

## **Studying Brittle Deformation of Taknar Zone, Central Iran by Calculation of the Statistical and Fractal Characteristics on the Structural Fracture Map**

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### **Abstract**

*Structural Fracture Map of Taknar Zone in Central Iran has been drawn using 6 applied remote sensing methods. In this paper detected fractures were classified to 6 main directions. Then rose diagrams of the fractures were drawn for 5 different regions of the zone. Most of the fractures and variety of them were concentrated in the central and southern part. In the next part of the study, Length values (L) of the fractures were calculated and classified in 3 main classes. It was found that the number of each fracture set decreased exponentially by increasing the length values. Calculating Spacing (S) values of each set and comparing them with the number of fractures showed similar conclusions: the number of each set decreased exponentially by increasing the spacing values. The other two calculated factors were Intensity (I) and Density ( $\rho$ ). Most of the frequencies of the both factors were concentrated in the central and southern part. The next important calculated factor was "Fractal Dimension" (D). For the whole zone "D" was linear, which demonstrates the self-similarity of the fractures in different scales. In addition, it was found that the most values of "D" were related to the central and southern fractures. Based on above, reliability of remote sensing techniques for detecting faults has been demonstrated. It also seems that Doruneh Fault has had the main effect in the recent structural deformation and fracture development of Taknar Zone.*

### **Introduction**

Studying statistical and fractal characterizations of fractures and faults has been frequently noticed recently. Taknar Zone, in the northern edge of Central and Eastern Iranian Continental Microplate (Muller & Walter 1983) was chosen for these two reasons: first, Taknar is highly fractured (brittle) and mainly alluvium uncovered. Second, for being prone to have metal ore reservoirs, particularly massive sulfides (Karimpour *et al.* 2004) that can be oriented spatially by the structural fractures (Trip & Vearncombe 2004). Based on above, Structural Fracture Map of Taknar Zone was drawn using 6 applied remote sensing methods, based on local morphological and structural characteristics. In this paper detected fractures will be classified after studying their distribution in the related diagram. Then some statistical and geometrical parameters of the fractures will be calculated. Finally, fractal model of them will be studied and used with the other results for interpreting the brittle deformation related to the main faults of the Zone.

### **Classification of Fractures**

Fig 1 shows the rose diagram of all the fractures of Taknar zone. As it can be seen, the main directions of them are N-S and NE-SW. To classification of fractures by their orientations, first they were divided into 4 main directions: N-S, E-W, NE-SW, NW-SE. The fractures in the first two diagrams were well oriented and in the last two ones they were not. So, each of

the foregoing two directions was classified to 2 equal smaller directions again. Therefore 6 directions were finally resulted: N-S, E-W, NNE-SSW, ENE-WSW, NNW-SSE, and WNW-ESE. Next, diagrams of the whole fractures were drawn for 5 selected small regions of the zone, for finding how each group of the 6 sets has been distributed. It can be easily seen that most of the fractures and variety of them were concentrated in the central and southern part of the zone (Fig 2). Hence it can be said that the fractures of the zone have been developed mostly around Doruneh Fault.

#### **Calculation of Length and Spacing Values**

In this part of the study, Length values (L) of the fractures were calculated and classified in 3 main classes: short fractures (0.01-10 km) with the frequency of more than 250; medium fractures (10.01-20 km) with the frequency of about 50, and tall fractures (20.01-50 km) with the frequency of about 10. It was found that the number of each fracture set decreases exponentially by increasing the length values. This fact has been shown in histogram of Fig 3. Calculating Spacing (S) values of each fracture set and comparing them with the number of fractures showed similar conclusions: the number of each set decreases exponentially by increasing the spacing values, as it has been shown in histogram of Fig 4. These two relations show structural “maturity” and well developing of the fractures in usual.

#### **Calculation of Intensity and Density Values**

The other two calculated factors were Intensity (I) and Density ( $\rho$ ). “I” is sum of the lengths of the fractures in a specific area over the same area (area unit), and “ $\rho$ ” is the number of fractures in a specific area over the same area. So, for calculating these two spatial parameters a network of 90 4×4 km square cells was drawn, covering all over the zone. Then the calculations were done for each cell. The resulted values were plotted on the area map via contour diagrams (Fig 5 & 6). Most of the frequencies of the both factors were concentrated in the central and southern part of the zone, as it has been shown in the maps. These two facts demonstrate that Doruneh Fault has had the main rule to reform and distribute the fractures of the zone.

