Magnetic susceptibility mapping of the Cambrian El Hongo pluton, Eastern Sierras Pampeanas, Argentina

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ABSTRACT

A map of bulk magnetic susceptibility was obtained on El Hongo trondhjemite, a small Cambrian pluton intruding the metamorphic basement in Eastern Sierras Pampeanas, Argentina, based on systematic magnetic susceptibility measurement at 450 sites using a SM30 susceptibility meter. Samples were collected on 58 sites and their bulk magnetic susceptibility was measured in laboratory with a Bartington MS2 system. Point-to-point comparison showed differences, that were attributed to the effect of roughness of the surveyed surfaces, and to the development of a weathered cap. However, the difference was systematic and in accordance with expected values predicted by manufacturer tables, whereby, once corrected with the appropriate factor, the obtained values with SM30 susceptibility meter were regarded as representative of fresh rocks. The resulting map was interpreted in terms of variation in abundance of magnetite, which is present in the rocks as a magmatic mineral, altered to hematite (martitized) in varying degrees. The map revealed that El Hongo trondhjemite is a weakly magnetic pluton, with a typical bulk susceptibility of about 500×10^{-6} *SI, which would correspond to an abundance of magnetite below 0.2 vol%, but with conspicuous variations. Lows in the outer sector and in the vicinity of metamorphic xenoliths were interpreted as due to destruction of magnetic minerals linked to reactions between magma and host rock. A distinct concentric pattern in the western area could indicate the presence of a separate intrusion. Finally, alternate highs and lows in susceptibility follow the undulations in regional schistosity, which in turn would have controlled the emplacement of the pluton. Thus we provide a good example of the utility of magnetic susceptibility mapping in granitoid terrains, as an expeditious way for preliminary mapping that could guide further and more detailed research.*

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1. INTRODUCTION

Magnetic susceptibility κ is a measure of the extent to which a material may be magnetized in relation to a given applied magnetic field. Materials may be classified by their response to externally applied fields as diamagnetic, paramagnetic, or ferromagnetic. As these magnetic responses differ greatly in strength, the magnitude of magnetic susceptibility of rocks reflects mainly the abundance of ferromagnetic (s.l.) minerals, namely magnetite. Rocks whose magnetic susceptibility is dominated by this ferromagnetic contribution are said "ferromagnetic", while rocks with magnetic susceptibility carried almost exclusively by the iron-bearing silicates are said to be "paramagnetic". Due to the strong magnetism of ferromagnetic minerals, a rock is paramagnetic only if ferromagnetic minerals are virtually absent.

Given the availability of simple, portable and cheap instruments for its determination in the field, measuring magnetic susceptibility turns in an easy and straightforward way of determining the amount of ferromagnetic (s.l.) minerals, even if they are present in a very subordinate percentage. As the presence or absence of magnetite in rocks has petrogenetic implicances (see *Frost, 1991*), the measurement of magnetic susceptibility turned in a powerful tool for geological mapping. Magnetic susceptibility mapping has been increasingly used to determine limits for metamorphic transitions/facies (e.g., *Hageskov, 1984*), or the extent of certain alteration processes (*Kontny and Dietl, 2002*).

Ishihara (1981) proposed a descriptive classification of calc-alkaline granitoids into a magnetite-series and an ilmenite-series, based on iron-titanium oxide mineralogy, which in turn can be estimated from magnetic properties, because magnetite-series granitoids are ferromagnetic, usually containing 2 vol% oxides, whereas ilmenite-series are generally paramagnetic, and very low in opaque oxide content. The magnetic susceptibility mapping technique has been used for the characterization of paramagnetic granitic plutons. In such granitoids the bulk susceptibility directly correlates with the whole rock iron content determined by chemical analyses (*Rochette, 1987*), and can therefore be used as a proxy for different lithologies, hence magma batches (e.g., *Gleizes et al., 1993*; *de Wall et al., 2000*). The technique was also extended to ferromagnetic plutons, considering that ferromagnetic or paramagnetic character has resulted from the prevalence of different oxygen fugacites, and therefore magnetite content provides important information on the redox state of any given granitoids (e.g., *Ishihara et al., 2002a*).

In this work we present results of magnetic susceptibility mapping of El Hongo trondhjemite, a small Middle-Late Cambrian pluton (500.6 ± 4.5 Ma, *D'Eramo et al., 2013*) in Eastern Sierras Pampeanas, Argentina (Fig. 1). The Sierras Pampeanas of central Argentina are composed to a great extent of Pre-Mesozoic basement that was accreted to the southern palaeo-margin of Gondwana during two Early Paleozoic orogenic events, the Pampean (Ediacaran–Early Cambrian) and Famatinian (Ordovician–Silurian) orogenies (e.g., *Aceñolaza and Toselli, 1981*; *Pankhurst and Rapela, 1998*). Although the El Hongo pluton is post-kinematic with regard to the main regional phases of deformation recognized in the country rocks, its emplacement was interpreted as tectonically controlled by *D'Eramo et al. (2006, 2013)*. Its emplacement linked to key events in the history of Gondwana assembly, and a relatively complex pattern in the magnetic properties observed by *Pinotti et al. (2004)*, lead us to address the detailed magnetic susceptibility mapping of El Hongo pluton, in an attempt to reveal subtle variations that could have passed unnoticed to conventional geological mapping.

