Geochronological and paleomagnetic constraints on evolution of Palaeozoic plutonic basement and Miocene-Pleistocene volcanic succession of the Las Minas mining area (E-part of the Trans-Mexican Volcanic Belt)

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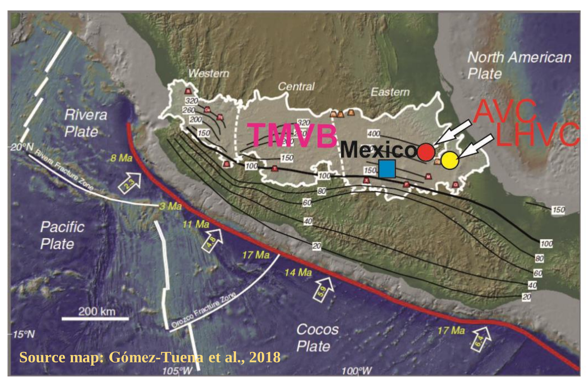
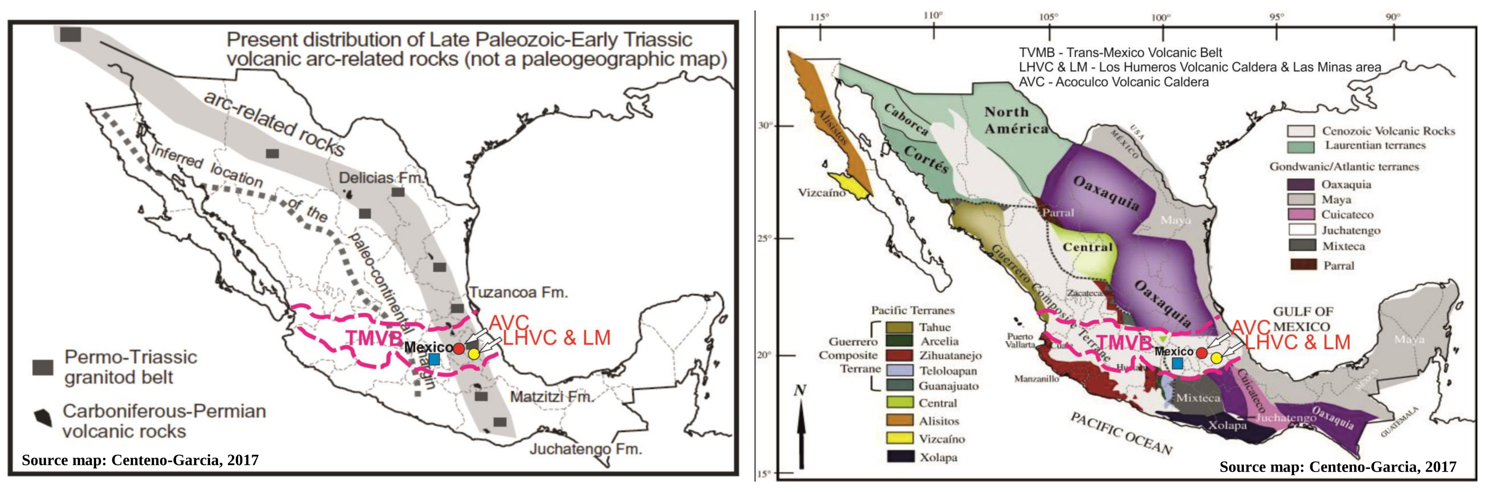
REGIONAL GEOLOGICAL SETTING

The Los Humeros volcanic caldera (LHVC) and Acoculco volcanic caldera (AVC) represent super-hot geothermal fields located in the eastern part of the latitudinal Trans-Mexican Volcanic Belt (TMVB) active from Neogene to recent times, due to ongoing subduction of the Cocos plate under North Amercan Plate.



Exhumed analogs of the oldest, “pre-caldera” part of the Los Humeros volcanic succession and basement rocks outcrop in the Las Minas mining area (LM), located 15 km east of LHVC, where Miocene basalts lay unconformable on Jurassic and Cretaceous carbonates (Sierra Madre Oriental Basin), underlain by metamorphic shales of Chililis unit and granitoids of the Teziutlán Massif. These rocks presumably constitute small fragments of much larger, NNW-SSE directed volcanic arc zone of the Late Paleozoic-Triassic age, stretched along the eastern part of Mexico, and containing Permo-Carboniferous vulcanites and Permo-Triassic granitoids (Rosales-Lagarde et al., 2005, Centeno-Garcia, 2017).

