Setting the basis for hydrogeological mapping: Harmonizing geological maps and aquifer property databases

Heckmann M[1], Bosch K[1], Broda S[1], Preissler R[1]

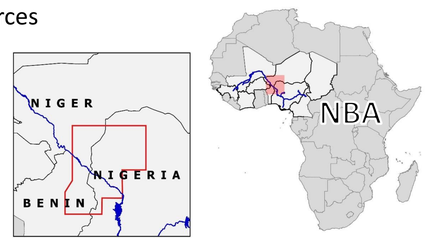
[1] Appui à l'ABN pour la Gestion des Eaux Souterraines (AGES)
Federal Institute for Geosciences and Natural Resources (BGR) & Niger Basin Authority (NBA)

Improving baseline data for groundwater management

Sustainable management of groundwater resources builds on reliable base-line data, most of all:

A) Aquifer properties

B) Geological maps.



To improve the (hydro-)geological base-line data and to set the basis for planning and decision making, the technical cooperation project AGES collates and harmonizes hydrogeological data and maps available from published and grey literature such as project reports, drilling documentations, etc.

Technical cooperation: groundwater within the NBA

The technical cooperation project *Support to the NBA for groundwater management* ("Appui à l'ABN pour la Gestion des Eaux Souterraines", AGES) of the Federal Institute for Geosciences and Natural Resources (BGR) supports the Niger Basin Authority (NBA) and its nine member states to elaborate and apply tools for groundwater management. The project AGES aims to bring together experts from science and administration to improve (hydro-) geological knowledge and facilitate baseline information for groundwater management in planning and decision making. The project is funded by the German BMZ (PN° 2013.2465.6 & PN° 2014.2272.4).

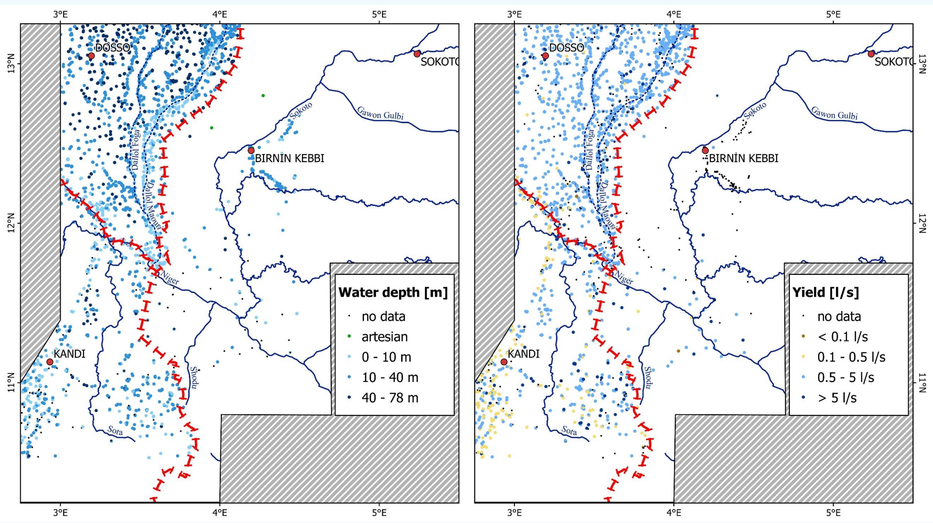
A) Aquifer properties

Problem

- Contemporary drilling operations by governments, development projects, non-governmental organizations, or private investors lack scientific monitoring.
- Coverage and quality of national groundwater databases are often not sufficient for spatially comprehensive analyses.

➡ **Aquifer database** of the transboundary region Benin-Niger-Nigeria

- Around 4500 wells (generally single measurements only!)
- ➡ (Un-)published hydrogeological data is a hidden treasure which so far has neither been exhaustive explored nor found its ways into national databases.
- ➡ Existing literature provides initial baseline data for groundwater management.
- ➡ Collation of data, although time consuming, does not require further resources.
- ➡ Data gaps highlight areas and topics requiring further hydrogeological studies.