2. GEOLOGICAL SETTING

The basement of the Sierra Chica de Córdoba (Fig. 1) consists of high-grade gneisses, with minor marbles, amphibolites and ultrabasic rocks, intruded by granitic plutons

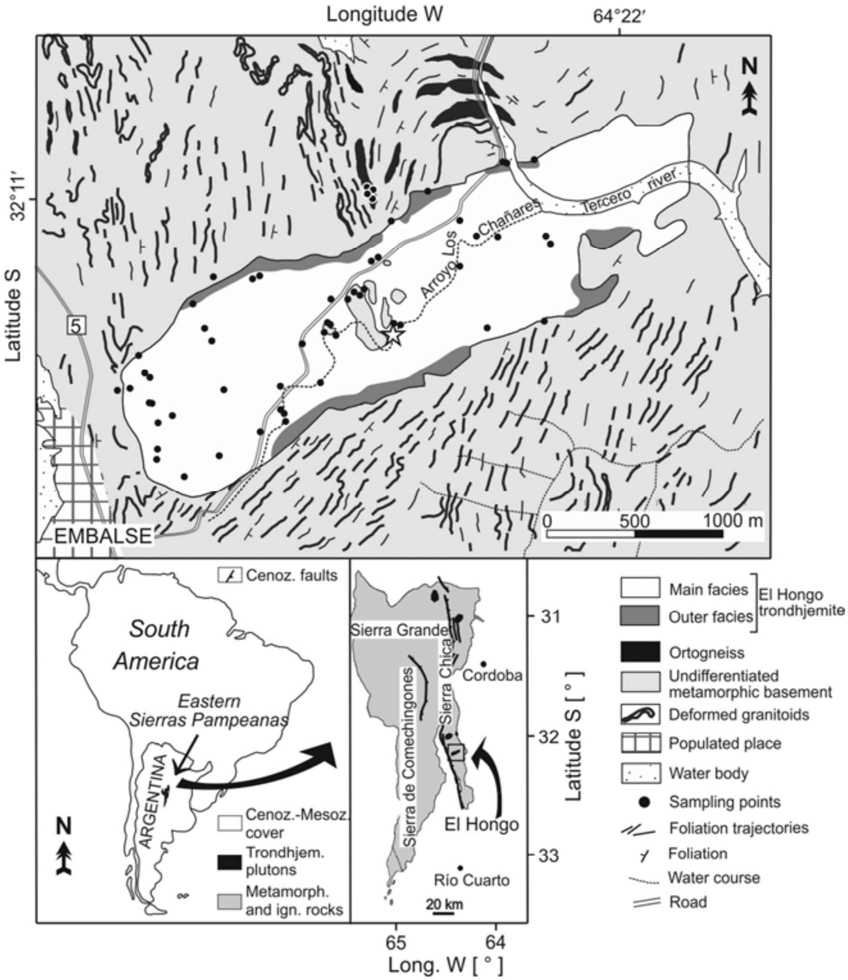

Fig. 1. Geological map of El Hongo trondhjemite, modified after *D'Eramo et al. (2006)*. Location of sites where samples were extracted is shown; the star marks the position of the small xenolith in Fig. 6.

emplaced at various crustal levels. The protoliths for these rocks have been interpreted as a predominantly clastic sedimentary sequence that was deposited in the accretionary prism of the Pampean subduction system (*Dalla Salda et al., 1992*; *Rapela et al., 1998*).

El Hongo trondhjemite is one of a dozen of small, discordant plutons, interpreted as emplaced at shallow depths in a rigid basement (*Bonalumi and Baldo, 2002*). It is a small massif of nearly rectangular shape (4 km long and 1 km wide) with an ENE-WSW elongation that transects the dominant north-south structure of the metamorphic country rocks (Fig. 1; *D'Eramo et al., 2006*). The contacts with the country rocks are sharp, steeply dipping and discordant. Large blocks of wall-rocks fragments are concentrated in a north-south-trending corridor in the central part of the pluton (Fig. 1; *D'Eramo et al., 2006*).

The El Hongo pluton includes two granitoid facies with similar composition but different grain-size. The most abundant rock type is a coarse-grained, hypidiomorphic trondhjemite. Fine-grained porphyritic varieties are restricted to the marginal facies that occur along the northern and southern contacts (Fig. 1).

