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Empirical Models for Determination of Hydraulic Conductivity of the Ajali Formation using Sedimentological Analysis in the Idah Area, Northern Anambra Basin, Nigeria

Ikenna A. Obasi[1*], Godwin O. Aigbadon[2], Nneka M. Onwa [3], Sikiru A. Salami[2], Chidimma N. Chukwu[1], Ikechukwu M. Onwe[1]

[1]Department of Geology,
Alex Ekwueme Federal University Ndufu-Alike,
P.M.B. 1010, Abakaliki,
Ebonyi State,
Nigeria.

[2]Department of Geology,
University of Benin,
Edo State,
Nigeria

[3]Department of Geology,
University of Calabar,
Nigeria.

Email: ikenna.obasi@funai.edu.ng
ORCID: https://orcid.org/0000-0003-4332-7102

Abstract

This study examines the hydraulic conductivity of the Ajali Sandstone Formation in Idah axis of the northern Anambra Basin, Nigeria. The investigation aims to determine the hydraulic conductivity cut-off for the Ajali Sandstone, which is important for the development and management of groundwater resources in Idah area. The study utilizes thin section and grain size analysis on five samples to determine hydraulic conductivity. The Sedimentological analysis indicates medium to coarse-grained, subangular quartz, monocrystalline structures. The modal composition from the thin section ranges from 65-85% of quartz, 10-20% of feldspar, 5-25% of others. Iron-rich samples in the study area display that quartz is between 25-30%, with opaque matrix containing Fe-oxides between 70-75%, respectively. The coefficient of uniformity (U) estimated based on Hazen's model ranges from 0.21 to 4.95, with an average of 2.92. The hydraulic conductivity estimated from other model ranges between 3.61×10^{-4} *to* 4.41×10^{-4} *m/s, with an average of* 4.24×10^{-4} *m/s. This finding provides evidence that the beds of Ajali Sandstone in Idah area have the capability to serve as aquifer zones, exhibiting a hydraulic conductivity of medium magnitude. The hydraulic conductivity values, determined using the USBR method, range from 189.17 m/day to 1054.0 m/day, aligning with the results obtained from the Hazen model. This study is in line with previous research on established relationships, despite the lack of comparison on hydraulic conductivity in the study area. Differences in estimation model are observed, with Hazen's technique yielding more consistent but smaller values, while the USBR method provides a wider range. Further investigation is advised to address these inequalities and improve understanding.*

Author for Correspondence

Keywords: Hydraulic Conductivity, Sieve Analysis, Anambra basin, Empirical approach, Ajali Formation.

INTRODUCTION

The ease with which a fluid permeates a granular media is known as hydraulic conductivity (*k*), and it depends on both the material and the permeating fluid (Strobel, 2005). Hydraulic conductivity is dependent on the fluid's viscosity, density and the characteristics of the porous media (Schwartz and Zhang, 2003). As it helps to quantify the volume of fluid that can move through rocks and soils, this parameter is crucial to ground water flow. To conduct reliable and precise assessments of hydraulic systems, it is crucial to be aware of hydraulic conductivity values and their distribution (Award and Al-bassam, 2001). Due to the importance of hydraulic conductivity, hydrogeologists always look for reliable techniques to determine the hydraulic conductivity of the aquifers with which they are concerned, for better groundwater development, management, and conservation (Justine, 2008). Its value has been determined using a variety of ways, including computations, field procedures (such as well pumping tests, auger hole tests, and tracer tests), and other laboratory methods (Todd and Mays, 2004). Empirical approaches have been designed to directly and indirectly estimate conductivities through material medium such as grain size because they consume less time, labour, and money-efficient (Vukovic and Soro, 1992; Salarashayeri and Siosemarde, 2012; Petalas and Pilakas, 2011).

Hydraulic conductivity and grain-size distribution of granular porous media have long been known to be related, and this relationship is very helpful for estimating conductivity values in situations where direct permeability data are scarce, such as in the early stages of aquifer exploration (Justine, 2008). Numerous equations, derived from experimental findings, elucidate this relationship. The Kozeny-Carman equation is among such equations. It originated from Kozeny (1927) formula and was later modified by Carman (1937 and 1956). Similar equations were developed by Shepherd (1989), Alyamani and Sen (1993), and Terzaghi and Peck (1964). The suitability of these equations for assessing hydraulic conductivity relies on the specific soil type under examination. The USBR (Justin et al., 1945; Mallet and Pacquant, 1951) and the Hazen (1892) equations have been extensively applied in the determination of the *k* of earth materials (Ishaku et al., 2011, Pucko and Timotej Verbovšek, 2015; Kabalar and Akbulut, 2016; Říha et al, 2018; Aguilla et al., 2023), respectively. The objective of this research is to empirically derive the hydraulic conductivity of the sandstone members of the Ajali Formation in Idah area using sedimentological methods (grain size and thin section). The outcomes of this research will contribute to the improved development and management of groundwater resources in the study area.

Climatic and Geological settings of the study area

The research area falls within the Idah sheet region of north Anambra Basin, Nigeria (Fig. 1). It is also situated in a tropical climate zone that exhibits two different seasons: the rainy season, which spans from April to October, and the dry season, which occurs from November to March (Oparaku and Iwar, 2018). The mean annual temperature exhibits a fluctuation between 31 ^{o}C during July or August and 35 ^{o}C in March. Concurrently, the relative humidity spans in the range of 75 – 98 % (Saliu, 2021). The vegetation within the designated study area is categorised as guinea savanna grassland, which is distinguished by the presence of shrubs interspersed with orchard bushes. The region experiences drainage mostly towards the river Niger as a result of the modest topographical incline. The mean yearly precipitation amounts to 1,260 millimetres. (Annually, a range of 73.4 to 166.9 millimetres (2.9 to 6.6 inches) of water undergoes evaporation.