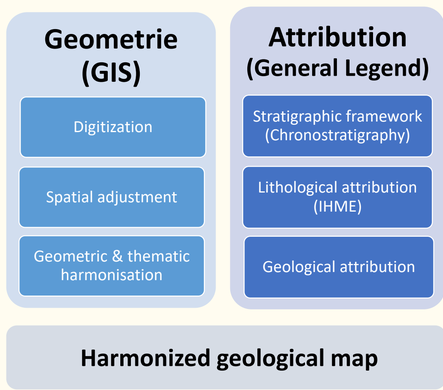
B) Transboundary geological map: Benin-Niger-Nigeria

Problem

- 8 national geological maps of the border region Benin, Niger, and Nigeria
- Varying scale, level of detail, accuracy, reliability
- Different lithostratigraphic classifications and denominations

Harmonization process

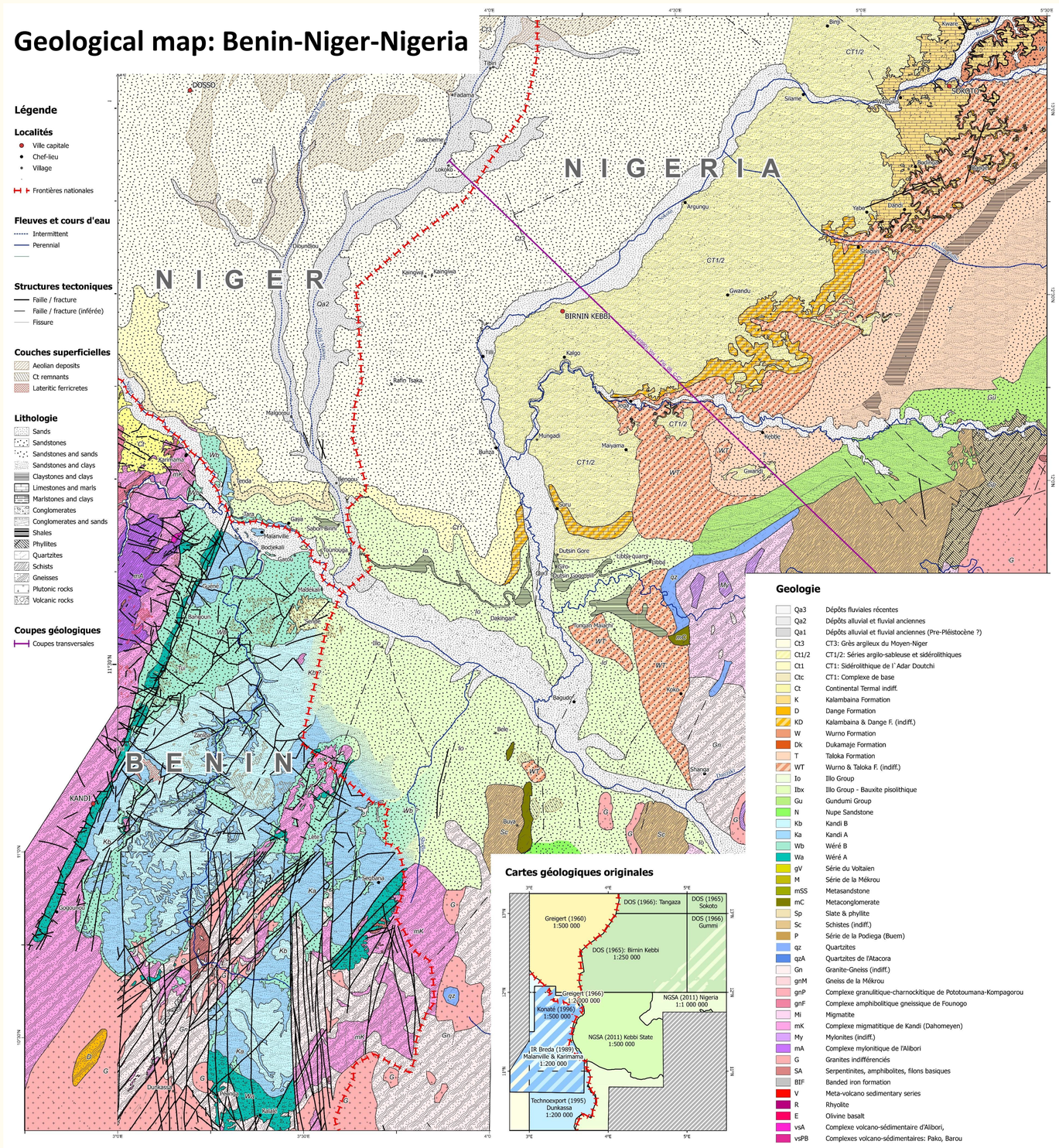
- Digitization, georeferencing, spatial adjustment
- Geometric and thematic harmonization
- General legend: stratigraphic correlation and attribution
- Lithological classification (following the *International Hydrogeological Map of Europe (IHME) 1:1 500 000* (Duscher et al., 2015)



