New Insights on West African Tectonics and Iron Mineralisation Based on Zircon U-Pb SHRIMP Geochronology and Structural Mapping

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Three main types of iron mineralisation occur in West Africa: Palaeoproterozoic BIF-style on the Leo-Man Shield (e.g. Simandou), Neoproterozoic specularite of hydrothermal origin (e.g. in the Marampa Group), and metamorphic magnetite (e.g. in the Kasila Group). Understanding the distribution of major tectonic units and reconstruction of the geological evolution of the region are keys to assessing the prospectivity for iron mineralisation in underexplored areas.

Mapping, combined with zircon U-Pb geochronology of key units in Guinea and Sierra Leone, confirmed the presence of Archaean units with low metamorphic grade, ascribed to the Leo-Man Shield, structurally verlain by allochthonous units of the Marampa Group, which includes metavolcanics. To the west, an upper-amphibolite to granulite-facies grade metasedimentary/metavolcanic succession occurs (Kasila Group). To the east of the Marampa Group, a succession of largely undeformed coarse clastics and volcanics occurs (Rokel River Group).

New zircon U-Pb geochronology of gneisses from the basement to the Marampa Group (Kenema Assemblage) in Sierra Leone indicated ages between ~3.17 and 2.85 Ga, within the range of published U-Pb data on rocks from the Leo-Man Shield farther east (3.54 – 2.71 Ga). One sample from a magnetite-rich unit in the Kasila Group, interpreted to be of volcanic origin, gave a crystallisation age of 1.94 Ga. Detrital zircons from two samples of the Marampa Group, one chloritic schist and one quartzite, yielded a broad range of between 3.2 and 1.1 Ga, including main populations at 3.05, 2.85, 2.2 – 1.8, 1.5 and 1.1 Ga. The youngest concordant detrital zircon, dated at 1030 ± 40 Ma, provides a maximum age of deposition. Source regions for some of these populations in the Marampa samples are not present within the West African Craton, but are present in the Amazonia Craton. Most samples analysed show evidence of Pb-loss, with regressions towards 0.5 Ga. Four concordant analyses in one sample provide an age of 588 ± 7 Ma, interpreted to reflect peak metamorphism in the Rokel-Kasila Belt. This metamorphic age falls within cooling age ranges on biotite, muscovite and hornblende across the region, ranging from 585 to 510 Ma.

Based on the new data, a new tectonic model is proposed for the Rokel-Kasila Belt, in which the Kasila Group is interpreted to form a remnant part of the Amazonia Craton, left attached to the Leo-Man Shield after Neoproterozoic collision. The Marampa Group represents the thrusted nappes of intervening oceanic sedimentary successions, which show derivation from both the Amazonian and West African margins, while the Kenema Assemblage forms part of the Leo-Man Shield.

This interpretation facilitates reclassification of the known iron mineralisation, and enables regional-scale prospectivity analysis. Palaeoproterozoic BIFs are widespread over the Archaean shield in greenstone belts and are the most extensive and highest in grade. Specularite deposits are regionally restricted to the Marampa Group, and are controlled by the basal thrust contact with the underlying Kenema-Man Shield. These deposits are generally smaller and have lower grades. Metamorphic magnetite-rich units occur only in the Kasila Group, but are sub-economic because of their low grade and small size.

