Highly scattered paleomagnetic directions of middle Miocene volcanic rocks in the Inase area in Northeast Japan: vertical-axis rotations?

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We present paleomagnetic data showing highly scattered remanent magnetization directions obtained from middle Miocene (ca. 15 Ma) andesitic rocks in the Inase area in Northeast Japan. The aim of this study was originally to elucidate the timing of termination of counterclockwise rotation of entire Northeast Japan that occurred in association with backarc opening of the Japan Sea by determining a paleomagnetic direction of dated volcanic succession. Surprisingly, however, andesitic lavas and intrusive rocks in this area showed a fairly large dispersion of site-mean directions of characteristic remanent magnetizations (ChRMs).

Oriented rock samples were collected at 22 sites, and standard paleomagnetic analyses including stepwise demagnetization experiments were conducted to obtain reliable ChRMs. Of 20 site-mean directions determined, 19 were successfully corrected for gentle post-emplacement tilt. They have both positive and negative inclinations and show considerable scatter in the declinations, although many of the directions are northerly to easterly when the directions with negative inclinations are flipped. It seems that the scatter in the inclinations is relatively small compared to that in the declinations; the directions yield a best-fit small circle with an almost vertical conical axis. An inclination-only calculation gives a mean inclination of ca. 47˚, which is close to the middle Miocene inclination value expected in the study area. Demagnetization data indicate that the main magnetic mineral carrying ChRMs is magnetite or Ti-poor titanomagnetite.

Two possible mechanisms can explain the observed scatter of the directions. One is that the sampling sites are within ancient hummocks in volcanic debris avalanche deposits. During a debris avalanche event, hummocks can rotate around vertical axes like teacups of an amusement ride, and such movement can result in the distribution of site-mean directions along a small circle. However, we do not prefer this mechanism because we have no geological observations supporting a debris avalanche origin of the volcanic formation in this area. Another mechanism that can cause the distribution of directions along a small circle is vertical-axis tectonic rotations. These rotations could be related to what a recent model suggests: the western half of Northeast Japan was broken into several “dominos” by middle Miocene strike-slip faulting. The Inase area is located near the eastern end of the possible dominos, and domino rotations might have resulted in vertical-axis rotations of smaller blocks near the end of the dominos. This hypothesis could be tested by structural mapping in the Inase area.

Keywords: middle Miocene, Northeast Japan, paleomagnetism, vertical-axis rotation

