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Specific Relation of Faults and Copper Mineralization in Chahargonbad Area, Iran

[1]R. Derakhshani, [2]A. Mehrabi and [3]Z. Baghfalaki
[1]Department of Geology, Shahid Bahonar University, Kerman, Iran
[2]Geological Survey of Iran, Kerman, Iran
[3]Mining Engineering Organization, Kermanshah, Iran

Abstract: The main goal of this study is determining of relationship between faults and copper potential in Chahargonbad area in Southern part of Central Iranian Volcanic Belt. This area has some of the known copper deposits in Kerman Province of Iran. Fault map of the area is prepared by studying of aerial photographs and after field checking of photogeological map of the region. Also, remotely sensed data from Landsat 7, helped us to provide a lineament map of the study area which was also controlled in the field for establishment of faults. Seventeen porphyry copper deposits in the study area are detected. These deposits are mapped, digitized and finally rasterized using GIS advantages. After digitizing and rasterizing of faults, some buffers are determined around them for measuring the situation of deposits within them. Then weight of evidence modeling is applied to quantify the spatial association between faults and porphyry copper deposits. Using remote sensing, GIS, weights of evidence modeling and field checking, it is recognized that porphyry copper deposits in Chahargonbad area, are concentrated through 1 km buffers around faults.

Key words: Tectonics, weight of evidence, RS, GIS, faults

INTRODUCTION

Recently, specific relation of known mineral deposits with different structural features, such as faults, is a factor in some exploration programs (Derakhshani and Mehrabi, 2009a) specially for the regions where geology is known but geoexploration data are lacking. Porphyry copper deposits genetically could associate with faults and plutons according to plate tectonic theory (Shahabpour and Doorandish, 2008; Hezarkhani, 2006a, b). Recently, curvy-linear structural features are studied from mineral deposit concentration viewpoint (Derakhshani and Mehrabi, 2009b; Mayer and Sausse, 2007; Carranza 2002, 2009; Carter and Cheng, 2008).

The specific relation of some mineral deposits and curvy-linear structural features is due to the localizing mineralization by those structures. For example, faults can canalize mineralizing fluids whilst igneous intrusions cause chemical reactions with the intruded rocks by providing heat sources which may cause mineral deposition there (Niemeyer and Munizaga, 2008).

Since, faulting could play a close relation with copper mineralization, specific association of them is quantitatively calculated in Chahargonbad area, taking advantages of GIS, RS and weight of evidence modeling.

Corresponding Author: Reza Derakhshani, Department of Geology, Shahid Bahonar University, Kerman, Iran Tel/Fax: +983412510643

MATERIALS AND METHODS

This research is studied the specific relation of faults and porphyry copper deposits in Chahargonbad area that is situated at the Southern part of Central Iranian Volcanic Belt. Remotely sensed data from Landsat 7 are used for deriving lineaments of the study area by applying some filters, such as Laplacian and Sobel and also some directional filters in 8 different directions: N, N45E, E, S45E, S, S45W, W and N45W. Since, this lineament map may include some non-geological lineament, such as roads and rivers, so fault map of the area is provided from lineament map after field checking. Porphyry copper deposits of the area are mapped and finally rastrised using GIS advantages. Weight of evidence method is applied finally to find a quantitative specific relation between faults and copper deposits.

Measuring of specific relations of faults and copper deposits involved the following steps:

- Digitizing faults as lines
- Rasterizing fault maps and generating buffers around rastered fault lines
- Digitizing porphyry copper deposits as points
- Rasterizing porphyry copper deposit points
- Calculating number of copper deposit points in and out of a binary domain by crossing or overlaying each of the raster maps of the binary domains with the raster map of copper deposits
- Determining the weights base on Eq. 1 and 2
- Measuring C and Studentised C

RESULTS AND DISCUSSION

Calculating of weights to estimate specific relation requires polygonal domains. Chahargonbad area, have both curvy-linear structural features (such as faults) and points (such as porphyry copper deposits). Distance buffering is performed to convert faults to polygonal domains.

These faults were detected by studding of Landsat satellite images, aerial photographs and field checking (Fig. 1). Finally 122 faults identified in Chahargonbad area. Fault map converted to raster from vector form. Buffer zones of 500 m interval are provided around each faults using ArcGIS software. After mapping and rasterizing of porphyry copper deposits of the area, it is overlaid on the buffered fault map by using spatial data modeler software.

