パルス磁気緩和と高周波磁気ヒステリシス

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Pulsed-field relaxation and high-frequency-field hysteresis

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Dynamic magnetizations in time domain and frequency domain were measured on different kinds of natural samples (igneous rocks and sediments). In the time domain, the rapid decay of magnetization after switching off a pulse was measured with variable pulse lengths (10^{-5}s to 10^{-2}s) and amplitudes (0.5 mT to 0.7 T). Hysteresis curves were measured in one cycle of positive and negative pulses with the different rate of field variation. In the frequency domain, low-field magnetic susceptibility was measured over the frequency rage (1 kHz to 500 kHz) corresponding to the pulse lengths in the time domain measurements. The hysteresis curves were broadly comparable to the corresponding portions of the hysteresis loops measured by a quasi-static method using a VSM. The dynamic coercivity, defined as the intersect with the abscissa in the negative field regime, increased as the pulse length reduced or the pulse peak increased. In strong fields (>0.5 T), irrespective of the kinds of samples, small amount of magnetization remained at the end of a pulse and decayed exponentially with the time constant being a few ms. In weak pulsed-fields, no such rapid relaxation was observed with the volcanic rocks except the sediments and soils rich in superparamagnetic (SP) particles. These results suggest that the relaxations in the strong fields could be due to the dynamics of the domain walls in the MD particles of the volcanic rocks, while those in weak fields may be ascribed to the SP particles present in these sediments. Results in the frequency domain were presented in the form of the frequency spectrum of the real and imaginary components of complex susceptibility. Comparisons and interpretations of the data in these different domains were made in terms of the relaxation times. Discussions on the numerical transformation of these data as well as their rock magnetic implications will be provided.

パルス磁場を利用することによって、ごく短時間の磁気緩和を測定することができる（Kodama, 2015）。本研究では、単一パルスだけでなく、連続した正負２パルスを印加できるパルス磁化測定器を用いて、高周波の磁気ヒステリシスに相当する磁化曲線と ”保磁力 ” を得た。パルス磁場は、継続時間 10^{-5}s〜10^{-2}s、強度 0.5 mT〜0.7 T の範囲で可変である。これらのパラメータを変えることによって、いくつかの火山岩や堆積物（Tiva Canyon tuff、中国黄土）を対象に、緩和曲線や保磁力の変化を調べた。その結果、１）強パルス（>0.5 T）では、すべての試料で磁気緩和が観測され、それらの緩和時間は 10^{-4}s〜10^{-3}s である。２）短時間（〜10^{-5}s）の弱パルス（〜0.5 mT）では火山岩試料に磁気緩和は見られないが、堆積物では時定数〜10^{-3}s の緩和が見られる。３）パルス磁場変化率（dH/dt）が大きくなるにつれて、すべての試料で保磁力が増加し、それに応じてヒステリシス曲線（minor loop）が広がる。これらの時間領域での測定結果と周波数領域の結果（高周波磁化率スペクトル）を、相互にフーリエ変換・逆フーリエ変換して比較検討した。その結果とその他の岩石磁気特性とを総合すると、上記１）〜３）は、MD 粒子中の磁壁形成や不可逆磁壁移動などに伴う ”hysteresis relaxation ”（Betancourt, 2011）、SP 粒子の緩和時間の磁場強度や周波数に対する依存性（Alexander et al., 2007）などによって説明することができる。

文献

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