Modeling of Tabriz north fault by four permanent GPS station in Azerbaijan from 2011 to 2020

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Abstract

In this atticle notice to seismicity of the North Tabriz fault which was built many buildings around it, we calculated relevant Stress using GPS observations. We calculated tabriz Fault and the other near faults rupture lenghts using historical earthquakes and GPS data relationship between normal stress and reverse slip region tend by using historical tensions extracted from GPS , which happened in the city of Tabriz and rupture along the fault lines. Also we calculate slip tendency of Tabriz region using slip tendency; normal and reverse stress.

The results indicate a high slip tendency of the Tabriz fault specially northwest in Marand to southeast in Miyaneh.

Keywords: North Tabriz fault, Slip Tendency, GPS data

1. Introduction:

Seismicity of Azerbaijan has been proved by historical devastating earthquake. Generally, along the northwest - southeast due to the compressive forces caused by movement of the Arabian plate, and in the eastern regions strike-slip faults activity of the North – South, in the north as a result of strike action of east-west, and forces obtained from collision of Saudi Arabia and Turan plates to each other frequency earthquakes occur in the geographical area of Iran. One of the fundamental fault of Azerbaijan region is the Tabriz fault that considered as the basic and linear structures in Iran, traceable in 100 kilometers of Misho Mountain (in the West) to Bostanabad (in the East). Its general trend is EX115 and its dip is vertical (Berberian, 1976). To understand the importance of the Tabriz earthquake, it is sufficient to note that the earthquake of 1158 hejri shamsi (1780 AD), as one of the most destructive and deadly earthquakes in the world with 77 thousand deaths, has been panache in a list published by the America's Geological Survey. Also Tabriz has been destruction during the last century more than six times. Thus the importance of the Tabriz North fault activity due to the current lack of significant activity is remarkable in the history of the activities by various methods including analysis of slip tendency.

2. Measurement and Observation

Slip tendency analysis, valuable tool for evaluating the reactivation of a fault and seismic hazard assessment. This analysis provides useful tool to quantify the potential slip, on the known or unknown faults in the known or hypothetical stress field (Angelier, 2002). In addition to identifying potential faults for the reactivation can be used for the potential slip, also determined Focal mechanism that using this to check the our compatibility between mechanism and geological structures of the (Khattri, 1973). Perform this analysis in the case of a fault and in a series of faults can be done. Slip potential into the regional tension, depends on the friction coefficient, fault plane (right, 1393). Analysis of possible reactivation of pre-existing weak pages slip is critical on many branches of geology. Analysis of reactivation slip in estimating seismic hazard is also very important, because it provides a means by using it can be quantified known or unknown potential slip faults and known or presumed in the stress field. Reactivation of the fault to slip depends on the frictional resistance against slip (Mckenzie, 1969). Usually it is assumed that after the shear failure in the rock, adhesion were not seen, So the reactivation condition of the Navier - Coulomb for fault-free adhesive that can be expressed as follows:

$$\tau = \mu \left(\sigma_n - p_f\right) \qquad (1)$$

That the shear and normal stresses τ, σ_n and acting respectively at fault, μ is the coefficient of sliding friction and pore fluid pressure is p_f.

Relation (1) only in the brittle crust that is affected by frictional processes are applicable.

Slip tendency analysis, is a method for predicting possible directions instability of faults and tectonic in different activity (Gephart. et al, 1984). Coulomb stress changes caused by one or more earthquakes can cause subsequent earthquakes. Slip tendency analysis of faults to identify fault-prone will help to calculated Coulomb stress changes for the next big earthquake. In this study Tabriz's active fault slip tendency, calculated by using regional tensions GPS observations with Berny's software. Geometry of Known fault and the coefficient of friction between 0.2 to .0.8 with the probable mechanism of deep earthquakes is calculated by Matlab software (Annold. et al, 2007).

