



COLIMA VOLCANO ACTIVITY IN THE PERIOD 1999-2014 AND UPDATING VOLCANIC HAZARD MAP

IUGG-4127



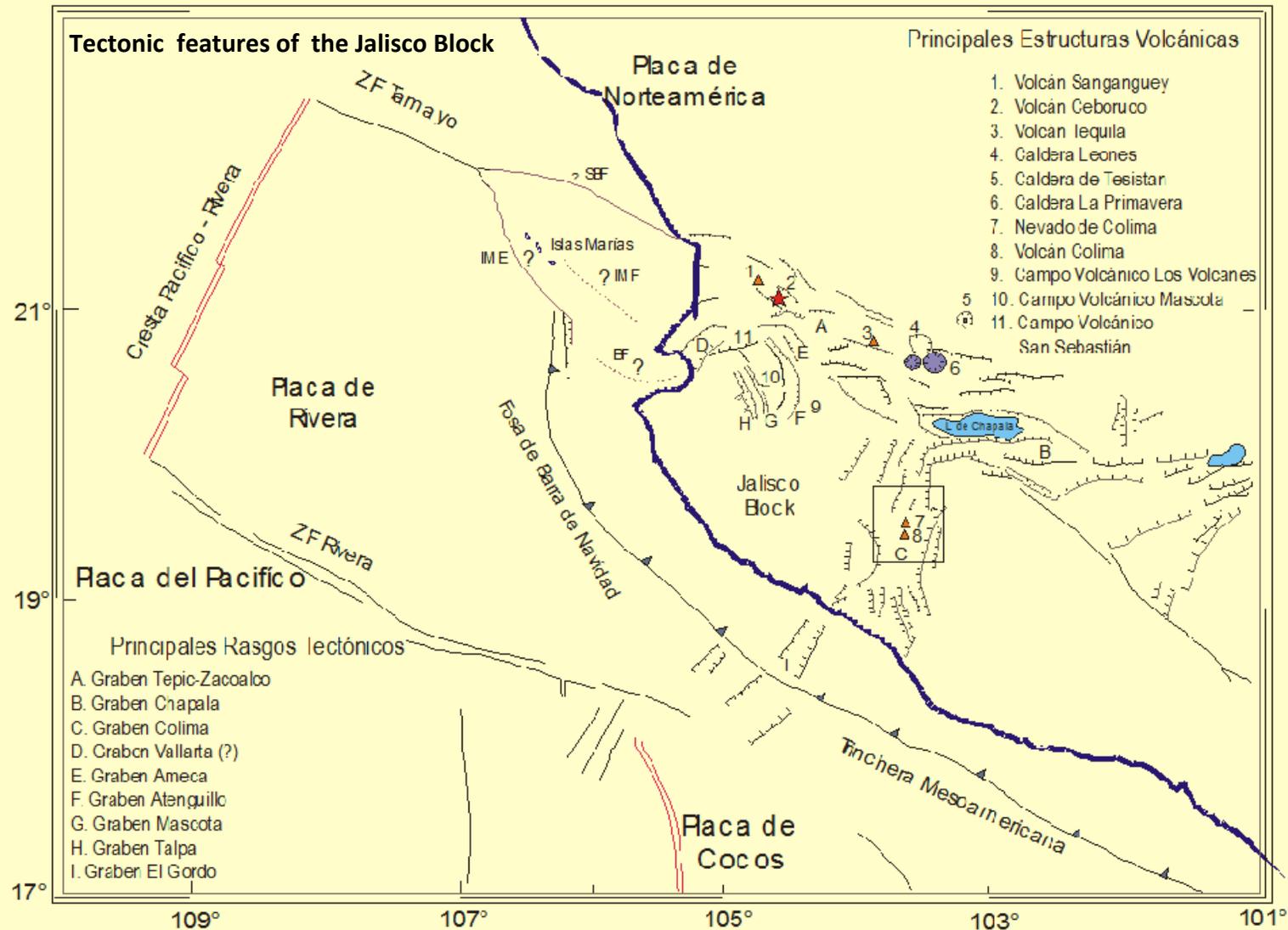
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VS22b IAVCEI (Volcanology, Geochemistry)

VS22 Volcanic Risk - Bridging Hazard Assessment, Modeling Volcanic Processes, and Society



Hernando Rivera / Volcán de Colima



Colima volcano, also known as Volcan de Fuego ($19^{\circ} 30.696$ N, $103^{\circ} 37.026$ W), is located on the border between the states of Jalisco and Colima and is the most active volcano in Mexico

Background of the Colima volcano activity

Colima Volcano activity began to be continuously recorded from 1576 by different observers. The analysis of these records show four cycles of activity (Lurh and Carmichael, 1980), each lasting approximately one hundred years and exceedance rate ± 15 years):

First cycle lasted from 1576-1611,
Second from 1611 to 1818,
Third from 1818 to 1913 and
Fourth from 1913 to the present.,

This cyclic activity is characterized by the following phases:

- 1) Violent eruption with continued disintegration of the domes that are occupying the crater with significant emission of pyroclastic flows reaching 10-12 km and emission and ash fall from the volcano long distances (over 500 km).
- 2) Period of rest for several decades.
- 3) Period resumption of activity with lava ascent through the volcanic conduit.
- 4) Creating continuous domes, lava flows are formed by the flanks of the volcano, continuous explosions begin to occur forming columns that can reach 5000 m above the crater, emission and ash fall reaching up to 150 km.
- 5) Termination of the cycle, with the characteristics of phase 1.

Activity of the late nineteenth and early twentieth centuries.



1903 y 1905 effusive-explosive events, view from the northeast sector

(Photos by Efimerides Ilustradas Magazine and Waitz Photo).



Photography of Ciudad Guzmán, muestra el depósito de ceniza emitido por el volcán en su erupción del 20 de enero de 1913

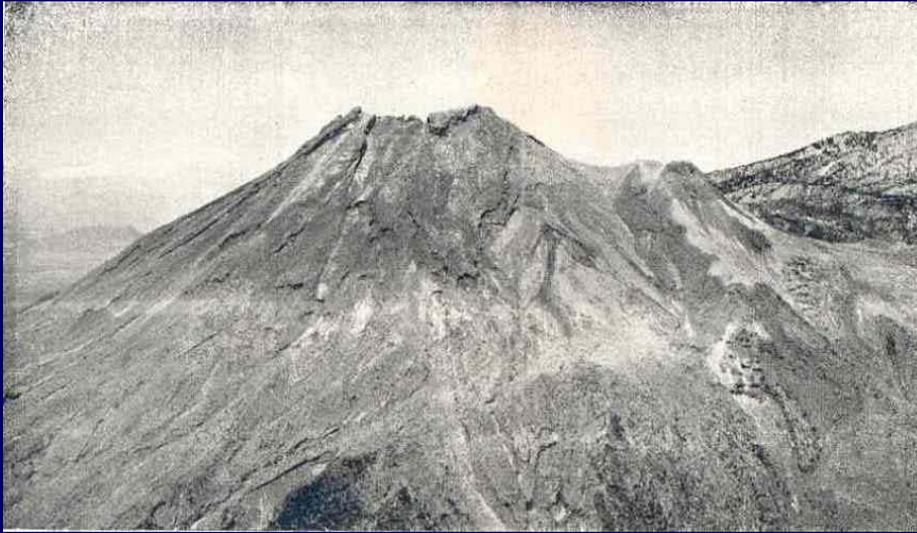


Fotografía de Waitz (1915) que muestra el grado de destrucción de la cima del volcán Colima, causado por la explosión del 20 de enero de 1913

