

Magmatic Evolution, Aeromagnetic Structure, and Geological Framework of the Mascota Volcanic Field, Central Jalisco Block, Western Mexico

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Magmatic Evolution, Aeromagnetic Structure, and Geological Framework of the Mascota Volcanic Field, Central Jalisco Block, Western Mexico.

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Abstract

The Mascota Volcanic Field (MVF), located near the structural center of the Jalisco Block in western Mexico, represents one of the youngest and most compositionally diverse volcanic provinces of the Trans-Mexican Volcanic Belt (TMVB). Its evolution reflects the interplay between arc magmatism, transtensional tectonics, and lithospheric modification associated with the subduction of the Rivera Plate beneath the North American Plate. This study integrates geological, petrological, and aeromagnetic datasets to characterize the magmatic evolution and crustal structure beneath the Mascota region. Stratigraphically, the region comprises Cretaceous granitoids, metamorphic basement rocks, and thick silicic ignimbrites, overlain by Plio–Quaternary volcanic units of the Central Jalisco Volcanic Lineament (CJVL). The MVF hosts both potassic (minettes, absarokites) and calc-alkaline (basaltic andesites to andesites) lava types. K–Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dating indicate ages between 1.0 and 0.5 Ma, making Mascota the youngest volcanic center within the CJVL (Bandy et al., 2001; Ownby et al., 2008). Aeromagnetic interpretation reveals low-amplitude anomalies aligned northwest–southeast, coinciding with the structural graben system and suggesting that deep crustal fractures have been reactivated from older back-arc domains (López-Loera et al., 2022). Together, these data suggest that the Mascota region constitutes a key locality for understanding mantle metasomatism, fault-controlled magma ascent, and the geodynamic evolution of the western Jalisco Block.

Keywords: Mascota Volcanic Field; Jalisco Block; Magmatic Evolution; Aeromagnetic Structure; Geological Framework.

Introduction

The Jalisco Block (JB) is a tectonic microplate located along the western margin of Mexico, bounded by the Tepic–Zacoalco Rift (TZR) to the north, the Colima Rift (CR) to the east (Allan, 1986), and the Middle America Trench to the southwest (Rosas-Elguera et al., 1996;

Ferrari et al., 2001). This block, roughly 200 km wide and 300 km long, accommodates oblique subduction of the Rivera Plate beneath the North American Plate, producing a transtensional stress regime and widespread late Cenozoic volcanism. Internally, the block is dissected by NW–SE and WNW–ESE fault systems, which define a series of extensional grabens, including those of Atenguillo, Talpa, and Mascota (Bandy et al., 2001; Maillol et al., 1997).

Within the JB, several Quaternary volcanic provinces align along the Central Jalisco Volcanic Lineament (CJVL), a NW-trending structural corridor hosting the Ayutla, Atenguillo, Los Volcanes, and Mascota volcanic centers. (Lange and Carmichael, 1990; Wallace and Carmichael, 1992). These fields exhibit remarkable geochemical diversity, including the coexistence of highly potassic lamprophyres with more typical calc-alkaline andesites. Such bimodal associations are rare in continental arc settings and have generated considerable debate concerning their mantle sources and crustal evolution (Carmichael et al., 1996; Richter and Rosas-Elguera, 2001).

The MVF is the youngest center along the CJVL (Fig. 1) and provides an exceptional natural laboratory for studying the interplay among lithospheric extension, mantle metasomatism, and fault-controlled magma ascent. Most of its activity occurred between 1.0 and 0.5 Ma (Ownby et al., 2008), producing over 100 monogenetic vents distributed across a NW–SE graben system (Bandy et al., 2001). The field provides a natural laboratory to study the interaction between transtensional tectonics, lithospheric extension, and complex mantle metasomatism within a subduction-related environment.

Previous petrologic studies (Lange and Carmichael, 1991; Carmichael et al., 1996; Ownby et al., 2008) demonstrated that potassic lamprophyric magmas (minettes and absarokites) display high K_2O and $Mg\#$ values, indicating derivation from a metasomatized mantle wedge. In contrast, calc-alkaline andesites likely evolved through processes of fractional crystallization and crustal assimilation in shallow magma reservoirs. Geochronological and paleomagnetic data (Maillol et al., 1997) constrain the eruptive history and confirm limited tectonic rotation since the late Pleistocene, suggesting that the JB has behaved as a relatively rigid crustal fragment since its separation from mainland Mexico.

Despite numerous petrological and tectonic investigations, few studies have integrated aeromagnetic data with the structural and magmatic evolution of the Mascota region. Recent magnetic modeling (López-Loera et al., 2022) reveals domains of low magnetic susceptibility along the CJVL, interpreted as deep crustal fractures or ancient back-arc basins reactivated during Neogene extension. This paper, therefore, combines geological, geochronological, and aeromagnetic data to:

- (1) Characterize the stratigraphy and structure of the Mascota region;
- (2) Describe the compositional and temporal evolution of its volcanism; and
- (3) Interpret subsurface architecture and crustal processes using aeromagnetic anomalies.

These findings provide new insights into the tectonomagmatic framework of the Jalisco Block and its role in the evolution of the western Trans-Mexican Volcanic Belt.

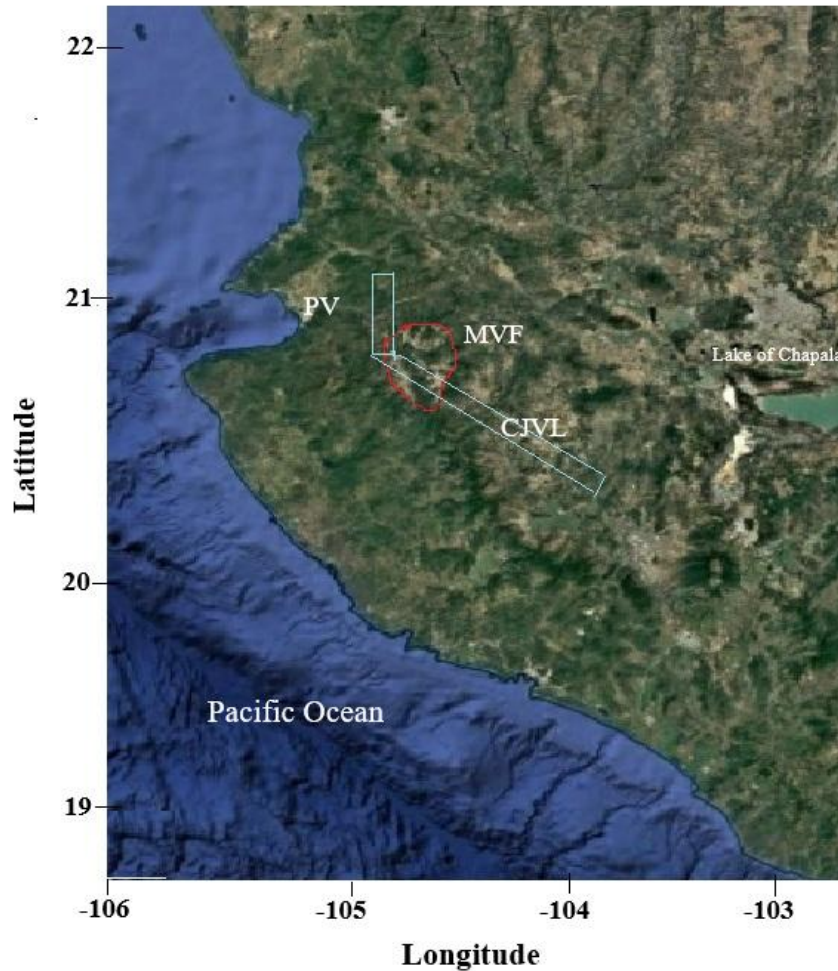


Fig. 1. Jalisco Block Showing the Tepic-Zacoalco Rift, Colima Rift, and position of the MVF within the central Jalisco Volcanic Lineament (San Sebastian-Mascota-Talpa de Allende-Los Volcanes-Ayutla).

2. Geological Setting

The Mascota region occupies the central portion of the Jalisco Block, a tectonic fragment that was detached from mainland Mexico during the late Miocene to Pliocene time due to the oblique subduction of the Rivera Plate (Rosas-Elguera et al., 1996; Ferrari et al., 2001). The block is bounded by two major continental rifts: the TZR to the north and the CR to the east, both of which are interpreted as divergent arms of a continental triple junction (Luhr, 1997; Ferrari and Rosas-Elguera, 2000). The Middle America Trench defines its southwestern boundary, where the Rivera Plate subducts beneath the North American Plate at rates of 4–5 cm/yr and dip angles of 45–50° (Espindola et al. 2011).

2.1 Structural Framework

Within the Jalisco Block, the Mascota–Talpa graben system constitutes a prominent NW–NW-SE-trending structural depression (Fig. 2). This system extends roughly 40 km and is bounded by steeply dipping normal faults that locally display right-lateral strike-slip components, indicating a transtensional regime (Bandy et al., 2001; Maillol et al., 1997). The graben is 2–5 km wide and exhibits up to 900 m of topographic relief between its floor and bounding horsts (Ownby et al., 2008), (Fig.3).

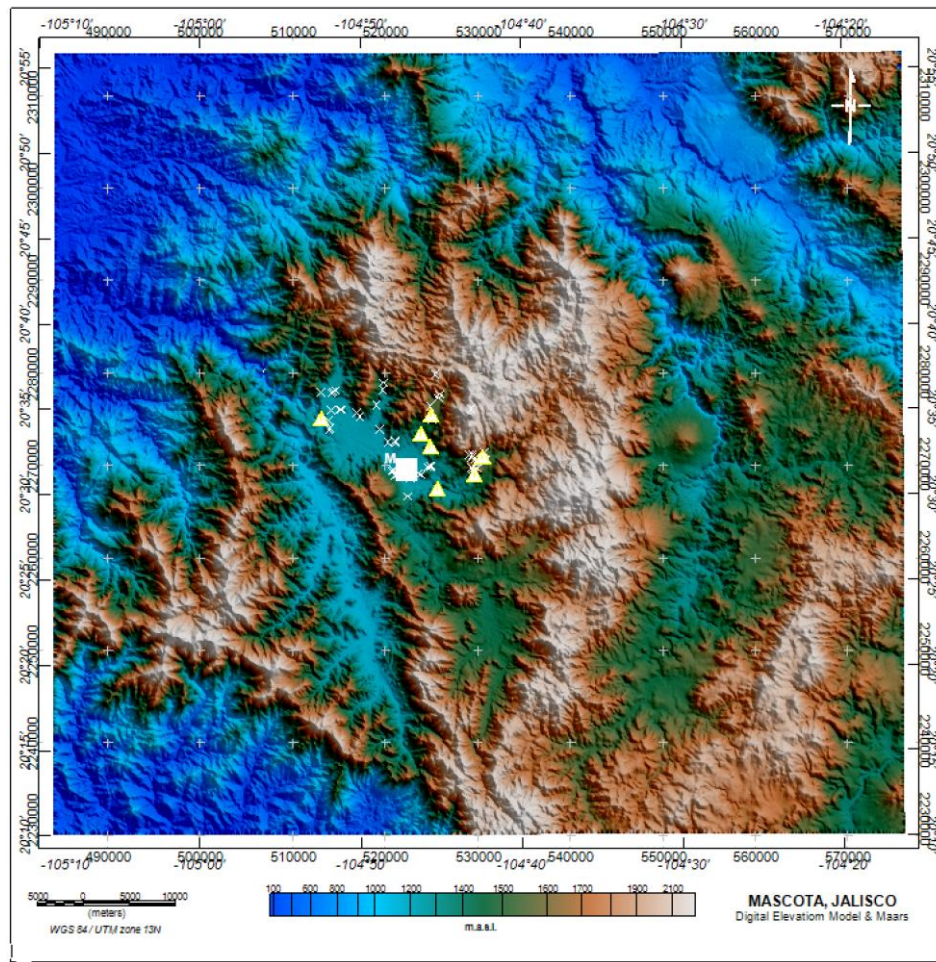


Fig. 2. Digital Elevation Model showing the location of volcanic structures (maars, yellow triangles) in the Mascota Volcanic Field, as well as the sites of magnetic susceptibility sampling (x). The topographic elevations range from 100 to more than 2,200 m.a.s.l.

