# *Calculation of Fractal Dimension of the Geological Formations and Their Relationship to the Formation Sensibility*

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## Extended abstract

### Introduction

Fractal analysis is one of the quantitative modeling of river networks. By determining the fractal dimension of linear structures such as faults, canals, and meandering river paths, it is possible to estimate many features. Fractal of figure is a component with static geometric patterns that illustrates the general pattern of a phenomenon. The initial studies to create quantitative, mathematical, and geometric proper models for river networks were mainly developed by Horton in 1932 and 1945. The study of relationship and comparison between quantitative parameters with fractal geometry goes back to the last two decades.

### Study area

The study area is consisted of 12 watersheds including Holeylan, Doyraj, Tangesazbon, Kolm, Nazar Abad, Jezman, Vargach, Chomgez, Chaviz, Siagav, Jafar Abad, and Ema, Ilam Province. Table 1 showed that the formation of study area.

In Table (1), we can see that by increasing the numerical value of resistance degree, the formation sensitivity to erosion is reduced.

In FayzNiya classification (1995) which is based on Rosovski's classification, the rocks with greater resistance have higher value (max 20) and the rocks with lesser resistance have lower value (min 1). Therefore, resistance to the erosion of the existing formations in the study areas can be ranged from 1 to 9.

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**Table 1. the details of formations in the study area**

| Sensitivity to erosion | Lithology | Symbol | Formation name |
|---|---|---|---|
| 1 | Alluvial deposits of the platform | Qal | Quaternary |
| 5 | Alluvial fan | Qt | Quaternary |
| 6 | Sandstone, marl, sandy limestone, conglomerate | Aj | Aghajari |
| 3 | Marl, limestone marl | Gs | Gachsaran |
| 9 | Karstic limestone, dolomite | Sb | Asmari |
| 7 | Mliky gray shale and marl with limestone | Pd | Pabdeh |
| 9 | Conglomerate and sandstone and siltstone red | Kn | Kashkan |
| 9 | The average white to cream-colored limestone marl layers | Tz | Ahak Tele Zang |
| 7 | Siltstone and sandstone olive to dark brown color | Am | Amiran |
| 8 | Rifi fossils of cream-colored limestone with interlayers of Chile | Ehm | Ahak Imam |
| 9 | Thin layer of limestone | Sr | Sarvak |
| 7 | Medium to thin and milky gray limestone layer | Il | Ilam |

## Materials and methods

### Extraction of drainage network via ArcGIS

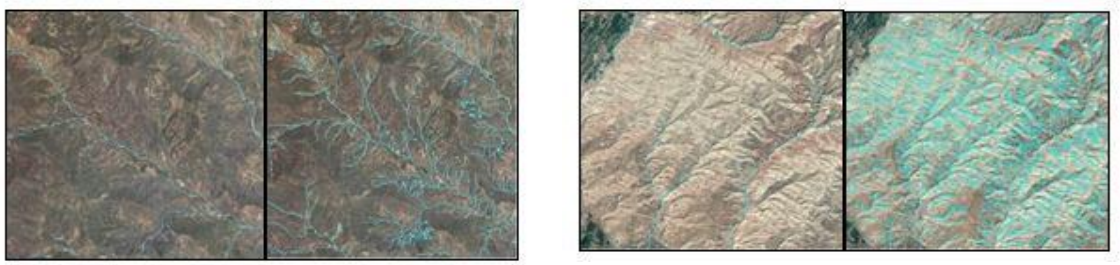
These networks were provided based on 50 DEM coordinates that in many cases, there isn't enough accuracy. Therefore, after transferring data to Google Earth, it was fully matched with the natural drainage and with 5-meter accuracy; hydrographic network map was drawn and completed to reflect the full details of the network.

It is possible to scale the maps via "Fractalys", the fields with the same space of 25 kilometers on similar formations in different areas. For each study formation, three 25 sq. km. fields were selected by the accuracy of 5 meters. These maps had the same drawing accuracy and spacing, in the same scales via GIS on an A4 page in ".bmp" and then were brought to Fractalys and finally, their fractal dimensions were calculated and extracted by the geometric method of counting boxes.

## Results and discussion

The results show that a canal with an accuracy of 50 meter on DEM with corresponding 5x5 sq. km pixels has much less accuracy than the drainage networks drawn via Google Earth with less than a 5-meter accuracy. In formations resistant to density changes of the hydrographic network, some have more changes in their fractal dimension as a result.

