197-2

Paleomagnetic Constraints on the Extent of the Miocene Tuff of San Felipe/Tuff of Hermosillo, Sonora, Mexico

Gianna L. Hernández Méndez[1], Joann Stock[1], Jesus Vidal Solano[2], Francisco Paz Moreno[2], [1]California Institute of Technology, [2]Universidad de Sonora

Abstract

The Tuff of San Felipe is a peralkaline rhyolite pyroclastic density current deposit 12.4 Ma in age cropping out in NW México. It is a key horizon in the reconstruction of the Gulf of California Extensional Province because it erupted at the onset of extension in part of the Gulf. Rifting of the Gulf of California divided the ignimbrite leaving part of it on the North America Plate in Sonora, and part on the Pacific Plate, northern Baja California. An exceptional feature of this ignimbrite is its unique, low-inclination, reversed magnetization. Along with its mineralogy and age, this magnetization is vital for the correlation of the tuff across the region because the deposits are highly disrupted by subsequent normal faulting and outcrops are sparse and discontinuous away from the vent. We carried out paleomagnetic and other studies of the Tuff of San Felipe to determine its geographic extent in Sonora and Baja California. We examined new possible exposures of the Tuff of San Felipe in four widely separated Sonoran localities: San Miguel de Horcasitas, El Gavilán, Rancho el Pilar (Sierra Libre), and Cerro la Ceja. Oriented samples were analyzed for Natural Remnant Magnetization (NRM), Low Temperature Demagnetization (LTD), Alternating Field demagnetization (AF, 25mT-75mT), and High AF demagnetization (100mT-800mT). The results from the High AF demagnetization were extremely linear and heading for the origin for all the cores studied. Tilt-corrected magnetization direction was nearly horizontal, slightly reversed with a southwest direction. This is consistent with previous paleomagnetic results for the Tuff of San Felipe from Baja California, Tiburon Island, coastal Sonora and Hermosillo, inland Sonora. We conclude that these outcrops, spread out over a N-S distance of 125 km, comprise yet another major set of exposures of the Tuff of San Felipe.

Geologic Background

❖Peralkaline rhyolitic pyroclastic flow deposit crops out in scattered mesas in coastal and central Sonora and Baja California, México. Correlated in Baja California by Stock et al. (1999) and on Tiburon Island and coastal Sonora by Oskin (e.g., Oskin, 2002; Oskin & Stock 2003).

❖ $^{40}Ar/^{39}Ar$ geochronology on sanidine and U-Pb geochronology on zircon crystal found within the tuff date the unit at around 12-12.5 Ma (Vidal-Solano et al., 2005; Vidal-Solano et al., 2007a; Vidal-Solano et al., 2007b).

❖Unit exposed over a distance of at least 430 km; it is a key horizon in the reconstruction of the Gulf Extensional Province because it was erupted at the time of the onset of extension in part of the Gulf of California (Stock et al., 1999).

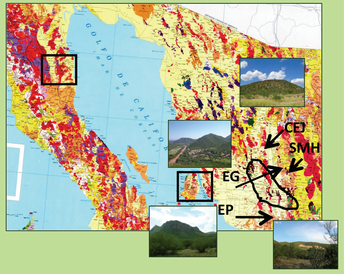


Figure 1: Geologic map of the Sonora and Baja California region of Mexico, photographs of outcrop localities. Arrows mark sample locations. Areas outlined in black contain outcrops of this tuff identified in previous studies.

❖Crystal-rich, strongly indurated, lithic-lapilli pyroclastic flow deposit with black basal vitrophyre, grading down into a narrow zone of brown, moderately welded tuff, and grading up into a red spherulitic horizon followed by a zone of densely welded magenta colored cliff forming ignimbrite (Stock et al., 1999).

❖ It has 5-15% alkali feldspars and can be up to 180 m thick in some locations near the vent (Stock et al., 1999).

❖Petrographically the unit can be distinguished by its peculiar mineralogical association with fayalite, Fe-rich augite and alkali feldspar phenocrysts and zircon as a common trace mineral (Vidal-Solano et al., 2008).