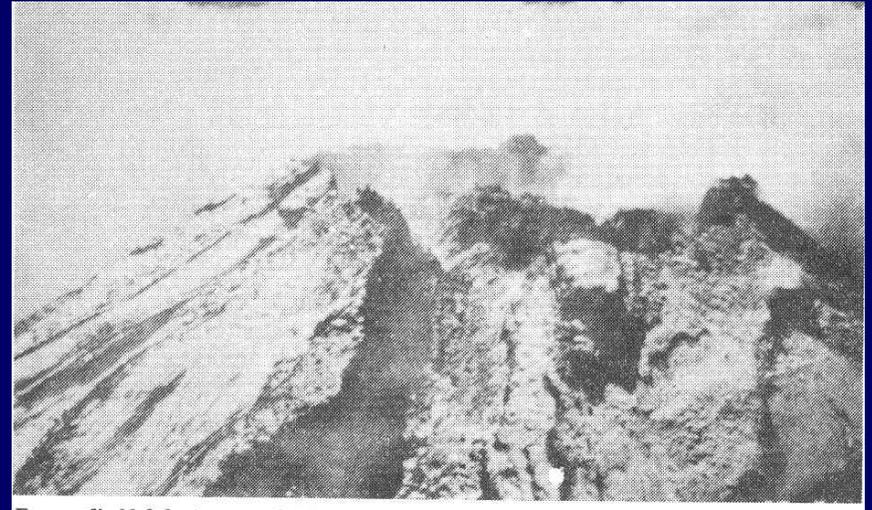
Plinian explosion January 1913.

Began on January 17 and peaked on the 20th, the eruption column reached 21 km in height. The volume of magma emitted 1.7 km³ and the height of the column indicate that this explosion had VEI 5.

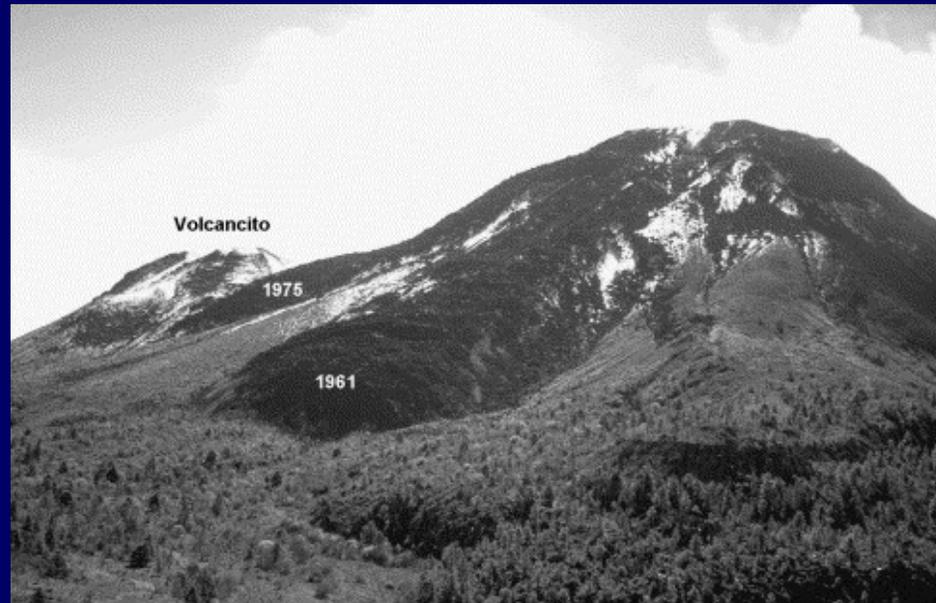
The fall of volcanic ash spread to the northeast and reached the towns of Ciudad Guzman to 21 km, 123 km and Guadalajara to Saltillo 725 km.



Crater in the year 1944 (Photo by Ortiz Santos)



Crater in the year 1960 (Félix Sobota file)



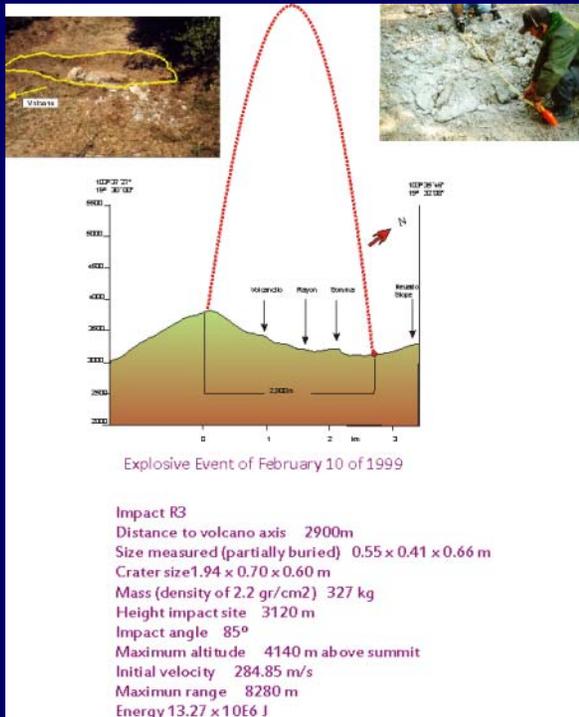
In 1961 lava flow from the north flank it is formed and had a volume of 0.6 km³, and was called "Big Vein".

Activity from February 1999 to June 2015



Volcán:

Eruptive Process of February 10, 1999.

