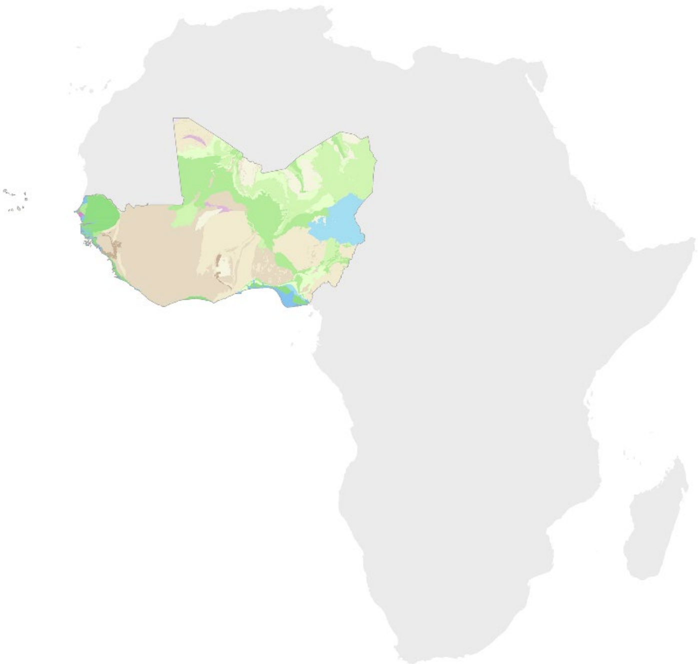
Groundwater resources in the ECOWAS region

Expected aquifer productivity

Technical Note



2022

ECOWAS　AMCOW　NBA

An initiative of BGR, BGS, BRGM, Eawag, IGRAC, and UNESCO to raise awareness of the potential and limitations of groundwater resources in the ECOWAS region of West Africa.

A contribution to the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)

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1 Groundwater resources in the ECOWAS region

1.1 Background

The *Groundwater resources in the ECOWAS region* map has been developed to raise awareness of the potential and limitations of groundwater resources in the ECOWAS region of West Africa. Groundwater plays an important role in supporting agricultural and domestic water supply in West Africa, with more than 50 % of the population currently dependent on groundwater for their main drinking water source (Danert 2020; JMP 2020). Groundwater could play an increasingly important role in adapting to climate change in West Africa, which is projected to cause „increases in drying and agricultural and ecological droughts as well as delayed onset and retreat of the monsoon season“ (IPCC 2021).

This new map, *Groundwater resources in the ECOWAS region*, is a contribution to the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) of the UNESCO Intergovernmental Hydrological Programme (IHP). It was developed under the auspices of the African Ministers' Council on Water (AMCOW) Pan-African Groundwater Program (APAGroP), the Economic Community of West African States (ECOWAS) Water Resources Coordination Centre (WRCC), and the Niger Basin Authority (NBA). The map was produced by a consortium comprising the Federal Institute for Geosciences and Natural Resources (BGR), British Geological Survey (BGS), Bureau de recherches géologiques et minières (BRGM), Swiss Federal Institute of Aquatic Science and Technology (Eawag), and the International Groundwater Resources Assessment Centre (IGRAC). Map development was funded by the geological surveys themselves, UNESCO, and a contribution to BRGM by the French Ministry of Foreign Affairs. A map draft was reviewed by a group of hydrogeologists with regional groundwater expertise.

The printed map was released at the 9th World Water Forum in Dakar, 2022, accompanied by this Technical Note. The map, the technical note, and the digital dataset of the expected aquifer productivity map are available for download on the WHYMAP-website (www.whymap.org); the inset maps on the respective institutions' websites (cf. 4.2 Inset maps).

1.2 A new aquifer productivity map

Many regional and continental scale overview maps on groundwater resources cover West Africa, largely developed by European Geological Surveys under the auspices of international organisations such as UNESCO, ACSAD (Arab Centre for the Studies of Arid Zones or Dry Lands), or CIEH (Comite Interafricain d'Etudes Hydrauliques). A summary of earlier groundwater maps in the West Africa region is given in a section of the Africa Groundwater Atlas: *Groundwater and Hydrogeological Maps of Africa* (British Geological Survey 2022).

The new map, *Groundwater resources in the ECOWAS region*, shows the potential for assimilating and harmonising existing hydrogeological information to improve regional groundwater mapping across Africa. The map captures and standardises existing groundwater data and understanding developed in individual ECOWAS countries, and updates older regional hydrogeological maps of West Africa, to give a consistent regional overview not available from individual national maps. It provides a quantitative assessment of aquifer productivity, as a measure of groundwater potential, highlighting the suitability of aquifers for water supply at different scales but also the physical limits of groundwater development potential.

The main map – *expected aquifer productivity* – is based on geological linework and hydrogeological information in the two most recent Africa-wide hydrogeological mapping efforts: the continental-scale *Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 000 000* (Seguin 2016); and overview country hydrogeology maps for each ECOWAS country, at a nominal scale of 1 : 5 million, from the *Africa Groundwater Atlas* (British Geological Survey 2019). Regional-scale maps were consulted to improve the mapped geometry of hydrogeological units in Ghana (Jordan et al. 2009; Carney et al. 2010), Mali (Bassot et al. 1980; Girard et al. 1998), Niger (Greigert & Pougnet 1966), Nigeria (Dessauvagie 1974), and Senegal (Sane 2015). The new map draws on these base maps to present a revised hydrogeological overview of the ECOWAS region, with consolidated geological geometry, harmonised across country boundaries, showing hydrogeological units at 1 : 5 million scale labelled with commonly accepted stratigraphic names. The hydrogeological units are attributed with key hydrogeological parameters, primarily a quantitative estimate of *expected aquifer productivity* that was derived by compiling documented borehole yields for each unit. This is expressed as the expected size of borehole yield and water supply that is available from each unit, an easy-to-interpret parameter for the general public.

The new map and accompanying datasets provide:

- an open digital GIS spatial dataset, released under a Creative Commons Attribution-ShareAlike Licence (CC BY-SA);
- a printed map available as a hard copy or as a digital downloadable pdf, with bilingual map annotations and marginalia in French and English to be accessible across West Africa and foster scientific exchange;
- seamless, harmonised and consolidated transboundary geological and hydrogeological information;
- lithostratigraphic classification of hydrogeological units using common stratigraphic names, not abstract chronostratigraphic nomenclature;
- quantitative estimation of *expected aquifer productivity* based on documented literature.

The inset maps (section 4.2) show published datasets relating to:

- long-term average recharge (MacDonald et al. 2021);
- predicted fluoride naturally present in groundwater (Podgorski & Berg 2020);
- predicted arsenic naturally present in groundwater (Amini et al. 2008);
- long term groundwater level hydrographs from monitoring boreholes across West Africa (Cuthbert et al. 2019);
- structural geology and the thickness of sediment fill in the main sedimentary basins (adapted from Milési et al. 2010; and Thiéblemont et al. 2016).

Released as an open, digital dataset available for use in GIS, as well as a printed or digital pdf map with detailed marginalia, the new map and accompanying information provide a consistent, reliable, authoritative basis for regional assessments of groundwater resources in West Africa. However, the regional scale of the map and the required generalisation of the underlying data mean it is not sufficient for detailed national or sub-national assessments. For this, further systematic hydrogeological mapping at larger scales is needed, with the proactive participation of national geological surveys, water ministries, and hydrogeological services.

2 Mapping methodology

Development of the *expected aquifer productivity* map included the following stages:

- geometric harmonisation and generalisation of hydrogeological unit boundaries;
- selection of relevant hydrogeological units at an appropriate scale;
- attribution and generalisation of expected aquifer productivity and other attribute data for each hydrogeological unit, using information from published sources;
- review by regional hydrogeological experts.

2.1 Harmonisation of hydrogeological unit geometry

The geometry of the mapped hydrogeological units was defined by combining existing digital geological linework from two primary sources:

- the continental-scale *Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 million* (Seguin 2016);
- overview country hydrogeology maps for each ECOWAS country, at a nominal scale of 1 : 5 million, from the *Africa Groundwater Atlas* (British Geological Survey 2019).

These two primary input maps were designed as continental or national overview maps with a broad scope. Both use a chronostratigraphic legend for geological units and differentiate a limited number of hydrogeological classes and units, with a high level of simplification with regard to both the spatial differentiation of unit geometries and hydrogeological descriptions.

The derived *expected aquifer productivity* map provides a more detailed differentiation of hydrogeological units, incorporating information from additional regional, national, and larger scale geological maps to delimit specific aquifers that are not shown in detail on the input base maps. The following maps provided major regional contributions (see also 6 Bibliography):

- *Geological Map of Nigeria* (Dessauvagie 1974) for the Benue basin in Nigeria;
- *République du Niger. Carte Géologique, 1 : 2 000 000* (Greigert & Pougnet 1966) for the Iullemmeden, Tchad, and Djado basins in Niger;
- *République du Mali. Carte géologique à 1 : 1 500 000* (Bassot et al. 1980) and its digital update the *République du Mali. Carte Géologique. 1 : 1 500 000* (Girard et al. 1998) for the Taoudeni basin, the Inner Niger Delta, and the Gourma region in Mali;
- the work of Jordan et al. (2009) and Carney et al. (2010) for the Volta basin in Ghana;
- an overview map published in Sane (2015) and enhanced by DGPRE (2019) for the Intermediate Aquifer System in Senegal.

Delimitation of geological linework and hydrogeological attribution focused on the hydrogeological relevance (i.e., the importance for groundwater resources) of the respective mapped units, with compromise between the mapped geometry of geological units and the aim of a consistent classification of hydrogeological attributes at the regional scale.

2.1.1 Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 million

The *Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 000 000* (Seguin 2005, 2008, 2016) differentiates 11 hydrogeological units using a mixed classification including the depositional environment of sedimentary rocks (e.g. Cretaceous carbonate formations), chronostratigraphy (e.g. Jurassic-Trias sedimentary formations), supergroups (e.g. “Karoo” type – Carboniferous to Jurassic or Formations of “Nubian Sandstone” type), or lithology and rock types (e.g. sedimentary to volcanosedimentary formations and associated plutonism). It also distinguishes and labels large sedimentary basins, and shows estimated groundwater recharge, drawing on the work of Döll et al. (2003) and Döll & Flörke (2005). The map does not explicitly show aquifer productivity, but by combining information on aquifer flow type – inferred from the hydrogeological units – and groundwater recharge, it provides a key hydrogeological characterisation of the most important aquifers and the major sedimentary basins.

An updated version of the 1 : 10 000 000 scale hydrogeological map was published in 2016, in parallel with an updated version of the underlying 1 : 10 000 000 scale geological map (Thiéblemont et al. 2016). An unpublished digital version of this geological linework, at a scale of 1 : 2 000 000, provided updated geological linework for the development of the ECOWAS map. The mapped geological geometries are generally smooth and often reflect geological boundaries from more detailed national scale or regional maps used to develop the continental scale map.

2.1.2 Africa Groundwater Atlas Country Hydrogeology Maps

The *Africa Groundwater Atlas Country Hydrogeology Maps* (British Geological Survey 2019) are a series of digital, GIS (shapefile) format maps for individual countries. The geological linework was based on a 1 : 5 million scale chronostratigraphic geology map originally published by UNESCO (Furon & Lombard 1964), that was digitised by, and is made available through, the USGS (Persits et al. 1997). The level of detail in the mapped geometry is, therefore, that of a continental-scale map.

The Africa Groundwater Atlas maps classify geological units using a combination of a simple chronostratigraphic framework (e.g. Tertiary, Quaternary); rock type descriptions (e.g. sandstone, granite) and regional differentiation (e.g. major sedimentary basins); where possible they use accepted geological unit names in the relevant country. The maps classify hydrogeological units using a combination of geological formation environment, including degree of rock consolidation (e.g. unconsolidated sedimentary, consolidated sedimentary or basement); aquifer flow and storage type (e.g. intergranular, fracture or karst); and aquifer productivity (using expected borehole yield data as a proxy).

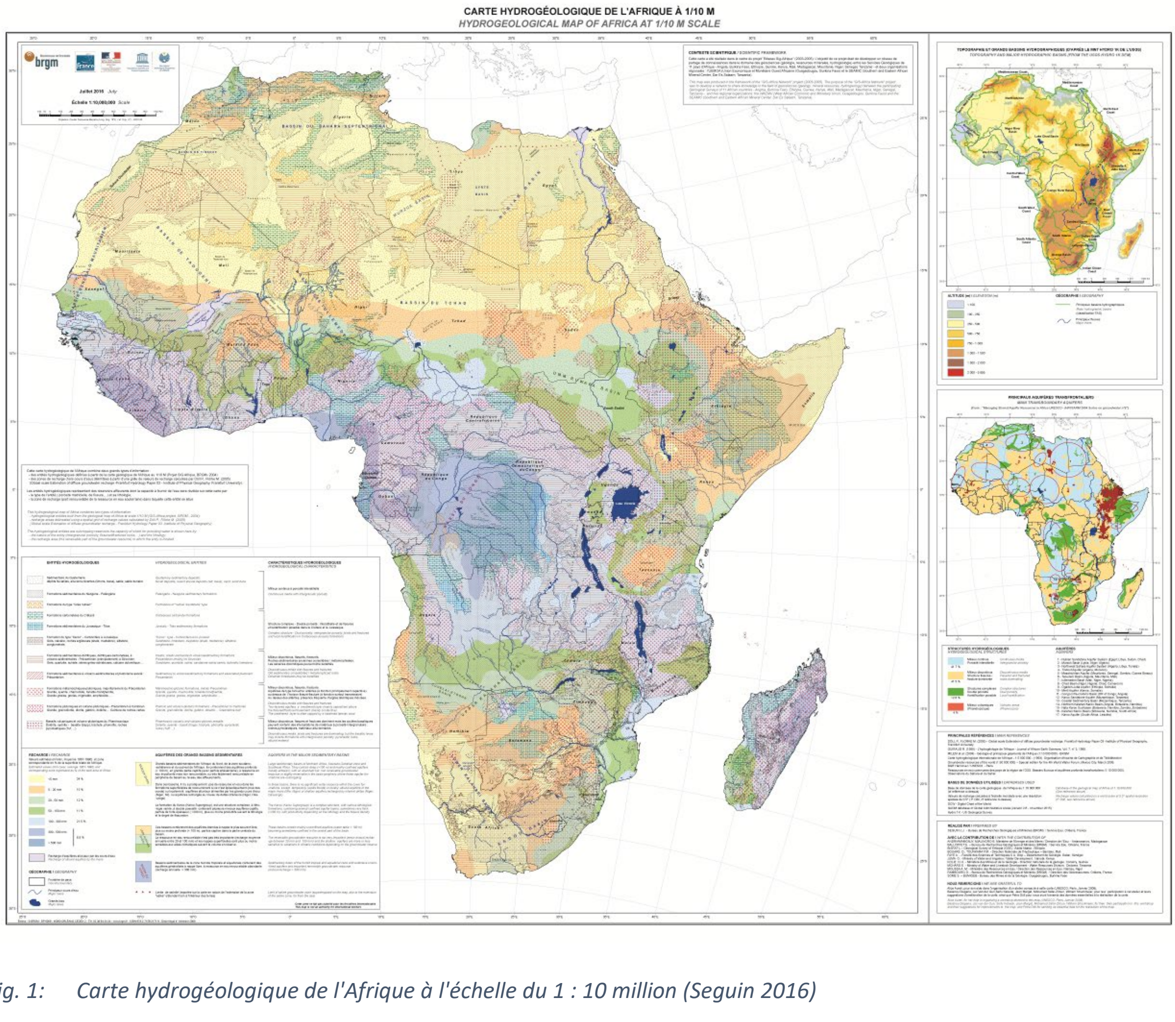

Fig. 1: Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 million (Seguin 2016)

An initial working step in developing the new map was to combine and harmonise the 14 available Africa Groundwater Atlas maps covering the countries of the ECOWAS region (a map for Cape Verde is not available). Because the maps were developed for individual countries, there were discrepancies along country boundaries. The initial harmonised map distinguished some 59 hydrogeological units that were grouped into eight combined hydrogeological classes (Figure 2). This was the base map that was combined with the *Carte hydrogéologique de l'Afrique à l'échelle du 1 : 10 000 000* in order to create the new ECOWAS aquifer productivity map.

2.2 Selection of hydrogeological units

The essential element of the expected aquifer productivity map is the hydrogeological unit. The hydrogeological units displayed on the map encompass the mapped outcrop area of the respective geological unit. The map therefore presents information on the **uppermost aquifer** also referred to as the **phreatic or unconfined aquifer** hosted within the geological unit at the surface.

The selection and delimitation of hydrogeological units, their unit geometry, and their descriptions are based on the assumption that a certain mapped hydrogeological unit is characterised by common properties such as a particular lithology, groundwater flow type, and productivity. Drawing on regional geological maps and supporting literature, the geological units mapped in the two base maps were, where necessary, modified, grouped, or divided to create new hydrogeological units characterised by similar hydrogeological properties on the scale of the ECOWAS region. There are two layers of geological information, a **hydrogeological unit base layer** (showing the uppermost bedrock aquifer, Section 3.1) and a **cover layer** (showing superficial Quaternary deposits, Section 3.2).

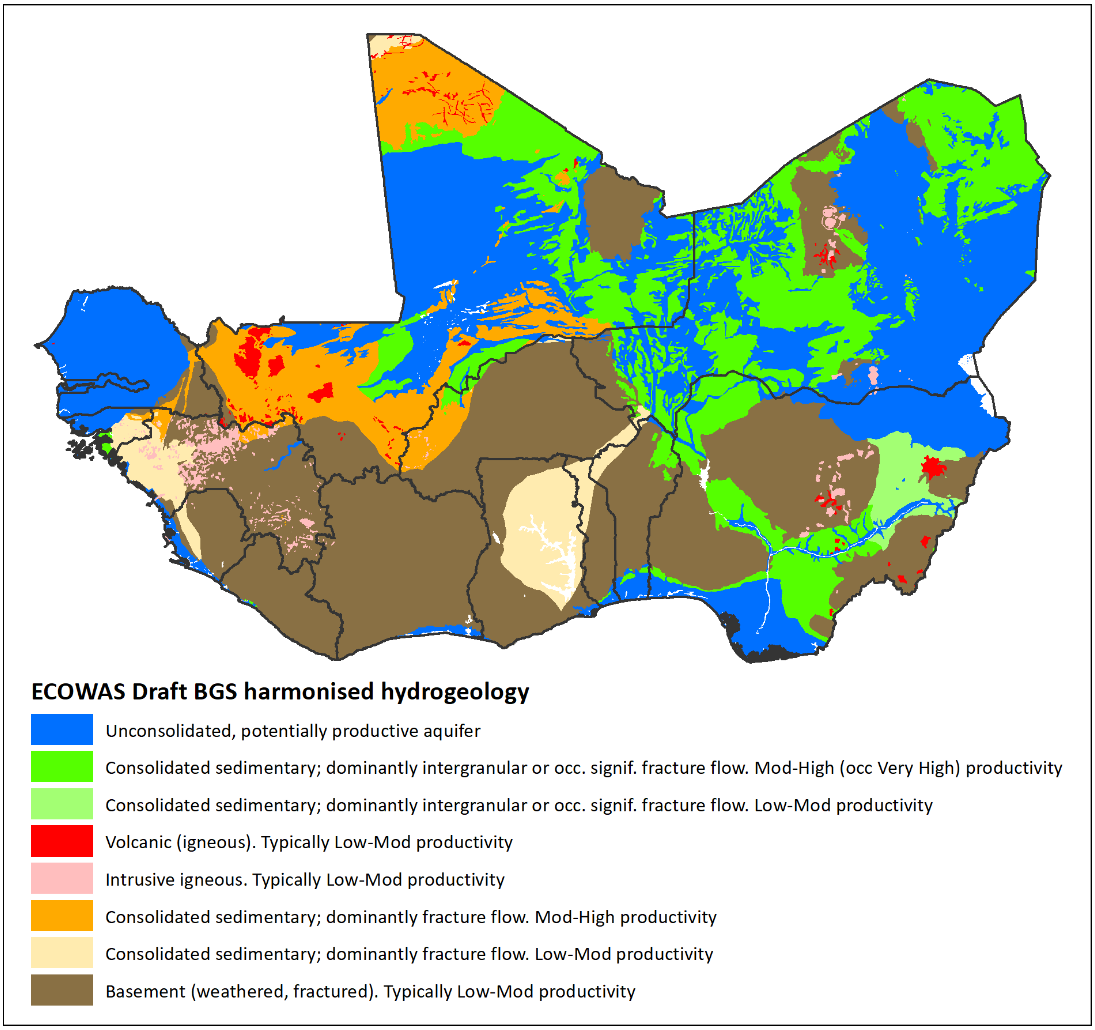

Fig. 2: Harmonised Africa Groundwater Atlas Country Hydrogeology Maps for the ECOWAS region (British Geological Survey 2019)

2.3 Expected aquifer productivity

How much groundwater can an aquifer supply? Or in other words, what is the aquifer productivity? The answer to this crucial question is not straightforward. The amount of abstractable water depends on many parameters, and is influenced not only by highly variable (hydro-) geological conditions but also the size and type of borehole construction, siting, and last, but not least, the capacity of any installed pumping device.

