

Digital geological map and geochronological database of the Cenozoic cover of the southern Mesa Central province, Mexico[☆]

Mapa geológico digital y base de datos geocronológica de la cobertura cenozoica del sur de la provincia Mesa Central, México

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Abstract

The digital geological map of the southern sector of the Mesa Central province is presented, covering an area of 41 000 km² in central Mexico. This first interactive map is a compilation of the geological maps available in the literature and the unpublished maps done by our work team. The map focuses on the Cenozoic stratigraphy, supported by a geochronological database of 261 isotopic ages derived from K-Ar, U-Pb, Ar-Ar, and fission tracks methods. The interactive map displays the lithostratigraphic and chronostratigraphic units and the major and second-order Cenozoic faults. Map construction considered lithostratigraphy and geochronological correlation criteria and the main unconformities. Integrating these data in a single digital map allows a regional vision of the southern Mesa Central, making the map a valuable work tool to better understand the Cenozoic geologic evolution of central Mexico.

Keywords: Mesa Central province, interactive geological map, geochronological database, Central Mexico, Cenozoic stratigraphy

Resumen

Se presenta el mapa geológico digital del sector sur de la provincia Mesa Central, cubriendo un área de 41 000 km² en el centro de México. Este primer mapa interactivo es una compilación de los mapas geológicos disponibles en la literatura y de los mapas inéditos realizados por nuestro grupo de trabajo. El mapa se enfoca en la estratigrafía cenozoica, apoyada por una base de datos geocronológicos de 261 edades isotópicas K-Ar, U-Pb, Ar-Ar y trazas de fisión. El mapa interactivo muestra las unidades litoestratigráficas y cronoestratigráficas, y las fallas cenozoicas mayores y de segundo orden. La construcción del mapa consideró criterios de correlación litoestratigráficos, geocronológicos y las discordancias principales. La integración de esta información en un mapa digital unificado permite una visión regional del sur de la Mesa Central, haciendo del mapa una herramienta de trabajo valiosa para un mejor entendimiento de la evolución geológica del centro de México.

Palabras clave: Provincia Mesa Central, mapa geológico interactivo, base de datos geocronológica, centro de México, estratigrafía cenozoica

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1. Introduction

The Mesa Central province (MC) forms an elevated plateau at an average 2000 m above sea level in central Mexico (Figure 1). This province is characterized by an extensive Cenozoic continental volcanic and clastic cover affected by extensional deformation (Nieto-Samaniego et al., 2007). A major angular unconformity (Upper Cretaceous-Paleocene) separates two stratigraphic groups associated with different tectonic regimes. Below the unconformity, the pre-Cenozoic rocks are affected by shortening structures related to the building of the Mexican orogen (Fitz-Díaz et al., 2018), which ceased between 73–52 Ma in a broad region of the southern MC (Tristán-González et al., 2009b; Cuéllar-Cárdenas et al., 2012; Angeles-Moreno et al., 2017; Nieto-Samaniego et al., 2020). Above the unconformity, the Cenozoic rocks are affected by the Basin and Range extensional tectonics and consist of continental sedimentary and magmatic successions (Figure 2). Eocene rocks include conglomerates and intermediate to silicic ignimbrites and lavas, followed by a voluminous succession of Oligocene silicic ignimbrites and rhyolites. Miocene-Quaternary andesites and basalts occur in the upper part of the stratigraphic column (Nieto-Samaniego et al., 2007). At a more regional scale, the Oligocene rocks are part of the ignimbrite flare-ups that occurred at 32–28 Ma and 24–20 Ma in western-central Mexico, building the the Sierra Madre Occidental silicic large igneous province (Ferrari et al., 2002; 2007).

Besides the major Upper Cretaceous-Paleocene unconformity, other second-order unconformities (Lutetian-Priabonian, Priabonian-Rupelian, Rupelian-Chattian, and Miocene) have been documented and used to organize the stratigraphy in the southern MC (Figure 2). These unconformities mark episodes of volcanic quiescence with changes in the volcanic style and composition, associated with regional tectonic events (Nieto-Samaniego et al., 2007; Angeles-Moreno, 2018). Recently, Del Pilar-Martínez et al. (2020a; 2020b) documented that the limit Rupelian-Chattian coincides with a change in the deformation style, which evolved from biaxial domino-like faulting to triaxial polymodal faulting.

Many authors addressed the Cenozoic stratigraphy and geologic cartography of the MC (Figure 1). Particularly, in the past decade a great effort has been made to provide new geological maps with a stratigraphic framework supported by isotopic ages, which allowed a refinement and a better understanding of the geologic evolution of the MC. In this contribution, we integrated the geological maps available in the literature and compiled a comprehensive geochronologic database. With this information, we elaborated a digital interactive map encompassing the whole southern sector of the MC, which is limited by regional structures: the San Luis-Tepihuanes fault system to the north, the El Bajío fault system to the south, the Taxco-San Miguel de Allende fault system to the east, and the Aguascalientes graben to the west. The mapped area comprises part of the states of Guanajuato, San Luis Potosí (S. L. P.), Jalisco, Aguascalientes, and Zacatecas, covering an area of approxi-

mately 41 000 km².

2. Methods

The compilation included geological data from Labarthe-Hernández et al. (1982), Loza-Aguirre et al. (2008), Tristán-González et al. (2015), González-Cervantes et al. (2019), Del Pilar-Martínez et al. (2020b), and Sieck et al. (2021) (Figure 1), and the unpublished theses of Ruiz-González (2015), Olmos-Moya (2016), Angeles-Moreno (2018), Suárez-Arias (2019), and Del Pilar-Martínez (2021). In the areas not covered by these works, we used the geological maps at 1:50 000 scale (Table 1) published by Servicio Geológico Mexicano (SGM) available at <https://www.gob.mx/sgm>. The pre-Cenozoic rocks were grouped in a single unit as “Mesozoic rocks”. Because of the large number of Cenozoic lithostratigraphic units (formal and informal), we group them in several chronostratigraphic units as shown in Figure 3, based on the International Chronostratigraphic Chart 2021/05 (Cohen et al., 2021). The map is supported by 261 isotopic ages: 125 K-Ar, 95 U-Pb, 29 Ar-Ar, and 3 fission-tracks (see the supplementary information). The ages were compiled from published papers, technical reports, and theses. Data georeferencing and digitization were done using ESRI ArcMap. We carefully verified and traced the geologic contacts as well as the major and second-order extensional faults, ensuring the consistency between isotopic ages and the correspondent chronostratigraphic unit. Google Earth satellite images (Map data: ©2021 Maxar Technologies), digital elevation models from Earth Explorer (<https://earthexplorer.usgs.gov>), and topographic maps from the Instituto Nacional de Estadística y Geografía (INEGI) were used for a more precise drawing of contacts and faults. The final static map layout and figures were elaborated using CorelDRAW X7®.