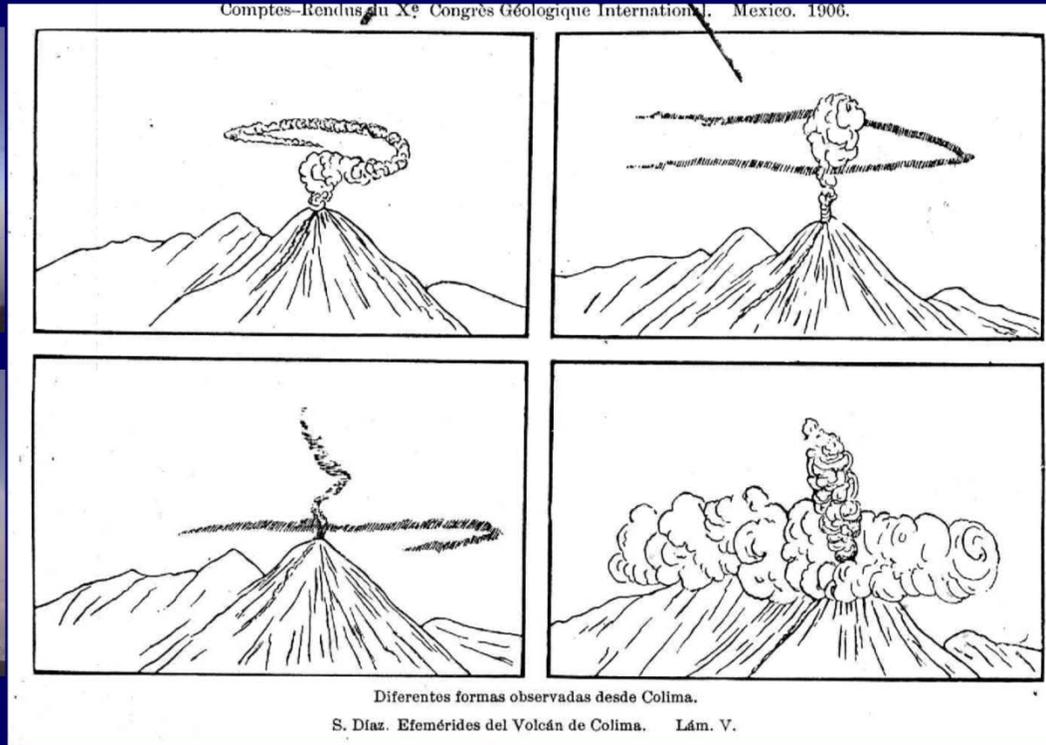


This explosion was the largest after 1913, and was similar to those reported by Jose Maria Arreola in the eruptive process between 1894 and 1905.

The explosion produced an explosive column that reaches 2500 meters over the top. this destroyed an old dome and the incorporation of new magmatic material into the crater.



Comparison of the activity of the years 2003-2008 with that presented in the late nineteenth and early twentieth centuries.



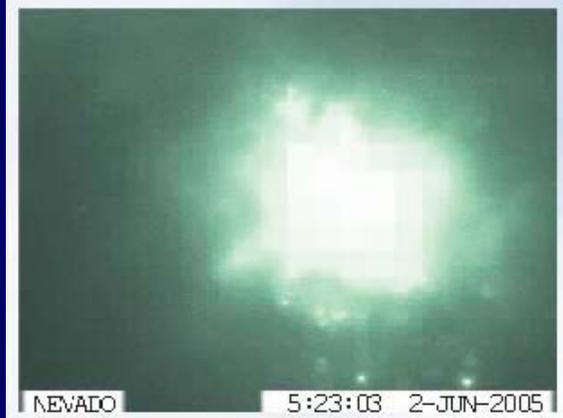
Drawings by Jose Maria Arreola and Severo Diaz Galindo

During the period 2003-2008, the volcano presented a strong-explosive effusive activity very similar to that which took place during the period 1894-1905.

In 2003, the month of July was characterized by intense activity. There were 13 explosive events. Six explosions column reached 1000 meters high; two 2000 meters, and July 17 reached the explosive column three thousand meters above the crater.



Eruptive process in 2005



The volcano shows strong activity during 2005-2007 but this did not exceed VEI 3. 2005 activity resulted in the formation of domes and their immediate destruction by explosive events. This activity produced eruptive columns that reached altitudes between 4,500 and 9,000 meters, however pyroclastic flows reached distances of up to 3.5 km and the ash clouds generated ashfall up to a distance of 100 km from the crater.

ACTIVITY 2013



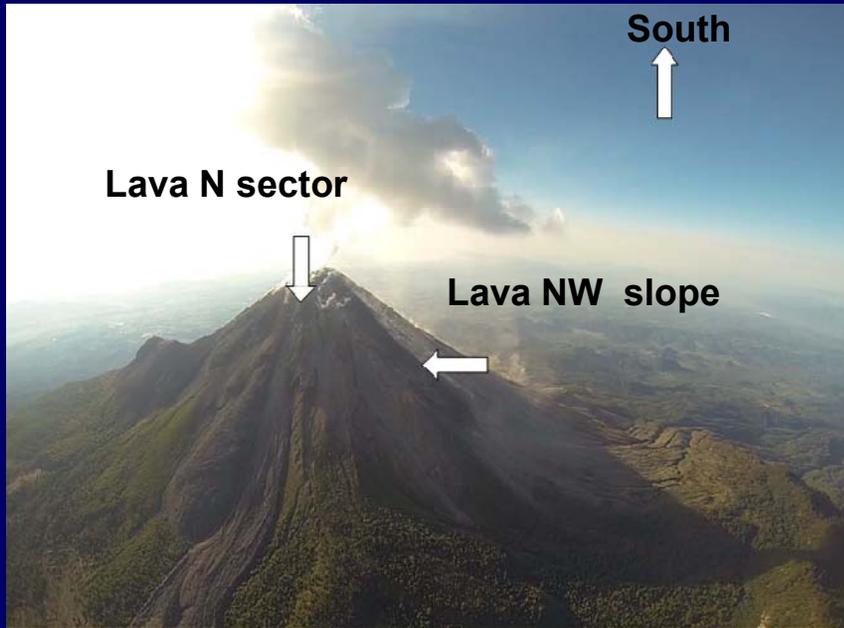
After a volcanic calm of two years, the 6 and January 10, 2013 two explosions occur, forming a new crater on the existing dome since 2008, the approximate dimensions of the crater was 220 meters in diameter and average depth of 50 meters, driving approximately 1.5 million m³.



The February 18, 2013 the growth of a new dome inside the crater was observed. The development of dome was accompanied by continuous exhalations, some explosions and ash emissions.



ACTIVITY 2014



The activity during 2014 was predominantly effusive, and the extruded volume was higher than the similar episodes of 1962 and 1976.

The approximate area that has covered this lava flow in blocks until November 20th is 64.41 hectares, with a thickness ranging between 20 and 30 m, giving a volume of extruded material about 16'102,500 m³, the blocks which generate constant landslides and whose volume has not been calculated so far off.



The November 21, 2014 an explosion at 12:29 hours, reaching 3,200 meters above the summit of the volcano, generating pyroclastic flows that traveled through the west slopes, south and southeast, and ash dispersion occurs north and northeast area, reaching people as Mazamitla and the Juarez Valley 76 and 84 km away from the volcano.



Evolution of the crater from January to May 2015.



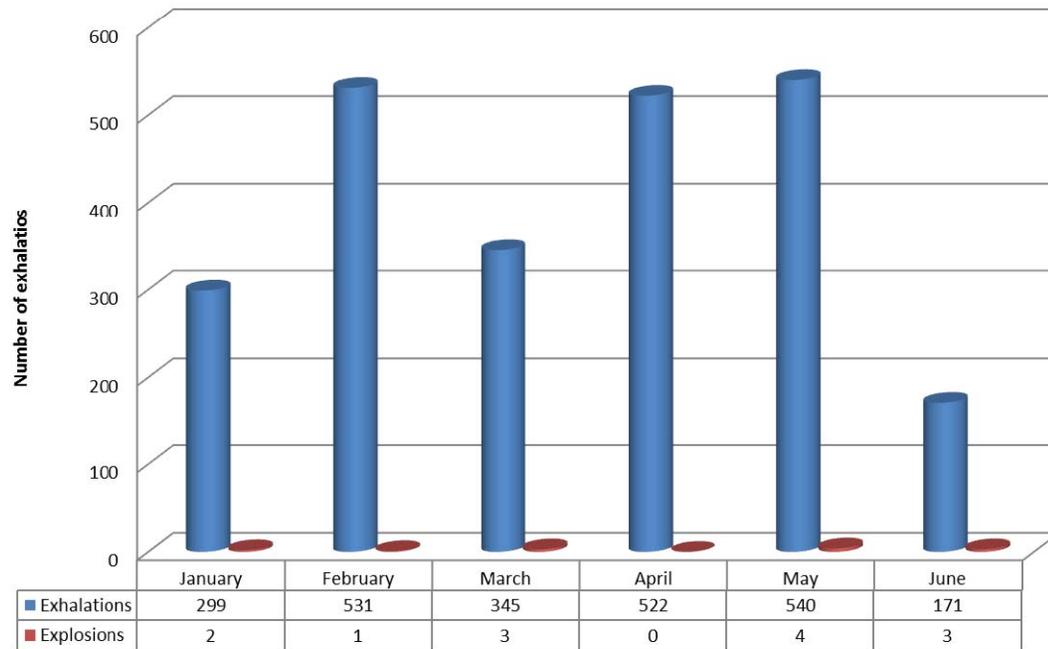
Images showing the process of destroying the dome beginning January 10 until 27 May.

