

Proceeding Paper

Analysis of the Current Dynamic of the Jalisco Block, Mexico through GNSS Observations [†]

Juan L. Cabanillas Zavala * , Manuel E. Trejo Soto and Xóchitl G. Torres Carrillo

Faculty of Earth and Space Sciences, Autonomous University of Sinaloa, Culiacan 80040 Sinaloa, Mexico; mtrejosoto@uas.edu.mx (M.E.T.S.); xochitl.torres@uas.edu.mx (X.G.T.C.)

* Correspondence: jcabanillaszavala@gmail.com; Tel.: +52-6679950433

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Abstract: Mexico is surrounded by a highly dynamic tectonic environment, where the area of greatest influence is in the west, since it is where large earthquakes occur and tectonic blocks are generated due to the subduction of two oceanic plates in the North American plate. In the present study, the horizontal velocities of 15 GNSS stations of continuous operation are calculated, over a period of 11 years, which are located within the Jalisco Block, Mexico with the objective of analyzing the current dynamics of this tectonic block, which is mainly influenced by the oblique subduction of the Rivera plate.

Keywords: Jalisco Block; GAMIT/GLOB-K; North American plate; velocities; GNSS

1. Introduction

Mexico is one of the countries with the highest tectonic and seismic activity in the world, mainly due to the interaction of five tectonic plates (Pacific, Cocos, Rivera, Caribbean and North America), where most of its territory is located on the North American plate. In the north and southeast region, it borders the Pacific and Caribbean plates (respectively) through transform boundaries [1,2]. The western region of the country presents the highest seismicity, as well as the largest magnitude earthquakes, since it is influenced by the subduction of the Rivera and Cocos plates [3], where, according to [4], earthquakes of a magnitude greater than $M_w > 9.0$ could occur.

The study area is located in western Mexico (Figure 1), where the existence of a tectonic unit called the Jalisco Block (JB) has been proposed [5]; in addition, it is known as one of the areas with the greatest tectonic and seismic influence in the country [6]. The JB is mainly influenced by the oblique subduction of the Rivera plate in the western part; likewise, it is delimited by two continental deformation zones. To the east is the Colima rift (CR), trending N-S [7], which is a tectonic structure with purely extensional deformation [8] that has been considered by some as researchers as the eastern limit of the JB [9], whereas in the north is the Tepic-Zacoalco (TZR) rift [10], which runs NW-SE [11].

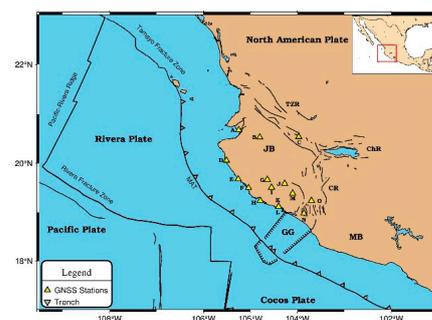


Figure 1. Study area map with yellow triangles representing GNSS stations. JB: Jalisco Block. MB: Michoacan Block. GG: El Gordo Graben. CR: Colima Rift. TZR: Tepic-Zacoalco Rift. ChR: Chapala Rift.



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2. Materials and Methods

The GNSS stations used come from different continuously operating geodetic networks such as the TLALOCNet (<https://www.unavco.org/projects/past-projects/tlalocnet/tlalocnet.html>, accessed on 10 December 2020), the CORS (https://geodesy.noaa.gov/CORS_Map/, accessed on 10 December 2020), and the RGNA (https://www.inegi.org.mx/temas/geodesia_activa/, accessed on 10 December 2020). Quality analysis was carried out on the GPS observations only for a period of 11 years (2010–2020) through the TEQC program [12], which focuses on the multipath effect, observation effectiveness, cycle skip count (CSR), and signal-to-noise ratio (SNR).

Subsequently, the processing of the observations was carried out through the GAMIT/GLOB-K software version 10.71, the software has been developed by MIT, Scripps Institution of Oceanography and Harvard University with support from the National Science Foundation, by T. A. Herring, M. A. Floyd, R. W. King, S. C. McClusky, United States of America [13] in order to obtain the time series that describes the rate of speed and direction of JB stations. For this, various parameters such as precise ephemeris (SP3), orientation parameters of the earth, ocean charge model, among others, were used. Likewise, the North American plate was used as a reference since according to [14], the movements of the GPS sites in Jalisco are better described in relation to this plate than with a global reference frame, since the speeds of the reference site are minimized [15]; thus, the displacements are obtained purely from the phenomenon in question. The Tsview tool, by Thomas Herring, United States of America, complemented the GAMIT/GLOB-K software for GPS time series analysis [16]. It filtered out atypical data and outliers using the 3-sigma criterion [17–19]. Corrections were made for hardware/firmware changes and earthquake-induced landslides. The “Real Sigma” algorithm provided precise noise properties and realistic uncertainty estimation.