➡ **unified, multi-scale geological map** for hydrogeological analyses and groundwater mapping

- ➡ Geological state-of-art summary of the southern Iullemmeden Basin, the Sokoto Basin, and the Kandi Basin.
- ➡ Inconsistencies highlight gaps in the present knowledge and point out topics requiring further geological research.
- ➡ (Hydro-)geological mapping is a continuous process:
  Please contribute your expertise to improve the geological map & database!

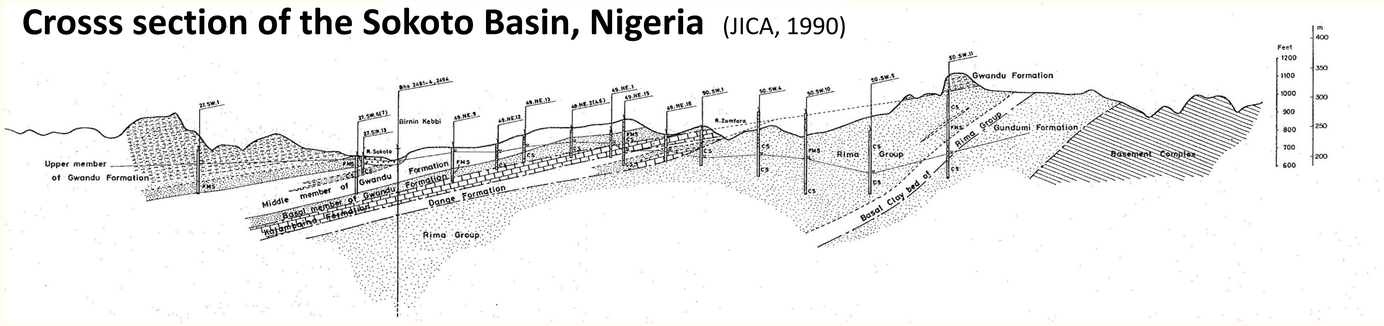
Geological map: Benin-Niger-Nigeria



Harmonized stratigraphic legend (Excerpt: Continental Hamadien (Niger), Illo-Gundumi (Nigeria), and Sendé (Benin)