The internal morphology change in each exhalation, small craters appearing and disappearing, as seen in the images below.



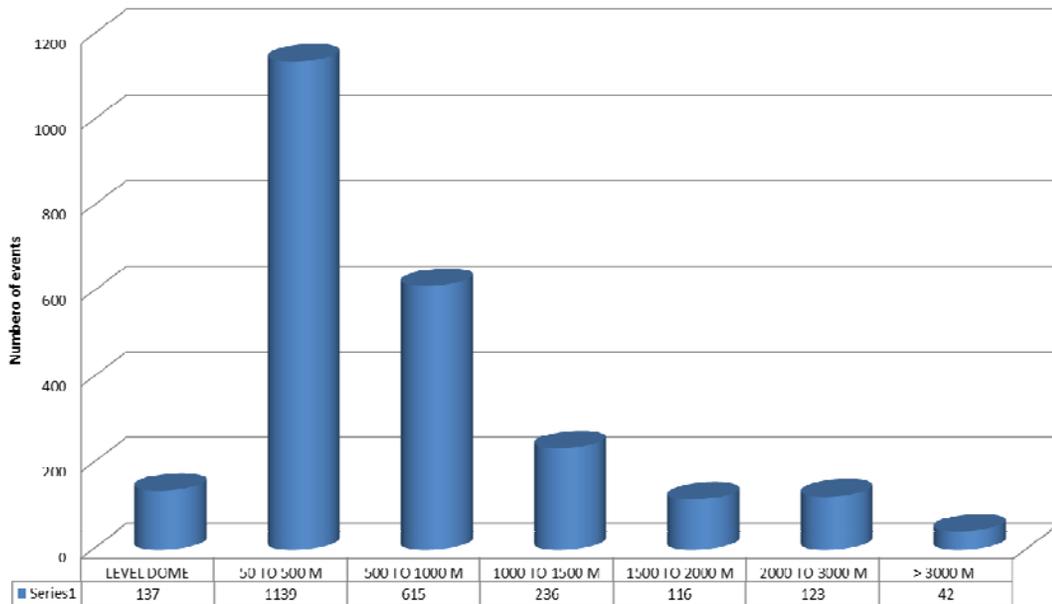
Aspects of events recorded in the month of April with the camera installed in the Volcanological Observatory of Nevado de Colima (VONC), both with ash scattering to the northeast and the second to the southwest. On April 6, a pyroclastic flow was formed by the northern slope.

Number of exhalations from January 1 to June 18, 2015



Graphs showing the distribution of the eruptive activity of the volcano recorded in the period 1 January to 18 June 2015. Where there have been 2408 events exhalation and 13 explosions.

Height of eruptive columns from January 1 to June 18, 2015



53% of these corresponds to a height between the level dome and 500 m, 35% between 500 and 1500 m, 10% between 1500 and 3000 m and only 2% for events where the column reaches over 3000 m over the top.

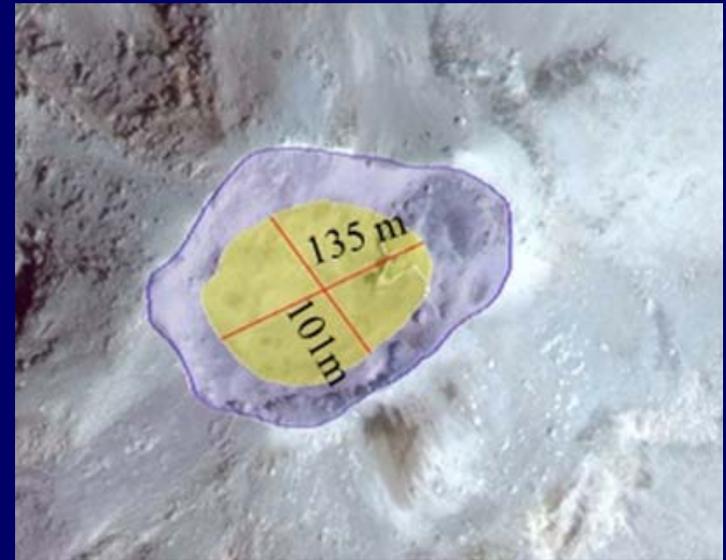


Aspects of changes in the morphology of the crater:

- Elliptical shape
- North-South axis 224 m. East-west axis 166 m.
- Average depth between 25 and 40 m.
- Area of 2.6 hectares.
- Volume expelled approximately 1.17 million m^3 of rock, sand and ash.



On May 5, it viewed the extrusion of a new dome, which was accompanied by a steady and persistent period of incandescence in the crater.



Images from the flyby on 27 May, where new dome growth was observed, its dimensions are 135 m NS axis EW axis of 101 m and a height not exceeding 20 m. Inside the crater and its borders it has developed an important fumarole activity.