3. Results and Discussion

The stations used for our study presented effectiveness values greater than 95% in their entirety, likewise, the SNR values turned out to be greater than 30 dBHz for all the stations, which reflects the quality of the signal (according with IGS recommendations (<https://igs.org/station-resources/#site-guidelines>, accessed on 25 October 2020) and [15]). However, most of the stations present an average multipath value of 0.5 m in MP1 and 0.4 m in MP2 (with values close to those recommended) (Table 1).

Table 1. Quality analysis of GPS observations.

Station	Effectiveness	MP1	MP2	SNR1	SNR2	CSR
	%	(m)	(m)	(dBHz)	(dBHz)	(1000/(σ/slps))
A	98.1	0.9	0.9	46.6	42.5	0.1
B	98.5	0.5	0.4	45.2	33.3	0.8
C	99.7	0.4	0.3	45	33.6	0.1
D	98.9	0.7	0.5	44.7	30.7	0.5
E	99.6	0.4	0.3	44.5	30	0.1
F	99.7	0.4	0.3	45.1	33.4	0.2
G	99.1	0.5	0.4	44.0	30.0	0.6
H	99.4	0.5	0.3	44.0	30.0	0.1
I	99.4	0.4	0.3	44.7	33.3	0.2
J	77.7	0.9	0.5	44.7	34.3	3.3
K	99.5	0.4	0.3	44.7	30.7	0.5
L	99.5	0.4	0.3	44.7	30.7	0.5
M	90.4	0.6	0.7	44.4	30.4	4.9
N	97.8	0.6	0.4	44.4	30.7	0.6
O	99.2	0.1	0.3	39.2	41.7	4.5

The velocity vectors obtained through the analysis carried out in Tsview show preferential directions in a north-northwest direction in most of the stations, which is consistent

with the direction and geometry of subduction of the Rivera plate. Likewise, the stations located in the south-southeast zone and in the coastal zone present the highest velocities, with values ranging from 6.29 to 10.81 mm/year, while the stations located to the north-northwest, near the Tepic-Zacoalco rift present values of approximately 3.0 mm/year (Figure 2). On the other hand, in the central zone of the Jalisco Block, a decrease in velocity was observed at station G, which could be related to a blockage of the Rivera plate at the subduction interface proposed by Cosenza-Murales et al. [20] in this zone.

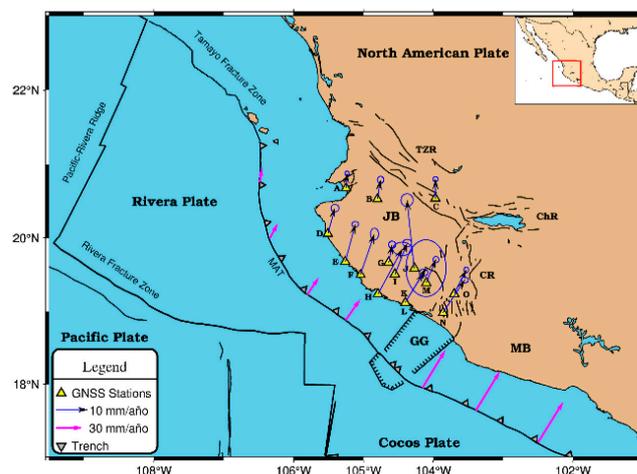


Figure 2. Velocity map. Blue arrows: Velocities of GNSS stations. Magenta: Velocities of Rivera and Cocos plate.

The velocities obtained in our study suggest a counterclockwise rotation of the JB, with a preferential direction towards north-northwest in most stations, which agrees with the subduction direction estimated by the Rivera plate movement model proposed by DeMets et al. [21]. The above shows the influence of the movement of the Rivera plate on the movement of the Jalisco Block.

Considering the information presented above, the ground velocity shortening observed near station G could be related to the blocking zone observed at the subduction interface in this same region [20], which would indicate that it is observing a deformation within the JB due to the coupling between the Rivera plates and said block.

4. Conclusions

The velocity gradient observed in the JB reveals the influence of the oblique subduction of the Rivera plate, as well as its influence on the generation of earthquakes in this area. On the other hand, the decrease in velocity observed in the central zone is associated with the possible accumulation of tension with the potential to generate an earthquake greater than $M_w > 7.0$. Future studies intend to estimate the b-value in the JB area using freely accessible seismic catalogs to verify if tension is actually being generated in this area and correlate it with the results.

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Conflicts of Interest: The authors declare no conflict of interest.

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