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Comment

Comment on: “Geochronological arguments for a close relationship between surficial formation profiles and environmental crisis (c. 3000–2000 BP) in Gabon (Central Africa)” – D. Thiéblemont et al., 2013, C.R. Geoscience, 345, 272–283

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Thiéblemont et al. (C.R. Geoscience 345, 2013) consider that the soils from Central Africa and Gabon were restored by aeolian deposits after an environmental crisis, c. 2000 BP. The authors are convinced that the surficial formation laying on the stone-lines are sediments rather than soil horizons (discussion, pp. 277–278). The main argument sustaining this conviction lies in the fact that the upper layers are relatively homogenous on a particle-size point of view, which would be incompatible with biological activity (p. 278, l. 15 and following).

It is not possible to consider that all soil scientists who work – or did work – in the area mistake (or mistook) the geological surficial formation with the thick soils, known as *sols ferrallitiques*, *oxisols*, *ferralsols*, which characterize Central Africa. The formation of these soils and their morphological features have been discussed in numerous papers. Soils from Gabon, Congo, and Cameroun with stone-line profiles alone have been the subject of hundreds of articles, which have notably shown the high genetic relationships between the rocks from the substratum and the loose levels that cover the stone-lines (see, for example: Schwartz, 1996; Vogt and Vincent, 1966a,b). Furthermore, the argumentation raised by the authors contradicts the numerous studies highlighting the role of bioturbation as a major process of soil dynamics. Reworking of ground by termites or worms leads to the homogenization of particle-size fractions, although a slow increase with depth in the clay fraction is often observed in the case of sandy soils. As a consequence, bioturbation also leads to the scattering of coarse elements originally laying on the topsoil within the soil.

This process is frequent for charcoal (Carcaillet and Talon, 1996), but also for archeological artifacts. In a recent paper, Schwartz and Gebhardt (2011) have described a real case study: scattering and sinking of Bronze Age shards at 50 to 75 cm depth into a sandy soil due to bioturbation by worms, the soil becoming strictly homogenous on a particle-size point of view. These articles refer to temperate areas, but the conclusions reached should also apply in the case of intertropical regions given the very fast biological activity. Termites especially are very abundant, and can bring ground from several meters depth up to the surface. Moreover, the description of a profile given by Thiéblemont et al. (Fig. 6 of the commented paper) argues in favor of the presence of biological activity. On a 1 m depth profile, several charcoal layers having approximately the same age (about 2000 years) occur. Such a feature most likely results from scattering of charcoal by bioturbation after a single forest fire event, rather than being due to several distinct fire events, each of them being followed by quick and fast aeolian deposits.

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The theory of a recent (2000 years) aeolian origin of the soil horizons overlaying the stone-lines, both in Gabon or all Central Africa, and the generalized formation of the stone-lines predating this event, is supported neither by field observations nor by analytical measurements.

Typical aeolian landforms are completely lacking in Central Africa, except coastal linear dunes edging the coastal plains. In other areas, aeolian landforms are often well preserved. For example, in Amazonia, fields of linear dunes have been formed between 32000 and 8000 BP (Carneiro Filho et al., 2002). Since that, they are stabilized. However, they can still be easily recognized (see, for example, Carneiro Filho and Zinck, 1994, or Google Earth: 0° 32′ 18,78"N; 63° 18′ 43,15" O). How would it be possible that strong/intense aeolian episodes, not older than 2000 years, did not leave recognizable features in Central Africa?

Aeolian transport leaves typical impacts on sand particles (Le Ribault, 1977). However, in Central Africa, such impacts cannot be observed by scanning microscopy. For example, on the Bateke sands, aeolian marks are contemporary with Tertiary deposits, these marks being all polished by more recent fluviatile reworking (Schwartz, 1985).

Aeolian transport should also result in the formation of lacustrine silt deposits. Many lakes have been investigated in Cameroon, Gabon and Congo during the last twenty years (see in Maley's comment). Up to now, the only aeolian deposit that has been recognized consists of Saharan diatoms (Nguetsop et al., 2004).

Particle-size composition of soil horizons overlaying the stone-lines is very variable in Central Africa, and reflects the composition of the parent material. The proportion of the loam fraction is low ($< 15\%$), which is the general rule in ferralsols. The part of clays and sands is very variable, and the soils are generally poorly sorted, whereas aeolian processes should result in very well-sorted sediments.

Aeolian sediments can be transported over long distances. This is totally in contradiction with the general case noticed in Central Africa, i.e. the high genetic relationship between the mineralogical and petrographical features of the soil horizons overlaying the stone-lines and the parent rocks in place (Schwartz, 1996; Lanfranchi and Schwartz, 1991; Vogt and Vincent, 1966a,b).

Many archeological prospections in Gabon, south-Cameroon, North and South-Congo have shown the large occurrence of Sangoan type (70000–40000 BP) artefacts on the top of the stone-lines (Lanfranchi and Clist, 1991; Lanfranchi and Schwartz, 1990) in all these areas. It was sometimes possible to recognize structures such as knapping sites, which demonstrate that the artefacts are strictly in position and that the soil profiles were not disturbed since burial (at least, 40000 BP). On the contrary, the more recent lithic industries are rarely directly on contact with the stone-lines, except in some savannah areas that were submitted to high erosion processes during the Upper Holocene (Nyanga and Lopé in Gabon, Niari in Congo). In the latter case, lithic industries are mixed on the top of the stone-lines, whereas in the general case Tshitolian (10000–6000 BP), Neolithic (6000–c. 2400 BP) and Iron Age industries occur within the soil horizons overlaying the stone-lines. As a consequence, these horizons were predominantly formed before the presumed "aeolian" crisis reported by Thiéblemont et al. The oldest metallurgic site of the Congo (about 2100 BP), for example, was discovered at 50 cm depth, well above (i.e., 1 m) the stone-line (Schwartz et al., 1990).

The $\delta^{13}C$ composition of the organic matter (SOM) of savannah soils from Congo (Schwartz, 1991) and Gabon (Delègue et al., 2001) also brings good proxies. As a very general feature, the $\delta^{13}C$ fingerprint of SOM in the upper horizons (0–30/50 cm) is typical of savannah, whereas this $\delta^{13}C$ signature is typical of forest in the deep soil horizons. In the medium horizons, one can notice a very progressive change from savannah to forest signature, as a consequence of the mixing between young savannah SOM and ancient forest SOM. This mixing is the result of millennia of bioturbation activity, at least 7000 years according to the mean residence time of SOM in deep horizons. As a consequence of this bioturbation, the distribution of the SOM follows a bi-modal model, as shown by Schwartz et al. (1992). If the surficial formations overlaying the stone-lines were consisting of sediments deposited during several distinct episodes, the $\delta^{13}C$ changes of the SOM should not be progressive, but should show (very) abrupt changes.

According to me, there are no solid elements to argue in favor of strong aeolian processes in Central Africa during the Upper Holocene, except in coastal plains. The general formation of stone-lines at about 3000 BP and its burying c. 2000 BP are not demonstrated. On the contrary, this hypothesis is not suitable given the numerous field and analytical observations.

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