3. The Tendency Slip

According to Moho stress σ = σ_n- p_f, which considers the effect of pore pressure, critical condition to slip on weak pre-existing faults can be written as follows:

$$\mu = \tau / \sigma \qquad (2)$$

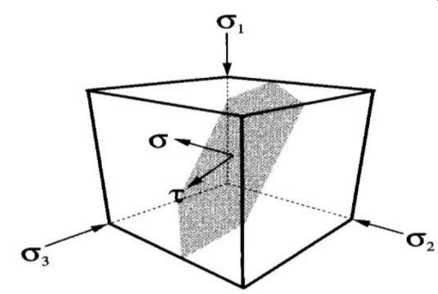

Fig.1. The normal stress σ_n, and shear stress τ, on a desired level of tension in the field defined by the main compressive stresses σ_1, σ_2, σ_3

Tend to slip is defined as the ratio of shear stress to normal stress on the surface:

$$T_s = \tau / \sigma \qquad (3)$$

So it is clear that slip tendency is equal of coefficient sliding friction. The fault pages where likely to slip, are pages closed to μ whit high proportion of shear stress to normal stress.Slip tendency analysis is based on the truth that failure dip criterion are the coefficient friction of a range that usually covers between 0.2 to 0.85. By fixing the ratio of stress difference (Moho diameter) range of compounds (μ, ɵ) is created when landslides are possible. In an area with a certain rock, presumption a certain μ, determines the optimum angle slip. Relation (4) that is the most appropriate formula for the maximum compression ratio failure page. In this page the slip tendency is maximum:

$T_s = T_s^{max}$.

$$2\theta = \tan^{-1}(1/\mu) \quad (4)$$

4. Input and Output Variables

According to the theory of slip tendency, the fault pages susceptible to reactivation justify the stress tensor, the stress of φ (Or the difference between the principal stresses R) The coefficient friction is μ and the pore fluid pressure p_f (by using effective stress is considerd implicitly).

Input parameters required for analysis are as follows:

1. The main tension direction;
2. The ratio of stress difference R
3. The geometry of the fault system (known)
4. The coefficient of friction (8 / 0-2 / 0)

The right coordinate system defined main tension directions shown by X_1, X_2, X_3 .

The direction of each main axis defined according to Azimuth and dip. Azimuth ψ in the horizontal plane in degrees clockwise is measured from north within origin 〖360〗 ^ ° ≥ψ≥0 ^ ° ^ ° ≥ψ≥ 〖〗 or 〖180〗 -180 ^ °. Dip δ is measured in the vertical plane perpendicular to azimuth within 〖90〗 ^ ° ≥δ≥0 ^ ° . The main stress values shown with σ_1, σ_2, σ_3 and according to our definition: σ_1≥σ_2≥σ_3. Conventionally used in geology compressive stresses are positive, so the main tension compression sorted from highest to lowest. R is used in tension difference to place the main stress levels is sufficient for slip tendency analysis. Faults are considered flat and it is assumed that they have no interaction. For those determined with azimuth and tilt.

Using GPS observation to calculate Tensor stress by Berenese software

Bernese software, is an advanced tool to achieve accurate values in geodetic applications. The accuracy of the results of this software is better than other processors for large networks. The processing of this software includes more than 100 programs that are written in FORTRAN language. Each project is a set of observations that must be processed. In this way, each of the measures will be processed in the form of independent projects. In this article, GPS observations processing were performed by using the Bernese v4.2 software.

5. Disconnection Parameters

To calculate the length and width of the rupture and detachment of the earthquake of were used empirical (Wells, L and Donald) between the intensity of earthquake and rupture parameters. In the above equations, MW moment magnitude, RLD rupture length in kilometer, RW rupture width along the fault dip in kilometer, AD medium separation in meter, are obtained using the following formula:

$$\log(RLD) = -2.57 + 0.62 \times M_w \quad (5)$$

$$\log(RW) = -0.76 + 0.27 \times M_w \quad (6)$$

$$\log(AD) = -1.7 + 1.04 \times M_w \quad (7)$$

The result of Tabriz north fault listed in table (1).

6. Method and Calculation

According to the theory of slip tendency, the fault pages susceptible to reactivation according to the Tensor stress, the stress φ (or the difference of main tension R), the friction coefficient μ and the pore fluid pressure is p_f.