2.2 Basement and Volcanic Stratigraphy

The regional basement comprises Mesozoic plutonic and metamorphic rocks, including Cretaceous granitoids, granodiorites, and metamorphosed volcano-sedimentary sequences associated with the Guerrero Composite Terrane (Centeno-García et al., 2008). Overlying these are Cretaceous to Paleogene ignimbrites and volcanic tuffs, forming part of the "Carmichael Volcanic Succession" (Rosas-Elguera et al., 2022). These units are widely exposed along the Sierra de Cacoma and Sierra de Manantlán. They are interpreted as remnants of a pre-TMV arc system developed before the opening of the Jalisco rifts.

The Neogene to Quaternary stratigraphy of Mascota consists of three principal units:

1. Pre-volcanic basement (Cretaceous granitoids and metamorphic rocks).
2. Ignimbritic and rhyolitic sequences of late Cretaceous to Oligocene age are locally preserved in the highlands east of Mascota.
3. Plio-Quaternary volcanic deposits, mainly basaltic andesites, andesites, and lamprophyric flows that define the Central Jalisco Volcanic Lineament (CJVL) (Wallace and Carmichael, 1989; Bandy et al., 2001).

The CJVL extends from the Ayutla volcanic field in the southeast through Atenguillo and Los Volcanes toward Mascota and San Sebastián del Oeste (Fig. 1) in the northwest (Lange and Carmichael, 1990; Bandy et al., 2001). It parallels the structural trend of the TZR and coincides with a chain of small monogenetic cones and lava flows of Pliocene to Quaternary age. Volcanism along the lineament migrated northwestward over time, from ~3 million years ago (Ma) near Ayutla to ~0.6 Ma in Mascota, as indicated by K–Ar ages (Bandy et al., 2001).

The Mascota Volcanic Field (MVF) itself covers approximately 2,000 km² and comprises more than 100 monogenetic cones, lava flows, and maars (Ownby et al., 2008). The cones are typically aligned along NW–SE faults, reflecting tectonic control on vent distribution. The dominant volcanic rocks are basaltic andesites and andesites, although highly potassic minettes, absarokites, and basic hornblende lamprophyres are also present (Lange and Carmichael, 1991; Carmichael et al., 1996). These potassic lavas occur in proximity to calc-alkaline flows, suggesting contemporaneous activity from compositionally distinct magma sources.

Petrographic and geochemical data indicate that potassic lavas originated from small degrees of partial melting in a phlogopite-bearing mantle wedge, whereas calc-alkaline magmas underwent fractional crystallization and crustal assimilation at shallow crustal levels (Righter and Rosas-Elguera, 2001; Ownby et al., 2008). The coexistence of these two magmatic series within the same tectonic setting implies a dynamic mantle beneath Mascota, influenced by both subduction-derived fluids and lithospheric extension.

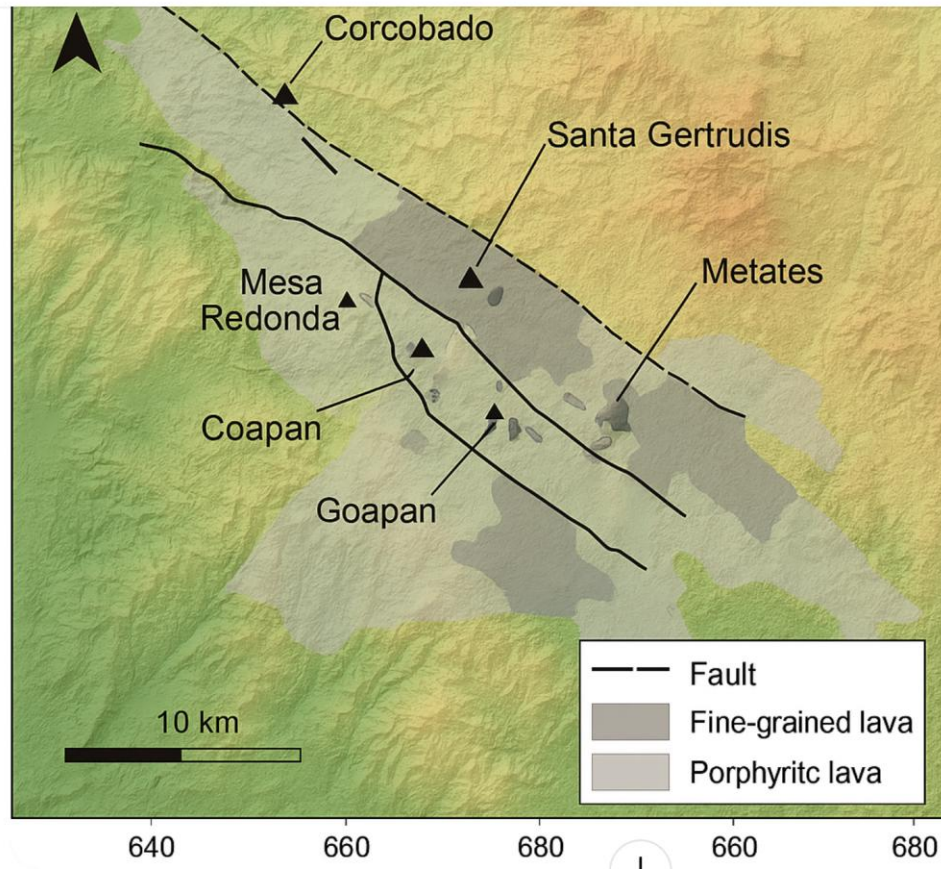


Fig. 3. Simplified geological and structural map of the Mascota region showing the margin of the Mascota-Talpa graben (faults shown in black lines), volcanic cones (triangular symbols), and the Central Jalisco Volcanic Lineament (CJVL).

Table 1: Summary of radiometric ages for volcanic units along the CJVL (after Bandy et al., 2001; Ownby et al., 2008).

Volcanic Field / Locality	Sample ID	Method	Age (Ma, $\pm 1\sigma$)	Reference
Ayutla (SE CJVL)	B95-4	K–Ar	2.94 $\pm$ 0.06	Bandy et al. (2001)
Atenguillo (central CJVL)	B95-1	K–Ar	1.93 $\pm$ 0.10	Bandy et al. (2001)
Atenguillo (central CJVL)	B95-2	K–Ar	1.77 $\pm$ 0.12	Bandy et al. (2001)
Mascota (NW CJVL)	MAS-5	K–Ar	0.166 $\pm$ 0.038	Bandy et al. (2001)
Mascota (NW CJVL)	MAS-409	$^{40}\text{Ar}/^{39}\text{Ar}$	1.935 $\pm$ 0.012	Ownby et al. (2008)
Mascota (NW CJVL)	MAS-1a	$^{40}\text{Ar}/^{39}\text{Ar}$	0.163 $\pm$ 0.013	Ownby et al. (2008)
Mascota (NW CJVL)	MAS-48 (Absarokite)	$^{40}\text{Ar}/^{39}\text{Ar}$	0.799 $\pm$ 0.007	Ownby et al. (2008)
Mascota (NW CJVL)	MAS-32 (Phlogopite separate)	 $^{39}\text{Ar}/^{39}\text{Ar}$	imprecise (< 1 Ma, argon loss)	Ownby et al. (2008)

These ages reveal a progressive temporal sequence from the southeast (Ayutla) to the northwest (Mascota), with dates decreasing from approximately 3 million years ago (Ma) to less than 0.2 million years ago (Ma). This trend supports the model of northwestward migration of volcanism within the Jalisco Block, associated with an extensional regime linked to the progressive increase in the obliquity of the Rivera Plate subduction. The temporal pattern reveals a systematic decrease in age from southeast to northwest, ranging from 2.9 Ma in Ayutla to 0.16 Ma in Mascota, supporting the hypothesis of a northwestward migration of volcanism within the Jalisco Block, associated with crustal extension and reactivation of inherited structures.

3. Aeromagnetic Setting

3.1 Data and methods

In this study, we present the results of our analysis of the aeromagnetic data obtained from the Mascota region. The aeromagnetic data were acquired through aerial surveys conducted by the Natural Resources Council, now the Mexican Geological Survey (SGM in Spanish), in 1983 as part of a research program aimed at determining geological and structural conditions, primarily for selecting prospective mining areas. All surveys and data reductions were conducted by the above institution using a BN2-B27 Islander aircraft, with flight lines spaced at 1,000-meter intervals in a NE-SW direction, and an average altitude of 300 meters

above ground level. The data were obtained from a Geometrics G-803 magnetometer with a sensitivity of 0.25 nT, a Geometrics G-704 data acquisition system, a base station magnetometer (Geometrics G-826A) with a sensitivity of 1 nT, and a Sperry radar altimeter. Digital compilation was performed with aircraft motion correction (magnetic compensation), diurnal variation correction, and subtraction of the International Geomagnetic Reference Field (IGRF 1980).

We used the trademark Oasis Montaj 9.4 software to obtain anomaly maps of the Residual Magnetic Field and Reduction to the Magnetic Pole (Baranov and Naudy, 1964). The values of magnetic intensity were 42,109 nT, and the inclination and declination for the study date were $47^{\circ}10'$ and $08^{\circ}51'$, respectively.

Basing the analysis on the Reduction to the Pole as a base, the Nabighian (1972), Henderson and Zietz (1949), and Henderson (1970) filters were applied, known as analytic signal, derivatives (first 1Dz and second 2Dz), and upward continuation, in that order.

Inversion of the data into 3D models was carried out using VOXI Earth Modeling, integrated within Oasis Montaj.

