Support for Groundwater Management
in the Niger Basin
(AGES)

Map n°1: Geology

Geological map

of the transboundary region
Benin, Niger, and Nigeria

Sedimentary basins: Iullemmeden - Kandi - Sokoto

1 : 625 000

coopération allemande
DEUTSCHE ZUSAMMENARBEIT

2019

Transboundary geological mapping

Geological baseline information is the fundament for higher-level environmental analyses and natural resource management such as groundwater potential and vulnerability assessments, and regional development. Geological maps differ, however, by scale, detail, coverage, and most importantly by unit denomination and regularly show divergent interpretations along map sheet boundaries—particularly along national borders. The "Geological map of the transboundary region of Benin, Niger, and Nigeria" presents a thematically and geometrically harmonized geological overview of the border region of Benin, Niger, and Nigeria incorporating data from eight different geological map series. Inset maps visualize the coverage of the geological base maps and data sources, the lithological classification, and the tectonic structure. Geological cross-sections provide insights into the three-dimensional geological structure of the southern Iullemmeden Basin.

Harmonization: concept and approach

Harmonization comprises a) semantic generalization and attribution of chronostratigraphic and lithological units followed by a unified classification, and b) spatial and geometric harmonization along map sheet boundaries and across map series. The original map units were correlated within a chronostratigraphic framework and a common unit was assigned. Lithological descriptions were harmonized following the lithological aggregation scheme proposed for the International Hydrogeological Map of Europe (IHME1500, Duscher et al. 2015). The harmonization approach, important aggregation steps, and assignment decisions are discussed in the accompanying report. The mapping approach highlights ambiguous geological interpretations and unresolved inconsistencies calling for a renewed effort of geological field mapping. Important ambiguities are associated with the transition from the Continental Intercalaire/Hamadien to the Continental Terminal: a) the extent of the Continental Intercalaire/Hamadien (Illo/Gundumi/Sende Formations) and its transboundary extension, b) the spatial distribution of the intercalated Late Cretaceous to Palaeocene marine strata between the Zamfara and the Niger River, and c) occurrence and differentiation of the so-called 'Continental Terminal—complexe de base' along the Niger River.

This map was elaborated within the technical cooperation project 'Support for Groundwater Management in the Niger Basin—Appui pour la Gestion des Eaux Souterraines dans le Bassin du Niger" (AGES)—a joined project between the Niger Basin Authority (NBA) and the German Federal Institute for Geosciences and Natural Resources (BGR) financed by the Federal Ministry for Economic Cooperation and Development (BMZ). The aim of the project is to provide baseline information and tools for groundwater management in the Niger Basin.

Map preparation

Editing: Heckman, M., Bosch, K., Broda, S., Konaté, M.
Cartography: Heckmann, M., Krombholz, M.

Geodetic Datum: World Geodetic System (WGS) 1984
Map Projections: Main maps: Universal Transverse Mercator (UTM) Zone 31N (EPSG: 32631)
West Africa: Lambert Conformal Conic (EPSG: 102024)

Recommended citation

BGR & NBA (2019). Geological map of the transboundary region of Benin, Niger, and Nigeria: Sedimentary basins Iullemmeden, Kandi, Sokoto. Berlin & Niamey.

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Konaté, M. (1996): Evolution tectono-sédimentaire du bassin paléozoïque de Kandi (Nord Bénin, Sud Niger). Un témoin de l'extension post-orogénique de la chaîne panafricaine. Dissertation thesis, Universités de Bourgogne & Nancy I, Nancy.