Both facies contain more than 90% plagioclase and quartz, with biotite as the most abundant mafic mineral. Accessory minerals include epidote, apatite, magnetite, zircon and titanite. Idiomorphic epidote with allanite core is frequent as inclusions in biotite (*D'Eramo et al., 2006, 2013*). The content of dark minerals in the trondhjemite is lower than 5%, mostly biotite. The amount of opaque minerals may reach 1 vol%, but usually is far below that value. El Hongo pluton shows a conspicuous N-S trending magmatic banding, given by biotite-rich bands alternating with plagioclase + quartz-rich bands. *D'Eramo et al. (2006)* completed a study of anisotropy of magnetic susceptibility (AMS) on 28 sites, and a gravity survey on El Hongo pluton, which allowed to propose an emplacement model based on two elongated roots oblique respect to the longer axis of the pluton, controlled by extensional structures related to left lateral strike-slip deformation and by the previous foliation of metamorphic host rocks (*D'Eramo, 2003*; *D'Eramo et al., 2006, 2013*).

3. METHODS

Bulk magnetic susceptibility in the trondhjemite and surrounding rocks was measured in outcrop surfaces in the field using a hand-held SM30 susceptibility meter (ZHInstruments, Brno, Czech Republic). The instrument has a 56 mm diameter pick-up coil, corresponding to a sensing area of 2462 mm^2 located below the digital display (Fig. 2a,b). The sensor coil has an operating frequency of 9 kHz and a sensitivity of 1×10^{-7} SI units (*Heritage Geophysics Inc., 2003*). Measures were taken in 450 points, using the extrapolation mode to correct for thermal drift; 5 to 10 measurements were averaged in each point, to explore small-scale variability of the data at the outcrop level (Fig. 2c). The surveyed points were selected at random, except for 7 points chosen to coincide with sampling sites used by *D'Eramo et al. (2006)*. A detailed survey was additionally performed in the surroundings of a gneissic xenolith 2×0.3 m in size, taken on a regular mesh of 10×20 cm in an area of about 4 m^2 (see location in Fig. 1).

Ideally a magnetic susceptibility reading should be taken on a perfectly flat surface; readings obtained on non-perfect natural rock surfaces are less than readings obtained on

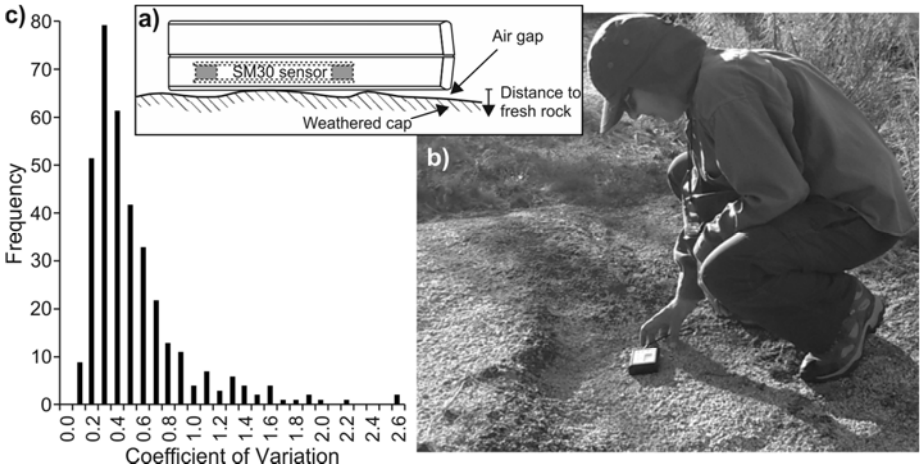

Fig. 2. **a)** Scheme of the measurement of SM30 on outcrop (reproduced from the user manual, *Heritage Geophysics Inc., 2003*). The size of the air gap between sensor and rock depends on the surface roughness, and the thickness of the weathered cap depends on proneness to alteration and environmental conditions. Both effects can easily reach 3–4 mm in thickness, where 30–40% of the signal sensed by the instrument comes from. **b)** Typical view of El Hongo trondhjemite outcrops. **c)** The relative frequency distribution of the geometric coefficient of variation of magnetic susceptibility (estimated from sample standard deviation of the data after a natural log transformation) observed at outcrop level (5 to 10 readings in about 10 m^2).

a flat surface of the same rock, as air occupies the volume between rock and sensor (Fig. 2a). This means that unevenness in the surface, virtually unavoidable in coarse-grained granitoid rocks (Fig. 2b) will cause significant variations to instrument readings. Weathering can also affect in situ susceptibility data acquisition, usually by reducing the amount of magnetic minerals within the volume of rock sampled. While the obvious recommendation is to select planar and unaltered surfaces for measurement, this condition can hardly be completely achieved.