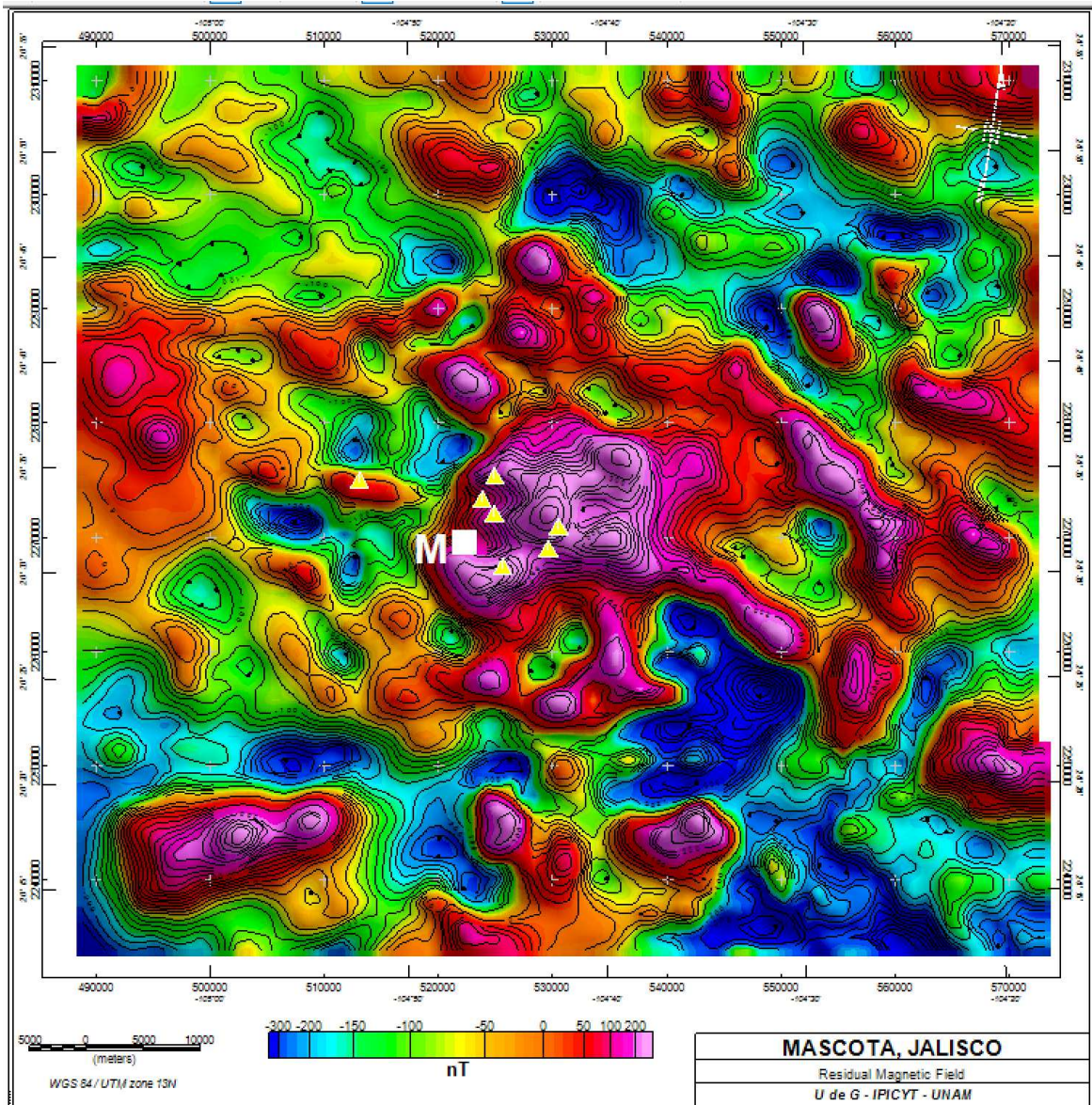


Fig. 4. Contour map of the Residual Magnetic Field and location of some of the main volcanic structures (yellow triangles) in the Mascota Volcanic Field. The white square marks the center of the town of Mascota.

The area surveyed by aeromagnetometry covers a surface of 6,630 km² (85 km E–W and 78 km N–S). The Residual Magnetic Field contour map displays a central zone associated with an amorphous, monopolar-type magnetic anomaly with general dimensions of 15 km (N–S) and 20 km (E–W). The anomaly exhibits maximum magnetic intensities on the order of 300 nT, and most of the volcanic structures are associated with it.

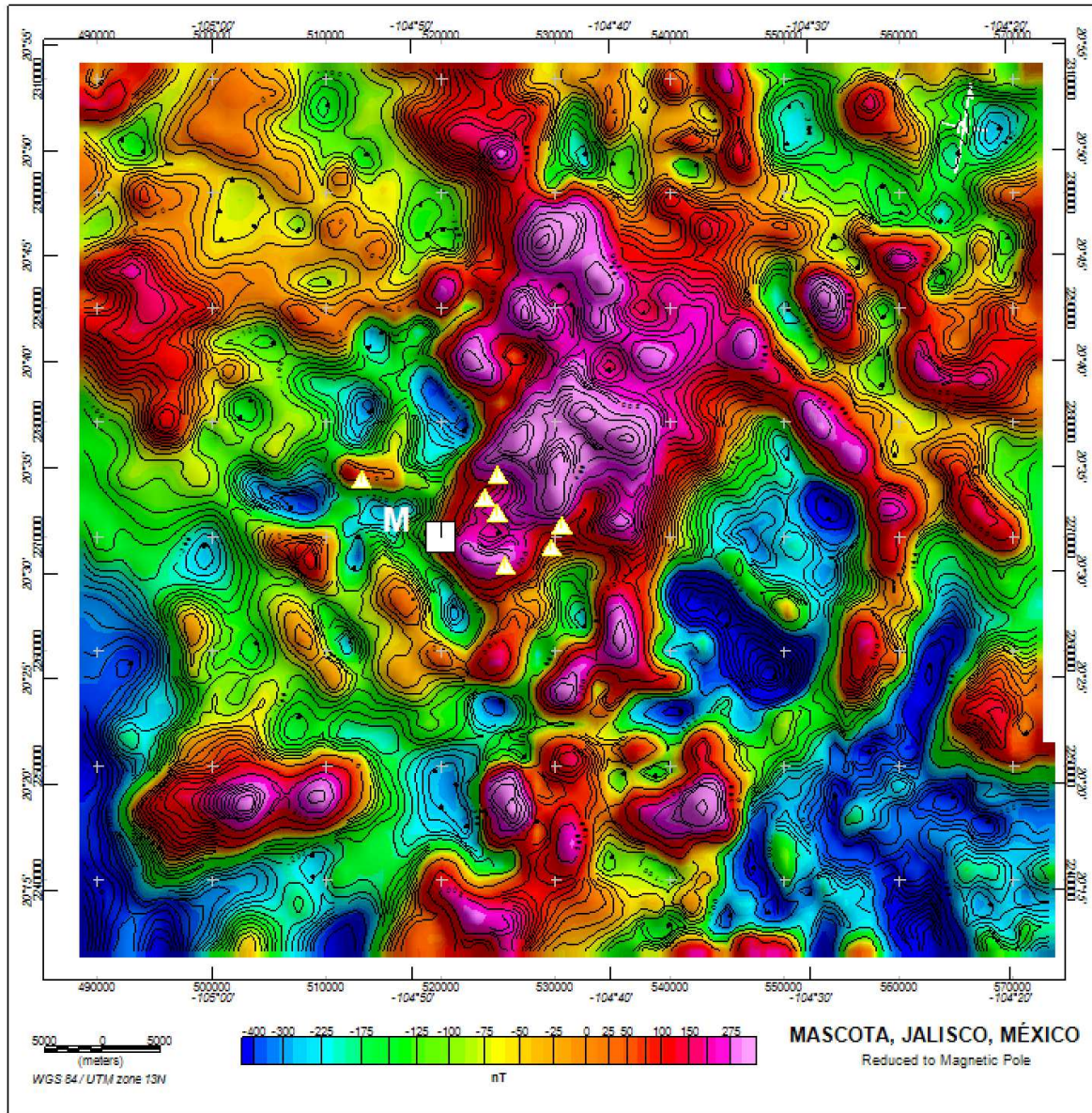


Fig. 5. Reduced-to-the-Pole Magnetic Field map. Symbols as in fig. 4.

The contour map of the Reduced-to-the-Pole Magnetic Field (RTP) shows a series of magnetic highs in the central, southern, and northern parts, associated with an elongated monopolar anomaly trending northeast, with dimensions of 34 km in that direction and 23 km along the northwest–southeast axis. In the central portion, the anomaly displays magnetic highs with intensities exceeding 400 nT. Most of the volcanoes are located to the south and southwest of these highs.