The basin evolution of Anambra Basin (Fig. 2) was discussed by Murat (1972); Nwajide (1996, 2013); Obaje (1999, 2005) and Aigbadon et al. (2024). They believe that the formation of the basin process began with the splitting and drifting of the African and South American plates during the Late Jurassic. The basin is believed to be the failed armed of the triple junction (RRR triple junction ridge system). This is discussed in Burke et al. (1971), Benkhelil (1982), Gubanov and Mooney (2009). The Y-shaped, RRR triple-junction ridge system, as suggested by Burke et al. (1971), Benkhelil (1982), Gubanov and Mooney (2009) is the starting point for the tectonic evolution of the sedimentary basins of southeast Nigeria (Fig. 2). Immediately after the Santonian episode, two depositional cycles contributed to the Anambra Basin's sedimentation: the first, known as the Late Campanian–Early Maastrichtian Nkporo depositional cycle, which was further separated into the Maastrichtian Mamu, Ajali, and Nsukka (Coal Measures) and the Campanian Nkporo group (Fig. 3).

The Nkporo, Enugu, and Afikpo/Owelli Sandstones are the three constituents of the Nkporo Group. The lateral equivalent of the Nkporo Formation in the Afikpo and Anambra Basins are the arenaceous facies of the Afikpo and Owelli Sandstone, respectively (Okeke et al., 2014). The Owelli Sandstone, which includes the Lokoja and Lafia Sandstone that are characterized by medium- to coarse-grained, feldspathic sandstone that is cross-stratified lying unconformably over the Agwu Formation (Nwajide, 1990, 2013). The Maastrichtian Mamu Formation also, known as Lower coal measure comprises by sandstone units, siltstone, claystone and majorly dark-brown shale units (Aigbadon et al., 2024).

The Ajali Formation, which is deposited in the basin in the Early Maastrichtian period, is situated above the Mamu Formation, which represents the Mid-Maastrichtian period (Fig. 3). According to Ezim et al. (2017), the Ajali Sandstone aquifer is predominantly unconfined across the majority of its geographical extent. Uma et al. (1989), classified this Formation as a primary aquifer group. According to Agagu et al. (1985), the Sandstone exhibits a high degree of permeability and is easily replenished within its outcrop region surrounding the Idah-Nsukka-Enugu escarpment. Furthermore, the distribution of transmissivity in the region exhibits a comparable pattern, with the maximum value of 2423 m^2/day observed at Ede-Oballa-Opi. This observation implies the presence of a high-quality reservoir within the area. It is also apparent that areas underlain by the Ajali Formation are expected to have higher transmissivity as discussed by Ezeh and Ugwu (2010). However, to properly understand the aquifer characteristics of the study area, hydraulic conductivity is very important since it plays a crucial role in groundwater studies, particularly in assessing groundwater resources (Freeze and Cherry, 1979). The Nsukka Formation is referred to as the upper coal measures, which is from the mid-to-late Maastrichtian age (Reyment, 1965; Nwajide, 2013; Obi, 2000). The Nsukka Formation overlies the Ajali Sandstone conformably and the formation is characterized by predominantly dark grey shales siltstones and fine sandstones units. The deposition of the Nsukka Formation marked the end of the Cretaceous sedimentation in the Anambra Basin (Nwajide, 2022; Fig. 3).

