

PALEOMAGNETISM OF THE JURASSIC-CRETACEOUS VACA MUERTA FORMATION, NEUQUÉN BASIN, ARGENTINA

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ABSTRACT

A paleomagnetic study was carried out in three drill cores and an outcrop section from the Vaca Muerta Formation in the Neuquén basin, Argentina, one of the most important unconventional hydrocarbon reservoirs in the world. This geologic unit is up to *ca.* 400 m-thick and bears ammonites from the Andean Region that indicate Late Jurassic - Early Cretaceous ages. We isolated several normal and reverse polarity zones that were correlated with the International Geomagnetic Polarity Time Scale using the corresponding ammonite zones. Preliminary results are very consistent, and the paleomagnetic analysis is still in progress. Rock magnetic studies suggest that the magnetic carriers are pyrrhotite and Ti-magnetite.

Keywords: Jurassic-Cretaceous, magnetostratigraphy, Neuquen Basin

RESUMEN

Se realizó un estudio paleomagnético en tres testigos corona de pozo y en una sección aflorante correspondiente a la Formación Vaca Muerta de la Cuenca Neuquina, Argentina, la cual constituye uno de los reservorios de hidrocarburos no convencionales más importantes del mundo. Esta unidad geológica presenta hasta 400 m de espesor y porta amonites de la Región Andina que indican edades Jurásico Tardío-Cretácico Temprano. Las zonas de polaridades reversas y normales fueron correlacionadas con la escala de polaridades geomagnéticas internacional usando las zonas de amonites correspondientes. Los resultados preliminares muestran ser muy consistentes, aunque el estudio paleomagnético se encuentra aún en curso. Los estudios de magnetismo de rocas efectuados en las muestras sugieren que los portadores magnéticos son pirrotina y Ti-magnetita.

Palabras clave: Jurásico-Cretácico, magnetoestratigrafía, Cuenca Neuquina

Introduction

The palaeomagnetic study was carried out in core samples from three wells which comprise the marine Jurassic-Cretaceous Vaca Muerta Formation (Weaver 1931, Leanza *et al.*, 1978, Uliana *et al.*, 1999), in the southern Neuquén basin. We correlate these data with those obtained at the Loncoche outcrop section in the northern area of the basin (Fig. 1). As this geologic unit is one of the most important unconventional hydrocarbon reservoirs in the world, its thorough study has become a relevant target in Argentina. And since it comprises the J-K boundary, precisely dated with marine fossils within tuffs, Vaca Muerta Formation represents an excellent opportunity to obtain the first Late Jurassic-Early Cretaceous magnetostratigraphy of the southern hemisphere, which is in the interest of the oil industry as well.

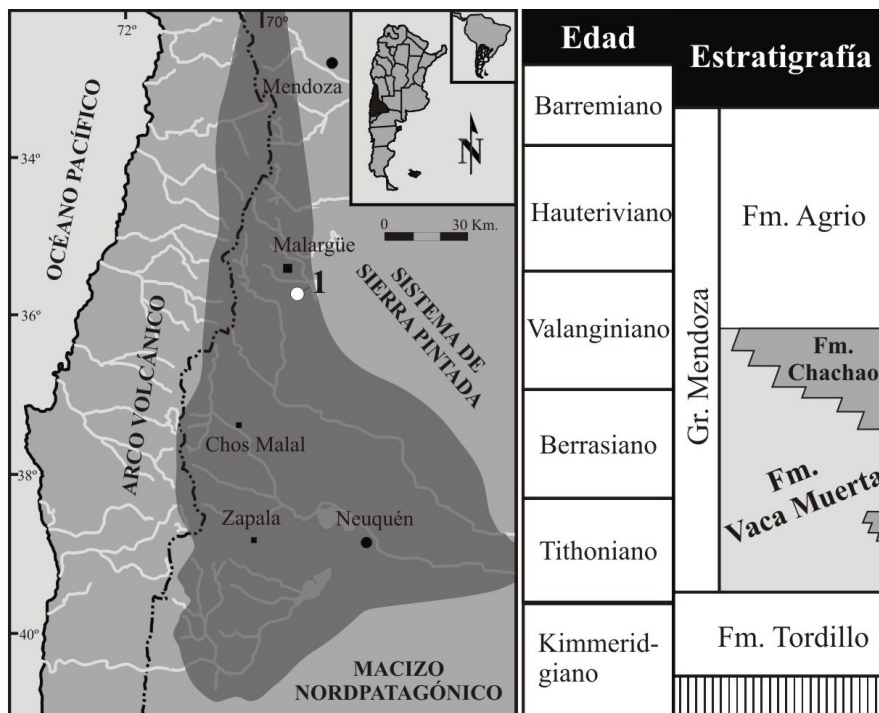
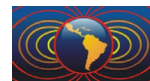


Figure 1. Location map of the Neuquén basin in western Argentina with detail of the study area (1) and stratigraphic chart of the Mendoza Group (modified from Kietzmann, Palma, 2010)

Objectives

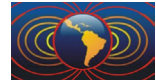
This contribution is focused on the polarity sequence and magnetic mineralogy, and is the continuation of those presented by Rapalini *et al.* (2013). Finally, the polarity sequence from cores has been correlated with that obtained in the Loncoche section, in continuation with the preliminary magnetostratigraphic study from Iglesia Llanos *et al.* (2013). The Vaca Muerta Fm. represents a carbonate ramp system of up to 400 m-thick, whose lower part is affected in some places, as in our study, by the intrusion of Miocene andesitic sills. The biostratigraphy is well studied in the area (*e.g.* Quattrocchio *et al.* 2003, Bown and Concheyro, 2004) and, particularly by using ammonite biozones (Riccardi 2008, Riccardi *et al.* 2011), we have been able to chronostratigraphically tie the paleomagnetic sites.