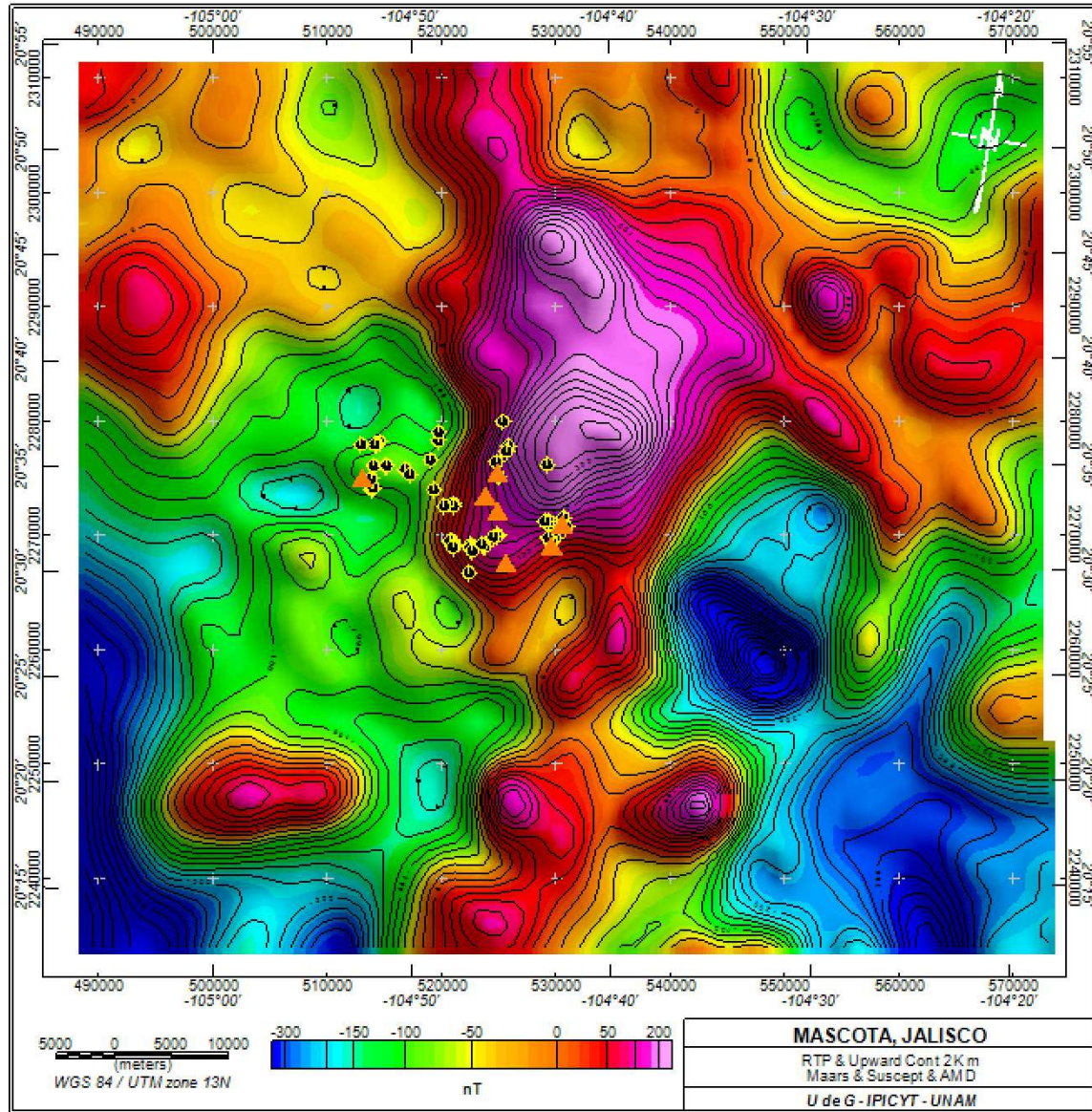


Fig. 6. Contour map of the Reduced-to-the-Pole Magnetic Field Upward Continued to 2 km. Circles (○) indicate sites where magnetic susceptibility measurements were made. Triangles mark the location of the nearby volcanoes.

The contour map of the RTP field upward continued to 2 km in the study area shows a primary amorphous anomaly elongated in the N–S direction, featuring two principal magnetic highs. The strongest one is in the central portion of the study area, with magnetization intensity values exceeding 300 nT. The volcanic structures are in the southwestern portion of the primary anomaly, within the gradient zone.

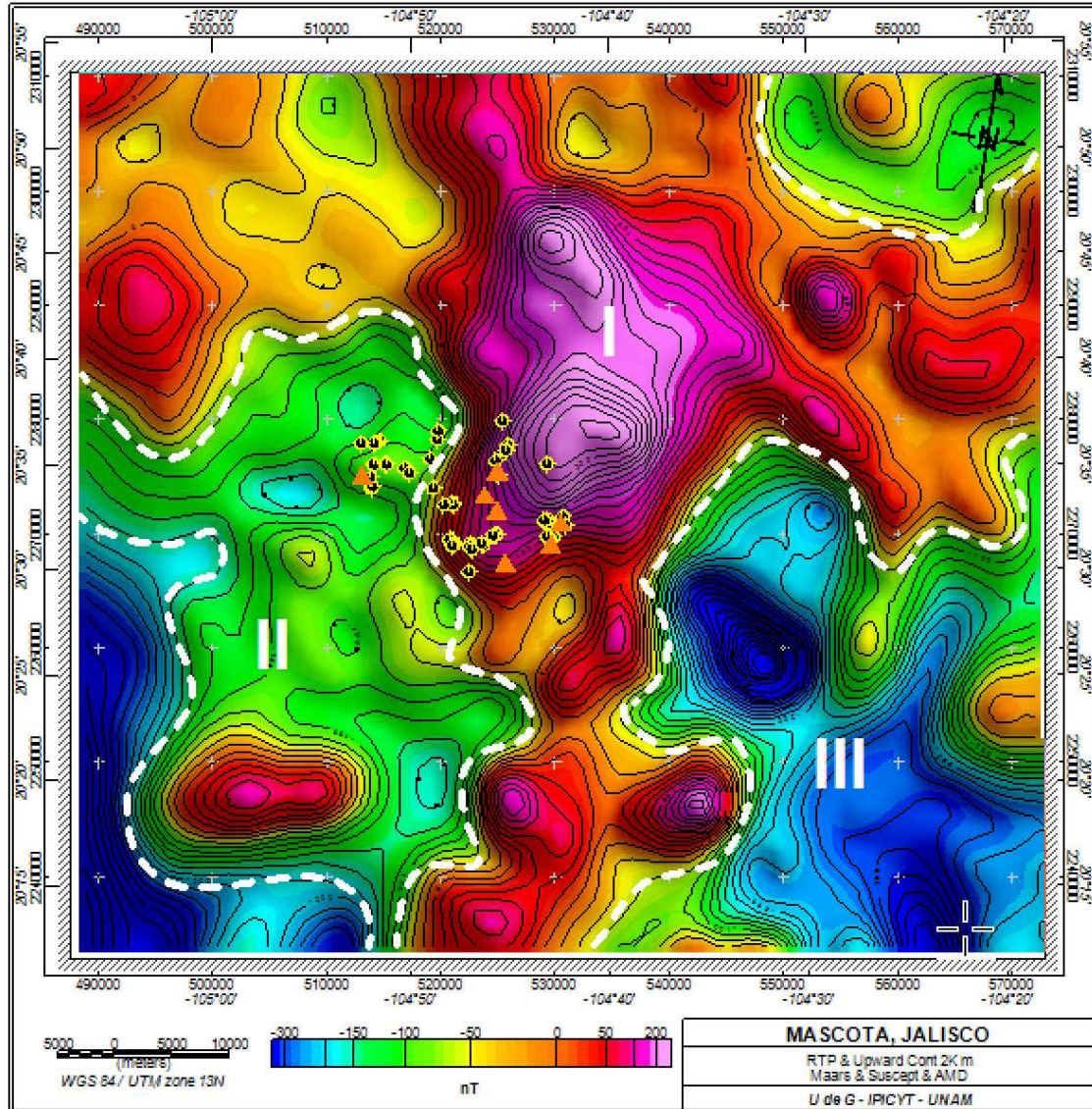


Fig. 7. Contour map of the RTP field, upward continued to 2 km, and Aeromagnetic Domains (DAMs I, II, and III). Symbols as in Figure 6.

Aero Magnetic Domains (AMD)

The contour map of the RTP_2 km upward continuation reveals the existence of three Aeromagnetic Domains (AMDs) characterized by their magnetic intensities, morphology, and geology.

AMD I

The first domain (AMD I) is situated in the central portion of the study area and has a T-shaped form. It displays magnetic intensity values ranging from -126 to 522 nT, with an average of 195 nT. Morphologically, it exhibits elevations ranging from 929 to $2,471$ m

above sea level, with an average elevation of 1,787 m above sea level. Geologically, it is interpreted as being associated with intrusive and basic volcanic rocks.

AMD II

The aeromagnetic domain II (AMD II) is located in the western portion of the study area, characterized by an elongated N–S shape and magnetization intensity values ranging from –245 to 104 nT, with an average of –112 nT. Topographically, it has elevations ranging from 1,109 to 2,014 m above sea level (asl) and is geologically associated with intermediate-composition rocks, specifically andesites.

AMD III

The AMD III lies in the southwestern and southeastern portions of the study area, separated by DAM I, and remains undefined in those directions. It is characterized by magnetic intensity values ranging from –1,346 to 13 nT, with an average of approximately –428 nT. Topographically, it shows elevations between 1,229 and 2,624 masl., with an average of 1,514 masl.

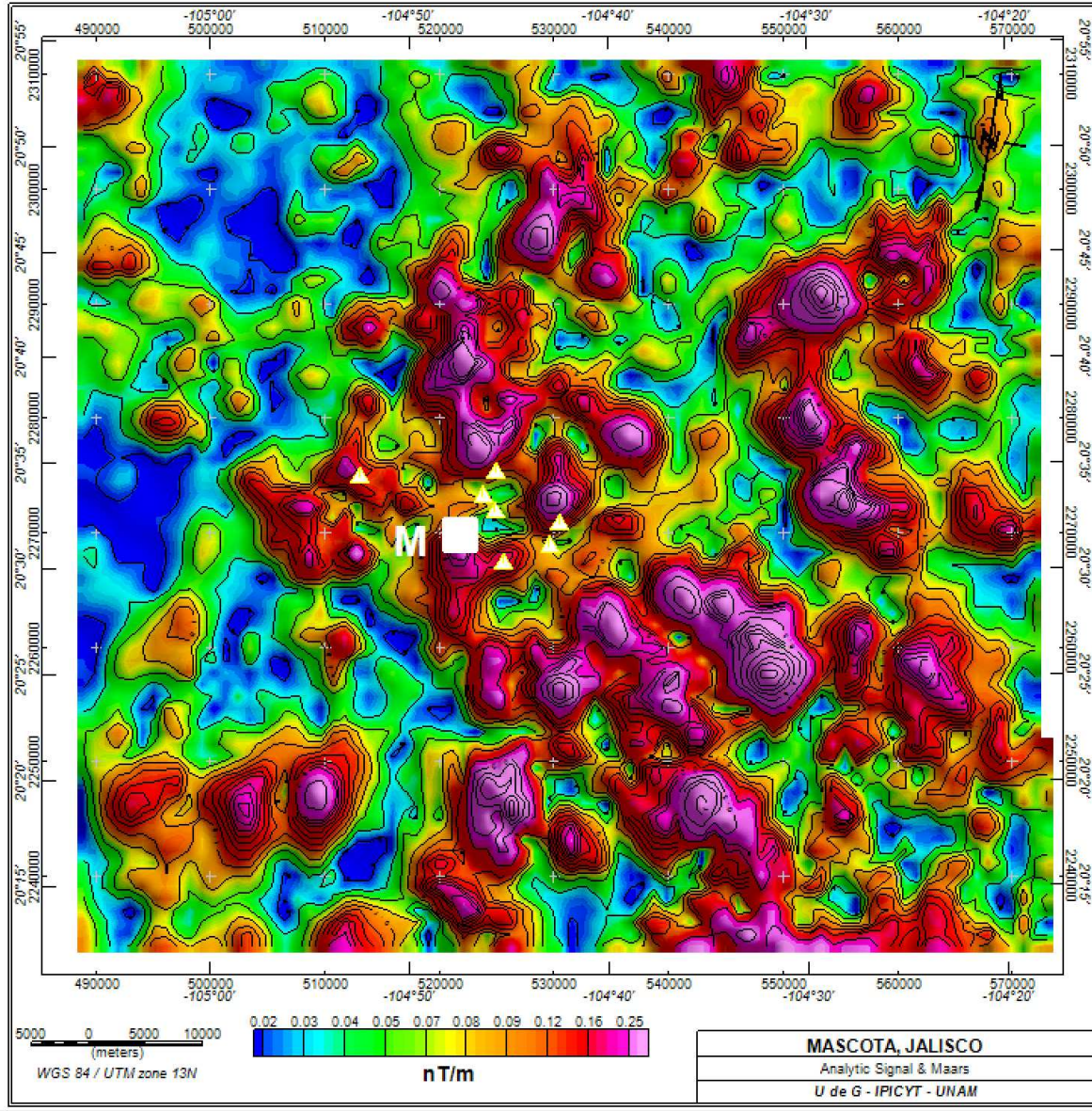


Fig. 8. Contour map of the Analytical Signal and location of nearby volcanic cones. Symbols as in the last figures.