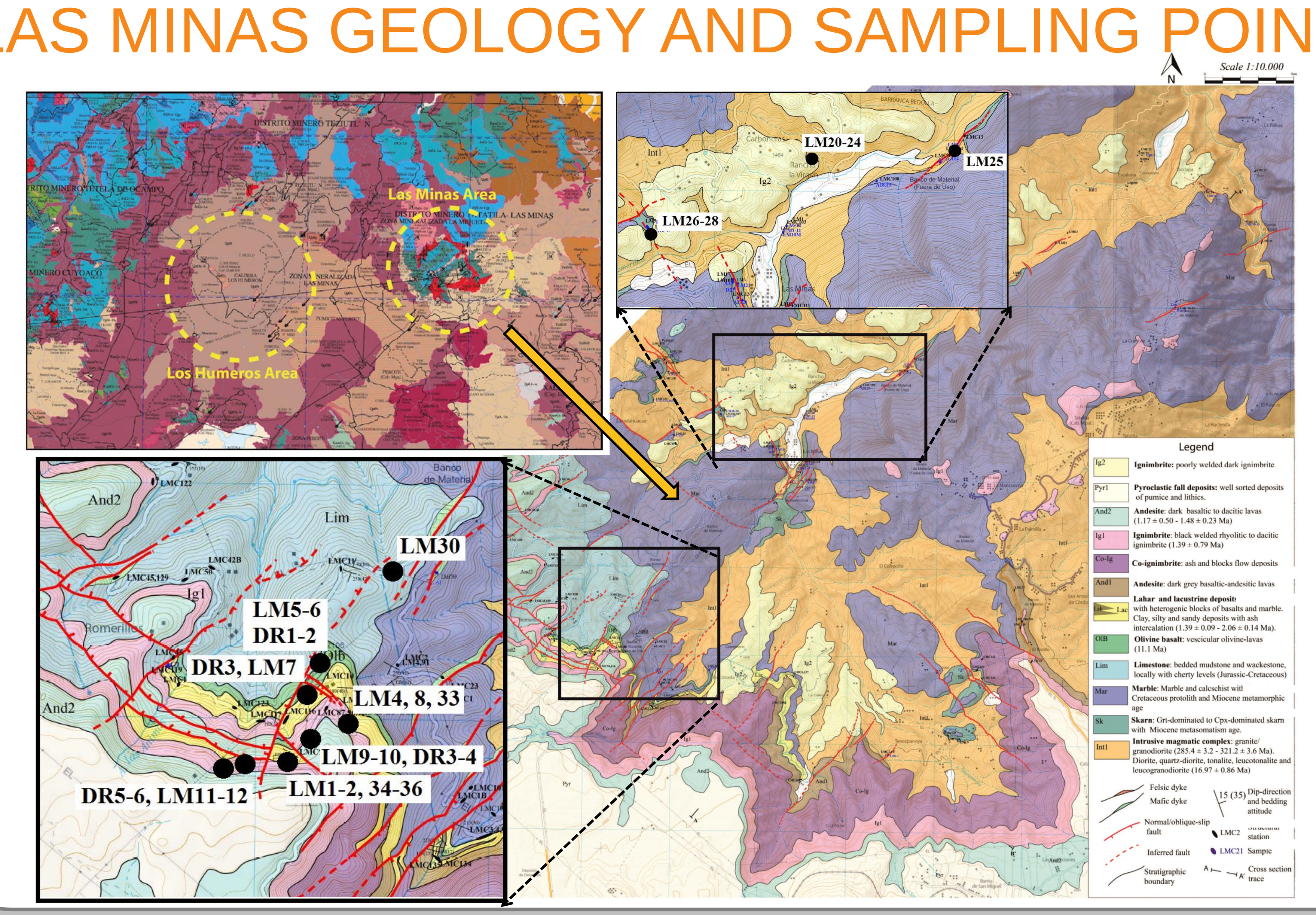


The Late Palaezoic arc was built on much older, deeply hidden substrate known as the Oaxaquia microcontinent (Ortega-Gutiérrez et al., 1995), composed of Meso-and Neoproterozoic gneisses and anorthosites.