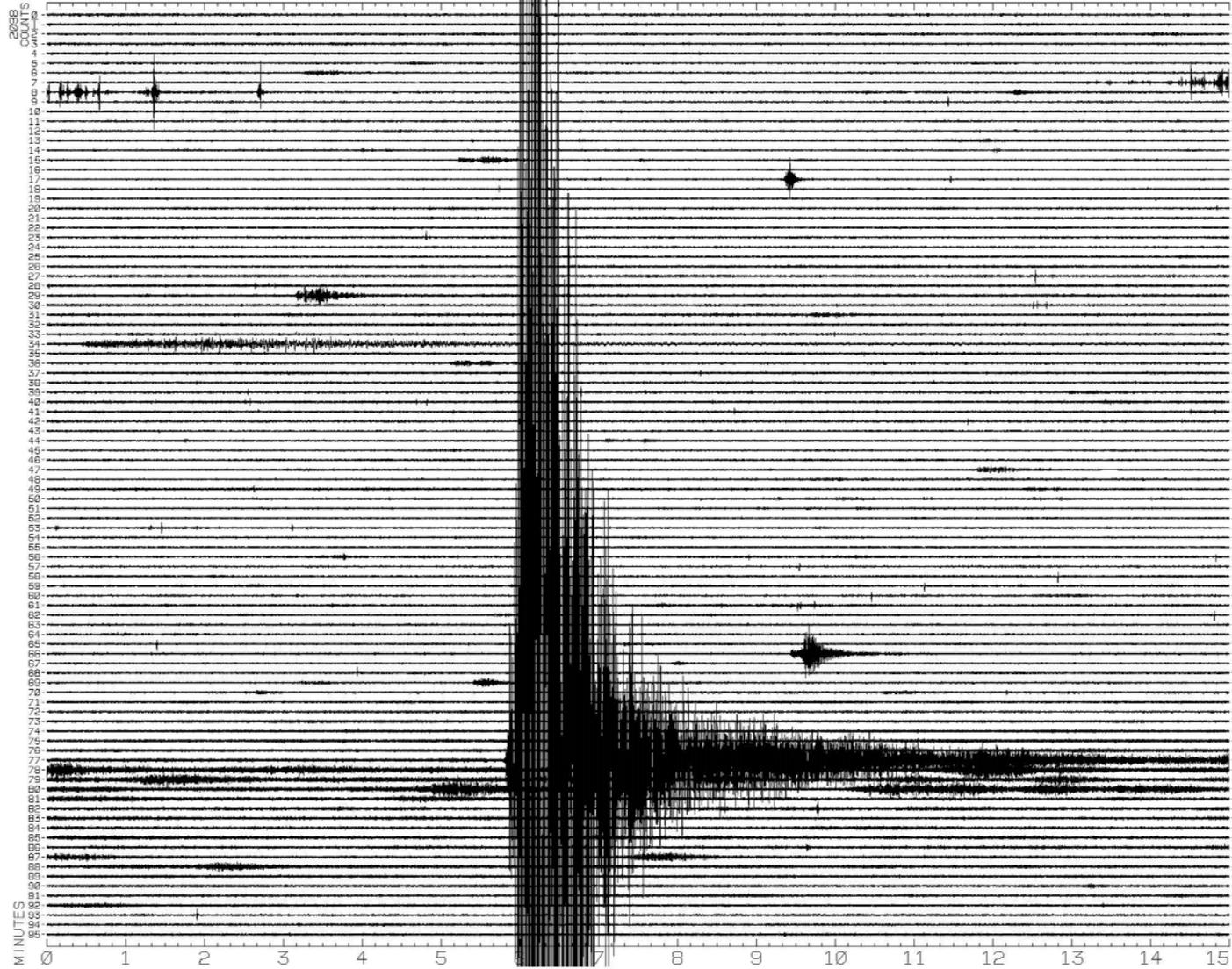
Images of May 20 and June 19 (provided by the University of Colima), where a new lava dome seen, this was covered by ash and fragmented material with outstanding piers and rocks loosened by the continuous and constant exhalations.



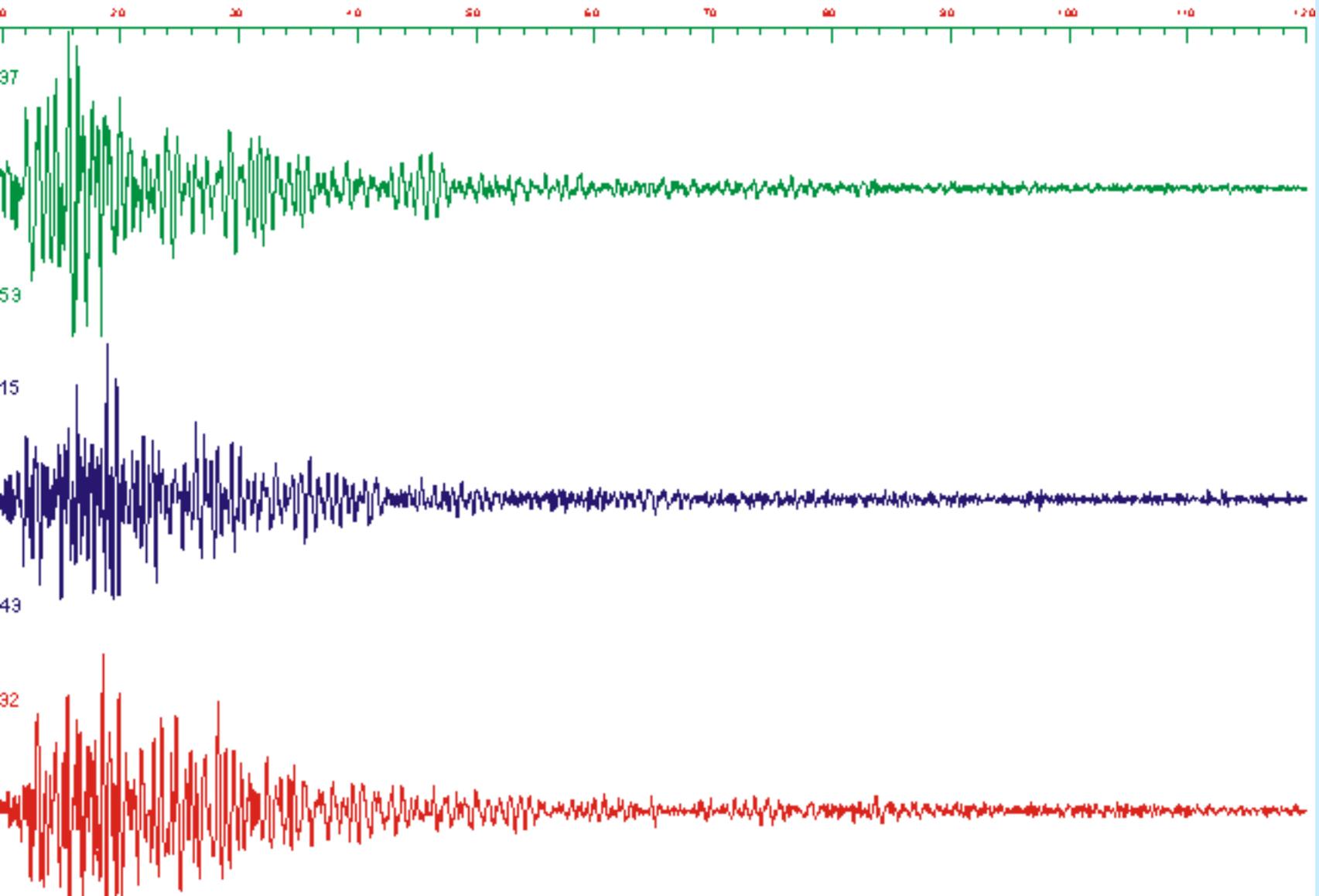
Exhalations and explosives occurred since the November 21, 2014 until June 18, 2015, they calculated a VEI 1 and in some cases reached the VEI 2.

Eruptive columns reached up to 3,500 m above the crater (7,500 masl), with dispersion of ash to the NE and N sector and some emissions of small pyroclastic flows, as seen in the above pictures.

