Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

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Speleothems can be an ideal record of paleomagnetism since they retain continuous geomagnetic records in stable condition as well as having applicability of high-precision radiometric dating via U-series and radiocarbon techniques. Although their weak magnetic signals hinder this archive to be widely used in the field, Lascu et al. (2016) successfully reconstructed paleomagnetic signatures during the Laschamp excursion from a stalagmite. A scanning SQUID Microscope (SSM) can image very weak magnetic fields at high spatial resolution, and hence could potentially solve this obstacle. However, only a primitive paleomagnetic mapping without interpretation has been made on a speleothem using SSM (Myre et al., 2019). In this study, we have conducted magnetic imagings at submillimeter scale with an SSM at Geological Survey of Japan, AIST on a speleothem collected at Anahulu cave in Tongatapu Island, the Kingdom of Tonga. The ^{14}C age of the surface part of the stalagmite is around 10 ka. The stalagmite block samples were cut perpendicular to the growing direction and shaped to a thickness of ca.0.2 mm before measurements with the SSM. The measured magnetic field is ~±1.5 nT at a senor-to-sample distance of ~200 μm. In association with the laminated structures of the speleothem, we observe stronger magnetic field for the surface layer compared with that of the inner layers. Furthermore, we conducted several magnetic experiments; i.e. first-order reversal curve (FORC) measurements, and low temperature magnetometry. We also conducted decomposition of Isothermal Remanent Magnetization (IRM) acquisition curves at a room temperature and a temperature below Verwey transition. These results show that the speleothem contains a mixture of magnetite and maghemite with different magnetic domain states. The proportion of magnetite and maghemite are shown to be different between the surface layer and the inner layers. These observations are consistent with the magnetic image of a rock magnetic parameter representing coercivity (S-ratio) calculated by inversion of a series of IRM measurements with the SSM.

Keywords: Scanning SQUID microscopy, paleomagnetism, speleothem

