Magnetic granulometry of superparamagnetic-single domain particles in obsidians using alternating current susceptibility

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Particle size distributions of superparamagnetic (SP) - single domain (SD) particles in obsidians were estimated using alternating current (AC) susceptibility. Magnetic properties of particles near SP-SD boundary exhibit high sensitivity to particle size especially in AC susceptibility. Obsidians are essentially quenched glassy materials but contain abundant submicron Ti-poor titanomagnetite particles. AC susceptibilities of obsidians samples, which were collected at five source sites of archeological stone tools, were measured using Quantum Design MPMS at 20-300 K in temperature and at 0.1-1000 Hz in AC frequency. These obsidians showed Curie temperatures of 540-580 deg.C confirming Ti-free or -poor titanomagnetites. Hysteresis parameters of these samples plotted on a Day diagram suggest that some samples contain mixtures of single-domain and multidomain particles or pseudo-single-domain particles and others have high fractions of superparamagnetic particles. Samples possessing Ti-free titanomagnetites (stoichiometric magnetites) showed a peak of in-phase AC susceptibility at about 120 K irrespective of AC frequency. Two samples of Ti-poor titanomagnetites indicated gradual increases of in-phase susceptibilities, little frequency dependence and almost no out-of-phase susceptibilities, suggesting that there are no significant superparamagnetic fractions present in these samples. In contrast, large out-of-phase susceptibilities comparable to in-phase susceptibilities and strong frequency dependence were observed for another two samples. Temperature dependences both of in-phase and out-of-phase susceptibilities exhibit systematic variations in the peak temperatures in response to varying AC frequency.