Geological base maps

Akibou, T., Bozzola, A., Cremante, G., Lazzarotto, V., Maraga, F., Martinotti, G., Maranzana, F., Novero, F., Piovano, E., Roman, E., Sadonou, N., Zauli, M., Zerbato, M., Kogblevi, J.C., Alidou, S., Tsawlassou, G. & Houessou, A. (1989a): Carte Géologique - Feuille Karimama (ND-31-III/IV). Projet FED N° 4105-011-13-20, Istituto ricerche Breda & OBEMINS, Italie.
Akibou, T., Bozzola, A., Cremante, G., Lazzarotto, V., Maraga, F., Martinotti, G., Maranzana, F., Novero, F., Piovano, E., Roman, E., Sadonou, N., Zauli, M., Zerbato, M., Kogblevi, J.C., Alidou, S., Tsawlassou, G. & Houessou, A. (1989b): Carte Géologique - Feuille Malanville (NC-31-XXII). Projet FED N° 4105-011-13-20, Istituto ricerche Breda & OBEMINS, Italie.
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Parker, D.H. & Carter, J.D. (1965b): Geological Survey of Nigeria, 1:250,000 Series, Sheet 6, Birnin Kebbi. Directorate of Overseas Surveys.
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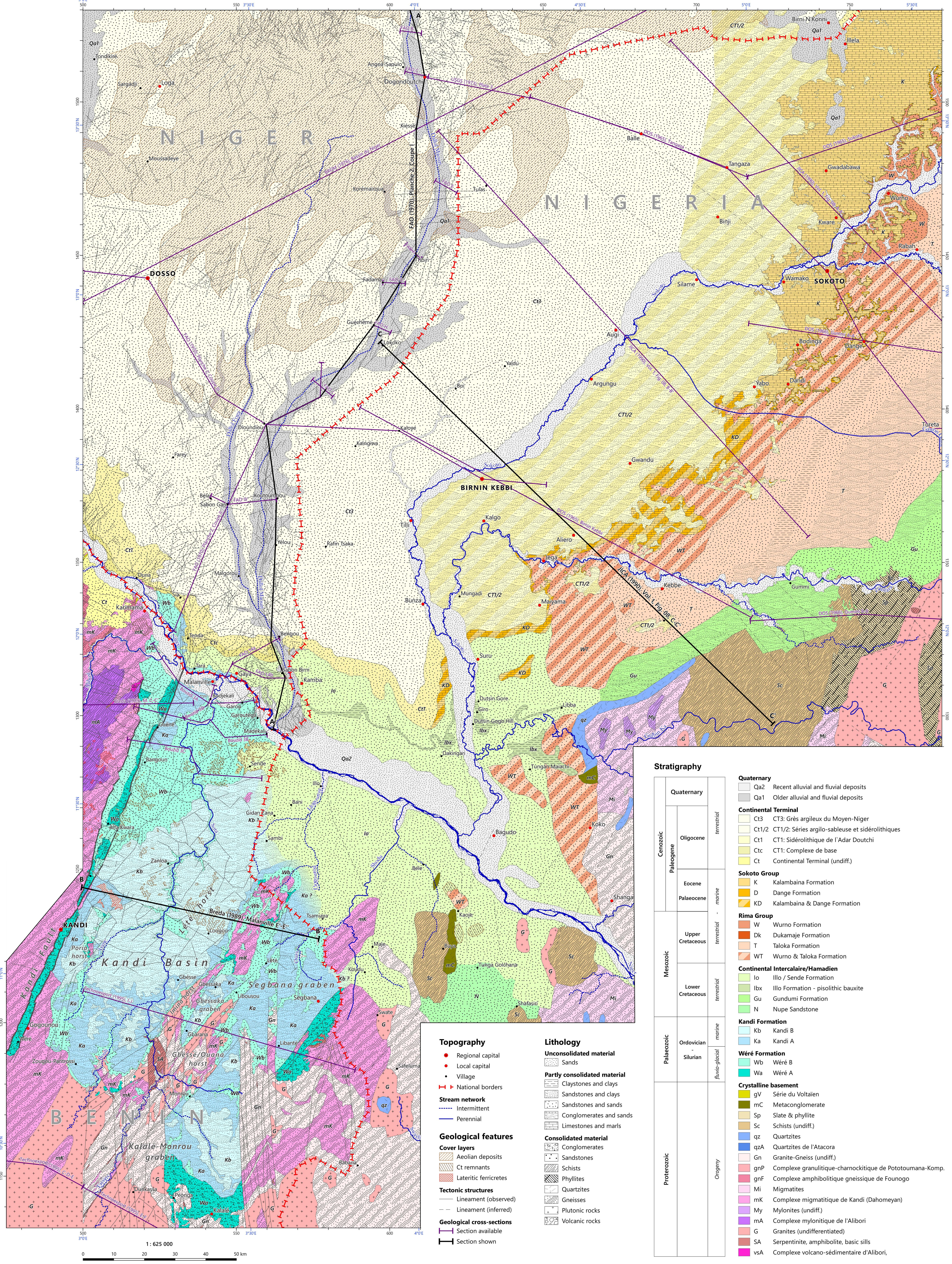
Topographic data

