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Testing paleointensity determination using Wilson method

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The classical Thellier method still remains most reliable for paleointensity determination, but requires a quite demanding and rarely satisfied condition; a natural remanent magnetization (NRM) must be completely replaced by a laboratory thermoremanence (TRM) at every temperature interval. If a significant amount of multidomain grains is present, this condition is not satisfied and resulting in erroneous paleointensities as obtained from curvatures seen on the Arai diagrams.

A single-step heating method, which sounds quite primitive as adopted in early times (e.g., Folgheraiter [1899]) but is essentially still alive as in the Shaw method, escapes from the strict condition posed on the Thellier method. The Wilson method, being a sort of single-step heating methods, was developed a half century ago (Wilson, 1961 & 1962); comparison of high-temperature continuous thermal demagnetization curves, measured for a natural remanent magnetization (NRM) and then a thermal remanent magnetization (TRM) acquired in a known laboratory field, yield a paleointensity. The reason why the Wilson method was rarely used for paleointensity studies is that magnetization needs to be measured at elevated temperature. Yet this method has a great advantage of being extremely quicker than the other paleointensity methods. If using a modern automated high-temperature magnetometer, we can complete a Wilson measurement within one hour for a 1-cc cube.

We performed testing paleointensity measurements based on the Wilson method for 27 1-cc cubes of basalts and scorias of the 1983 eruption in Miyakejima (the expected field of 45.1 microT). A 1-cc cube was heated in air at the rate of ~40 deg.C per minute along with measuring three-component NRM at elevated temperature using a Orion three-component vibrating sample magnetometer at the Borok Geophysical Observatory. When the magnetization is decreased less than 1 percent of the initial value, heating was stopped and then total TRM was imparted during cooling down in the magnetic field of 45 microT. The total TRM was also continuously demagnetized in the same way as NRM.

We did find nicely straight lines on the NRM-TRM diagrams for 85% of measured samples, indicating that the shapes of unblocking temperature spectrum are essentially unchanged for NRM and TRM. We obtained the expected field intensity of 45.1 microT for the about half of the samples. The Thellier method for the sister samples also gave the expected field, but some of the samples did not. For the another half, the gradients of NRM-TRM lines significantly deviated from unity to higher or lower values. This means that thermal alteration (NOT including domain alteration) increased or decreased TRM capacity but did not appreciably changed unblocking temperature spectrum. Such a kind of alteration is not detected on NRM-TRM diagrams, therefore it is possible to give erroneous paleointensities.

Although the Wilson method is quick and robust even for samples containing multidomain grains, we need to take caution that thermal alteration is not necessarily detected from the linearity on NRM-TRM diagrams. This caution should be exercised for other kinds of single-step heating methods.

Keywords: paleointensity, Wilson method, Thellier method, high-temperature magnetometer