Hydrogeologists use various hydrogeological parameters to describe the general ability of an aquifer to transmit groundwater, or more specifically the ability of a borehole to deliver water. The most commonly used parameters, in decreasing order of quantitative rigour, are:

- ***Transmissivity*** *[L^2/T, commonly m^2/d]*: the rate of water flow through an aquifer cross section of unit width under a unit hydraulic gradient over the full saturated thickness of the aquifer;
- ***Hydraulic conductivity*** *[L/T, commonly m/d]*: the rate of water flow through a unit cross sectional area of an aquifer under a unit hydraulic gradient;
- ***Specific capacity*** *[$L^3/T/L$, commonly $m^3/d/m$ or l/s/m]:* the rate of discharge per unit of drawdown, ability of a borehole to deliver groundwater (independent of the pumping capacity);
- ***Yield*** *[L^3/T, commonly l/s or m^3/d]*: actual yield of a borehole with respect to the installed pumping capacity;
- **Qualitative classifications** based on expert knowledge [e.g. low, moderate, high productivity].

Determination of the first three parameters requires detailed information about aquifer geometry and groundwater levels and sophisticated hydraulic investigations (pumping tests). Although these provide the most reliable data for characterising physical aquifer properties, they are often not available, and in practice, less rigorous yield data, or qualitative assessments, are often used to assess and map aquifer productivity. In data-poor aquifers, borehole yield data have been shown to be a reasonable proxy for transmissivity (Graham et al. 2009).

Most hydrogeological maps show a **qualitative classification** of **potential aquifer productivity**, assigned by hydrogeological experts. Potential aquifer productivity is usually estimated from aquifer lithology; and aquifer flow type (e.g. intergranular, fractured or karst), and is often classified using a simple qualitative scheme (e.g. low, moderate, and high). One widely applied and well-known aquifer productivity classification scheme is that proposed for the *International Legend for Hydrogeological Maps* developed by IAH/IAHS/UNESCO working groups (UNESCO et al. 1970; Struckmeier et al. 1983), published as *Standard Legend for Hydrogeological Maps* (Struckmeier & Margat 1995). This classification has been adopted worldwide both in its original and in numerous modified versions, for example in the *International Hydrogeological Map of Europe - IHME1500* (BGR & UNESCO 2013).

The blue/green to brown-coloured aquifer classification system (Fig. 3) shows six aquifer productivity classes, combining information on the type of aquifer (groundwater) flow regime (intergranular flow in porous aquifers

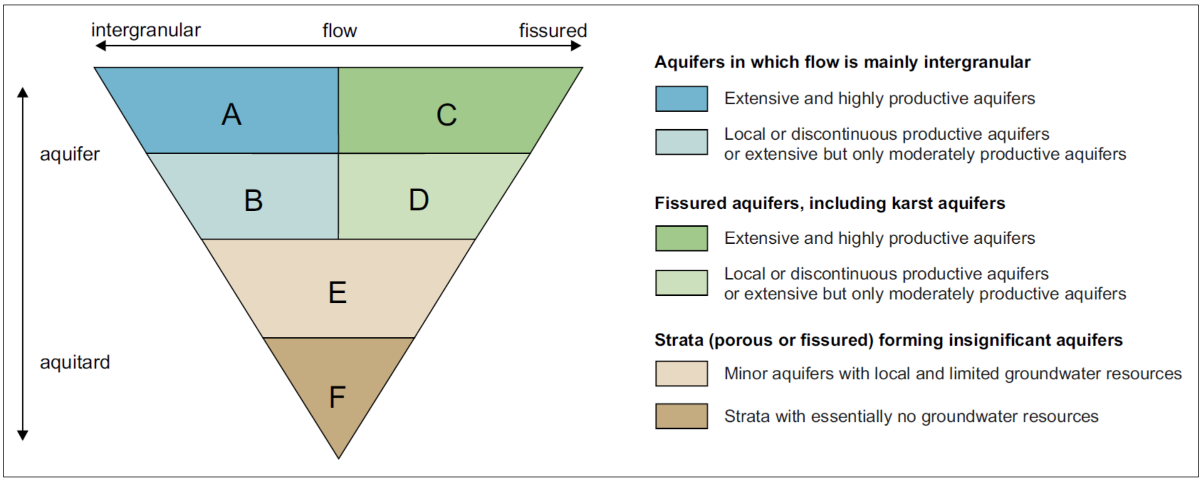

Fig. 3: Aquifer classification adapted from the Standard Legend for Hydrogeological Maps (Struckmeier & Margat 1995)

or fractured flow in a consolidated and fractured aquifers) and aquifer potential (four qualitative classes focusing on the aquifer size (lateral extent), and its productivity).

The classification strongly depends on expert knowledge and, given expert-based generalisations, it can be applied to even data-poor aquifers. It relies on an assumed but unspecific relationship between aquifer lithology, groundwater flow type, and potential aquifer productivity. These qualitative maps, therefore, must usually be interpreted by a hydrogeological expert in order to provide decision makers with quantitative estimates of the range of borehole yields that can be expected from an aquifer of a given productivity. To increase the value of such qualitative maps for planning, future improvements in data collection are needed at a local and regional level, to improve quantitative assessments of aquifer productivity.

2.3.1 A quantitative, yield-based approach to groundwater productivity classification

The expected aquifer productivity classification developed for the *Groundwater resources in the ECOWAS region* map improves on a qualitative assessment and provides a **quantitative estimate of expected borehole yield**, which reflects the most likely range of borehole yields expected for a given hydrogeological unit. Expected aquifer productivity is an appropriate and easy-to-interpret parameter that describes groundwater resource potential for the general public.

Borehole yield was chosen as it is the most widely recorded and reported quantitative hydrogeological parameter in the ECOWAS region: as discussed in Section 2.3, more robust hydrogeological parameters to characterise aquifer productivity such as transmissivity and hydraulic conductivity are more data-demanding and are less widely available. Borehole yield, or flow or pumping rate, is influenced not only by the aquifer productivity – its ability to provide water (transmissivity) but also by site location and technical characteristics including the borehole geometry, construction, and the installed pumping capacity. However, borehole yield has been shown to be a reasonable quantitative proxy for transmissivity (Graham et al. 2009), and it is the most relevant parameter of interest for most borehole owners, communities, contractors, planning agencies, and decision makers. Borehole yield data, compiled from documented sources, including published literature, are relatively widely available for most mapped hydrogeological units in the ECOWAS region, and allow a comprehensive and relatively consistent attribution of hydrogeological units at the regional scale.

2.3.2 Classification of expected aquifer productivity

Expected aquifer productivity is shown on the map using a two-dimensional legend evolved from the *Standard Legend of Hydrogeological Maps.* It combines the expert classification of aquifer flow type (colour), generally linked to state of consolidation, with an independently derived estimate of expected borehole yield (lightness) for a properly sited and constructed borehole. The legend differentiates:

Aquifer flow type by colour on the x- axis:

- **Blue**: Unconsolidated sediments forming porous aquifers with intergranular groundwater flow;
- **Green:** Partly consolidated, sedimentary rocks spanning the continuum from weakly consolidated Tertiary sediments to partly metamorphosed Precambrian metasedimentary rocks, with an unspecified combination of intergranular and fractured groundwater flow;
- **Brown:** Strongly consolidated crystalline basement rocks, including metamorphic, plutonic, and volcanic rocks, all with only fractured groundwater flow;
- **Violet:** Consolidated carbonate rocks formed predominantly of limestone or dolomite, for which significant karst features have been reported.

Expected borehole yield by lightness on the y-axis:

- **> 10 l/s:** Abstractions of regional importance (can supply large towns, large industries, large-scale irrigation);
- **2 - 10 l/s:** Abstractions that can supply small towns, villages, small-scale irrigation;
- **0.5 - 2 l/s:** Abstractions that can supply village-sized communities via small motorised pumps;
- **0.1 - 0.5 l/s:** Abstractions that can supply small communities via hand pumps;
- **< 0.1 l/s:** Abstractions that may be able to supply small numbers of households via hand pumps.

The borehole yield classes include more resolution for lower yields (< 2 l/s) than higher yields. This is deliberate, in response to the importance of decentralised groundwater supply in this region, which means the most frequent water demand is for relatively small supplies, such as for villages or other small communities. The higher resolution for lower yields is also driven by the available information in the hydrogeological literature. Although very high borehole yields (> 10 l/s) in individual aquifers are frequently highlighted, there is little evidence for their representativeness, as other data often indicates that the average yield range of that hydrogeological unit is lower. The aquifer productivity map therefore aims to provide a suitable level of resolution in low-yielding aquifers, but in doing so it may underestimate the productivity of high-yielding aquifers.

The selected aquifer productivity classes have been guided by WASH classifications, in particular those of Olley (2008) and Baumann (2000). They differ from similar classification approaches by MacDonald et al. (2012, 6 classes), Krásný (1993, 6 classes) and Bäumle et al. (2007, 4 classes), and from approaches by European geological surveys that focus on high yielding boreholes for centralised water supplies.

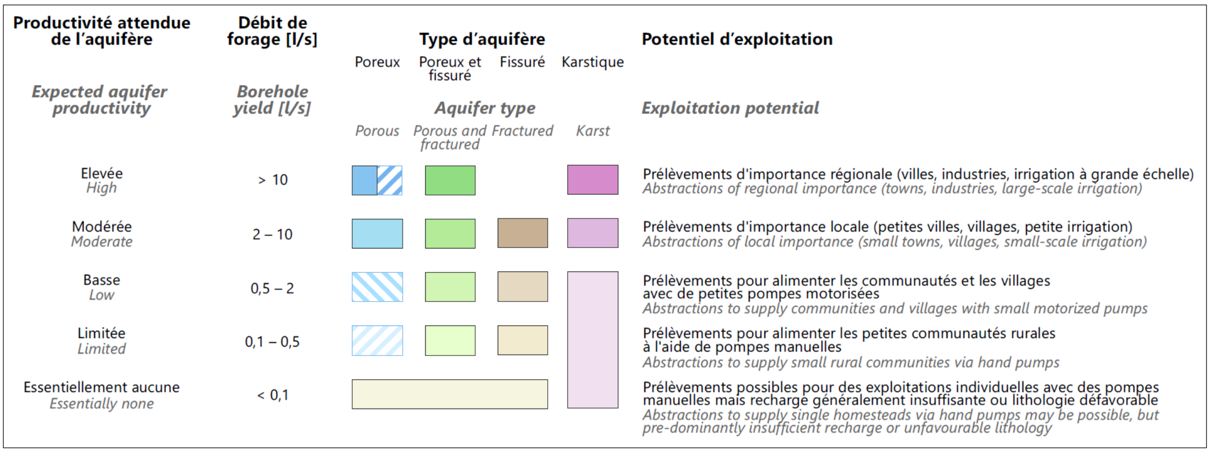

Fig. 4: Expected aquifer productivity classification scheme

2.3.3 Description of expected aquifer productivity classes

High productivity aquifers (> 10 l/s): abstractions of regional importance that can supply large towns, large industries, large-scale irrigation

High productivity aquifers allow groundwater abstractions of regional importance that can supply large towns, large industries or large-scale irrigation projects. Borehole yields of > 10 l/s are common. These are often unconsolidated, sedimentary aquifers with intergranular flow, high permeability, and high storage capacity, and are generally continuous and extensive over a large area. High productivity aquifers in the ECOWAS region include:

- unconsolidated sediments of Quaternary age, such as alluvial and coastal sediments;
- partly consolidated sediments of the coastal Continental Terminal;
- karstified limestone aquifers in Senegal (Système aquifère intermédiaire: Calcaires du Paléocène).

Moderate productivity aquifers (2 - 10 l/s): abstractions that can supply small towns, villages, small-scale irrigation

Moderate productivity aquifers allow groundwater abstractions that can supply small towns, villages, and small-scale irrigation. Borehole yields of between 2 - 10 l/s are common.

Moderate productivity aquifers can be of any lithology, and groundwater flow may be intergranular, fractured or mixed. Most extensive in the ECOWAS region are partly consolidated sedimentary hydrogeological units with a mixture of intergranular and fractured groundwater flow, they are usually continuous and extend over large areas. They are often heterogeneous in lithology and aquifer properties, characterised by mixed sandstones, siltstones, and mudstones, with occasional thick, extensive high permeability sandstone beds forming zones of moderate to high productivity, alternating with clay-rich, low-permeability beds forming zones of low to limited productivity. They are often, therefore, only moderately productive on average when classed over their whole mapped extent. Examples of moderately productive aquifers in the ECOWAS region include:

- Chad Formation and Continental Terminal of the intracratonic Iullemmeden and Taoudéni basins;
- Cretaceous sandstones (Continental Hamadien, Ajali, Bima and Nupe Sandstones);
- Neoproterozoic sandstones (Anyaboni Sandstone, Pita Formation);
- limestone aquifers (Formation d'Irma/Group de Hombori, Formation de Safia and Haricha).

Low productivity aquifers (0.5 - 2 l/s): abstractions that can supply village-sized communities via motorised pumps

Low productivity aquifers allow groundwater abstractions that can supply village-sized communities via small motorised pumps. Borehole yields of up to 2 l/s are common. The most common low productivity aquifers in the ECOWAS region are basement, consolidated sedimentary and metasedimentary hydrogeological units, with fractured flow, but they also include some hydrogeological units with mixed groundwater flow, as well as unconsolidated alluvial deposits in the cover layer (Section 3.2). These aquifers are typically highly heterogeneous, discontinuous and spatially restricted. Covering large areas of the basement, this class is one of the most prevalent in the ECOWAS region. Examples of low productivity aquifers in the ECOWAS region are:

- unconsolidated alluvial aquifers of limited extent, with intergranular flow, in the Adar-Doutchi area;
- mixed intergranular/fractured flow aquifers such as Menaka and Trichet Formations, Groupe de Majia, Grès de Tégama, Kerri Kerri Sandstone, Gongila, Pindiga & Fika Formations;
- fractured aquifers such as the Bandiagara & Koutiala Sandstones in Mali, Dunkro & Densubon Sandstones in the Volta Basin, the Groupe d'Youban, and the Asu River Group;
- extensive fractured basement aquifers.

Limited aquifer productivity (0.1 - 0.5 l/s): abstractions that can supply small communities via hand pumps

Aquifers with limited productivity allow small abstractions that can supply small communities via hand pumps. Yields of between 0.1 and 0.5 l/s are common. These aquifers are generally local and discontinuous, with low permeability and groundwater storage capacity. Much of the metamorphic and plutonic basement rocks of the West African Cratons are of limited aquifer productivity. Sedimentary aquifers of limited productivity are typically fine-grained, such as mudstone or shale. In the arid areas of the Sahara desert, expected aquifer productivity is limited by low precipitation and consequently insufficient recharge to replenish available aquifer storage, so that even sedimentary aquifers with favourable hydrogeological properties can have limited aquifer productivity. Examples of the limited aquifer productivity class in the ECOWAS region are:

- mixed intergranular/fractured flow aquifers such as the Formation de Khnachich (Mali), Formation de Farak (Niger), or the Lower Hydrogeological Group (Nigeria);
- fractured aquifers such as the Groupes de l'Azlaf & l'Erg Chech (Mali);
- extensive areas of fractured basement aquifers.

Essentially no groundwater (very limited aquifer productivity): (< 0.1 l/s): abstractions that may be able to provide small numbers of households via hand pumps (rocks with very little groundwater, either due to lithology (very low transmissivity and storage) or to insufficient recharge)

Groundwater sources even for small domestic water supplies are difficult to find and cannot be guaranteed everywhere. However, these aquifers may provide significant local supplies in areas with few other water resources. These are mainly clay-dominated sedimentary rocks with very low groundwater storage capability, but may include all other rock types. In the arid areas of the Sahara desert, expected aquifer productivity is also limited by low precipitation and consequently insufficient recharge to replenish available aquifer storage. Here, otherwise limited or low productivity aquifers, particularly of the basement but also including sedimentary and metasedimentary rocks, are all likely to contain essentially no groundwater resources. Similarly, unconsolidated aeolian and lacustrine sediments in areas of restricted recharge do not contain any significant groundwater resources, and so these units are included in the cover layer (Section 3.2). Examples of very limited productivity aquifers in the ECOWAS region include:

- the Argilites de l'Irhazer (Niger), Plaine de Gondo (Mali).

2.3.4 Assignment of expected aquifer productivity classes

The classification of hydrogeological units (aquifers) by the expected range of borehole yields differed depending on the type of unit: sedimentary, crystalline basement, or alluvial aquifers in the cover layer (Section 3.2). In addition, areas with restricted groundwater recharge were treated separately.

Sedimentary basins

Borehole yield data for aquifers of the major sedimentary basins was compiled from a meta-survey of relevant hydrogeological literature, with a strong focus on review papers summarising more detailed local studies. Based on this literature review, common yield ranges were identified for each designated hydrogeological unit, and one of five yield classes was assigned (Section 2.3.3).

Crystalline basement

The attribution of productivity to basement aquifers was informed by a meta-survey of hydrogeological review papers and a reassessment of yield values from available hydrogeological studies. The productivity of basement aquifers in West Africa typically ranges between 0.1 l/s and 2 l/s, spanning the classes *limited* (0.1 - 0.5 l/s) and *low* (0.5 - 2 l/s). Further hydrogeological subdivisions of the basement have been made in the past – commonly based on dominant lithology or regolith thickness – but these subdivisions have not shown a significant influence on borehole yield (Diluca & Muller 1985; Hazell et al. 1992; Courtois et al. 2010; Carrier et al. 2011); it is difficult to predict the number of saturated open fractures a borehole will intersect from the parameters used. Nevertheless, detectable regional trends and differences in aquifer productivity are observed across the basement aquifers in West Africa.

In order to reflect this variability as best as possible, basement aquifers were subdivided by structural domains (Fig. 5, Bianchi et al. in prep.), characterised by a common tectonic, metamorphic, and weathering history, and which share similar sedimentary features such as sets of lithologies, or general trends in regolith thickness and water table depth. Assignment to yield classes was based on a calculation of the statistical distribution of yields for different basement regions following the approach of Bianchi et al. (2020).

Alluvial aquifers

The literature review carried out for sedimentary basins revealed a significant gap in information for the arid Sahara region. However, the available data indicated that recharge strongly controls the productivity of alluvial aquifers in this region (Greigert 1968). Three types of alluvial sediments are distinguished for this map:

- **Alluvial sediments in (semi-) humid climates**
  Alluvial sediments are made up of a mixture of coarse and fine-grained sediments with generally high permeability, and are an important and easy to access groundwater resource for domestic and irrigation use. They have been assigned high aquifer productivity (> 10 l/s).

- **Alluvial sediments in arid regions**
  Despite their generally high permeability, limited recharge in these regions restricts the groundwater potential of these sediments. Greigert (1968) states that alluvial sediments in the Iullemmeden basin north of about 14°N latitude do not form continuous aquifers. However, small amounts of groundwater storage may occur locally, and is an essential resource for both nomadic and sedentary populations. They have been assigned limited aquifer productivity (0.1 - 0.5 l/s).

- **Alluvial sediments in the semi-arid region of the Adar Doutchi**
  Greigert (1968) provides detailed information for the alluvial sediments in the valleys of the Adar Doutchi, the Tarka, and the Goulbi N'Kaba and they have been treated as a special case. They have been assigned low aquifer productivity (0.5 - 2 l/s).