Input parameters for the slip tendency analysis previously mentioned.

According to the result that extracted from GPS software, Barnes and historical earthquake occurred in Tabriz, the fault rupture length and faults surrounding, were done by Donald and Wells relations (PR 5, 6, 7) and is given in Table 1. Output results is drawn by using Genertic Mapping Tools.

The seismicity and magnitude of the earthquake in a seism tectonics state changed from one place to another due to local tectonic. So in a seism tectonics state, that has the potential seismic sources with different earthquake magnitude and different rate of activities, limits must be determined, until show the region of seismic potential. Generally area is divided into 2 independent zone (Figure 2). Also, by using mentioned slip tendency formula in measurement and calculation part, normal stress, reverse stress, has been obtained by MATLAB saftware. (Figure3).

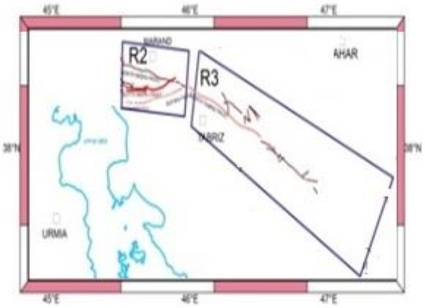

Fig.2. The division of areas around North Tabriz fault for slip tendency

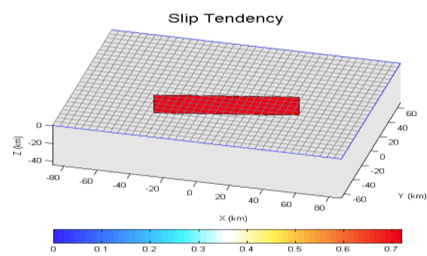

Fig.3. The calculated slip tendency of Tabriz fault

As it stands in Tabriz faults show the high-slip tend calculations that in 250 years earthquake not occurred due to the recent earthquake in Tabriz, and research's of this field that show low creep of Tabriz fault which achieved from GPS observation, high slip tendency can be expected from this area. The calculated number of output tension is in Table 2. According to calculated tensions output, Coulomb stress has a maximum value of 13.86, and the average 1.19- 15.78-'s Minimum. Shear stress also has a 16.94 in maximum, minimum and average 1.16- 15.07- and normal stress has a maximum value of 13.42, and the average 0.07- 15.97-'s minimum. This numbers show a readiness to work of Tabriz fault.

To examine different movement's changes in fault for two to two, we analyze how the Tabriz fault behavior. Figure 4 show the shift changes of eastern and northern component. Due to this the fault of Tabriz in the eastern and northern components relative have counterproductive behavior to each other.

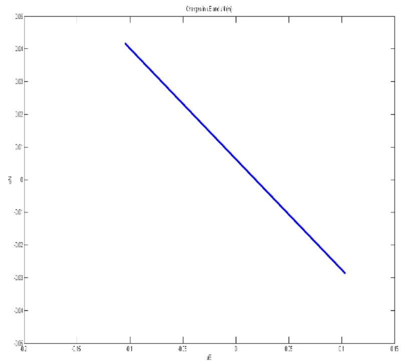

Fig.4. shift changes of eastern and northern component

Figure.5 shows the eastern and height component, due to this eastern and height component have parabolic behavior to each other, which shows the impossibility of predicting the movements of the earth is in the range of North Tabriz fault.

Figure 6 shows changes in the components movement of the North and height. Due to this the fault of Tabriz in north and height component has a parabolic behavior towards each other in 2 Grade.