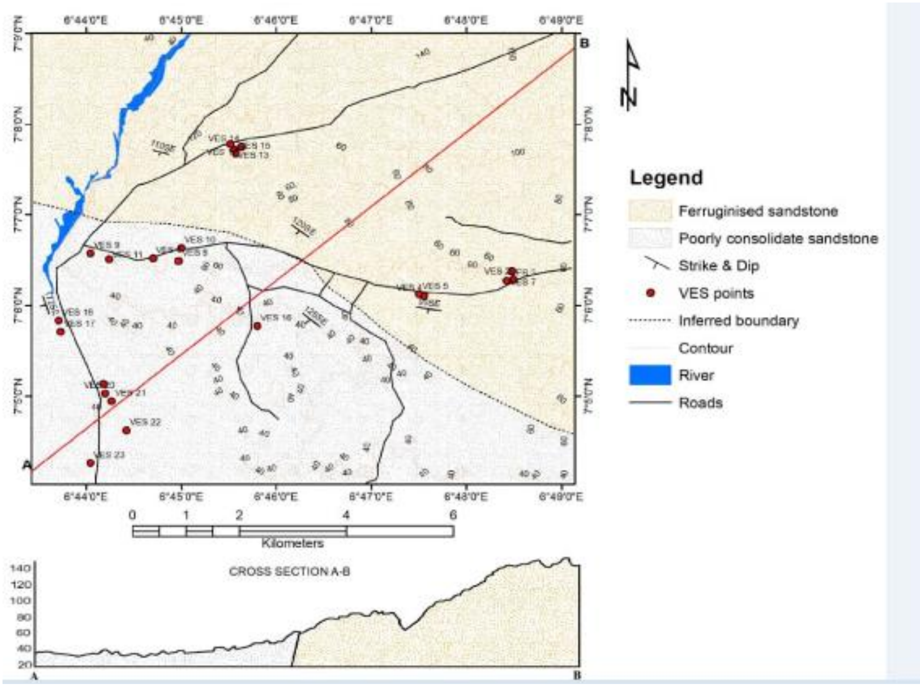


Figure 1: Geology map of the study area

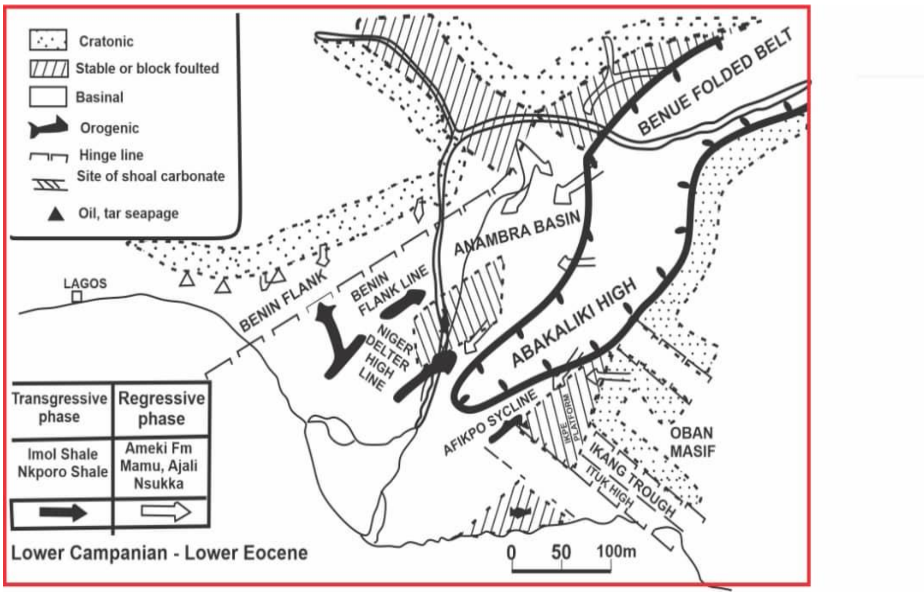


Figure 2: The tectonic map of southeastern Nigeria during the Campanian-Eocene (after Murat 1972)

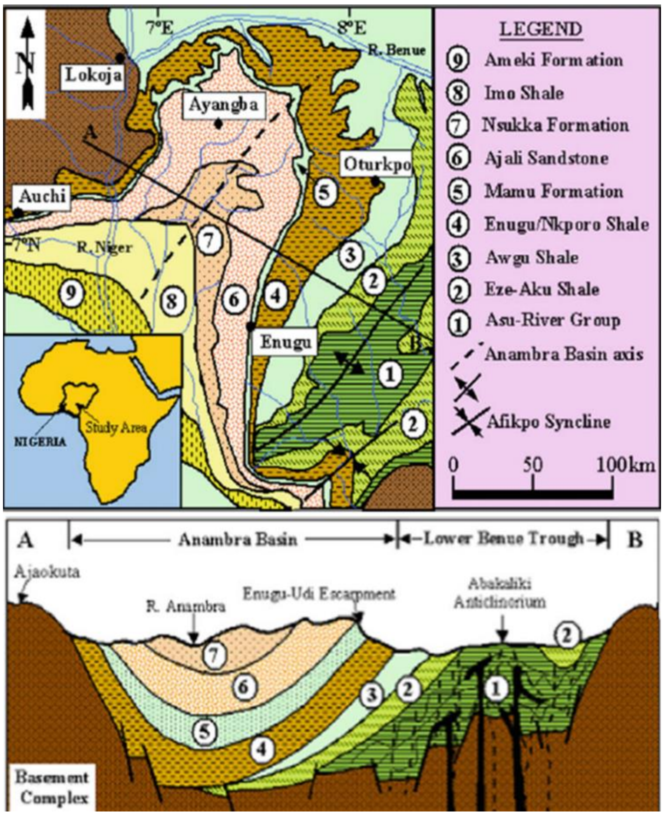


Figure 3. The geological map of Southern Benue Trough and Anambra Basin (Nwajide, 2013).

MATERIALS AND METHODS

Field study

For this study, geological field mapping was conducted throughout the research areas. To ensure accuracy and appropriate documentation, rock types including contacts, boundary were carefully identified and rock samples collected. Every sampling site's coordinates were recorded using a Global Positioning System (GPS), and the strike and dip of formations were measured using clinometer compass with rock units were recorded on the base map. A hand lens was used for the first field inspection of the mineral composition and texture after fresh rock samples were retrieved with a hammer and chisel. Layer thicknesses and feature spacing were measured using a measuring tape, and samples were labelled with markers and masking tape. For comprehensive documentation and further analysis, all measurements, observations, and sample specifics were noted in a field notebook. All the aforementioned information was used to produce a geological map of the study area.

Sieve Analysis

Five rock samples from various locations within the study area were subjected to sieve analysis at Federal University Lokoja's Sedimentology Laboratory to determine the parameters relating to the particle size distribution and grain size. A rubber-padded pestle and mortar were used to break up the samples. Weighing empty sieves (4.0mm, 2.0mm, 1.0mm, 0.5mm, 0.25mm, 0.125mm, 0.063mm, and pan) was done using a balance. The sieves were positioned so that the smallest grains would be caught by the lid covering the pan and the bottom 0.063mm mesh sizes. Following the attachment of the sieves, bottom pan, and mechanical shaker, 100 kg of samples were poured into the upper (4.0 mm) sieve. The apparatus quivered for ten minutes, recording the sediments from the sieves and bottom pan by weight. The sieves were shaken and then gently separated so as not to spill sediment. In order to preserve grain structure, materials were broken down without being crushed or ground. The cumulative frequency curve was used to calculate grain size parameters like graphic mean (M_Z), sorting (σ_1), and graphic skewness (Sk_1) for grain sizes at 5ϕ, 16ϕ, 25ϕ, 50 ϕ, 75ϕ, 84ϕ, and 95ϕ percentiles.

$$M_Z = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3} \quad (1)$$

The chart provided by Folk (1968), expressed in phi units, was used to determine the mean grain size, where 16, 50, and 84 represent the grain sizes corresponding to the 16th, 50 th, and 84 th percentiles of the sample's weight distribution. The calculated values will be interpreted using Tables 1- 3.

