

Fibonacci Spatial Hazardology of Earthquakes (FSHE) (West of Iran)

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Abstract

A borderline destructive earthquake ($M: 7.3$) hints the urban regions of Ezgeleh, Sar-Pol-Zahab and Ghasre-Shirin in Kermanshah province (western part of Iran) and left more than 600 kills, hundreds of injured peoples and building damages in 12 November 2017. In this research, I have used Fibonacci numbers to set 117 years epicenters (USGS catalogue, 1900-2017) based on a post predictive model contained the main and aftershocks of this region. This scenario reveals unique geometrical associations (30 and 137.5 degrees) between the recent epicenters and more than one century seismic onsets according to triangular-circular distributions. The primary results showed that Kermanshah epicenters tend to be patterned by golden shapes and golden angles in self-organized geometrical distributions. Also many of Ezgeleh aftershocks illustrate spiral distribution that is because of their inherent association with fault systems. As the final result, a forecast map issued in the end of research to realize the spatial hazard assessments and prognosis of seismic potentials based on Fibonacci simulation of the aftershock locations.

Keywords: Earthquake, Fibonacci sequence, Kermanshah province, Spatial hazardology.

Introduction

Leonardo Fibonacci was a famous Italian scientist introduced a numerical sequence was known as "Fibonacci Number" in his book released in 1202 [1]. This is a series of numbers where a number is found by adding up the two numbers before it. Starting with 0 and 1, the sequence goes 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, and so forth. Written as a rule, the expression is:

$$F_n = F_{n-1} + F_{n-2} \quad (1)$$

Where, F_n is obtained Fibon-number and F_{n-1} , F_{n-2} are two sequences before F_n respectively [2].

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Both real sets and integer sequences of Fibo-numbers have impressed many of natural phenomena and therefore known as the mathematical keys for terrestrial and infra-terrestrial solutions. For instance, earthquakes and climate changes are two main threats have close relationships with golden spiral distribution as a result of spatio-temporal evolutions in nature.

A simple sequence of Fibo-numbers is shown as below:

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ..., Fn

In above sequence, a ratio of (F_n/F_{n-1}) gives constant value (golden ratio, ϕ) equal with 1.618.

$$\phi = F_n / F_{(n-1)} = 1.618 \quad (2)$$

This ratio has important roles in bio-creatures. Also it plays a global game in galactic strategies for expansion. From geological point of view, many of mantle related geodynamics have been regulated by ϕ to prompt the self-organized patterns of the crustal appearances. As a rule of geometrical properties, golden ratio gives rise to producing golden shapes such as triangles, circles and rectangles. Golden triangles have two isosceles with exactly 36 degree of angle between the isosceles. Golden circles consist of two unequal arcs which one of them has golden angle equal with 137.5 degrees. Golden rectangles are usual natural patterns mostly studied by geoscientists [3]. As it is shown in Figure1, seismic events and their focal mechanisms are relevant examples from golden rectangles with affinity of the events to spiral distributions.

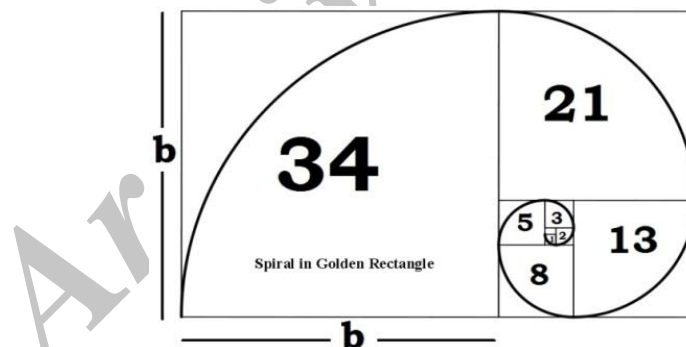


Fig. 1. Spiral distribution of natural events (such as earthquakes) in golden rectangles

A simple consideration for geometrical behavior of earthquakes is golden triangular distribution which can be modified as golden Pentagon-Gnomons and extended toward golden decagons (resemble to circles) around the huge events (such as Ezgeleh earthquake) (Figure2).