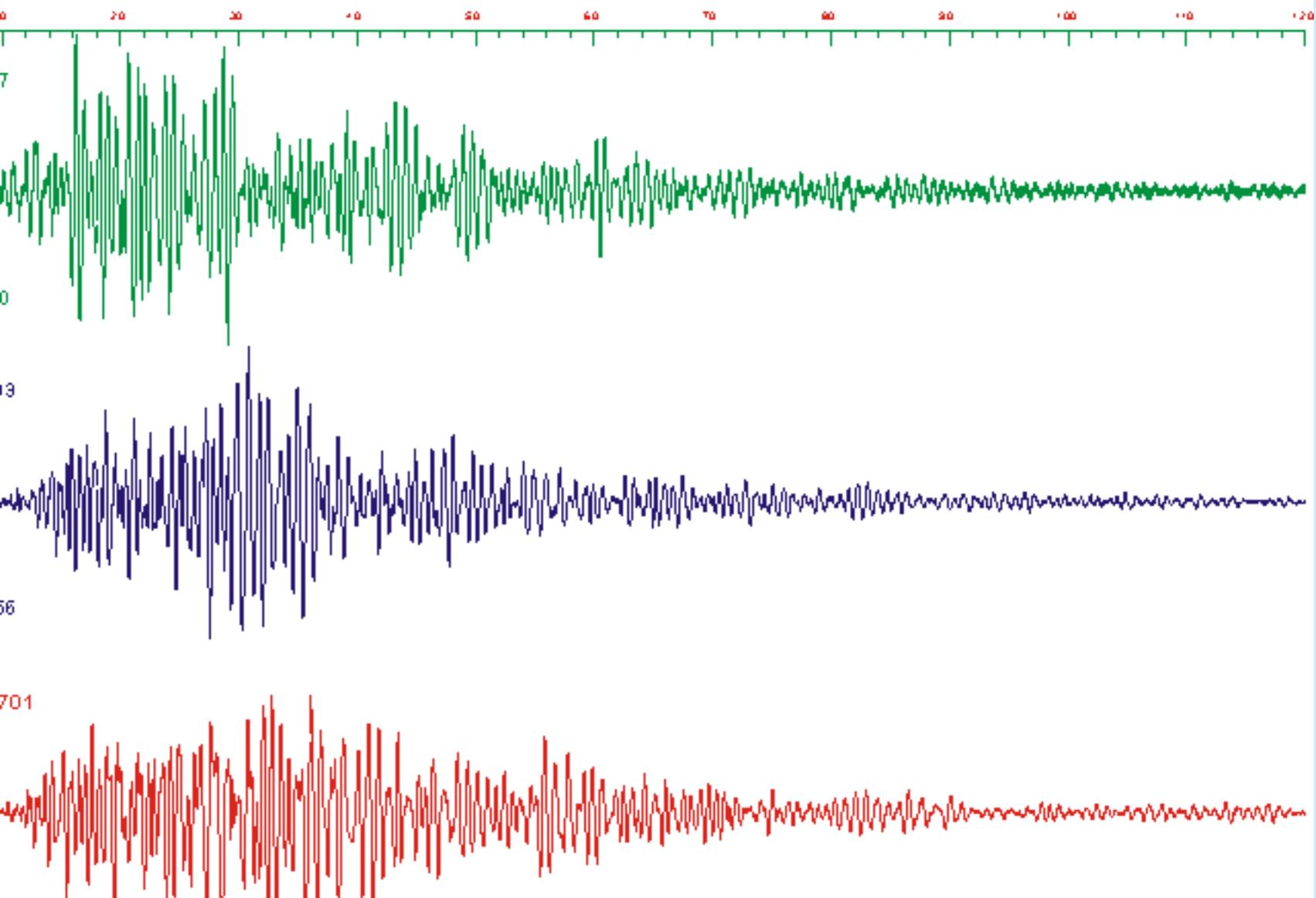
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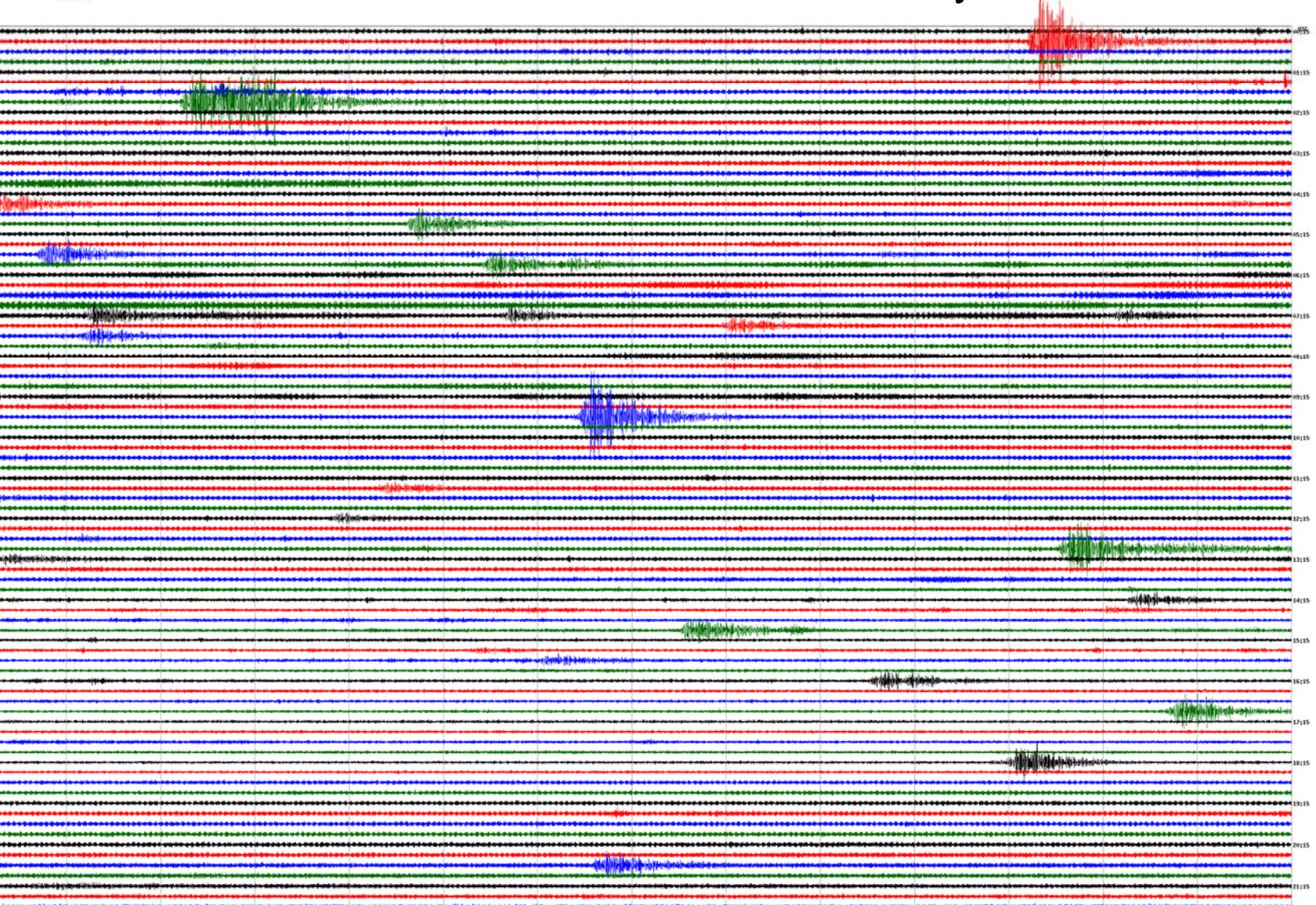
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RESAJ