W+ and W-factors of each buffer zone are calculated by counting of the porphyry copper deposits in and of it. After doing this process for each buffer zone, it is resulted that the number of Studentised C in 3500 m buffer zone is 1.9021 which is the minimum one among buffer calculated numbers. According to weight of evidence method, this number show that the specific relation of faults and copper mineralization is in its minimum state in 3500 m wide buffer zone. The spatial association of faults and copper deposits is positive in 500 to 2000 m wide buffer zones. Studentised C is cached to its maximum level, 4.3662, in 1000 m wide buffer zone. So, the most relation of faults and copper deposits could be found in 1000 m wide buffer zone around faults.

The general basis of area selection in many mineral exploration programs is quantitative knowledge about the specific relation between faults and mineral deposits. Here, the specific relation between faults and porphyry copper deposits in Chahargonbad area are quantified using weight of evidence modeling. Chahargonbad area located at the Southern part of

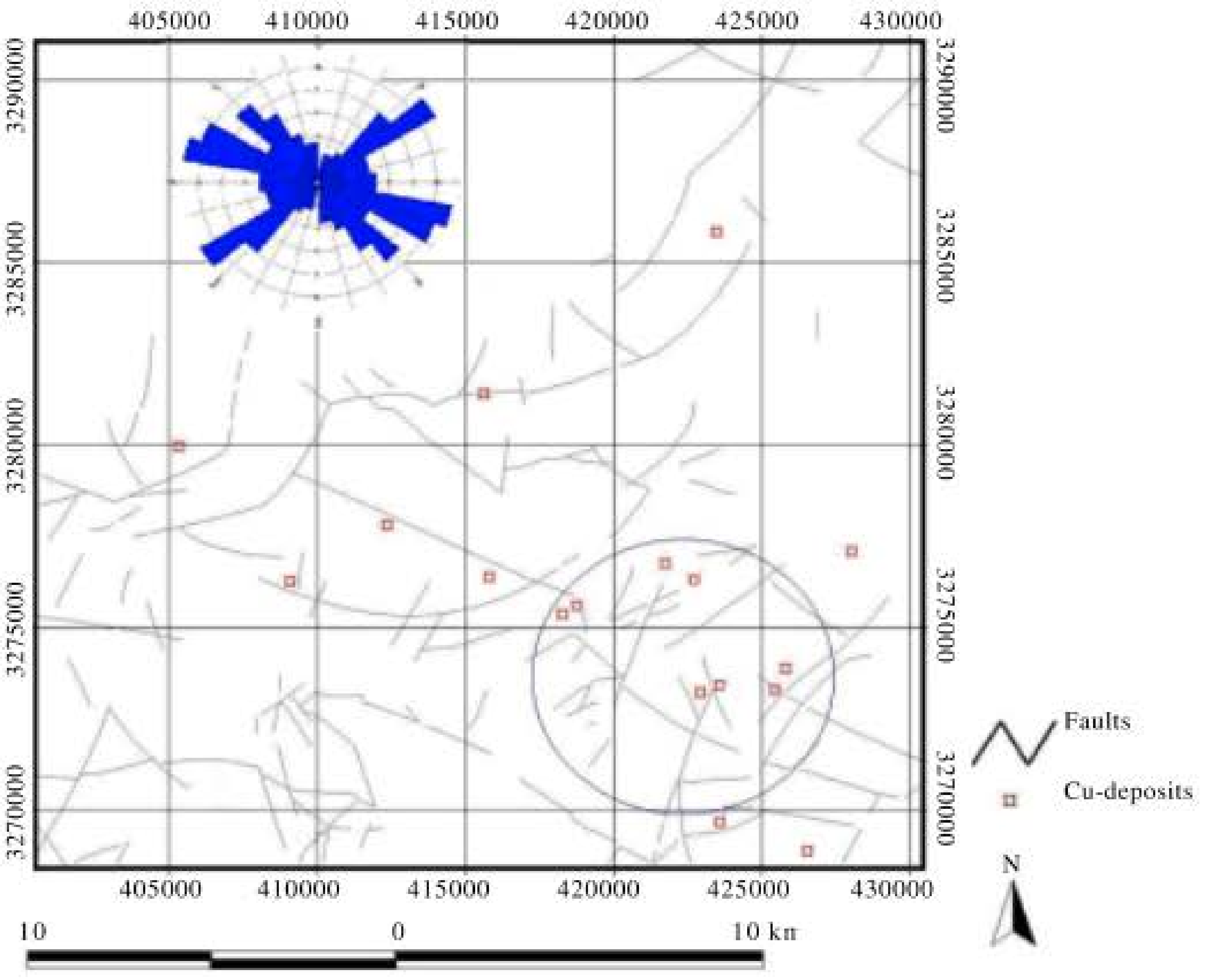

Fig. 1: Strike-slip faults and fractures map and porphyry copper deposits in the study area

Central Iranian Volcanic Belt, between 29°30´-29°45´N latitudes and 55°55´-56°15´E longitudes (Fig. 2). There are 17 porphyry copper deposits in this area while Chahargonbad deposit with 530 km^2 area is an active cupper mine there.