Influence of recharge on aquifer productivity

The productivity of aquifers with limited storage volume – such as basement or alluvial aquifers – is strongly controlled by variations in precipitation, which controls recharge. In modern times, aquifers of the Sahel and the Sahara desert receive little annual recharge, because of very low precipitation, which has been the case since the end of the African Humid Period (c. 5 ka). For example, long-term average recharge (MacDonald et al. 2021) in the Adrar des Iforas and the Aïr regions is less than 10 mm/a, and in Damagara-Mounio less than 25 mm/a.

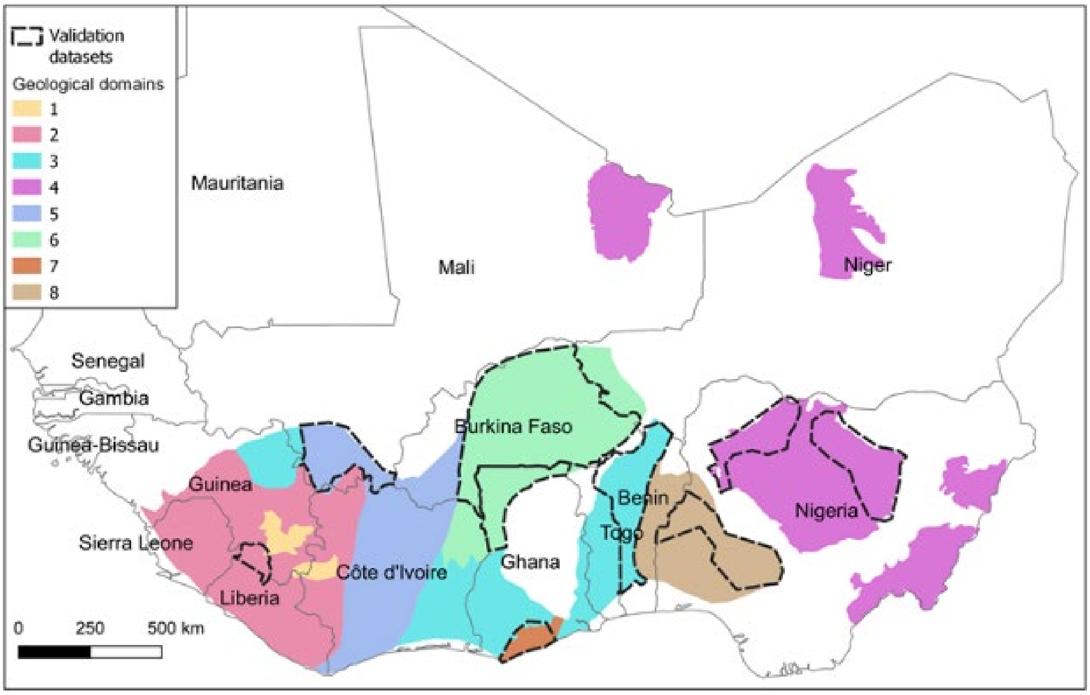

Fig. 5: Structural domains used for the classification of expected aquifer productivity (from Bianchi et al. in prep.), where 1. African surface on igneous basement - Kénéma-Man domain; 2. Igneous basement with thick regolith - Kénéma-Man domain (Liberia, Sierra Leone); 3. Metasediment basement with variable regolith - Dahomeyide Belt (Benin, Togo), Baoulé-Mossi domain (Ghana, Côte d'Ivoire, Mali); 4. Plutonic basement and fracture zone with minimal regolith - Jos Plateau (Nigerian shield); 5. Volcanic-volcano-sedimentary (50:50) basement with thick regolith - Baoulé-Mossi domain (Côte d'Ivoire, Mali); 6. Volcanic-volcano-sedimentary (70:30) basement with thick regolith - Baoulé-Mossi domain (Burkina Faso); 7. Igneous basement with minimal regolith and mainly alluvium - Baoulé-Mossi domain (southern Ghana); 8. Plutonic basement and fracture zone with thin regolith - Southwestern Nigeria (Nigerian shield).

Consequently, most shallow crystalline basement aquifers in the Sahara desert (Adrar des Iforas, Aïr, Damagara-Mounio, Termit, etc.) are assumed to be dry for most of the time. However, they do contain some locally relevant groundwater resources, such as in deeply weathered areas, in deep fracture zones, or where there is hydraulic interaction with, and recharge from, alluvial aquifers that may be periodically recharged from rare ephemeral river flows. This is supported by Greigert (1968) for the Iullemmeden basin, where Quaternary alluvial sediments south of latitude 14°N form continuous and often high yielding aquifers, whereas further north they only contain limited, local, and discontinuous groundwater resources.

Given the significant lack of recharge, and limited available borehole yield information, basement aquifers of the Adrar des Iforas and Aïr regions are classed as having very limited productivity (< 0.1 l/s) with essentially no groundwater resources. Alluvial aquifers of the Adar Doutchi area are classed as having low aquifer productivity (0.5 - 2 l/s), based on information from Greigert (1968); other alluvial aquifers in the region are classed as having limited productivity (0.1 - 0.5 l/s).

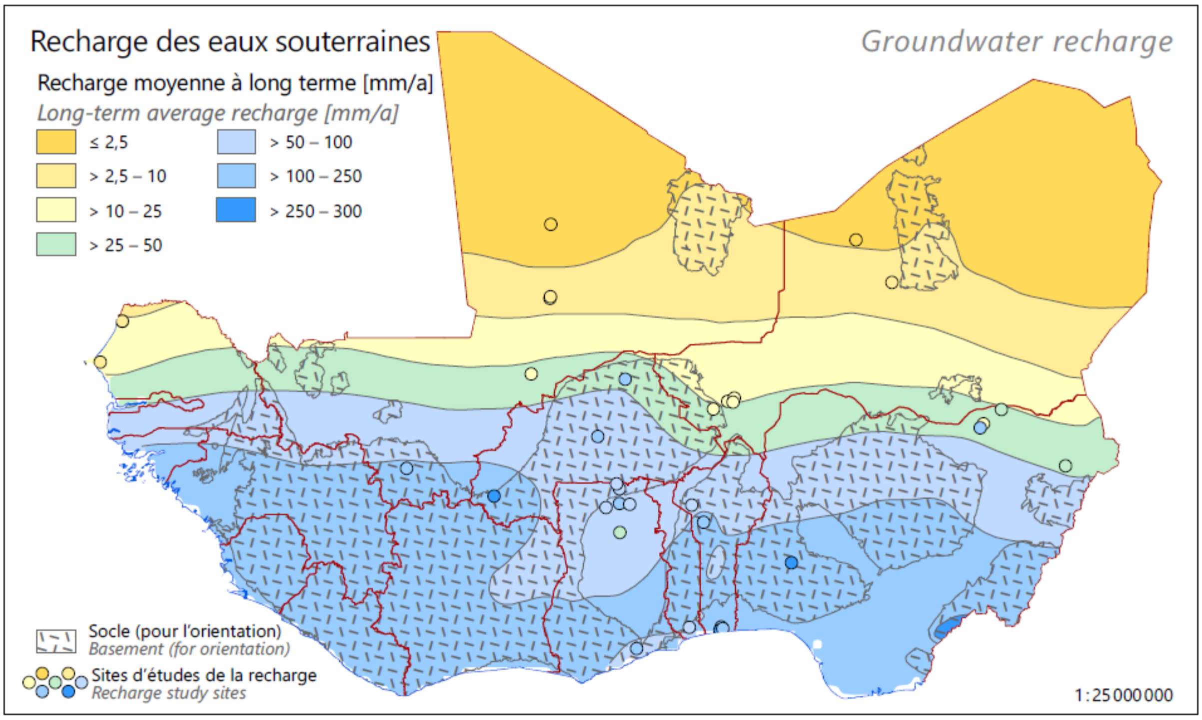

Fig. 6: Long-term average recharge (MacDonald et al. 2021). Insufficient recharge in arid climates limits the productivity of crystalline basement and alluvial aquifers in the cover layer.

2.3.5 Limitations of the expected aquifer productivity map

A key limitation of the new map is the lack of available quantitative aquifer properties data, which led to the use of borehole yield as a proxy for aquifer productivity. Although borehole yield is a reasonably reliable and representative parameter (e.g. Graham et al. 2009), it is not as rigorous as transmissivity or specific capacity. An important bias of the meta-survey was the selection and the availability of the literature reviewed for the map. This was heterogeneous in quality, quantity, and coverage, and focused regionally on the large sedimentary basins of Mali, Niger, and Nigeria. This bias in available information drove the use of expert knowledge to assess and weight the available aquifer properties data and assign the yield and aquifer productivity classes. The limited timeframe and resources for the development of this map also restricted its scope, for example by excluding the collection of new data or the consistent statistical evaluation of available borehole yield distributions – a standard approach for the hydrogeological characterisation of aquifers (cf. DNHE 1990; Krásný 1993; Wright 2000; Banks et al. 2005; Graham et al. 2009; Abesser & Lewis 2015). This approach was applied to basement aquifers, but was limited by the low number and the spatial representativeness of available studies.

The inherent heterogeneity of many of the mapped hydrogeological units also influences the representativeness of the assigned aquifer productivity classes. Many units, although mapped as a single lithology, have highly variable aquifer properties, including a wide range of potential borehole yields. Assigning each hydrogeological unit to a single expected aquifer productivity class required generalising the whole known, often large, range of yields in the unit, which inevitably led to a loss of information on the yield distribution. The boundaries between the assigned classes are, therefore, not absolute, but are estimates of the dominant range of yields of properly-sited and well-constructed boreholes. Individual borehole yields may vary substantially above or below the given ranges. Additionally, as discussed above, aquifers in arid areas, where recharge is very low, may have high intrinsic (potential) productivity, but the lack of recharge means that in shallow aquifers there is little or no groundwater available. Any groundwater storage in deeper aquifers is likely to be non-renewable.

2.4 Review by regional hydrogeological experts

A draft of the map was kindly revised by a team of West African hydrogeologists with extensive experience in the hydrogeology and groundwater resources of the region.

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MSc. Bazoun, Janvier (ECOWAS-WRCC):	Water Resources Coordination Centre (WRCC), ECOWAS
MSc. Bojang, Landing (The Gambia):	Principal Hydrologist & Hydrological Adviser (WMO-PR), Department of Water Resources
Prof. Boukari, Moussa (Bénin):	Hydrogeologist, Faculté des Sciences et Techniques, Université d'Abomey-Calavi
Prof. Gnazou, Masamaéya (Togo):	Hydrogeologist, Hydrogéologie et Hydrologie, Département de Géologie, Faculté Des Sciences, Université de Lomé
Dr. Godau, Thomas (Bénin):	Program director, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Prof. Kebede, Seifu (IAH):	Hydrogeologist, Centre of Water Resources Research, University of KwaZulu-Natal, South Africa
Prof. Konaté, Moussa (Niger):	Professor, Département de Géologie, Université Abdou Moumouni de Niamey (UAM)
Kouadiou EK (Côte d'Ivoire):	Hydrogeologist, Université Felix Houphouët Boigny
Dr. Guero, Abdou (NBA):	Director of the Technical Department, Niger Basin Authority (NBA)
Issaka, Amadou Roufaye (Niger):	Hydrogeologist, GIS data officer, Millenium Challenge Account, Mcc funds, Niamey
Dr. Macdonald, David (BGS):	Principal Hydrogeologist, British Geological Survey, Wallingford, UK
Dr. Ouedraogo, Issoufou (Burkina Faso):	Lab. Geosciences and Environmental, Dept.Mining / Dept. Civil Engineering, École Supérieure d'Ingénieurs de Fada (ESI-F), University of Fada N'Gourma, Burkina Faso
Dr. Oularé, Sekouba (Côte d'Ivoire):	Hydrogeologist, UFR STRM / Université Félix H. Boigny, Abidjan
Sanoussi Rabe (Niger):	Directeur de l'Hydrogéologie, Direction Générale des Ressources en Eau, Ministère de l'hydraulique et de l'assainissement

2.5 The way forward

Any map is only as good as the available data it is based on. This map provides a transparent quantitative assessment of aquifer productivity based on available data and resources: it is hoped that it can be the basis for improved maps at national scales. The collection of reliable new aquifer properties data from borehole testing, their analysis, and the development of more robust, representative aquifer productivity maps at national and regional level is a challenging task for national and regional hydrogeological institutions.

It is likely that any revision of this map by regional and/or national authorities and experts will result in major updates to the mapped geometry of the hydrogeological units (aquifers) and the expected yield ranges and aquifer productivity classifications presented here. Constant revisions will be necessary to include new hydrogeological data as it becomes available and thence to improve future maps. Constructive contributions to whymap@bgr.de are welcome.

3 Map description

The *expected aquifer productivity map* is composed of two layers. A seamless **hydrogeological unit base layer** showing the bedrock geological units forming the uppermost aquifer and a **cover layer** showing superficial Quaternary deposits that are either non-aquifers (aeolian sands and lacustrine sediments), or shallow alluvial aquifers overlying hydrogeologically relevant bedrock geological units

3.1 Hydrogeological unit base layer

The hydrogeological unit base layer provides a seamless dataset of the uppermost, hydrogeologically relevant bedrock formations, including unconsolidated, partly consolidated, and consolidated formations. Where information on the extent of bedrock formations was missing in the original datasets – such as below surface water bodies or below areas of unconsolidated superficial deposits, most of which are included in the cover layer (Section 3.2) – the hydrogeological units in the base layer have been extrapolated. The only unconsolidated superficial deposits included in the hydrogeological unit base layer are those where information on bedrock geology is missing, could not be extrapolated, or is not reliable. These are:

3.1.1 Undifferentiated sedimentary units

In regions with poor data quality, even the uppermost aquifers are not well-known or cannot be assigned to a single hydrogeological unit. In order to deal with this, these areas are mapped in the geological base layer as combined, undifferentiated units, including both unconsolidated superficial deposits and the underlying bedrock. The map unit codes used in the geological base layer reflect this uncertainty and the necessary assumptions about the geology.

A particularly challenging example is the Ténéré desert in Niger. Despite a good knowledge of the deep Kafra-Seguedine, Grein, Bilma, Ténéré, Tefidet and Termit graben structures, obtained in the course of petroleum exploration, the nature and spatial extent of the near surface stratigraphic units have not been mapped, and it's not possible to differentiate between unconsolidated aeolian deposits and the assumed underlying sediments. Distinction between the cover layer and bedrock is also challenging for sedimentary strata such as the extensive Chad Formation or the even more extensive Continental Terminal. The Continental Terminal includes, by definition, all post-Eocene continental sediments, which complicates differentiation of the degree of consolidation and aquifer flow type within the unit. For example, in Mali, continuous continental sedimentation since the Miocene makes it impossible to differentiate between older sediments of the Continental Terminal and more recent alluvial (Inner Delta) and aeolian (Azaoud Nord and Azaoud Sud) deposits.

3.1.2 Coastal and deltaic deposits

Unconsolidated coastal and deltaic deposits along the Atlantic coast generally form notable aquifers containing significant groundwater resources. Their thickness and extent exceeds those of alluvial and aeolian deposits, which is reflected on the geological source maps, where these deposits are often classified as a separate hydrogeological unit, without consideration of underlying bedrock aquifers. The new map follows this approach, classifying unconsolidated coastal and deltaic deposits as part of the geological base layer.

3.2 Cover layer (superficial deposits)

The superficial deposits cover layer comprises unconsolidated, mostly Quaternary deposits of limited thickness – aeolian, alluvial, and lacustrine deposits – that cover or overlie the hydrogeologically relevant geological base units. As mentioned above, superficial coastal deposits are classified as a hydrogeological unit within the geological base layer, and are not included in the cover layer.

Superficial (cover) hydrogeological units are distinguished according to their hydrogeological significance. Aeolian deposits such as dune fields, ergs, or sand sheets, and clay-dominated lacustrine sediments usually contain no usable groundwater and do not form significant aquifers. They are represented on the map using red ornaments (dots for aeolian and dashes for lacustrine sediments). Alluvial sediments often form significant aquifers and are represented by a striped blue ornament, the lightness of the colour depending on their assigned aquifer productivity class.

3.2.1 Aeolian deposits

Dunes, sand sheets, ergs, and dune corridors cover vast areas of the Sahel and the Saharan desert. They range in thickness from a few metres up to several hundred metres and conceal the underlying bedrock in most of the Taoudéni, Ténéré de Tamesna, and Ténéré de Taffasset deserts. Following the differentiation of Greigert (1968), which was reproduced by subsequent geological maps, two aeolian landforms are mapped: Sand flats and sand sheets (Qs), mainly occurring in the northern Ténéré du Tafassasset, and undifferentiated (both active and inactive generations of) dunes (Qe).

These aeolian deposits are typically permeable, facilitating the infiltration of any occasional rainfall as recharge to underlying bedrock aquifers. The limited rainfall in most areas of their outcrop, combined with their generally high permeability that facilitates rapid groundwater flow, means the aeolian deposits themselves are generally dry. However, in some areas the deeper parts of the aeolian deposits are likely to form part of a multilayer aquifer system with underlying bedrock aquifers (e.g. in Mali: Continental Intercalaire and Quaternary deposits of the Azaoud Nord, Azaoud Sud, and Fossé de Nara units - or in Eastern Niger: Chad Formation, Nappe de Manga, Ténéré). On the map, some of these are combined and mapped as undifferentiated sedimentary units (Section 3.1.1), while others are not distinguished.

Locally, small temporary perched aquifers in aeolian deposits may form, particularly at the clay-rich footslopes of fixed dunes or in topographic depressions and valley bottoms, sometimes even establishing seasonal water bodies (*mares*). Strong precipitation events can recharge such perched aquifers, which may store groundwater for weeks, months or even years. However, the locations of these are not mapped at a regional scale, and they are not distinguished on this map.

3.2.2 Lacustrine deposits

Lacustrine (lake) deposits do not generally contain significant groundwater resources. Lake sediments occur throughout the Sahel and the Sahara, formed during wetter climatic conditions, most recently during the mid-Holocene African Humid Period, when there was widespread occurrence of surface water bodies in the nowadays arid Sahara. The mid-Holocene highstand (~5 ka) of Megalake Chad is marked by the Bama ridge (329 m); a subsequent highstand (~3 ka) is marked by the 290 m high Ngelewa beach ridge (Drake & Bristow 2006; Armitage et al. 2015). On the map, these ridges enclose, respectively, superficial lacustrine sediments of the Plaine de Kadzell and the continually receding present-day Lake Chad. The extent of the mid-20th-century (c. 1963) historic Lake Chad is indicated by seasonally flooded wetlands.

3.2.3 Alluvial deposits

Alluvial deposits are important, although spatially limited, aquifers, supplying drinking water to villages and towns as well as being an important source for small and medium-scale irrigation along the courses of the main rivers. Alluvial aquifers benefit from regular recharge by infiltrating surface water. Even flash floods and seasonal discharge of intermittent streams can efficiently recharge alluvial groundwater bodies. Where alluvial aquifers are connected with the underlying bedrock, they may play an important role in supplying regular recharge to underlying aquifers. In certain topographic positions alluvial aquifers may benefit from lateral groundwater flow and in (regional) discharge areas (e.g. Dallols of Niger), the upward discharge of groundwater from deeper aquifers into overlying alluvial aquifers may contribute to an increase in their aquifer productivity.

On the scale of this regional map, alluvial aquifers have been assumed to be mainly coarse textured, and therefore to have generally high aquifer productivity. However, this assumption does not hold true for many fine-grained overbank and flood deposits, which are likely to have a lower porosity, permeability, and aquifer productivity, particularly those occurring along major rivers with slow drainage, and especially the Inner Delta of the River Niger.

4 Digital data sets

4.1 Expected aquifer productivity map

The digital version of the *Groundwater resources in the ECOWAS region* map is made available as a series of shapefiles for use in a Geographic Information System (GIS). Each shapefile has an associated attribute table with a consistent description of relevant hydrogeological parameters. The provision of these parameters for each hydrogeological unit allows the user to select combinations as required.

The data of the printed map is provided in the master shapefile:

- **GWR_ECOWAS_v1_HydrogeologicalUnits:** A geological base layer (as described above) showing individual hydrogeological units as codes, with an accompanying attribute table containing the hydro-geological parameters listed in sections 4.1.1 to 4.1.15.