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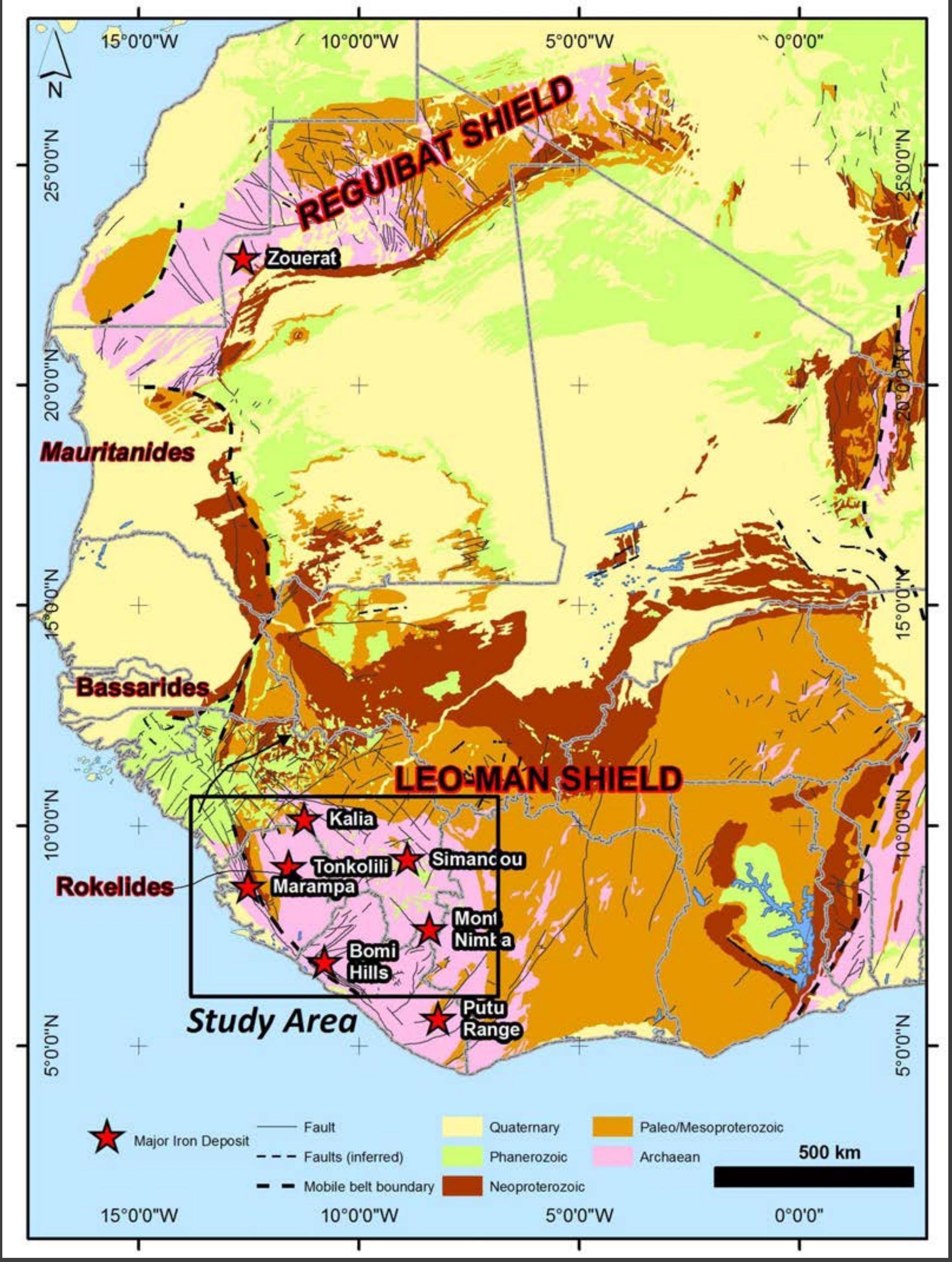

Regional Overview

West Africa is underlain by the West Africa Craton, which is exposed as the Reguibat Shield in the north, and the Leo-Man Shield in the south.

The western portions of these shields are Archaean in age, while the eastern portions are strongly affected by Palaeoproterozoic reworking in the Eburnean orogeny (also knows as "Birimian").

Along the west, a series of Neoproterozoic belts occur, from north to south the Mauritanide, Bassaride and Rokelide belts.

Much of the craton is covered by Phanerozoic successions and Quaternary sands of the Sahara.