The Central Iranian Volcanic Belt with the NW-SE direction extends as the same direction of Zagros Mountain Range (Derakhshani and Farhoudi, 2005) and mostly, includes volcanic-alluvial parts of Eocene period (Fig. 2). One of major features of the region is great amount of volcanic Eocene rocks which have been considered as the main ore creating part (Derakhshani and Abdolzadeh, 2009a). Porphyry coppers of this Volcanic Belt are created by injection of diorite to granodiorit bodies from middle Oligocene to Miocene. (Derakhshani and Abdolzadeh, 2009b). Weight of evidence method which was developed by Carter and Cheng (2008) helped us to find a quantitative relation between faults and copper deposits in the southern part of this volcanic belt.

Given the absence or presence of a domain, e.g., a buffer zone around a fault, a weighting performed between that domain and a set of points, e.g., porphyry copper deposits. The weighting yields (1) W+ weights in the domain (DP) and (2) W- weights out of the domain (DA). T = DP + DA; where, T is the total area being studied. Because the aria of a deposit is much smaller than the domain being considered, the weights of evidence are estimated by taking the natural logarithms of the probability ratios.

$$W+ = \log_e ((\%\text{ deposits in DP}), (\%\text{ of total area occupied by DP})) \tag{1}$$

$$W- = \log_e ((\%\text{ deposits in DA}), (\%\text{ of total area occupied by DA})) \tag{2}$$

