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THE GEOLOGIC SETTING, PHYSICO-CHEMICAL CHARACTERISTICS AND UTILIZATION SCHEME OF SPRING WATER AT PATTI RIDGE, LOKOJA, CENTRAL NIGERIA

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ABSTRACT

Geological mapping of the lithostratigraphic units of the Patti Ridge at Lokoja indicates that ground water issues out as spring water at the contact between sandstone beds and the underlying siltstone/claystone intercalation of the Patti Formation in the Lokoja sub-basin of the Bida Basin. Discharge from the spring water locations is perennial but varies from 2 *l/s* during the dry season to 6 *l/s* during the rainy season. The Patti spring water is tasteless and without odour. The colour averages 10 on the platinium-cobalt scale while the average turbidity (NTU) is 3. The average specific conductivity of the spring water is 5 µS/cm while the pH is in the range 6.9 to 7.2. The total dissolved solids and total suspended solid contents of the spring averages 45 mg/l, and 40 mg/l, respectively. NO_3 and SO_4 contents in the spring water averages 4.6 mg/l and 16.3 mg/l, respectively. These parameters indicate that the Patti spring is portable. In addition, a three stage water supply scheme that can provide at least 1000 m^3 of water daily to the metropolis has been developed to utilize water discharge from the spring. It comprises of a collection reservoir, filtration well and storage and treatment tank that uses gravity only. The exclusion of the use of electricity and submersible pumps in the scheme makes it easy to maintain and suitable also for a rural setting.

KEYWORDS: Lokoja Formation, Patti Formation, Spring Water

INTRODUCTION

Patti Ridge is the southern part of the Bida Basin, Nigeria. The Bida Basin (also known as the Middle Niger Basin) is a northwest-southeast trending depression perpendicular to the main axis of the Benue Trough (Fig. 1). The evolution of the Basin has been described as a rift bounded tensional structure produced by faulting (Kogbe *et al.*, 1981; Braide, 1992). The Middle Niger Basin is subdivided into the Upper and the Lower Niger Basins (Offodile, 2002). The Lower Niger Basin is also known as the Lokoja or Southern sub-basin of the Bida Basin (Kogbe *et al.*, 1981). Olugbemiro and Nwajide (1997), and Braide (1992) and Ojo and Akande (2003) have interpreted the sediments of the Lokoja sub-basin as continental deposits.

According to the Kogi State Ministry of Water Resources (oral interview, 2007), the population of Lokoja Metropolis has increased from less than 5,000 during the colonial period to over 300,000 as at the 2007 census. This population explosion has led to increased demand for portable water and exploitation of surface and ground water sources leading to the drilling of several bore holes in the metropolis by both government and private agencies. In 1999, an exploration programme led to the discovery of spring water on the northern escarpment of the Patti Ridge at a site near the Kogi State Polytechnic, Lokoja. The spring water was developed and reticulated to the Polytechnic campus to supplement the water needs of the staff and students.

The present work focuses on the determination of the discharge rates, portability and development of spring water located at the southern escarpment of the Patti ridge. The work provides description of lithostratigraphic associations, physical and chemical characteristics, and a utilization scheme to be used in harvesting the spring water.

PHYSIOGRAPHY

Patti Ridge lies between latitudes N 7° 48' and N 7° 51' 2" and longitudes E 6° 41' 15" and E 6° 45' (Fig. 1). The Patti Ridge covers a land area of 25 km^2. It lies within the tropics and has an annual rainfall of between 1250 and 1500mm (Iloeje, 1981). The Ridge outcrops with steep sided slope and flat top (as a mesa). It rises from a point of 96 m to 405 m above sea level and serves to delineate the northern limit of a catchment basin of some tributaries to river Niger around Lokoja. The active source of the spring water is located at latitude N 7° 49' 06.8" and longitude E 6° 43' 22" at altitude 365m above sea level.

STRATIGRAPHIC SETTING

The oldest of the sedimentary rocks in the Lokoja sub-basin is the Lokoja Formation which nonconformably overlies the Basement Complex. It is overlaid by the Patti Formation which is capped by the Agbaja Ironstone (Adeleye and Dessauvagie, 1976; Ojo and Akande, 2003). The rocks in the formations have been correlated with mappable stratigraphic units of the northern Bida Basin, all of which are Campanian to Maastrichtian in age (Adeleye 1973, Offodile 2002). Ojo and Akande (2003) described the sediments of the Lokoja Formation as generally poorly sorted and composed mainly of quartz and feldspar, and therefore texturally and mineralogically immature. The Agbaja Ironstone consists of the oolitic, concretionary and massive varieties (Abimbola *et al.*, 1999).