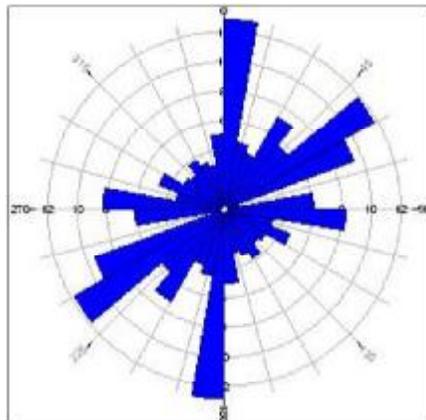
#### **Calculation of Fractal Dimension**

The next important calculated factor is “Fractal Dimension” (D). This factor shows values of “Self Similarity” of the fractures of a specific zone in 2 or more scales. The method used in this research is called “Box Counting”; almost the whole zone was split into 27 separate 10×10 km square shaped areas (boxes), each box overlapped %50 of the adjacent one to gain the maximum precision (some alluvium covered part of the zone in the SW was eliminated to avoid any probable inaccuracies). In each box “D” was calculated in 5 different scales and compared with those of the other boxes. A line chart (logarithm of the number of cells which the fractures have entered them over the logarithm of the number of cells in one side of the box) for each box was drawn to calculate D (or the line slope) and its spatial variations, also to find how much the fractures are “self-similar” which depends directly to the linearity of the points (5 points = 5 scales of calculation). All the 27 related graphs were linear, demonstrating well self-similarity of the fractures. Fig 7 shows 2 typical diagrams of all. In the next step, contour diagram map of all calculated D values was drawn as it has been shown

in Fig 8. It was found that the most values of  $D$  are related to the central and southern fractures of the zone. Based on above, reliability of remote sensing techniques for detecting faults has been demonstrated. The mean of  $D$  values of Taknar zone was calculated to be 1.46 and the most  $D$  value of Taknar zone was 1.6. This value is the upper limit of  $D$  for a mature and highly developed zone (Hirata 1989). Thus Doruneh Fault seems to have the main effect on fracture development, recent structural deformation and evolution of Taknar zone, comparing with Taknar (Rivash) Fault.

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**Fig 1. Rose diagram of all the fractures of Taknar zone; the dominant orientations of fractures are N-5-E and N-55-E.**

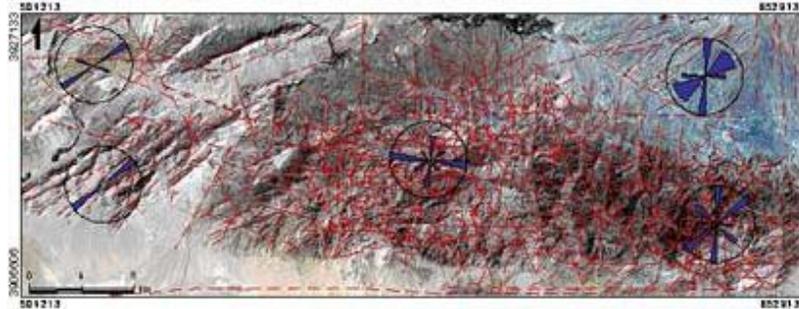


Fig 2. Variations of distribution and orientation of the fractures in Taknar zone; both the number and variety of fractures increase in the center and south of the zone.

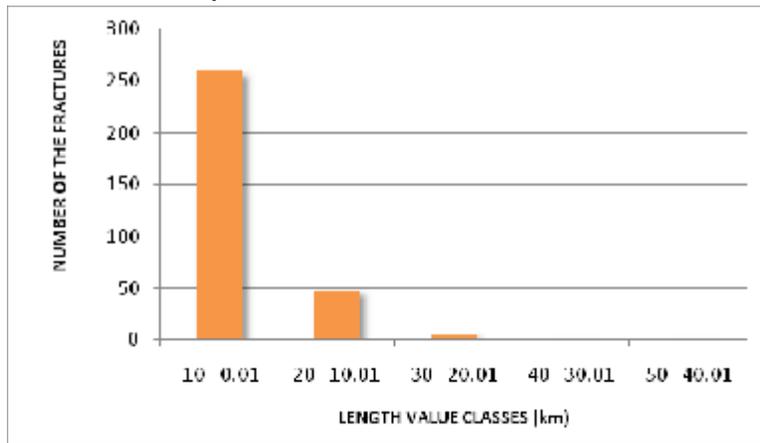


Fig 3. Histogram of length (L) variations by the number of fractures of Taknar zone; the most fractures are the “short” ones and vice versa.