Simplified shapefiles have been prepared for the key parameters shown in the printed map:

- **GWR_ECOWAS_v1_Aquiferproductivity:** Expected aquifer productivity of the hydrogeological unit base layer (as described in detail in section 2.3)
- **GWR_ECOWAS_v1_CoverLayer:** Superficial deposits including local alluvial aquifers and non aquifers (Section 3.2)
- **GWR_ECOWAS_v1_Lithology:** Generalised lithological classes of the hydrogeological units (Section 4.1.9)

Download: www.whymap.org

4.1.1 Stratigraphic unit (St_unit)

Denominations of geological units. Units have been selected for representativeness on the map and include, depending on their spatial relevance and the available geological background information, Groups, Formations, Members and/or facies names. In the process of generalisation, many minor stratigraphic units have been combined under the most dominant unit. As far as possible they are named using the most common established regional lithostratigraphic nomenclature, but alternative names and local variants may exist.

4.1.2 Stratigraphic code (ID_Strat)

The stratigraphic unit code is composed of a chronostratigraphic prefix (e.g.: Q: Quaternary, nP: Neoproterozoic) or regionally accepted abbreviations (e.g.: Ci: Continental Intercalaire, Cm: Cretaceous marine, CH: Continental Hamadien, CT: Continental Terminal) and a composite unit code based on the stratigraphic unit (e.g.: T: Grès de Tégama, YGPF: Yolde, Gongila, Pindiga, Fika Formations), for some units facies were separated (e.g.: nP-OP-Ba-s: Neoproterozoic Oti-Pendjari Group: Bimbila Fm, (Chereponi & Bunya) sandstones), whereas for others a comma, separates a regional suffix (Qc, Bv: Quaternary coastal, Basin Bové) differentiating stratigraphic units occurring in more than one sedimentary basin.

4.1.3 Unit code (ID_unit)

Stratigraphic code with suffixes to differentiate regional unit variants with the same hydrogeological parameters but which for technical purposes have been separated to allow for regional distinction. This is relevant for units occurring throughout West Africa, such as the Continental Terminal or coastal deposits.

4.1.4 Basin or structural unit [Basin]

The major sedimentary basin or the respective structural basement unit (Fig. 8).

4.1.5 Chronostratigraphy [CS_era, CS_system, CS_series, CS_stage]

For each stratigraphic unit the approximate chronostratigraphy is given on the levels of erathem/era, system/period and, if available, series/epoch and stage/age.

4.1.6 West African stratigraphic group [St_group]

This classification of stratigraphic groups in West Africa builds on that proposed by Kilian (1931) (Tab. 1) and combines elements of various existing classifications. This approach may be useful when addressing the complex geology of the region, and, therefore, it is released as an attribute with the digital map. It is proposed as a working classification to further discussion and awaits review by experts on the geology of West Africa (Tab. 2).

The stratigraphic group in West Africa classes the geological units in a high level hierarchy according to depositional environment, chronostratigraphy, and rock type (degree of metamorphism, igneous rocks, and basement). Conventional stratigraphic designations broadly follow the stratigraphic intervals proposed by Kilian (1931; see also Swezey 2009) differentiating marine (*Couverture* or *Série*) and continental (*Continental*) sequences of the broader Saharan region. While widely adopted (e.g. *Continental Terminal* has been adopted throughout West Africa for the coastal continental deposits), the classification developed for the Hoggar area approaches its limits in other regions such as Nigeria, Mali, or Guinea – particularly where the implied link between chronostratigraphic interval and lithology fails due to facies changes or an entirely different sedimentary environment. In Niger, continental deposition along the shores of the Upper Cretaceous Trans-Saharan seaway early on required the introduction of the *Continental Hamadien* concurrent with the eponymous marine *Série hamadienne*.

For Mali, the established differentiation between *Infracambrien plissé* and *Infracambrien tabulaire* is adopted to discriminate between Upper Neoproterozoic to Cambrian sedimentary strata that have – or have not – undergone folding and weak metamorphism. A classification that perhaps could be extended to the Cambrian to Devonian strata of Guinea.

Basement rocks are classed as cratonic shields, igneous rocks, and Pan-African mobile belts (Trans-Saharan Belt). The Pan-African mobile belts consist of Neoproterozoic volcano-sedimentary sequences that have undergone locally varying degrees of metamorphism and folding during the Pan-African orogeny. The mobile belts are differentiated from the metamorphic complexes of the Paleoproterozoic cratonic shields that have experienced reworking and metamorphism during multiple orogenies. Igneous, intrusive and extrusive, rocks are separated into intrusive "Older Granites" (Neoproterozoic), CAMP intrusives, "Younger Granites" (Mesozoic) and Cenozoic and Quaternary volcanic rocks.

Tab. 1: Marine and continental stratigraphic intervals following Kilian (1931)

Marine environment (predominantly)	**Continental environment** (predominantly)	**Stratigraphic interval**	**Examples**
	Quaternary continental sediments	Pleistocene to Holocene (Quaternary)	Coastal sediments
	Continental Terminal (CT)	Cenozoic i.e Paleogene (Eocene) to recent	Continental Terminal, Kerri-Kerri
Série hamadienne (Cm, E)	Continental Hamadienne (CH)	Upper Cretaceous (Cenomanian) to Lower Paleocene (Danian) later including Eocene marine strata (E)	Rima Group, Calcaires blancs, Schistes papyracées/ Continental Hamadien
	Continental Intercalaire (Ci)	Upper Carboniferous (Moscovian) to Upper Cretaceous (Cenomanian)	Grés de Tégama, Nubian sandstone
Série post-Tassilienne		Upper Devonian (Frasnian, Famennian) to Middle Carboniferous (Visean, Namurian)	Série de Tagora/Talach
Couverture Tassilienne		Ordovician, Silurian (Gothlandian) to Lower Devonian	Kandi Group
	Continental de base		Grès de Timesgar, Grès du Cambrian

Tab. 2: Major stratigraphic groups in West Africa

West African stratigraphic group		Predominant depositional environment
Sedimentary basins (Classification of Kilian, 1931)		
Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)		sedimentary, aeolian/ alluvial/ lacustrine/ coastal
Continental Terminal (Post-Eocene, terrestrial deposits)		sedimentary, continental
Continental Hamadien (Terrestrial deposits of the Upper Cretaceous)		sedimentary, continental
Série hamadienne (Marine transgressions of the Upper Cretaceous/Paleocene)		sedimentary, marine (to continental)
Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)		sedimentary, continental (to marine)
Undifferentiated Continental Intercalaire, Série Hamadien, Continental Terminal and recent deposits		sedimentary
Série post-Tassilienne (Transgression marine du Dévonien supérieur et Carbonifère)		sedimentary, marine (to continental)
Couverture Tassilienne (Transgression marine du Ordovicien-Silurien)		sedimentary, marine (to continental)
Continental de base (pre-Ordovician continental strata)		sedimentary, continental (to marine)
Sedimentary basins - Volta Basin		
	Accraian & Sekondian	sedimentary, continental
	Voltaian Supergroup	sedimentary, continental - marine
Sedimentary basins - Metasediments		
	Infracambrien tabulaire	metasedimentary, continental - marine
	Infracambrien plissé (Pan-African)	metasedimentary, marine
	Supergroup 1 (Hodh)	metasedimentary, marine
	Youkounkoun Group	metasedimentary, cont. & marine, volcanic
	Pan-African: Rockelide Belt	(meta-) volcano-sedimentary
	Pan-African: Bassaris Belt	(meta-) volcano-sedimentary
	Pan-African: Pharuside Belt	(meta-) volcano-sedimentary
	Pan-African: Dahomeyide Belt	(meta-) volcano-sedimentary
Basement		
Trans-Saharan Belt	Pan-African: Pharuside Belt	plutonic & metamorphic complexes & (meta-) volcano-sedimentary terranes
Trans-Saharan Belt	Pan-African: Dahomeyide Belt	
Trans-Saharan Belt	Pan-African: Benin-Nigerian Shield	
West-African Craton	Eburnean: Baoulé-Mossi Domain	plutonic & metamorphic complexes & (meta-) volcano-sedimentary Birimian terranes
West-African Craton	Archean: Kénéma-Man Domain	plutonic & metamorphic complexes & (meta-) volcano-sedimentary sequences
Igneous rocks		
Extrusive rocks	Quaternary & Cenozoic volcanics	extrusive/volcanic (mafic)
Intrusive rocks	CAMP intrusives	intrusive/plutonic rocks (mafic)
Intrusive rocks	Younger Granites	intrusive/plutonic rocks (felsic)
Intrusive rocks	Pan-African intrusives: Plutonic ring-complexes of the Aïr, Batholiths of the Adrar des Iforas, Older Granites (syn- & post-tectonic pan-African granitoids)	

4.1.7 Lithostratigraphic description [St_desc]

The lithostratigraphic description [St_desc] provides an unabbreviated description of the stratigraphic unit including conventional stratigraphic designations (e.g.: *Continental Terminal*), common names (e.g.: *Lower Hydrogeological Group*), and generalised regional, stratigraphic or lithological descriptions (e.g.: *Grès du Cambrien, Alluvial and fluvial deposits, Azaoud Nord*) as well as stratigraphic members, formations, and groups, if available.

4.1.8 Environment [Envirnmnt]

Summary classification of the type of depositional or rock formation environment (sedimentary, metasedimentary, plutonic, volcanic, basement, or mobile belt), and, where relevant, environmental conditions (continental, marine), as well as the degree of metamorphic overprint or geological age (Archean, Eburnean, Birimian, Pan-African) (Tab. 3, Fig. 7).

Tab. 3: Depositional environment, geological domain, degree of metamorphic overprint

Depositional environment / Geological domain	N° of units
Sedimentary	
Sedimentary, aeolian	2
Sedimentary, alluvial	4
Sedimentary, lacustrine	3
Sedimentary, coastal	6
Sedimentary, continental	40
Sedimentary, continental & marine	11
Sedimentary, marine & continental	10
Sedimentary, marine	17
Metasedimentary	
Metasedimentary, continental	2
Metasedimentary, continental & marine	1
Metasedimentary, continental & marine, volcanic	1
Metasedimentary, marine & continental	1
Metasedimentary, marine	6
Basement	
Archean basement (plutonic and metamorphic complexes)	1
Archean basement, (meta)volcano-sedimentary	1
Eburnean basement (plutonic and metamorphic complexes)	6
Birimian terranes, (meta)volcano-sedimentary, deep water basins	6
Pan-African basement (plutonic and metamorphic complexes)	6
Pan-African Mobile Belt, (meta)volcano-sedimentary	10
Pan-African terranes, (meta)volcano-sedimentary	5
Igneous rocks	
Extrusive/volcanic (mafic)	3
Intrusive/plutonic rocks (felsic)	2
Intrusive/plutonic rocks (mafic)	4
Intrusive/plutonic rocks (undifferentiated)	1

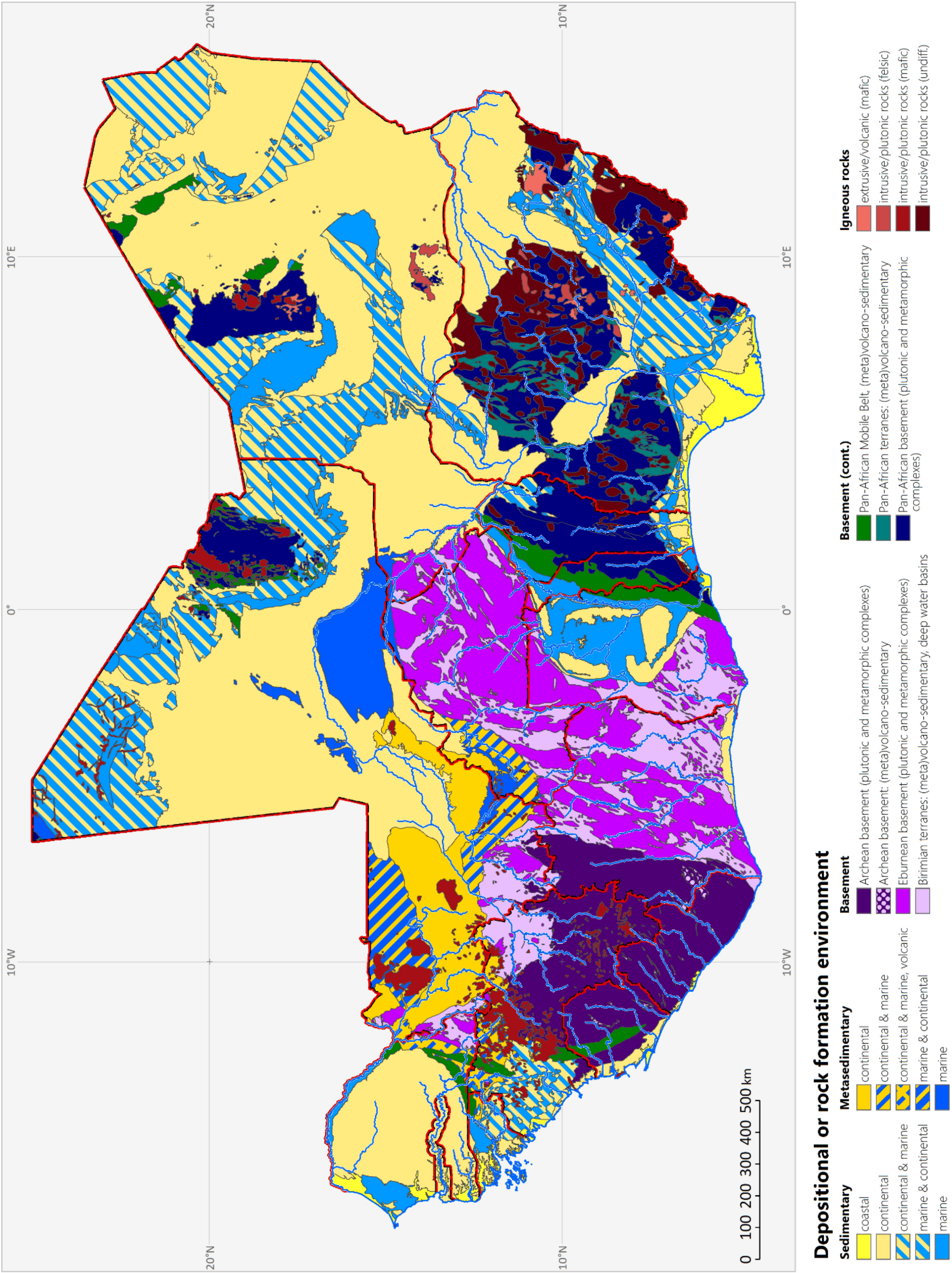

Fig. 7: Depositional or rock formation environment

4.1.9 Lithology [Lithology]

This is a tentative classification into 16 generalized lithological classes (Tab. 4, Fig. 9). Two classes only occur in the cover layer and are not depicted on the printed map; the other 14 classes occur in the hydrogeological unit base layer and are shown on the printed map (where acid and basic plutonic rocks are not differentiated).

4.1.10 Consolidation type [Consoldtn]

Consolidation refers to the consolidation status of the sediment or rock. Drawing on the lithological classification of the *International Hydrogeological Map of Europe* (Duscher et al. 2015), the three original consolidation levels (unconsolidated rocks, partly consolidated rocks, consolidated rocks) were amended to differentiate unconsolidated rocks, partly consolidated rocks, consolidated sedimentary and consolidated metasedimentary rocks, as well as consolidated, metamorphic rocks of the crystalline basement and consolidated, igneous rocks (Tab. 4, Fig. 10).

4.1.11 Aquifer flow type [Aq_type]

The dominant aquifer flow type characterises the hydraulic properties of an aquifer and is a relevant parameter for successful groundwater prospection. The two flow type categories of the *Standard Legend for Hydrogeological Maps* (Struckmeier & Margat 1995) – intergranular (porous) and fractured – were amended with two additional categories, a mixed intergranular and fractured regime, and a specific karst flow regime (Tab. 4, Fig. 11). The aquifer flow type regimes roughly correspond to the consolidation type, but some deviations occur. Aquifer flow type, together with lithology and expected aquifer productivity, is portrayed on the published map.

4.1.12 Expected yield [Yield]

Average yield values gathered from literature using the approach described in Section 2.

4.1.13 Expected aquifer productivity [Aq_prod]

Expected aquifer productivity defined as a combination of aquifer flow type and expected borehole yield regionalised using the approach described in Section 2 (Fig. 12).

Tab. 4: Lithological classes, rock consolidation type, and aquifer flow regimes

<table>
<tr><th>Lithology</th><th>Consolidation</th><th>Aquifer flow type</th><th>N° of units</th></tr>
<tr><td colspan="4">Cover layer</td></tr>
<tr><td>Sand</td><td rowspan="2">unconsolidated</td><td rowspan="2">intergranular (porous)</td><td>2</td></tr>
<tr><td>Clay</td><td>4</td></tr>
<tr><td colspan="4">Hydrogeological unit base layer</td></tr>
<tr><td>Sand and clay</td><td>unconsolidated</td><td>intergranular (porous)</td><td>11</td></tr>
<tr><td>Sandstone and clay</td><td rowspan="3">partly consolidated</td><td rowspan="3">intergranular / fractured</td><td>38</td></tr>
<tr><td>Marl</td><td>4</td></tr>
<tr><td>Claystone and sand</td><td>9</td></tr>
<tr><td>Sandstone</td><td rowspan="6">consolidated, (meta-)sedimentary</td><td rowspan="5">fractured</td><td>20</td></tr>
<tr><td>Sandstone and claystone</td><td>3</td></tr>
<tr><td>Claystone</td><td>10</td></tr>
<tr><td>Shale</td><td>3</td></tr>
<tr><td>Limestone and marlstone</td><td>2</td></tr>
<tr><td>Limestone</td><td>fractured (karst)</td><td>4</td></tr>
<tr><td>Schist and quartzite</td><td rowspan="2">consolidated, metamorphic rocks</td><td rowspan="6">fractured</td><td>17</td></tr>
<tr><td>Granite, gneiss, and schist</td><td>12</td></tr>
<tr><td>Volcanic rock</td><td rowspan="4">consolidated, igneous rocks</td><td>3</td></tr>
<tr><td>Plutonic rock</td><td>3</td></tr>
<tr><td>Plutonic rock (acid)</td><td>1</td></tr>
<tr><td>Plutonic rock (basic)</td><td>3</td></tr>
</table>