The contour map of the Analytical Signal reveals, in most of the study-area, a pattern of magnetic highs resembling bulbous or "bowl-shaped" features, which are geologically associated with basaltic rocks. In contrast, magnetic lows characterize the northwestern portion. Only two of the maars—one located toward the south and the other toward the west—correlate directly with magnetic sources.

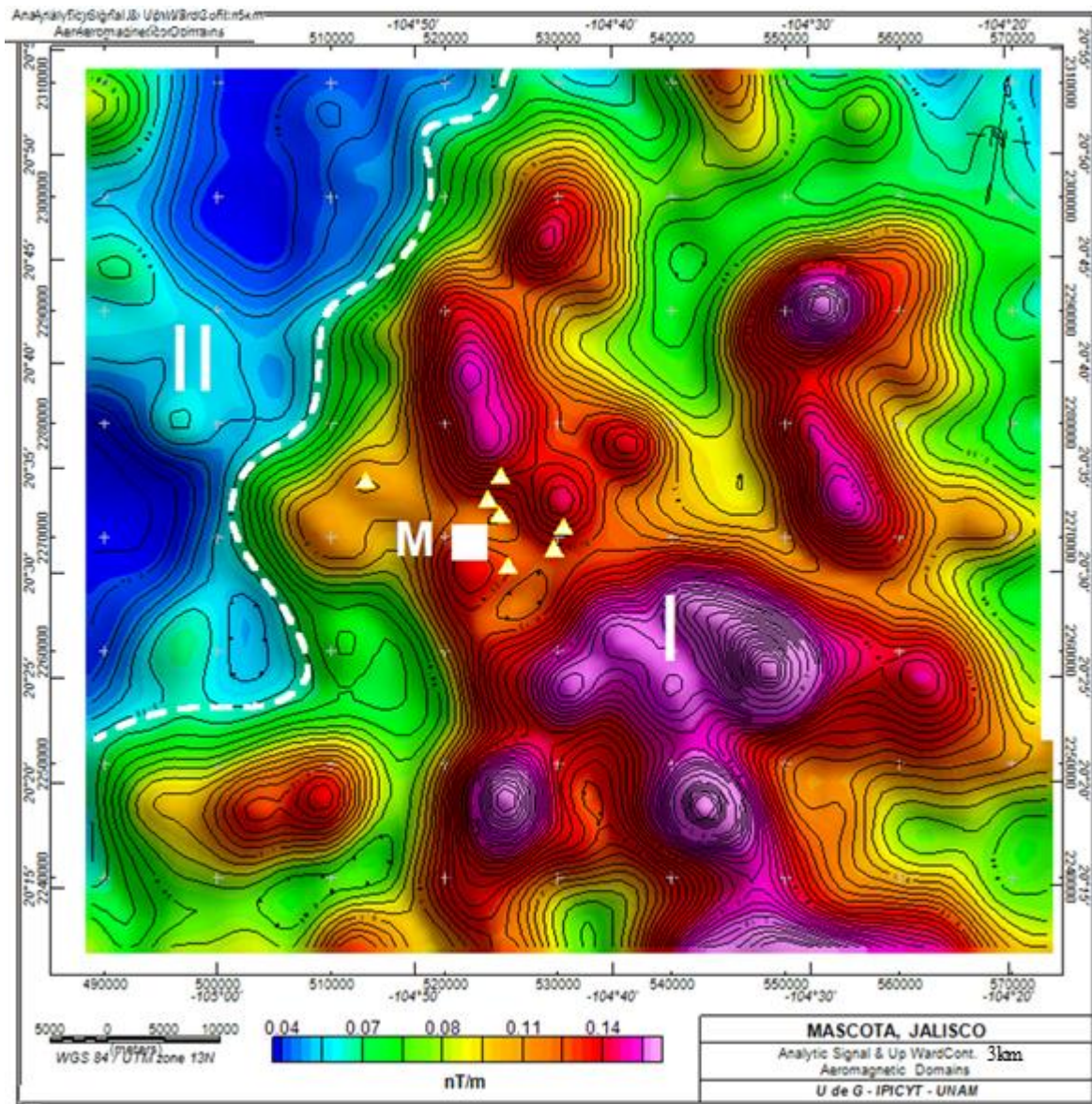


Fig. 9. Contour map of the Analytical Signal 3 upward continued. Two clearly contrasted Aeromagnetic Domains (I–II) can be observed. Symbols as in above figures.

The contour map of the Analytical Signal, continued upward 3 km, reveals two Aeromagnetic Domains (DAMs). The first (I) is characterized by magnetic high anomalies that correlate with magnetic sources, while the second (II) exhibits elongated magnetic low values trending NE–SW. Most of the maars are located south of one of the elongated magnetic sources oriented NNW–SSE.

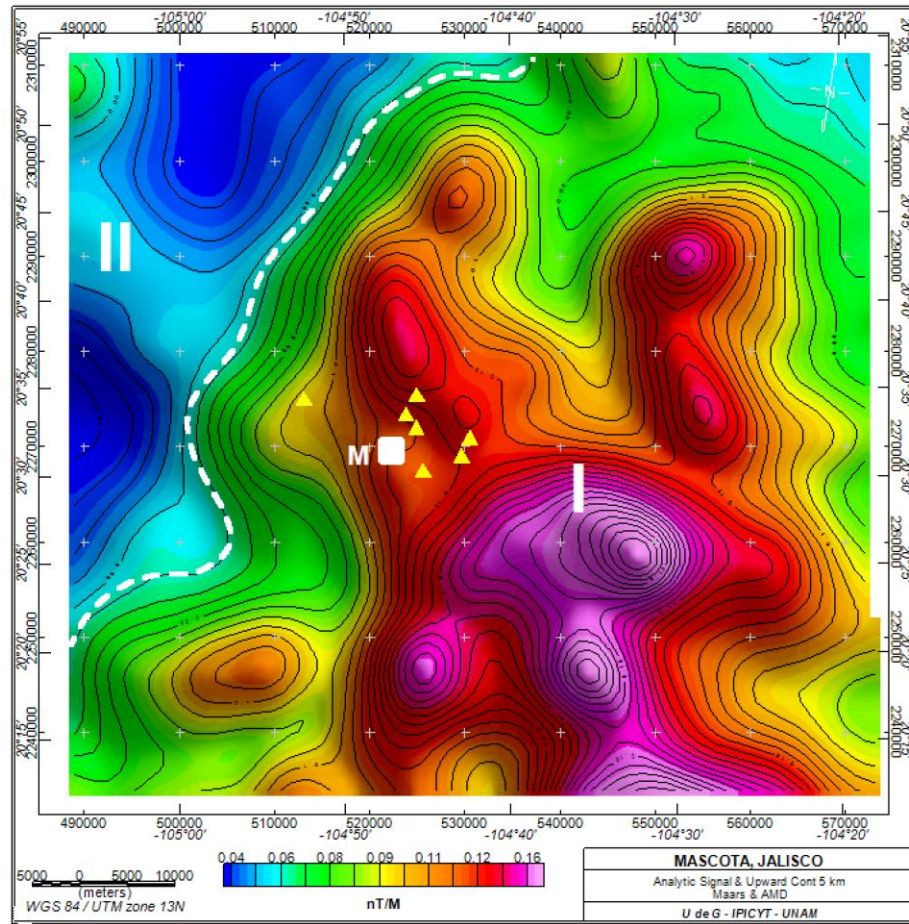


Fig. 10. The contour map of the Analytical Signal upward continued to 6 km. The Aeromagnetic Domains (DAMs) are clearly defined—one (I) associated with magnetic highs and the other (II) with magnetic lows. Symbols as in above figures.

The contour map of the Analytical Signal, 5 km upward continued, shows the location of the maar volcanic structures to the south of an elongated magnetic high and to the northwest of a large T-shaped magnetic anomaly, measuring approximately 30 km (E–W) by 27 km (N–S). At depth, the studied area is clearly defined into two geological units: a volcanic one (DAM I) and another volcano-sedimentary unit associated with magnetic lows.

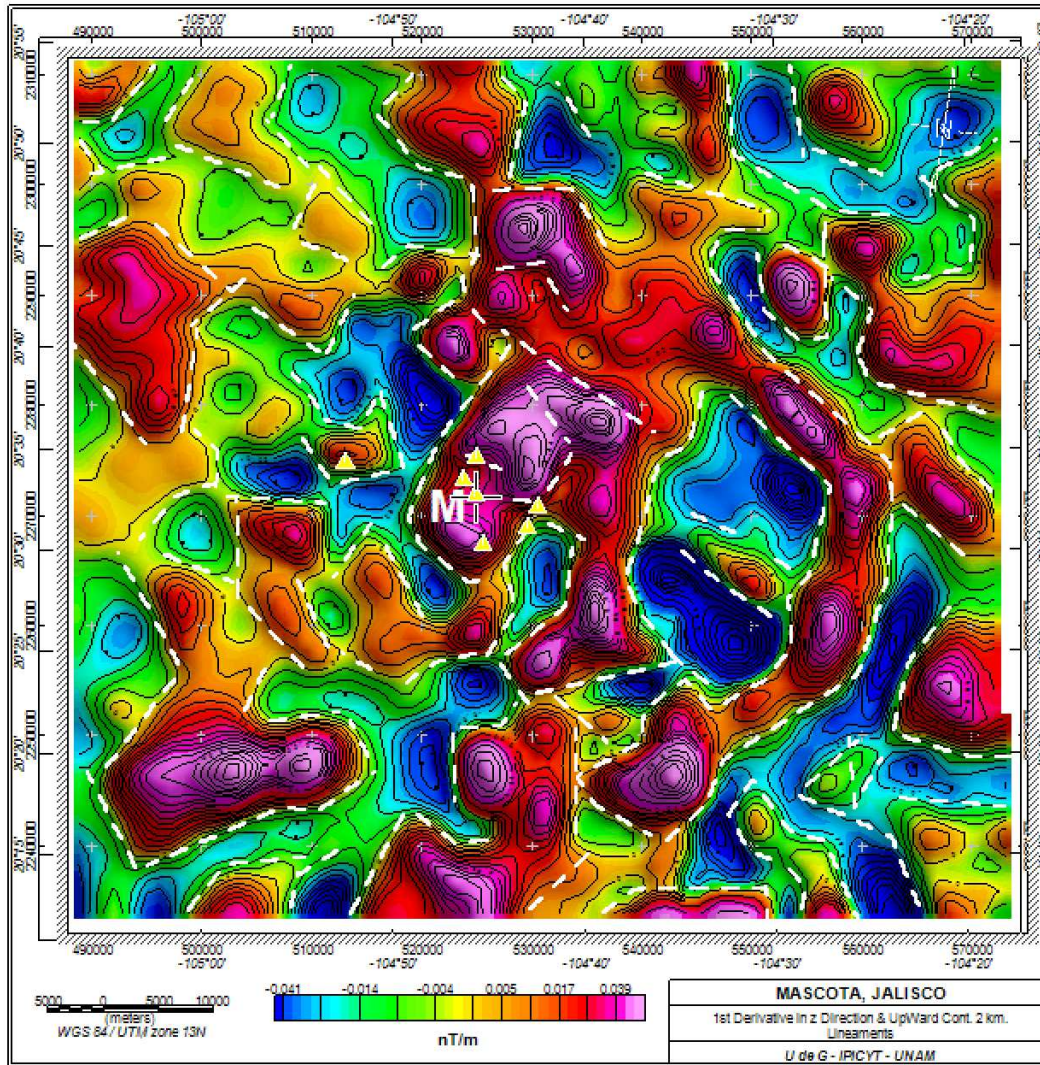


Fig. 11. The contour map of the First Vertical Derivative (1st Dz) and the Upward Continuation to 2 km, with lineaments, are shown. Symbols as in above figures.