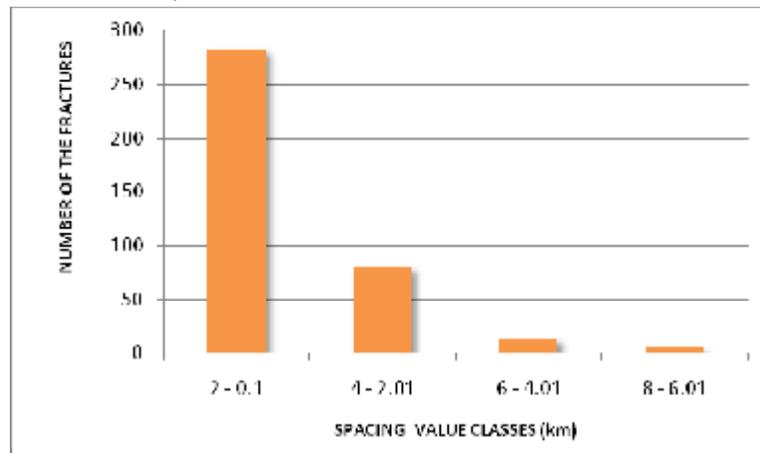


Fig 4. Histogram of spacing (S) variations by the number of fractures of Taknar zone; the most fractures are the “near” ones and vice versa.

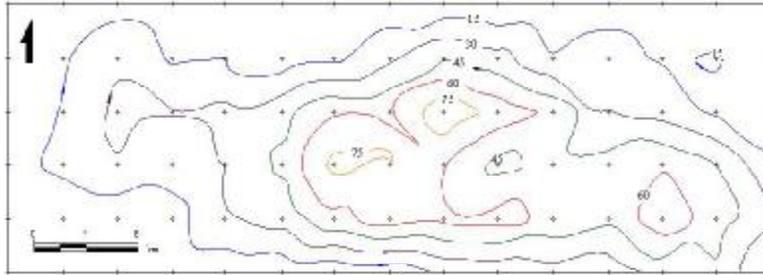


Fig 5. Contour diagram map of intensity ( $I$ ) variations of Taknar zone; the most values of  $I$  are relevant to the central and southern parts of the zone.

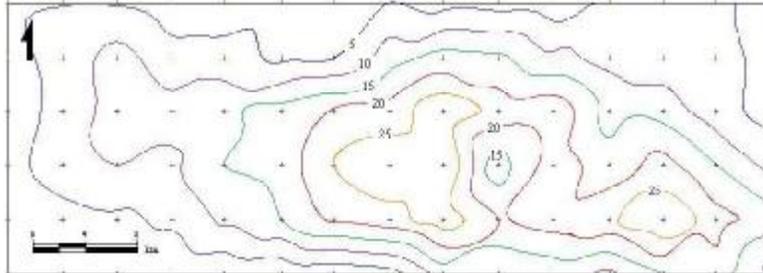


Fig 6. Contour diagram map of density ( $\rho$ ) variations of Taknar zone; the most values of  $\rho$  are relevant to the central and southern parts of the zone.

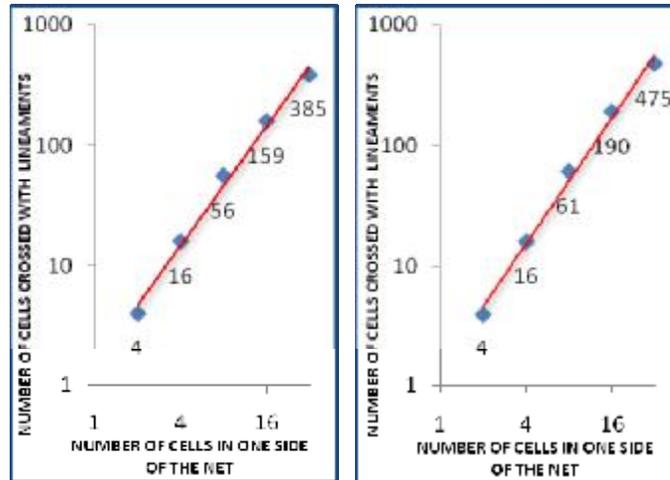


Fig 7. Typical "D" graphs for 2 areas of the 27 selected areas (boxes) of Taknar zone;  $D$  (= line slope) is linear in all of the boxes.

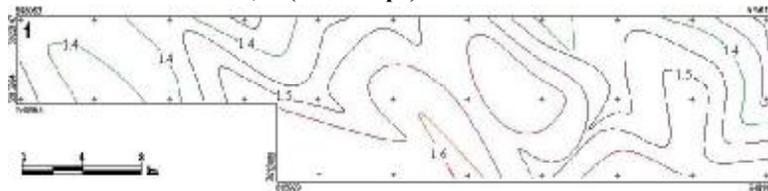


Fig 8. Contour diagram map for studying spatial variations of  $D$  values; the high values are relevant to the central and southern parts of the zone.