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The power requirement of the geodynamo from scaling Joule dissipation in numerical models

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In order to constrain models of the thermal evolution of the core, the nucleation time of the inner core and possible requirements for core heat sources, the power needed to maintain the geomagnetic field against Joule dissipation must be known. Here we use results from a large number of convection-driven spherical shell MHD dynamo models to derive a systematic scaling of the magnetic decay time $\tau$ defined as the time-average of magnetic energy over Joule dissipation. The magnetic Reynolds number $Rm$ covers the range between 50 and 1000, Ekman numbers are between $3 \times 10^{-7}$ and $10^{-5}$ and magnetic Prandtl number $Prm$ between $0.25$ and $3$. The results are fitted fairly well by a simple relation of the form $\tau \sim Rm^{-1/4}$. A weak dependence on the magnetic Prandtl number is found. We use this fit and the parameter fit of the form $\tau \sim Rm^{-1/2} Prm^{1/2}$ to explore the effect of heat flow at the core-mantle boundary. Although the age of the inner core is constrained to be maintained is the constraint that makes it possible requirements for core heat sources, the power of the core, the nucleation time of the inner core and factors affecting the vigor of that convection, such as the viscosity of the mantle and barriers to convection. We investigate the effect which is significant especially for marine MT data. Such possibility, however, arise from the Cenozoic fallout of marine MT data. The tephra melts originated from similar mantle sources as the recent plinian and subplinian volcanic eruptions. The Cenozoic fallout layers from the Kagua Trench and Mariana trough during the cruise YK01-11, Kobe University cruise staff. The Cenozoic tephra glasses (approximately 1500 individual glasses from 43 layers) display coherent elemental systematics through time. At any given age, the tephra glasses display a distinct bimodal distribution, with maxima at 53-54 wt% SiO2 (basaltic andesitic) and 70-72 wt% SiO2 (rhyolitic), respectively. Basaltic andesitic glasses overlap widely with the Izu VF lavas, whereas the dacitic-rhyolitic pole is almost exclusively represented by the tephra glasses. A marine magnetotelluric (MT) experiment was carried out in the central Mariana area from 2001 to 2002 to elucidate electrical structure of the subduction arc-back arc system. The electrical conductivity is mainlly subject to temperature, partial melt, and volatiles such as water in the mantle. 10 ocean bottom electromagnets (OEMs) were deployed along the line crossing the central Mariana trough during the cruise YK01-11, in October 2001. This OEM array covers the Pacific plate to Parece-Vela basin through the Mariana trough. 5 of them were successfully recovered during the cruise using R/V Kaga, and 2 were located during the cruise KRO2-14 in October 2002. The MT analysis has been carried out using the data at the 5 sites and another 3 sites. Those additional data were collected by past experiments (Fukuda et al., 2003) and the sites locate near the survey line of one experiment. Gotu et al. (2003) analyzed 3 MT data sets around Mariana islands and Izu VF, and the sublithospheric conductive layer in the mantle wedge beneath the arc and fore arc region. In this study, we analyzed the 5 MT data sets in Mariana trough and Parece-Vela basin, so far. The MT responses were first corrected for the topographic effects which is significant especially for marine MT data. Then, the corrected responses are separated to TE and TM modes assuming then intrinsic dimensional (2D) model space independent. The responses for each mode are sensitive to electric current flowing either parallel or perpendicular to the 2-D strike. Obtained results show that the mantle resistivity decrease from several hundreds or more to several tens or less ohm-m at the depth of 60-70 km. The mantle below 60-70 km is, more conductive. The conductive mantle is result from drying out of olivine due to partial melting and lower conductive and anisotropic features manifestation of the alignment of olivine crystals to the mantle flow direction in wet condition.