Manufacturer provides a table with percentage of correction that should be applied depending on the thickness of the air gap or weathered cap; that thickness, however, may be variable and difficult to assess in every places (Fig. 2b). To evaluate the possible impact of the effects of uneven surfaces and weathering, we collected 222 samples in 51 sites representative of a wide range of magnetic susceptibilities, as follows: 28 sites on trondjhemite, 8 on xenoliths, 5 on ortogneiss, 4 on high-grade metamorphic rocks (amphibolite and migmatite), and 6 on late clastic veins and basaltic dikes crosscutting the pluton. Sampled localities are shown in Fig. 1.

After taking magnetic susceptibility readings in situ on each point, cylindrical samples were collected using a gas powered drill, with approximately 25 mm in diameter; from them, 353 specimens were sliced with 22 mm height. In addition, 7 sites sampled by *D'Eramo et al. (2006)* were revisited, where 22 specimens (from 12 samples) had been taken. Bulk magnetic susceptibility of these samples was measured in laboratory using a Bartington MS2B dual frequency sensor, at 4.65 kHz frequency. Laboratory measurements were performed at room temperature (21°C), corrected by drift and referred to the calibration sample provided by the manufacturer. Volume was determined by the instantaneous water immersion method.

The mathematical treatment of the data considers that both bulk magnetic susceptibility as well as oxide content, follow a lognormal distribution in fresh igneous rocks (*Shaw, 1961*; *Latham et al., 1989*).

Nine polished sections were examined under optical microscope with oil-immersion objectives, to identify the opaque minerals responsible for the magnetic properties.

4. RESULTS

The magnetic susceptibility of trondhjemite, measured in laboratory with the Bartington MS2 system, at low field (80 A/m), ranges from 50 to 7720 × 10^{-6} SI, with an average at 1187×10^{-6} SI. Metamorphic rocks showed a wide range of variation, according to differences in lithology. The range of measured magnitudes was completed by including data from later clastic veins and basaltic dikes, which provided the lowest and highest magnetic susceptibility values, of around $50–100 \times 10^{-6}$ SI, and 16750×10^{-6} SI, respectively. Thus, the selected sites allowed obtaining values of magnetic susceptibility spanning 3 orders of magnitude, creating adequate conditions for comparison of readings taken by diverse instruments.

Magnetic susceptibility values were obtained in situ with the SM30 hand-held susceptibilimeter, in the 51 + 7 sampled sites, and in other 392 points, totaling 450 surveyed sites. Geometric mean was calculated for each point, from 5 to 10 readings obtained in about 10 m^2. Variability at the outcrop level was typically of 30% (coefficient of variation 0.3, Fig. 2c). Higher variation, of up to 200%, was not uncommon, and it shows up indistinctly in sites with high or low susceptibility values, reflecting the essentially inhomogeneous nature of the distribution of magnetic minerals in the rock.

4.1. Comparison between field and laboratory results

As stated previously, a difference was expected between field and laboratory measurements of magnetic susceptibility, mainly ascribable to the effect of unevenness and weathering of field surfaces. This effect is expected to be significant, as the measure taken by SM30 integrates a total volume of about 200 cm^3 (the first 10 cm from the surface), where half of the signal comes from the first 6 mm, and 25–30% of it comes from the first 2–3 mm below surface. This quality for the measurements is specified by the manufacturer in the user manual (*Heritage Geophysics Inc., 2003*) and was also experimentally inspected by *Jordanova et al. (2003)* and *Gattacceca et al. (2004)*.

Given that the pluton is relatively small and exposed in an area with relatively constant exposure to exogenous agents, we assumed that impact of weathering was also constant, and decided to find the optimal correction factor as the slope of the least squares line of best fit relating measurements in laboratory and in the field.

At first sight, both quantities are linearly correlated (coefficient of determination $R^2 = 0.9471$), with a slope of 0.63, that is, SM30 data are 37% lower than MS2 data (Fig. 3a). This amount of reduction would be expected if the first 2–3 mm below sensor