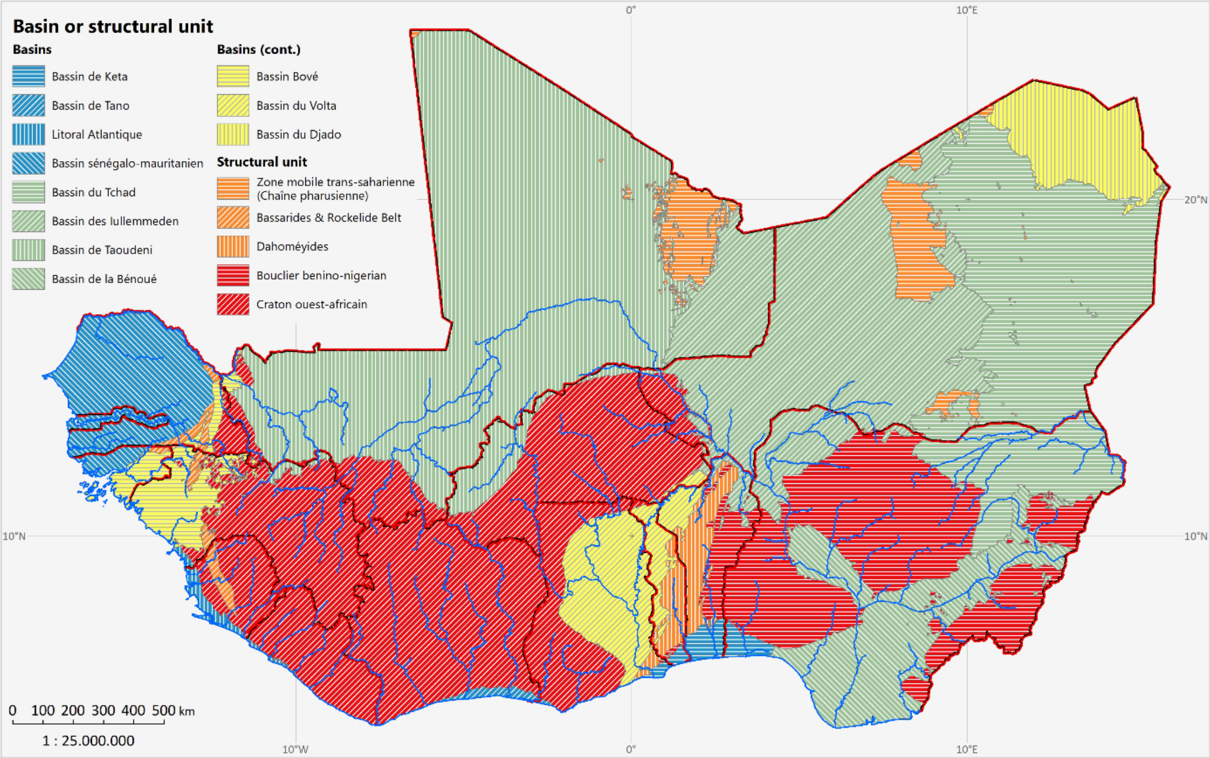

Fig. 8: Basin or structural unit

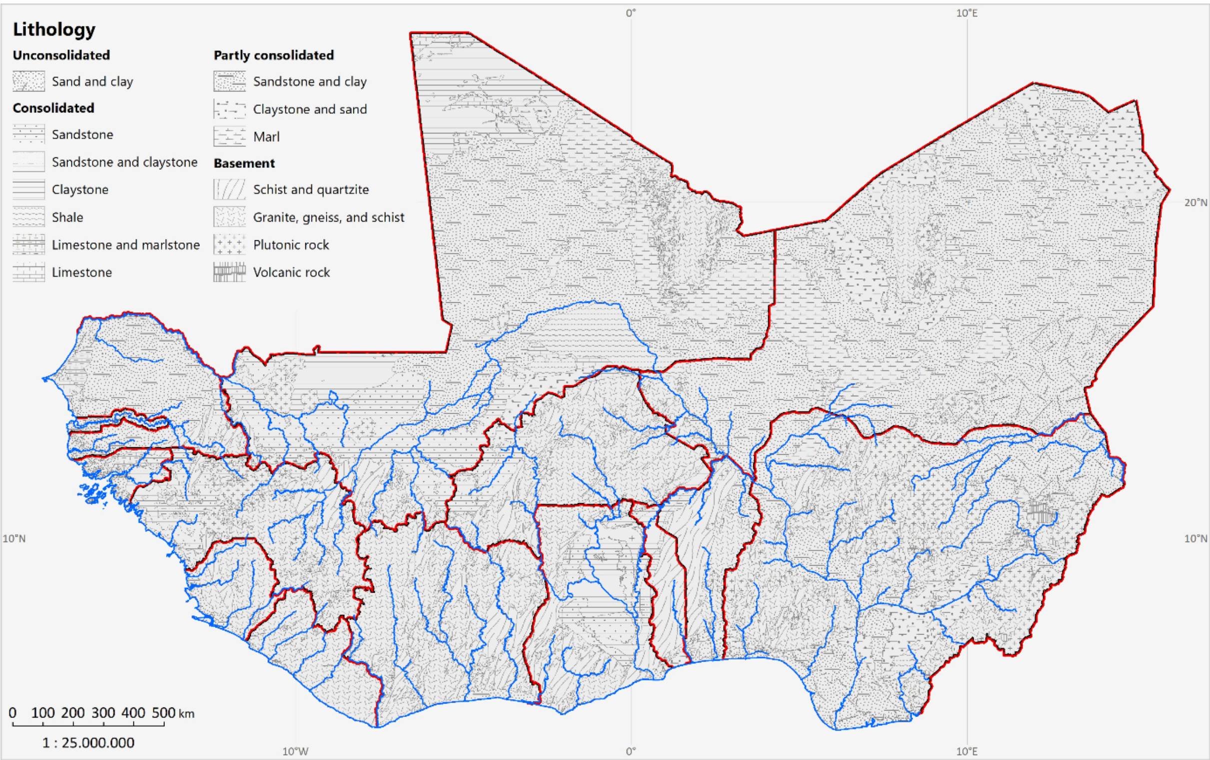

Fig. 9: Lithology

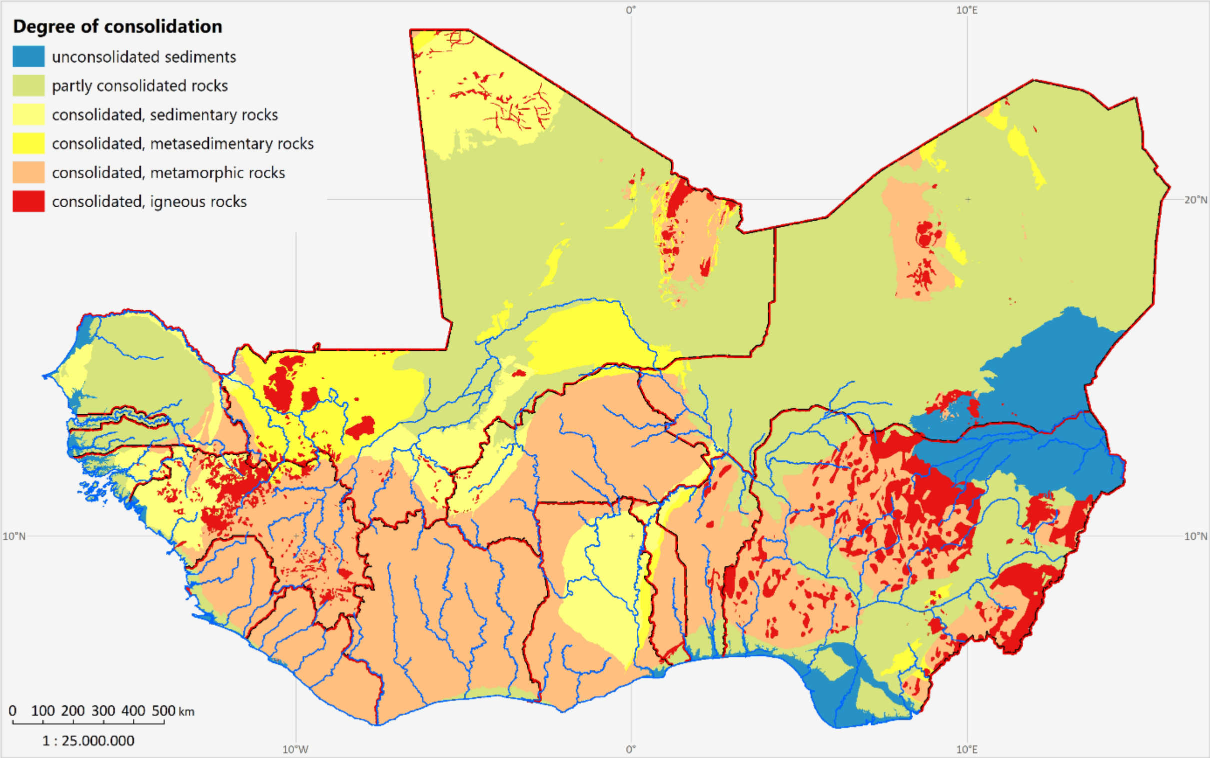

Fig. 10: Degree of consolidation

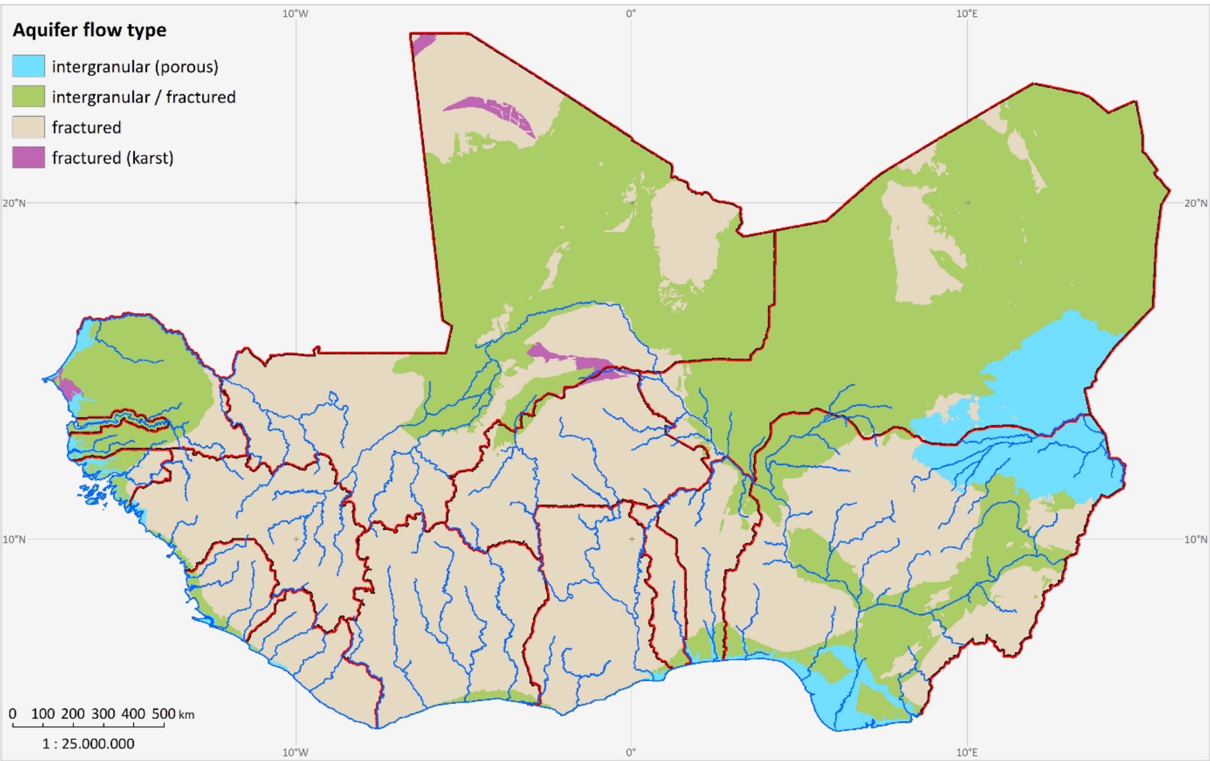

Fig. 11: Aquifer flow type

4.1.14 Carbonate rocks [Carb_rock]

Calcareous rocks may occur in virtually all rock types. Probably due to limited thicknesses and extents, or to the difficulty in assessing the proportion of calcareous material, lithological descriptions rarely provide sufficient information to judge their significance. Where information is available, significant amounts of calcareous (marls, etc.) or carbonate rocks (significant occurrence of limestone) are flagged in the attribute table (Tab. 5, Fig. 13). The classification is a tentative first approximation and requires reviewing on a case-by-case basis.

Despite its high relevance for hydrogeological assessments, reports of carbonate karst are rare in the West African geological literature. Given a considerable number of studies on sandstone karst in Northern Niger (Busche & Sponholz 1992; Sponholtz 1994; Vicat & Willems 1998; Willems et al. 2002; Wray & Sauro 2017), overall environmental conditions must have been suitable for the development of karst and a wider spread of carbonate karst should be expected. Documented carbonate karst features with sufficient extent to be shown as karstic aquifers on the map are reported for the

- Formation d'Irma, Mali (DNHE 1990);
- Calcaires à Stromatolites du Hank, Groupe d'El Mreïti, Mali (DNHE 1990);
- Formation Safia & Haricha, Mali (DNHE 1990);
- Calcaires du Paléocèene (Intermediary Aquifer System), Senegal (Myers et al. 1984; Travi et al. 2017; DGPRE 2018; Madioune et al. 2020).

In addition, karst features are reported for the Mfamosing Limestone Formation, Calabar Flank, Nigeria (Reijers, 1998). However, the Mfamosing Limestone is not included as a mapped unit due to its limited size. A complex lithology including intercalated karstified limestone does not justify the characterisation of an extended lithostratigraphic unit as karstified carbonates. Such is the case for the Calcaires blancs of the Majia Group in Niger (Greigert 1966), the Rima and Sokoto Groups in Nigeria (Anderson & Ogilbee 1973; Kogbe 1981; JICA 1990), or the Terrecht I & II (Menaka Formation) in Mali (O'Leary et al. 2019). These are flagged as containing carbonates in the accompanying attribute table. Outside of the above-mentioned regions, the thickness and extent of karstified limestones are probably not sufficient for the development or the reporting of any significant karst features.

Tab. 5: Carbonate rocks

Typology of carbonate rocks	Description	N° of units
No data	assumptions about the occurrence of carbonate rocks not possible	32
Basement	carbonate rock classification not applicable	37
No mention of calcareous strata	occurrence of major calcareous strata unlikely	33
Likely occurrence of calcareous strata	occurrence of minor calcareous strata likely	12
Calcareous rocks	includes calcareous strata (e.g. marls, calcareous sandstones or minor occurrence of limestone)	19
Carbonate rocks	substantial occurrences of carbonate rocks (limestone, dolomite), no reports of karst features	12
Carbonate rocks, karst	karstified carbonate rocks with documented occurrence of relevant karst features	4

4.1.15 References [Sources]

This field lists the most relevant references for the geological and hydrogeological characterisation of the map units. In addition, references are listed in the respective parameter fields.

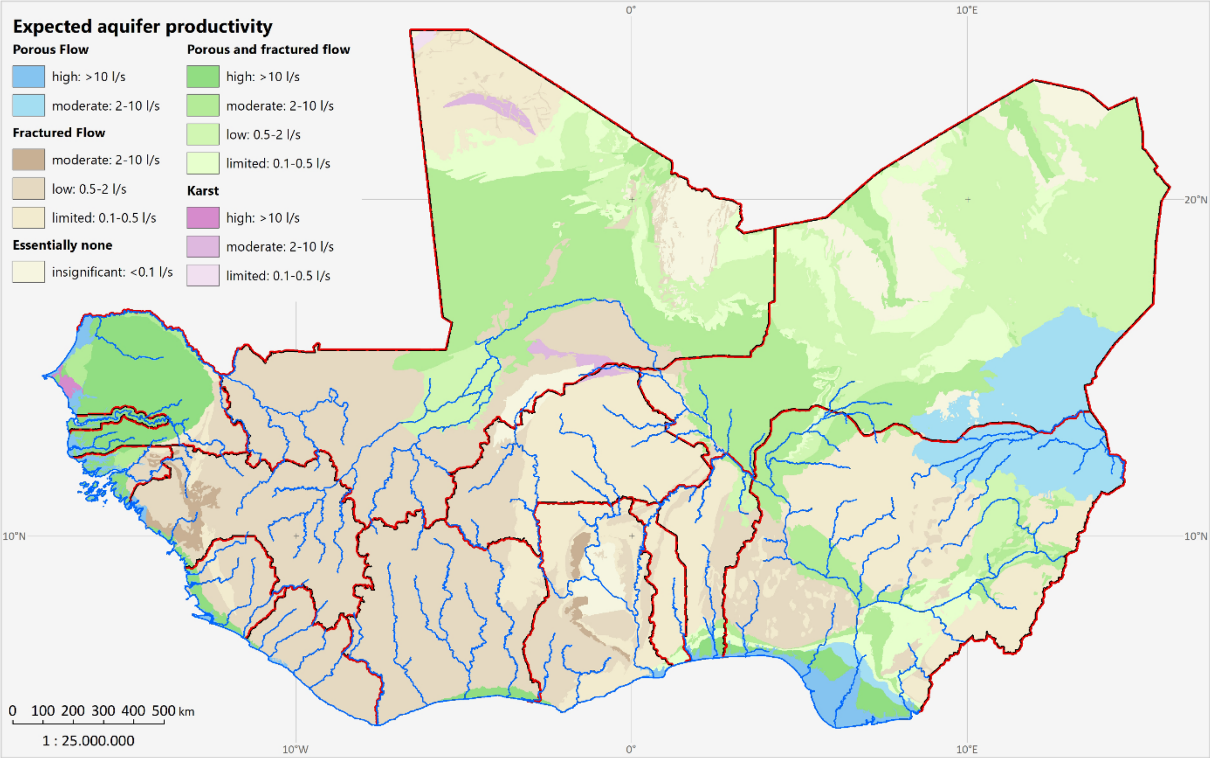

Fig. 12: Expected aquifer productivity

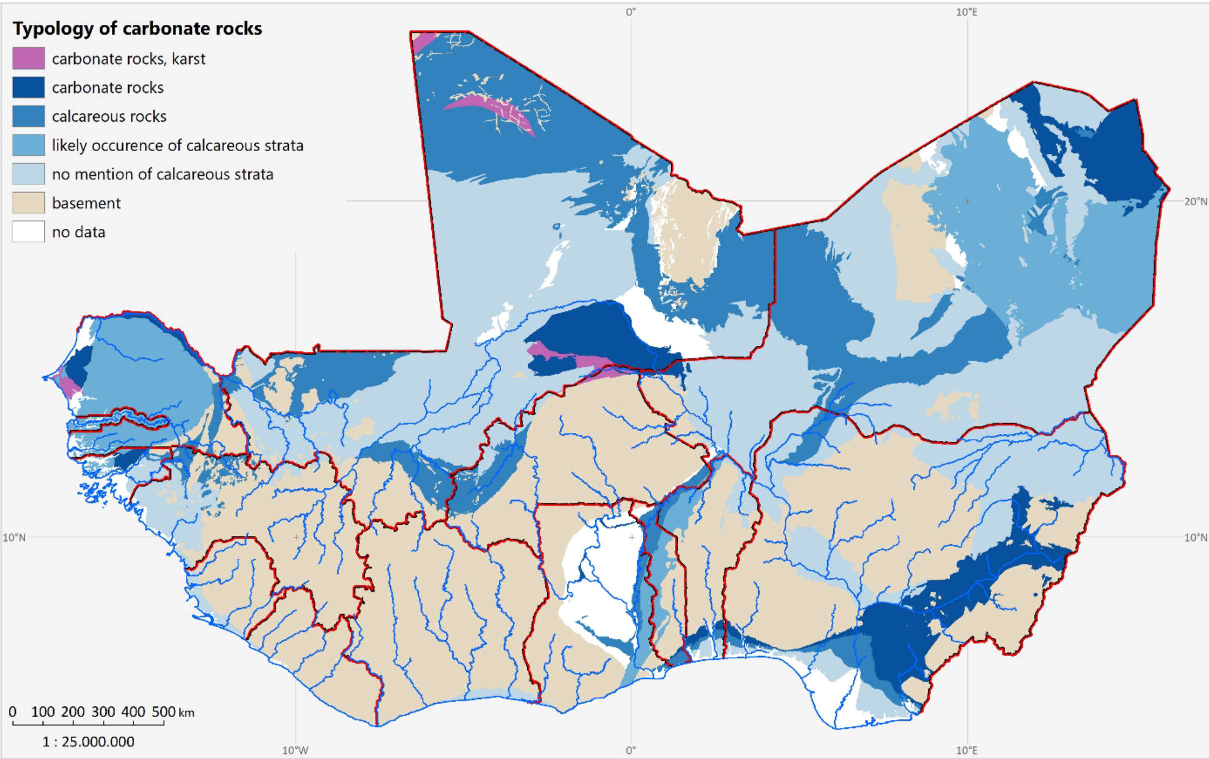

Fig. 13: Typology of carbonate rocks

4.2 Inset maps

4.2.1 Arsenic

Probability of geogenic arsenic in groundwater exceeding the WHO guideline of 10 µg/l. This map is adapted from a global arsenic prediction map (Podgorski & Berg 2020) which was created through machine-learning modelling using > 50,000 global arsenic measurements. This map is not a replacement for the independent assessment and monitoring of arsenic in groundwater sources.

Download at Groundwater Assessment Platform (GAP): https://www.gapmaps.org/

4.2.2 Fluoride

Probability of geogenic fluoride in groundwater exceeding the WHO guideline of 1.5 mg/l. This map is adapted from a global fluoride prediction map (Amini et al. 2008) which was developed using a rule-based statistical model. Although moderate amounts of fluoride can benefit dental health, excessive amounts can cause dental and skeletal ailments. This map is not a replacement for the independent assessment and monitoring of fluoride in groundwater sources.