Table 1: Standard value of Mean after Folk (1974).

Phi ϕ (Range)	Descriptive terms
(-2.00) - (-1.00)	Very fine gravel
(-1.00) - (0.00)	Very coarse sand
(0.00) - (1.00)	Coarse sand
(1.00) - (2.00)	Medium sand
(2.00) - (3.00)	Fine sand
(3.00) - (4.00)	Very fine sand
(4.00) - (5.00)	Coarse silt

$$\sigma_1 = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6} \quad (2)$$

The obtained result can be interpreted using the table below;

Table 2: Standard Value of Sorting after Folk and Ward (1957)

Graphic Standard deviation	Interpretations
<0.35	Very well sorted
0.25 - 0.50	Well sorted
0.50 - 0.71	Moderately well sorted
0.71 - 1.00	Moderately sorted
1.00 - 2.00	Poorly sorted
2.00 - 4.00	Very poorly sorted
>4.00	Extremely poorly sorted

Graphic Skewness (SK_1)

$$Sk_1 = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi_5)} \quad (3)$$

The obtained result were interpreted using the table below;

Table 3: Standard value of Skewness after Folk (1974.)

Interpretation	Skewness values
Strongly fine skewed	(+1.00) - (+0.30)
Fine skewed	(+0.30) - (+0.10)
Near-symmetrical	(+0.10) - (-0.10)
Coarse skewed	(-0.10) - (-0.30)
Strongly coarse skewed	(-0.30) - (-1.00)

Thin Section

Thin section petrography was conducted on five samples at the Mineralogy Laboratory of Federal University Lokoja. The samples were air-dried and impregnated with epoxy resin (A and B). After impregnation, the samples were trimmed using a GTS cut-off saw, ensuring that one surface was perfectly flat. This flat surface was then lapped on a glass plate with 600-grit carborundum. The lapped surface of the sample and the slide were bonded using epoxy, and the slide was placed in the CL 50 lapping machine to reduce the sample thickness to 30 microns. Finally, the slide was covered with Canada balsam, a cover slip was applied, and the thin section was examined under a petrographic microscope. Understanding hydraulic conductivity based on grain size can be enhanced through the analysis of thin sections. By examining thin slices of a geological sample under a microscope, the grain composition, arrangement, and porosity of the material can be observed, all of which influence hydraulic conductivity.

Established Empirical Formulae and applications

Using empirical formulas, particle size analysis of the sediment of interest can be used to estimate hydraulic conductivity (K). Table 4 below summarizes the commonly used empirical methods for determining hydraulic conductivity (K).

Table 4: Established Empirical formulae and conditions of application

Authors	Value of β	Function of porosity	Effective Grain diameter d_e	Domain of Applicability
Beyer (1964)	$6\times 10^{-4}\log\frac{500}{C}$	1	$d_e = d_{10}$	0.06mm<d_e<0.6 1<C<20
Hazen (1982)	6×10^{-4}	$[1+10(n-0.26)]$	$d_e = d_{10}$	0.1mm< d_e<3mm C<5
Kozeny (1972)	8.3×10^{-4}	$\frac{n^3}{(1-n)^2}$	$d_e = d_{10}$	Large grain sands
Sauerbrei (1932)	3.75×10^{-3}	$\frac{n^3}{(1-n)^2}$	$d_e = d_{17}$	Sands and sandy clay d_e<0.5mm
USBR (Oh et al., 2013)	$4.8\times 10^{-4} d_{20}^{2.3}$	1	$d_e = d_{20}$	Medium-grain sands C<5
Pavichich (1991)	1	$\frac{n^3}{(1-n)^2}$	$d_e = d_{17}$	0.06mm< d_e<1.5mm

When the homogeneity coefficient (C) is less than 20 and the grain size diameter at 10% (D_{10}) is between 0.06 mm and 0.6 mm, the Beyer method is applied. For homogeneity coefficients

(C) below d_5 and d_{10} between 0.1 mm and 3 mm, the Hazen method is used. The Kozeny (1972) method is applicable to coarse sands, while Sauerbrei is employed for sand or sandy clay samples with an effective diameter (d_e) less than 0.5 mm. The USBR method is used for medium-grain sands with a homogeneity coefficient (C) less than 5 and a d_{20} value. The Pavich method applies when d_{17} (grain size diameter) is between 0.06 mm and 1.5 mm without considering uniformity coefficients (Moshood and Tijani, 2008).