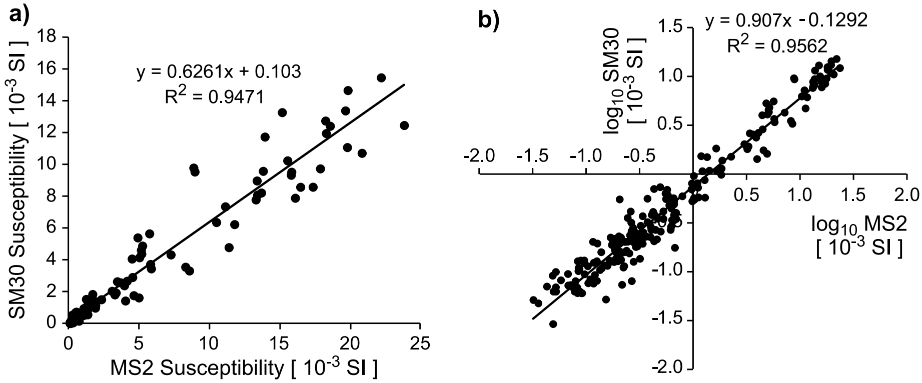

Fig. 3. Comparison of equivalent magnetic susceptibility readings taken in laboratory (with Bartington MS2 instrument) and in the field (with ZH Instruments SM30 device), showing the best-fit least-squares line; **a)** linear scale; **b)** logarithmic scale.

were not occupied by fresh rock, according to the manufacturer's specifications. However, the slope is not constant along the whole range, but it seems to vary from 0.55 for higher to 0.76 for lower susceptibility values. It is noteworthy that *de Wall et al. (2000, 2008)* followed a similar approach employing a KT-6 (Geofyzika, Brno, Czech Republic) field susceptometer, and found quite similar slopes in the least squares line. A better correlation, and a smoother slope, was found when logarithms of susceptibility were tested: a slope of 0.91 was found to relate both quantities (Fig. 3b). Common logarithm ($\log_{10}$) of magnetic susceptibility obtained with SM30 was therefore corrected by using this factor. We find that this correction is a good approximation to account for the effect of unevenness and weathering, experimentally tested as valid for this particular lithological and environmental conditions.

4.2. Magnetic susceptibility map

Measured and corrected field values of the magnetic susceptibility of El Hongo granitoid are shown in Fig. 4a. Mean values for 19 sites reported by *D'Eramo et al. (2006)* and not revisited here, were also added. The sample set is lognormally distributed, with a median value of 520×10^{-6} SI, and spanning three orders of magnitude. The maximum reached values indicate a modal abundance of magnetite rarely exceeding 1 vol%, and typically lower than 0.1 vol% (*Clark and Emerson, 1991*).

Metamorphic surrounding rocks show a bimodal distribution, where only orthogneiss is systematically weakly magnetic, while migmatite and amphibolite may be either very strongly or weakly magnetic (Fig. 4b). Xenoliths of tonalite gneiss located in the central area of the pluton are the most magnetic rocks, with values of up to 0.02 SI.

A magnetic susceptibility map was produced using Surfer™ (Golden Software) gridding software. The map is based on 457 measures of magnetic susceptibility, as 14 points corresponding to small or unrelated features (xenoliths and clastic veins) were excluded. Minimum curvature gridding was applied with a mesh of 10 meters, and results are presented in Fig. 5.

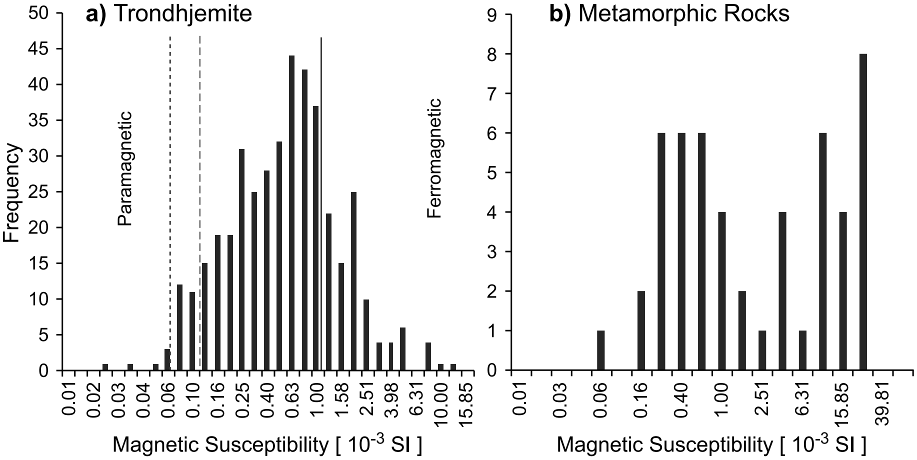

Fig. 4. Histogram of magnetic susceptibility values. **a)** Trondhjemite. Vertical dotted/dashed lines mark the average/maximum paramagnetic susceptibility that would be expected if all the available Fe in rocks was allocated in iron-bearing silicates (no ferromagnetic contribution). Ferromagnetic contribution is expected to be present in the whole spectra to the right of these lines; magnetic susceptibility is completely controlled by ferromagnetic (s.l.) abundance for values to the right of the vertical continuous line. **b)** Metamorphic rocks.

Figure 6 shows the map of magnetic susceptibility variation for the trondhjemite in an area of 4 m^2 surrounding a small xenolith of tonalite gneiss (see location in Fig. 1).

