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Full Length Research Paper

Hydrocarbon trapping mechanism and petrophysical analysis of Afam field, offshore Nigeria

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The structural trapping mechanism and petrophysical attributes of Afam field, offshore Niger Delta was evaluated using 3D seismic reflection data and composite well logs data. The structure maps and seismic sections show that the anticlinal structure at the centre of the field, which is tied to the crest of the rollover structure assisted by faults, is the principal structure responsible for the hydrocarbon entrapment in the field. Distinctive fault closures are the dominant structural plays in the field. Structural highs, fault assisted closures comprising two-way closure and four-way dip closed structures are evident on the depth structure maps. Petrophysical analysis of four mapped reservoir sand horizons quantitatively revealed water saturation ranging from 3.07 to 12.02% in Well1 and 7.25 to 19.32% in Well 5; hydrocarbon saturation with range 87.98 to 96.93% (well 1), 80.68 to 92.75% (well 5). The porosity and permeability values of the reservoirs within the field proved them to be quite prolific with the porosity ranging from 24.5 to 31% (well 1), 21.25 to 28.25% (well 5) and permeability range of 2606.91 to 11,777.71 mD (well 1), 1050 to 6502.20 mD (well 5).

Key words: Niger Delta, trapping mechanism, petrophysical analysis, structural highs, fault assisted closures.

INTRODUCTION

The ubiquitous economic constraints of developing offshore fields demand assessment of essential reservoir characteristics at the earliest possible opportunity. Characterization of the reservoir sands through petrophysical logs interpretation is quite useful and essential tool for selecting, planning and implementing operationally sound supplementary schemes. Integration of the seismic reflection data and well logs suites are commonly used in exploration for reservoir sands correlation, isopach and structural mappings. They are also useful for the estimation of certain physical properties of the subsurface geology such as the porosity, permeability, litho-facie characterization and possibly pore geometry. Recovery from producing fields on the other hand can be enhanced significantly through the more gradual process of production monitoring in combination with detailed reservoir modelling and simulations. These efforts continued from the early development stage until a reservoir has reached its economic limits. The integration of geophysical, petrophysical and reservoir engineering data is the key to designing realistic dynamic reservoir models. In the early stage of field appraisal, the emphasis is on detailed seismic analysis combined with geological modelling with

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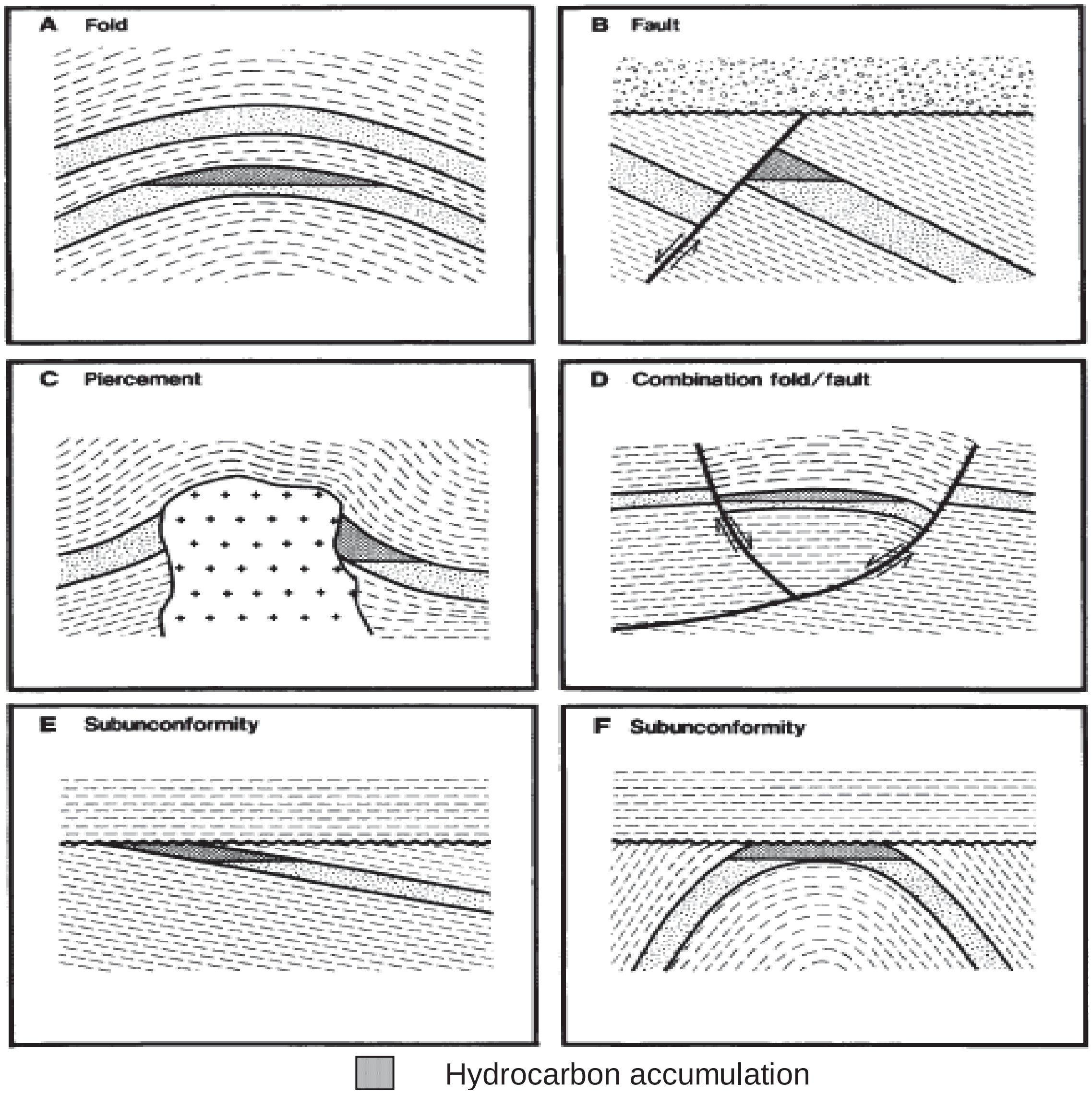

Figure 1. Major categories of structural traps: (A) Fold, (B) Fault, (C) Piercement, (D) Combination Fold-Fault, (E) and (F) Subunconformities. The situation in (E), that is, pinchout is usually excluded from structural category (Modified after Biddle and Wielchowsky, 1994).

the aim of delineating structures, faulting and reservoir architecture.

Evaluation of the trapping styles is fundamental in the analysis of a prospect and an essential part in any successful oil and gas exploration program or resource assessment program. A trap is any geometrical arrangement of rock that allows the significant accumulation of oil or gas or both in the subsurface (North, 1985). For a trap to be effective, there are several factors that must be in place including adequate reservoir rocks, seals and timing of the trap-forming process in relation to the hydrocarbon migration. The variability of these factors has led to many different trap classifications by several authors (Clapp, 1929; Levorsen, 1967; Perrodon, 1983; North, 1985). Structural traps similar to those localised in Niger Delta petroleum province are products of syn-to-post depositional deformation of strata into geometrical structure that permits the accumulation of hydrocarbons in the subsurface. Varieties of schemes have been used to propose subdivisions of structural traps (Figure 1). Clapp (1929) distinguished between anticlinal, synclinal, homoclinal, quaquaversal and fault-dominated traps. Harding and Lowell (1979) used the concept of structural styles, emphasising basement involvement or non-involvement, inferred deformational force and mode of tectonics transport. Perrodon (1983) categorized structural traps into those caused by folding, faulting, fracturing, intrusion and combinations of these

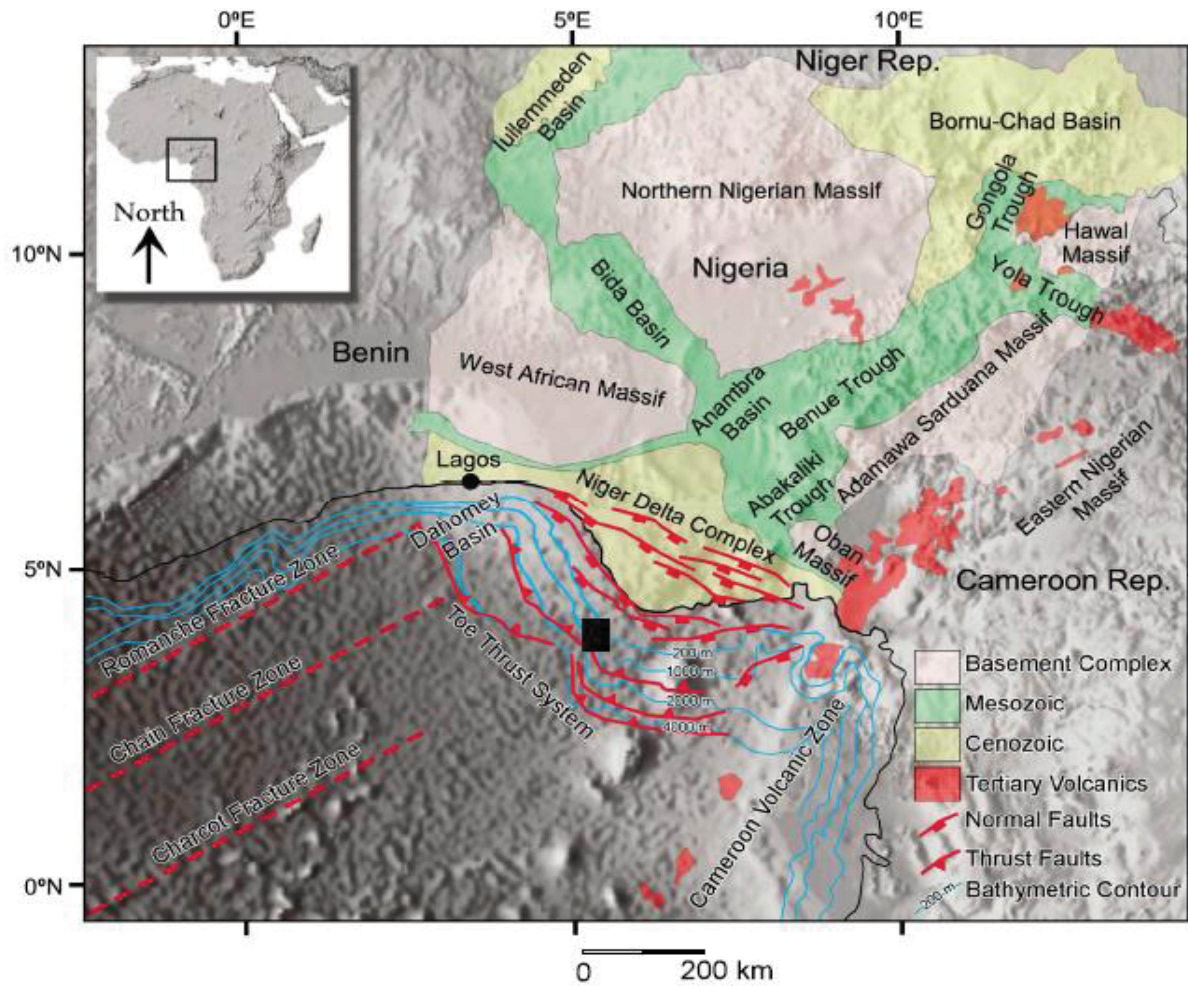

Figure 2. Map of Niger Delta showing the study area.

processes. North (1985), focusing on fold-dominated traps, distinguished between the buckle or thrust-fold, bending fold and immobile convexity traps. Most of the oil field structures and associated traps styles in the Niger Delta have been sufficiently discussed by Weber and Dakoru (1975), Doust and Omatsola (1990), Ojo (1996), Opara and Onuoha (2009) and Reijers (2011).