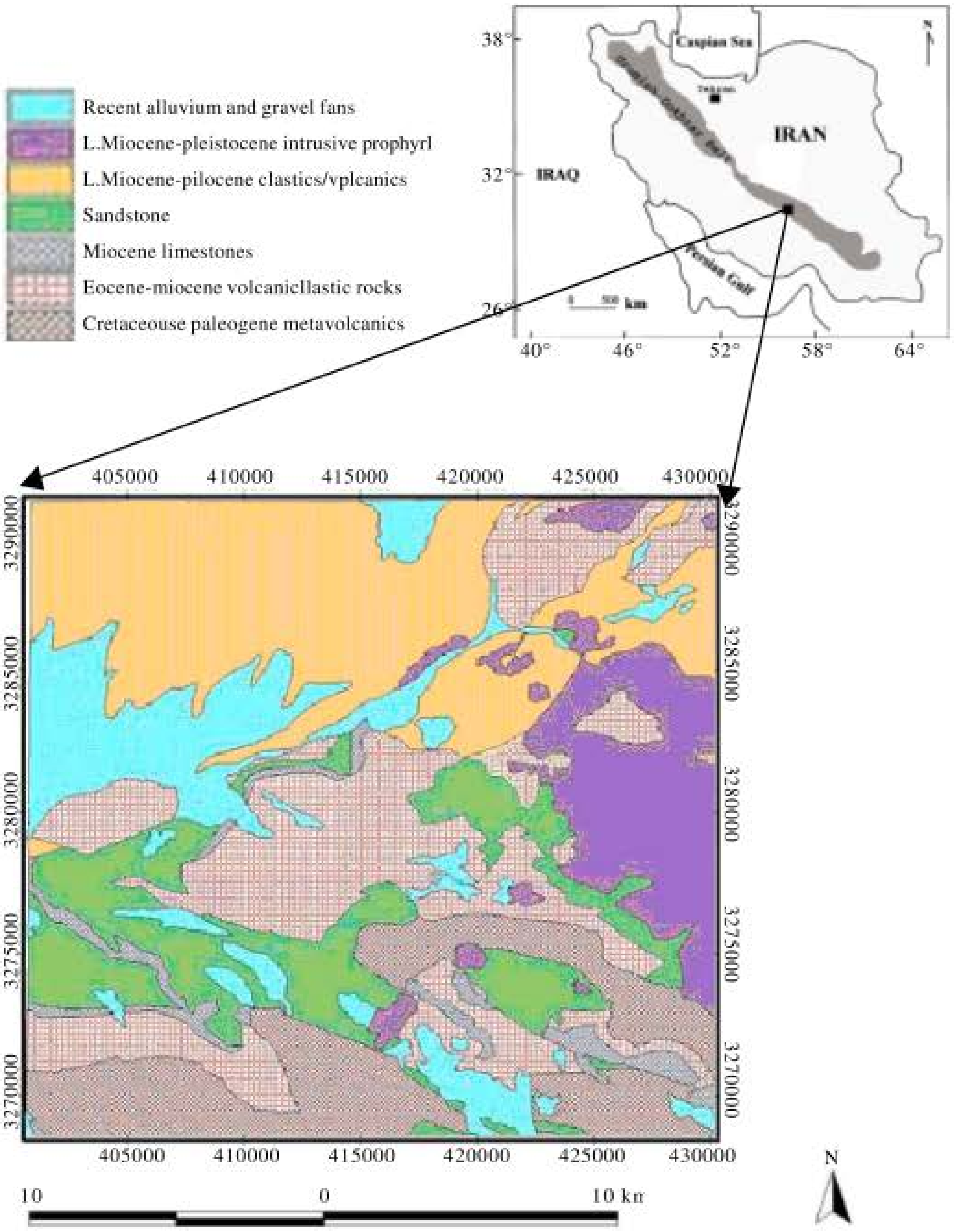

Fig. 2: Location and geological map of study area

W+ and W- present measures of the specific relation between the deposits and a fault buffer zone. (W+) >0 and (W-) <0 present positive specific association, (W+) <0 and (W-) >0, imply negative spatial relation and (W+) = (W-) = 0 present no spatial association. The variances of the weights can be calculated from:

$$s^2(w+) = \frac{1}{mD_p} + \frac{1}{bD_p} \quad (3)$$

$$s^2(w-) = \frac{1}{mD_A} + \frac{1}{bD_A} \quad (4)$$

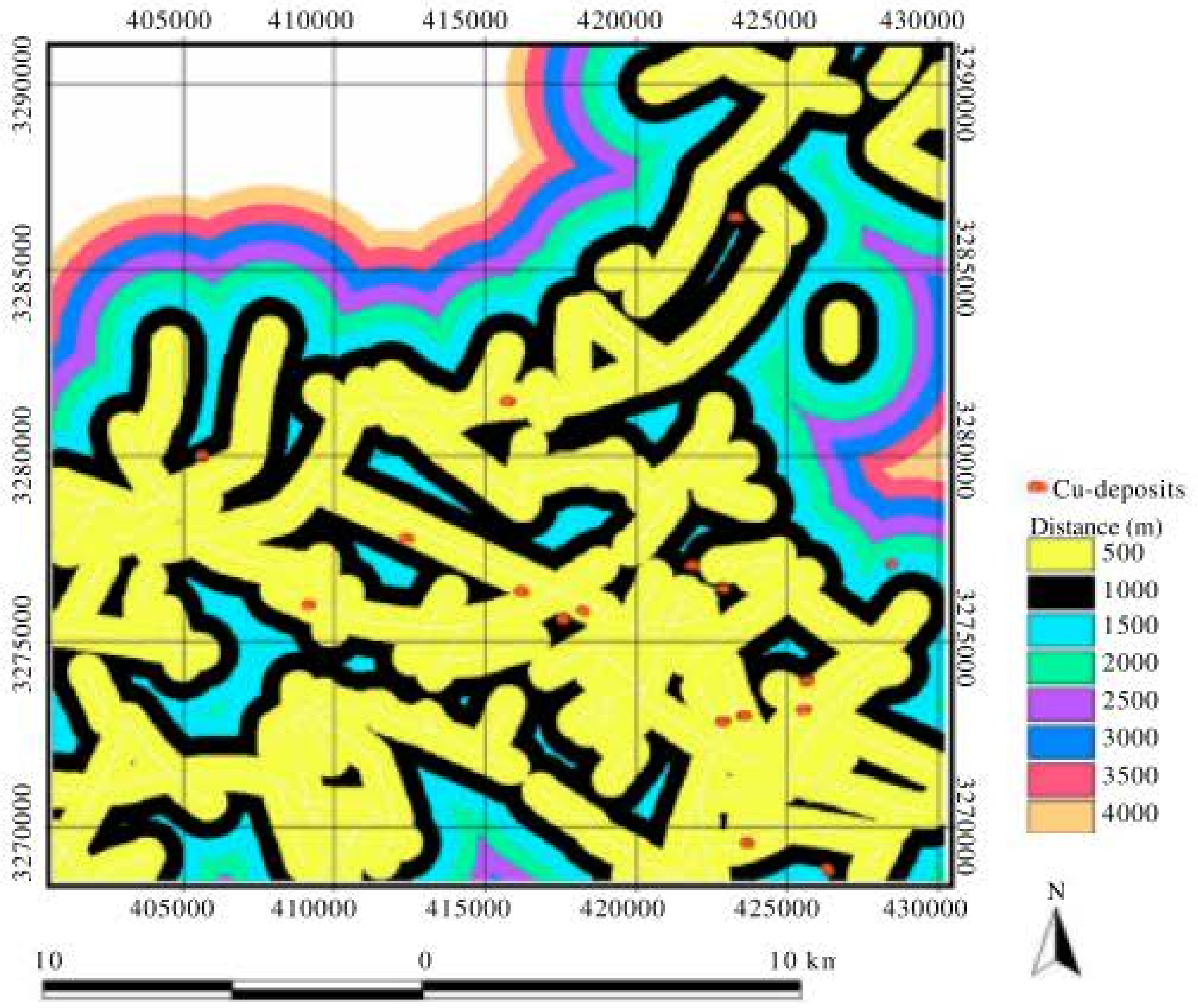

Fig. 3: Representation of optimum distance between porphyry copper deposits and strike-slip fault fractures

where, mDP and mDA are, respectively the number of pixels with copper deposits in and out of a given buffer zone; bDP and bDA are, respectively the number of pixels without copper deposits in and out of a given fault buffer zone and DP = mDP + bDP and DA = mDA + bDA.

The contrast C combines these weights into an overall measure of the specific relation with a set of copper deposit points for each binary domain and is defined as:

$$C = (W+) - (W-) \tag{5}$$

where, C will have negative values in the case of negative specific association while for a positive spatial relation, C will have positive values. Usually the maximum C gives the cutoff distance buffer at which there is optimal specific relation between a fault domain and a set of porphyry copper points. C would be meaningless in cases of a small number of copper deposit points such as the study area, because of the uncertainty of the weights which could be large. In such areas with small number of copper deposit points, a useful measure to determine the most significant cutoff distance is to calculate the studentised value of C. The Studentised C, measured as the ratio of C to its standard deviation, C/s(C), shows the statistical significance of the specific relation. The standard deviation of C is measured as:

$$s(C) = \sqrt{s^2(W+) + s^2(W-)} \tag{6}$$

Studentised C more than 2 presents a statistically significant specific association. Due to the small number of porphyry copper deposits in the study areas, the cutoff distance within which their specific relation with a given buffer is optimal was chosen according to the maximum amount of Studentised C (Fig. 3).

Table 1: Variation of weights and contrasts for cumulative distances from strike-slip fault fractures respect to porphyry copper deposits

C/s(C)	s(C)	C	s(W-)	W-	s(W+)	W+	No. points	Area (km^2)	Distance buffer (m)
4.1655	0.2283	0.9509	0.1743	-0.4545	0.1474	0.4964	10	631.93	500
4.3662	0.3059	1.3357	0.2801	-0.9754	0.1230	0.3603	16	1017.81	1000
4.0664	0.5905	2.4013	0.5792	-2.0949	0.1150	0.3064	17	1221.00	1500
3.3922	0.7182	2.4364	0.7091	-2.2146	0.1140	0.2218	17	1337.85	2000
2.9190	0.7188	2.0983	0.7098	-1.9410	0.1138	0.1572	17	1421.65	2500
2.4004	1.0089	2.4219	1.0026	-2.3066	0.1129	0.1153	17	1497.05	3000
1.9021	1.0104	1.9219	1.0041	-1.8547	0.1128	0.0671	17	1566.84	3500
							17	1690.01	4000

According to the above discussion, it is obvious that calculation of weights to estimate specific relation requires polygonal domains. Present study domains, however, are either point (porphyry copper deposit) or linear geological features (faults). Distance buffering was performed to convert these point and linear domains into polygonal domains.

By calculating the Studentised C, the specific relation between faults and porphyry copper deposits in the study area is obvious (Table 1). This specific relation between faults and copper deposits is due to the role of faults in canalizing mineralization. This finding is supported by some researches in other areas (Carranza, 2009; Meyer and Sausse, 2007; Derakhshani and Mehrabi, 2009a) and findings of this research correlate with the aim of the project. The positive specific relation is statistically significant within 500 to 2000 m; however, based on the highest Studentised C, it is optimal within 1000 m. There is very little published work in the study area on the large scale analysis of specific relation of copper mineralization and faults in Central Iranian Volcanic Belt and to the best of our knowledge, this is of the first studies of its kind that concentrates on the quantitatively interpretation of this specific relation by using of weights of evidence modeling, remote sensing and GIS.

CONCLUSION

Porphyry copper deposits in Chahargonbad area are associated spatially within 1 km buffer zones.

According to these quantifications of specific relations, it could be concluded that fault zones can canalize magmatic fluids and are favorable for the emplacement of porphyry copper deposits. Consequently, these fault zones are favorable loci for copper exploration.

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