3. Cenozoic magmatism and extension in the southern Mesa Central province

3.1. Eocene

3.1.1. Ypresian-Lutetian

The lower Eocene record comprises continental sediments interbedded with volcanic rocks and granitic intrusions, reported in several localities in the MC (Figure 3). The volcanic rocks consist of lavas and ignimbrites with the composition varying from andesite to rhyolite, which represent the onset of volcanism after the end of the Laramide orogeny (Cuéllar-Cárdenas et al., 2012; Angeles-Moreno et al., 2017). Sieck et al. (2021) reported a small outcrop in the Villa García-Loreto region (Zacatecas state) with the oldest (60.4 Ma) volcanic rocks with a subduction signature in the MC, which they named La Milpa Andesite. In the Sierra de Guanajuato (SG), the Ypresian volcanic rocks, including the Laborcita rhyolite, Duarte dike-strata, and Palo Blanco ignimbrite, were mapped by Angeles-Moreno (2018) and Ruiz-González (2015). Aranda-Gómez and McDowell (1998) reported andesitic lavas of 49 Ma interbedded

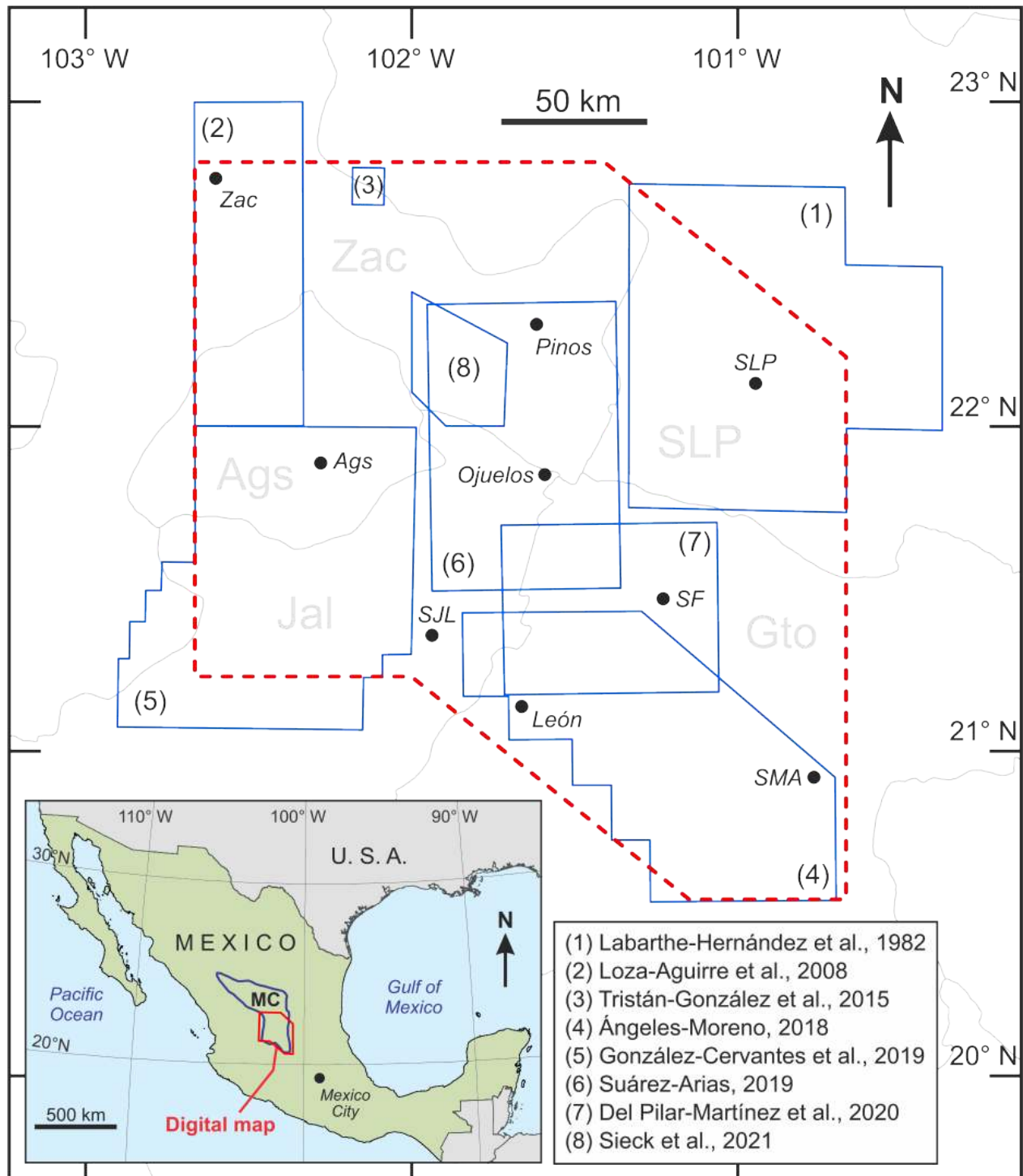


Figure 1: Location of the study area. The inset map displays the location of the Mesa Central province in central Mexico. The red polygon with a dashed line is the mapped area, and the blue polygons are the available published maps compiled to construct this map. The gray lines are the state boundaries, and the black dots are the main localities. MC: Mesa Central province, Zac: Zacatecas, Ags: Aguascalientes, SJL: San Juan de los Lagos, SF: San Felipe, SLP: San Luis Potosí, SMA: San Miguel de Allende. / Figura 1: Localización del área de estudio. El mapa muestra la localización de la provincia Mesa Central en el centro de México. El polígono rojo con línea punteada es el área mapeada y los polígonos azules son los mapas publicados disponibles para construir este mapa. Las líneas en gris son los límites estatales y los puntos en negro son las localidades principales. MC: provincia Mesa Central, Zac: Zacatecas, Ags: Aguascalientes, SJL: San Juan de los Lagos, San Felipe, SLP: San Luis Potosí, SMA: San Miguel de Allende.