The contour map of the 1st Dz and 2 km Upward Continuation reveals main lineaments trending NW–SE and NE–SW. A clear relationship can be observed between the volcanoes and these zones of structural weakness, as most of them are correlated with their presence.

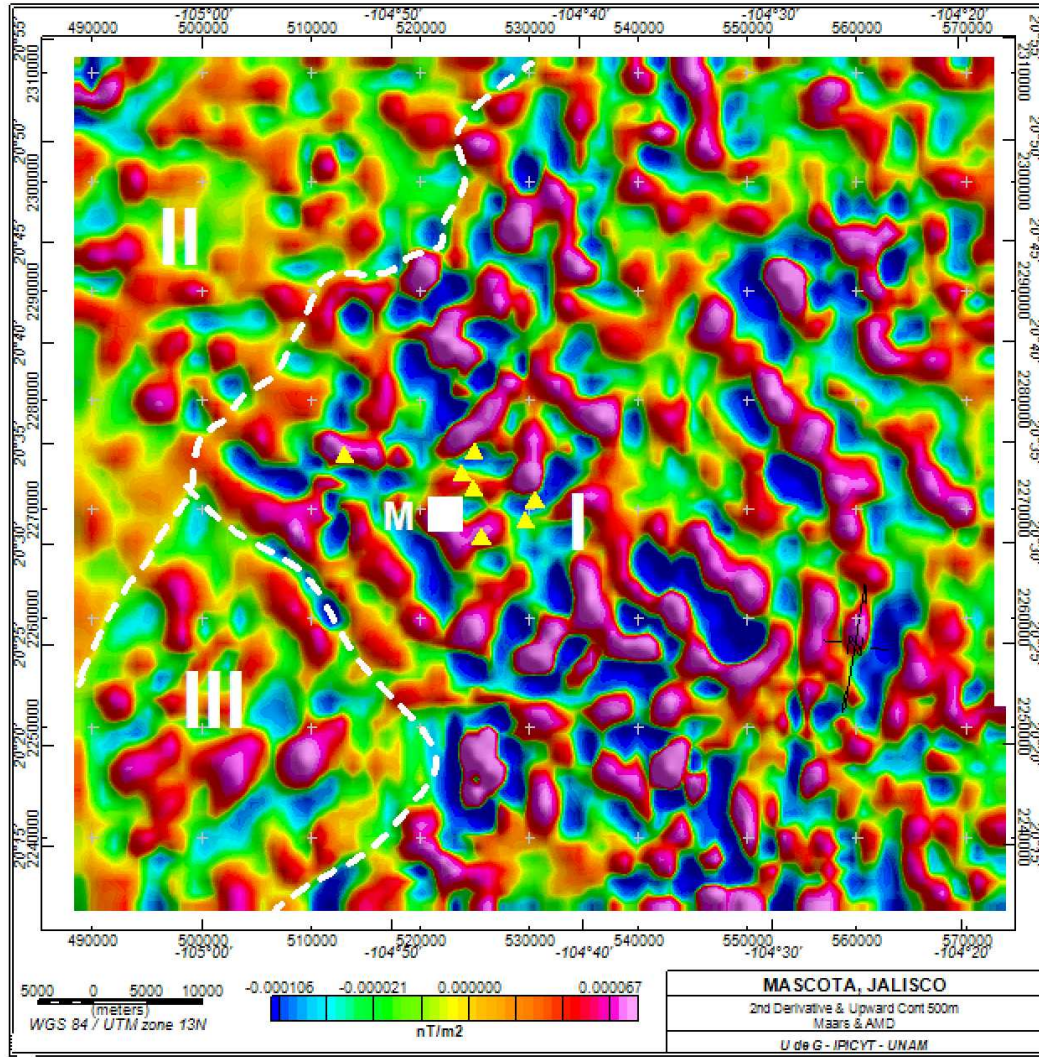


Fig. 12. The contour map of the Second Vertical Derivative (2nd Dz) Upward Continued to 500 m is shown. Three Aeromagnetic Domains (DAMs) are observed. Symbols as in above figures

The contour map of the 2nd Dz, 3 km upward, continued 500 m, shows three zones associated with contrasting magnetic susceptibilities, defining three Aeromagnetic Domains (AMDs). The first (I) covers most of the study area, extending from the central portion to the entire eastern sector, and correlates with volcanic rocks of basic composition. The second DAM is located in the northwestern part of the study area and correlates with volcano-sedimentary rocks. The third DAM is situated in the northeastern portion and is correlated with volcanic rocks of intermediate composition.

VOXI 3D MODELS

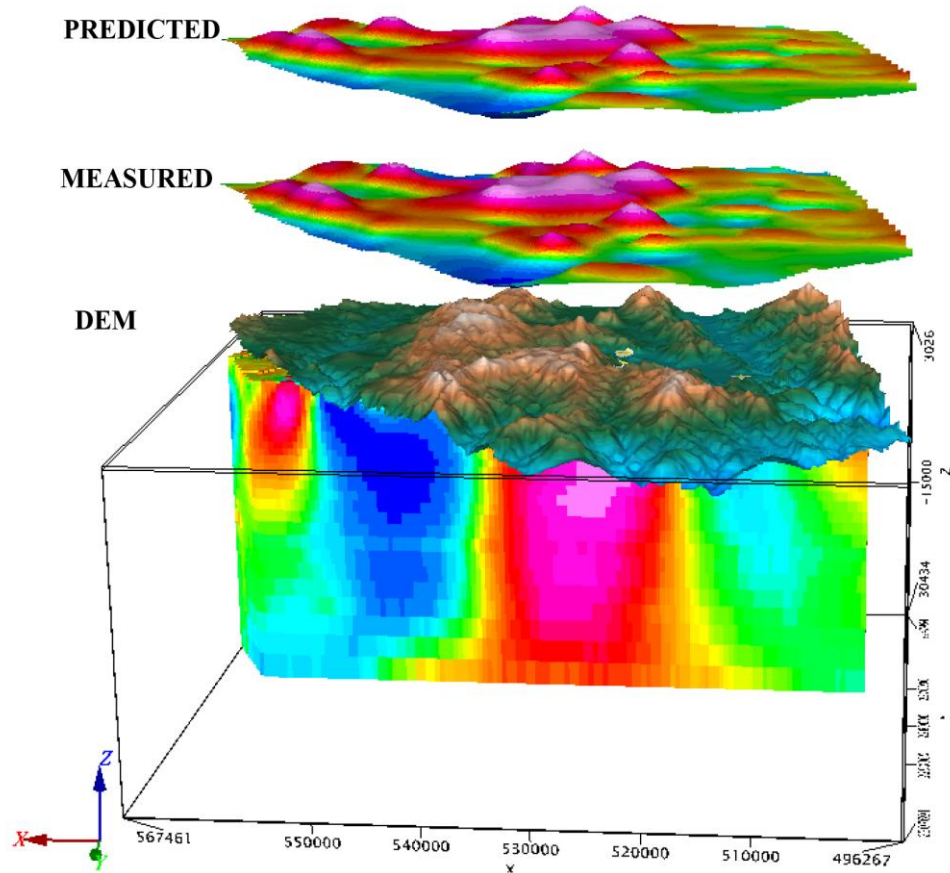


Fig. 13. Subsurface Residual Magnetic Field model. The contour maps of the Digital Elevation Model, theoretical and measured magnetic fields, are shown atop the model.

In the subsurface configuration of the Residual Magnetic Field (RMF), an elongated zone associated with high magnetic intensity values can be observed, extending to depth (Fig. 14). It is bounded to the east and west by elongated zones of low magnetic intensity that also extend downward.