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The dominant lithostratigraphic units at Patti Ridge are the Lokoja and the Patti Formations. The Lokoja Formation consists of facies of conglomerates and sandstones while the Patti Formation consists of repeated sequence of coarse to medium grained sandstone with intercalations of siltstone and claystone (Ojo and Akande, 2003). The Ridge therefore consists essentially of aquiferous horizons defined by conglomerate and sandstone members of the Lokoja and Patti Formations. The siltstone / claystone intercalations, however, are essentially non-permeable and, acting as acquicludes, behave as barriers, both laterally and vertically such that ground water that collects at this interface flows from the aquifer to the ground surface as spring water.

The active source (eyelet) of the spring water (Plate 1) is at altitude 365m at the contact between the medium grained sandstone sub facies and the underlying siltstone/claystone of the Patti Formation (Fig. 2).

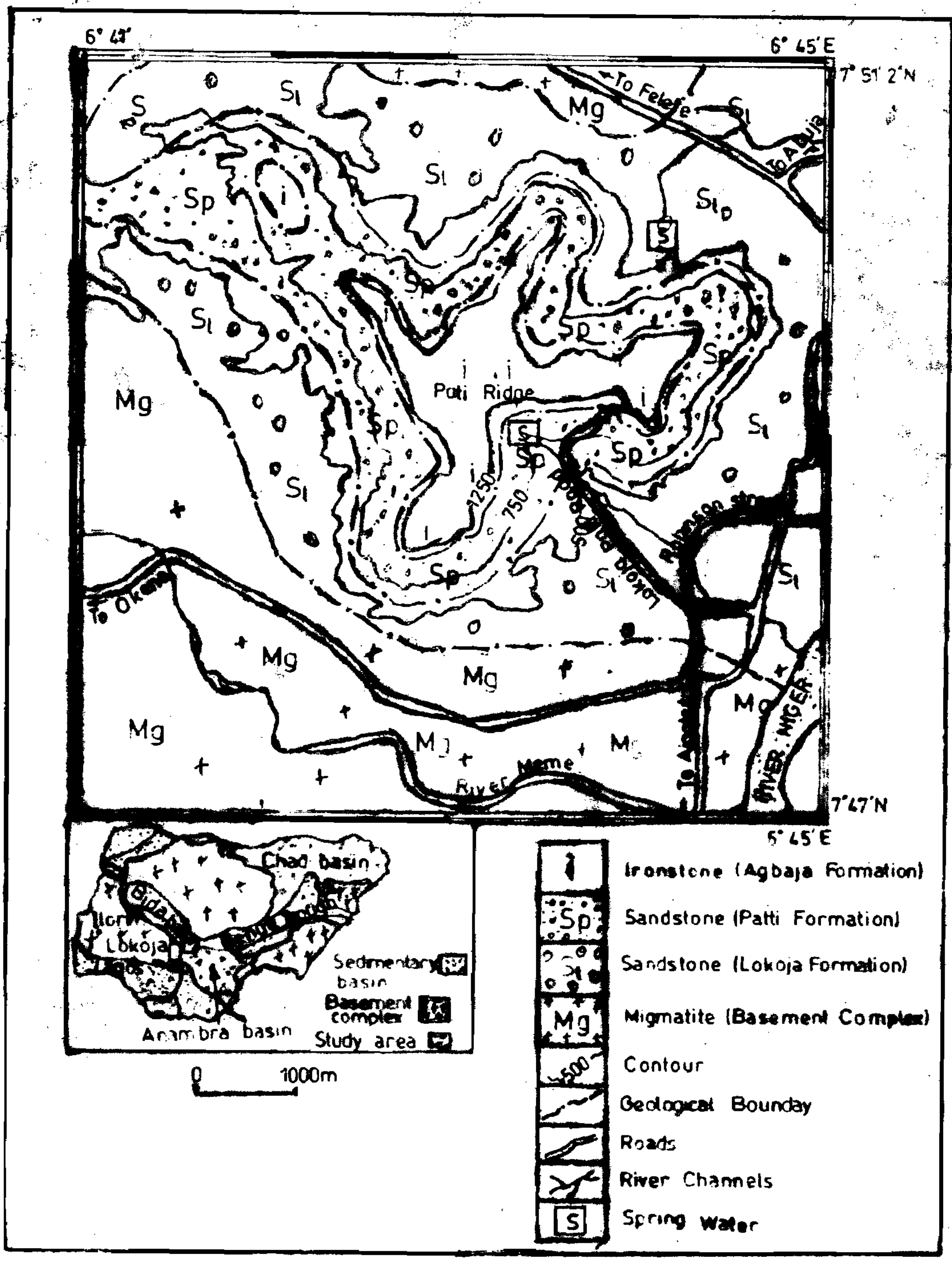

Figure 1: Geologic map of the Patti Ridge. Insert: map of Nigeria showing location of study area in relation to the sedimentary basins of Nigeria.