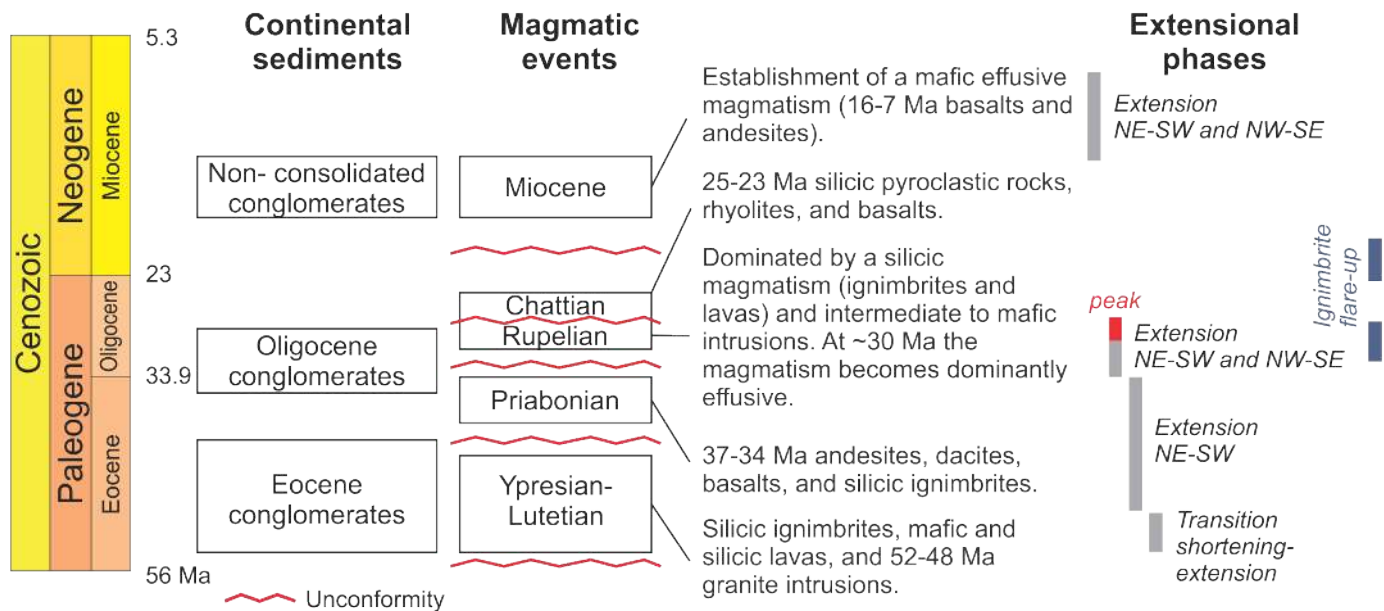


Figure 2: Cenozoic stratigraphic synthesis and deformation events from the southern Mesa Central. The information was taken from Alaniz-Álvarez et al. (2001), Ferrari et al. (2002), Aranda-Gómez et al. (2007), Nieto-Samaniego et al. (2007), Cuéllar-Cárdenas et al. (2012), Angeles-Moreno et al. (2017), Angeles-Moreno (2018), Del Pilar-Martínez et al. (2020a; 2020b), and Del Río-Varela et al. (2020). / Figure 2: Síntesis estratigráfica y eventos de deformación cenozoicos del sur de la Mesa Central. La información fue tomada de Alaniz-Álvarez et al. (2001), Ferrari et al. (2002), Aranda-Gómez et al. (2007), Nieto-Samaniego et al. (2007), Cuéllar-Cárdenas et al. (2012), Angeles-Moreno et al. (2017), Angeles-Moreno (2018), Del Pilar-Martínez et al. (2020a; 2020b) y Del Río-Varela et al. (2020).

in the lower member of the Guanajuato Conglomerate in the Guanajuato mining district (southeastern SG). Ponce and Clark (1988) reported the 47 Ma Los Alamos ignimbrite located near to Zacatecas city, and Loza-Aguirre et al. (2008) the El Devisador Ignimbrite (middle Eocene), the 49 Ma La Bufa Rhyolite, and the 42 Ma Presillas Formation. Also, Escalona-Alcázar et al. (2016) dated at 43.5 Ma the volcanic rocks of Cerro La Bufa. Tristán-González et al. (2015) reported lavas of 50 Ma (La Leona rhyolite) and 44.5 Ma (La Cardona rhyolite) cropping out in La Tesorera region (Zacatecas state). The same

authors reported volcanic rocks older than the Eocene, which termed El Gato dacite of 63 Ma; however, the new isotopic ages published by Nieto-Samaniego et al. (2020) indicated a Lutetian age (47.5 Ma) for these rocks. Tristán-González et al. (2009a) reported an age of 44.5 Ma for the Casita Blanca Andesite in S. L. P. Nieto-Samaniego et al. (1996) documented the 47 Ma Presa Los Arquitos ignimbrite and the 40 Ma El Venaderito rhyolite in the Aguascalientes region. Although there is no record of Ypresian-Lutetian volcanic rocks in the San Felipe region (Guanajuato state), the age of ca. 50 Ma de-

Table 1: List of the geological maps 1: 50000-scale of the Servicio Geológico Mexicano (SGM) used for the compilation of this work / Tabla 1: Lista de los mapas geológicos a escala 1:50000 del Servicio Geológico Mexicano (SGM) usados para la compilación de este trabajo.