The study area is offshore Niger Delta and the research is carried out to determine the trapping style and petrophysical attributes evaluation in this field. The abundant evidence of structural traps, good quality reservoir sands and hydrocarbon indicators make the area particularly attractive exploration target. The trapping styles in the field include anticlinal dip closures, upthrown fault (footwall closures) and downthrown fault (hanging wall closures).

Location and geological setting of the field

Afam field is situated in the offshore of the Cenozoic Niger Delta (Figure 2). The deposits in Niger Delta are Tertiary age siliciclastic which are attributed to three lithostratigraphic formations, namely Akata, Agbada and Benin Formations. The Akata Formation (marine shale) is characterized by uniform pro-delta shale, which generally is dark grey and medium hard with flora fossils in its upper part. The Akata Formation likely extends to the basement rock. Overlying this formation is the Agbada Formation which is over 10,000 ft thick and range from Eocene in the north to Pliocene in the south and recent in the delta surface. Agbada Formation forms paralic sequence comprises of the oil and gas reservoirs of the Niger Delta, and is composed of the intercalations of sandstone and shale bedsets representing the delta front, distributaries channel and the deltaic plain. The increasing quantities of the sandstone content from the lower part to the upper part connote the seaward advance of the Niger Delta over some periods of geologic time. The continental plain sand of Benin Formation consists of massive, highly porous sandstones with a few minor shale interbeds indicating an alluvial depositional

Table 1. The available well logs for the research and their principle uses.

Well log	Log type	Well 1	Well 2	Well 5
Lithology/correlation logs	GR	**	**	**
	SP	**	**	**
Resistivity logs	Laterolog	--	--	--
	Lateral	--	--	--
	Short normal	--	--	--
	Long normal	**	**	**
	Spherical focussed	--	--	--
	Medium induction	--	--	--
	Deep induction	--	--	--
Porosity log	Sonic	**	--	--
	Neutron	**	--	**
	Density	--	--	**
Caliper		--	--	**

****** Available; --, not available.

environment. Though minor oil shows have been reported in Benin Formation, the formation is generally fresh water bearing and it is the main source of potable groundwater in the Niger Delta area.

The most striking structural styles of the Cenozoic Niger Delta complex are the syn-sedimentary structures which deform the delta beneath the Benin continental sand facie. The structures, regarded as the products of gravity sliding during the deltaic sedimentation, are polygenic in nature and their complexity increases generally in down delta direction (Merki, 1972). These syn-sedimentary structures are called growth faults which are predominantly trending NE to SW and NW to SE (Hosper, 1971). Rollover anticlines, shale ridges and diapers resulting from the upheaval ridges are the associated structures to the growth faults. The predominant structural trapping mechanisms for oil and gas within the study area are roll over anticlines and fault closures. The stratigraphic traps below unconformity surfaces include the paleo-channel fills, crestal accumulations, sand pinch-outs and erosional truncations, nonetheless above the unconformity surfaces are incised valley and lowstand fans (Orife and Avbovbo, 1981).

METHODOLOGY

Seismic and well logs data

The data used for this study are 3D seismic sections, composite geophysical well log suites and checkshot (for time-to-depth conversion). The 3D seismic reflection data comprise 637 inlines with interval of 25 m and 595 crosslines with interval of 25 m which covers an area of 102 km^2 .The number of samples per trace is 1251 with the sample interval of 4 mS. The reflection quality of the seismic data was improved by applying structural smoothening volume attributes to suppress the noise so that faults and stratigraphic picks for the horizons are easily recognizable on the time section. The geophysical well logs (Table 1) for wells 1, 2 and 5 were available for this study (Figure 3); however, only wells 1 and 5 were used for the quantification of petrophysical attributes as porosity logs for well 2 were not available.

Horizons and fault mapping

The gamma ray and resistivity logs were used for lithologic identification, well correlation, and reservoirs zonation. The 3D seismic reflection data was also utilized to study the hydrocarbon trapping styles within the entire field through identification and mapping of Faults and horizons at step intersection plane of 10 across both the inlines and crosslines of the seismic sections. Four (4) hydrocarbon bearing zones R1, R2, R3 and R4 were identified and correlated (Figure 4). The overlay of the four (4) horizons with the drilled wells is displays in Figure 5. The sand units in Niger Delta are regarded as the reservoir units because shale formations are not porous enough to retain and release fluid. Therefore in the reservoir sand units delineated, differentiation between reservoir fluids (hydrocarbon and water) was done using the resistivity log (Schlumberger, 1989). The tops of the identified reservoirs across the wells were tied to the seismic sections for identification and mapping of horizons using the checkshot data from the wells (Figure 5). The horizons were mapped/tracked on these seismic reflections, mapping both inline and crossline seismic sections across the entire field to produce the time structure (isochrones) maps. The derived velocity information from the checkshot data was used to generate the depth structure maps from the time structure maps.

Petrophysical evaluation

Different mathematical models and relations were employed for quantitative interpretation of the well logs to estimate petrophysical parameters. Shale volume estimation (V_{sh}) was calculated using

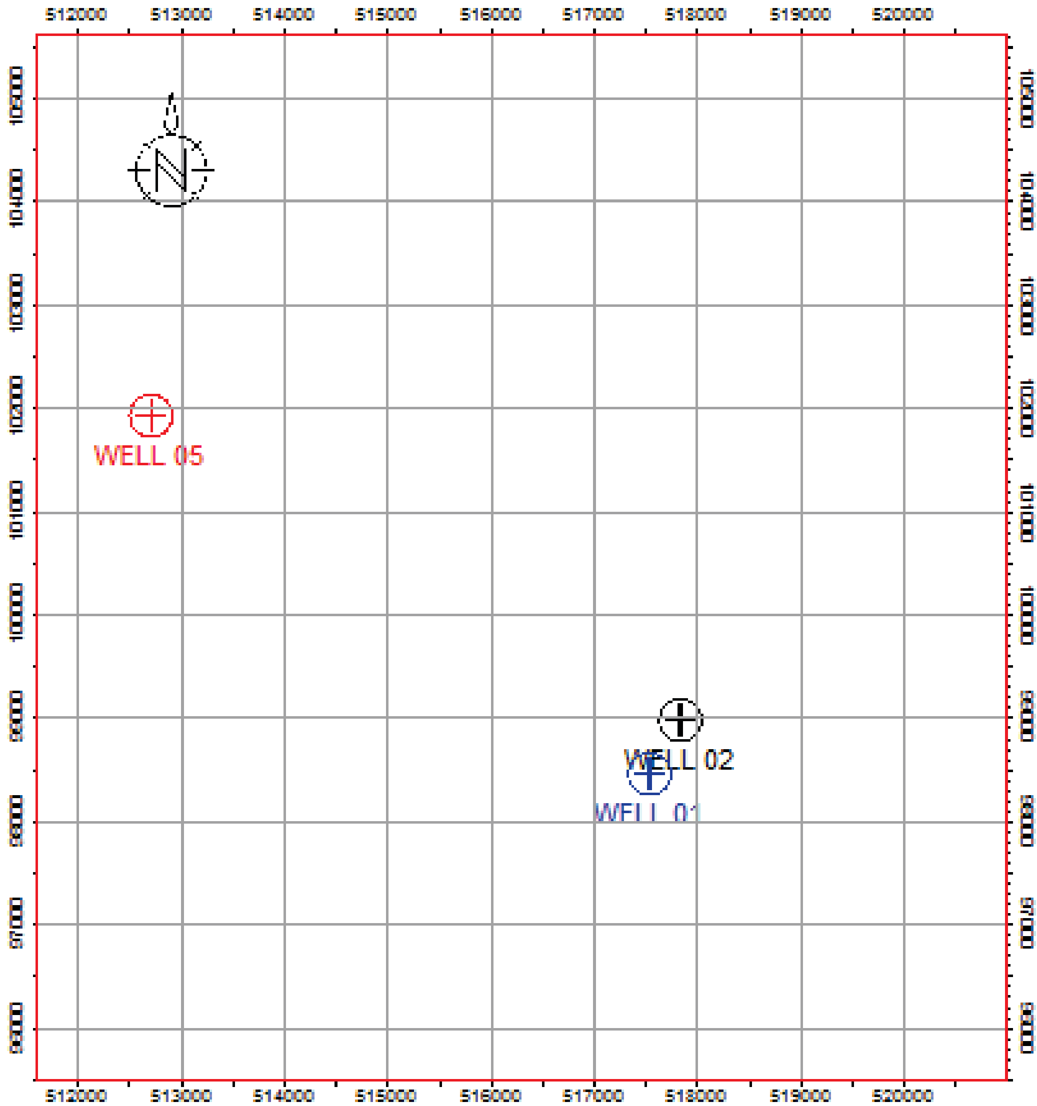

Figure 3. Basemap showing the locations of wells.

the Larionov's (1969) relation for tertiary rocks after gamma ray index I_{GR} (Schlumberger, 1974) was determined as follows:

$$V_{sh} = 0.083\left[2^{(3.7*I_{GR})} - 1.0\right] \tag{1}$$

Where:

$$I_{GR} = \frac{GR_{\log} - GR_{\min}}{GR_{\max} - GR_{\min}} \tag{2}$$

Porosity values for the hydrocarbon reservoirs were estimated. The amount of pore spaces or voids in the rock is a measure of the amount of fluid (notably, water, oil or gas) the rock will hold. The porosity log utilized was the bulk density log which records only the bulk density of the formation; therefore, density porosity was estimated using Asquith equation (Asquith, 2004) for the intervals of interest (hydrocarbon bearing intervals). The porosity from the sonic log is given as:

$$\phi = \frac{\Delta t - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}} \tag{3}$$

where ϕ is the porosity, Δt is the log reading in microseconds/foot ($\mu s/ft$), Δt_f is the transit time for liquid filling the pore and Δt_{ma} is the transit time for the rock type matrix comprising the formation. The porosity derived from the density log is given as:

$$\phi_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \tag{4}$$

where ϕ_D is the apparent density porosity, ρ_{ma} is the matrix density, ρ_b is the bulk density and ρ_f is the fluid density. The

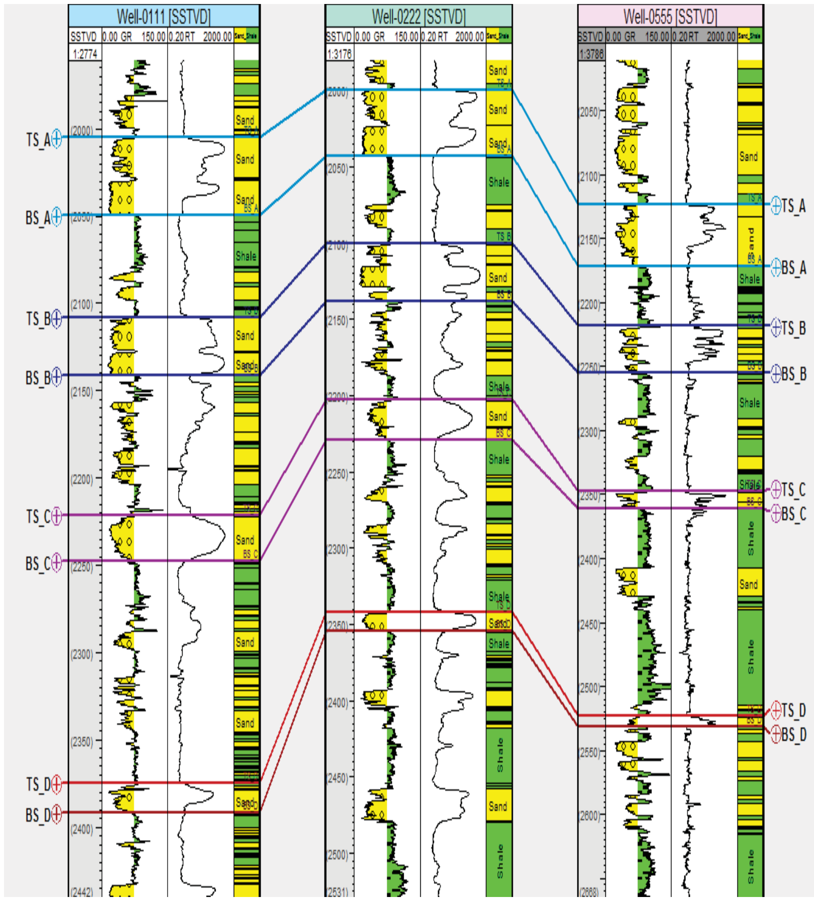

Figure 4. Well section window showing the reservoir zonation and correlation.