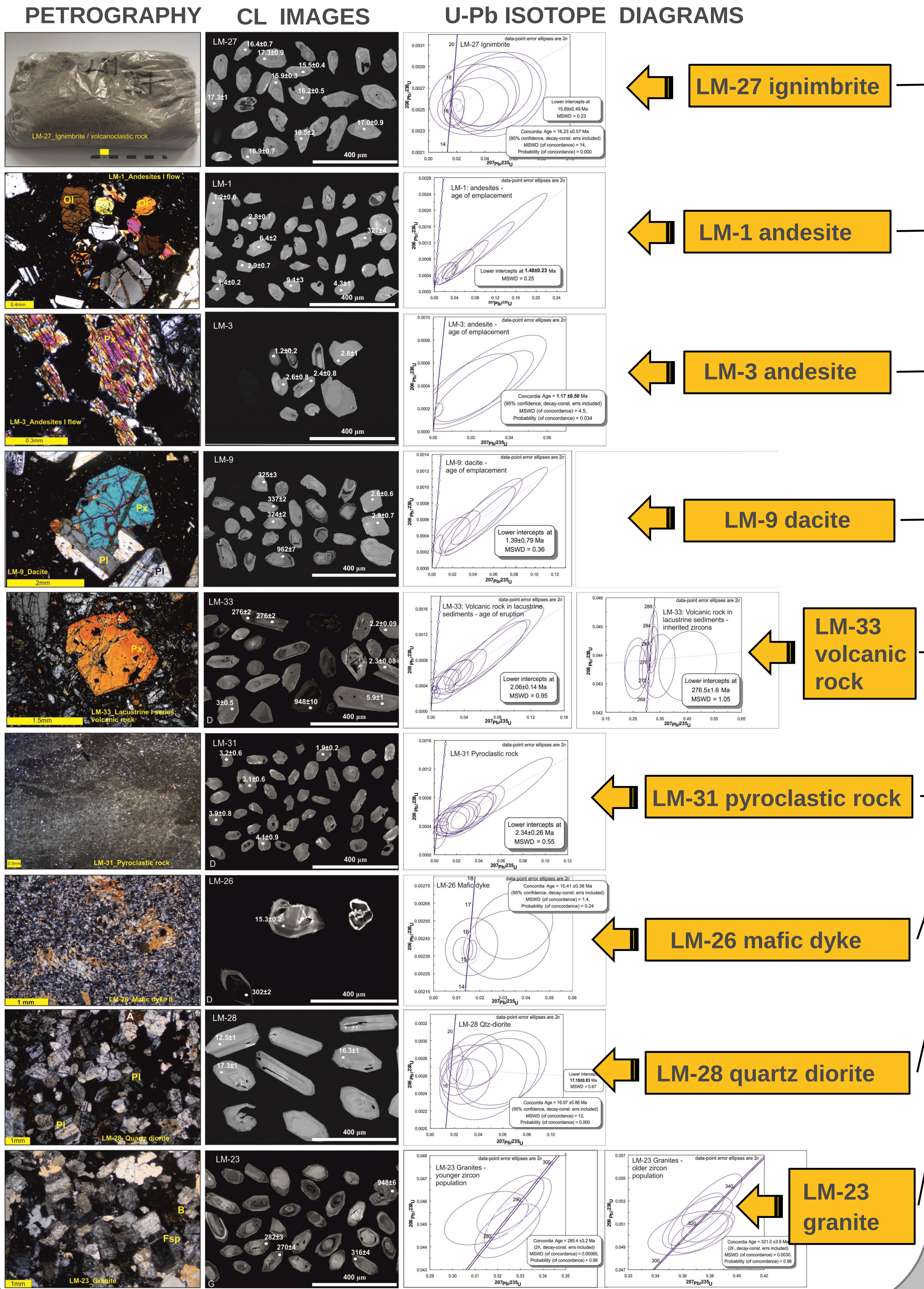
OBJECTIVES

The geochronology of selected rocks from the Las Minas (LM) exhumed system was studied using the U-Pb single-grain zircon technique performed on the SHRIMP IIe device. Isotope analyses were conducted on 23 zircon populations from various magmatic rocks. Supporting studies of 26 independently oriented palaeomagnetic samples gave the characteristic directions and magnetic polarities. Additionally, the anisotropy of magnetic susceptibility of samples from the lava flows was analyzed in order to define the direction of magma transport.