Key	Name	Authors
F13-B69	Ojo Caliente	Sociedad Exploradora Minera S.A. de C.V. (1999)
F13-B79	Luis Moya	GYMSA, Estudios de Planeación Regional S.A. de C.V. (2001)
F12-B89	Rincón de Romos	Torres et al. (2001)
F14-A61	Salinas de Hidalgo	Hernández-Loredo (2007)
F14-A71	Loreto	Montañez-Castro and Bustos-Gutiérrez (2002)
F14-C31	Lagos de Moreno	García-Ruiz (1999)
F14-A62	Espíritu Santo	Romo-Ramírez (2007)
F14-A72	Pinos	Sociedad Exploradora Minera S.A. de C.V. (1999)
F14-C24	Melchor	Gámez-Ordaz and Ávila-Ramos (2017)
F14-C34	San Diego de la Unión	Procesos Analíticos Informáticos S.A. de C.V. (2008)
F14-C44	Dolores Hidalgo	Pérez-Vargas et al. (1996)

rived from detrital zircons reported by Del Pilar-Martínez et al. (2020b) was interpreted as evidence of a source of Ypresian volcanism that possibly formed a lithological cover now completely eroded.

The plutonic rocks include the 62–60 Ma Cerro de San Pedro intrusive exposed in S. L. P. (Cuéllar-Cárdenas et al., 2012; Díaz-Bravo et al., 2021); the 59 Ma Chepinque intrusive in Zacatecas state (Franzetti, 2009); the 52 Comanja Granite in the SG (Botero-Santa et al., 2015; Angeles-Moreno et al., 2017); and the 51 Ma Peñón Blanco Granite in S. L. P. and Zacatecas states (Aranda-Gómez et al., 2007). The oldest intrusion crops out in Zacatecas state and corresponds to the 75–73 Ma Tesorera Granodiorite (Cuéllar-Cárdenas et al., 2012; Tristán-González et al., 2015).

The Eocene continental sedimentary rocks include the Guanajuato Conglomerate and Duarte Conglomerate (Edwards, 1955; Martínez-Reyes, 1992; Aranda-Gómez and McDowell, 1998; Miranda-Avilés et al., 2016), the Zacatecas Conglomerate (Escalona-Alcázar et al., 2016), the Cenicera Formation (Labarthe-Hernández et al., 1982), and the Pinos conglomerate (Aranda-Gómez et al., 2007). They contain clasts derived from intrusive rocks suggesting that intrusive bodies were exhumed contemporaneously with sedimentation during the Late Cretaceous-early Eocene. The time of exhumation overlaps with the transition between the Laramide shortening and the Basin and Range extension, associated with a crustal relaxation and gravitational collapse (Tristán-González et al., 2009b; Nieto-Samaniego et al., 2020). In northern S. L. P., this transition produced uplift of crustal blocks through strike-slip faults trending NNE and NNW (Tristán-González et al., 2009b). These faults exhumed the Triassic-Jurassic metamorphic successions and formed basins filled with the continental volcanic and clastic deposits. In the SG, the transition was recorded in the tourmaline veins hosted in the Ypresian Comanja Granite, which display brittle-ductile deformation structures related to strike-slip faults with a small thrust component (Angeles-Moreno et al., 2017).

3.1.2. Priabonian

The Priabonian stratigraphic record is scarce in the southern MC. Ponce and Clark (1988) reported the 36.8 Ma La Virgen Formation near Zacatecas city. In the same region, Escalona-Alcázar et al. (2016) documented tuffs of 37 and 35 Ma interbedded in the Zacatecas Conglomerate. Suárez-Arias (2019) documented the 34.6 Ma El Gallo rhyolite in Ojuelos region (Jalisco state). Del Pilar-Martínez et al. (2020) reported the 34.4 Ma El Aguaje Dacite in San Felipe (Guanajuato state). In S. L. P., Labarthe-Hernández et al. (1982) mapped the Jacavaquero dacite, which was assigned to the early Oligocene based on its stratigraphic position, although a late Eocene age can not be discarded.

The Priabonian pyroclastic rocks interbedded with the continental conglomerates suggest that sedimentation coeval with volcanism reached the late Eocene. Extensional structures with Priabonian age have not been documented in the MC.

3.2. Oligocene

The Oligocene volcanism is the most abundant in southern and western MC (Labarthe-Hernández et al., 1982; Ferrari et al., 2007; Nieto-Samaniego et al., 2007; Tristán-González et al., 2009a). It comprises mainly silicic volcanic rocks, both of effusive and explosive origin, and subordinate mafic to intermediate rocks. Oligocene granitic intrusions also have been reported and recently have been shown to be highly relevant for understanding the Oligocene geological evolution of the MC (Del Pilar-Martínez, 2021; Díaz-Bravo et al., 2021). We separated all these rocks into four chronostratigraphic units according to regional faulting events described below.

3.2.1. Lower Rupelian

The lower Rupelian unit comprises andesites, silicic ignimbrites, and intrusive rocks of ca. 33–31 Ma (indicated as Rupelian₁ in Figure 3 and the static map). These rocks have been reported in the states of Guanajuato, Jalisco, S. L. P., and Zacatecas. In the Guanajuato mining district, they were named Guanajuato Volcanic Group by Nieto-Samaniego et al. (2016). In the San Felipe-León-Ojuelos region this unit is represented by the 31 Ma Alfaro, Los Juanes, and Rincón de Ortega ignimbrites, the 31 Ma Bernalejo andesite, and the 30 Ma Cedro Formation (Botero-Santa et al., 2015; Angeles-Moreno, 2018; Suárez-Arias, 2019; Del Pilar-Martínez et al., 2020b). In S. L. P., the 31 Ma Santa María Ignimbrite belongs to this unit (Tristán-González et al., 2009a). In the Villa García-Loreto region this volcanism is represented by the 31 Ma Villa García Ignimbrite (Sieck et al., 2021). On the other hand, the intrusive rocks have ages of 31–30 Ma with the composition varying from gabbro, quartz monzodiorite, and granite (Labarthe-Hernández et al., 1982; Martínez-Reyes, 1992; Del Pilar-Martínez et al., 2020b).