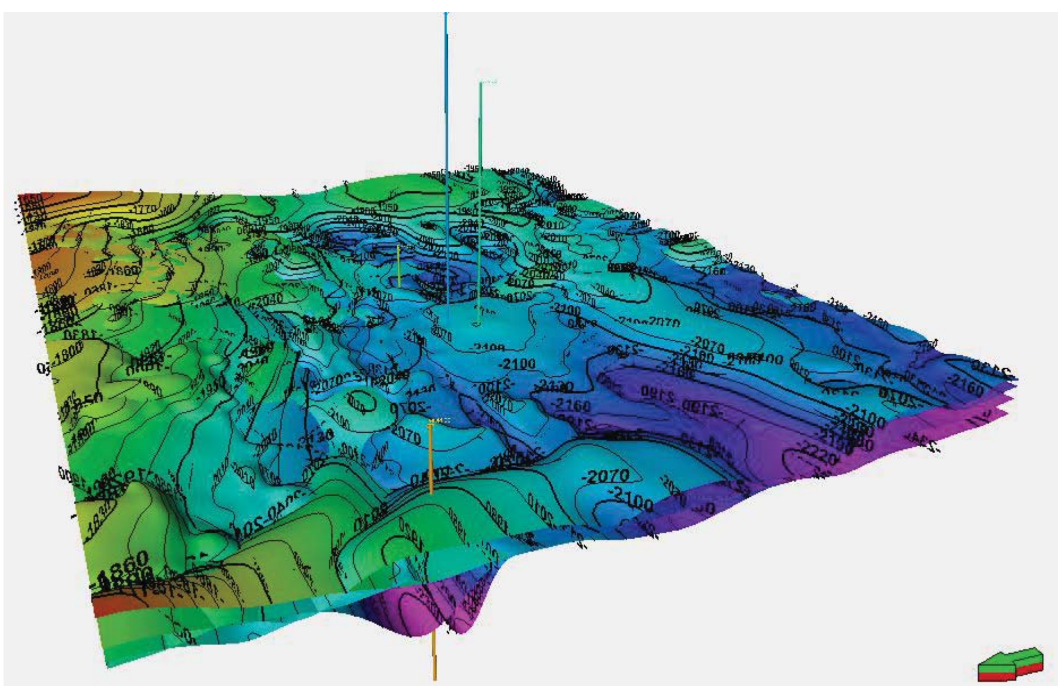

Figure 5. Overlay of the four (4) time structure maps and the wells.

effective porosity was estimated using the relation:

$$\phi_{eff} = (1 - V_{sh}) \times \phi \quad (5)$$

where V_{sh} is the volume of shale and ϕ_{eff} is the effective porosity. The formation factor is calculated as:

$$F = \frac{R_o}{R_w} \quad (6)$$

where F is the formation resistivity factor or formation factor, R_o is the resistivity of the rock when water saturation is 1 and R_w is the formation water resistivity. The formation factor can also be calculated as:

$$F = \frac{a}{\phi^m} \quad (7)$$

where F is the formation factor, a is the tortuosity factor, ϕ is the porosity and m is the cementation exponent or factor. To calculate water saturation, S_w of uninvaded zone, the method used requires a water resistivity R_w value at formation temperature calculated from the porosity and resistivity logs within clean water zone using Equation (8). The water saturation was calculated using Equation (9) obtained from Archie's method:

$$R_w = \frac{\phi^m R_o}{a} \quad (8)$$

$$S_w = \sqrt{\frac{a \times R_w}{\theta^m \times R_t}} \quad (9)$$

where S_w is the water saturation and R_t is the true formation resistivity. Hydrocarbon Saturation S_h is the percentage of pore volume in a formation occupied by hydrocarbon. It can be determined by subtracting the value obtained for water saturation from 100% as:

$$S_h = (100 - S_w)\% \quad (10)$$

Bulk volume of water was evaluated using Equation (11). It shows whether a formation is at irreducible water saturation or not. For instance, if the estimated BVW values at several depths within a formation are coherent, then the zone is considered homogeneous and is at irreducible water saturation. Morris and Briggs (1967) opined that production from such zone should be water free.

$$BVW = S_w \times \phi \quad (11)$$

Permeability (K), the property of a rock to transmit fluids was estimated for each reservoirs using Timur's model expressed as:

$$K = \frac{a\phi^b}{S_{wirr}^2} \quad (12)$$

Where ϕ is the porosity, S_{wirr} is the irreducible water saturation, a is given as 0.136 and b is given as 4.4, if the values of the porosity and irreducible water saturation are in percentage.

RESULTS AND DISCUSSION

Structures and hydrocarbon prospects

The well-to-seismic match is shown in Figure 6. Figure 6 shows the four (4) hydrocarbon bearing reservoirs (R1, R2, R3, and R4) that were delineated and three (3) principal major faults (F_1, F_2 and F_4) that were mapped along with other intermediate faults (F_3 and F_6) and minor faults (F_7 and F_8) using the variance edge structural seismic attributes (Figure 7). The structure maps and seismic sections revealed that the probable principal structure responsible for the hydrocarbon entrapment in the field is the anticlinal structure at the centre of the field which is tied to the crest of the rollover structure assisted by faults. The depth structure maps (Figures 13 to 16) were generated from the time structure maps (Figures 8 to 11) using the time-depth conversion curve (Figure 12) and revealed three (3) major Faults. The field is characteristically associated with large faults closures ("X" and "Y") against a series of down-to-south growth faults. The main body of the field is dissected by several intermediate faults which are majorly synthetic and antithetic faults. F1, F_2 and F_4 are thought to be the growth faults while F_7 and F_8 are both interpreted to be antithetic and synthetic faults respectively. Structural highs like diapiric structures (Figure 6) are observed in the field which perhaps constitute the structural traps for hydrocarbon.

Petrophysical analysis

The wireline logs expedite the evaluation of the field's petrophysical attributes. The lithologic identification along with well logs correlation was achieved using gamma ray (GR) log (Figure 4) and the major lithologies encountered in the study area were basically shale and sand, some of which occur as interbeds. It was noted that the shale units serves as seal to the reservoir sand units. Table 2 shows details of the four (4) stratigraphic zones correlated across Wells 01, 02 and 05. Lithological characterization for each identified reservoir comprising their gross thickness, net-gross ratio and shale streak across Wells 01 and 02 are presented in Tables 3 and 4. The reservoir sand units were evaluated quantitatively for petrophysical properties such as porosity, water saturation, shale volume, hydrocarbon saturation and permeability. The summary of these estimated attributes towards formation evaluation analysis are presented in Tables 5 and 6. Porosity values for the entire mapped surface are very good according to Levorsen (1967) with

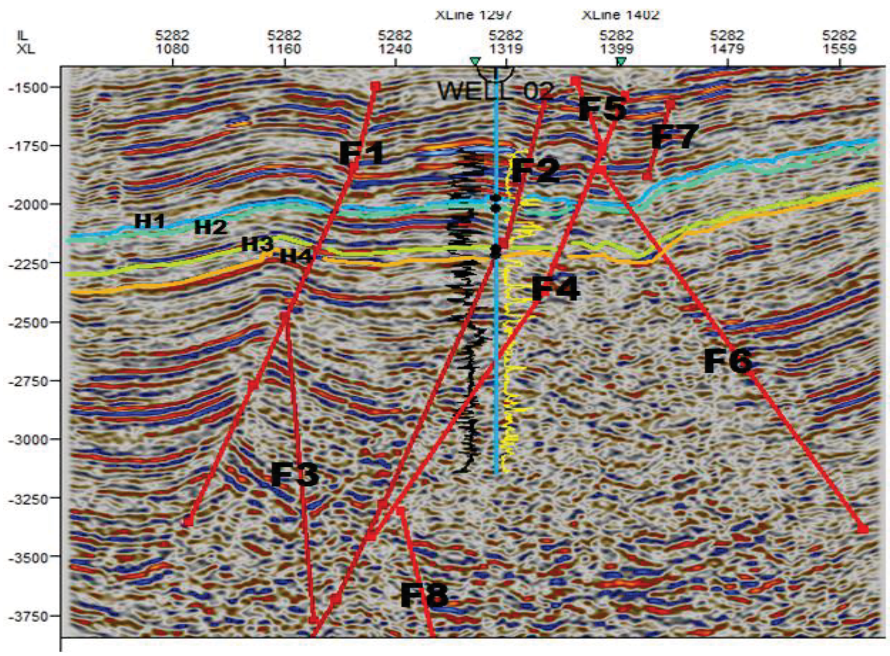

Figure 6. Well - to - seismic tie showing mapped faults and horizons.

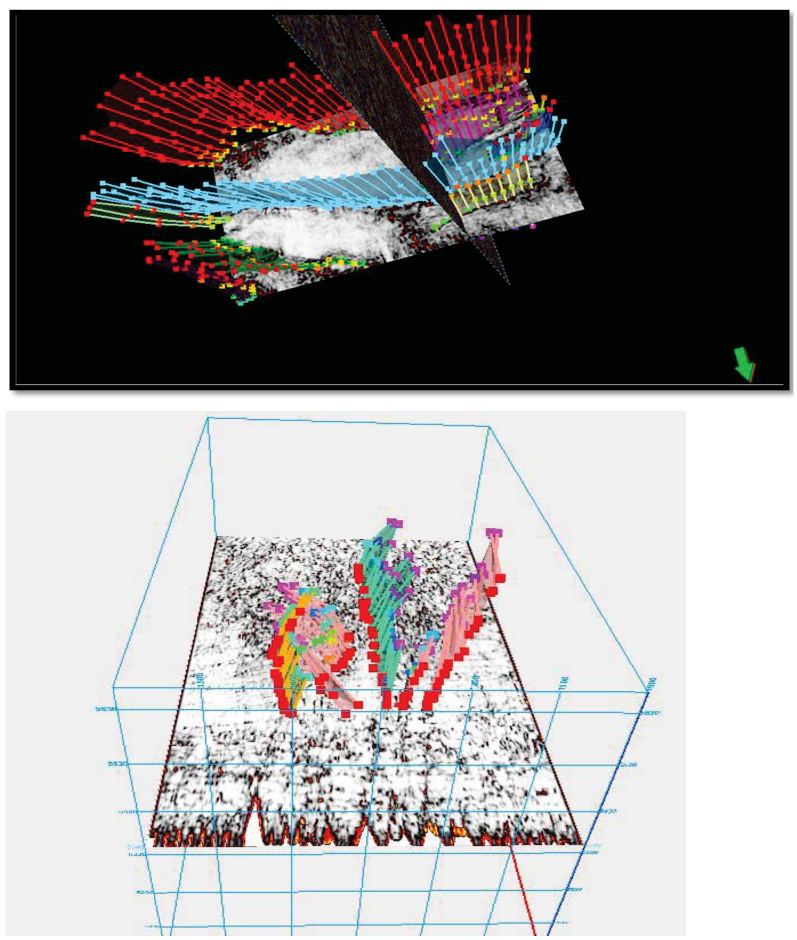

Figure 7. Variance edge attributes displaying mapped faults.