The coarse pattern of distribution shown in Fig. 5a can be complemented with close inspection of the weighted map in Fig. 5b. There it can be seen that high magnetic susceptibility values occur sporadically in the areas with dominant low magnetic susceptibility, and viceversa, reflecting that low values may occur intimately juxtaposed with high values. This mixed occurrence of high and low values was noticed before in Archean granitoids (*Ishihara et al., 2002a,b*). It seems to fractally reproduce the intra-site variation at outcrop level responsible for very high coefficients of variation observed at many sites (right tail in Fig. 2c). However, despite the inhomogeneous nature of the distribution of magnetic minerals in the rock as discussed, it does not obliterate an overall pattern that emerges at the scale of the map, with distinct characteristics, as follows (Fig. 7):

- The marginal facies is characterized by lower susceptibility values, in the range of 70–200 × 10^{-6} SI, and is not continuous along the pluton border, as already shown by field mapping (*D'Eramo et al., 2006*).
- The granitic terrane in the vicinity of the metamorphic remnants in the central area, tend to record low magnetic susceptibility values ("peripheral low" in Fig. 7), in a similar way as it was observed around the small xenolith shown in Fig. 6.
- A distinct pattern of bimodal magnetic susceptibility is observed in the western area, where a center of about 50–100 × 10^{-6} SI is surrounded by a halo of high

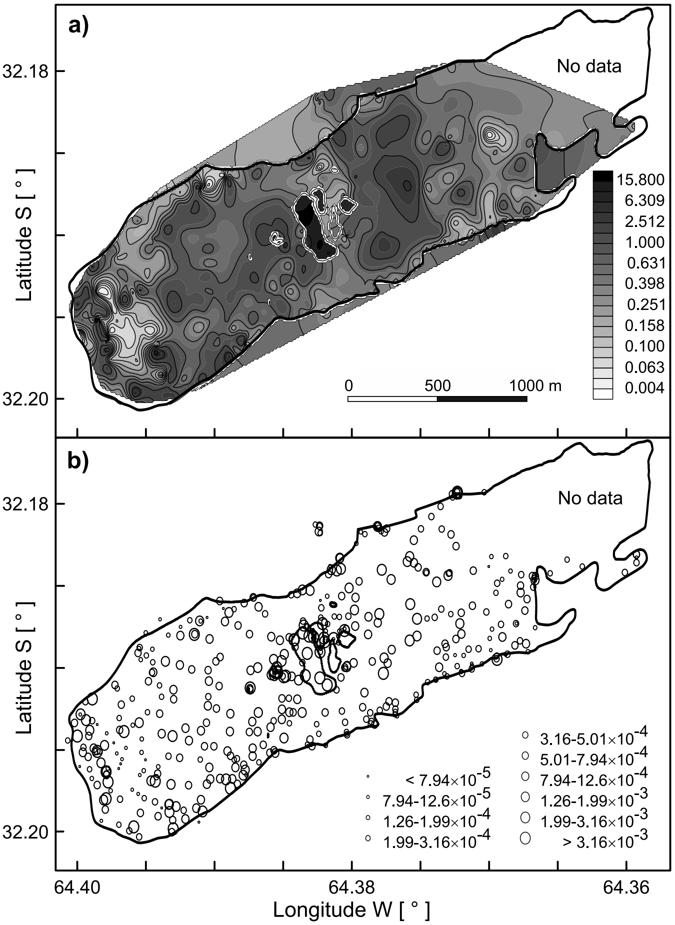

Fig. 5. **a)** Bulk magnetic susceptibility map (in 10^{-3} SI units); **b)** Weighted map for the 450 points surveyed by magnetic susceptibility (in SI units, 58 sampled sites are also included). NE corner of the pluton was not accessible from the right bank of Tercero river.

magnetic susceptibility of 5000–15000 × 10^{-6} SI units (“outer high” and “inner low” in Fig. 7).

- The overall distribution of highs and lows in magnetic susceptibility follows a N-NE trend (Fig. 5a), oblique in respect to the long axis of the pluton, in agreement with magnetic and magmatic fabric previously determined, and parallel to gravity lows (*D’Eramo et al., 2006*).

4.3. Reflected light microscopy

Polished sections were examined under reflected light to determine the nature and textural relationships of magnetic minerals in the trondhjemite. All of the observed

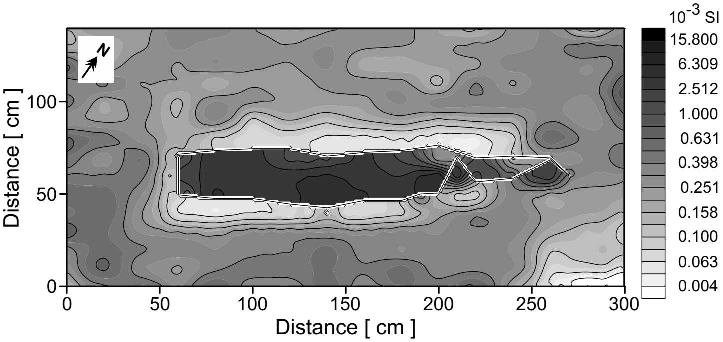

Fig. 6. Magnetic susceptibility map around P7 xenolith. Details of measuring, sampling and variation in magnetic properties were reported in *Geuna et al. (2016)*.