During the early Rupelian, a NW trending domino-like fault system was active in a broad region of the southern MC (Del Pilar-Martínez et al., 2020a, and references therein). The domino fault-domains are well preserved in the Sierra de San Miguelito (S. L. P.), San Felipe region, and the Guanajuato mining district. The record of syn-extensional sedimentation coeval with volcanism is present in the Pinos conglomerate, which is interbedded with tuffs of 32 Ma (Aranda-Gómez et al., 2007).

3.2.2. Middle Rupelian

This unit comprises voluminous silicic effusive rocks and subordinated pyroclastic successions of 30–29 Ma (indicated as Rupelian₂ in Figure 3 and the static map). It marks a change in the chemical composition of the magmas in the MC, from high-K to high-silica, peraluminous, and fluorine-rich rhyolites (Orozco-Esquivel et al., 2002). The middle Rupelian unit includes the San Miguelito Rhyolite, Portezuelo Latite, Ojo Caliente Trachyte, Quelital Rhyolite, Chichíndaro Rhyolite, La Montesa Rhyolite, and Altamira rhyolite (Figure 3). Faults controlled the emplacement of these rocks because in Guanajuato and S. L. P. states, is shown by many rhyolitic lava-domes

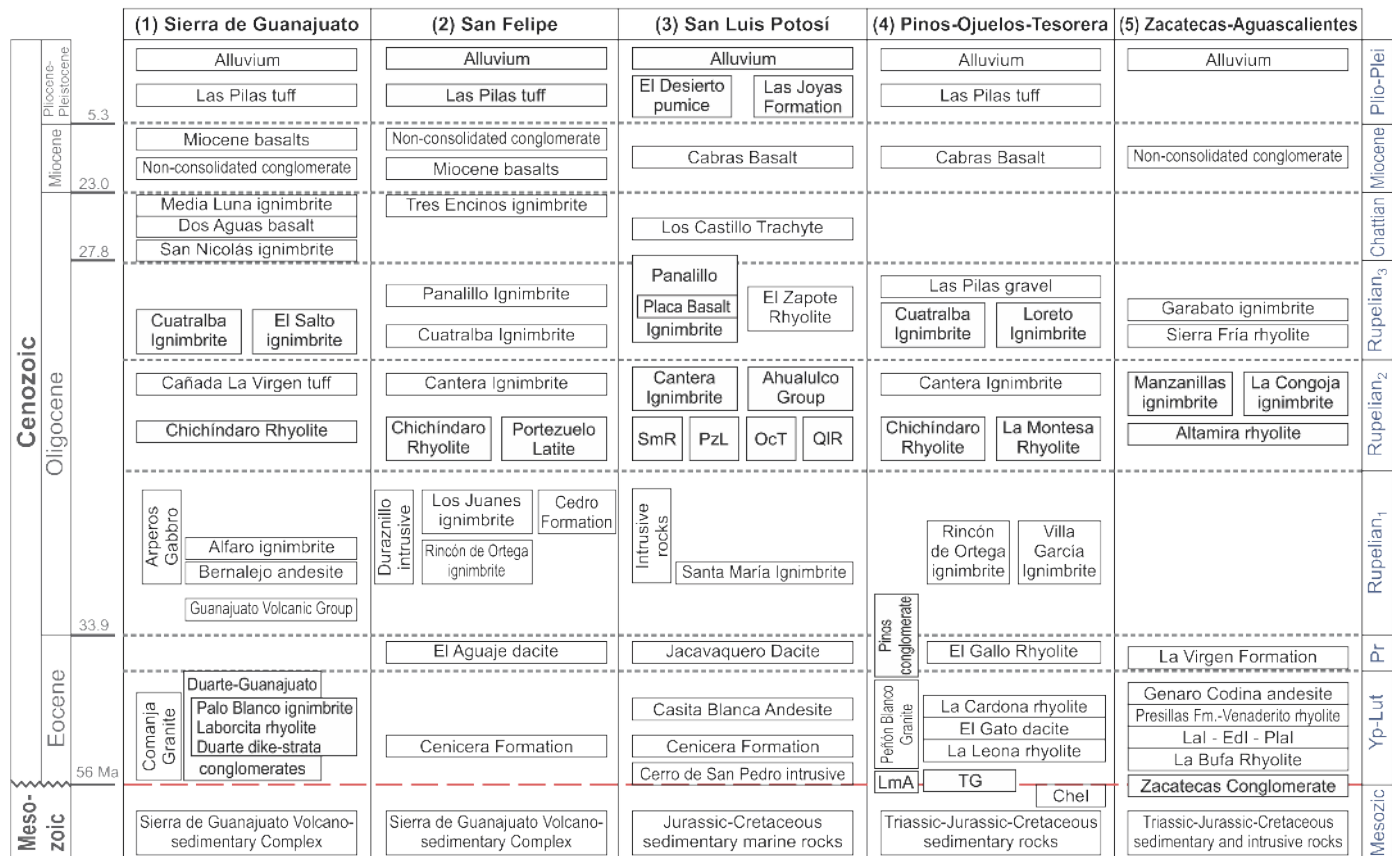


Figure 3: Simplified stratigraphic columns from the southern Mesa Central. The lithostratigraphic unit names and ages are mentioned in the text. The discontinuous lines indicate the unconformities identified in the MC, which were used to define the chronostratigraphic units indicated in blue text. SmR: San Miguelito Rhyolite, PzL: Portezuelo Latite, OcT: Ojo Caliente Trachyte, QIR: Quelital Rhyolite, TG: Tesorera Granodiorite, Chel: Chepinque intrusive, LmA: La Milpa Andesite, LaI: Los Alamitos ignimbrite, EdI: El Devisador ignimbrite, PlAI: Presa Los Arquitos ignimbrite, Yp-Lut: Ypresian-Lutetian, Pr: Priabonian, Plio-Plei: Pliocene-Pleistocene. References of stratigraphic columns: (1) Martínez-Reyes (1992), Nieto-Samaniego et al. (1996), Botero-Santa et al. (2015), Ruiz-González (2015), Ángeles-Moreno (2018); (2) Del Pilar-Martínez et al. (2020b); (3) Labarthe-Hernández et al. (1982); (4) Aranda-Gómez et al. (2007), Franzetti (2009), Tristán-González et al. (2015), Suárez-Arias (2019), Sieck et al. (2021); (5) Ponce and Clark (1988), Nieto-Samaniego et al. (1996), Loza-Aguirre et al. (2008), Cuéllar-González (2016). / Figure 3: Columnas estratigráficas simplificadas del sur de la Mesa Central. Los nombres y edades de las unidades litoestratigráficas son mencionadas en el texto. Las líneas discontinuas indican las discordancias identificadas en la MC, las cuales fueron usadas para definir las unidades cronoestratigráficas señaladas en texto azul. SmR: Rioluta San Miguelito, PzL: Latita Portezuelo, OcT: Traquita Ojo Caliente, QIR: Rioluta Quelital, TG: Granodiorita Tesorera, Chel: intrusivo Chepinque, LmA: Andesita La Milpa, LaI: ignimbrita Los Alamitos, EdI: ignimbrita El Devisador, PlAI: ignimbrita Presa Los Arquitos, Yp-Lut: Ypresiano-Lutetiano, Pr: Priaboniano, Plio-Plei: Plioceno-Pleistoceno. Referencias de las columnas estratigráficas: (1) Martínez-Reyes (1992), Nieto-Samaniego et al. (1996), Botero-Santa et al. (2015), Ruiz-González (2015), Ángeles-Moreno (2018); (2) Del Pilar-Martínez et al. (2020b); (3) Labarthe-Hernández et al. (1982); (4) Aranda-Gómez et al. (2007), Franzetti (2009), Tristán-González et al. (2015), Suárez-Arias (2019), Sieck et al. (2021); (5) Ponce y Clark (1988), Nieto-Samaniego et al. (1996), Loza-Aguirre et al. (2008), Cuéllar-González (2016).