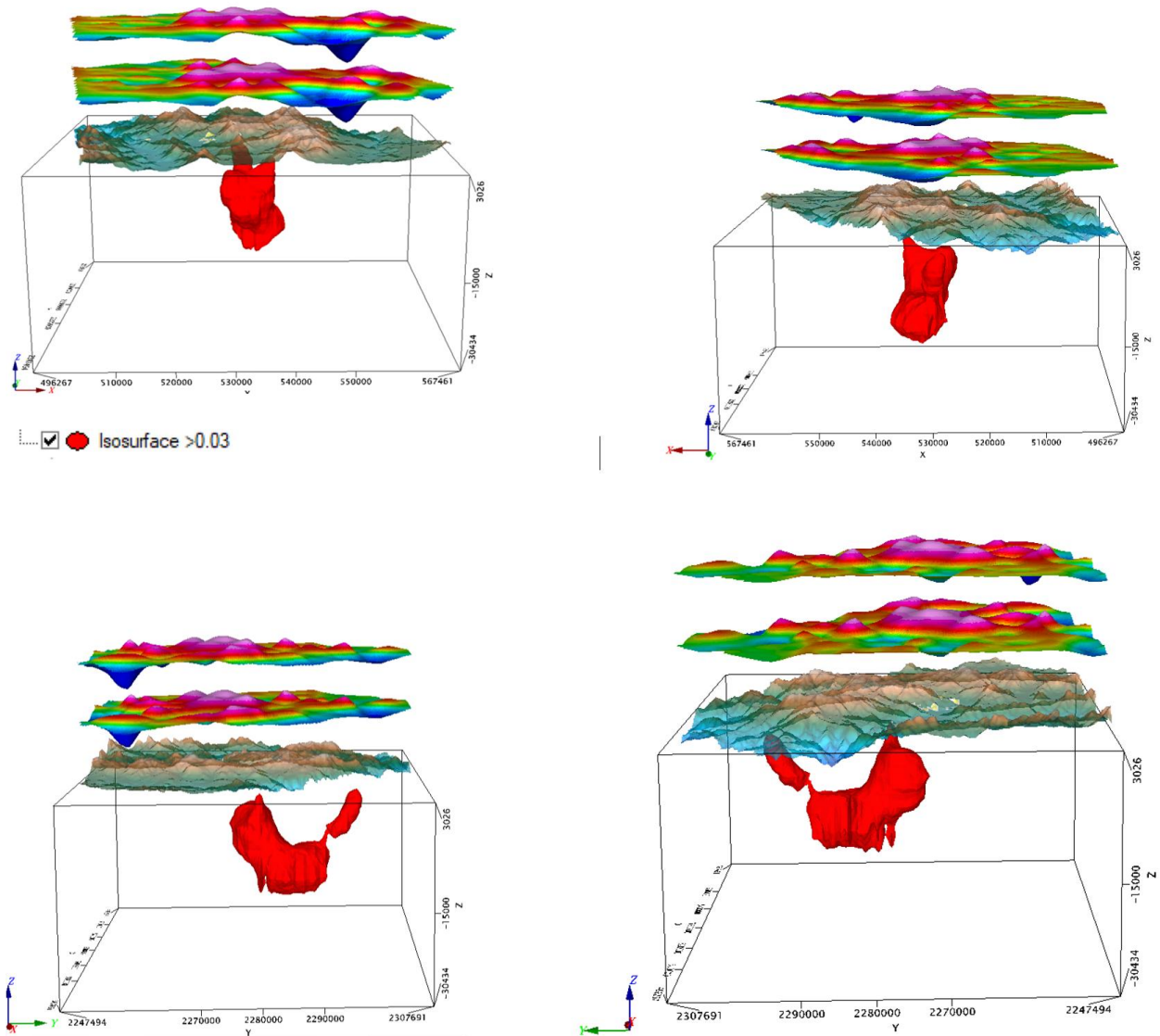


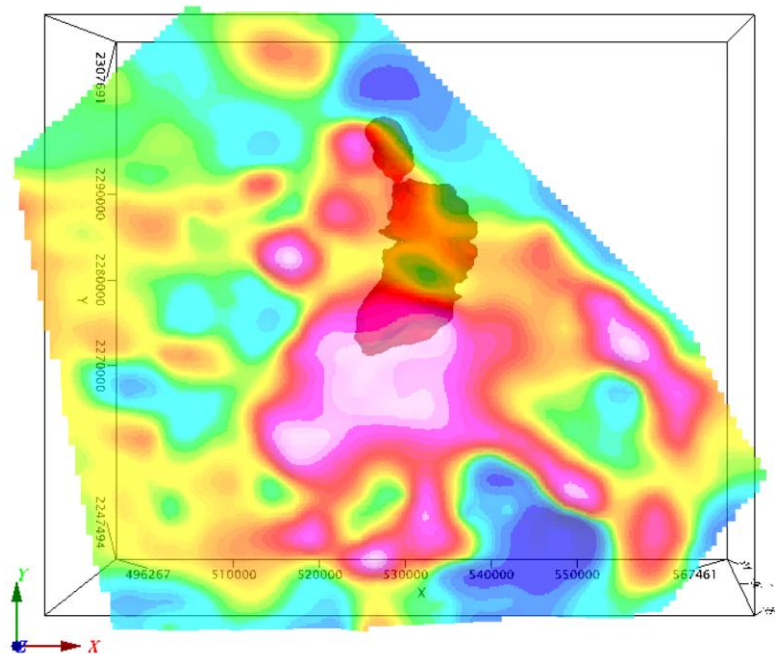
Fig. 14. Different views of the magnetic susceptibility isosurface $k = 0.03$ IS. The green vector points to the north. The contour map at the top corresponds to the theoretical magnetic field, the middle one depicts the measured field, and the lower the digital elevation model.

The isosurface of $k = 0.03$ is interpreted as the host rock of a solidified magma chamber. It covers an area of 918.7 km^2 and has a volume of $1,255,596 \text{ km}^3$. The body has an amorphous, elongated shape in a general N–S direction, with average dimensions of $X = 12.56 \text{ km}$, $Y = 38.3 \text{ km}$, and $Z = 19.5 \text{ km}$. In the east–west view, its shape resembles that of a Maltese dog, with an "ear" reaching depths of about 2.75 km below the surface, a "head" at 4.9 km , and a "body" extending from approximately 11.2 km down to 19.5 km .

Table 2. The characteristics of the modeled isosurface with a magnetic susceptibility of **0.03 IS**.

Name:	Isosurface >0.03		
Source file:	A_6_PROF_2024-01-25_11-25-38_Susc.geosoft_voxel		
Surface value:	>0.03		
Extents:	Min X:	526464.29	Max X: 539043.65
	Min Y:	2259400.8	Max Y: 2297710.3
	Min Z:	-19512.627	Max Z: 14.514286
Type:	Closed		
Area:	918695756.7 m ²		
Volume:	1255596871000 m ³ (± 3795.83)		
Vertices:	3690		
Triangles:	7380		

(A)



(B)

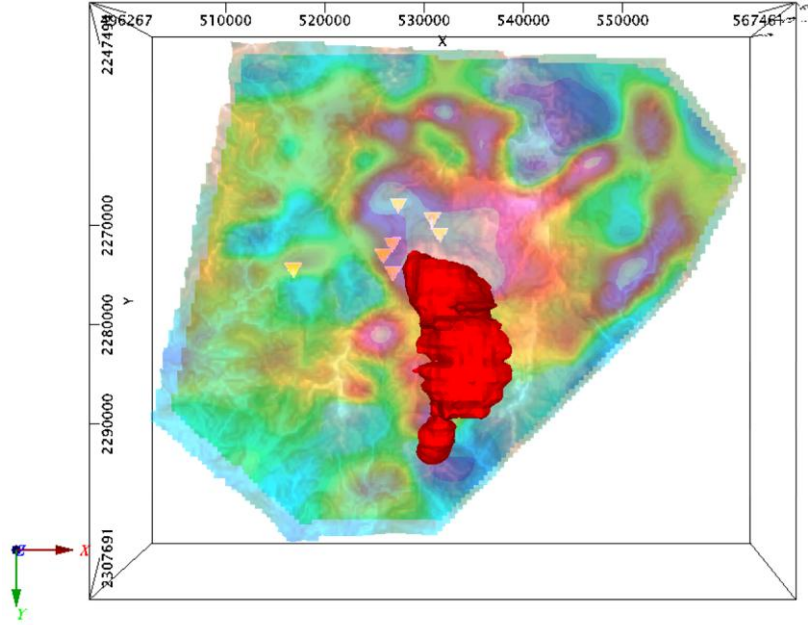


Fig. 15. (A) Top-down and (B) Bottom-up view of the VOXI 3D model of the magnetic susceptibility isosurface $k = 0.03$ SI, and contour map of the Residual Magnetic Field. Notice that the source body long axis is oriented N–S and lies in the northern gradient zone of the main magnetic anomaly.

5. Discussion

5.1 Structural Framework and Tectonic Evolution

The structural architecture of the Mascota region is characterized by a system of NW–SE normal and oblique faults that form the Mascota–Talpa graben (Bandy et al., 2001). This system reflects the transtensional stress regime produced by the northwestward escape of the Jalisco Block relative to North America (Rosas-Elguera et al., 1996). Faults bounding the graben display steep dips ($60\text{--}80^\circ$) and locally preserve slickensides and striations indicative of right-lateral components, consistent with dextral shear (Maillol et al., 1997).

Geological and geophysical data indicate that the Mascota graben represents the surface manifestation of deep crustal extension zones that evolved concurrently with volcanism. The association of volcanic vents with fault traces and fissures confirms structural control on magma ascent (Ownby et al., 2008). The overall geometry of the graben aligns with the Central Jalisco Volcanic Lineament (CJVL), which represents a first-order crustal discontinuity across the central Jalisco Block (Fig. 1).

Paleomagnetic data from Pliocene–Quaternary lavas show no significant block rotation since their emplacement (Maillol et al., 1997), indicating that the deformation has been accommodated by localized faulting rather than regional torsion. This structural behavior contrasts with that of the northern Tepic–Zacoalco Rift, where paleomagnetic rotations of up to 15–20° have been reported (Rosas-Elguera et al., 1996). The Mascota segment, therefore, behaves as a rigid crustal fragment internally segmented by transtensional fault systems.

The kinematic evolution of the Mascota graben is intricately linked to the late Neogene tectonic reorganization of western Mexico. Between 5 and 3 million Years Ago, rifting, and volcanic activity intensified along the TZR, coinciding with the onset of large rhyolitic eruptions and the detachment of the Jalisco Block (Ferrari et al., 2001). By the late Pliocene, deformation propagated southward, reactivating inherited NW–SE crustal fractures and creating a chain of small grabens including Atenguillo, Los Volcanes, and Mascota (Bandy et al., 2001). K–Ar ages show a progressive younging of volcanism toward the northwest, suggesting that extension and magmatism migrated simultaneously (Bandy et al., 2001).

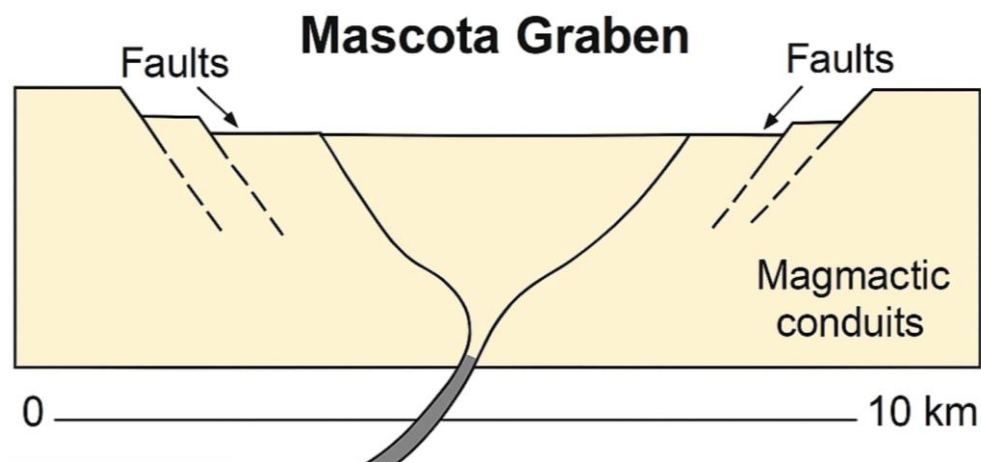


Fig. 16. Structural cross-section through the Mascota graben showing fault geometry, volcanic vents, and inferred magma ascent pathways.

5.2 Magmatic Evolution

The Mascota Volcanic Field exhibits one of the most striking examples of bimodal volcanism within the western TMVB. Lamprophyric and calc-alkaline lavas occur contemporaneously and often within a few kilometers of each other (Lange and Carmichael, 1991; Carmichael et al., 1996; Ownby et al., 2008). This coexistence implies distinct magma sources and evolutionary paths.

Potassic magmas, including minettes, absarokites, and basic hornblende lamprophyres, are characterized by high K₂O (2–6 wt.%), high Mg# (0.80–0.90), and elevated contents of incompatible elements such as Ba, Sr, and LREE (Lange and Carmichael, 1991; Carmichael et al., 1996). These geochemical traits suggest it is derived from a phlogopite-bearing,

metasomatized mantle wedge influenced by subduction fluids (Richter and Rosas-Elguera, 2001). The limited differentiation trend of these lavas—ending near 55 wt.% SiO₂—indicates rapid ascent through a relatively cool and rigid lithosphere with minimal crustal interaction (Ownby et al., 2008).