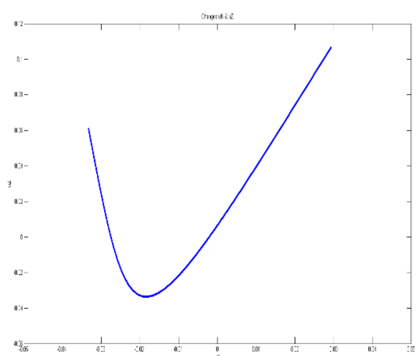

Fig.5. East and elevation changes of moving components to each other

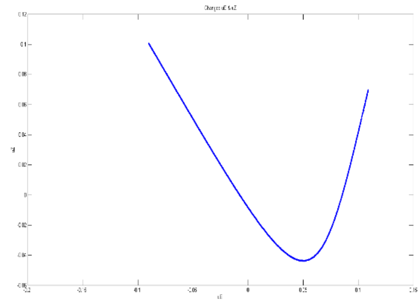

Fig.6. North and height movement changes

Conclusion

In this article has been done the analyzes of slip tendency of Tabriz north fault. Despite the great historical earthquake in Tabriz, a significant earthquake has not been reported in the last century. Tabriz north fault is a strike-slip component. The maximum depth of the earthquake was 30 km. The greater earthquake has happened in the depth of 10 to 20 km. According to Table 2 the following results achieved:

1. Coulomb stress has a maximum 13.86, minimum and average 1.19- 15.78-'s. The shear stress has a maximum value of 16.94, and the average 1.16- 15.07- minimum and normal stress has a maximum value of 13.42, and the average 0.07- 15.97-'s minimum.
2. In Tabriz fault displacement of East and North components have counterproductive behavior.
3. Tabriz fault North and height components displacement has degree 2 parabolic behavior towards each other.
4. Tabriz north fault has a high slip tendency and is in the scope of the risk that the fault of Southeast Asia and the North West also has a high tendency to Marand.

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Table 1. Specifications Used earthquake with rupture parameters

Fault length	Fault width	Earthquake magnitude	Date
7.76	7.24	6	858
71.12	16.25	7.3	1042.4.21
7.1	5.4	6.5	1272
8.5	6.7	6.8	1641.2.5
42.2	13.1	7.3	1721.4.26
32.4	12.7	7	1727.11.18
55.1	33.1	7.4	1779.12.27
7.4	5.1	6.9	1879.3.22
4.5	2.4	5.5	1983.7.22
42.2	13.1	7.3	1990.6.20
4.8	2.6	5.6	1990.6.21
5.8	2.8	5.7	1991.11.28
7.8	5.4	6.5	2012.8.11
7.1	5.3	6.3	2012.8.11

Table 2. The number of output calculated stresses

x	y	z	coulomb	Shear	normal
(km)	(km)	(km)	(bar)	(bar)	(bar)
-87.1423	-66.717	12	-0.1512	-0.17775	0.066383
-87.1423	-61.1572	12	-0.14247	-0.15697	0.036267
-87.1423	-55.5975	12	-0.12033	-0.12068	0.000879
-87.1423	-50.0377	12	-0.08	-0.06517	-0.03707
-87.1423	-44.478	12	-0.0172	0.011763	-0.07242
-87.1423	-38.9182	12	0.069657	0.108565	-0.09727
-87.1423	-33.3585	12	0.176107	0.216916	-0.10202
-87.1423	-27.7987	12	0.287863	0.319291	-0.07857
-87.1423	-22.239	12	0.379424	0.389774	-0.02587

-87.1423	-16.6792	12	0.418938	0.401074	0.044661
-87.1423	-11.1195	12	0.380863	0.337219	0.109112
-87.1423	-5.55975	12	0.260725	0.204756	0.139923
-87.1423	0	12	0.080676	0.032758	0.119796
-87.1423	5.559746	12	-0.12009	-0.14021	0.050299
-87.1423	11.11949	12	-0.30302	-0.28259	-0.05107
-87.1423	16.67924	12	-0.44336	-0.37884	-0.1613
-87.1423	22.23899	12	-0.53303	-0.42849	-0.26136
-87.1423	27.79873	12	-0.57607	-0.43997	-0.34027
-87.1423	33.35848	12	-0.5824	-0.42458	-0.39454
-87.1423	38.91822	12	-0.56301	-0.39276	-0.42563
-87.1423	44.47797	12	-0.52751	-0.35256	-0.43738
-87.1423	50.03772	12	-0.48327	-0.30953	-0.43434