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Laser-selective stepwise demagnetization: Application of a new technique in paleomagnetism with a scanning MI magnetic microscopy

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Thermal demagnetization is essential technique for a paleomagnetic cleaning and paleointensity determination. Previous thermal demagnetization are furnace-based, microwave-based and laser-based techniques. Furnace-based thermal demagnetization has proven to be useful adjuncts to both bulk samples and extracted non-oriented single grains demagnetization, but cannot be used to the in-situ one-to-one correspondence between magnetic components and individual oriented mineral grains. Microwave enables selectively to demagnetize ferromagnetic minerals through ferromagnetic resonance, but this technique is hard to determine how much temperature rises during demagnetization (Shaw et al., 1999). Previous laser-selective demagnetization enables the determination of the magnetic moment associated with individual mineral grains in thin sections of rock (Renne and Onstott, 1988). This technique used a high power pulse ruby laser, supplying 100 J of energy to the specimen through the optical system of a metallurgical microscope in a mu-metal box. However, the high power laser pulses produced a fusion crater and completely demagnetized the remanence. To overcome these restrictions of thermal demagnetization, we have been developing a laser-selective stepwise thermal demagnetization technique in cooperation with a scanning magneto-impedance (MI) magnetic microscopy (Uehara et al. 2005) that will map the triaxial components of the magnetic field above the surface of oriented rock slices. We employed 1.5W Diode Pumped Solid State (DPSS) green laser (532nm), supplying a tunable energy to the specimen through the hand-made optical system of a metallurgical microscope (laser module was rented from Pneum co. Ltd.). The laser spot size is approximately 0.05 to 0.15mm in diameter, resulting in a heating size of c.a. 1mm in diameter. The optical absorption of laser to solid materials depends on laser wavelengths and material's absorption coefficients. At 532nm, green laser is absorbed 60% by Fe and Ni, while it is absorbed only c.a. 10% by silicate glass. This difference could achieve a selective heating of metal-phase magnetic minerals from silicates. Moreover, our preliminary heating test with K-type thermocouple demonstrated a heating temperature control by tuned laser powers and a temperature rise up to 750 degree Celsius with a maximum laser power, being equivalent to Curie temperature of kamacite. Therefore, our green laser demagnetization system appears to be able selectively and stepwisely to demagnetize individual metal-phase magnetic minerals in rock slices. In the presentation, we will show a one-to-one correspondence between scanning magnetic microscope images and the stepwise laser-selective demagnetization of shocked granite slices from Vredefort crater.