Localities: OpenStreetMap (2018), www.openstreetmap.org, modified; Administration: GADM28 (2018), https://www.gadm.org; Stream network: ABN (2016), modified; DEM: NASA Shuttle Radar Topography Mission Global 30 arc second (NASA JPL, 2013)



Stratigraphy

Quaternary (Quaternary, terrestrial)
- Qa2 Recent alluvial and fluvial deposits
- Qa1 Older alluvial and fluvial deposits

Continental Terminal (Cenozoic, Paleogene, Oligocene, terrestrial)
- Ct3 CT3: Grès argileux du Moyen-Niger
- Ct1/2 CT1/2: Séries argilo-sableuse et sidérolithiques
- Ct1 CT1: Sidérolithique de l'Adar Doutchi
- Ctc CT1: Complexe de base
- Ct Continental Terminal (undiff.)

Sokoto Group (Eocene, Palaeocene, marine)
- K Kalambaina Formation
- D Dange Formation
- KD Kalambaina & Dange Formation

Rima Group (Mesozoic, Upper Cretaceous, terrestrial - marine)
- W Wurno Formation
- Dk Dukamaje Formation
- T Taloka Formation
- WT Wurno & Taloka Formation

Continental Intercalaire/Hamadien (Lower Cretaceous, terrestrial)
- Io Illo / Sende Formation
- Ibx Illo Formation - pisolithic bauxite
- Gu Gundumi Formation
- N Nupe Sandstone

Kandi Formation (Palaeozoic, Ordovician - Silurian, marine)
- Kb Kandi B
- Ka Kandi A

Wéré Formation (fluvio-glacial)
- Wb Wéré B
- Wa Wéré A

Crystalline basement (Proterozoic, Orogeny)
- gV Série du Voltaïen
- mC Metaconglomerate
- Sp Slate & phyllite
- Sc Schists (undiff.)
- qz Quartzites
- qzA Quartzites de l'Atacora
- Gn Granite-Gneiss (undiff.)
- gnP Complexe granulitique-charnockitique de Pototoumana-Komp.
- gnF Complexe amphibolitique gneissique de Founogo
- Mi Migmatites
- mK Complexe migmatitique de Kandi (Dahomeyan)
- My Mylonites (undiff.)
- mA Complexe mylonitique de l'Alibori
- G Granites (undifferentiated)
- SA Serpentinite, amphibolite, basic sills
- vsA Complexe volcano-sédimentaire d'Alibori,

Topography
- Regional capital
- Local capital
- Village
- National borders

Stream network
- Intermittent
- Perennial

Geological features

Cover layers
- Aeolian deposits
- Ct remnants
- Lateritic ferricretes

Tectonic structures
- Lineament (observed)
- Lineament (inferred)