Google Earth images below are the examples of 25-kilometer zones which their hydrographic networks were revised.



Quaternaryn Gachsaran

**Fig. 6. modified hydrographic network of 25 km in Google Earth**

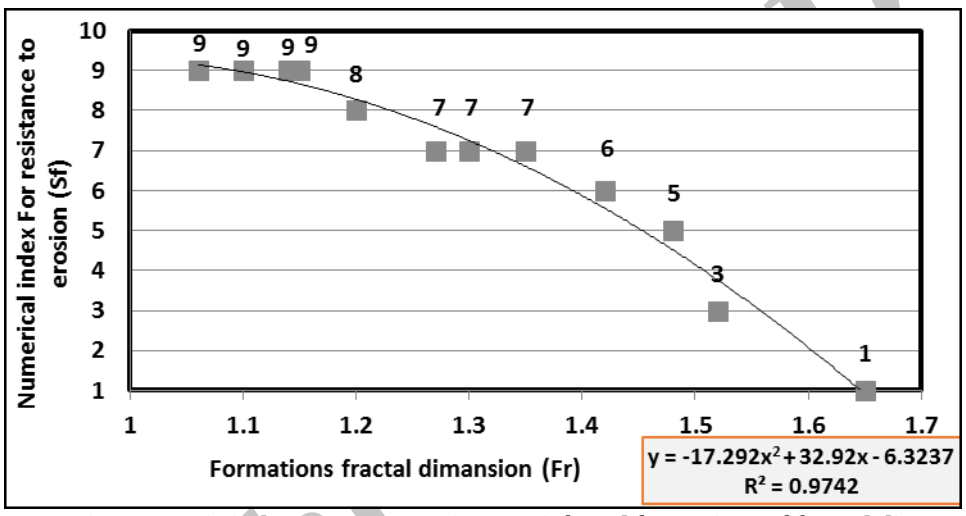



**Fig (6) Regression numeric index to erosion resistance (Sf) and formations of fractal dimansion (Fr) after modification of 25 km units**

In Fig (6), the amount of $R^2$ is 0.9742 that shows high correlation and significant relationship of fractal dimension to numerical index for resistance to erosion. By increasing the resistance of the formaion, numerical value of fractal dimension will be decreased.

Table 3 showed statistical analysis between SF and FR.

**Table 3. The formations resistance data (from 20) (Sf) and fractal number (Fr) of formations after correcting the 25-kilometer units**

| | | **Sf** | **Fr** |
|---|---|---|---|
| Sf | Pearson Correlation | 1 | -965.0 |
| | Sig. (2-tailed) | | 000.0 |
| | N | 12 | 12 |
| Fr | Pearson Correlation | -965.0 | 1 |
| | Sig. (2-tailed) | 000.0 | |
| | N | 12 | 12 |

Table (3) shows the values of data correlation (-965). The values are always ranged between +1 and -1. The more close its absolute gets to 1, the correlation coefficient will be higher, and the more close it gets to zero, the data correlation will get lower. As a result, there is a

meaningful connection between formation resistant and fractal dimension. The minus sign indicates a negative data correlation.

**Table 4. Regression of the formation resistance values (Sf) and fractal number (Fr) of the areas after the 25-kilometer unit correction**

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | 0.965[a] | 0.931 | 0.924 | 0.05116 |

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In the table above, "R" is the correlation coeeficient and its value are always between zero and +1 and "Square" is the coefficient of determination. The more closer "R" value gets to 1, the higher the correlation is between two variables. Therefore, the number of 0.965 illustrates high correlation of the formatuion resistance and its fractal number.

## Conclusion

The results show that there is a significant and negative correlation between the fractal dimension and hydrographic network. The highest amount of fractal dimension in study areas is for the Quaternary formation of granule (equals to 1.65) and the lowest numeral amount of fractal dimension belongs to "Sarvak" formation (equals to 1.06).

In formations with greater sensitivity relative to resistant formations after the correction of the hydrographic network via Google Earth, more changes are observed in the hydrographic network congestion, thereupon their fractal dimension change is also observerd more.

***Keywords: fractal dimension, hydrographic network, geological formations, Ilam.***