Methods

A total of 370 specimens were obtained in the three drill cores, oriented according to Rapalini *et al.* (2013). Cores are 130 to 325 m-long, and paleomagnetic sites have been dated according to the ages provided by ammonites. In the Loncoche section on the other hand, where the paleomagnetic study is still in progress, results from a total of 150 specimens have been added for this analysis.

All measurements have been performed at the Laboratorio de Paleomagnetismo Daniel Valencio, IGEB (CONICET-UBA). Rock magnetic studies consisted of *k vs. T* at both low and high temperatures, as well as *k vs. H* curves. These data integrated with demagnetization diagrams, allow us to interpret that magnetic carriers in the Vaca Muerta Fm. are titanomagnetites and pyrrhotite.

For paleomagnetic studies, both thermal and AF demagnetization methods have been used that proved to be successful. In the thermal demagnetization, 50, 100, 150, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500, 525, 550 and occasionally, 575°C, whereas in the AF, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 21, 25, 30, 35, 40, 45, 50, 60, 70 and occasionally, 110 mT steps were applied. Residual remanent magnetizations were measured with a 2G DC SQUID cryogenic magnetometer and a JR-6 spinner magnetometer.



Results

The resultant polarity succession is made up of 7 normal and 6 reverse polarity zones spanning the *Virgatospinctes mendozanus* to *Spiticeras damesi* ammonite zones (early Tothonian to late Berriasian). These polarities have been correlated with the international geomagnetic time scale of Ogg and Hinnov (2012) and the results will be presented.

References

- Bown, P., Concheyro, A., 2004. Lower Cretaceous calcareous nannoplankton from the Neuquén Basin, Argentina. *Marine Micropaleontology* 52, 51–84.
- Iglesia Llanos, M.P., Palma, R.M., Kietzmann, D.A., 2013. First magnetostratigraphic results of the Upper Jurassic-Cretaceous Vaca Muerta Formation, Neuquén basin, Argentina. *Latinmag Letters*, 3, *Special Issue*, OB022, 1-2. Proceedings Montevideo, Uruguay.
- Kietzmann, D.A., Palma, R.M., 2010. Primer registro de microcoprolitos de crustáceos de la Cuenca Neuquina: el icnogénero *Palaxius* en el Tithoniano de la Formación Vaca Muerta, Mendoza. *Ameghiniana*, 47 (2), 257-261.
- Leanza, H.A., Marchese, H.G., Riggi, J.C. 1978. Estratigrafía del Grupo Mendoza con especial referencia a la Formación Vaca Muerta entre los Paralelos 35° y 40° L.S. Cuenca Neuquina-Mendocina. *Revista Asociación Geológica Argentina* 32 (3), 190-208.
- Quattrocchio, M.E., Martínez, M.A., García, V.M., Zavala, C.A., 2003. Palinoestratigrafía del Tithoniano-Hauteriviano del centro-oeste de la Cuenca Neuquina, Argentina. *Revista Española de Micropaleontología* 354, 51–74.
- Rapalini, A. E., Luppo, T., Iglesia Llanos, M. P., Vásquez, C. A., 2013. Successful paleomagnetic azimuthal orientation of drill cores from a hydrocarbon source rock reservoir: The case of the Vaca Muerta Formation, Neuquen Basin, Argentina. *Latinmag Letters*, 3, *Special Issue*, OB12, 1-5. Proceedings Montevideo, Uruguay.
- Riccardi, A. C., 2008. The marine Jurassic of Argentina: a biostratigraphic framework. *Episodes*, 31, 326–335.
- Riccardi, A. C., Damborenea, S. E., Manceñido, M. O., Leanza, H. A., 2011. Mega invertebrados jurásicos y su importancia geobiológica. In: Leanza, H.A., Arregui, C., Carbone, O., Danieli, J.C., Vallés, J.M. (Eds.), *Geología y Recursos Naturales de la Provincia del Neuquén*. Asociación Geológica Argentina, Buenos Aires, 441–464.
- Uliana, M. A., Legarreta, L., Laffitte, G. A., Villar, H. J., 1999. Estratigrafía y geoquímica de las facies generadoras en las cuencas petrolíferas de Argentina. In: *IV Congreso de Exploración y Desarrollo de Hidrocarburos, Mar del Plata, Actas* 1, 91 pp.
- Weaver, C., 1931. Paleontology of the Jurassic and Cretaceous of West Central Argentina. *Mem. Univ. Washington*, 1, 469 p. Seattle, USA.