United States Bureau of Reclamation (USBR)

$$K = \frac{g}{v} \times 4.8 \times 10^{-4} d_{20}^{0.3} d_{20}^{2}$$

The purpose of table 4 presented above is to offer a detailed summary of the empirical approaches utilized in previous studies. However, in the framework of the U.S. Bureau of Reclamation (USBR) formula, hydraulic conductivity is exclusively influenced by the effective grain size (d_{20}) and is unaltered by differences in porosity. As a result, the porosity function is assigned a value of one. Based on the findings of Cheng and Chen (2007), this equation is particularly suitable for medium-grain sand that displays a homogeneity coefficient lower than 5. The current investigation aimed to evaluate the hydraulic conductivity of the Ajali Formation in the Anambra Basin using the United States Bureau of Reclamation (USBR) formula. The motivation for choosing this particular excerpt was based on the measured particle size diameter (d_{10}) obtained during the process of sieve analysis, which exhibited a range spanning from 1.10 mm to 2.10 mm.

The Hazen's equation

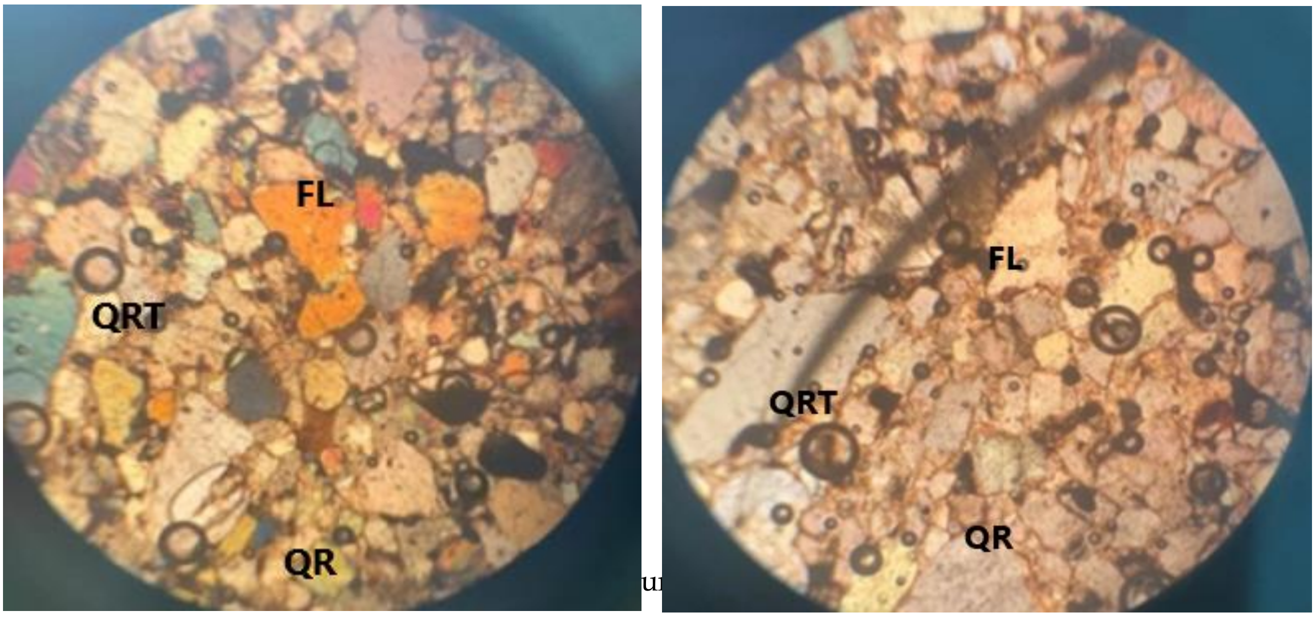
The values of d_{60} and d_{10} were obtained from grain-size distribution curves and included into Hazen's (1892) equation to determine hydraulic conductivity of soil samples. The rule applies to soils with a uniformity coefficient (d_{60}/d_{10}) less than five (5), which is applicable to the grain size and uniformity coefficient obtained in this study. The d_{10} particle size ('effective grain size') and d_{60}/d_{10} ('uniformity coefficient') were found to be significant influences. To estimate hydraulic conductivity K, Hazen's equation was used, $K = C(d_{10})^2$

Note: C is a correlation factor, and d_{10} represents the 10% particle size from particle size distribution curves.

Results and Discussion

Thin section

Thin sections reveal the mineral composition and grain sizes within the rock or sediment. Since different minerals exhibit varying porosities and permeabilities, they impact water flow differently. By studying grain sizes, shapes, and configurations in thin sections, water flow patterns can be identified. Figure 4 shows a generally medium to coarse-grained texture. The grains range from subangular to angular, with the predominant quartz crystals being monocrystalline. Approximately 70% of the sample is composed of quartz, most of which displays uniform to moderate undulose extinction, high relief, and is largely free of inclusions. The modal composition consists of 75% quartz, 15% feldspar, and 10% other minerals (Figure 4). Petrographic data (Fig. 4) highlights the medium to coarse-grained nature, with subangular to angular grains, and quartz being the most common mineral, primarily monocrystalline.



The grain sizes are generally medium to coarse grained (Fig 5). The grains are sub-angular to angular, the most common crystal structures of quartz are monocrystalline, with low relief. Modal composition: Quartz 65%, Feldspar 10%, others 25%.