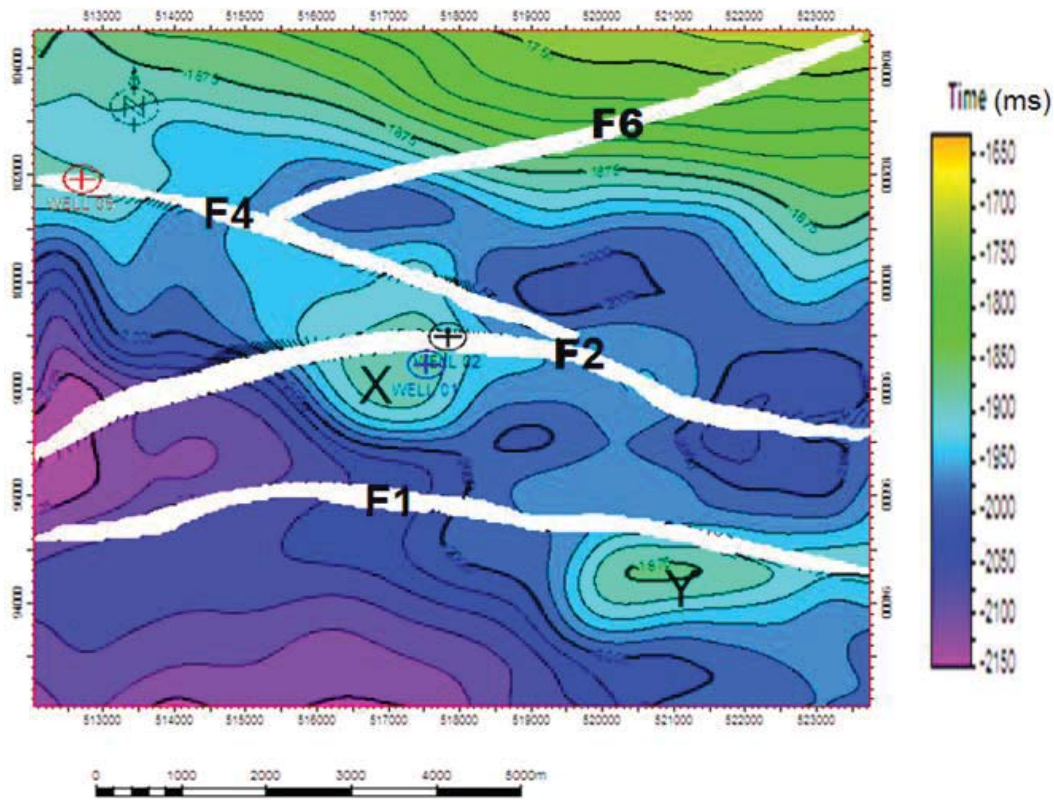

Figure 8. Time structure map of horizon R1.

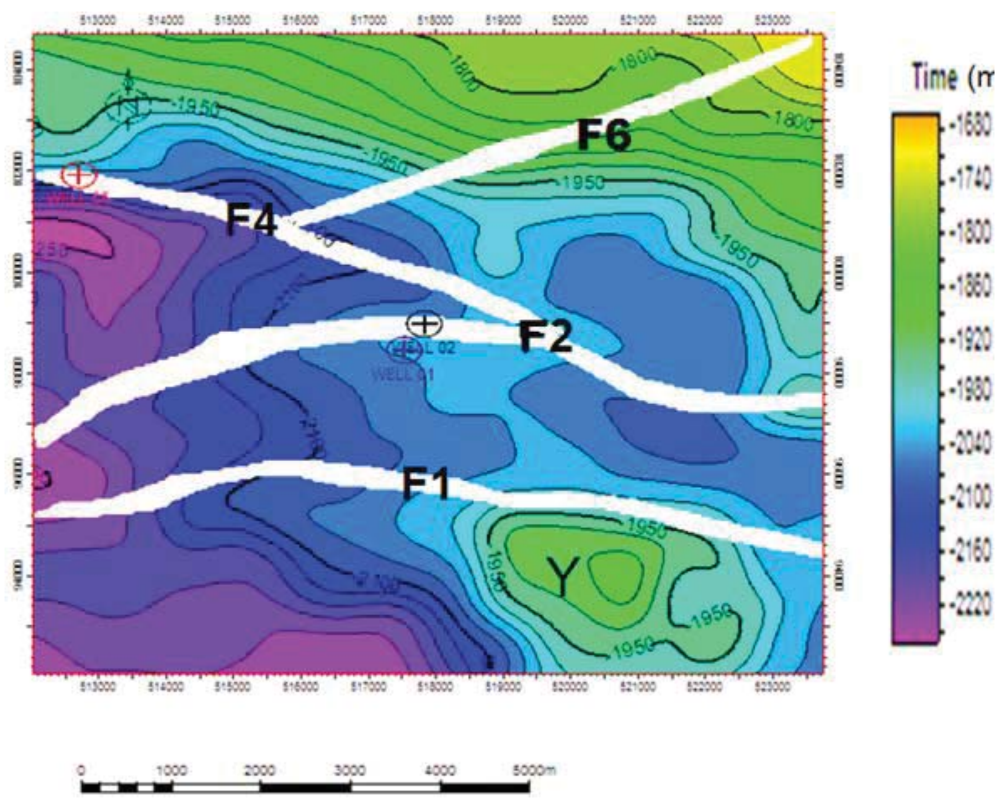

Figure 9. Time structure map of horizon R2.

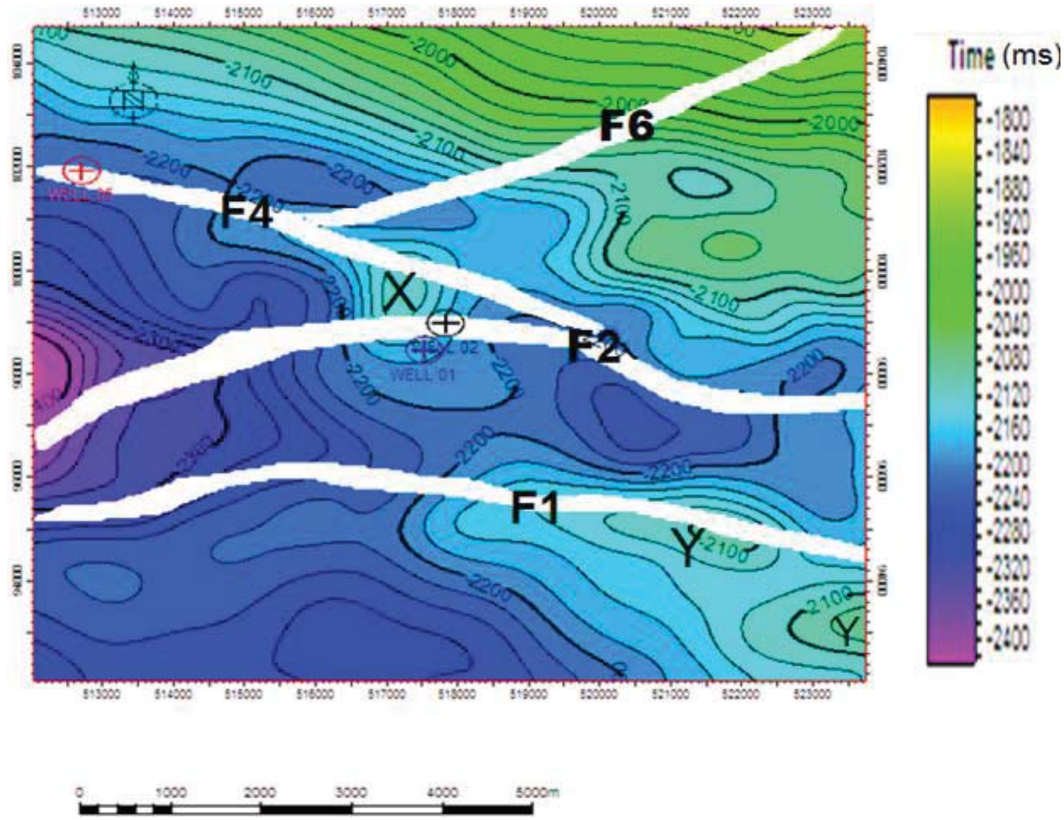

Figure 10. Time structure map of horizon R3.

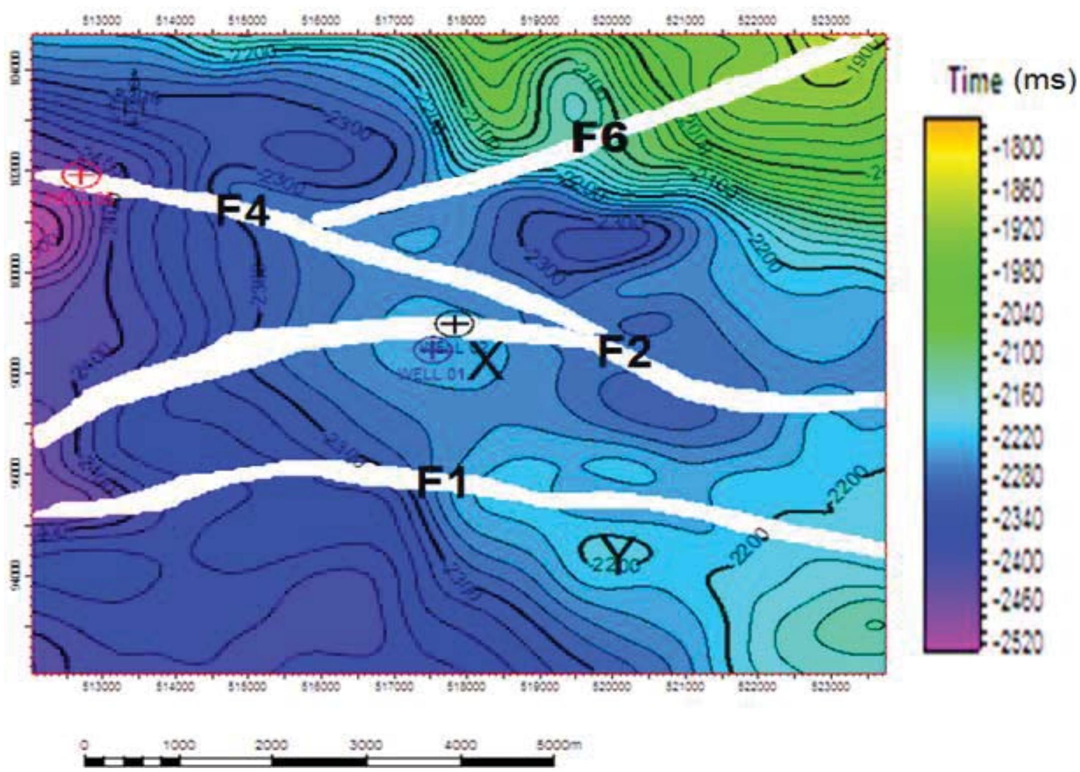

Figure 11. Time structure map of horizon R4.