❖Unit has unique, low-inclination, reverse magnetization vital for correlation of tuff along the region (Stock et al, 1999).

Figure 2: Tie points on opposite sides of the Gulf of California (Oskin & Stock, 2003).

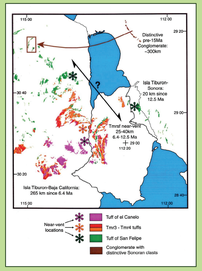


Figure 3: Reconstruction of the Gulf of California

Methodology

Sample Preparation:

❖ Five oriented hand samples from four localities were obtained: San Miguel de Horcasitas (SMH), two from El Gavilán (EG), Rancho El Pilar (EP) in the Sierra Libre, and Cerro la Ceja (CEJ) (see Fig. 1 for locations).

❖The rock sample blocks were re-oriented and photographed in their original positions in the laboratory. Large samples were cut down with a rock saw.

❖Three to five cores were drilled from each rock depending on size.

❖The rock samples were then re-oriented back to their original field positions and the cores were measured for strike and dip relative to North (Figure 5).

❖Cores were then sliced into cylindrical chips using a special rock saw. All chips were given specific labels and orientation marks to be used during the demagnetization process.

Demagnetization and analysis:

❖We used two DC SQUID magnetometers equipped with custom-built pick-and-put automated sample changers and multi-axis, computer-controlled, remanence rock-magnetics systems (Figs 7 and 8).

❖Natural Remanent Magnetization (NRM) was measured.

❖Low temperature step: chips were cooled to 77 K (liquid nitrogen treatment) then allowed to warm up back to room temperature. Magnetization of sample was then measured.

❖Alternating Field (AF) steps from 25mT to 75mT with increments of 25mT.

❖High AF demagnetization from 100mT to 800mT at the following steps: 100mT, 150mT, 200mT, 300mT, 450mT, 600mT, and 800mT.

❖High AF steps were used to obtain the best fit for a linear vector of magnetic remanence for each core, and these were combined for each locality to obtain Fisher and Bingham statistics for the locality (Figs. 8-11).

❖Powder studied in a Quantum's Design Magnetic Property Measuring system (MPMS) confirmed single-domain magnetite in sample EP-07-48.

Figure 4

Figure 5

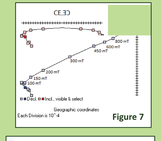


Figure 7

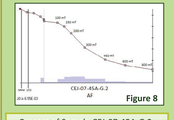


Figure 8

Process of Sample CEJ-07-45A-G.2. Sample collection and core orientation (Figures 4 and 5), raw, uncorrected data for alternating field demagnetization for the cores (Figure 6), and J/J0 curve (Figure 7).

Acknowledgements:

This research was supported by the U.S. National Science Foundation under Grant No. EAR-0336961 and by Mexican Consejo Nacional de Ciencias y Tecnología under Project CONACyT I0002-CB-2006-1-61198-J1.

References

•Oskin, M. E., 2002. Tectonic evolution of the northern Gulf of California, México, deduced from conjugate rifted margins of the upper Delfin Basin.: Unpublished Ph.D thesis, California Institute of Technology, Pasadena, 487 pp.

•Oskin, M. E., and Stock, J.M., 2003. Cenozoic volcanism and tectonics of the continental margins of the Upper Delfin basin, northeastern Baja California and western Sonora. *In*: S.E. Johnson, S.R. Paterson, J.M.Fletcher, G.H.Girty, D.l Kimbrough & A. Martin-Barajas. Eds., Tectonic evolution of northwestern México and southwestern USA: Geol. Soc. Amer. Sp. Paper, v. 374, 421-438

•Stock, J.M., Lewis, C.J., Nagy, E.A., 1999. The Tuff of San Felipe: an extensive middle Miocene pyroclastic flow deposit in Baja California, México: Journal of Volcanology and Geothermal Research, v. 93, p. 53-74

•Vidal-Solano, J., Paz-Moreno, F.A., Iriondo, A., Demant, A., Cochemé, J.J., 2005. Middle Miocene peralkaline ignimbrites in the Hermosillo region (Sonora, México). Geodynamic implications: C. R. Geoscience Elsevier, 337, 1421-1430.