aligned along normal faults oriented NW–SE and NE–SW (Nieto-Samaniego et al., 2007; Aguillón-Robles et al., 2009; Rodríguez-Ríos et al., 2013). The pyroclastic successions are represented by the 30 Ma Cantera Ignimbrite and Ahualulco Group in S. L. P. (Labarthe-Hernández et al., 1982; Tristán-González et al., 2009a; 2009b), the 29 Ma Manzanillas ignimbrite in the Asientos mining district (Aguascalientes state) (Cuéllar-González, 2016), and the ~29 Ma Cañada La Virgen tuff in the SG (Ángeles-Moreno, 2018). The ignimbrites could have been emplaced from volcanic calderas and most probably through linear fissure-vents (Aguirre-Díaz and Labarthe-Hernández, 2003). Pyroclastic dikes associated to explosive eruptions were also recognized, in some case controlled by faults in the Sierra de San Miguelito and Sierra de Guanajuato (Torres-Hernández et al., 2006; Xu et

al., 2013; Nieto-Samaniego et al., 2016).

All these rocks record the cessation of the domino faulting and predate the onset of the polymodal faulting documented in the southern MC (Del Pilar Martínez et al., 2020b).

3.2.3. Upper Rupelian

This unit comprises pyroclastic rocks <29 Ma, which have been documented in the central-eastern, southern, and western MC (indicated as Rupelian₃ in Figure 3 and the static map). In S. L. P., they include the 28 Ma Panalillo Ignimbrite (Labarthe-Hernández et al., 1982; Tristán-González et al., 2009a) and the 27 Ma El Zapote Rhyolite (Nieto-Samaniego et al., 1996). In the Sierra de Guanajuato and Sierra de Codornices, the 28 Ma Cuatralba and El Salto ignimbrites belong to this unit (Nieto-

Samaniego et al., 2007; Angeles-Moreno, 2018) as well as the 28 Ma Loreto Ignimbrite in the Villa García-Loreto region (Sieck et al., 2021). In the western border of the MC are the 28 Ma Garabato ignimbrite and the 27 Ma Sierra Fría rhyolite (Loza-Aguirre et al., 2008). The coeval occurrence of sedimentation and volcanism is recorded by 27 Ma tuffs interbedded in the Las Pilas gravel, exposed in the Pinos region (Zacatecas state) (Aranda-Gómez et al., 2007).

The upper Rupelian rocks recorded the polymodal faulting that accommodated the brittle triaxial deformation in the MC (Nieto-Samaniego et al., 1999; Del Pilar Martínez et al., 2020a).

3.2.4. Chattian

A hiatus in volcanic activity from 27 Ma to 23 Ma is evident in most of the southern MC. The only exceptions are two K-Ar ages of ca. 25 Ma for ignimbrites exposed in the SG (San Nicolás Ignimbrite; Nieto-Samaniego et al., 1996; 2007) and S. L. P. (upper Panalillo Ignimbrite; Labarthe-Hernández et al., 1982). In the SG and San Felipe region are the 23 Ma Media Luna ignimbrite and 23.5 Ma Tres Encinos ignimbrite, respectively (Botero-Santa et al., 2015; Del Pilar-Martínez et al., 2020b). These pyroclastic rocks are locally associated with basaltic lavas called Dos Aguas basalt (Martínez-Reyes, 1992) and La Placa Basalt (Labarthe-Hernández et al., 1982), which show the bimodal character of the late Oligocene volcanism. The Chattian rocks are slightly tilted due to the reactivation of the Rupelian faults (Botero-Santa et al., 2015; Del Pilar-Martínez et al., 2020b).