Download at Groundwater Assessment Platform (GAP): https://www.gapmaps.org/

4.2.3 Structural map

The structural map shows the geological framework of West Africa reflecting the tectono-metamorphic, magmatic, and sedimentary history of the past c. 3.5 billion years. The basin-and-swell structure is formed by major crustal Precambrian domains – the Archean-Paleoproterozoic West African craton, the Trans-Saharan Mobile Zone, and the fold and thrust belts of the Pan-African Orogeny – and large intracratonic sedimentary basins, intracontinental rift basins (Central Africa Rift System), and the Atlantic margin basins reflecting the Meso-Cenozoic history of West Africa.

4.2.4 Sedimentary basin isopachs

The isopach, or sediment thickness, map shows the spatial distribution and thickness of the sediments constituting the main sedimentary basins. Irrespective of the surface geology, the map distinguishes the major sedimentation cycles of the Proterozoic, Paleozoic, Mesozoic, and Cenozoic domains. These reflect a history of major tectono-sedimentary interactions, including large-scale rift structures (data from Milési et al. 2010; and Thiéblemont et al. 2016).

4.2.5 Recharge map

This map shows long-term average annual groundwater recharge (mm/a), calculated over the period 1970-2020 (MacDonald et al. 2020, 2021).The map was produced from published ground-based observations at 134 sites across the African continent. These observations were subject to a rigorous QA procedure and combined with a fitted linear mixed model to predict spatially distributed LTA recharge as shown. Recharge estimates are more uncertain in the wetter areas of coastal West Africa as there are limited recharge observations.

Download: https://doi.org/10.5285/45d2b71c-d413-44d4-8b4b-6190527912ff

4.2.6 Hydrograph data

These multi-decadal time-series were compiled by the Chronicles Consortium (Cuthbert et al. 2019) from records of observation wells maintained by government departments and academic institutions. All records were subjected to a rigorous review. Differences in response reflect a complex interplay of climate, geology, soil, and land cover. Most hydrographs show seasonal fluctuations indicating recharge in excess of net drainage at some point during the year. In Benin (Natitingou), recharge is greatly restricted by the very low dynamic storage capacity of the crystalline basement (quartzite). In Burkina Faso (Ouagadougou), focussed recharge from controlled barrages explains the increasing trend from the early 1990s. The long-term rising trend in Niger reflects re-equilibration of the system following clearance of woody savannah land cover.

Download: https://dx.doi.org/10.5285/a6d78c2e-3420-4346-9182-4fd437672412

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The aquifer productivity dataset drew on a large number of sources. Besides the two base maps, national geological maps and grey literature played a crucial role for the spatial differentiation, geometric harmonisation and the hydrogeological attribution. The most relevant maps consulted for the revision of the geometric line work and the major hydrogeological literature used for hydrogeological attribution of hydrogeological units are listed in alphabetic order by countries.

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Expected aquifer productivity map
- Attribute table -

Stratigraphy ID_Strat	Unit ID ID_unit	Cover Layer ID_cover	Lithostratigraphic unit / Hydrogeological unit St_unit	Basin Basin	Chronostratigraphy: Erathem / Era CS_era	Chronostratigraphy: System / Period CS_system	Chronostratigraphy: Series / Epoch CS_series	Chronostratigraphy: Stage / Age CS_stage	West African stratigraphic group St_group	Lithostatigraphic description St_desc	Environment / rock type Envirnmnt	Lithology Lithology	Consolidation type Consoldtn	Carbonate rocks Carb_rock	Aquifer flow type Aq_type	Expected Yield Yield	Aquifer productivity Aq_prod	Sources Sources
Cover layer	Cover layer	Qs	Aeolian deposits (sand sheets)	Bassin du Tchad	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Aeolian sand deposits & older alluvial deposits	sedimentary, aeolian	Sand	unconsolidated sediments	no data	intergranular (porous)	assumed dry	assumed dry	Greigert (1968)
		Qe	Aeolian deposits (ergs, dune complexes)	Bassin du Tchad	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Aeolian sand deposits & older alluvial deposits	sedimentary, aeolian	Sand	unconsolidated sediments	no data	intergranular (porous)	assumed dry	assumed dry	Greigert (1968)
		Qa	Alluvial and fluvial deposits	all regions	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Alluvial and fluvial deposits	sedimentary, alluvial	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Greigert (1968)
		Qa, S	Alluvial and fluvial deposits (Fossé de Gao)	Bassin des Iullemmeden	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Alluvial and fluvial deposits	sedimentary, alluvial	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	0.1-0.5 l/s (limited)	TP (porous, limited: 0.1-0.5 l/s)	Greigert (1968)
		Qa, DI	Alluvial and fluvial deposits, Inner Delta	all regions	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Alluvial and fluvial deposits	sedimentary, alluvial	Clay	unconsolidated sediments	no data	intergranular (porous)	0.5-2 l/s (low)	LP (porous, low: 0.5-2 l/s)	DNHE (1990)
		Qa, AD	Alluvial and fluvial deposits (Adar Doutchi)	Bassin des Iullemmeden	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Alluvial and fluvial deposits	sedimentary, alluvial	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	0.5-2 l/s (low)	LP (porous, low: 0.5-2 l/s)	Greigert (1968)
		Ql	Lacustrine deposits	all regions	Cenozoic	Quaternary	Pleistocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Lacustrine deposits	sedimentary, lacustrine	Clay	unconsolidated sediments	likely occurence of calcareous strata	intergranular (porous)	assumed dry	assumed dry	
		Ql, BN	Bama & Ngeiwa ridge: lacustrine deposits	Bassin du Tchad	Cenozoic	Quaternary	Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Bama & Ngeiwa ridge: lacustrine deposits corresponding to Holocene highstands of the Lake Megachad	sedimentary, lacustrine	Clay	unconsolidated sediments	likely occurence of calcareous strata	intergranular (porous)	assumed dry	assumed dry	no data
		Ql, Kz	Plaine de Kadzell: lacustrine deposits	Bassin du Tchad	Cenozoic	Quaternary	Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Plaine de Kadzell: lacustrine deposits	sedimentary, lacustrine	Clay	unconsolidated sediments	likely occurence of calcareous strata	intergranular (porous)	assumed dry	assumed dry	no data
Qc	Qc, SM	no cover	Coastal/deltaic deposits	Bassin sénégalo-mauritanien	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Coastal & deltaic, quaternary deposits: Nappe du Quaternaire de Kayar, St. Luis, Dakar (Senegal)	sedimentary, coastal	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Côte d'Ivoire etc: Bourgeois (1978), Senegal: Travi (2017),
Qc	Qc, Bv	no cover	Coastal/deltaic deposits	Bassin Bové	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Coastal & deltaic, quaternary deposits: Nappe du Quaternaire de Kayar, St. Luis, Dakar (Senegal)	sedimentary, coastal	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Côte d'Ivoire etc: Bourgeois (1978), Senegal: Travi (2017),
Qc	Qc, LA	no cover	Coastal/deltaic deposits	Litoral Atlantique	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Coastal & deltaic, quaternary deposits: Nappe du Quaternaire de Kayar, St. Luis, Dakar (Senegal)	sedimentary, coastal	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Côte d'Ivoire etc: Bourgeois (1978), Senegal: Travi (2017),
Qc	Qc, Ke	no cover	Coastal/deltaic deposits	Bassin de Keta	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Coastal & deltaic, quaternary deposits: Nappe du Quaternaire de Kayar, St. Luis, Dakar (Senegal)	sedimentary, coastal	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Côte d'Ivoire etc: Bourgeois (1978), Senegal: Travi (2017),
Qc	Qc, Be	no cover	Coastal/deltaic deposits	Bassin de la Bénoué	Cenozoic	Neogene to Quaternary	Pliocene to Holocene		Quaternary continental sediments (Neogene to Quaternary, unconsolidated deposits)	Coastal & deltaic, quaternary deposits: Nappe du Quaternaire de Kayar, St. Luis, Dakar (Senegal)	sedimentary, coastal	Sand and clay	unconsolidated sediments	no data	intergranular (porous)	> 10 l/s (high)	HP (porous, high: >10 l/s)	Côte d'Ivoire etc: Bourgeois (1978), Senegal: Travi (2017),
Q-?C	Q-?C	no cover	Fm de Agadem (?). Aeolian Quaternary and post-Cretaceous sediments over Grès d'Agadem/Grès de de Bilma and Lower Cretaceous strata (Series Tégama) (?)	Bassin du Tchad	Mesozoic to Cenozoic	Lower Cretaceous to Quaternary			Undiff. Continental Intercalaire, Serie Hamadien, Continental Terminal and recent deposits	Fm de Agadem (?). Undifferentiared aeolian Quaternary and post-Cretaceous sediments over an undifferentiated sequence of Lower Cretaceous Formations de Dibelle et d'Achegour (Serie Tégama) and Upper Cretaceous marine (Zoo Baba, Kafra, Ezerza) and continental formations (Grès d'Agadem, Grès de Bilma (Galhama) and Cenozoic (F. Homodji ~Continental Hamadien) as well as Quaternary (Chad formation) sediments under a Cenocoic cover and aeolian sands	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	likely occurence of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
Q-?AB	Q-?AB	no cover	Fm de Bilma (?). Aeolian Quaternary and post-Cretaceous sediments over Grès d'Agadem/Grès de de Bilma and Lower Cretaceous strata (Series Tégama) (?)	Bassin du Tchad	Mesozoic to Cenozoic	Upper Cretaceous to Quaternary			Undiff. Continental Intercalaire, Serie Hamadien, Continental Terminal and recent deposits	Fm de Bilma (?). Nappe d'Agadem/Nappe de Bilma. Undifferentiared aeolian Quaternary and post-Cretaceous sediments over an undifferentiated sequence of Upper Cretaceous marine (Zoo Baba, Kafra, Ezerza) and continental formations (Grès d'Agadem, Grès de Bilma)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	likely occurence of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
Q-?TO	Q-?TO	no cover	Nappe de Ounissouni & Ténéré: Aeolian Quaternary and post-Cretaceous sediments over Cretaceous strata (Series Tégama, Fm de Dibella et d'Achegour) ?	Bassin du Tchad	Mesozoic to Cenozoic	Lower Cretaceous to Quaternary			Undiff. Continental Intercalaire, Serie Hamadien, Continental Terminal and recent deposits	Nappe de Ounissouni & Ténéré: Undifferentiated Aeolian Quaternary and post-Cretaceous sediments covering the the Ténére & Termit graben (comparable to the Chad Formation) over Cretaceous strata Series Tégama, Fm de Dibella et d'Achegour (Continental Intercalaire, Lower Cretaceous)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	likely occurence of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
CF	CF	no cover	Chad Formation	Bassin du Tchad	Cenozoic	Neogene	Miocene to Pleistocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Chad Formation	sedimentary, continental	Sand and clay	unconsolidated sediments	no mentioning of calcareous strata	intergranular (porous)	2-10 l/s (moderate)	MP (porous, moderate: 2-10 l/s)	Boeckh (1965), (BGS (2019)), Greigert (1968), Obaje (2009), Miller (1965) Onugba & Yaha (2008)
CT-KK	CT-KK	no cover	Kerri Kerri Fm	Bassin du Tchad	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal: Kerri Kerri Formation	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Obaje (2009), Adelana et al. (2008), BGS (2019),
CT-FG	CT-FG	no cover	Fossé de Gao	Bassin de Taoudeni	Cenozoic	Paleogene to Neogene	Eocene to Pliocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal & Quaternary: Inner Delta & Fossé de Gao	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no data	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	DNHE (1990)
CT-DI	CT-DI	no cover	Delta intérieur du Niger	Bassin de Taoudeni	Cenozoic	Paleogene to Neogene	Eocene to Pliocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal & Quaternary: Inner Delta & Fossé de Gao	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	DNHE (1990)
CT-Go	CT-Go	no cover	Plaine de Gondo	Bassin de Taoudeni	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Plaine de Gondo: Continental Terminal and quaternary cover	sedimentary, continental	Claystone and sand	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	<0.1 l/s (insignificant)	NM (mixed, insignificant: <0.1 l/s)	DNHE (1990)
CT-AzS	CT-AzS	no cover	Continental Terminal: Azouad Sud & Gourma NW	Bassin de Taoudeni	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal: Azouad Sud	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968) & Greigert et Pougnet (1967), FAO (1970), DNHE (1990)
CT	CT, Ke	no cover	Continental Terminal costière (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone), Mpundu Formation (Cameroon)	Bassin de Keta	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Nigeria: Adelana et al (2008), Obaje (2009), Côte d'Ivoire, Ghana, Togo, Benin: Bourgeois (1978), GIZ-DGE (2012), Senegal: Travi (2017), DGPRE (2019), BGS (2019)
CT	CT, Ta	no cover	Continental Terminal costière (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone), Mpundu Formation (Cameroon)	Bassin de Tano	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Nigeria: Adelana et al (2008), Obaje (2009), Côte d'Ivoire, Ghana, Togo, Benin: Bourgeois (1978), GIZ-DGE (2012), Senegal: Travi (2017), DGPRE (2019), BGS (2019)
CT	CT, LA	no cover	Continental Terminal costière (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone), Mpundu Formation (Cameroon)	Litoral Atlantique	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Nigeria: Adelana et al (2008), Obaje (2009), Côte d'Ivoire, Ghana, Togo, Benin: Bourgeois (1978), GIZ-DGE (2012), Senegal: Travi (2017), DGPRE (2019), BGS (2019)
CT/BF	CT-BF, Be	no cover	Benin Formation (Continental Terminal)	Bassin de la Bénoué	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Nigeria: Adelana et al (2008), Obaje (2009), Côte d'Ivoire, Ghana, Togo, Benin: Bourgeois (1978), GIZ-DGE (2012), Senegal: Travi (2017), DGPRE (2019), BGS (2019)
CT	CT, SM	no cover	Continental Terminal costière (Senegal)	Bassin sénégalo-mauritanien	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	likely occurence of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Sane (2015), Travi (2017), DGPRE (2018, 2019), Myers et al. (1984), Roger et al (2009), UN (1988), BGS (2019)
CT	CT, Bv	no cover	Continental Terminal costière (Guinea-Bissau, Guinea)	Bassin Bové	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal (Côte d'Ivoire, Ghana, Togo, Benin, Senegal), Benin Formation (Nigeria), Bullom Group (Sierra Leone)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no data	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Senegal: Travi (2017), DGPRE (2019), BGS (2019), Alves (2010)
CT	CT, Iu	no cover	Continental Terminal: Iullemmeden, Taoudeni, Tchad	Bassin des Iullemmeden	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal: Iullemmeden & Niger E	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968), Greigert et Pougnet (1967), FAO (1970), DNHE (1990), Adelana et al (2008), BGS (2019)
CT	CT, Td	no cover	Continental Terminal: Iullemmeden, Taoudeni, Tchad	Bassin des Iullemmeden	Cenozoic	Paleogene	Eocene to Oligocene		Continental Terminal (Post-Eocene, terrestrial deposits)	Continental Terminal: Iullemmeden & Niger E	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968), Greigert et Pougnet (1967), FAO (1970), DNHE (1990), Adelana et al (2008), BGS (2019)
E-Sp	E-Sp, Iu	no cover	Schistes papyracés': Garadoua Fm (Niger), Sokoto Group (Nigeria), Tamaguélelt Fm (Mali)	Bassin des Iullemmeden	Cenozoic	Paleogene	Palaeocene to Eocene		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série Hamadien: Schistes papyracés et Zones à Operculinoïdes et Lockhartia (Niger), Sokoto Group (Nigeria), Maastrichtien à Éocène moyen (Mali)	sedimentary, marine	Marl	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968), Greigert et Pougnet (1967, Note exp.), Obaje (2009), Anderson & Ogilbee (1973), Offodile (2002), DNHE (1990)
E-Sp	E-Sp, Td	no cover	Schistes papyracés': Garadoua Fm (Niger), Sokoto Group (Nigeria), Tamaguélelt Fm (Mali)	Bassin des Iullemmeden	Cenozoic	Paleogene	Palaeocene to Eocene		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série Hamadien: Schistes papyracés et Zones à Operculinoïdes et Lockhartia (Niger), Sokoto Group (Nigeria), Maastrichtien à Éocène moyen (Mali)	sedimentary, marine	Marl	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968), Greigert et Pougnet (1967, Note exp.), Obaje (2009), Anderson & Ogilbee (1973), Offodile (2002), DNHE (1990)
E-SAI	E-SAI	no cover	Système aquifère intermédiaire: Calcaires du Éocène	Bassin sénégalo-mauritanien	Cenozoic	Paleogene	Eocene	Lutetien	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Système aquifère intermédiaire: Calcaires du Lutétien (Éocène)	sedimentary, marine	Limestone and marlstone	consolidated, sedimentary rocks	carbonate rocks	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Sane (2015), Travi (2017), DGPRE (2018, 2019), Myers et al. (1984), Roger et al (2009), UN (1988), BGS (2019)
P-SAI	P-SAI	no cover	Système aquifère intermédiaire: Calcaires du Paléocène	Bassin sénégalo-mauritanien	Cenozoic	Paleogene	Palaeocene		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Système aquifère intermédiaire: Calcaires du Paléocène	sedimentary, marine	Limestone	consolidated, sedimentary rocks	carbonate rocks, karst	fractured (karst)	> 10 l/s (high)	HK (karst, high: >10 l/s)	Sane (2015), Travi (2017), DGPRE (2018, 2019), Myers et al. (1984), Roger et al (2009), UN (1988), BGS (2019)