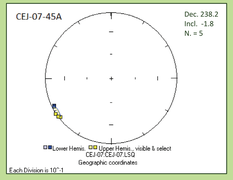
•Vidal-Solano J.R., Paz-Moreno, F.A.,.Demant, A.,Lopez-Martinez, M.,2007a.Ignimbritas hiperalcalinas del Mioceno medio en Sonora Central: revaluación de la estratigrafía y significado del volcanismo terciario: Revista Mexicana de Ciencias Geológicas, v. 24, p47-67

•Vidal-Solano, J., Paz-Moreno, F.A., Demant, A., Iriondo, A., Wooden, J.L., 2007b. Estudio geoquímico y geocronológico de los zircones presentes en las ignimbritas hiperalcalinas del Mioceno medio en la región de Hermosillo, Sonora, México: ACTAS INAGEQ, Número especial dedicado al 17º Congreso Nacional de Geoquímica. Pachuca, Hidalgo, México: 13 (1), p. 39-45.

•Vidal Solano, J.R., LaPierre, H., Stock, J.M., Demant, A., Paz Moreno, F.A.,Bosch, D., Brunet, P., Amortegui, A., 2008. Isotope geochemistry and petrogenesis of peralkaline Middle Miocene ignimbrites from central Sonora: relationship with continental break-up and birth of the Gulf of California: Bull. Soc. géol. Fr.,v. 5 p. 453-461

Results

Figure 8: Vectors of paleomagnetic remanence, for sample CEJ-07-45A, Tuff of San Felipe/ Tuff of Hermosillo, Sonora, México.



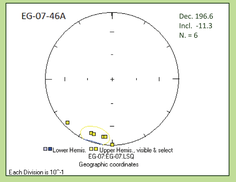
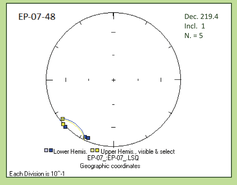


Figure 9: Vectors of paleomagnetic remanence, for sample EG-07-46A, Tuff of San Felipe/ Tuff of Hermosillo, Sonora, México.

Figure 10: Vectors of paleomagnetic remanence, for sample EP-07-48, Tuff of San Felipe/ Tuff of Hermosillo, Sonora, México.



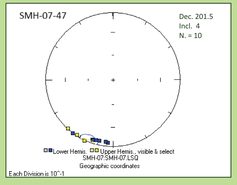


Figure 11: Vectors of paleomagnetic remanence, for sample SMH-07-47, Tuff of San Felipe/ Tuff of Hermosillo, Sonora, México.

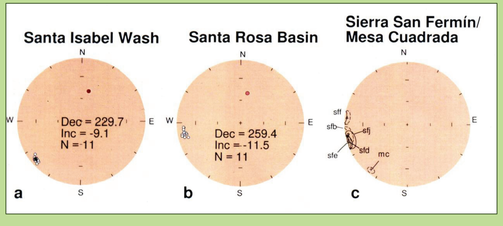


Figure 12: Vectors of paleomagnetic remanence, Tuff of San Felipe in Baja California. Results from three localities: Santa Isabel Wash, Santa Rosa Basin, and Sierra San Fermín/ Mesa Cuadrada (Stock et al., 1999).

Conclusions

The paleomagnetic remanence vectors of the four localities studied (Cerro La Ceja, El Portal in the Sierra Libre, San Miguel de Horcasitas, and El Gavilán) are nearly horizontal towards the SSW direction. This direction is very unlike the expected Miocene field direction for this latitude but it is similar to the direction found in the Tuff of San Felipe in Baja California and coastal Sonora. We conclude that these four locations additionally represent the Tuff of San Felipe/ Tuff of Hermosillo and extend its range beyond that previously known. However to improve our results and decrease the margin of error, more cores need to be analyzed. Geochemical and geochronological studies on these locations are in progress under the CONACyT project.