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Secular variation of the Earth magnetic field recorded in Holocene lava flows from Chile

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The recent secular variation of the Earth's magnetic field is mainly characterized by the large growth of the South Atlantic Magnetic Anomaly during the last three centuries, first documented in the geomagnetic field model GUFM (Jackson et al., 2000). This present-day magnetic anomaly is characterized in Chile by low magnetic inclinations and low intensities of the geomagnetic field (-40° and 25.7μT at 40°S). In order to better describe the secular variation during the Holocene, we sampled 21 dated lava flows or pyroclastic flows from several Chilean volcanoes (Lonquimay, Llaima, Solipulli, Villarrica, Mocho-Choshuenco, Osorno, Calbuco). Juvenile clasts from basaltic-andesitic pyroclastic flow deposits provide reliable paleomagnetic results (Roperch et al, 2014). We also sampled 56 sites in Holocene lava flows with only relative ages with respect of the dated units.

Paleomagnetic results were obtained from several sites in two well-dated historic lava flows; 9 sites and 11 paleointensity results (PI) from the 1835AD eruption of the Osorno volcano and 8 sites and 23 PIs from the 1751AD eruption of the Llaima volcano. In addition, 14 PIs were obtained in bricks from shelters built along the main path across the Andes from Santiago (Chile) to Mendoza (Argentina) in 1768AD. These results confirm the high reliability of the global geomagnetic model GUFM for the last three centuries.

At Villarrica, results from 10 sites in lava flows (calibrated age 1440AD$\pm$30) provide paleomagnetic directions that are different from the CALS3k.4 model (Korte et al., 2011) indicating that more paleomagnetic results in well dated lava flows are necessary to improve the robustness of global geomagnetic models prior to 1700AD. The steepest inclination of the geomagnetic field (-71.6°) and the highest intensity (70μT$\pm$5) are found in the time range 850-900AD. This observation is made from paleomagnetic results from a pyroclastic flow from the Osorno volcano (calibrated age range of 782-966AD). The steep inclination is also observed in dated lava flows of the same age range to the north of the Llaima volcano (calibrated age range from 720 to 980AD). The VGP associated with the steep inclination is not much different from the VGP recorded at European sites suggesting a significant dipole wobble at that time.

Mean PIs of 63, 60.3 and 57.5μT obtained in three dated units in the time range 0-2000BC confirm the high geomagnetic dipole moment of the Earth's magnetic field for the two millennia BC. In contrast, paleointensity results from the Lican ignimbrite at Villarrica and the Curacautin ignimbrite at Llaima volcano show that the magnetic field strength was low just prior to the Holocene (-14000 -15000 BC).

The available paleomagnetic results from Chile indicate little geomagnetic secular variation in direction during the Holocene. Thus the large and rapid secular variation during the last three centuries appears to be a recent anomalous feature of the Earth's magnetic field.

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