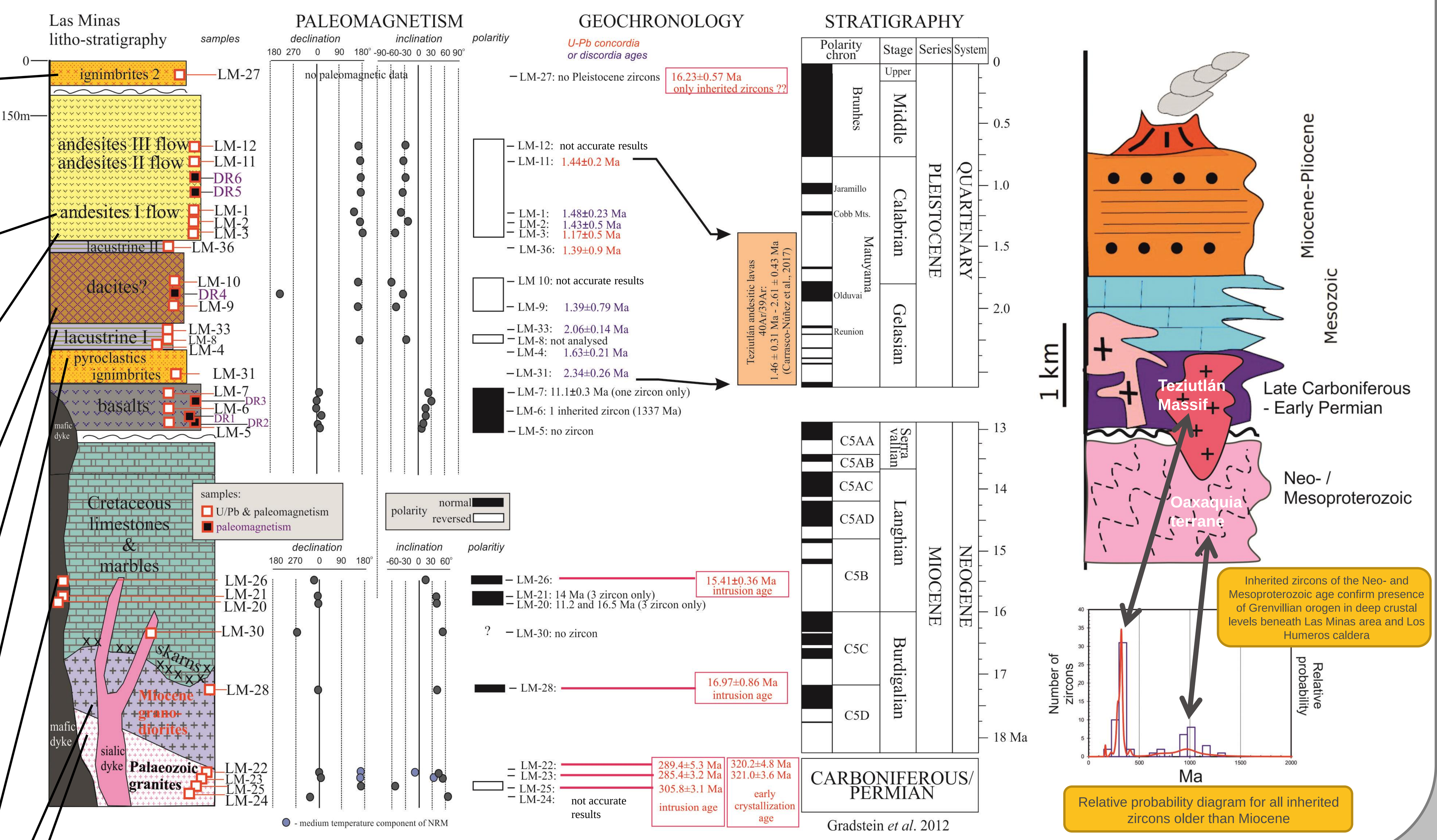
LAS MINAS GEOLOGY AND SAMPLING POINTS



ANALYTICAL MATERIAL



ANALYTICAL DATA - RESULTS



RESULTS - INTERPRETATION

Two analyzed samples of granites (LM-22 & LM-23) representing regional basement of the Teziutlán Massif contain very similar populations of zircons - one cluster of the Late Carboniferous age (U-Pb Concordia ages: 321 ± 3.6 Ma, 320 ± 4.8 Ma) and the second of Early Permian (U-Pb concordia ages: 289 ± 5.3 Ma, 285.4 ± 3.2 Ma respectively). This data may indicate primary Late Carboniferous granite intrusion affected later by high-temperature processes forming new zircons in the Early Permian or alternatively, very long, protracted live-span of magma chamber with initial zircon crystallization in Carboniferous and final cooling during intrusive episode in Early Permian. Both Paleozoic granites contain several inherited zircons with significant population dated from 936 to 1244 Ma suggesting source rocks of Grenvillian affinities.

Mesozoic sediments are locally intruded by younger Miocene granitoids (responsible for creation of skarns), and in some places cut by mafic dykes. Quartz-diorite (LM-28), devoid of inherited zircons, yielded U-Pb age of 16.97 ± 0.86 Ma and a mafic dyke (LM-26), that cut the basement granites, Cretaceous marbles and overlying basalts (the oldest part of the Las Minas “pre-caldera” volcanic succession), a bit younger U-Pb age of 15.41 ± 0.36 Ma. The latter rock contains few inherited zircons of 302 Ma, 412 Ma and 1321Ma. All these rocks and overlying basalts are exclusively of normal magnetic polarity and because of this it cannot be excluded that they represent a very narrow time interval when the Miocene magmatic activity took place. However, a significant error of U-Pb ages and frequent changes of magnetic polarity at that time make more precise stratigraphic correlation rather impossible.

