magnetic anomaly map made in Gonançtepe in the region where the iron ore is located and the obtained CNN anomaly maps were compared with the drilling data in the region. In the Gönaçtepe vertical magnetic anomaly anomaly map, which was discussed first, polarizations are observed in areas close to the surface and with high grade. High anomaly values are generally between 25,000 NT and -24,000 NT values. In places with high anomaly values, the effect of the mine close to the surface is seen. In addition, we can see that G1, G6, G13 and G21 drillings are carried out in Gönaçtepe locality where anomalies are weak. When these drillings are examined, it is seen that there is a 2.00 meter sediment cover up to 10.80 meters of muddy sediment, low-grade ore between 10.80-12.85 meters, sediment between 12.85-17.50 meters, and high-grade ore between 17.50-19.95 meters at the G1 drilling site. There is a very low anomaly where the G1 drilling is done. Since this is not a very large amount of ore, it is normal for the anomaly effect to be low. When the G6 drilling site is examined, it is seen that there is a drilling site outside the anomaly with high values in the CNN output given in Figure 5. Here, there is sediment up to 3.00 meters, medium grade ore between 4.65-6.70 meters and low grade ore between 6.70-19.90 meters. This harmony is also seen in the CNN output obtained from the magnetic anomaly map. When the G13 drilling site is examined, a sediment of 4.75 meters is observed. Low grade ore was found between 4.75-7.20 meters, high-grade sediment between 7.20-29.15 meters, and medium-grade apatitic ore between 29.15-38.00 meters. There is an anomaly with low values at the place where the G13 drilling in Figure 6 was made. We can talk about a good overlap between the result of the CNN output in Figure 5 and the location of the G13 drilling. In the G21 drilling, it is seen that after a sediment of 5.00 meters, medium grade apatite ore enters the sediment cover between 5.00-

10.70 meters and after 10.70 meters. When the CNN output given in Figure 8 is examined, G21 drilling was carried out in the place where the weak anomaly effect coincides with the middle of the anomaly with two longitudinal traps. High-grade ore is thought to exist where there are strong anomalies. As a result of the field study, magnetic anomaly maps give a wide anomaly effect in regions with magnetic effect. However, if the CNN method is applied to these anomaly maps, it is seen that a good residual anomaly map is obtained. When compared with the boreholes drilled in the field, we can say that it gives very good results where anomalies are strong.

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