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Rock magnetic investigation of possible sources of the Bangui magnetic anomaly

M. Ouabego [a,b], Y. Quesnel [b,*], P. Rochette [b], F. Demory [b], E.M. Fozing [c], T. Njanko [c], J.-C. Hippolyte [b], P. Affaton [b]

[a] Geosciences Laboratory, Bangui University, Bangui, Central African Republic
[b] Aix Marseille University, CNRS, IRD, CEREGE UM34, 13545 Aix-en-Provence, France
[c] Environmental Geology Laboratory, Dschang University, BP67 Dschang, Cameroon

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ABSTRACT

The Bangui magnetic anomaly (BMA) is the largest lithospheric magnetic field anomaly on Earth at low latitudes. Previous studies investigated its geological source using constraints from satellite and ground magnetic field measurements, as well as from surface magnetic susceptibility measurements on rocks from the Panafrican Mobile Belt Zone (PMBZ). Here we combine magnetic field data modelling and rock magnetic property measurements (susceptibility and natural remanent magnetization, NRM) on many samples from this PMBZ and the surrounding formations. It reveals that NRM is a significant component of the total magnetization (Mt) of the BMA source, which reaches 4.3 A/m with maximum thicknesses of 38 and 54 km beneath the western and eastern parts of the BMA. Only the isolated and relatively thin banded iron formations and some migmatites show such Mt values. Thus we suggest that the thick BMA source may be composed either by overlapped slices of such metamorphic rocks, or by an iron-rich mafic source, or by a combination of these two geological structures.

1. Introduction

Located in Centrafrican Republic, the Bangui magnetic anomaly (BMA) is one of the largest lithospheric magnetic field anomaly on Earth, proeminent even at satellite altitude. Different models have been proposed concerning its geological source. First, Regan and Marsh (1982) suggested that a geological metamorphic process affected the entire crust of this area during the Panafrican orogenesis, creating physical property contrasts between cratonic regions and collisional belts. Ravat (1989) reinforced this model but suggested an additional concentrated near-surface ore-like body (see also Ravat et al., 2002; Langel and Hinze, 1998). This shallow body could correspond to the remains of an iron meteorite that fell in this area during the Proterozoic era (Girdler et al., 1992; see also De et al., 1998; Gorshkov et al., 1996). Shock, thermal and/or chemical remanent magnetizations acquired during and after the impact should have led to this highly-magnetized body. However, the impact hypothesis is less suitable since the impactor material does not survive in significant amount in large craters and thus cannot contribute to such a large magnetic anomaly (Koeberl, 1998). Furthermore no shock remanent magnetization was observed on the rock samples from this area (Marsh, 1977). All these studies lack of constraints from magnetic property measurements on the corresponding rocks of this area. Here we combined rock magnetic measurements with magnetic field anomaly modelling in order to investigate the possible source of the BMA.

In the first section, we summarize the geological context of the Centrafrican Republic, especially in our studied area. Then, the BMA is introduced before the description of the methods used. The next section details the results of magnetic property measurements and BMA modelling over the studied area. The last section corresponds to a discussion on the origin of the BMA, in the context of the general challenge involved in understanding large and deep crustal anomalies using limited access to rock samples (e.g. Frost and Shive, 1986; McEnroe et al., 2004; Rochette et al., 2005).

2. Geological context

Central Africa is a key area of the African Plate since it constitutes the transition between several old cratons (Fig. 1a and b). This transition corresponds to several orogenic belts such as the Panafrican belt (Nickles, 1952; Gérard, 1958; Black, 1966; Mestraud, 1971; Alvarez, 1992, 1995; Rolin, 1995a,b). These belts are mobile zones of the Panafrican Orogenesis at 600 ± 100 Ma (Kennedy, 1964; Rocci, 1965; Black, 1966). During this orogeny plate movements closed oceanic areas leading to a belt of suture zones around the cratons in the African regions of Gondwana. Our study

* Corresponding author. Tel.: +33 442971590; fax: +33 442971595.
E-mail address: quesnel@cerege.fr (Y. Quesnel).