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Scope of work and methodology

- The work presented in this study is the result of structural mapping work in Guinea, Sierra Leone and Liberia for various iron ore explorers.
- The mapping included various parts of the Leo-Man Shield (granite-greenstone terrain), the "Kenema-Assemblage" of Sierra Leone, and the Rokelide Belt in Guinea and Sierra Leone.
- Structural mapping results were integrated into regional map data and formed the basis of a reinterpretation of the regional geological framework and genetic models of iron ore mineralisation in the region[1].
- Geochronological samples were collected for zircon U-Pb SHRIMP[2] work from :
  - Granite-gneiss units of the Leo-Man Shield
  - Basement units exposed in the Rokelide Belt ("Kenema Assemblage")
  - A metavolcaniclastic unit of the Kasila Group
  - Two clastic units of the Marampa Group
- The new structural and geochronological[2] data allows a reinterpretation of the tectonic framework of the (present-day) SW margin of the West African Craton, within the context of pre-Gondwanan supercontinent models (Rodinia, Nuna/Colombia)

[1] An overview of iron deposits in the study area is shown on the last slide of this presentation
[2] Geochronological results are shown at the end of the presentation

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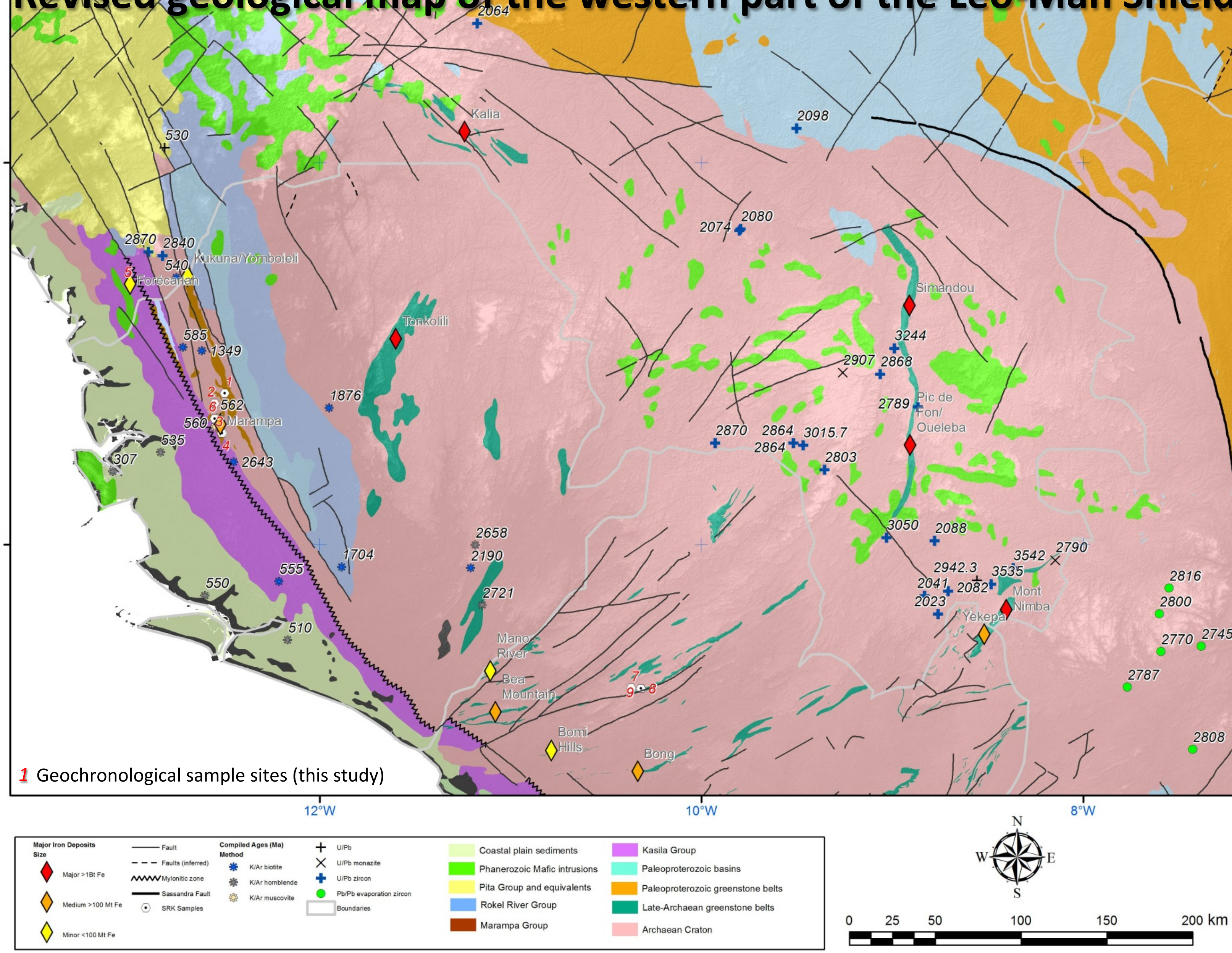
Revised geological map of the western part of the Leo-Man Shield