January 17, 2015





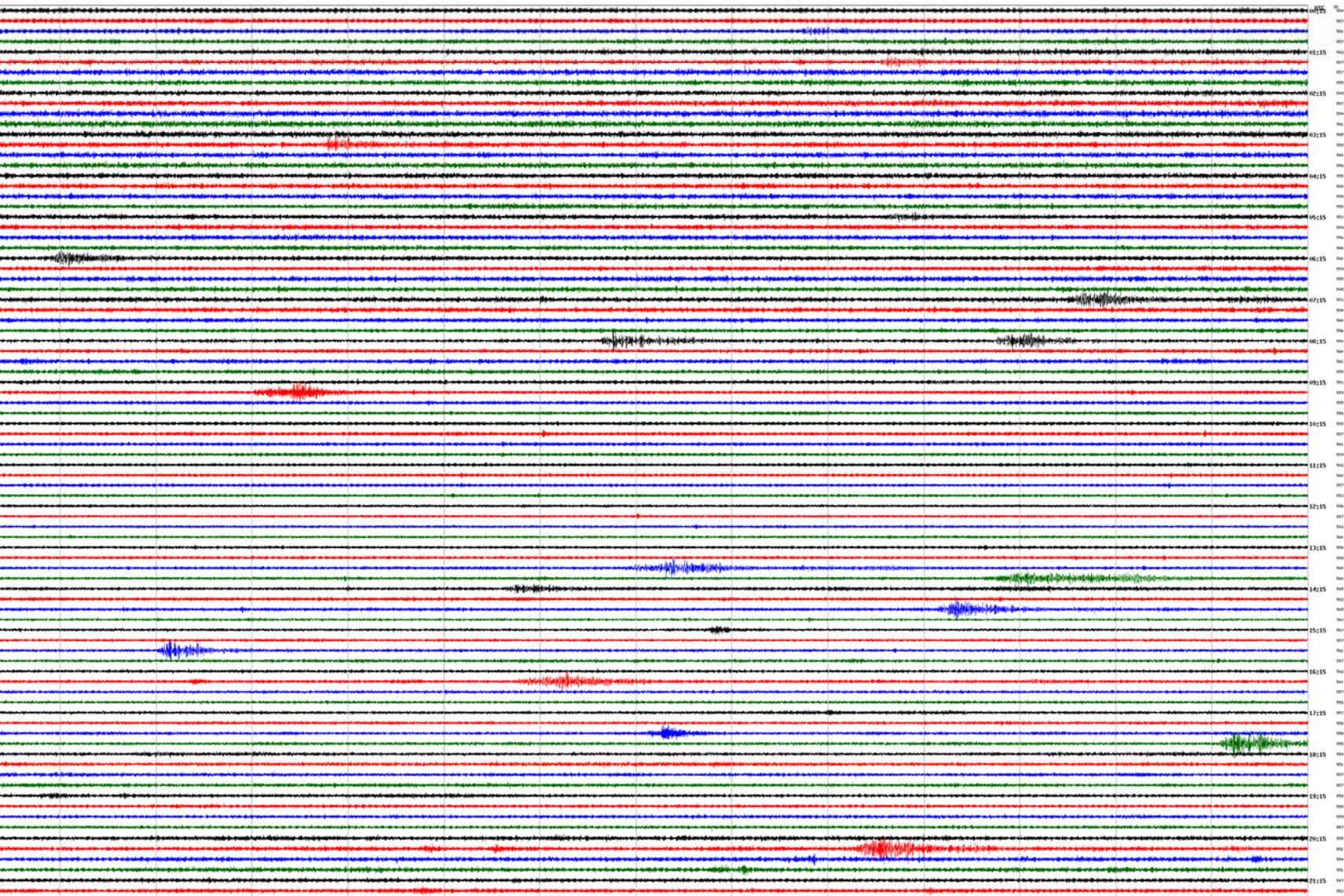
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RESAJ



