**Supplementary Material**

**Data processing**

Cruises FUTUNA 1 and 3 have been respectively carried out with the Autonomous Underwater Vehicle (AUV) *Idef-X* and *Aster-X*, and the manned submersible DSS *Nautile*. Both submersibles had a three-component fluxgate magnetometer mounted on them. We therefore have two datasets with relatively different characteristics arising from the specificities of the dives.

On both the AUVs and the *Nautile*, the magnetometer sensor was rigidly fixed to the metallic frame of the submersibles to avoid the risks of collision between the instrument and the seafloor. Because of this close proximity, the sensor measures the magnetic anomaly combined with the magnetic influence of the submersibles. These influences must therefore be removed from the data to get the magnetic anomalies.

In order to quantify this influence, we use calibration patterns, generally made of Figure-8s for the AUV while still at or near the sea surface. At that time, the submersible is far enough from the ship and the seafloor, so that the measured magnetic field should be that predicted by the International Geomagnetic Reference Field (IGRF) (X: 32814.7nT, Y: 6782.2nT, Z: -22068.7nT, T: 40122.7nT, Incl: -33.37°, Decl: 11.68°) (Thebaut et al., 2015). Any observed deviation from this assumption is seen as a consequence of the submersible magnetic influence, as other external sources are neglected. By completing these Figure-8s, we therefore get an estimation of the magnetic influence of the submersible in all directions and with varying values of pitch and roll, so that all the positions the submersible can get during the dive itself are taken into consideration. Based on this calibration pattern, we estimate the magnetic susceptibility tensor (3x3 square matrix) and the remanent magnetization vector (3 coefficients) that are removed from the data using an improved least square method (Honsho et al., 2009).

Because of the local orientation of the geomagnetic field, magnetic anomalies are phase-shifted with regards to their sources. They are impossible to directly interpret and need to undergo a further transformation called Reduction to the Pole (RTP) to replace them above their sources. Several methods exist to complete this processing step. The one we chose consists of inverting the magnetic anomalies (devoid of the AUV magnetic influence) into equivalent magnetization using Honsho’s Bayesian inversion (Honsho et al., 2012) and compute the RTP magnetic anomaly in the geometry of the experiment assuming a vertical geomagnetic field. Unlike other magnetic inversion methods (e.g., Parker and Huestis, 1974; Hussenoeder et al., 1995), this Bayesian inversion does not require any numerical filtering and preserves the wavelength content that makes near-seafloor signals of high value. We present the inversions and the computed RTP magnetic anomalies for all the studied areas (Kulo Lasi, Ono, Fatu Kapa and Tasi Tulo) in Fig. 2, 3, 4 and 5.

The thickness of the magnetized layer is one of the parameters to define prior to the inversion. A thinner magnetized layer leads to higher magnetization contrasts, as a smaller volume of magnetized material is taken into consideration to generate the observed magnetic anomaly. In theory, the thickness of the magnetized layer should not have any significant impact on the computed RTP anomaly, as the same thickness is used in computing the RTP anomaly by forward modeling. In practice, edge effects may affect the equivalent magnetization depending on the geometry of the experiment (magnetized layer thickness, roughness of the bathymetry, amplitudes of the AUV altitude variations, etc…). These edge effects appear as elongated magnetization contrasts along the AUV tracks. We tested different parameters and adopted the layer thickness that minimize the edge effects to compute a RTP magnetic anomaly devoid of noise. A 50 m thickness has been chosen for all studied areas except the Ono caldera, where a significant layer of sediments increases the distance between the magnetometer sensor and the underlying magnetized layer. Given this distance, the magnetometer images sources at greater depths and a thicker magnetized layer has been considered.

For the *Nautile*, the situation is slightly different, as the submersible is loaded with lead bags at the beginning of each dive to ensure a negative buoyancy. Because of its shape the submersible is naturally rotating at a nearly constant speed during the descent. The number of loops therefore depends on the depth of the dive. We use these loops to quantify the *Nautile* magnetic influence and remove it from the data in order to resolve the magnetic anomaly.

As the *Nautile* does not follow regular paths made of parallel profiles, its data cannot be gridded. The idea consists of computing the magnetic response a uniformly (1 A/m) magnetized seafloor would produce in the geometry of the experiment (i.e., along the route of the submersible). We estimate the coherency between the observed and the synthetic signals in the spectral domain along sliding windows. This coherency varies between 0 (different signals) and 1 (identical signals). If the coherency is high enough (>0.8), the seafloor absolute magnetization is estimated as the ratio between the observed and the synthetic signals. This comparison does not only provide the value of the rocks magnetization but also its polarity, as phases are being compared as well. This polarity is the key to constrain our interpretations of the Ono caldera (Fig. 3D) (Szitkar et al., 2015).

**References**

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