Rocks of the younger part of the “pre-caldera” Las Minas succession including volcanic (LM-33), pyroclastic (LM-31) and volcanoclastic inlayers in lacustrine sediments, dacites (LM-9) and andesites (LM1 & LM-3) yielded mostly unprecise, some of them discordia U-Pb ages, bracketed within 2.34 ± 0.26 Ma - 1.39 ± 0.09 Ma and can be correlated with the unit named Teziutlán (pyroxene) andesitic lava flows defined recently with $^{40}Ar/^{39}Ar$ ages varying from 1.46 ± 0.31 Ma to 2.61 ± 0.43 Ma (Carrasco-Núñez et al., 2017). Quite often the volcanics contain numerous inherited zircons grouped in two clusters, one of the Late Carboniferous-Early Permian age (335-275 Ma) and the second of Neo- / Mesoproterozoic age (948-1044 Ma) that point for origin of the final Pleistocene magmas by complicated, assimilation and mixing processes involving very old sources. All the “pre-caldera” rocks are magnetized in reversed polarity direction what allow to constrain their emplacement to the Matuyama reversed polarity chron and even to more narrow time interval enclosed between 1.26 and 1.5 Ma. The mean direction of maximum susceptibility axes and direction of imbrication of minimum susceptibility axes calculated for the group of andesites and dacites indicate that the magma was transported to the studied localities from the SSW direction.

CONCLUSIONS

- ✓ The U-Pb isotope studies of magmatic rocks from the Las Minas area emphasize their complex story of parent magma formation before final emplacement. High heterogeneity of zircon populations, often inherited from older, assimilated host rocks and signs of long, protracted magma crystallization in multi-level chambers make difficult to define accurate time of their final intrusion or extrusion.
- ✓ Detection of possible presence of the old, high-grade Grenvillian rocks in the upper/middle crustal level beneath Las Minas area is also an important information for advanced modelling of the Los Humeros geothermal site geometry.

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