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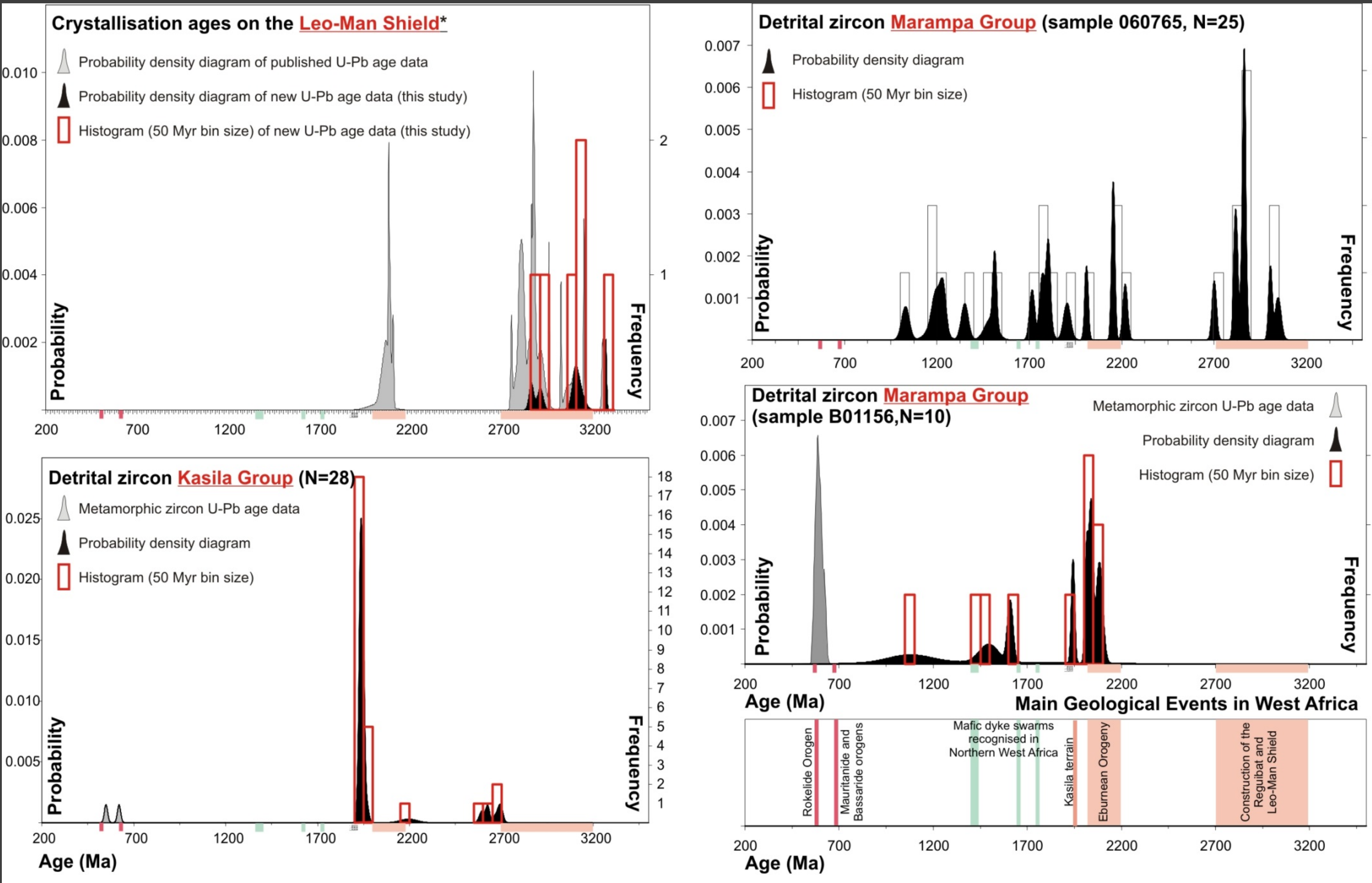
Geochronological results