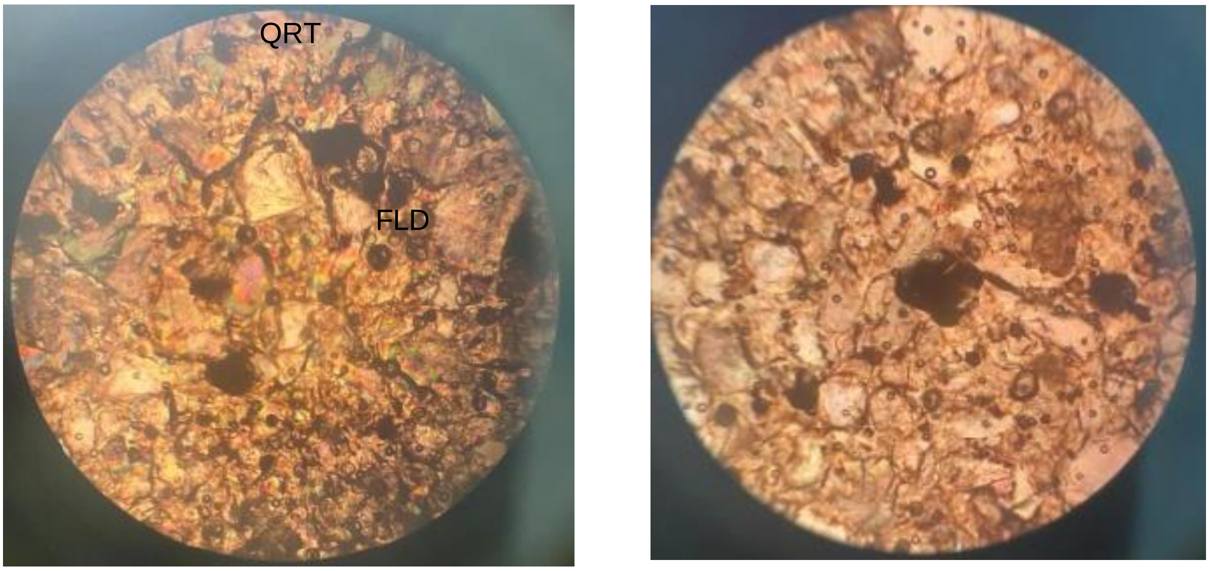


Fig 5: Thin section results for bed two viewed under the XPL and PPL microscope.

Figure 6 reflect that the grain sizes are generally medium to coarse grained. The grains are subangular to angular; the most common crystal structures of quartz are monocrystalline, most of which exhibit uniform to moderate undulose extinction with very low relief with inclusions. Modal composition: Quartz (70%), Feldspar (20%), Others (10%).

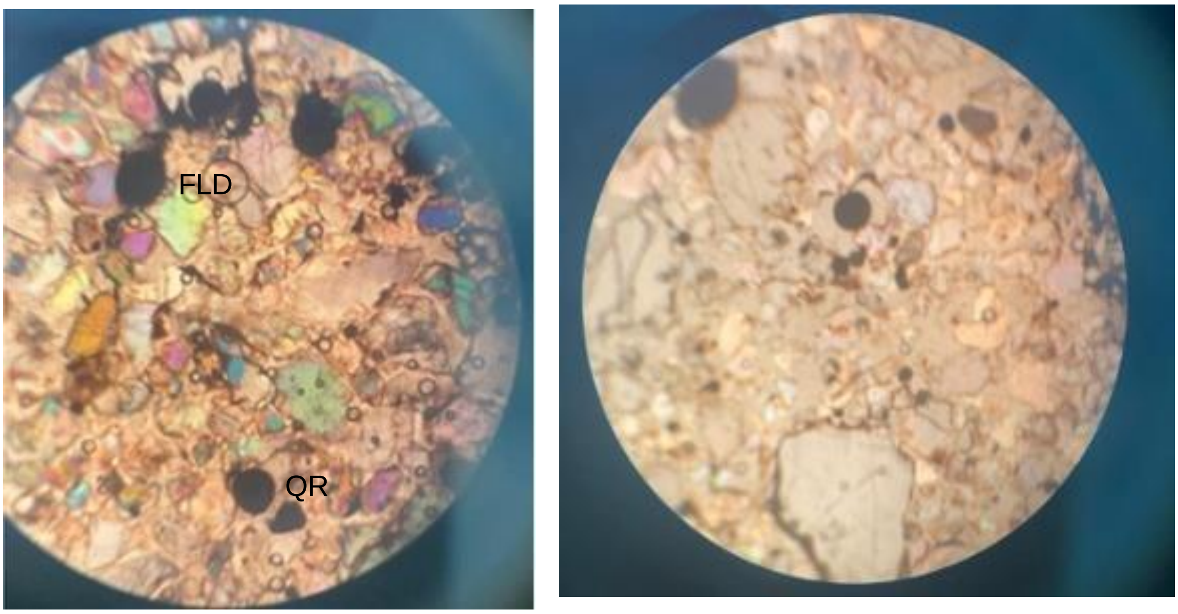


Fig 6: Thin section results for bed three viewed under the XPL and PPL microscope.

Figure 7 display generally medium to coarse grained. The grains are subangular to angular, the most common crystal structures of quartz are monocrystalline and they exhibit uniform to moderate undulose extinction with very low relief with inclusions. Modal composition displays that Quartz (85%), Feldspar (10%), Others (5%).

