

Elongation and distortion in distributions of paleomagnetic directions and their corresponding poles

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Properties of paleosecular variation (PSV), mainly derived from lava flow data for the last few million years, were often discussed in terms of the latitudinal dependence of the angular standard deviations (ASD) of the virtual geomagnetic pole (VGP) distributions after Cox (1970). Generally the ASD of VGP has a characteristic that it is smallest in the equatorial region and becomes higher in the higher latitude sites (e.g. McFadden et al., 1988). However mapping of each directional datum into the corresponding VGP is nonlinear and distorted on the unit sphere and its plots on a plane. Therefore it is not feasible that both distributions become synchronously circular except for sites around the geomagnetic poles. Recent accumulation of reliable paleomagnetic directional data has enabled us to discuss the more details of the nature of PSV, not only the ASD but also the shape of the distributions (Kono, 1997; Tanaka, 1999; Khokhlov et al., 2001).

In this study, by using Bingham statistics (Bingham, 1974; Onstott, 1980) we made a quantitative comparison in the shape of distributions between actual paleomagnetic data obtained from several sites on the Earth, where data from enough flows are available, and our recent PSV model (Hatakeyama and Kono, 2002) which has derived by nonlinear inverse procedures. Some important characteristics of the PSV appearing in the data and relation to the remarkable components in the Gauss coefficients were indicated as following, (1) the shapes of the VGP distributions show much circular than those of the field directions, which is general and especially significant in the low latitude region, (2) the distributions of the paleodirections are elongated toward the direction of the meridian, while those of the VGPs are elongated to the perpendicular direction, and (3) the circular nature of the pole distributions depends on the 'isotropic' PSV (Constable and Parker, 1988) which is independent of the order m in case of the same degree l , but the elongation perpendicular to the meridian is likely to be caused by large variances in a specific components ($l=2, m=1$) of spherical harmonics. This component also has been to be regarded as an importance for the latitudinal dependence of the ASD of VGP (Kono and Tanaka, 1995; Hulot, and Gallet, 1996).

More complex feature can be obtained from the paleomagnetic dataset, which is due to the mapping from the field direction to the pole or the opposite way. The distribution of the field directions seems the consequence of the mapping of comparatively circular or Bingham-like distribution of poles due to the field fluctuations. We define a new parameter describing degree of the the asymmetry in order to demonstrate such distortion.