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Archaeomagnetism study of iron metallurgy archaeological sites in Togo and Benin

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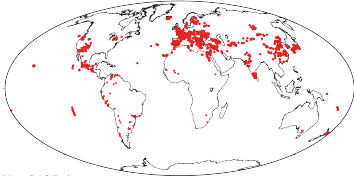
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Scientific context and objectives

Archaeomagnetic data are very rare in Sub-Saharan Africa, representing only 0.7% of GEOMAGIA50 global database. This lack of data makes poorly constrained the secular variation over the last millennia in this region, while intertropical Africa is one of the areas with the most rapid changes in the modern geomagnetic field, especially because of the proximity with the South Atlantic anomaly.

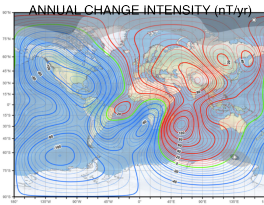
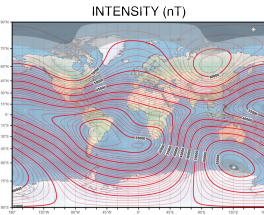


N = 6135 data
Geographic distribution of intensity data (from Brown et al., 2021)

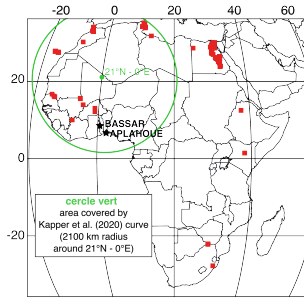
The archaeological potential is yet important. In Sub-Saharan Africa, the best-preserved baked structures are iron furnaces and several studies have been recently published in Kenya (Tchibinda et al., 2020), Burkina Faso and Ivory Coast (Kapper et al., 2017, 2020). Kapper et al. (2020) proposed an intensity secular variation curve defined with data from West- and North Africa. This "local" curve remains uncertain, particularly because it covers a very large area.

The objectives of our study are:

- ➔ Confirm the reliability of furnaces for directional and intensity study
- ➔ Acquire new archaeomagnetic data at low latitudes in Togo and Benin
- ➔ Improve the knowledge of the secular variation for 1000 years in West Africa



Intensity at the Earth's surface in 2020 (Chulliat et al., 2020)



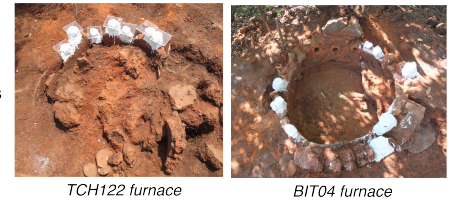
Archaeomagnetic data in Africa

Studied sites

1) Togo, Bassar country

9.5°N - 0.6°E, 3 sites
In situ sampling of 15 furnaces
¹⁴C dating: XVI-XXe c. CE (imprecise, plateau effect)

Directional study for dating + Archaeointensity study



TCH122 furnace

BIT04 furnace

2) Benin, Aplahoué region 7.0°N - 1.7°E

collect of baked clays in different layers of slag heaps (several artefacts per layer)
17 ¹⁴C dating on charcoals: XIV-XVe c. CE



Archaeointensity study

furnace wall

pottery

tuyere

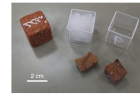
Archaeointensity results and interpretations

Theillier-Theillier protocol

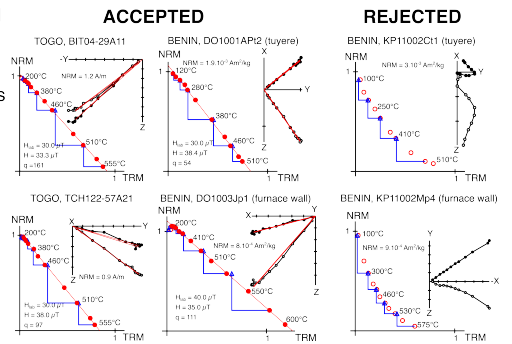
TRM anisotropy and cooling rate corrections

Togo: 20 standard cubes (success = 90%)

Benin: 110 specimens on 38 artefacts (success = 82%)



4 new data in Togo and 7 in Benin



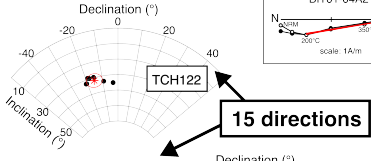
These good results highlight further the feasibility of archaeomagnetic analyses on such baked clays. The average intensity obtained on the most recent Togolese furnace dated [1923; 1977] (32.2±1.1 μT) is very close to the value predicted by IGRF model at this period (32.0 - 32.5 μT).