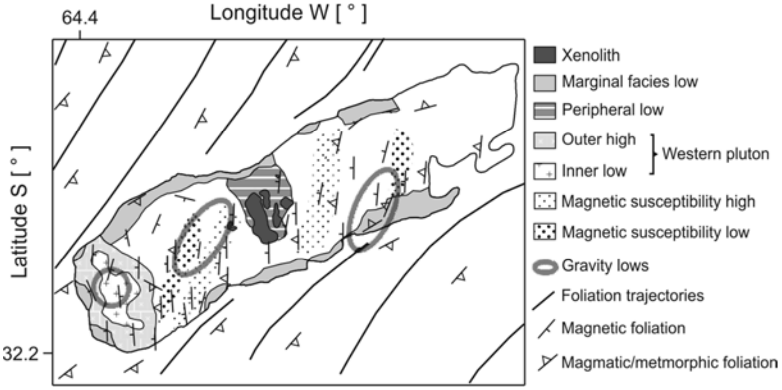

Fig. 7. Interpretation of magnetic susceptibility domains. Magnetic and magmatic foliation and schistosity planes after *D'Eramo et al. (2013)*; gravity lows after *D'Eramo et al. (2006)*.

opaque minerals are Fe-Ti-oxides: magnetite occurs as subhedral to euhedral grains, typically 0.1–0.3 mm in size, but some larger grains with a diameter up to 0.5 mm are also present. The replacement of magnetite by hematite along the fractures and grain boundaries (martitization) is common and sometimes very strong (Fig. 8a). Ilmeno-hematite with hemo-ilmenite lamellae is also present, usually anhedral and with corroded grain boundaries (Fig. 8b), and occasionally with rutile blitz texture.

The 15–30 cm surrounding the xenolith in Fig. 6, carry the same opaque assemblage (martitized magnetite + ilmenohematite); diminished susceptibility in this halo obeys to the minor modal abundance of the opaque minerals, as they appear surrounded and replaced by titanite.

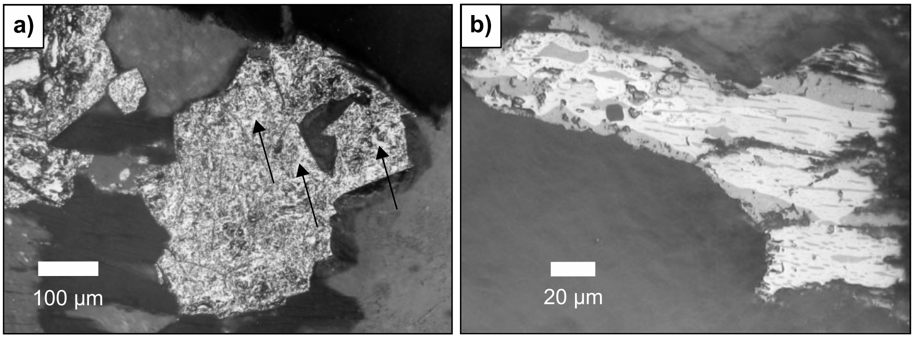

Fig. 8. Microphotographs, in reflected light and under oil-immersion objectives. **a)** Sample P3-7. Magnetite with advanced hematite replacement (martitization). Relict patches of magnetite (darker, marked with arrows) surrounded by hematite (white), with replacement progressing along borders and fractures. **b)** Sample H10-c2. Exsolved ilmenohematite, oriented rods of ilmenite (dark grey) hosted by hematite (light grey).

5. DISCUSSION

Magnetic susceptibility values measured and corrected for El Hongo trondhjemite peak at 520×10^{-6} SI, ranging from 17 to 11700×10^{-6} SI. The lower segment includes values typical of paramagnetic rocks, i.e., with magnetic susceptibility values low enough as to ensure that contribution of paramagnetic iron-bearing silicates is not masked by ferromagnetic contribution. On the other side, the higher segment reaches values of ferromagnetic rocks, as $\kappa \gg 10^{-3}$ SI can only be attained when a ferromagnetic fraction is present, and it completely masks the paramagnetic contribution (see for example *Rochette, 1987*). Values in between, most typical for the trondhjemite, must reflect the contribution of both the paramagnetic fraction, and of a volumetrically minor ferromagnetic (s.l.) fraction.