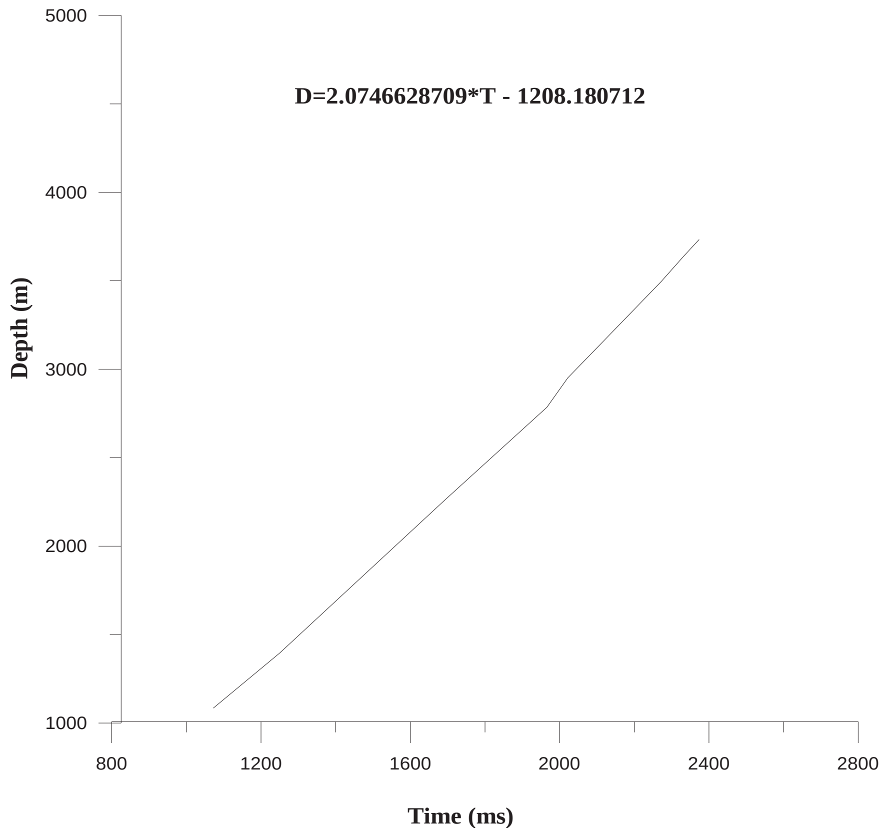

Figure 12. Time to depth conversion curve for Well 1.

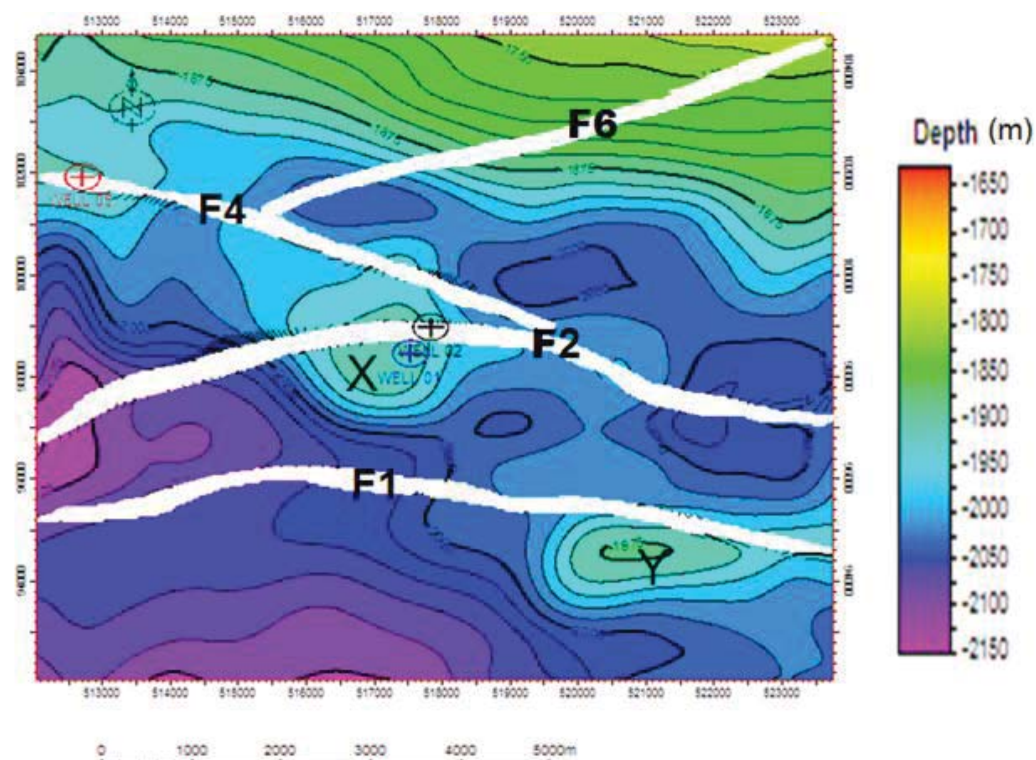

Figure 13. Depth structure map of horizon R1.

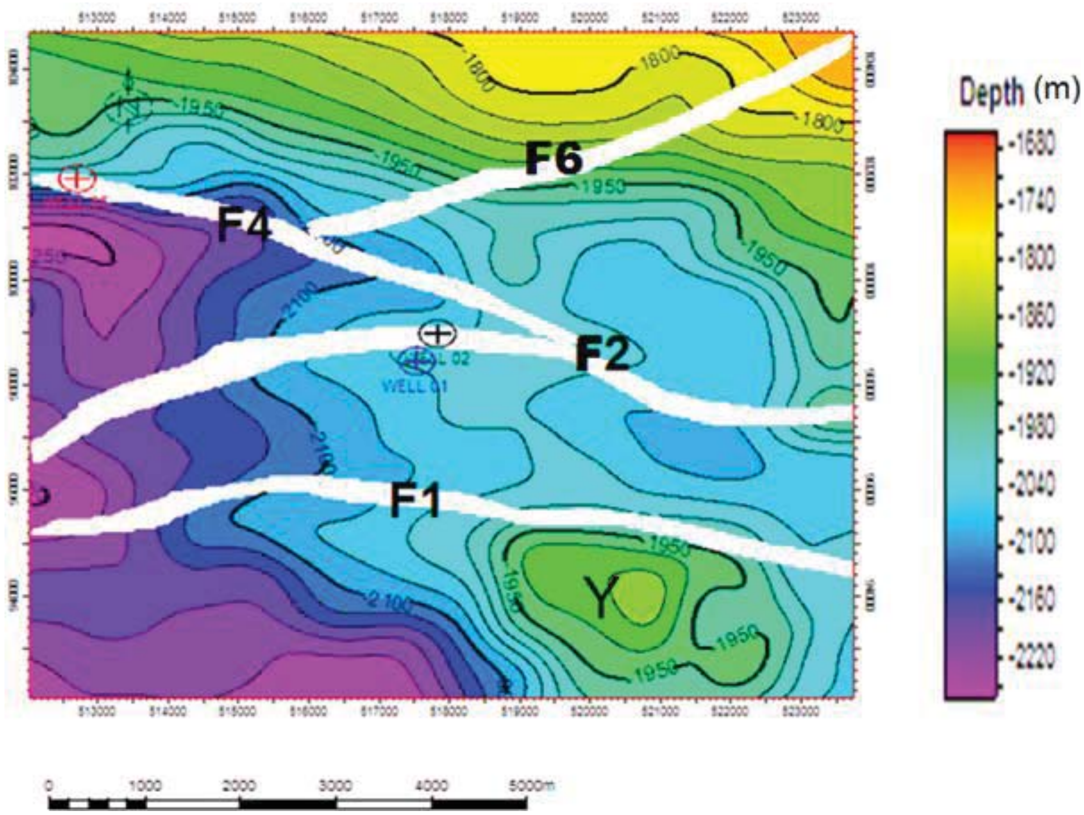

Figure 14. Depth structure map of horizon R2.

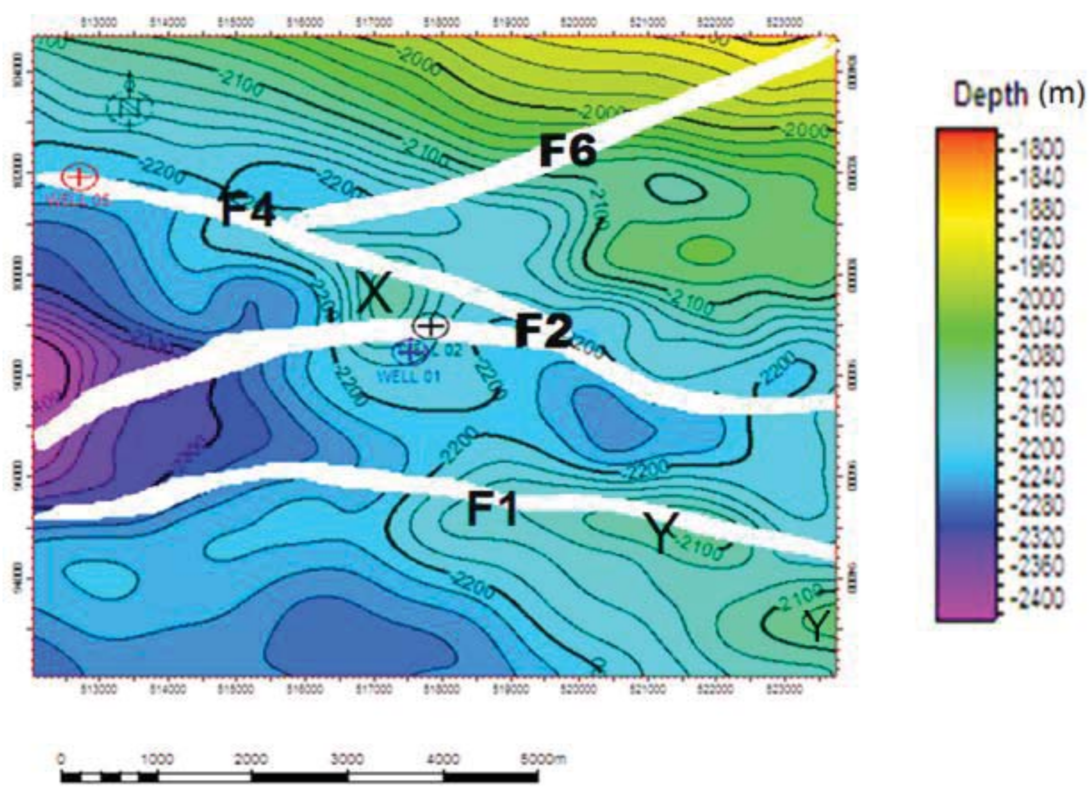

Figure 15. Depth structure map of horizon R3.

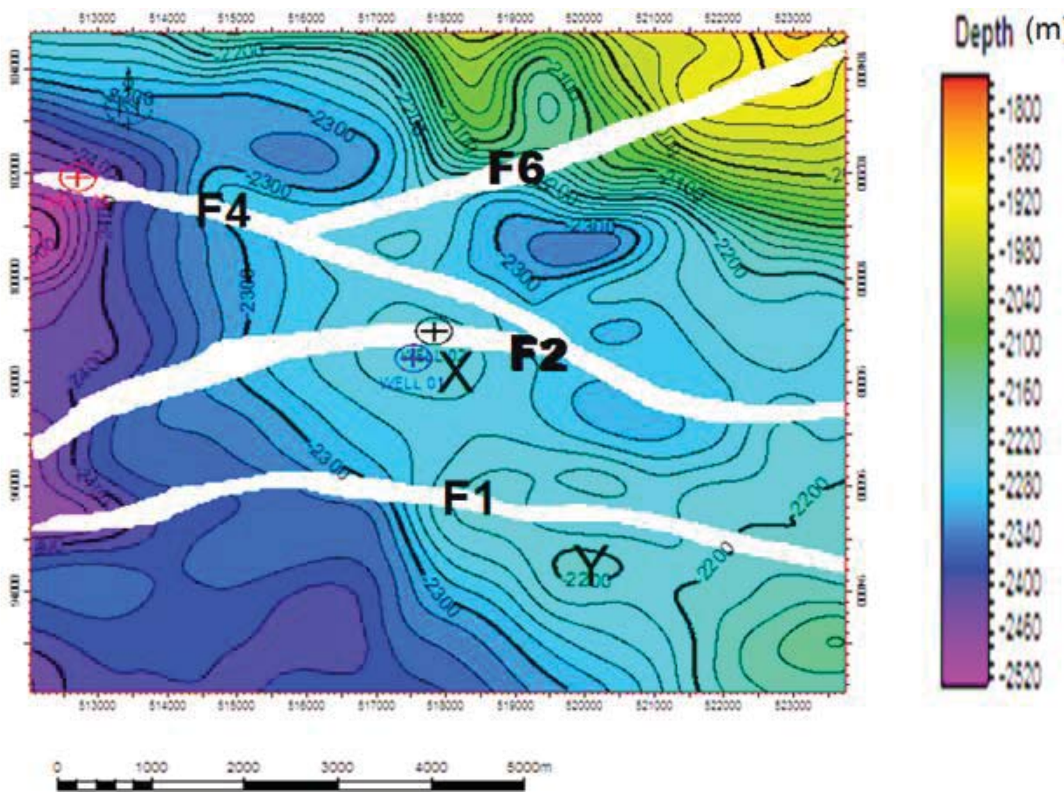

Figure 16. Depth structure map of horizon R4.