Geological cross-sections
- Section available
- Section shown

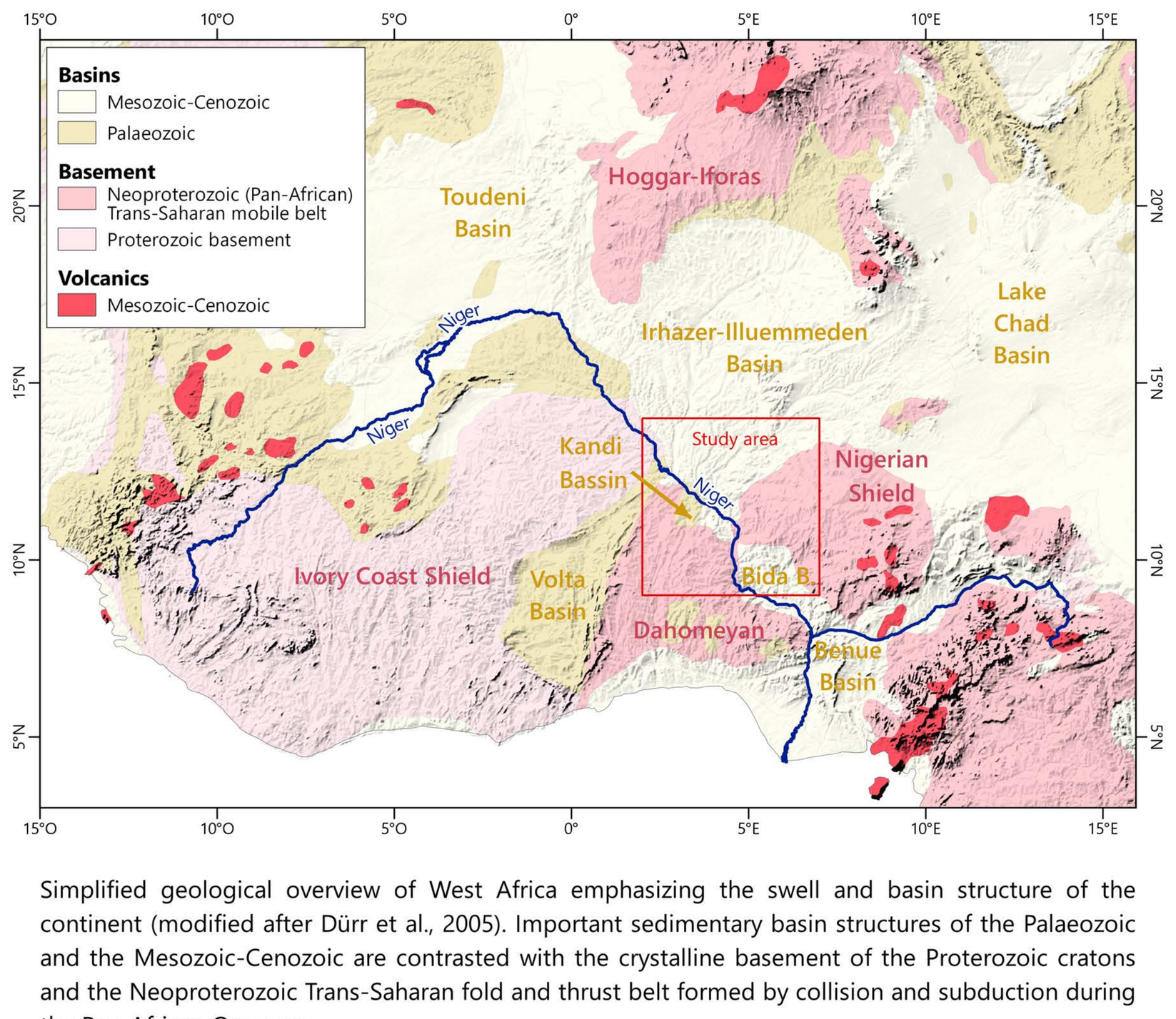
Lithology

Unconsolidated material
- Sands

Partly consolidated material
- Claystones and clays
- Sandstones and clays
- Sandstones and sands
- Conglomerates and sands
- Limestones and marls

Consolidated material
- Conglomerates
- Sandstones
- Schists
- Phyllites
- Quartzites
- Gneisses
- Plutonic rocks
- Volcanic rocks

Geological setting



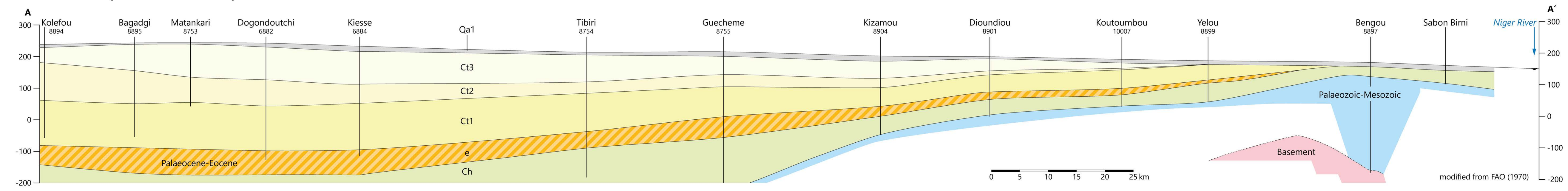
Simplified geological overview of West Africa emphasizing the swell and basin structure of the continent (modified after Dürr et al., 2005). Important sedimentary basin structures of the Palaeozoic and the Mesozoic-Cenozoic are contrasted with the crystalline basement of the Proterozoic cratons and the Neoproterozoic Trans-Saharan fold and thrust belt formed by collision and subduction during the Pan-African Orogeny.