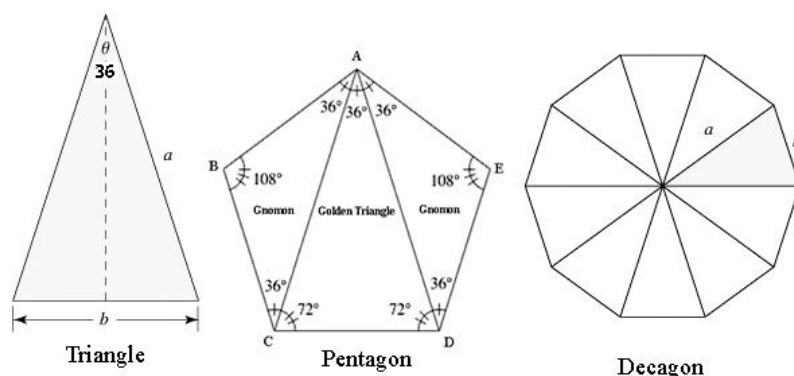


Fig. 2. Triangular-Decagonal distributions in nature (ratio $a/b = \Phi$)

Methodology

Here, a Post Prediction of Earthquake (PPE) is well done by applying Fibonacci numbers into USGS catalogue. Natural earthquakes usually distributed in spirals and used for spatial interpretations [3]. At least, 117 years backgrounds of seismic events (USGS, 1900-2017), provide this unique opportunity to answer the question of “where is the next destructive earthquake in the regional or local scales?”

It means, with a dense and accurate catalogue, scientists will be able to predict location of the future earthquakes and Fibonacci-based techniques have closely impressions to revealing the imitation games of the nature as an important key for earthquake prediction [3,4]. According to PPE, a main shock event not only initialized post seismic processes, but is relevant to middle or long term catalogues as a regional Fibonacci variable. In practice, seismic databases from west of Iran including epicenters [5], interferogram [6] and structural lineaments [6,5], have been gridded by GIS facilities to illustrate the possible golden peculiarities of the recent earthquakes.

Discussions

Ezgeleh event (2017-11-12) seems to be initial point for long ranges of post seismic events, which many of them should be considered as Ezgeleh aftershocks. In figure3, a significant spiral distribution can be seen in near territory of Ezgeleh epicenter. Also in this Figure, we can find an obvious golden circle within the radius lesser than 20 Km from main shock event.

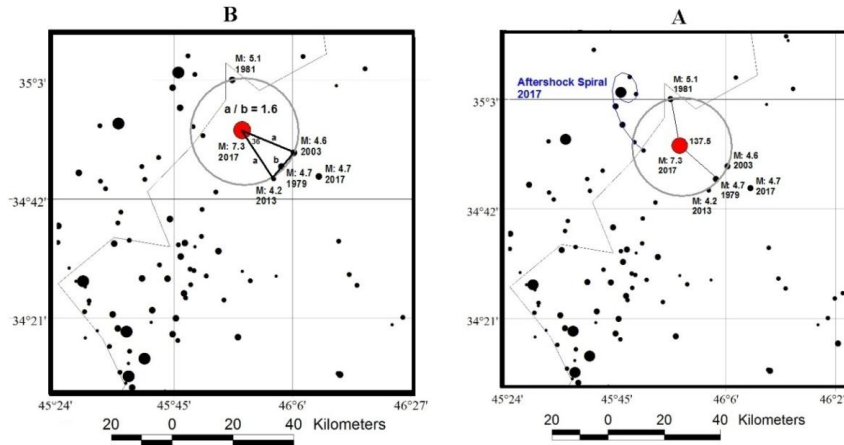


Fig. 3. A: aftershock spiral distribution (golden rectangle) next to golden circle of the main and before shock events B: geometrical properties of golden triangle in lesser 20 Km from main shock epicenter (Red Point).