Table 2. The stratigraphic reservoir zones from well correlation.

Resevoirs	Well 1 top-base (ft)	Well 2 top-base (ft)	Well 5 top - base (ft)
R1	2004.90 - 2049.62	2000.02 - 2043.27	2123.14 - 2171.74
R2	2108.13 - 2141.31	2100.28 - 2138.20	2218.28 - 2254.73
R3	2222.18 - 2247.62	2208.53 - 2229.13	2347.88 - 2361.06
R4	2374.73 - 2391.71	2342.02 - 2354.40	2523.00 - 2531.10

Table 3. Lithological identification of Well 1.

Reservoir name	Top	Base	Thickness (gross)	Shale streak	Thickness (net)	Net/gross	Net/gross (%)
RI	2000.4	2049.62	49.22	4.11	45.11	0.9165	91.65
R2	2108.4	2141.31	33.18	2.77	30.41	0.9165	91.65
R3	2222.18	2247.62	25.44	5.91	19.53	0.7677	76.77
R4	2374.73	2391.71	16.98	3.08	13.9	0.8186	81.86

Table 4. Lithological identification of Well 5.

Reservoir name	Top	Base	Thickness (gross)	Shale streak	Thickness (net)	Net/gross	Net/gross (%)
RI	2123.14	2171.74	48.6	3.82	44.78	0.9214	92.14
R2	2218.28	2254.73	36.45	3.65	32.80	0.8999	89.99
R3	2347.88	2361.06	13.18	2.05	11.13	0.8445	84.45
R4	2523.00	2531.10	8.10	2.54	5.56	0.6864	68.64

Table 5. Summary of Petrophysical attributes at Well 1.

Reservoir name	Depth interval	Reservoir thickness	V_{Sh} (%)	R_t	R_w	Ø (%)	F	S_w(%)	BVW (%)	S_{wirr} (%)	K (mD)	S_h (%)
R1	2004.90-2049.62	49.22	8.59	333.000	0.0189	24.5	13.5	3.07	0.75	8.22	2606.91	96.93
R2	2108.13-2141.31	33.18	7.03	242.362	0.1337	24.5	13.5	9.59	2.35	8.22	2606.91	90.41
R3	2222.18-2247.62	25.44	10.20	482.148	0.2091	31.0	8.43	6.72	2.08	6.49	11777.71	93.28
R4	2374.73-2391.71	16.98	26.56	93.460	0.0949	26.5	11.54	12.02	3.19	7.60	4307.19	87.98

Table 6. Summary of Petrophysical attributes at Well 5.

Reservoir name	Depth interval	Reservoir thickness	V_{Sh} (%)	R_t(Ωm)	R_w(Ωm)	Ø(%)	F	S_w (%)	BVW (%)	S_{wirr} (%)	K (mD)	S_h (%)
R1	2123.14-2171.74	48.6	12.83	177.737	0.1468	27.75	10.52	10.36	2.87	7.25	5797.22	89.64
R2	2218.28-2254.73	36.45	8.17	181.480	0.1344	28.25	10.15	9.63	2.72	7.12	6502.20	90.37
R3	2347.88-2361.06	13.18	16.47	316.325	0.0919	23.50	14.67	7.25	1.70	8.56	2001.40	92.75
R4	2523.00-2531.10	8.10	11.01	54.970	0.0927	21.25	17.92	19.32	4.11	9.47	1050.07	80.68

a range of 24.5 to 31% in Well 1 and 21.25 to 28.25% in Well 5, water saturation is 3.07 to 12.02% in Well 1 and7.25 to 19.32% in Well 5, hydrocarbon saturation 87.98 to 96.93% in Well 1 and 80.68 to 92.75% in Well 5.The permeability which is the ability of the reservoir formations to transmit fluid ranged between 2606.91 to 11,777.71 mD in Well 1, 1050 to 6502.20 mD in Well 5 making the reservoir sand highly productive. Figures 18 to 21 compare the petrophysical parameters for each mapped reservoir between Wells 01 and 05. Neutron density logs were used to define hydrocarbon type present in Afam Field. The combination of neutron and density logs was used for reservoir in both wells to detect gas zone (Figure 17). At these intervals, density porosity was observed to be greater than neutron porosity and the curves crossover each other, therefore were identified as gas bearing zones.

The results of these petrophysical attributes analysis revealed the presence of hydrocarbon in the four correlated reservoir sand units at quantities favourable for commercial exploitation with R4 having the highest average hydrocarbon saturation. The high values of the estimated porosity and permeability denote that the reservoir sand units are well sorted. The evaluated petrophysical parameters are in line with that of other researchers (Edwards and Santagrossi, 1990; Anyiam et al., 2010; Olowokere and Ojo, 2011; Aigbedion and Aigbedion, 2011). The variations in the porosity of the reservoir units across the Niger Delta basin could be ascribed to the differential volume of shale in the reservoirs. These petrophysical properties obtained are the parameters required for estimating the hydrocarbon in place.

Conclusion

The subsurface geology, hydrocarbon structural trapping mechanism and petrophysical attributes evaluation of Afam field, offshore Niger Delta have been studied using 3D seismic and composite well logs. The major and minor faults were delineated and mapped confirming the area to be highly faulted, typical of the tectonic setting of Niger Delta. Reservoir sand units marked R1, R2, R3 and R4 were mapped out based on log curve signatures of the gamma ray log, neutron log, formation density log, and resistivity logs. They were correlated across the wells and hydrocarbon intervals in Afam field were mapped on to the seismic section for well-to-seismic tie using time-depth data. The mapped horizons on the well logs suite were picked across the inlines and the crosslines, within the time window of 2126 and 2326 mS of the seismic section. Time and depth structural maps of these surfaces were also generated to study the geometry of the structure trapping oil and gas in the field. Depth maps by average velocity gave the various depth to the surface mapped. Trapping mechanism in Afam field were also revealed to be the anticlinal

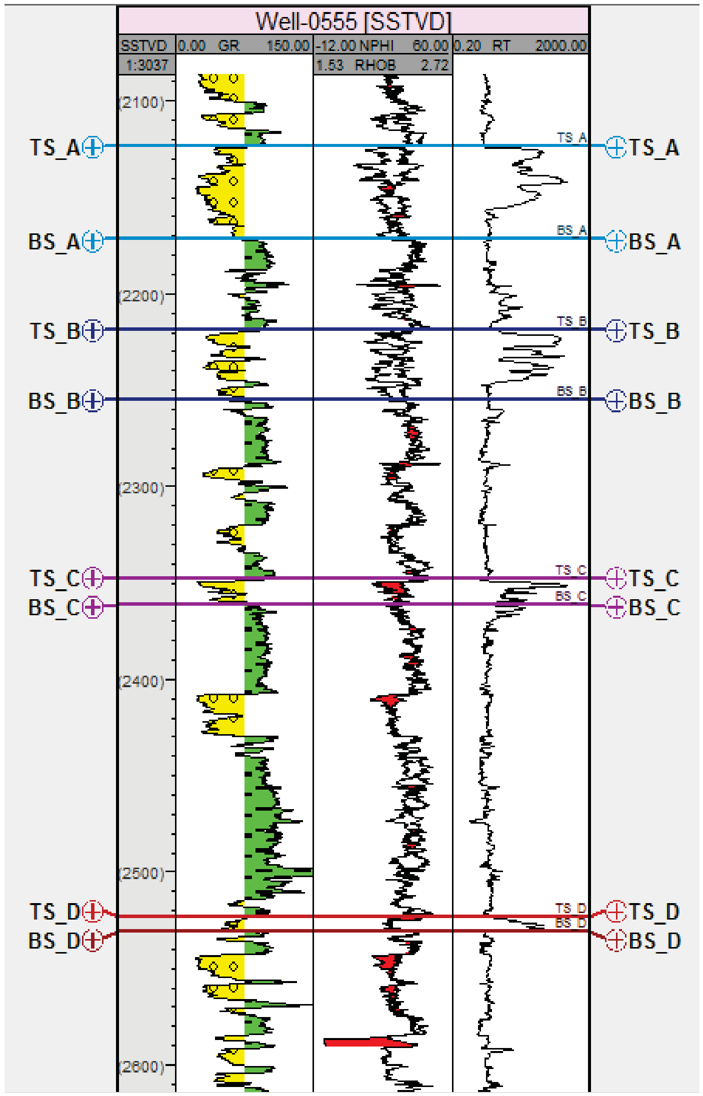

Figure 17. Hydrocarbon type identifications using neutron and density logs.

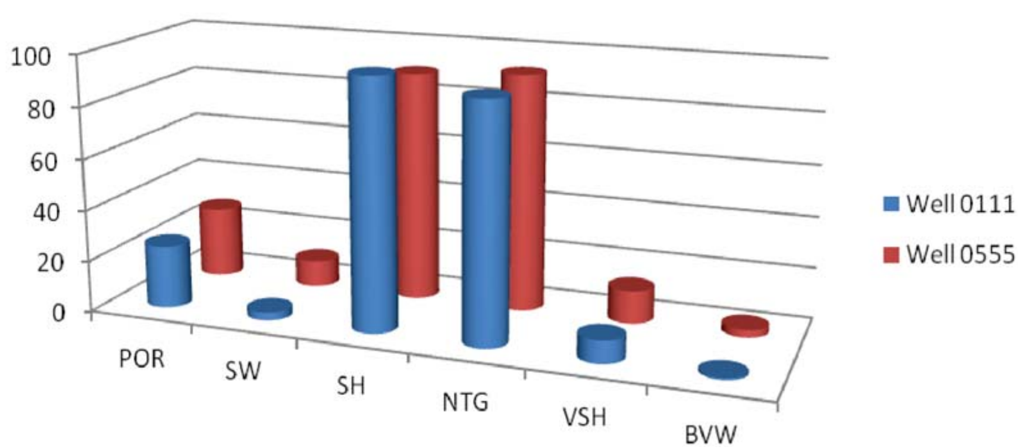

Figure 18. Chart showing relationship between percentage porosity, water saturation, hydrocarbon saturation and net/gross, volume of shale and bulk volume of water for R1.