Geological cross-sections

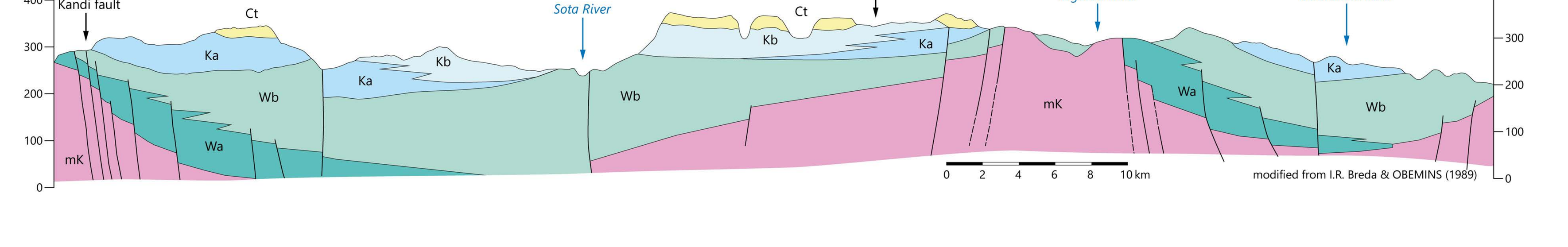
Locations of geological cross-sections compiled in the accompanying report are shown on the main map. Exemplarily, three relevant cross-sections are shown in detail (bold lines). The north-south section along the Dallol Maouri (FAO, 1970) and the east-west section through the Sokoto Basin (JICA, 1990) have been adapted to reflect the harmonized chronostratigraphy. The cross-section through the Kandi Basin (Istituto ricerche Breda & OBEMINS 1989) has been modified to comply with the revised chronostratigraphic classification of Konaté (1996).

Geological cross-sections

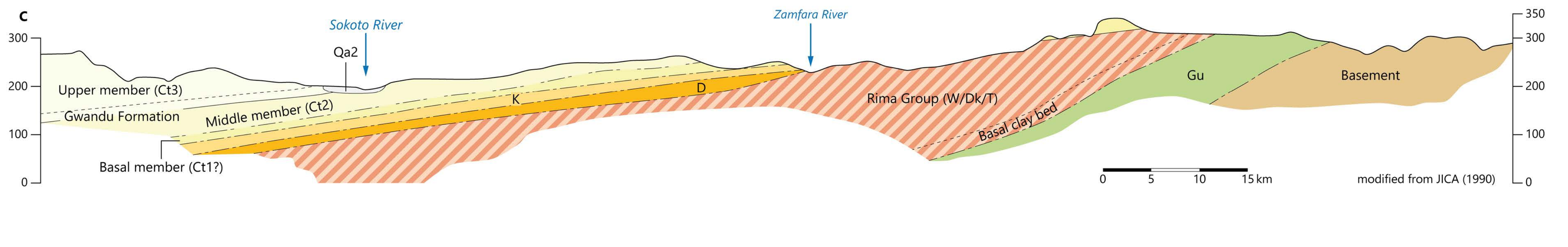
Dallol Maouri (Iullemmeden Basin)