3.3. Miocene

The Miocene stratigraphic record comprises clastic sedimentary sequences widely distributed and filling the grabens of the MC. This continental sedimentation started in the Oligocene and most of the basins remain subsequently active. Miocene rocks are poorly consolidated conglomerate and sandstone and fluvial and lacustrine deposits. In the states of S. L. P., Zacatecas, and Guanajuato, these sequences are interbedded with Oligocene or Miocene felsic and mafic volcanic rocks (Nieto-Samaniego et al., 2007). Based on U-Pb zircon ages of silicic pyroclastic levels interbedded within fluvial and lacustrine sediments González-Cervantes et al. (2019) documented that sedimentation in the Aguascalientes and Teocaltiche grabens occurred between 28 and 7 Ma. Del Pilar-Martínez et al. (2020b) assigned a 16.5 Ma maximum depositional age to poorly consolidated conglomerates in the San Felipe region from U-Pb detrital zircon ages of an interbedded tuffaceous sandstone.

Basaltic lavas from 14 to 7 Ma also belong to the Miocene record (Luhr et al., 1995; Pérez-Venzor et al., 1996; Aguirre-Díaz et al., 1997; Cerca-Martínez et al., 2000; Henry and Aranda-Gómez, 2000; Angeles-Moreno, 2018). They form isolated outcrops with a wide distribution in the MC (Nieto-Samaniego et al., 2007; Tristán-González et al., 2009a). In S. L. P., these rocks were mapped as the Cabras basalt by Labarthe-Hernández (1982). In the southernmost MC they were grouped as Miocene

basalts and define a hiatus between 22 Ma and 16 Ma (Cerca-Martínez et al., 2000; Alaniz-Álvarez et al., 2001). In the SG, this hiatus marks the cessation of the Sierra Madre Occidental silicic explosive volcanism and the inception of the mafic and effusive volcanism of the Transmexican Volcanic Belt (Angeles-Moreno, 2018).

3.4. Pliocene-Pleistocene

Pliocene-Pleistocene intraplate volcanism related to extension with geochemical signals of the primitive mantle has been reported in S. L. P. and other sectors of the MC (Luhr et al., 1995; Aranda-Gómez et al., 2005; Aguillón-Robles et al., 2014). Such rocks are alkali basalts and contain mantle xenoliths and granulites from the lower crust. In northern S. L. P., Labarthe-Hernández et al. (1982) defined these rocks as the Las Joyas Formation. On the other hand, Angeles-Moreno (2018) mapped in the SG a 1.16 Ma silicic fall-air pyroclastic deposit named Las Pilas tuff. The best outcrops of this unit were documented by Suárez-Arias (2019) surrounding Ojuelos region and other minor exposures are in San Felipe region (Del Pilar-Martínez et al., 2020b). A similar pyroclastic deposit, named El Desierto pumice, was reported by Labarthe-Hernández et al. (1982) in S. L. P. The source of this pyroclastic deposit is unknown, but it could come from some caldera structure hosted in the Transmexican Volcanic Belt (Del Pilar-Martínez, 2021).

4. Conclusions

We presented the first digital and interactive geological map of the whole southern sector of the Mesa Central province. It comprises part of the states of Guanajuato, San Luis Potosí, Jalisco, Aguascalientes, and Zacatecas, covering 41 000 km². The map shows the Cenozoic stratigraphy organized as lithostratigraphic and chronostratigraphic units, supported by a geochronological database of 261 isotopic ages. Also, the boundary and second-order Cenozoic faults are shown. The integration of these data in a single digital map makes it a valuable work tool for a better understanding of the geological evolution of Central Mexico.

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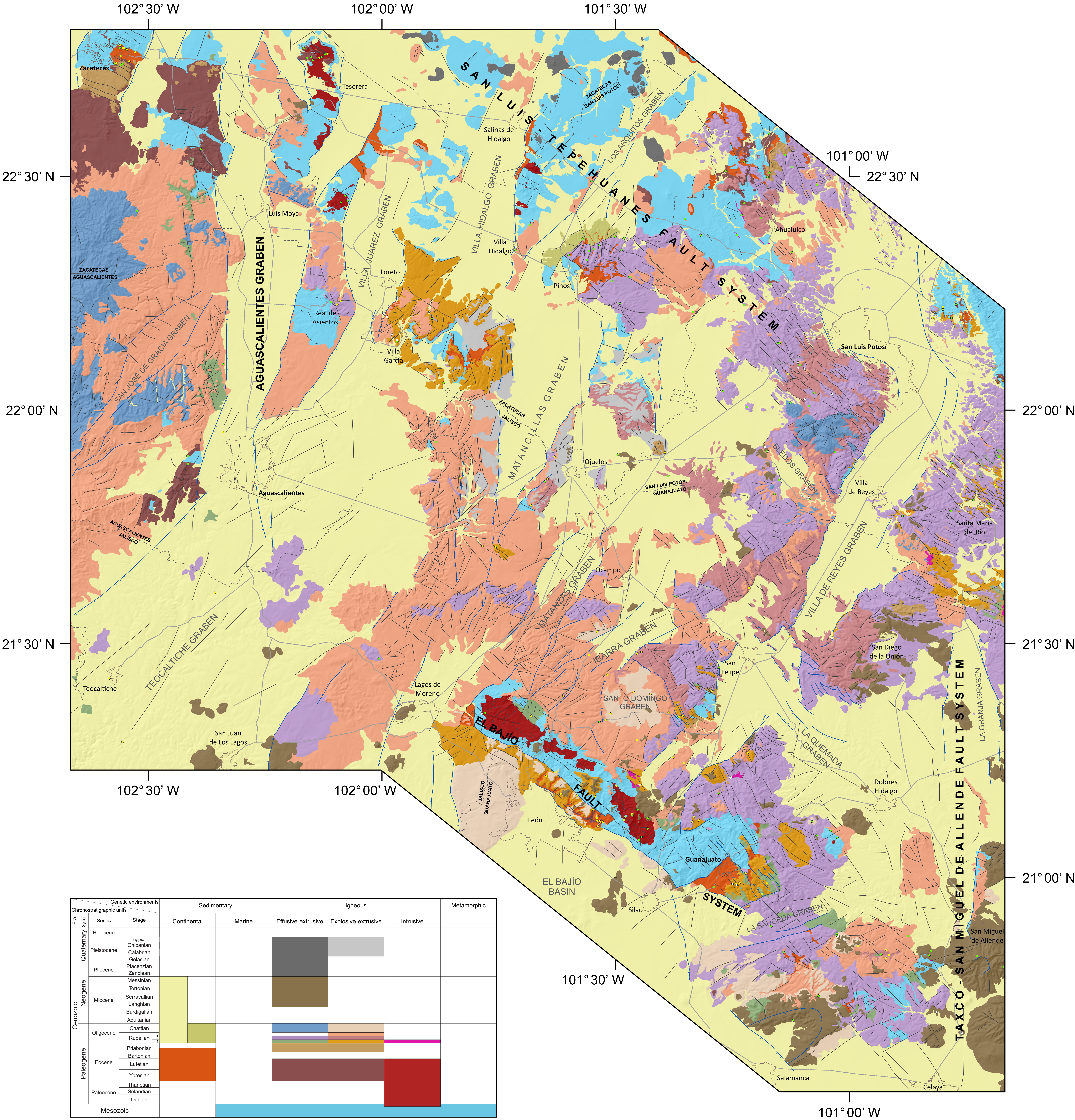
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Geological map of the Cenozoic cover of the southern Mesa Central province, Mexico