Calc-alkaline lavas, in contrast, comprise basaltic andesites and andesites with 53–63 wt.% SiO₂. They exhibit lower K₂O and Mg# values and follow continuous differentiation trends typical of subduction-related magmas. Petrologic models (Carmichael et al., 1996) attribute their evolution to fractional crystallization of olivine, augite, and plagioclase within shallow magma reservoirs (~5–10 km depth), possibly beneath the Mascota graben. Andesites are volumetrically dominant and represent the main eruptive phase of the field (Ownby et al., 2008).

The juxtaposition of these two series suggests a dual-source magmatic system, where mantle-derived potassic melts ascended through deep fractures while calc-alkaline magmas evolved in crustal chambers. Both series were likely triggered by the same regional extensional stresses that facilitated decompression melting and fault-controlled magma ascent (Lange and Carmichael, 1990; Richter and Rosas-Elguera, 2001).

Chronologically, eruptive activity at Mascota occurred between 1.0 and 0.5 million years ago (Ma), corresponding to the youngest volcanic phase of the CJVL (Bandy et al., 2001). Several lava-flows within the field exhibit reversed magnetic polarity, recording emplacement during the Matuyama Chron (>0.78 Ma) (Maillol et al., 1997). These data indicate that volcanism initiated at the transition between Matuyama and Brunhes epochs, contemporaneous with late Quaternary tectonic activity along the graben.

Table 3. Representative geochemical classification of the Mascota Volcanic Field lavas, compiled from Lange & Carmichael (1991), Carmichael et al. (1996), and Ownby et al. (2008). The data summarizes compositional variations between calc-alkaline and potassic lamprophyric series developed within the Central Jalisco Volcanic Lineament (CJVL)

Lava Type	SiO ₂ (wt%)	K ₂ O (wt%)	Mg#	Dominant Phenocrysts	Distinctive Characteristics
Basaltic andesite	53–58	1–2	0.55–0.70	Olivine, augite, minor plagioclase	Calc-alkaline, hypersthene-normative, relatively oxidized, H ₂ O-rich; orogenic affinity
Andesite	58–63	1–2.5	0.55–0.65	Plagioclase, clinopyroxene, hornblende	Transition toward more evolved magmas; main eruptive phase
Minette	48–53	4–6	0.8–0.9	Phlogopite, olivine, augite (no plagioclase)	Potassic lamprophyre; highly oxidized (Fe ³⁺ /Fe ^T ≈ 0.8); derived from phlogopite-bearing mantle source
Absarokite	48–52	2–4	0.8–0.9	Olivine, augite (no phlogopite or plagioclase)	Transitional between minette and basaltic andesite; Mg- and Ba-rich; partial melting of metasomatized peridotite
Hornblende lamprophyre (kersantite)	52–56	≤3.8	0.7–0.8	Hornblende, olivine, augite (no plagioclase)	Basic lamprophyre; intermediate between calc-alkaline and potassic compositions

5.3 Aeromagnetic Characterization and Crustal Interpretation

Aeromagnetic data across the Jalisco Block reveal a complex magnetic fabric reflecting its composite crustal architecture (López-Loera et al., 2022). In the Mascota region, the Residual Magnetic Field displays alternating high and low anomalies with amplitudes between ±400 nT, following a predominant NW–SE trend parallel to the CJVL. High magnetic amplitudes correlate with exposed Cretaceous intrusive rocks such as the Puerto Vallarta batholith, while low anomalies correspond to volcanic basins and fault-bounded depressions (López-Loera et al., 2022).

Inversion modeling of magnetic data using VOXI algorithms (Ellis et al., 2012) delineates low-susceptibility zones ($k < 0.001$ IS) beneath the Mascota graben, extending to depths of 15–20 km. These volumes represent thermally perturbed crustal domains or magma-depleted regions within the upper mantle. Conversely, moderate to high susceptibilities ($k = 0.01$ – 0.03 IS) are associated with shallow intrusive bodies aligned along NW–SE faults, which may be feeders for Quaternary lavas.

Regional magnetic domains correspond to contrasting basement terranes: (1) a southern granitic domain related to the Cretaceous Puerto Vallarta Batholith, and (2) a northern, low-magnetization volcanic–sedimentary domain correlated with the Guerrero Terrane (Rosas-Elguera et al., 2022; López-Loera et al., 2022). The magnetic discontinuity between these domains coincides with the CJVL interpreted as a lithospheric-scale shear zone or a reactivated back-arc trough.

Depth-to-Curie-point analyses reveal that the Curie isotherm is located at 10–12 km beneath volcanic centers and extends to 20 km in non-volcanic sectors, indicating a significant thermal anomaly below the MVF (López-Loera et al., 2022). Such shallow magnetic crust suggests partial melting or elevated geothermal gradients consistent with late Quaternary magmatism.

These geophysical observations reinforce geological evidence of transtensional deformation and crustal thinning. Thus, the Mascota graben represents a zone of lithospheric weakness that has repeatedly directed the magma ascent since the Pleistocene. The integration of magnetic inversion results with field mapping provides a coherent picture: the MVF overlies a crustal corridor of low magnetization that channels magmatism along inherited NW–SE faults, linking tectonic and magmatic processes within the Jalisco Block.

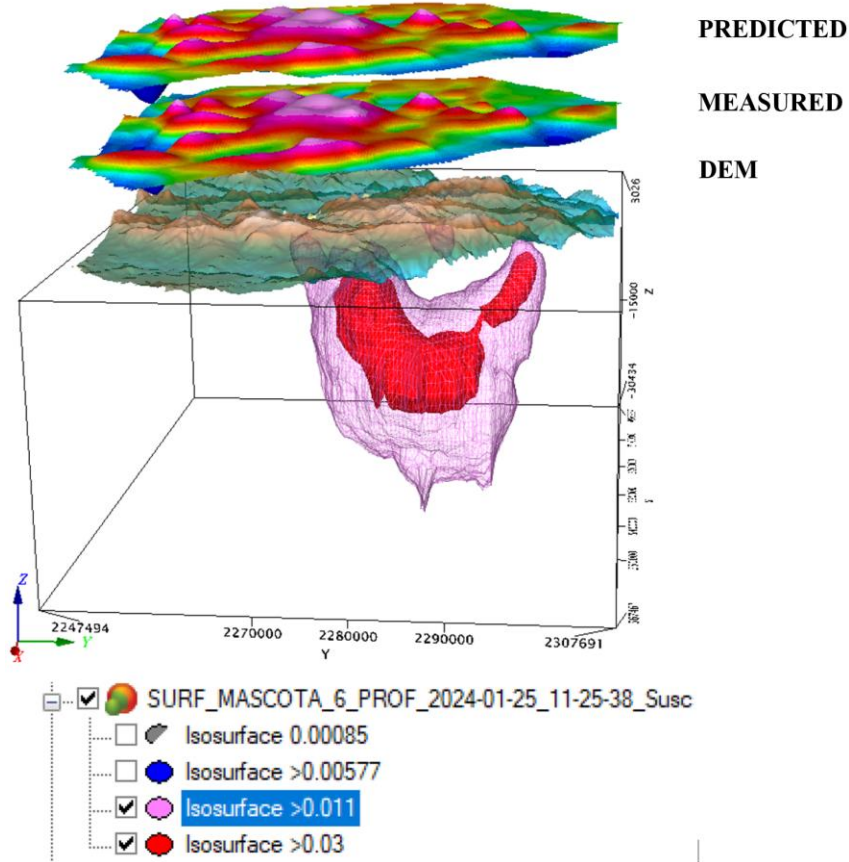


Fig. 17. VOXI model showing two isosurfaces (in red and pink) associated with a solidified magma chamber and its host body, respectively. The upper map represents the theoretical magnetic field, the middle one corresponds to the measured magnetic field, and the lower map shows the digital elevation model. The magnetic susceptibilities used for the two isosurfaces conforming the model are shown at the bottom.

1. Conclusions

The Mascota Volcanic Field represents one of the youngest and most compositionally diverse volcanic provinces within the western Trans-Mexican Volcanic Belt. Its geological evolution illustrates the dynamic interaction between transtensional tectonics, mantle metasomatism, and crustal processes associated with the ongoing subduction of the Rivera Plate.

The following conclusions summarize the key findings:

1. Structural framework:

The Mascota–Talpa graben is a NW-SE-trending extensional structure bounded by normal to oblique faults showing dextral components, indicating transtensional deformation within the Jalisco Block. The graben aligns with the Central Jalisco Volcanic Lineament (CJVL), a lithospheric-scale shear zone reactivated since the late Pliocene (Bandy et al., 2001; Rosas-Elguera et al., 1996).

2. **Chronology and migration of volcanism:**

K–Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dating demonstrates a northwestward trend of younger volcanism along the CJVL — from ~3 Ma in Ayutla to 0.5–0.6 Ma in Mascota (Bandy et al., 2001; Ownby et al., 2008). This progression reflects migration of crustal extension and mantle melting toward the northwest as the Jalisco Block continued its displacement.

3. **Magmatic diversity:**

The coexistence of lamprophyric (minettes, absarokites) and calc-alkaline (basaltic andesites, andesites) magma within the same field implies two distinct magma sources. Potassic melts originate from the partial melting of a phlogopite-bearing metasomatized mantle, whereas calc-alkaline magmas evolve through fractional crystallization in shallow reservoirs (Lange and Carmichael, 1991; Carmichael et al., 1996; Righter and Rosas-Elguera, 2001).

4. **Tectonomagmatic coupling:**

Magmatism was structurally controlled by the graben faults, which served as conduits for the ascent of magma. The combination of oblique extension and lithospheric thinning facilitated decompression melting, promoting the eruption of both lamprophyric and andesitic magmas.

5. **Aeromagnetic and crustal structure:**

Aeromagnetic inversion modeling reveals low-susceptibility zones ($k < 0.001$ SI) extending to depths of 15–20 km beneath the Mascota graben, coincident with zones of crustal thinning and elevated heat flow (López-Loera et al., 2022). These anomalies correspond to ancient back-arc structures reactivated during Pliocene–Quaternary extension. The Curie-isotherm depth (~10–12 km) beneath Mascota indicates anomalously warm crust compatible with magmatic intrusions.

6. **Geodynamic implications:**

The Mascota system provides compelling evidence of the continuing interplay between subduction, transtension, and localized rifting in the Jalisco Block. It demonstrates that extension within continental arcs can generate hybrid magmatic systems, where subduction-related and intraplate signatures coexist within the same crustal volume.

Overall, the integrated geological, geochronological, and aeromagnetic data portray the Mascota Volcanic Field as a key locality for understanding crustal deformation and mantle processes in western Mexico. Its evolution records the transition from a compressional to a transtensional regime during the late Neogene, illustrating how structural inheritance governs magma ascent in continental margins undergoing fragmentation.

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