As a primary result, above mentioned facts indicate a natural distribution of all seismic events in western part of Iran. For the second, spatial assessment of 117 years magnitudes (since 1900), provides spatial hazardology of the Kermanshah earthquakes based on post predictive algorithm [7]. In other word, Ezgeleh earthquake is a dependent spatial variable to post seismic events as well as its dependency to foreshocks in the catalogue.

Conclusion

-This research introduced a Fibonacci method for evaluation and analysis of 117 years Kermanshah earthquakes as an active seismic zone in western part of Iran.

- Spatial hazardology of Ezgeleh event, indicates a long distance association of Kermanshah post-seismic traces with other Seismogenic traces within 100 Km from 7.3 main shock epicenter (Figure4).

- Rectangular distribution of earthquakes, make an easier and accurate forecasting of future events (usually means aftershocks) and other post seismic activities originate from Ezgeleh event in golden radiuses (Figure 5).

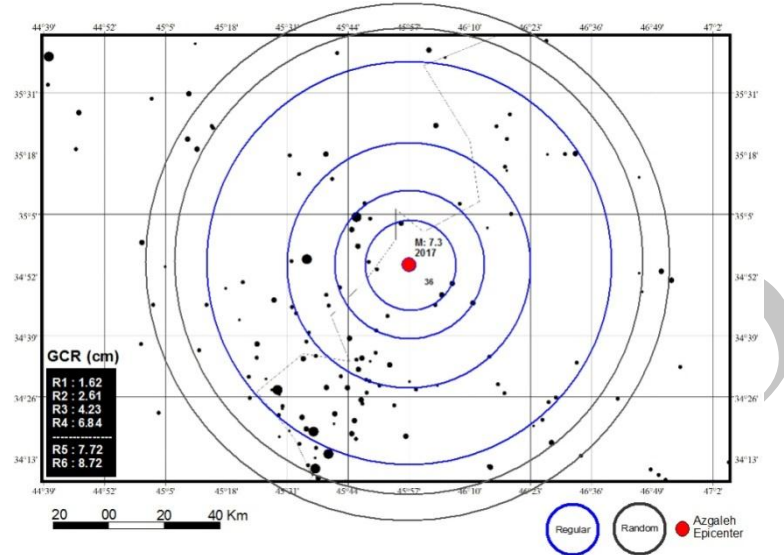


Fig. 4. Regional golden circles around Ezgeleh seismic event (Nov. 2017) according to regular (blue) and random (gray Fibonacci sequences) [8] .

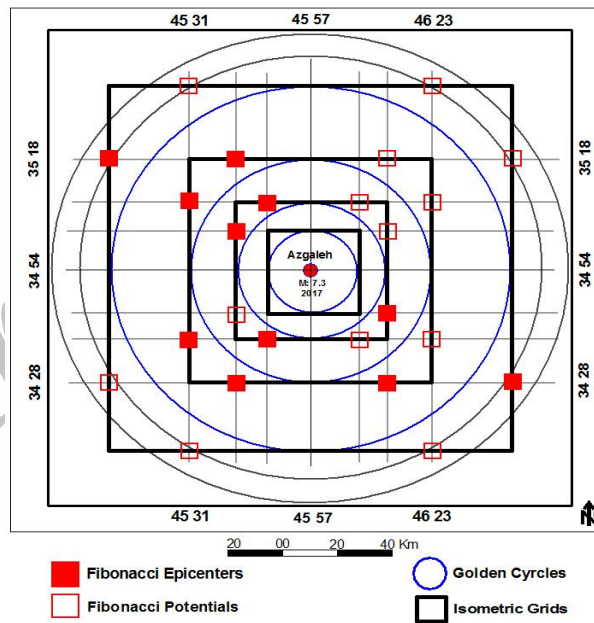


Fig. 5. A Fibonacci based spatial hazardology of Ezgeleh earthquake (12 Nov. 2017)

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