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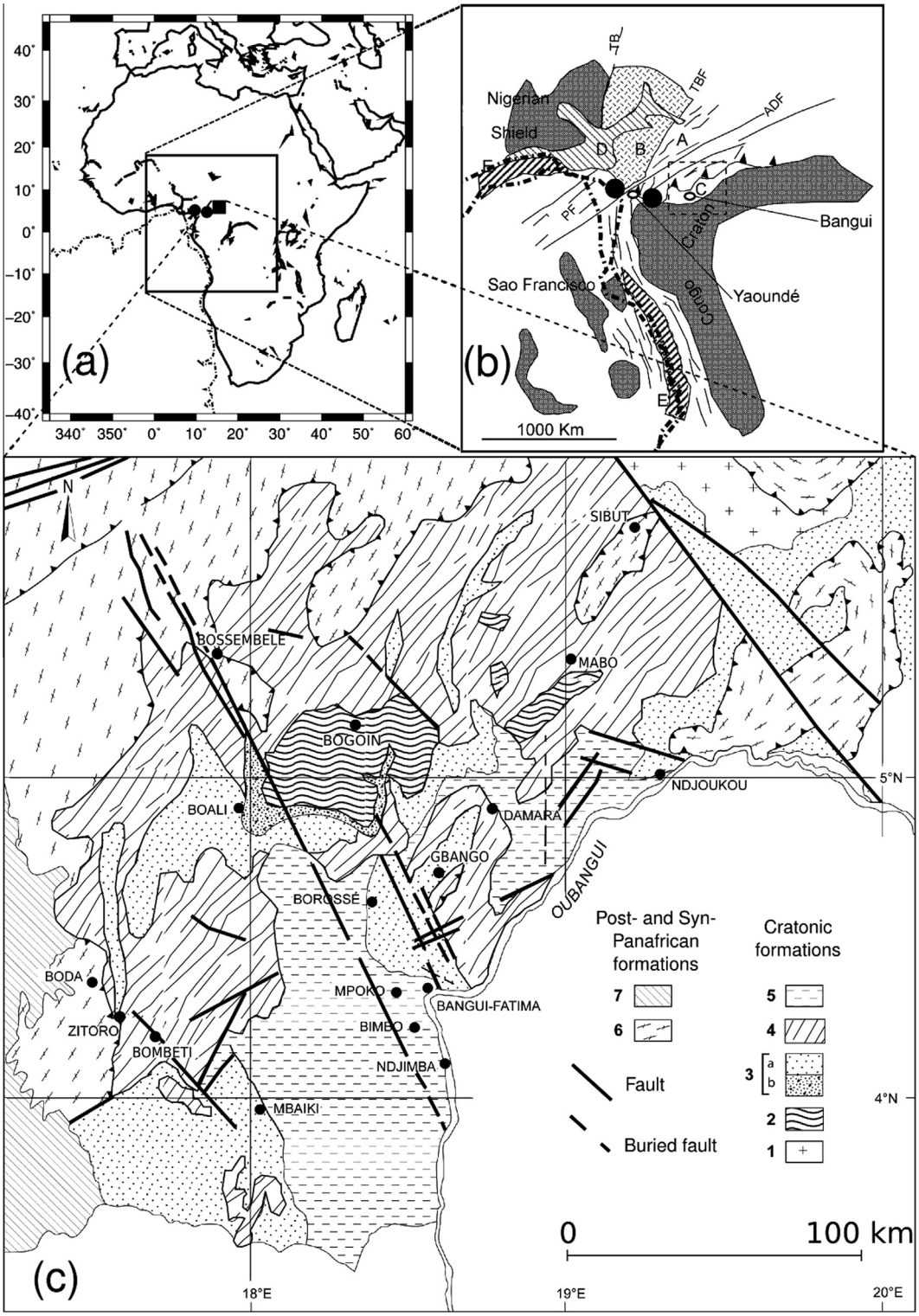

Fig. 1. Location (a), regional (b) and local (c) geological contexts of the studied area. In (a), the black rectangle and disks correspond to the sampled areas in Centrafrican Republic and Cameroon, respectively. The dotted-dashed line delineates the coastline of South America, translated and rotated next to Africa. A zoom is shown in (b) where the relationships between the different Archean blocks are reconstituted. Zone A corresponds to the Paleoproterozoic rocks with Archean inheritances underlining the border of the mega-Congo craton. Zone B are the Pan-African rocks with Paleoproterozoic inheritances. Zone C represents the nappes of the 600 Ma Central African Belt. Zone D corresponds to the Mesozoic sediments of the Benue trough and Zone E are the oceanic rocks. PF, Pernambuco fault; ADF, Adamawa fault; TBF, Tchollire–Banyo fault; dotted-dashed lines: reconstituted South America (SW one) and Africa (NE one) coastlines. This (b) regional map is modified from Penaye et al. (2004), Poidevin (1991), Ferré et al. (1996), Feybesse et al. (1998), Almeida et al. (2000) and Toteu et al. (2001). The dashed rectangle corresponds to the Centrafrican sampled area (c), while the black disks show the approximate locations of the sampled areas in Cameroon. In (c), modified from Rolin (1995a), details about the surface lithology and the structural features of the studied area nearby Bangui are shown. 1, Archean gneissic basement; 2, Paleoproterozoic migmatitic domain; 3, Lower-Neoproterozoic domain with (a) quartzites and (b) itabirites; 4, Upper-Neoproterozoic schists; 5, Upper-Neoproterozoic limestones/marbles; 6, Panafrican Gbayas Nappe with orthogneisses, granulites and granites; 7, Post-Panafrican cover with sandstones and clays. Black filled circles with names indicate the sampling sites.