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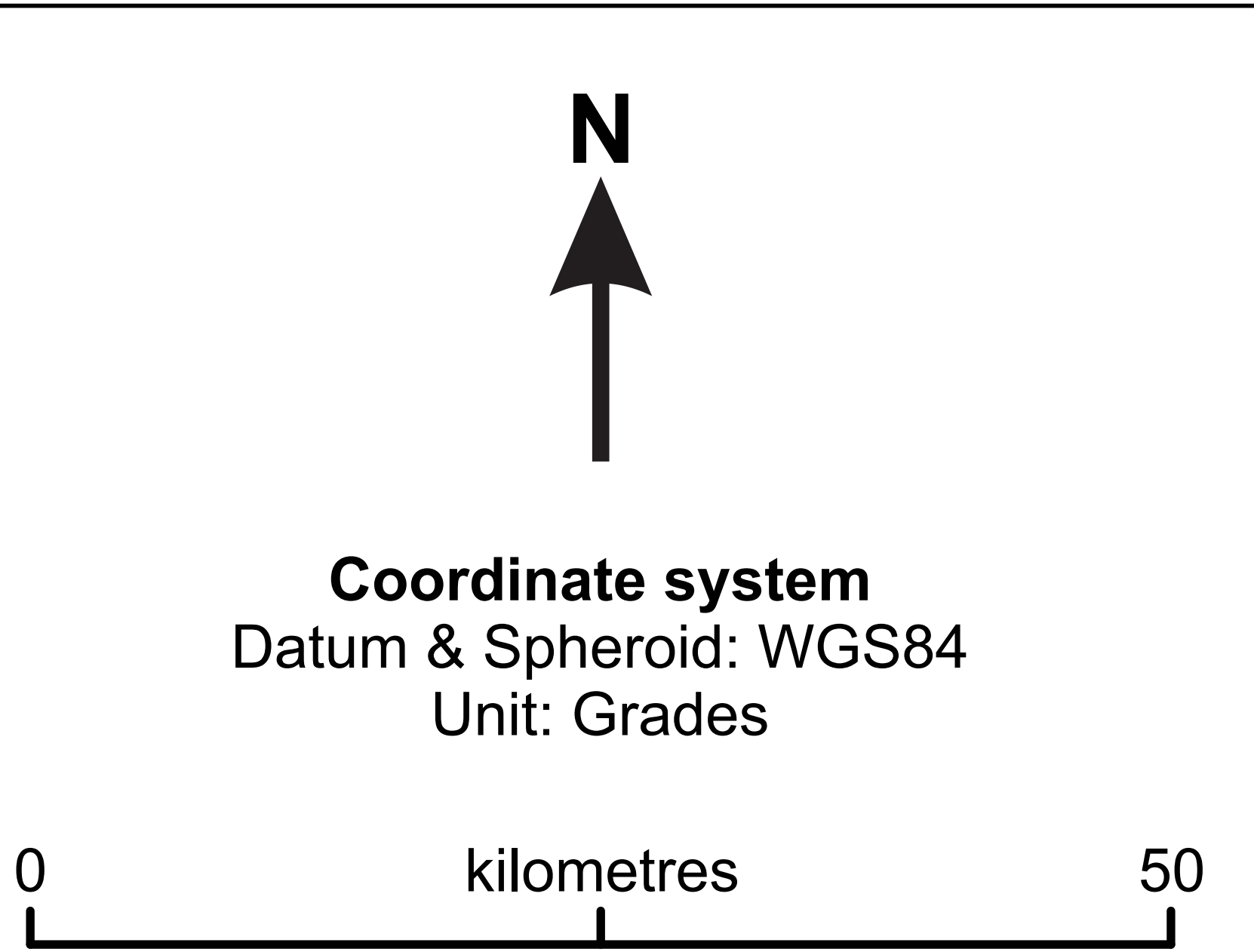
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Genetic environments			Sedimentary		Igneous			Metamorphic
Chronostratigraphic units								
Era	Series	Stage	Continental	Marine	Effusive-extrusive	Explosive-extrusive	Intrusive	
Cenozoic	Quaternary	Holocene						
		Pleistocene	Upper					
			Chibanian					
	Calabrian							
	Gelasian							
	Pliocene	Piacenzian						
		Zanclean						
	Miocene	Messinian						
		Tortonian						
		Serravallian						
		Langhian						
		Burdigalian						
	Oligocene	Aquitanian						
		Chattian						
		Rupelian						
		Paleogene	Priabonian					
			Bartonian					
	Lutetian							
	Ypresian							
	Thanetian							
Paleocene	Selandian							
	Danian							
Mesozoic								

Legend

- K-Ar age
- U-Pb age
- Ar-Ar age
- Fission tracks age
- First order fault
- Second order fault
- Main road
- City/town
- State boundary



Logos of the participating institutions and the publisher, terra digitalis.

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 Interactive map: 10.22201/igg.25940694e.2021.2.89.188
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