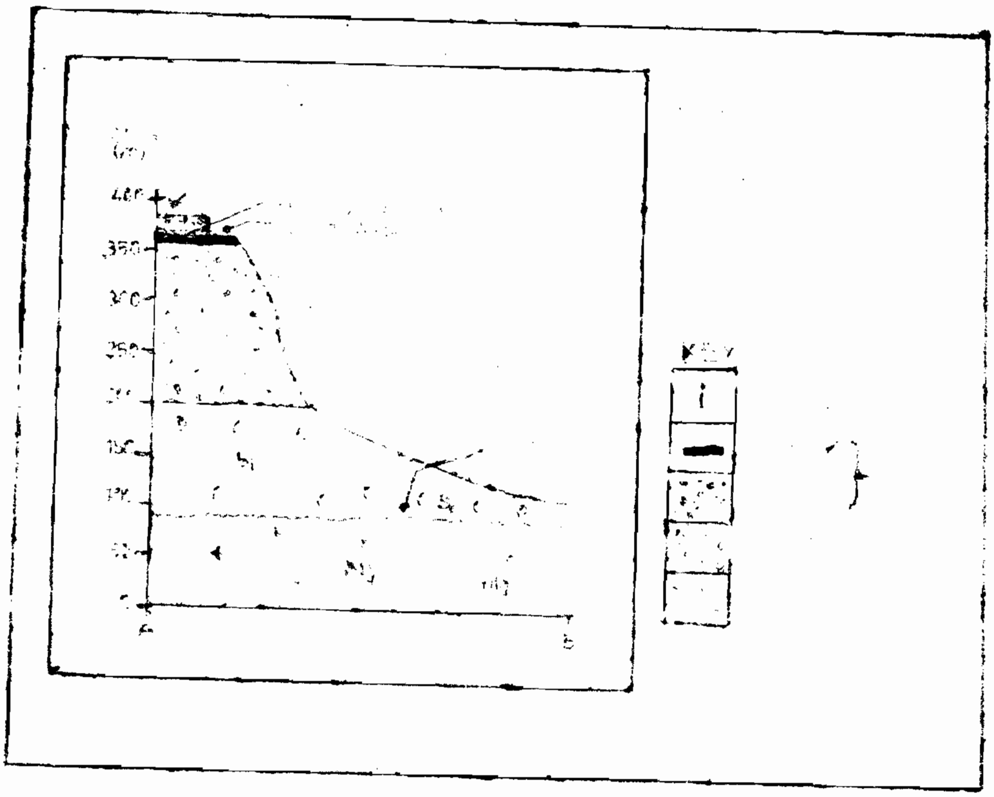

Figure 2. Stratigraphic section A-B across the Patti Ridge showing the location of spring water.

METHODS OF STUDY

Exposed lithostratigraphic units of the Lokoja sub-basin on southern escarpment of the Patti ridge were studied (Fig. 1) to situate the active source (eyelet) of the spring discharging from the ridge. Discharge rates were measured using stopwatch and a large bowl. The temperature of the spring water was taken using a thermometer. The physical characteristics such as colour, pH, conductivity, turbidity, total suspended solids, and total dissolved solids of the spring water were measured using HANA Model HI 83200 multi-parameter ion specific meter while the titration method was used to determine the NO_3 and SO_4 contents of the spring water. A small scale water collection and supply scheme has been designed to harvest the large volume of spring water discharged from the Patti Ridge.

Plate 1: A spring issuing out from sandstone of the Patti Formation at the Patti Ridge

DISCUSSION OF RESULTS

Physico-chemical Characteristics of the Patti Spring Water

The drainage area of the spring is moderately large. It flows rapidly downhill with a velocity of 0.5 m/s in the south-west direction into river Niger. Average discharge rate (during the dry season) is 2 litres per second. This however increases to 6 litres per second during the wet season (Table 1). The flow type, based on Reynolds's number, is transitional at the source. The temperature of the spring is 27 °C.

The Patti spring water is tasteless and without odour. The colour averages 10 on the platinium-cobalt scale while the average turbidity (NTU) is 3. The average specific conductivity of the spring water is 5 µS/cm while the pH is 6.9-7.2. The pH value indicates that the presence of carbonates in the solution is unlikely. Carbonates usually occur in solution at pH of 8.2 and above (Oteze, 1991). NO_3 and SO_4 contents are 4.6 mg/l and 16.3 mg/l, respectively. The total dissolved solids and total suspended solid contents of the spring averages 45 mg/l, and 40 mg/l, respectively. These values are all below the prescribed World Health Organization's highest desired level of concentrations for drinking water. The Patti spring is therefore portable and safe for domestic uses.