Stratigraphie: Ère	Stratigraphie: Systeme	Stratigraphie: Série / Étages	Lithostratigraphie: Transgression	Lithostratigraphie: Group	Konate (1996): Carte géologique du Bassin Paléozoïque de Kandi: Clé	Konate (1996): Lithologie	Société Istituto Ricerche Breda (1989): Notice Explicative de la Carte Géologique à 1/200.000 Feuilles: Karimama, Porga, Kandi, Malanville: Clé	Société Istituto Ricerche Breda (1989): Lithologie	Greigert (1966): Carte Geologique Republique du Niger. 1:2.000.000: Clé	Greigert (1966): Nom	D.O.S. (1965/6): Geological Survey of Nigeria, 1:200.000 map series: Clé	D.O.S. (1965/6): Nom	NGSA (2011) Geology and Mineral Resources Map of Nigerian States & Geological Map of Nigeria: Clé	NGSA (2011): Lithologie	Lithologie harmonisée: Clé	Lithologie harmonisée: Formation	Lithologie harmonisée: Lithologie (fr)	Lithologie harmonisée: Lithologie (eng)
Mésozoïque	Crétacé inférieur	probablement: **Albien, Aptien, Barrémien** (originalement: pre-Maastrichtien par fois Crétacé supérieur (p.e. Cénomanien à Sénonien; Turonien Campano-Maestrichtien, etc …)	*Continental intercalaire* *1st / 2nd marine transgression in north Niger (not Nigeria)*	Continental hamadien			C	Grès grossiers avex silts et argiles subordonnés. Dépôts de plaine d'inondation.							Io	Illo Group	Grès fins à grossiers à ciment kaolinique et de sables moyens à grossiers plus ou moins consolidé, microconglomeratique, argiles bariolés	cross-bedded, fine to coarse often angular sandstones; kaolinitique matrix, interbeddedd clays and microconglomerates, siltits, variegated clays
					S	Microconglomérats, grès et siltites (Crétacé inférieur) [evtl. Sende], fluviatil distal												
									Csc	Continental hamadien								
													Gilloss	Sandstones, siltstones and clays				
									Csc bp	Continental hamadien. Bauxite pisolithique					Ibx	Illo - Bauxite pisolithique	Argile blanche bauxitique, pisolithique et nodulaire	pisolitic and nodular low-grade, bauxitic white clays
															Gu	Gundumi Group	Grés moyene à grossier intercalé avec d'argile bariolé, vers le socle conglomerates de base (<6cm), graviers, induré (calcsilicic)	Medium to coarse-grained sandstones intercalated with variegated clays and clayey sandstones. Towards the contact with the basement basal conglomerates (<6cm), indurated (calcsilicic)
											GD	Gundumi Formation	Gliss	Clay, grit and pebbels (Sokoto, Nigeria);				
											GD	Gundumi Formation	Glgss	Gravel and sand				
											GD	Gundumi Formation	Glcg	Pebbels and grits				
													ssf	Ferrugenious sandstone	N	Nupe Sandstone	Grés	Sandstone

Crosss section of the Sokoto Basin, Nigeria (JICA, 1990)



Original geological maps

	Geological maps	
Niger	Greigert (1960)	Carte Géologique de Reconnaissance: Dosso, 1:500 000. BRGM
	Greigert & Pougnet (1966)	République du Niger. Carte Géologique, 1/2 000 000. BRGM
Nigeria	D.O.S. (1965-66)	Geological Survey of Nigeria, 1:250 000 Series, Directorate of Overseas Surveys. • Sheet 1, Tangaza • Sheet 2, Sokoto. • Sheet 6, Birnin Kebbi • Sheet 7, Gummi
	NGSA (2011a)	Geological and Mineral Resources Map of Kebbi State, Nigeria. 1:500 000. Digital dataset, Nigerian Geological Survey Agency.
	NGSA (2011b)	Geological Map of Nigeria. 1:1 000 000. Digital dataset, Nigerian Geological Survey Agency
Benin	Akibou et al. (1989)	Carte Géologique. 1 :200 000. Projet FED N° 4105-011-13-20, Istituto ricerche Breda & OBEMINS, Italie. • Feuille Karimama • Feuille Malanville
	Technoexport (1995)	Carte de Géologie et des Minéraux utiles. Conceil de la Géoscience, Pretoria. 1 :200 000 • Dunkassa
	Konate (1996)	Évolution tectono-sédimentaire du bassin paléozoïque de Kandi (Nord Bénin, Sud Niger). Un témoin de l'extension post-orogénique de la chaîne panafricaine. Figure 15, Dissertation, Université de Bourgogne, Dijon-Niamey.

References

Duscher, K, Günther, A, Richts, A, Clos, P, Philipp, U & Struckmeier, W (2015): The GIS layers of the 'International Hydrogeological Map of Europe 1:1,500,000' in a vector format. *Hydrogeology Journal*, vol. 23, no. 8 pp. 1867–1875.

JICA (1990): *The Study for Groundwater Development in Sokoto State*. Federal Department of Water Resources & Japan International Cooperation Agency, Tokyo p. vol 1-5.