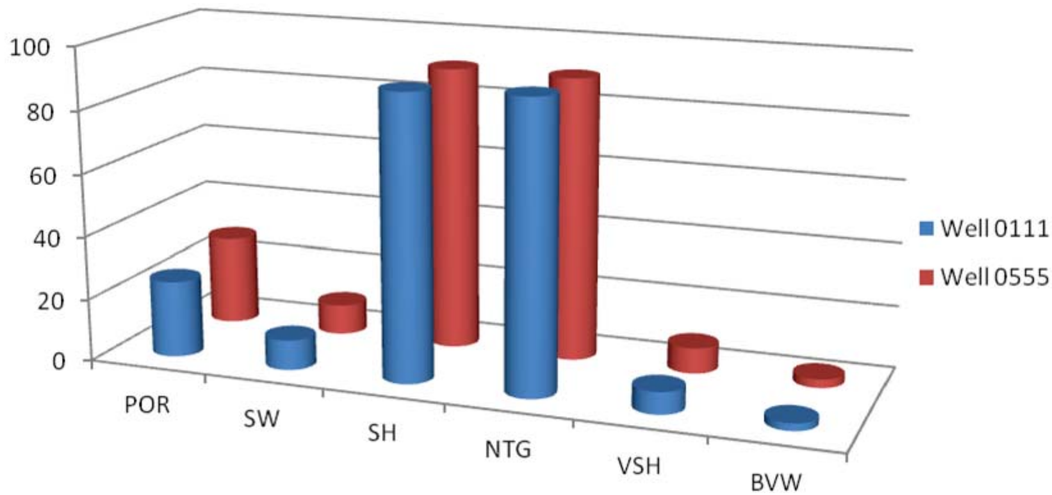

Figure 19. Chart showing relationship between percentage porosity, water saturation, hydrocarbon saturation and net/gross, volume of shale and bulk volume of water of R2.

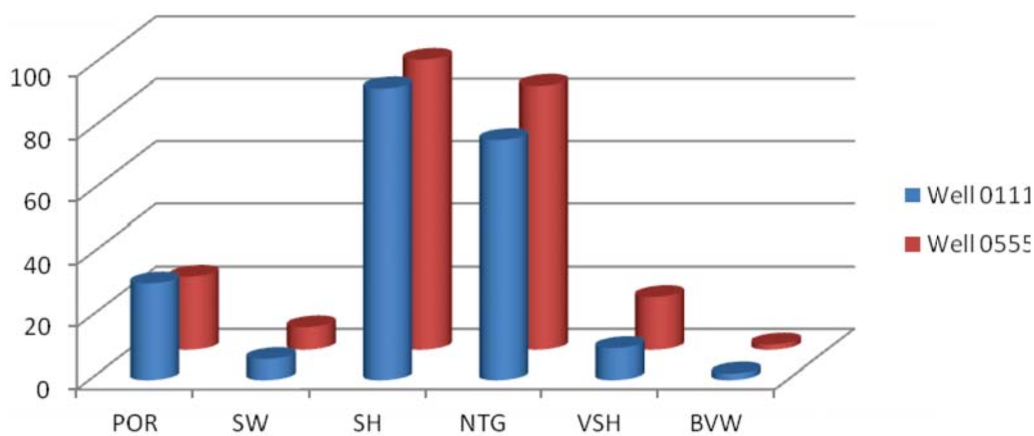

Figure 20. Chart showing relationship between percentage porosity, water saturation, hydrocarbon saturation and net/gross, volume of shale and bulk volume of water for R3.

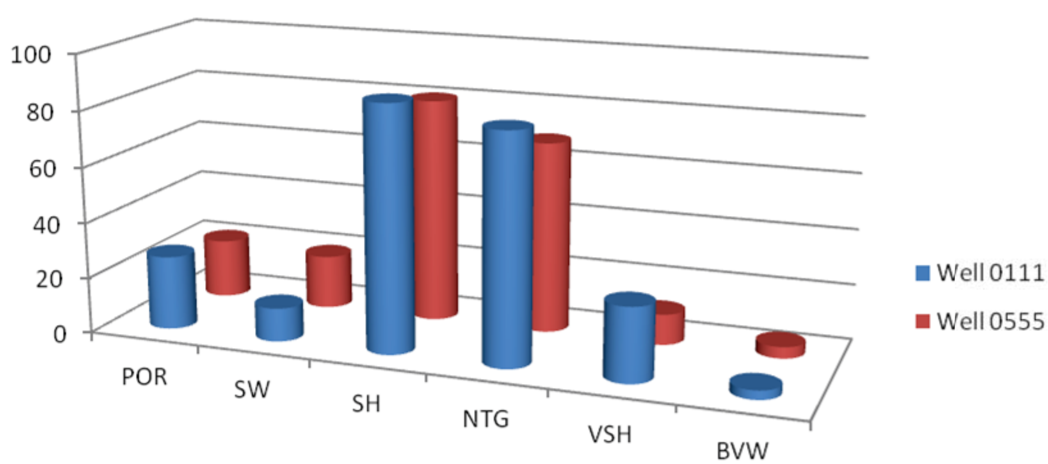

Figure 21. Chart showing relationship between percentage porosity, water saturation, hydrocarbon saturation and net/gross, volume of shale and bulk volume of water for R4.

structure at the centre of the field which is tied to the crest of the rollover structure assisted by faults and also largely by means of fault assisted closures (X and Y). The two way closure "Y" about SE section of the depth structure map is localized close to a fault and can consequently acts as a seal to further improve the integrity of the fault. The reservoir sand units were evaluated quantitatively for petrophysical attributes e.g. porosity, water saturation net pay, volume of shale, formation factor, irreducible water saturation, bulk water volume, permeability fluid content determinations and fluid contact. Neutron density logs were used to define hydrocarbon type present in Afam Field. Porosity values are between 21.25 and 31% for the mapped hydrocarbon bearing sand units which are productive reservoirs units. The hydrocarbon saturation of all the reservoir zones ranges from 80.68 to 96.93%. High resistivity R_t, porosity and permeability values in the entire hydrocarbon bearing reservoir zones were observed from the petrophysical data.

Conflict of Interest

The authors have not declared any conflict of interest.

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Review

Privacy preserving data publishing: Review

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Privacy preserving data publishing (PPDP) methods a new class of privacy preserving data mining (PPDM) technology, has been developed by the research community working on security and knowledge discovery. It is common to share data between two organizations in many application areas. When data are to be shared between parties, there could be some sensitive patterns which should not be disclosed to the other parties. These methods aims to keep the underlying data useful based on privacy preservation "utility based method based on privacy preservation, and created tremendous opportunities for knowledge- and information-based decision making. Recently, PPDP has received considerable attention in research communities, and many approaches have been proposed for different data publishing scenarios. In this survey, we will systematically summarize and evaluate different approaches to PPDP, study the challenges in practical data publishing, clarify the differences and requirements that distinguish PPDP from other related problems, and propose future research directions.

Key words: Privacy preserving, privacy preserving data publishing, privacy preserving data mining, republishing, security, privacy, decision making, knowledge.

INTRODUCTION

The development of IT and the collection of electronic information by data owners, such as governments, corporations, and individuals, have resulted in higher instances of data sharing. Many organizations are often willing to collaborate with other entities to perform a common action for mutual benefit (Gkoulalas-Divanis and Verykiosc, 2009; Qi and Zong, 2012). Driven by mutual benefits. Recent developments have helped improve decision making especially in the fields of medical information, research, and public health organization, among others. Many approaches have been proposed for different data publishing needs in different fields. Collaboration is an important factor in HISs (Ahmed and Yasin, 2012). According to Ohno-Machado (2013), privacy is an important requirement for collaboration in data sharing (Ohno-Machado, 2013). However, privacy concerns tend to become obstacles. According to Gkoulalas-Divanis and Loukides (2011) stated that 62% of patients were concerned about the disclosure of their EMRs. The sharing of data needs control and management to ensure system integration. Integration is required especially in the management of patient data to secure sensitive information such as patient identification.

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Privacy-preserving data publishing (PPDP) provides methods and tools for publishing useful information while preserving data privacy. Recently, PPDP has received considerable attention in research communities, and many approaches have been proposed for different data publishing scenarios (Gkoulalas-Divanis and Loukides, 2011). Several studies have focused on the management of data such as in medical applications to ensure system integration. However, the management and sharing of data in different fields but the challenge in misuse of information, and data owner’s identification and others related problem. Privacy protection and data-keeping utility remain problems that must be solved (Gkoulalas-Divanis and Loukides, 2011). Information privacy in the healthcare sector is an issue of increasing importance. The adaption of healthcare HISs and the increasing need for information among patients, providers, and payers, all point toward the need for better information protection (Appari and Johnson, 2010). The frequency of identity theft continues to increase. Consequently, concerns about the ability of organizations to protect the personally identifiable data with which they are entrusted has also increased (Appari and Johnson, 2010; Fung et al., 2010).

In June 2004, the President's Information Technology Advisory Committee (PITAC) published a report entitled “Revolutionizing Health Care Through Information Technology” (Committee, 2004). One of the key points of this report was the establishment of a nationwide system of EHRs that encourages the sharing of medical knowledge through computer-assisted clinical decisions. Data publishing is equally ubiquitous in other domains. EHRs are a type of health IT that assist in storing health data and improve collaboration to provide better care. EHRs also reduce the necessity for paperwork by eliminating the need for paper-based records and by improving administrative efficiency, thereby decreasing healthcare costs. EHRs improve healthcare by decreasing medical errors with an assurance that all healthcare providers will have accurate and timely information (Bowman, 2012; Wu et al., 2006). For example, contracts and agreements cannot guarantee that sensitive data will not be carelessly misplaced and end up in the wrong hands.

A task of the utmost importance is to develop methods and tools for publishing data in a more hostile environment, so that the published data remains practically useful while individual privacy is preserved (Fung et al., 2010). This undertaking is called PPDP. In the past few years, research communities have responded to this challenge and proposed many approaches. While the research field is still rapidly developing, it is a good time to discuss the assumptions and desirable properties for PPDP, clarify the differences and requirements that distinguish PPDP from other related problems, and the current gaps and systematically summarize and evaluate different approaches to PPDP.

PRIVACY PRESERVING DATA PUBLISHING

PPDP provides methods and tools for publishing useful information while preserving data privacy (Chen et al., 2012; Fung et al., 2010). Recently, PPDP has received considerable attention in research communities, and many approaches have been proposed for different data publishing scenarios. According to Fung et al. (2010) a typical scenario for data collection and publishing (Fung et al., 2010), as show in Figure 1. In the data collection phase, the data publisher collects data from record owners (e.g., X1 and X2 to Xn). In the data publishing phase, the data publisher releases the collected data to a data miner or to the public, called the data recipient, who will then conduct data mining on the published data.

In this context, data mining has a broad sense, not necessarily restricted to pattern mining or model building. For example, a hospital collects data from patients and publishes the patient records to an external medical centre. In this example, the hospital is the data publisher, patients are record owners, and the medical centre is the data recipient. The data mining conducted at the medical centre could be anything from a simple count of the number of men with diabetes to a sophisticated cluster analysis. According to Gehrke (2006) proposed two models for privacy preserving data analysis and publishing (Gehrke, 2006).

(i) The untrusted model. The data publisher is not trusted and may attempt to identify sensitive information from record owners. Various cryptographic solutions (Yang et al., 2005), anonymous communications (Chaum, 1981; Jakobsson et al., 2002), and statistical methods (Warner, 1965) have been proposed to collect records anonymously from their owners without revealing the identities of the owners.

(ii) The trusted model. The data publisher is trustworthy, and record owners are willing to provide personal information to the data publisher. However, the trust is not transitive to the data recipient. Models of data publisher are described in Figure 2.

This study assume the trusted model of data publishers and consider privacy issues in the data publishing phase. According to Fung (2010) mentioned that in practice, every data publishing scenario has its own assumptions and requirements of the data publisher, the data recipients, and the data publishing purpose. The following are several desirable assumptions and properties in practical data publishing, according to Fung et al. (2010).

(1) The non expert data publisher.
(2) The data recipient could be an attacker.
(3) Publish data, not the data mining result.
(4) Truthfulness at the record level.