Togo: archaeomagnetic dating with archaeodirections

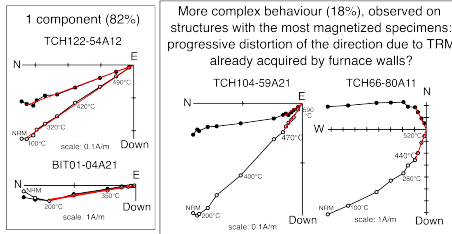
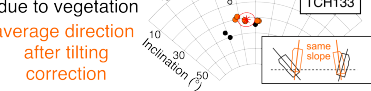
Large NRM intensity differences (0.03 - 30 A/m)

Thermal demagnetization TRM anisotropy correction

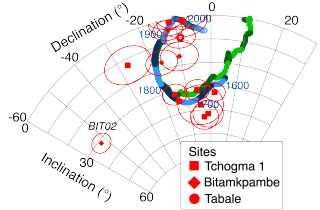
Case 1: 12 structures: well grouped directions



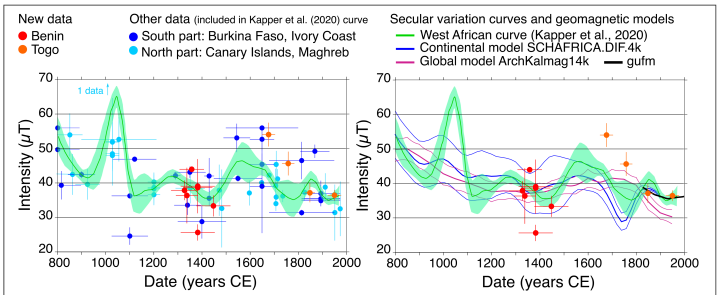
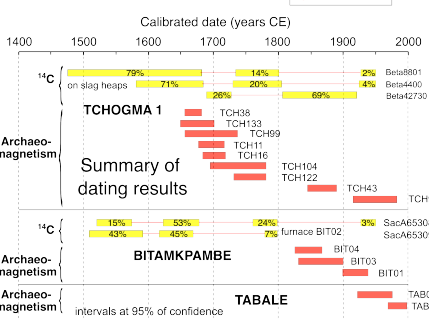
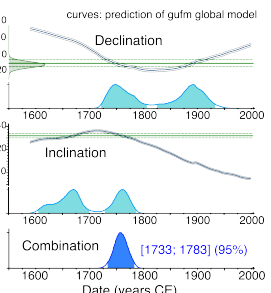
Case 2: 3 structures: scattered directions due to vegetation



Comparison of average directions with models gufm and BIGMUDIn.1 (Arneitz et al., 2021)



Example of dating: TCH122 furnace



Comparison of new data with selected data and curve in Kapper et al. (2020) and predictions of geomagnetic models (data relocated and curves calculated at 21°N - 0°E)

- ➔ Beninese data suggest a fast secular variation between 1300 and 1500 CE with an intensity minimum.
- ➔ Togolese data (still preliminary) show a sharp intensity decrease between 1650 and 1850 followed by a slower variation.
- ➔ New data are fairly in agreement with those from Burkina Faso and Ivory Coast (Kapper et al., 2017, 2020).
- ➔ The inconsistency with the regional curve of Kapper et al. (2020) and the prediction of the continental geomagnetic model SCHAFFRICA.DIF.4k (Di Chiara et Pavon-Carrasco, 2022) between 1600 and 1800 CE could highlight a different secular variation between Sahel and North Africa.
- ➔ The predictions of global models appear more consistent with the data, even though they smooth significantly the secular variation.

Conclusions

The new intensity data constitute a further step towards a better knowledge of the secular variation in West Africa. This study also highlights the potential of archaeomagnetic dating to better reconstitute the chronology of iron metallurgy, one of the main markers of past societies in Sub-Saharan Africa.

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