Table 1: Some physico-chemical Parameters of Spring Water at Patti

Parameter	Concentration level			WHO*** Maximum Permissible limit
	Dry season*	Wet season**	Average	
Discharge rate l/s	2	6	4	
Colour (Platinium cobalt scale)	9.5	10	9.75	15
Turbidity (NTU)	3	3	3	<5
pH	6.9	7.2	7.1	6.5-8.5
Total Dissolved Solids mg/l	40	50	45	500
Total Suspended Solids mg/l	30	50	40	Nil
Conductivity µS/cm	4.9	5.0	5.0	Nil
NO_3	4.5	4.6	4.6	50-70
SO_4	12.5	19.2	16.3	50

* Average of 5 readings taken in March, 2008
** Average of 6 readings taken in July, 2008
*** World Health Organization (WHO, 1993)

Spring Development

According to Skinner (2003), it is much better to find a source that provides naturally pure water and then protect it from pollution than to treat water from a polluted source. The location of the spring water at altitude 365 m above sea level at the southern escarpment of the Patti Ridge at a place that is not within easy reach of the dwellers in Lokoja Metropolis naturally protects the spring water from pollution. Since the spring water eyelet is at high altitude of 360 m above the sea level compared to the generally undulating plain of Lokoja Metropolis which is 90 to 120m above sea level, gravity rather than submersible pumps and the attendant electricity demands, is expected to play an important role in the water supply scheme to be developed for this spring water.

Given the above, a three-stage water supply development scheme that uses an underground collection reservoir, a filtration well, and a surface reservoir tank from which reticulation is made to the end users is here proposed (Fig. 3). All developments are to be done within 100 m in the vicinity of the spring and between altitudes 360 m and 200 m above the sea level.

The Collection Reservoir: The collection reservoir should be developed at not more than 10 m distance from the point of spring water discharge to avoid pollution of the spring water before collection. It should be built of concrete strengthened with reinforced bars or wires and made water tight. According to Skinner (2003), the roof of any underground tank should not be less than 300 mm above the ground level, to prevent the danger of surface water running into it. The outlet of the tank should not be less than 100 mm above the bottom of the tank to allow the silt that may have accompanied the intake settle to the bottom of the tank and not be part of the supply. At the bottom of the tank there should be a drain pipe with a locked valve that can be used to clean the tank at least once a year. Given the slope of the area, the reservoir should be developed in such a manner as to provide steps in an excavation outside the tank to give access to the drain pipe and a tap at the bottom. The reservoir should be built to a capacity of at least 80 m³ of water (Fig. 3).

The Filtration Well: The filtration well should be an underground well that is filled with alternating coarse and fine sand as the filtering medium. The filtration well should be built of concrete whose walls are made to be water tight. A drain pipe should be attached to the bottom of the well to be used in regulating flow. Slow rate of filtration (e.g. 0.5-4 $m^3/m^2/hr$) is encouraged because this is favourable to remove virtually all bacteria and other pathogenic organisms. It is recommended that the sand filter be cleaned at the end of every season and that the top layer of coarse sand be replaced at least after every two years.

The Storage Tank: This surface or overhead tank should be built taking into consideration the discharge from the filtration wells or tubes and the demand. It is recommended that chemical treatment may be applied to finally remove pathogens that may have made their ways into the tank. Tank capacity should be 120 m³ or more.