Cm-RM	Cm-RM, Td	no cover	Rima Group (Nigeria), Ménaka Fm (Mali), Majia Groupe, Calcaires blancs, Monte Iguellala (Niger)	Bassin de Taoudeni	Mesozoic	Cretaceous	Upper Cretaceous	Maastrichtian (Niger incl. Turonian & Senonian)	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série hamadien: Rima Group (Lower & Upper Sandstones, Mosasaurus Shales, Nigeria), Tichet & Ménaka Fm (Mali), au Niger incluyant tous les transgressions marines Crétacès: zones a Neolobites et à Nigericeras (Monte Iguellala, Calcaires blancs, Cenomanian et Turonian), zones à Libycoceras (Majia Groupe, Maastrichtien)	sedimentary, marine & continental	Marl	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968), Greigert et Pougnet (1967, Note exp.), Obaje (2009), Anderson & Ogilbee (1973), DNHE (1990)
Cm-RM	Cm-RM, Iu	no cover	Rima Group (Nigeria), Ménaka Fm (Mali), Majia Groupe, Calcaires blancs, Monte Iguellala (Niger)	Bassin des Iullemmeden	Mesozoic	Cretaceous	Upper Cretaceous	Maastrichtian (Niger incl. Turonian & Senonian)	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série hamadien: Rima Group (Lower & Upper Sandstones, Mosasaurus Shales, Nigeria), Tichet & Ménaka Fm (Mali), au Niger incluyant tous les transgressions marines Crétacès: zones a Neolobites et à Nigericeras (Monte Iguellala, Calcaires blancs, Cenomanian et Turonian), zones à Libycoceras (Majia Groupe, Maastrichtien)	sedimentary, marine & continental	Marl	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968), Greigert et Pougnet (1967, Note exp.), Obaje (2009), Anderson & Ogilbee (1973), DNHE (1990)
Cm-EZK	Cm-EZK	no cover	Formations d'Ezerza, de Zoo Baba et de Kafra (Agadem, Aschia Tinamou, Chaéffadéne, Séguédine, Arentigé)	Bassin du Tchad	Mesozoic	Cretaceous	Upper Cretaceous	Turonian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série Hamadien: Formations d'Ezerza, de Zoo Baba et de Kafra	sedimentary, marine	Marl	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert, 1968
Cm-TF	Cm-TF	no cover	Série ou formation de Farak et de Cheffadène	Bassin des Iullemmeden	Mesozoic	Cretaceous	Upper Cretaceous	Cenomanian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série hamadien: Formation de Farak (Grès de Tégama)	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968)
Cm-TF	Cm-TF-Tc	no cover	Série ou formation de Farak et de Cheffadène	Bassin du Tchad	Mesozoic	Cretaceous	Upper Cretaceous	Cenomanian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série hamadien: Formation de Farak (Grès de Tégama)	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968)
Cm-Go	Cm-Go	no cover	Gombe Fm	Bassin du Tchad	Mesozoic	Cretaceous	Upper Cretaceous	Maastrichtian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série Hamadien (Gombe sandstone)	sedimentary, marine & continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Obaje (2009), Adelana et al. (2008), BGS (2019),
Cm-YGPF	Cm-YGPF	no cover	Yolde, Gongila, Pindiga, Fika Fms	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous	Turonian to Santonian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Série Hamadien (Yolde/Gongila/Pindiga/Fika F.)	sedimentary, marine	Marl	partly consolidated rocks	carbonate rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Adelana et al (2008), Obaje (2009)
E-UHG-BA	E-UHG-BA	no cover	Upper Hydrogeological Group (Bende-Ameki/Nanka Sands, incl. Ogwashi-Asaba (Oshoshun, Lignite) Formation)	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Upper hydrogeological Group (Bende-Ameki/Nanka Sands & Ogwashi-Asaba (Oshoshun) Formation)	sedimentary, marine & continental	Sand and clay	unconsolidated sediments	calcareous rocks	intergranular (porous)	2-10 l/s (moderate)	MP (porous, moderate: 2-10 l/s)	Adelana et al (2008), Obaje (2009)
E-UHG-Ic	E-UHG-Ic	no cover	Upper Hydrogeological Group (Imo Shale)	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Upper hydrogeological Group (Imo Shale)	sedimentary, marine	Claystone and sand	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Adelana et al (2008), Obaje (2009)
E-UHG-Ic	E-UHG-Ic, Ke	no cover	Upper Hydrogeological Group (Imo Shale)	Bassin de Keta	Mesozoic	Cretaceous	Upper Cretaceous		Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Upper hydrogeological Group (Imo Shale)	sedimentary, marine	Claystone and sand	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Adelana et al (2008), Obaje (2009)
Cm-MHG	Cm-MHG	no cover	Middle Hydrogeological Group	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous	Campanian to Maastrichtian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Middle Hydrogeological Group (Mamu, Ajali and Nsukka F.) & Abeokuta F (west)	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	carbonate rocks	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Adelana et al (2008), Obaje (2009), Bourgeois (1978)
Cm-MHG	Cm-MHG, Ke	no cover	Middle Hydrogeological Group	Bassin de Keta	Mesozoic	Cretaceous	Upper Cretaceous	Campanian to Maastrichtian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Middle Hydrogeological Group (Mamu, Ajali and Nsukka F.) & Abeokuta F (west)	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	carbonate rocks	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Adelana et al (2008), Obaje (2009), Bourgeois (1978)
Cm-LHG	Cm-LHG	no cover	Lower Hydrogeological Group	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous	Albian to Campanian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Lower hydrogeological group: Ekenkpon Shale, New Ntetim Marl, Eze-Aku Shale, Awgu Shale, Nkporo Shale, Enugu Shale	sedimentary, marine & continental	Claystone and sand	partly consolidated rocks	carbonate rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Adelana et al (2008), Obaje (2009), BGS (2019)
Cm-LHG	Cm-LHG, Ke	no cover	Lower Hydrogeological Group	Bassin de Keta	Mesozoic	Cretaceous	Upper Cretaceous	Albian to Campanian	Serie Hamadien (Marine transgressions of the Upper Cretaceous/Paleocene)	Lower hydrogeological group: Ekenkpon Shale, New Ntetim Marl, Eze-Aku Shale, Awgu Shale, Nkporo Shale, Enugu Shale	sedimentary, marine & continental	Claystone and sand	partly consolidated rocks	carbonate rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Adelana et al (2008), Obaje (2009), BGS (2019)
CH-SAP	CH-SAP	no cover	Système aquifère profond du Maastrichtien	Bassin sénégalo-mauritanien	Cenozoic	Cretaceous	Upper Cretaceous	Maastrichtian	Continental Hamadien (Terrestrial deposits of the Upper Cretaceous	Système aquifère profond du Maastrichtien	sedimentary, continental	Sandstone and clay	partly consolidated rocks	likely occurence of calcareous strata	intergranular / fractured	> 10 l/s (high)	HM (mixed, high: >10 l/s)	Sane (2015), Travi (2017), DGPRE (2018, 2019), Myers et al. (1984), Roger et al (2009), UN (1988), BGS (2019)
CH-Np	CH-Np	no cover	Nupe Group (Bida, Patti, Lokoja F.)	Bassin de la Bénoué	Mesozoic	Cretaceous	Upper Cretaceous		Continental Hamadien (Terrestrial deposits of the Upper Cretaceous	Nupe Group (Bida, Patti, Lokoja F.)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Adelana et al (2008), Obaje (2009), Vrbka (1999), Ige (2018), Olabode et al (2012)
CH-BTG	CH-BTG	no cover	Formations de Bilma, Termit, Galhama	Bassin du Tchad	Mesozoic	Cretaceous	Upper Cretaceous	Senonian	Continental Hamadien (Terrestrial deposits of the Upper Cretaceous	Formations de Bilma & Temerit	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
CH-IG	CH-IG	no cover	Continental Hamadien (Illo & Gundumi Formations)	Bassin des Iullemmeden	Mesozoic	Cretaceous	Upper Cretaceous		Continental Hamadien (Terrestrial deposits of the Upper Cretaceous	Continental Hamadien (Niger), Gundumi & Illo Formation (Nigeria)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968), Carte de compilation géologique Mali, 200k (2005), (DNHE, 1990)
Ci-DA	CI-DA	no cover	Grès du Tégama. Formations de Dibella et d'Achegour	Bassin du Tchad	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès du Tégama. Formations de Dibella et d'Achegour	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
Ci-Tg	CI-Tg	no cover	Grès du Tégama (undiff)	Bassin des Iullemmeden	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès du Tégama (undiff). Lower Cretaceous continental sedimentary formation (Continental Intercalaire)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968) & Greigert (1979)
Ci-Ek	CI-Ek	no cover	Grès du Tégama. Formation d'Echkar	Bassin des Iullemmeden	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès du Tégama. Formation d'Echkar. Lower Cretaceous continental sedimentary formation (Continental Intercalaire)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968)
Ci-Rh	CI-Rh	no cover	Grès du Tégama. Formation d'El Rhas	Bassin des Iullemmeden	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès du Tégama. Formation d'El Rhas. Lower Cretaceous continental sedimentary formation (Continental Intercalaire)	sedimentary, continental	Claystone and sand	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968)
Ci-Ti	CI-Ti	no cover	Grès du Tégama. Formation de Tiguedi	Bassin des Iullemmeden	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès du Tégama. Formation de Tiguedi. Lower Cretaceous continental sedimentary formation (Continental Intercalaire)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968)
Ci-Ir	CI-Ir	no cover	Argilites de l'Irhazer	Bassin des Iullemmeden	Mesozoic	Jurrasic			Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Argilites de l'Irhazer (excl. Grés de Agadez, Grès de Teloua)	sedimentary, marine	Claystone and sand	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	<0.1 l/s (insignificant)	NM (mixed, insignificant: <0.1 l/s)	Greigert (1968)
Ci-Ag	CI-Ag	no cover	Groupe des Grès d'Agadès	Bassin des Iullemmeden	Mesozoic	Jurrasic			Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grés de Agadez (incl. Grès de Teloua)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968), Greigert (1979), Bourgeois (1965)
Ci-N	CI-N	no cover	Grès de Nubie du Djado	Bassin du Djado	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Grès de Nubie du Djado (Nubian sandstone-type)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	<0.1 l/s (insignificant)	NM (mixed, insignificant: <0.1 l/s)	Greigert et Pougnet (1967)
Ci-Bi	CI-Bi	no cover	Bima Sandstone	Bassin de la Bénoué	Mesozoic	Cretaceous	Lower Cretaceous	Albian to Cenomanian	Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Bima Sandstone	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	carbonate rocks	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Adelana et al (2008), Obaje (2009), BGS (2019)
Ci-AR	CI-AR	no cover	Asu River Group	Bassin de la Bénoué	Mesozoic	Cretaceous	Lower Cretaceous	Albian	Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Lower hydrogeological group: Asu River Group (Abakaliki Formation)	sedimentary, marine & continental	Shale	consolidated, metasedimentary rocks	carbonate rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Adelana et al (2008), Obaje (2009), BGS (2019)
Ci-AzN	CI-AzN	no cover	Azaoud Nord & Fossé de Nara: Continental Intercalaire & Continental Terminal	Bassin de Taoudeni	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Azaoud Nord & Fossé de Nara: Continental Intercalaire & Continental Terminal	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
Ci-Kh	CI-Kh	no cover	Formation de Khenachich	Bassin de Taoudeni	Mesozoic	Cretaceous	Lower Cretaceous		Continental Intercalaire (Terrestrial deposits of the Mesozoic/Lower Cretaceous)	Continental Intercalaire: Khenachich Formation	sedimentary, continental	Sandstone and clay	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
C-Ta	C-Ta	no cover	Série de Tagora	Bassin des Iullemmeden	Paleozoic	Carboniferous		Namurian	Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Série de Tagora: Grès de Guezouman, argiles, Grès de Tarat, argiles	sedimentary, marine & continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968), Boeckh (1979)
C-Th	C-Th	no cover	Série de Talach (Grés de Farazakat & Argiles de Talach)	Bassin des Iullemmeden	Paleozoic	Carboniferous		Visean	Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Série de Talach: Grés de Farazakat & Argiles de Talach	sedimentary, continental & marine	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968)
D-TT	D-TT	no cover	Grès d'Idekel, Grès de Touaret, Schistes d'Akara, Grès d'Amesgueuer, undifferentiated	Bassin des Iullemmeden	Paleozoic	Devonian			Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Devonian undifferentiated: Grès d'Idekel, Grès de Touaret, Schistes d'Akara, Grès d'Amesgueuer	sedimentary, continental & marine	Claystone and sand	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.1-0.5 l/s (limited)	TM (mixed, limited: 0.1-0.5 l/s)	Greigert (1968)
€O-TT	€O-TT	no cover	Grès d'In Azaoua, Grès de Tindi, Grès de Timesgar, undifferentiated	Bassin des Iullemmeden	Paleozoic	Cambrian to Ordovician			Continental de base (pre-Ordovician continental strata)	Cambro-Ordovician indifferencié: Grès d'In Azaoua, Grès de Tindi, Grès de Timesgar	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968)
OS-K	OS-K	no cover	Kandi Group (Fms de Wéré & Kandi)	Bassin des Iullemmeden	Paleozoic	Ordovician to Silurian			Couverture tassilienne (Transgression marine du Ordovicien-Silurien)	Kandi Group: Fms de Wéré & Kandi	sedimentary, marine & continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Konaté et. al (2006), (IGIP/GIZ, 2012), DH (1985), BGS (2019), Bouzid (1971)
C-Md	C-Md	no cover	Grès de Madama	Bassin du Djado	Paleozoic	Carboniferous		Westphalian	Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Westphalien continental (Grès de Madama)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	calcareous rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968, 1979), Greigert & Pougnet (1965 & 1967) Dodo & Zuppi (1997)
OC-Dj	OC-Dj	no cover	Ordovician to Carboniferous (marine, continental), undiff	Bassin du Djado	Paleozoic	Ordovician to Carboniferous			Couverture tassilienne (Transgression marine du Ordovicien-Silurien)	Ordovician to Carboniferous undifferentiated: Silurian (clay), Devonian (sandstones & clays), Viséen (clays, calcareous sandstones), Namurien (clays & carbonates), Westphalien marine	sedimentary, continental & marine	Claystone and sand	partly consolidated rocks	carbonate rocks	intergranular / fractured	0.5-2 l/s (low)	LM (mixed, low: 0.5-2 l/s)	Greigert (1968, 1979), Greigert & Pougnet (1965 & 1967) Dodo & Zuppi (1997)
€-Dj	€-Dj	no cover	Grés du Cambrien	Bassin du Djado	Paleozoic	Cambrian			Continental de base (pre-Ordovician continental strata)	Grès du Cambrien (Coarse sandstones & conglomerates)	sedimentary, continental	Sandstone and clay	partly consolidated rocks	no mentioning of calcareous strata	intergranular / fractured	2-10 l/s (moderate)	MM (mixed, moderate: 2-10 l/s)	Greigert (1968, 1979), Greigert & Pougnet (1965 & 1967) Dodo & Zuppi (1997)
D-Fa	D-Fa	no cover	Fm Faro	Bassin Bové	Paleozoic	Devonian			Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Fm Faro	sedimentary, continental & marine	Sandstone and claystone	consolidated, sedimentary rocks	no mentioning of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Mamédov & Bouféev (2006), Mamedov (2010), Villeneuve (2014), UN (1988), Teixeira (1968), Feybesse et al. (2004), Bering et al. (1998)
S-Te	S-Te	no cover	Fm Télimélé	Bassin Bové	Paleozoic	Silurian			Couverture tassilienne (Transgression marine du Ordovicien-Silurien)	Fm Télimélé	sedimentary, marine & continental	Claystone	consolidated, sedimentary rocks	no mentioning of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Mamédov & Bouféev (2006), Mamedov (2010), Villeneuve (2014), UN (1988), Teixeira (1968), Feybesse et al. (2004), Bering et al. (1998)
O-Pi	O-Pi	no cover	Fm Pita	Bassin Bové	Paleozoic	Ordovician			Continental de base (pre-Ordovician continental strata)	Fm Pita	sedimentary, continental & marine	Sandstone	consolidated, sedimentary rocks	no mentioning of calcareous strata	fractured	2-10 l/s (moderate)	MF (fractured, moderate: 2-10 l/s)	Mamédov & Bouféev (2006), Mamedov (2010), Villeneuve (2014), UN (1988), Teixeira (1968), Feybesse et al. (2004), Bering et al. (1998)
C-SH	C-SH	no cover	Groupe de Taoudeni: Formation Safia & Haricha	Bassin de Taoudeni	Paleozoic	Carboniferous		Visean to Namurian	Série post-Tassilien (Transgression marine du Dévonien supérieur et Carbonifère)	Groupe de Taoudeni: Formation Safia & Haricha	sedimentary, marine	Limestone	consolidated, sedimentary rocks	carbonate rocks, karst	fractured (karst)	2-10 l/s (moderate)	MK (karst, moderate: 2-10 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
€C-Td	€C-Td	no cover	Groupes de l'Azlaf, l'Erg Chech, Thérazza, Taoudeni	Bassin de Taoudeni	Paleozoic	Cambrian to Carboniferous			Couverture tassilienne (Transgression marine du Ordovicien-Silurien)	Cambrian to Carboniferous: Groupe de l'Azlaf (Fm du Greb En Naga, Cambrien), Groupe de l'Erg Chech (Ordovicien), Groupe de Thérazza (Fm des Sebkhas, Carbonifère), Groupe de Taoudeni (Fms de la Gara Hammou Salah & Gara Jakania,Carbonfère)	sedimentary, marine & continental	Claystone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-MH	nP-MH	no cover	Groupe d'El Mreïti: Calcaires à Stromatolites du Hank	Bassin de Taoudeni	Neoproterozoic				Supergroup 1 (Hodh)	Groupe d'El Mreïti: Calcaires à Stromatolites du Hank	metasedimentary, marine	Limestone	consolidated, metasedimentary rocks	carbonate rocks, karst	fractured (karst)	0.1-0.5 l/s (limited)	TK (karst, limited: 0.1-0.5 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
np€-YMF	np€-YMF	no cover	Groupes de Youkounkoun, Madina-Kouta & Falémé	Bassin Bové	Neoproterozoic to Cambrian	Ediacaran to Cambrian			Youkounkoun Group	Undifferentiated, undeformed, tabular post-Pan-African glacial, volcano-sedimentary continental, and marine series. Youkounkoun (west), Mali, Madina-Kouta, Falémé Groupes (east), equals Malian Cambrian Koniakari and Neoproterozoic Souroukoto Groupes	metasedimentary, continental & marine, volcanic	Sandstone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	DNHE (1990)