*Kouemélan et al., PR 86, 1996; Bering et al., BGR Report, 1998; Thiéblemont et al., JAES 39, 2004; Youbi et al., PR 236, 2013 and references therein

Our new mapping and geochronological data indicate:

- Archaean TTG Complex of granitoids and gneisses with several magmatic pulses building the Leo-Man Shield of the West African Craton between 3.2 and 2.7 Ga

- Development of volcanisedimentary (greenstone) deposits and associated Banded Iron Formation (BIF), with perhaps an older (~2.7 Ga) and a younger series (~2.2 Ga)

- Eburnean Orogeny (2.2 – 2.0 Ga) and development of "Birimian" structures and units; some reworking of BIF units to form metamorphosed BIF

- Late-Neoproterozoic collisions between Amazonia, Saõ Luis, Avalonian terrains and West Africa result in the Rokelide Orogen (Brasiliano Orogen in South America), with development of specularite-hematite deposits along the Sole Thrust of the Marampa Group. High-grade metamorphism of iron rich units in the Avalonian terrains result in small magnetite-rich gneiss units in the Kasila Group.

- Based on mismatch in detrital pattern of the Kasila Group, we propose it to be the remnant of a microcontinental block caught in the collision, i.e. a Peri-Gondwanan fragments still attached to West Africa. Ages for rocks from the "Kenema Assemblage" are identical to ages reported for the Leo-Man Shield. We interpret the Kenema Assemblage as part of the Leo-Man Shield.

- Marampa Group patterns correspond reasonably well to West African sources, but contain a range of Mesoproterozoic zircon for which no sources are known in West Africa, while potential sources in South America would have been distant. We propose that contributions from proximal peri-Gondwanan terranes (e.g. Murphy et al., Geol.Runsch 93, 2004) are recorded in the Marampa Group.

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Geochronological data (this study)

ID	Sample	Unit	Lithology	Age	Interpretation
1	G1623	West African Craton	Porphyritic granite	2854±13	Granite emplacement
2	G1526	West African Craton	Leucocratic Gneiss	3113±29	Protolith emplacement
3	B01160B	West African Craton	Migmatitic Gneiss	2903±16	Protolith emplacement
4	B01156C	Marampa Group	Chloritic schist	<1076	Maximum age of deposition
5	KK1	Kasila Group	Magnetite-quartz Gneiss	<1941	Maximum age of deposition
6	60575	Marampa Group	Specularite schist	<1030	Maximum age of deposition
7	MS6A-B	West African Craton	Migmatitic Gneiss	3261±5	Protolith emplacement
8	MS7	West African Craton	Gayama Granite	3108±26	Protolith emplacement
9	MS8	West African Craton	Quartz vein	3094±16	Vein emplacement

Iron deposits in the study area

	Age	Group	Deposit type	Example	Tonnage	Contained
Proterozoic	~0.55	Marampa Group	specularite-hematite schist	Marampa	1.078 Gt @ 31.26% Fe	530 Mt Fe
					680 Mt @ 28.21% Fe	
				Kukuna/ Yomboieli	235.8 Mt @ 27.86% Fe	66 Mt Fe
	~1.9	Kasila Group	magnetite-rich amphibolite and gneiss	Forecariah	-	-
	2.62-2.25	Simandou Nimba	BIF	Simandou	2.39 Gt @ 66.03% Fe	1.58 Gt Fe
				Oueleba	1.68 Gt @ 65.68% Fe	1.11 Gt Fe
				Mont Nimba	-	-
				Yekepa	526 Mt @ 48.40% Fe	255 Mt Fe
Archaean	3.0-2.7	Kambui S/ Group*	BIF	Tonkolili	11.6 Gt @ 30.1% Fe	3.49 Gt Fe**
				Kalia	5.54 Gt @ 27.95% Fe	1.55 Gt Fe**
	>3.2-3.0	Loko Group	-	none to date	-	-

*: Rollinson, 1983 and MacFarlane, 1981, other possibility: Kambui equivalent to Simandou Range (Hurley et al., 1971); **: reported as magnetite raw (measured, indicated and inferred) - Intierra database

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