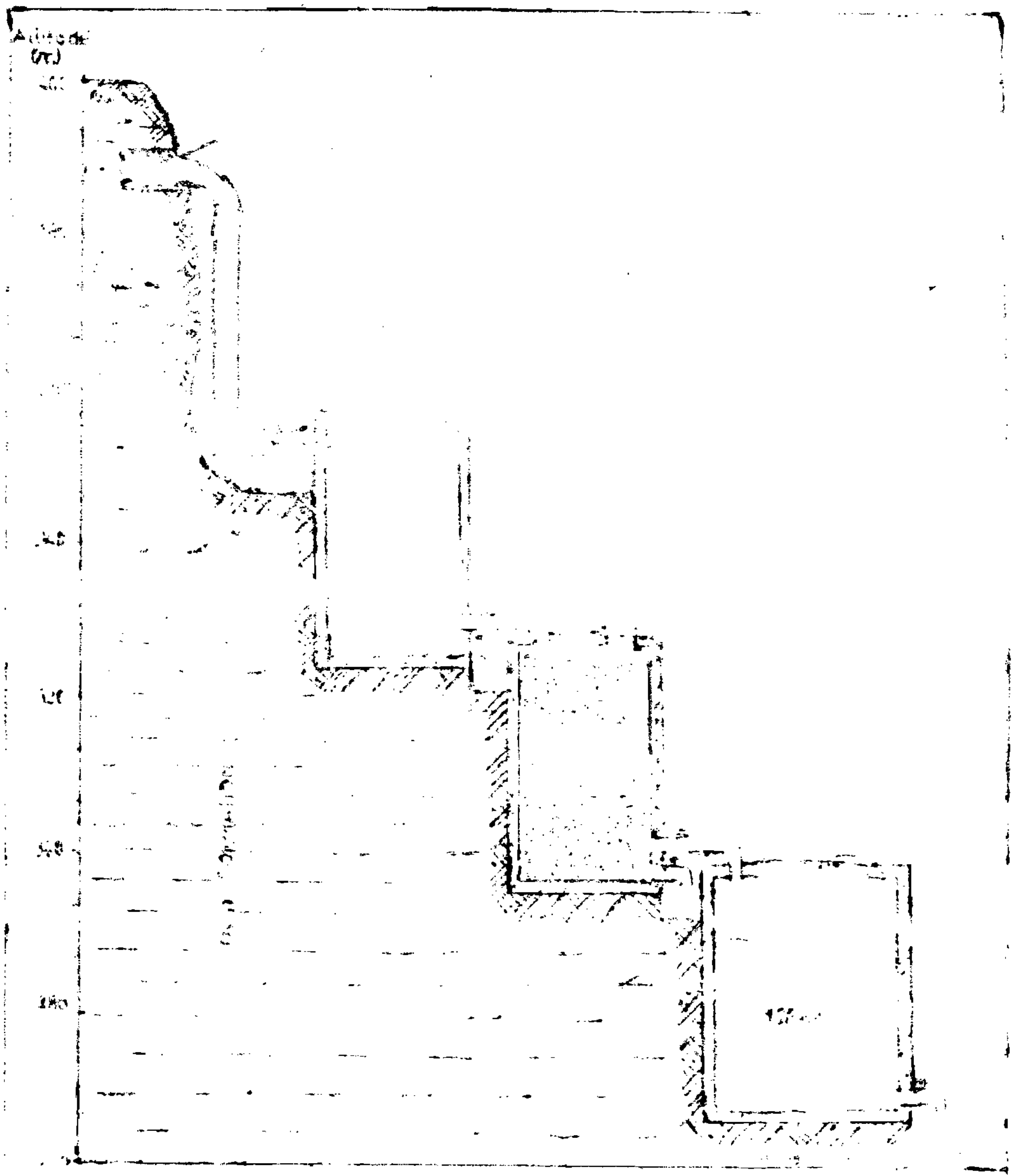

Figure 3: The design of the spring water development at Patti, Lokoja.

CONCLUSION

Geological mapping of the lithostratigraphic units of the Patti Ridge at Lokoja indicates that the Ridge consists of alternating sequence of conglomerate, sandstone and siltstone/claystone horizons. The sediments belong to the Lokoja Formation which nonconformably overlies the basement complex, the Patti Formation, and the Agbaja Formation, all of which are Campanian to Maastrichtian in age. The Patti spring water has one active source (eyelet) located at a high altitude on the southern escarpment of the Patti Ridge. Spring water discharge is 2 *l*/s during the dry season and 6 *l*/s during the rainy season. This means that water discharge from the spring water can provide at least 1000 m³ of water daily to the Lokoja Metropolis. The spring is tasteless and has no odour. The pH, turbidity, TDS, TSS, conductivity, NO_3 and SO_4 contents of the spring water are all within the World Health Organization's permissible limit for drinking water. The Patti spring water is therefore portable and fit for domestic consumption.

A water development plan has been developed using a gravity-driven scheme that involves the construction of each of a collection, filtration and storage tank. This scheme is three times bigger in capacity when compared with that developed at the northern escarpment of the Patti Ridge with a minimum daily requirement of 345.6 m^3. Also, this scheme does not require the use of electricity and submersible pumps; water collection, filtration, and distribution are by gravity only, unlike the Polytechnic scheme which uses electricity and two submersible pumps. It is therefore, simple to construct and relatively cheap to maintain.

A detailed chemical analysis of all the surface water sources in the Lokoja metropolis is recommended to monitor the level of pollution of the spring water as it passes through the metropolis.

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