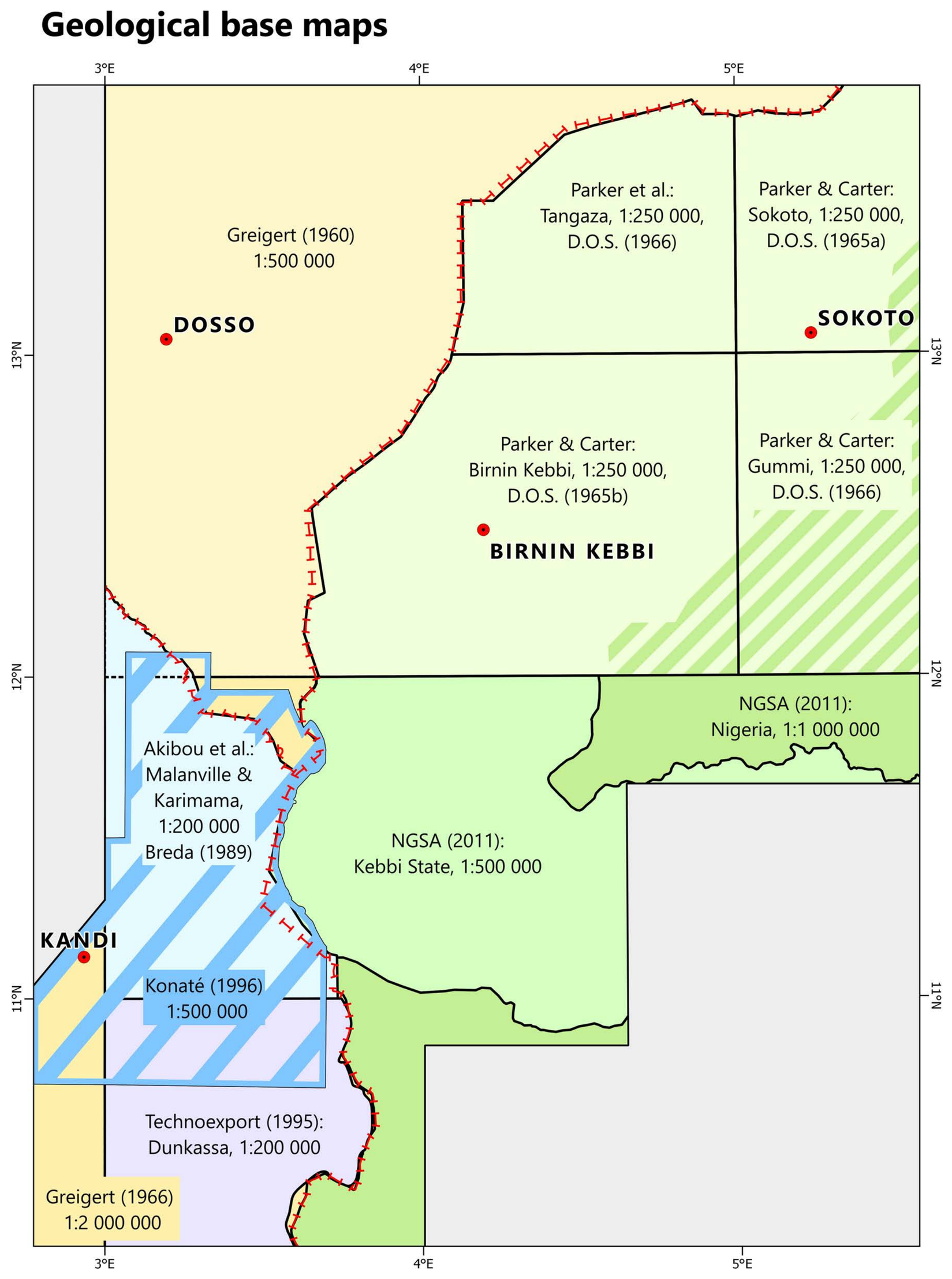
Kandi Basin



Sokoto Basin

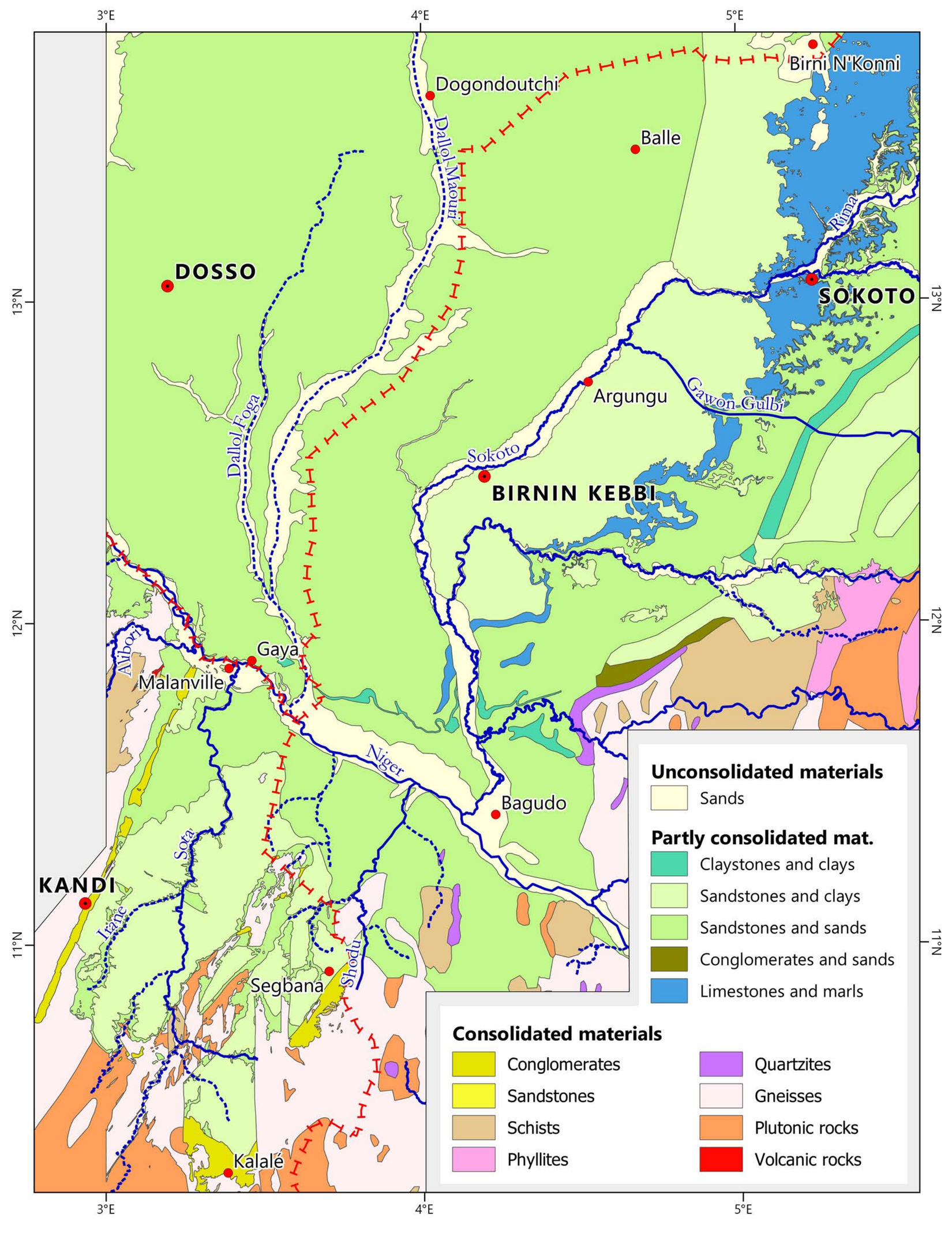


Geological base maps



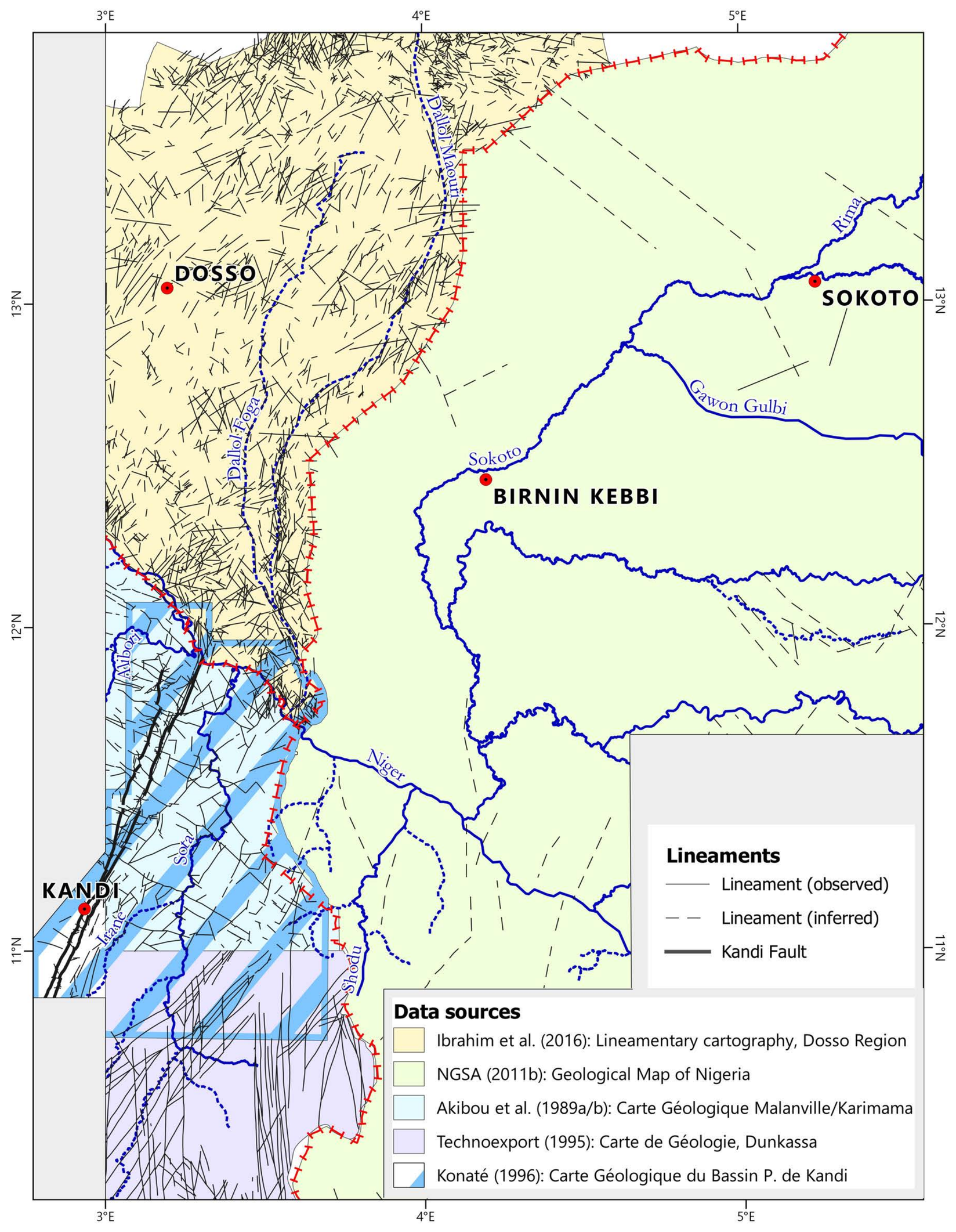
The geological map was compiled using 11 map sheets from 8 different map series. The labels refer to the original national or regional maps listed in the references to the geological base maps.

Lithology



Lithological harmonization comprises thematic and semantic generalization. Map legends and literature descriptions were harmonized following the hierarchical aggregation scheme proposed by Duscher et al. (2015) for the International Hydrogeological Map of Europe 1:1 500 000 (IHME1500). On the first of five aggregation levels, the scheme differentiates the degree of consolidation (unconsolidated, partly consolidated, consolidated) followed by a taxonomic classification based on main, secondary, and accessory components.
Most suitable for overview purposes is the IHME level 3 as shown on the map. Partly consolidated, fine and coarse clastic sediments dominate both terrestrial sediments of the Lower Cretaceous Continental Intercalaire/Hamadien and the Oligocene Continental Terminal (Sandstones and sands)—and lacustrine-marine sediments of the Upper Cretaceous and the Palaeozoic (Sandstones and clays).

Tectonic structures



Tectonic structures are compiled from: Istituto ricerche Breda (Akibou et al., 1989a & b), Technoexport (1995), and Konaté (1996) for Benin; NGSA (2011a & b) for Nigeria, and Ibrahim et al. (2016) for Niger. Level of detail, density, distribution, and orientation of structural elements reflect the different mapping approaches. Given the heterogeneity of the data, harmonization is not possible. The most important structural element is the dominant Kandi fault (N20°E) that marks the boundary between the Neoproterozoic (Dahomeyan) basement and the Palaeozoic Kandi Basin. For the basement, a dominantly S175°E orientation of tectonic contacts was mapped by the survey of Technoexport (1995).