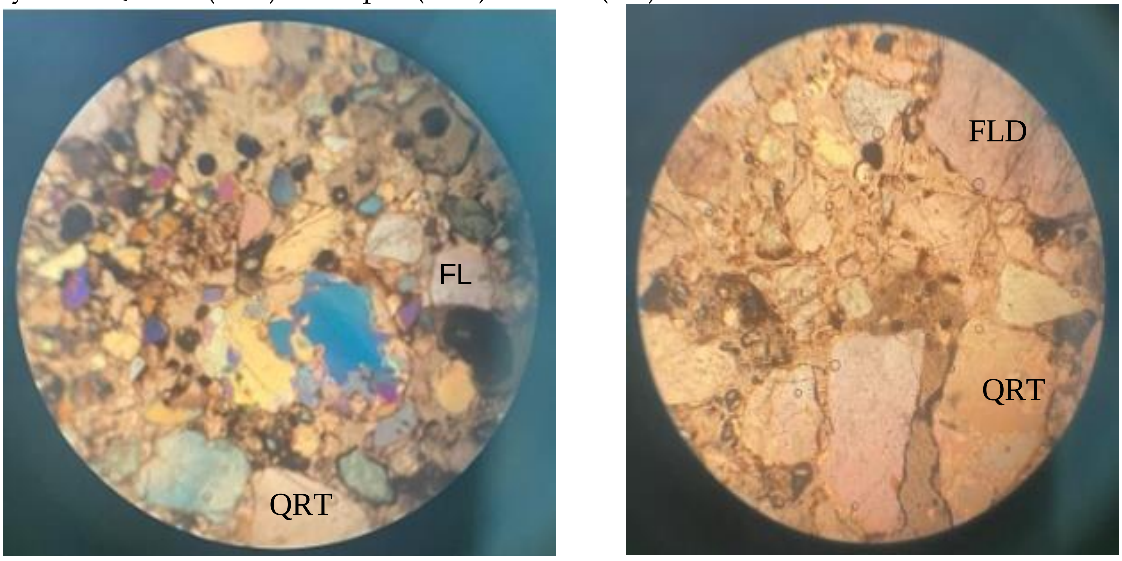


Fig 7: Thin section results for bed four viewed under the XPL and PPL microscope.

The rock samples contain more than 15% iron, including iron carbonate and inter-granular cement (Fig 8). When observed under a polarizing microscope with x40 magnification in cross-polarized light, the rock appears generally medium to coarse-grained, with subangular to angular grains. It is composed primarily of quartz and iron oxide (hematite). Based on modal composition, the sample is approximately 70% to 75% rich in iron (Fe-Os), which constitutes the majority of the sample's volume. Under the petrographic microscope, the iron component appears opaque with no discernible structure, forming the matrix in which the quartz grains are embedded. Quartz makes up about 25% to 30% of the sample by volume. The quartz grains are colorless, have low relief, display undulose extinction, and lack pleochroism, with occasional inclusions present in some grains. Modal composition for Fe is 90%, Quartz (5%), Others (5%).

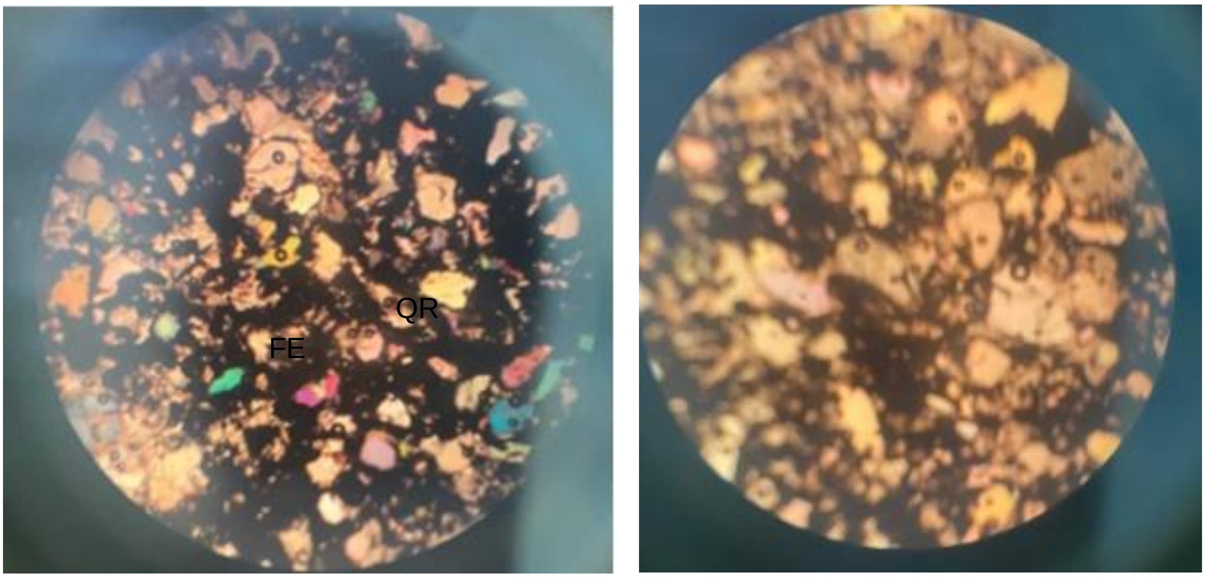


Fig 8: Thin section results for bed five viewed under the XPL and PPL microscope

Sedimentology

Based on the data provided in Table 10, calculated using the Hazen (1982) empirical formula, the coefficient of uniformity (U) for the Ajali Sandstone beds in the Idah area ranges from 0.21 to 4.95, with an average value of 2.92. This range indicates a significant level of sorting within the beds at the study site. According to Fetter's (2014) classification system for sandstones, which categorizes sandstones with coefficient of uniformity values between 0.1 and 5.4 as well-sorted, the observed values suggest that the Ajali Sandstone beds are predominantly well-sorted. The porosity (n) that was observed displayed a variation between 33% and 42%, with an average value of 39.6%. According to the findings of Freeze and Cherry (1979), unconsolidated sands with porosity levels between 25% and 50% possess geological characteristics that make them suitable for use as aquifers. In a similar vein, Todd and May ascribed the respective proportions of 33% and 37% to fine-grained sandstones, corroborating the prevailing composition of fine-grained material within the investigated layers (Table 5).