Expected aquifer productivity map
- Attribute table -

Stratigraphy	Unit ID	Cover Layer	Lithostratigraphic unit / Hydrogeological unit	Basin	Chronostratigraphy: Erathem / Era	Chronostratigraphy: System / Period	Chronostratigraphy: Series / Epoch	Chronostratigraphy: Stage / Age	West African stratigraphic group	Lithostatigraphic description	Environment / rock type	Lithology	Consolidation type	Carbonate rocks	Aquifer flow type	Expected Yield	Aquifer productivity	Sources
ID_Strat	ID_unit	ID_cover	St_unit	Basin	CS_era	CS_system	CS_series	CS_stage	St_group	St_desc	Envirnmnt	Lithology	Consoldtn	Carb_rock	Aq_type	Yield	Aq_prod	Sources
€O-NK	**€O-NK**	no cover	Groupes de Nioro & Koniakari	Bassin de Taoudeni	Paleozoic	Cambrian to Ordovician			Infracambrien tabulaire	Groupes de Nioro & Koniakari	metasedimentary, marine & continental	Claystone	consolidated, metasedimentary rocks	calcareous rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-BK	**nP-BK**	no cover	Grès de Bandiagara et Koutiala	Bassin de Taoudeni	Neoproterozoic				Infracambrien tabulaire	Infracambrien tabulaire: Grès de Bandiagara et Koutalia	metasedimentary, continental	Sandstone	consolidated, sedimentary rocks	no mentioning of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-ST	**nP-ST**	no cover	Schistes de Toun	Bassin de Taoudeni	Neoproterozoic				Infracambrien tabulaire	Infracambrien tabulaire: Schistes de Toun	metasedimentary, marine	Claystone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-SMS	**nP-SMS**	no cover	Formation gréseuse (Fm Sotuba-Kignan, Fm Massigui, Fm Sikasso, Mali) (Fm Samandéni-Kiébani, Bonvalé, Guéna-Souroukoudinga & Tin, Burkina-Faso)	Bassin de Taoudeni	Neoproterozoic				Infracambrien tabulaire	Infracambrien tabulaire: Formation gréseuse inferieure et avec intercalations dolomitiques: Fm Sotuba-Kignan, Fm Massigui, Fm Sikasso (Mali), Fm Samandéni-Kiébani, Bonvalé, Guéna-Souroukoudinga & Tin (Burkina-Faso	metasedimentary, continental & marine	Sandstone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-WS	**nP-WS**	no cover	Groupes Wassangara, Souroukoto & Sotuba	Bassin de Taoudeni	Neoproterozoic				Infracambrien tabulaire	Infracambrien tabulaire: Formations Wassangara, Souroukoto & Sotuba	metasedimentary, continental	Sandstone	consolidated, metasedimentary rocks	no mentioning of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-HO	**nP-HO**	no cover	Groupe de Hombori: Formation d'Ouala-Sarnièré (predominantly)	Bassin de Taoudeni	Neoproterozoic				Infracambrien plissé (Pan-African)	Infracambrien plissé: Groupe de Hombori, Formation d'Ouala-Sarnièré (predominantly)	metasedimentary, marine	Shale	consolidated, metasedimentary rocks	carbonate rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-HD	**nP-HD**	no cover	Groupe de Hombori: Formation d'Hombori-Douentza (predominantly)	Bassin de Taoudeni	Neoproterozoic				Infracambrien plissé (Pan-African)	Infracambrien plissé: Groupe de Hombori, Fm d'Hombori-Douentza (predominantly)	metasedimentary, marine	Sandstone	consolidated, metasedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990)
nP-HI	**nP-HI**	no cover	Groupe de Hombori: Formation d'Irma (predominantly)	Bassin de Taoudeni	Neoproterozoic				Infracambrien plissé (Pan-African)	Infracambrien plissé: Groupe de Hombori, Fm d'Irma (predominantly)	metasedimentary, marine	Limestone	consolidated, metasedimentary rocks	carbonate rocks, karst	fractured (karst)	2-10 l/s (moderate)	MK (karst, moderate: 2-10 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), Díaz-Alcaide et al. (2017), DNHE (1990)
nP-Yb	**nP-Yb**	no cover	Groupe d'Ydouban (predominantly)	Bassin de Taoudeni	Neoproterozoic				Infracambrien plissé (Pan-African)	Infracambrien plissé: Groupe d'Ydouban (predominantly)	metasedimentary, marine	Shale	consolidated, metasedimentary rocks	carbonate rocks	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), DNHE (1990), Reichelt (1967)
nP-TT	**nP-TT**	no cover	Nappe de Timétrine-Taounnant	Bassin de Taoudeni	Neoproterozoic				Pan-African: Pharuside Belt	Nappe de Timétrine-Taounnant	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone	consolidated, metasedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), Díaz-Alcaide et al. (2017), DNHE (1990)
nP-TZ	**nP-TZ**	no cover	Séries de Tin Zaouatène, Taféliant, Oumassène, Ourdjan, Tessalit	Bassin de Taoudeni	Neoproterozoic				Pan-African: Pharuside Belt	Séries de Tin Zaouatène, Taféliant, Oumassène, Ourdjan, Tessalit (volcano-sedimentary formations and associated volcano-plutonism)	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone	consolidated, metasedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Bassot et al. (1980, 1981), Girard et al. (1998), Díaz-Alcaide et al. (2017), DNHE (1990)
nP-Ph	**nP-Ph**	no cover	Pharusien du Djado	Bassin du Djado	Neoproterozoic				Pan-African: Pharuside Belt	Pharuside (Pan-African) mobile belt: Pharusien du Djado (metasedimentary: weakly metamorphic slates and sandstones)	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone	consolidated, metasedimentary rocks	no data	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	Greigert (1968), Greigert & Pougnet (1986)
nP-PT	**nP-PT**	no cover	Série du Proche Ténére	Bassin des Iullemmeden	Neoproterozoic				Pan-African: Pharuside Belt	Pharuside (Pan-African) mobile belt: Série du Proche Ténére (metasedimentary)	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone	consolidated, metasedimentary rocks	no data	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	Greigert (1968), Greigert & Pougnet (1986), Black et al (1967)
D-AS	**D-AS**	no cover	Accraian Fm, Sekondian Fm	Craton ouest-africain	Paleozoic	Devonian			Accraian & Sekondian	Accraian Fm, Sekondian Fm	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no mentioning of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
€O-Os	**€O-Os**	no cover	Obosum Group: undivided mudstones	Bassin du Volta	Paleozoic				Voltaian Supergroup	Obosum Group (insignificant): undivided mudstones	sedimentary, marine	Claystone	consolidated, sedimentary rocks	no data	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
€O-Os-s	**€O-Os-s**	no cover	Obosum Group: Dunkro Sandstone, Densubon Sandstone, Tamale Sandstone, Sang Conglomerate	Bassin du Volta	Paleozoic				Voltaian Supergroup	Obosum Group (low): Dunkro Sandstone, Densubon Sandstone, Tamale Sandstone, Sang Conglomerate	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-Ba	**nP-OP-Ba**	no cover	Oti-Pendjari: Bimbila Fm (undivided)	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (limited): Bimbila Fm (undivided mudstones and siltstones)	sedimentary, marine	Claystone	consolidated, sedimentary rocks	no data	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-Ba-s	**nP-OP-Ba-s**	no cover	Oti-Pendjari: Bimbila Fm (Chereponi & Bunya Sandstones)	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (low yield): Bimbila Formation (Chereponi Sandstone, Bunya Sandstone)	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-ET	**nP-OP-ET**	no cover	Oti-Pendjari: Ejura Sandstone, Tease Sandstone	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (low yield): Ejura sandstone, Tease sandstone	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011), CIDA, 2011)
nP-OP-Af	**nP-OP-Af**	no cover	Oti-Pendjari: Afram Fm	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (limited): Afram Fm	sedimentary, marine	Claystone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-Af	**nP-OP-Af, Iu**	no cover	Oti-Pendjari: Afram Fm	Bassin des Iullemmeden	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (limited): Afram Fm	sedimentary, marine	Claystone	consolidated, sedimentary rocks	calcareous rocks	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-Ak	**nP-OP-Ak**	no cover	Oti-Pendjari: Afram Fm, Akroso Conglomerate Mb	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (low): Afram Fm, Akroso Conglomerate Member	sedimentary, marine	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-OP-Kj	**nP-OP-Kj**	no cover	Oti-Pendjari: Kodjari Fm	Bassin du Volta	Neoproterozoic- Paleozoic				Voltaian Supergroup	Oti-Pendjari Group (limited): Kodjari Fm (siltstone, limestone)	sedimentary, marine	Limestone and marlstone	consolidated, sedimentary rocks	carbonate rocks	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Bm-Pg	**nP-Bm-Pg**	no cover	Bombouaka Group: Poubogou Fm	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Bombouaka (limited): Poubogou Fm	sedimentary, marine	Claystone	consolidated, sedimentary rocks	no data	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Bm-Ts	**nP-Bm-Ts**	no cover	Bombouaka Group: Tossiegou Fm	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Bombouaka (low): Tossiegou Fm	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Bm-Pn	**nP-Bm-Pn**	no cover	Bombouaka Group: Panabako sandstone	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Bombouaka (low): Panabako sandstone	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Bm-Pn	**nP-Bm-Pn, Iu**	no cover	Bombouaka Group: Panabako sandstone	Bassin des Iullemmeden	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Bombouaka (low): Panabako sandstone	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Kw	**nP-Kw**	no cover	Kwahu Group: undivided mudstones	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Kwahu Group (limited): undivided mudstones	sedimentary, marine	Claystone	consolidated, sedimentary rocks	no data	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Kw-s	**nP-Kw-s**	no cover	Kwahu Group: Yabraso Sandstone, Damongo Fm, Mpraeso Sandstone, Abetifi Sandstone, Obocha Sandstone	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Group: Kwahu Group (low): Yabraso Sandstone, Mpraeso Sandstone, Abetifi Sandstone, Obochoa Sandstone	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
nP-Kw-An	**nP-Kw-An**	no cover	Kwahu Group: Anyaboni Sandstone	Bassin du Volta	Neoproterozoic				Voltaian Supergroup	Bombouaka-Kwahu Soupergroup: Kwahu Group (moderate): Anyaboni Sandstone	sedimentary, continental	Sandstone	consolidated, sedimentary rocks	no data	fractured	2-10 l/s (moderate)	MF (fractured, moderate: 2-10 l/s)	Ó Dochartaigh et al (2011), Dapaah-Siakwan and Gyau-Boakye (2000), Jordan et al. (2009), Coueffe and Vecoli (2011)
pA-Bm	**pA-Bm**	no cover	Buem Fm	Bassin du Volta	Neoproterozoic				Pan-African: Dahomeyide Belt	Dahomeyide Belt: Buem Fm: metasedimentary, slightly deformed, low-grade metamorphism	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone and claystone	consolidated, metasedimentary rocks	likely occurence of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Engalenc (1985), Carrier et al, 2011)
pA-Bm	**pA-Bm, Iu**	no cover	Buem Fm	Bassin des Iullemmeden	Neoproterozoic				Pan-African: Dahomeyide Belt	Dahomeyide Belt: Buem Fm: metasedimentary, slightly deformed, low-grade metamorphism	Pan-African Mobile Belt, (meta)volcano-sedimentary	Sandstone and claystone	consolidated, metasedimentary rocks	likely occurence of calcareous strata	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Engalenc (1985), Carrier et al, 2011)
pA-At	**pA-At**	no cover	Atacora-Akwapimian-Togo Fm	Bassin du Volta	Neoproterozoic				Pan-African: Dahomeyide Belt	Dahomeyide Belt: Atacora-Akwapimian-Togo Fm: metasedimentary, deformed and metmorphised	Pan-African Mobile Belt, (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	likely occurence of calcareous strata	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Engalenc (1985)
pA-At	**pA-At, Iu**	no cover	Atacora-Akwapimian-Togo Fm	Bassin des Iullemmeden	Neoproterozoic				Pan-African: Dahomeyide Belt	Dahomeyide Belt: Atacora-Akwapimian-Togo Fm: metasedimentary, deformed and metmorphised	Pan-African Mobile Belt, (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	likely occurence of calcareous strata	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Engalenc (1985)
pA-RB	**pA-RB**	no cover	Rockelides Belt: Rockel River Group	Bassaris & Rockelide Belt	Neoproterozoic	Ediacaran			Pan-African: Rockelide Belt	Rockelides Belt: Rockel River Group, volcanosedimentary, partly/locally low-grade metamorphism	Pan-African Mobile Belt, (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Mamédov & Bouféev (2006), Mamedov (2010), Villeneuve (2014)
pA-BB	**pA-BB**	no cover	Bassaris Belt	Bassaris & Rockelide Belt	Neoproterozoic	Ediacaran			Pan-African: Bassaris Belt	Bassaris Belt: volcano-sedimentary, mid-grade metamorphism	Pan-African Mobile Belt, (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Mamédov & Bouféev (2006), Mamédov (2010), Villeneuve (2014)
pA-cpx	**pA-cpx, Air**	no cover	Pharuside Belt: Plutonic and metamorphic complexes	Zone mobile trans-saharienne (Chaîne pharusienne)	Neoproterozoic	Ediacaran			Pan-African: Pharuside Belt (Trans-Saharan Belt)	Pan-African: Pharuside Belt (reworked Archean and Eburnean basement and Neoproterozoic metamorphic sedimentary cover), metamorphic complexes	Pan-African basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
pA-vs	**pA-vs, Air**	no cover	Pharuside Belt: Volcano-sedimentary formations and associated volcano-plutonism	Zone mobile trans-saharienne (Chaîne pharusienne)	*Neoproterozoic*	Ediacaran			Pan-African: Pharuside Belt (Trans-Saharan Belt)	Pan-African: Pharuside Belt (reworked Archean and Eburnean basement and Neoproterozoic metamorphic sedimentary cover), volcano-sedimentary formations	Pan-African terranes: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
pA-cpx	**pA-cpx, If**	no cover	Pharuside Belt: Plutonic and metamorphic complexes	Zone mobile trans-saharienne (Chaîne pharusienne)	*Neoproterozoic*	Ediacaran			Pan-African: Pharuside Belt (Trans-Saharan Belt)	Pan-African: Pharuside Belt (reworked Archean and Eburnean basement and Neoproterozoic metamorphic sedimentary cover), metamorphic complexes	Pan-African basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
pA-vs	**pA-vs, If**	no cover	Pharuside Belt: Volcano-sedimentary formations and associated volcano-plutonism	Zone mobile trans-saharienne (Chaîne pharusienne)	*Neoproterozoic*	Ediacaran			Pan-African: Pharuside Belt (Trans-Saharan Belt)	Pan-African: Pharuside Belt (reworked Archean and Eburnean basement and Neoproterozoic metamorphic sedimentary cover), volcano-sedimentary formations	Pan-African terranes: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
pA-cpx	**pC-cpx, BM-K**	no cover	Kédougou-Kéniéba and Kayes Inliers	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-vs	**pC-vs, BM-K**	no cover	Kédougou-Kéniéba and Kayes Inliers	Craton ouest-africain	*Paleoproterozoic*	Rhyacian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-cpx	**pC-cpx, BM-Sg**	no cover	Baoulé-Mossi Domain: Plutonic and metamorphic complexes	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-vs	**pC-vs, BM-Sg**	no cover	Baoulé-Mossi Domain - Birimian terranes: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	*Paleoproterozoic*	Rhyacian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-cpx	**pC-cpx, BM-Cl**	no cover	Baoulé-Mossi Domain: Plutonic and metamorphic complexes	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	DNH Mali
pA-vs	**pC-vs, BM-Cl**	no cover	Baoulé-Mossi Domain - Birimian terranes: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	*Paleoproterozoic*	Rhyacian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-cpx	**pC-cpx, BM-BF**	no cover	Baoulé-Mossi Domain: Plutonic and metamorphic complexes	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Carrier, 2011
pA-vs	**pC-vs, BM-BF**	no cover	Baoulé-Mossi Domain - Birimian terranes: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	*Paleoproterozoic*	Rhyacian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Courtoise, 2010
pA-cpx	**pC-cpx, BM-Gh**	no cover	Baoulé-Mossi Domain: Plutonic and metamorphic complexes	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Gonyaglo, 2017
pA-vs	**pC-vs, BM-Gh**	no cover	Baoulé-Mossi Domain - Birimian terranes: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Gonyaglo, 2017
pA-cpx	**pC-cpx, BM-ClGh**	no cover	Baoulé-Mossi Domain: Plutonic and metamorphic complexes	Craton ouest-africain	*Paleoproterozoic*	Orosirian, Statherian			Eburnean: Baoulé-Mossi Domain	Plutonic and metamorphic complexes of the Baoulé-Mossi Domain	Eburnean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-vs	**pC-vs, BM-ClGh**	no cover	Baoulé-Mossi Domain - Birimian terranes: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	*Paleoproterozoic*	Rhyacian			Eburnean: Baoulé-Mossi Domain	Volcano-sedimentary formations and associated volcano-plutonism (Birimian terranes of the Baoulé-Mossi Domain)	Birimian terranes: (meta)volcano-sedimentary, deep water basins	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-vs	**pA-vs, DB**	no cover	Dahomeyide Belt: undifferentiated	Dahoméyides	*Neoproterozoic*	Ediacaran			Pan-African: Dahomeyide Belt (Trans-Saharan Belt)	Volcano-sedimentary formations and associated volcano-plutonism as well as plutonic and metamorphic complexes of the Dahomeyide Belt	Pan-African basement (plutonic and metamorphic complexes)	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Burgeap (2004), Wright (1986), Engalenc (1985)
pA-vs	**pA-vs, DB**	no cover	Dahomeyide Belt: Volcano-sedimentary formations and associated volcano-plutonism	Dahoméyides	*Neoproterozoic*	Ediacaran			Pan-African: Dahomeyide Belt (Trans-Saharan Belt)	Volcano-sedimentary formations and associated volcano-plutonism Dahomeyide Belt	Pan-African terranes: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Burgeap, 2004, Wright (1986)
pA-cpx	**pA-cpx, DB**	no cover	Dahomeyide Belt: Plutonic and metamorphic complexes	Dahoméyides	*Neoproterozoic*	Ediacaran			Pan-African: Dahomeyide Belt (Trans-Saharan Belt)	Plutonic and metamorphic complexes of the Dahomeyide Belt	Pan-African basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Burgeap, 2004
pA-cpx	**pA-cpx, BN**	no cover	Benin-Nigerian Shield: Plutonic and metamorphic complexes	Bouclier benino-nigerian	*Neoproterozoic*				Pan-African: Benin-Nigerian Shield (Trans-Saharan Belt)	Plutonic and metamorphic complexes of the Benin-Nigerian Shield	Pan-African basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Houston, 1992
pA-vs	**pA-vs, BN**	no cover	Benin-Nigerian Shield: Volcano-sedimentary formations and associated volcano-plutonism	Bouclier benino-nigerian	*Neoproterozoic*				Pan-African: Benin-Nigerian Shield (Trans-Saharan Belt)	Volcano-sedimentary formations and associated volcano-plutonism of the Benin-Nigerian Shield	Pan-African terranes: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
pA-cpx	**pA-cpx, Jos**	no cover	Nigerian Shield: Plutonic and metamorphic complexes	Bouclier benino-nigerian	*Neoproterozoic*				Pan-African: Benin-Nigerian Shield (Trans-Saharan Belt)	Plutonic and metamorphic complexes of the Benin-Nigerian Shield	Pan-African basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Hadzell, 1992
pA-vs	**pA-vs, Jos**	no cover	Nigerian Shield: Volcano-sedimentary formations and associated volcano-plutonism	Bouclier benino-nigerian	Neoproterozoic				Pan-African: Benin-Nigerian Shield (Trans-Saharan Belt)	Volcano-sedimentary formations and associated volcano-plutonism of the Benin-Nigerian Shield	Pan-African terranes: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Hadzell, 1992
A-cpx	**A-cpx, KM**	no cover	Kénéma-Man Domain: Plutonic and metamorphic complexes	Craton ouest-africain	Archean				Archean: Kénéma-Man Domain	Plutonic and metamorphic complexes of the Kénéma-Man Domain	Archean basement (plutonic and metamorphic complexes)	Granite, gneiss, and schist	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Elster, 2014
A-vs	**A-vs, KM**	no cover	Kénéma-Man Domain: Volcano-sedimentary formations and associated volcano-plutonism	Craton ouest-africain	Archean				Archean: Kénéma-Man Domain	Volcano-sedimentary formations and associated volcano-plutonism of the Kénéma-Man Domain	Archean basement: (meta)volcano-sedimentary	Schist and quartzite	consolidated, metamorphic rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
Q-v	**Q-v**	no cover	Quaternary volcanics	Bouclier benino-nigerian	*Cenozoic*	Quaternary			Quaternary volcanics	Quaternary, volcano-sedimentary formations: Mafic extrusive igneous rock (basalt flows, plugs, fluvio-volcanic deposits)	extrusive/volcanic (mafic)	Volcanic rock (basic)	consolidated, igneous rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	
Q-v	**Q-v, A**	no cover	Quaternary volcanics (arid regions)	Zone mobile trans-saharienne (Chaîne pharusienne)	*Cenozoic*	Quaternary			Quaternary volcanics	Quaternary, volcano-sedimentary formations: Mafic extrusive igneous rock (basalt flows, plugs, fluvio-volcanic deposits)	extrusive/volcanic (mafic)	Volcanic rock (basic)	consolidated, igneous rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
Ce-v	**Ce-v**	no cover	Cenozoic volcanics	Cabo Verde	Cenozoic				Cenozoic volcanics	Cenozoic volcan-(sedimentary) formations: Mafic extrusive igneous rock (pyroclastic flow, volcanic and plutonic rocks)	extrusive/volcanic (mafic)	Volcanic rock (basic)	consolidated, igneous rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	Heilweil, 2010
TJ-CAMP	**TJ-CAMP**	no cover	CAMP intrusives	Craton ouest-africain	Mesozoic	Triassic/Jurassic			CAMP intrusives	CAMP (Central Atlantic Magmatic Province) dolerite sills and dykes (e.g. Kakoulima intrusion, Hounde swarm, ...)	intrusive/plutonic rocks (mafic)	Plutonic rock (basic)	consolidated, igneous rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
TJ-CAMP	**TJ-CAMP, Td**	no cover	CAMP intrusives	Bassin de Taoudeni	Mesozoic	Triassic/Jurassic			CAMP intrusives	CAMP (Central Atlantic Magmatic Province) dolerite sills and dykes (e.g. Kakoulima intrusion, Hounde swarm, ...)	intrusive/plutonic rocks (mafic)	Plutonic rock (basic)	consolidated, igneous rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
TJ-yGr	**TJ-yGr**	no cover	Younger Granites	Bouclier benino-nigerian	Mesozoic	Triassic/Jurassic			Younger Granites	Younger Granites: Plutonic and volcano-plutonic ring-dyke complexes (Paleozoic-Cenozoic)	intrusive/plutonic rocks (felsic)	Plutonic rock (acid)	consolidated, igneous rocks	basement	fractured	0.5-2 l/s (low)	LF (fractured, low: 0.5-2 l/s)	
CP-Gr	**CP-Gr, DM**	no cover	Damagram-Mounio province	Zone mobile trans-saharienne (Chaîne pharusienne)	Paleozoic	Carboniferous/Permian			Pan-African: Plutonic ring-complexes of the Aïr	Younger Granites: Plutonic and volcano-plutonic ring-dyke complexes (Paleozoic-Cenozoic), eastern domain, desert regions	intrusive/plutonic rocks (felsic)	Plutonic rock	consolidated, igneous rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
OS-Gr	**OS-Gr, A**	no cover	Plutonic ring-complexes of the Aïr	Zone mobile trans-saharienne (Chaîne pharusienne)	Paleozoic	Ordovician/Silurian			Pan-African: Plutonic ring-complexes of the Aïr	Pan-African plutonic and volcano-plutonic intrusions	intrusive/plutonic rocks (mafic)	Plutonic rock	consolidated, igneous rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
nP-Gr	**nP-Gr, If**	no cover	Batholiths of the Adrar des Iforas	Zone mobile trans-saharienne (Chaîne pharusienne)	Neoproterozoic	Ediacaran			Pan-African: Batholithic intrusions of the Adrar des Iforas	Pan-African plutonic and volcano-plutonic intrusions	intrusive/plutonic rocks (mafic)	Plutonic rock (basic)	consolidated, igneous rocks	basement	fractured	<0.1 l/s (insignificant)	NF (fractured, insignificant: <0.1 l/s)	
nP-oGr	**nP-oGr**	no cover	Older Granites	Bouclier benino-nigerian	Neoproterozoic				Older Granites (Pan-African granitoids, syn- and posttectonic)	Older Granites: Pan-African plutonic and volcano-plutonic intrusions	intrusive/plutonic rocks (undiff.)	Plutonic rock	consolidated, igneous rocks	basement	fractured	0.1-0.5 l/s (limited)	TF (fractured, limited: 0.1-0.5 l/s)	Hadzell, 1992