January 27, 2015

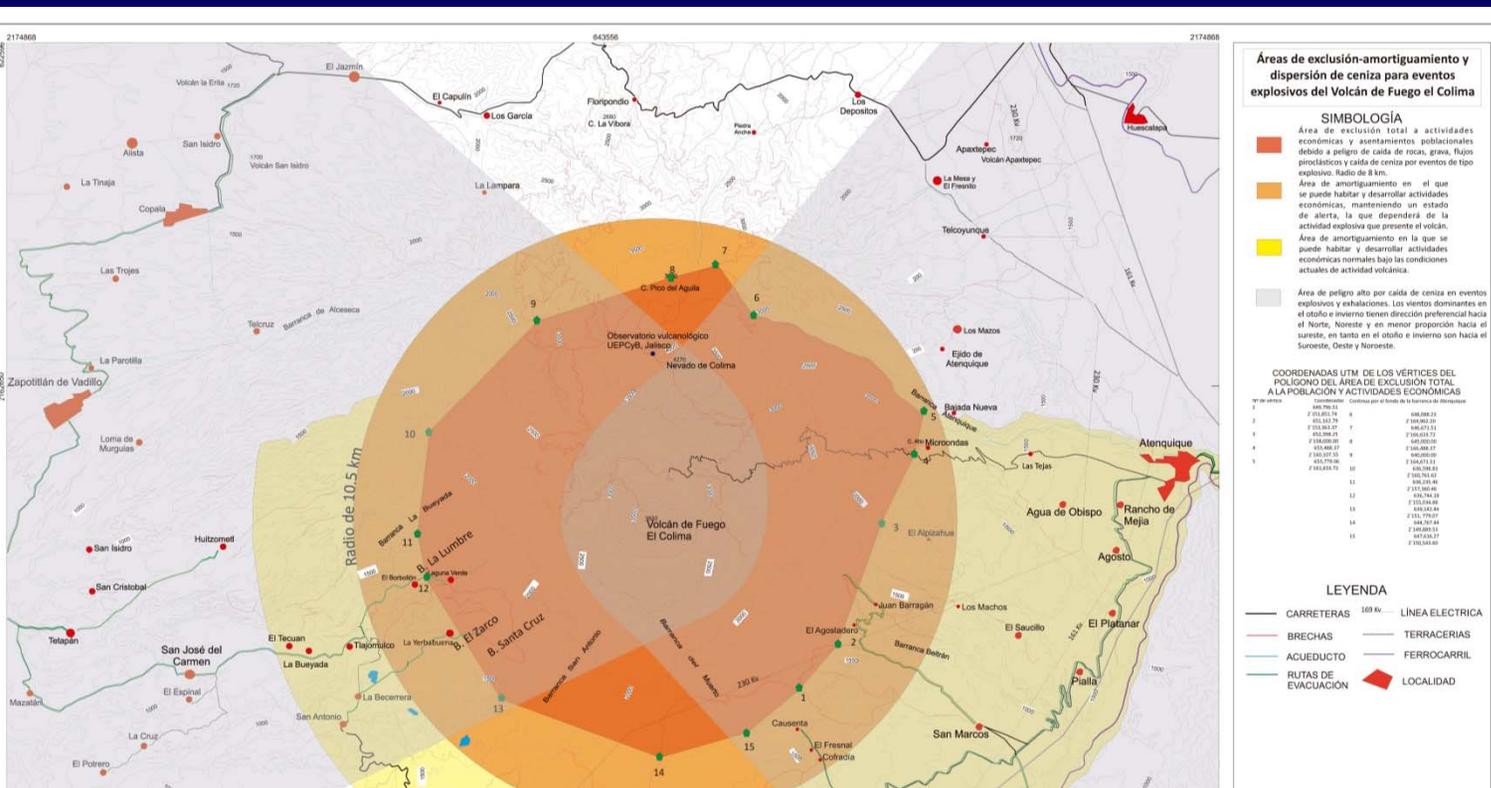


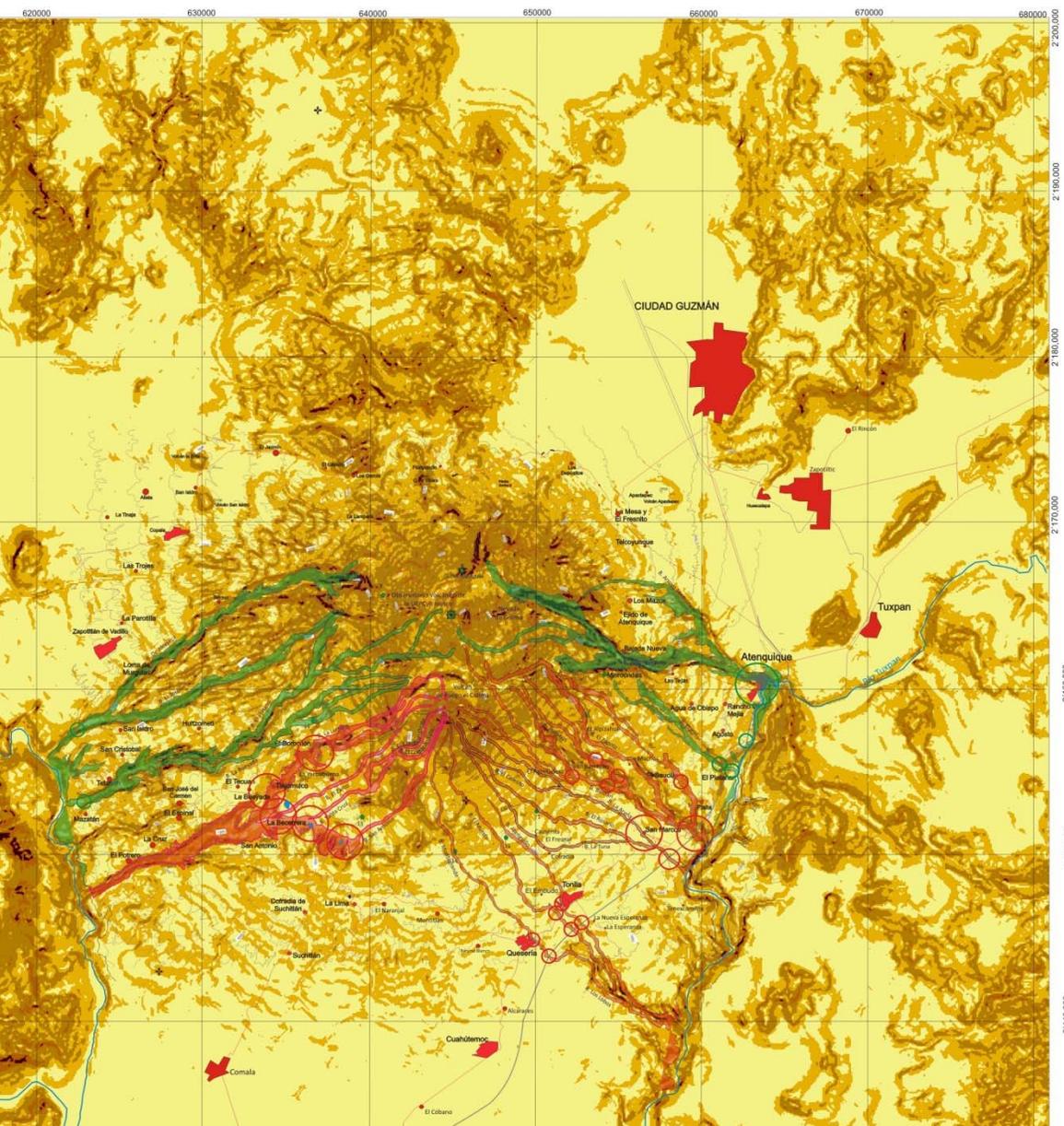
on this explosion, we build and update the **risk map to explosive events, and ballistic**, defining three zones:

High hazard: with a radius of 8 km of the crater, where all economic and personal tourism activities are not allowed.

Intermediate hazard: with a radius between 8 km and 10.5 km, where normal activities of the population can be performed under conditions of permanent alert.

Low Hazard: with a range between 10.5 km and 15 km, where you can perform normal activities.





MAPA DE PELIGRO A LAHARES Y FLUJOS DE DETRITOS EN EL VOLCÁN DE FUEGO EL COLIMA

Simbología

- CARRETERAS
- AUTOPISTA
- BRECHAS
- FERROCARRIL
- 📍 LOCALIDAD

Rangos de Pendientes

- 0-5°
- 5-15°
- 15-30°
- 30-45°
- >45°

Leyenda

- Red de Barrancos del Nevado de Colima, los cuales pueden generar flujos de detritos generados por la actividad erosiva de las barrancas de Atenquique, El Seco y el Platanar.
- Punto con Alta vulnerabilidad a Flujos de detritos
- Punto con Moderada vulnerabilidad a Flujos de detritos
- Red de Barrancos del Volcán de fuego el Colima susceptibles a lahares.
- Punto con Alta vulnerabilidad a lahares
- Punto con Moderada vulnerabilidad a lahares
- Área del sector Suroeste y Este del volcán que presenta Alta vulnerabilidad a lahares debido a la concentración de materiales emitidos durante esta etapa eruptiva y a que es la zona que presenta mayor precipitación pluvial anual.

Localidades		
Afectadas Directamente*		
San Marcos	El Borbollón	Causentla
Tonila	El Tecuán	El Fresnal
Quesería	San José del Carmen	El Agostadero
La Becerrera	La Bueyada	Juan Barragán,
San Antonio	Mazatan	Los Machos
La Yerbabuena	Tetapán	El Saucillo
	San Cristóbal	El Alpizahue
	San Isidro	
	Huitzometl	
	Lomas de Murguía	

* Al quedar incomunicadas por destrucción de los pasos sobre las barrancas.

- Infraestructura Carretera**
- Puente de Beltrán (autopista y carretera libre)
 - Puente Arenal (Autopista y carretera libre)
 - Puente El Muerto (Autopista y carretera libre)
 - Puente de la B. Montegrando (Autopista y carretera libre)
 - Puente La Becerrera
 - Puente La Lumbre
 - Paso del Arroyo el Huacal
 - Paso del Arroyo Alceseca

Conclusions:

The actual volcano activity is similar to the activity presented years before the Plinian eruption of January 20, 1913.

The volcanic conduit is actually open, so that it has continued producing eruptive columns of different heights with the presence of low energy seismic signals.

It will continue falling ash dispersed by local winds, affecting geographic areas near and far.

Seismic signals do not show, at this time, a change in the eruptive process, that could imply a change of the actual risk scenery to a high risk scenario (type Plinian eruption of January 1913).

Vulnerable elements within these areas have been gradually changed due to the expansion of the agricultural frontier on the east and southeast sides of the Colima volcano, the population growth in the towns on the lower slopes of the volcano, also the region has shown an increased vulnerability due to the development of economic activities, supported by the construction of roads, pipelines and electrical infrastructure.