The theoretical contribution of paramagnetic minerals to magnetic susceptibility can be easily calculated, if the amount of iron in the rock is known (*Rochette, 1987*). Chemical analyses performed by *D'Eramo (2003)* on El Hongo trondhjemite samples report values typically around 1.25 wt% of Fe_2O_3, ranging from 0.5 to 2.5 wt%. If all of the Fe_2O_3 was allocated in paramagnetic minerals, the susceptibility of the rock should be of around 65×10^{-6} SI (range from 15 to a maximum value of 140×10^{-6} SI). The modal susceptibility observed for El Hongo trondhjemite (see Fig. 5a), much higher than the calculated paramagnetic threshold, is in agreement with magnetite being present in the rocks. Its abundance, however, would typically be below 0.1 vol%, and very rarely exceed 1 vol%, according to the susceptibility values (*Clark and Emerson, 1991).*

The opaque assemblage is composed by martitized magnetite and ilmeno-hematite of magmatic origin, indicating oxidizing conditions during the emplacement and cooling. Characteristic modal values of magnetic susceptibility of about 500×10^{-6} SI are observed for sites that, despite of carrying 0.5–1.0 vol% of opaque minerals, became magnetically weaker because of the strong martitization of the primary magmatic magnetite. Magnetic susceptibility as high as $2–10 \times 10^{-3}$ SI reached locally, may correspond either to sites with higher modal abundance of primary magnetite, or to sites where martitization was less advanced.

The advanced degree of martitization (Fig. 8a) is interpreted as an evidence of cooling under oxidizing conditions in the presence of late magmatic fluids (*O'Reilly, 1984*). The remarkable coincidence in shape, position and orientation of susceptibility and gravity lows (Fig. 7) suggests a relationship between magnetic properties and the location of magmatic feeder conduits at depth. As these areas might locate the last magma pulses in the pluton growth, the observed distribution of magnetic susceptibility would reflect either primary heterogeneities in the magma, with decreasing magnetite content in the last stages, or a higher extent of deuteric oxidation close to the magmatic system roots, or both. In any case, the observed heterogeneities would reflect features acquired early, either during the accumulation of magma batches or during the primary cooling, as these features follow the undulations in regional schistosity (see Fig. 7), which have been interpreted to control the emplacement of the pluton (*D'Eramo et al., 2013*).

A third subdued minimum in gravity was determined by *D'Eramo et al. (2006)* in the western end of the pluton, and it also coincides with a magnetic susceptibility minimum, in this case surrounded by a concentric maximum halo. A separate feeder zone can be hypothetized, marked in Fig. 7 as a "Western pluton".

Particularly low values of magnetic susceptibility (diminished in one order of magnitude) were observed in the central corridor, around host rocks, as seen in the "peripheral low" in Fig. 5a. A closer look at contacts in small xenoliths revealed a similar feature, as shown in Fig. 6. The pattern seems restricted to areas surrounding host rock blocks, where susceptibility drops due to a decrease in magnetic mineral abundance; while the opaque assemblage in the magnetic low is the same as for the typical trondhjemite, it appears in a reduced amount and rimmed by titanite, presumably because of a reaction occurred between magma and host rocks during emplacement.

In summary, the above analysis shows a distinct magnetic pattern for El Hongo pluton, where local variations seem to result from differences either in the amount of magnetic minerals for sucessive magmatic pulses, or in the extent of interaction between magma and metamorphic country rocks.

6. CONCLUSIONS

The El Hongo trondhjemite shows a typical bulk susceptibility of about 500×10^{-6} SI (ranging from 17 to 11700×10^{-6} SI), which would correspond to an abundance of magnetite around 0.2 vol% (*Clark and Emerson 1991*). While the opaque assemblage may be more abundant (up to 1 vol%), the reduced values in magnetic susceptibility reflect the varying degree of martitization that affects the magmatic magnetite in the trondhjemite, which would have occurred during cooling under oxidizing conditions.

The observed magnetic susceptibility patterns have indicated an unsuspected heterogeneity in El Hongo trondhjemite. Lows in the outer sector and in the vicinity of metamorphic xenoliths were interpreted as due to destruction of magnetic minerals linked to reactions between magma and host rock. Alternate highs and lows in susceptibility, and a distinct concentric pattern in the western area, could provide data about rheology and magma behaviour, and therefore about dynamics in the magma chamber.

The resulting map, obtained after expeditive surveying during about one week, revealed subtle features which only could have been detected otherwise by doing very detailed fieldwork assisted with time-consuming petrographic determinations. Thus we provide a good example of the utility of magnetic susceptibility mapping in granitoid terrains, as an expeditious way for preliminary mapping that could guide further and more detailed research, provided that weathering effects could be neglected or corrected.

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