The hydraulic conductivity (K) of the Ajali Sandstone in Idah area ranges has a wide range of values, ranging from 3.61×10^{-4} to 4.41×10^{-4} m/s, with an average value of 4.24×10^{-4} m/s (Table 5). Based on the classification ranges of hydraulic conductivity in geologic materials as defined by Singhal and Gupta (1999), it can be observed that fractured sandstone generally exhibits hydraulic conductivity ranging from 10^{-3} m/s to 10^{-6} m/s. This suggests that the Ajali Sandstone beds in the Idah area have the potential to function as aquifer zones, demonstrating moderate hydraulic conductivity. In addition, Table 6 provides the hydraulic conductivity values utilizing the USBR method indicating that the hydraulic conductivity ranges from 189.17 m/day - 1054.0 m/day (Table 6).

It is worth noting that the Hazen technique yields hydraulic conductivity values that exhibit reduced variability but are of lesser magnitude. Conversely, the USBR method, which relies on grain size analysis, offers a wider and higher range of estimations for hydraulic conductivity (Table 6). Additional research may be necessary to resolve the discrepancies and ascertain which approach more accurately reflects the actual hydraulic conductivity of the Ajali Sandstone within the designated research region (Tables 5, 6 and 7).

Table 5: Summary of results using Hazen 1982 empirical formula

S/N	d_{10}	d_{60}	u	porosity	$K = C(d_{10})$ m/s	Interpretation
Bed one	0.21	1.04	4.95	33%	4.41×10^{-4}	Moderately sorted
Bed two	0.19	0.55	2.89	40%	3.61×10^{-4}	Moderately sorted
Bed three	0.21	0.50	2.38	41%	4.41×10^{-4}	Moderately sorted
Bed four	0.23	0.51	2.21	42%	5.2×10^{-4}	Moderately sorted
Bed five	0.19	0.42	2.21	42%	3.61×10^{-4}	Moderately sorted
Minimum	0.19	0.42	0.21	33%	3.61×10^{-4}	Moderately sorted
Maximum	0.23	1.04	4.95	42%	4.41×10^{-4}	Moderately sorted
Mean	0.20	0.60	2.92	39.6	4.24×10^{-4}	Moderately sorted

Table 6: Summary of result using the USBR empirical formula

Sample	Graphic Mean	Skewness	Standard deviation (Sorting)	Hydraulic conductivity K (m/day)	Interpretation (after Folk,1974)
Bed one	28.93	−0.233	−0.806	1054.0	Moderately sorted
Bed two	28.45	−0.388	−0.382	180.86	Well sorted
Bed three	28.51	−1.639	−0.546	244.10	Moderately well sorted
Bed four	28.46	−0.427	−0.43	237.91	Well sorted
Bed five	28.53	−0.763	−0.687	186.17	Moderately well sorted

Table 7: Hydraulic conductivity result.

Samples	USBR Hydraulic conductivity (m/day)
Bed one	1054.0
Bed two	180.86
Bed three	244.10
Bed four	237.91
Bed five	186.17

According to a study conducted by Obasi et al. (2013), the Ajali Sandstone exhibits porosity values ranging from 20% to 26%, while its hydraulic conductivity values range from 136.9m/day to 916.837m/day. The observed porosity and hydraulic conductivity values suggest a high specific yield for the sandstone, which is a favorable characteristic for the provision of economically viable water resources. According to Aleke et al. (2018) estimated the porosity values of the Ajali sandy aquifer to range between 30.19% and 34.20% respectively. The range of fractional porosity values observed in this study ranged between 32% to 42%, indicating a good porosity and fall in line with aforementioned published work. Similarly, the tortuosity values exhibit a wide variation, ranging from 2.91 to 22.85, illustrating the degree of tortuous pathways present within the material. There is variation in the calculated geohydraulic parameters across the research area. The formation factor exhibits a range of values spanning from 0.28 to 15.29. Similarly, the hydraulic conductivity ranges from 1.21 to 66.54 m/day, significantly impacting the natural flow of water within the aquifer. Additionally, the tortuosity values encompass a range of 2.91 to 23.27. Although various studies have been conducted on the Ajali Formation, no research to determine hydraulic conductivity has been undertaken specifically on the Idah sheet within the Ajali Formation.

Conclusion

This study examined the hydraulic conductivity of Ajali Sandstone in Idah axis of the northern Anambra Basin. Thin section petrography and grain size analysis revealed monocrystalline, medium-to-coarse-grained subangular quartz. Iron-rich samples had an opaque matrix with Fe_2O_3 (70-75% quartz) and variable median composition of 65-85% quartz, 10-20% of feldspar, and 5-25% of others. Hazen's calculation provided a coefficient of uniformity (U) of 0.21 to 4.95 (average 2.92), and hydraulic conductivity of 3.61×10^{-4} to 4.41×10^{-4}m/s (average 4.24×10^{-4}m/s). The Ajali Sandstone resembles cracked sandstone, supported by Singhal and Gupta's (1999) results. Based on the USBR and Hazen methods, the sandstone was identified to be cross-bedded, moderate to poorly sorted. The average hydraulic conductivity was 28.576 m/day, ranging from 180.86 to 1054.00 m/day. While agreeing with established relations, methodological variances necessitated further study. This study has contributed to the development and management of groundwater resources in Idah and its environs in northern Anambra Basin.

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