The initial idea of PPDM was to extend traditional data

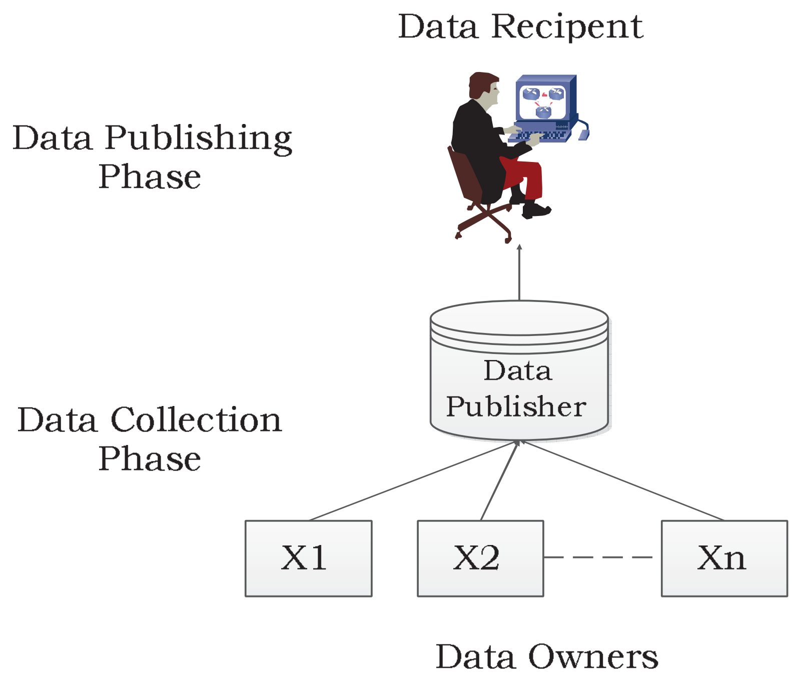

Figure 1. Scenario collection and publishing of data (Fung et al., 2010).

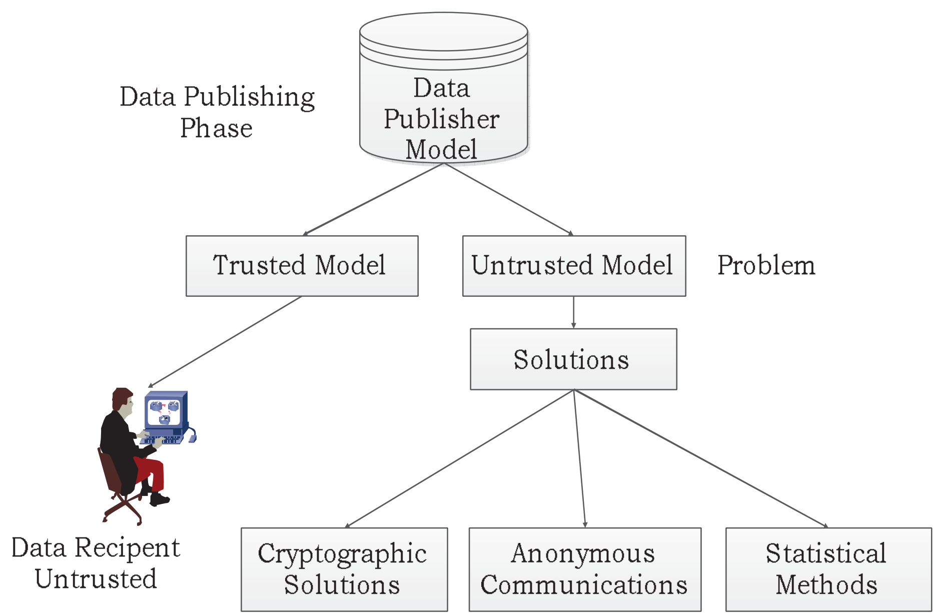

Figure 2. Models classification for data publishing.

mining techniques to work with the data modified to mask sensitive information. The key issues were how to modify the data and how to recover the data mining result from the modified data. The solutions were often tightly coupled with the data mining algorithms under consideration. In contrast, PPDP may not necessarily be tied to a specific data mining task, and the data mining task may be unknown at the time of data publishing. Furthermore, some PPDP solutions emphasize preserving the data truthfulness at the record level as discussed earlier, but often PPDM solutions do not preserve such a property in recent years, the term

Table 1. Comparison between PPDM and PDPP.

Variables	PPDM	PPDP
General Idea	PPDM is to allow data mining from a modified version of the data that contains no sensitive information	A new class of PPDM methods. PPDP allows the publication of useful information, while preserving data privacy (Benjamin et al., 2010; Gehrke, 2006). PPDP allow to anonymize the data by hiding identify of individuals, not hiding sensitive data.
Definition	Algorithms a new class of data mining methods, has been developed by the research community working on security and knowledge discovery (Bertino et al., 2005a; Fung et al., 2010).	Methods and tools for publishing useful information while preserving data privacy (Chen et al., 2012; Fung et al., 2010).
Aim	Extraction of relevant knowledge from large amounts of data, while protecting at the same time sensitive information (Bertino et al., 2005a).	Keep the underlying data useful based on privacy preservation "utility based method" (Fung et al., 2010).
Example	**Example to describe the scenario between them** A hospital may publish the patient data to a cancer research institute; although willing to contribute its data to cancer research, the hospital is not interested in and has expertise in data mining algorithms because cancer research is normal work.	
Demonstration	PPDM focuses on the data without sensitive information (Bertino et al., 2005b; Fung et al., 2007).	PPDP focuses on the data. Therefore, published records should be meaningful when examined individually (Chen et al., 2012).
Techniques	PPDM is to allow data mining techniques such as Association Rule Mining, Classification, Clustering (Fung et al., 2010)	PPDP seeks to anonymize the data by hiding identify of individuals, not hiding sensitive data. Hiding techniques such as k-anonymity, l-diversity, m-Invariance, T-Closeness (Fung et al., 2010).

"PPDM" has evolved to cover many other privacy research problems, even though some of them may not directly relate to data mining (Fung et al., 2010). Another related area is the study of the non-interactive query model in statistical disclosure control (Adam and Worthmann, 1989; Brand, 2002), in which the data recipients can submit one query to the system. This type of non-interactive query model may not fully address the information needs of data recipients because, in some cases, it is very difficult for a data recipient to accurately construct a query for a data mining task in one shot.

Consequently, there are a series of studies on the interactive query model (Blum et al., 2005; Dinur and Nissim, 2003; Dwork, 2008), in which the data recipients, unfortunately including attackers, can submit a sequence of queries based on previously received query results. One limitation of any privacy-preserving query system is that it can only answer a sub-linear number of queries in total; otherwise, an attacker (or a group of corrupted data recipients) will be able to reconstruct all but fraction of the original data (Blum et al., 2008), which is a very strong violation of privacy. When the maximum number of queries is reached, the system must be closed to avoid privacy leak. In the case of a non-interactive query model, the attacker can issue an unlimited number of queries and, therefore, a non-interactive query model cannot achieve the same degree of privacy defined by the interactive model. This study focuses mainly on the non-interactive query model (Fung et al., 2010), in this study; cover the review of recent studies on anonymization approaches to PPDP and provide our own insights into this topic. There are several fundamental differences between the recent work on PPDP and the previous work proposed by the official statistics community.

COMPARING BETWEEN (PPDM) AND (PPDP)

The general principle of this study is to release all data to facilitate the use of data sent or published in scientific fields, but the identities of people who are owners of such data and other sensitive properties found in the data must be protected. Therefore, the aim of this study falls outside the traditional work on access and authentication control (Sweeney, 2002). The latter area, PPDM and PPDP, explains the differences between two subjects. The results of the comparison are shown in Table 1.

CLASSIFYING THE PRIVACY PRESERVATION TECHNIQUES AND APPROACHES

The primary goal in privacy preserving is to protect the

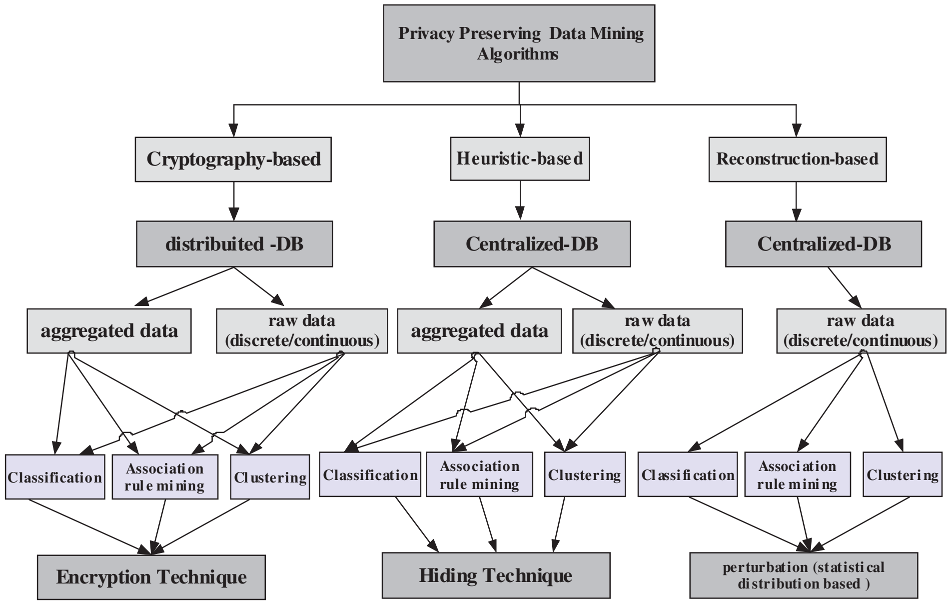

Figure 3. A taxonomy of the developed PPDM algorithms (Bertino et al., 2005b).

sensitive data before it is released for analysis or re-publishing. However, the data may reside at centralized or distributed data storage. In such a scenario appropriate algorithms or techniques should be used which preserves any sensitive information in the knowledge discovery process. To address this issue there are many approaches adopted for privacy preserving data mining (Parmar et al., 2011). Classifying the proposed privacy preservation techniques according to five different dimensions:

(1) Data distribution (centralized or distributed);
(2) The modification applied to the data (encryption, perturbation, generalization, and so on) in order to sanitize them;
(3) The data mining algorithm which the privacy preservation technique is designed for;
(4) The data type (single data items or a complex data correlation) that needs to be protected from disclosure;
(5) The approach adopted for preserving privacy (heuristic, reconstruction or cryptography-based approaches).

Figure 3 shows taxonomy of the existing PPDM algorithms according to those dimensions. Obviously, it represents a first organization in this new area and does not cover all the possible PPDM algorithms. However, it gives one overview of the algorithms that have been proposed so far, focusing on their main features. While heuristic and reconstruction-based techniques are mainly conceived for centralized datasets, cryptography based algorithms are designed for protecting privacy in a distributed scenario by using encryption techniques. Reconstruction-based algorithms recently proposed aim at hiding sensitive raw data by applying perturbation techniques based on probability distributions. Moreover, several heuristic-based approaches for hiding both raw and aggregated data through a hiding technique (perturbation, blocking, data swapping, aggregation, generalization and sampling) have been developed, first, in the context of association rule mining and classification and, more recently, for clustering techniques. Now, we briefly describe some of the algorithms proposed in the PPDM area (Bertino and Sandhu, 2005). Figure 4 show the approaches of privacy preserving data mining based on the above dimensions.

THE PRIVACY MODELS IN PRIVACY PRESERVING DATA PUBLISHING

The privacy protection is important issues when related with personal data we need to provide stringent definition about protection of privacy. The clear definition: access to the published data should not enable the attacker to learn anything extra about any target victim compared to no access to the database, even with the presence of any attacker's background knowledge obtained from other sources (Dalenius, 1977).

Most literature on PPDP considers a more relaxed, more practical notion of privacy protection by assuming the attacker has limited background knowledge. A privacy threat occurs either when an identify is linked to a record or when an identify is linked to a value on some sensitive, these threats are called record linkage, attribute linkage, table linkage. Below, we can broadly classify privacy

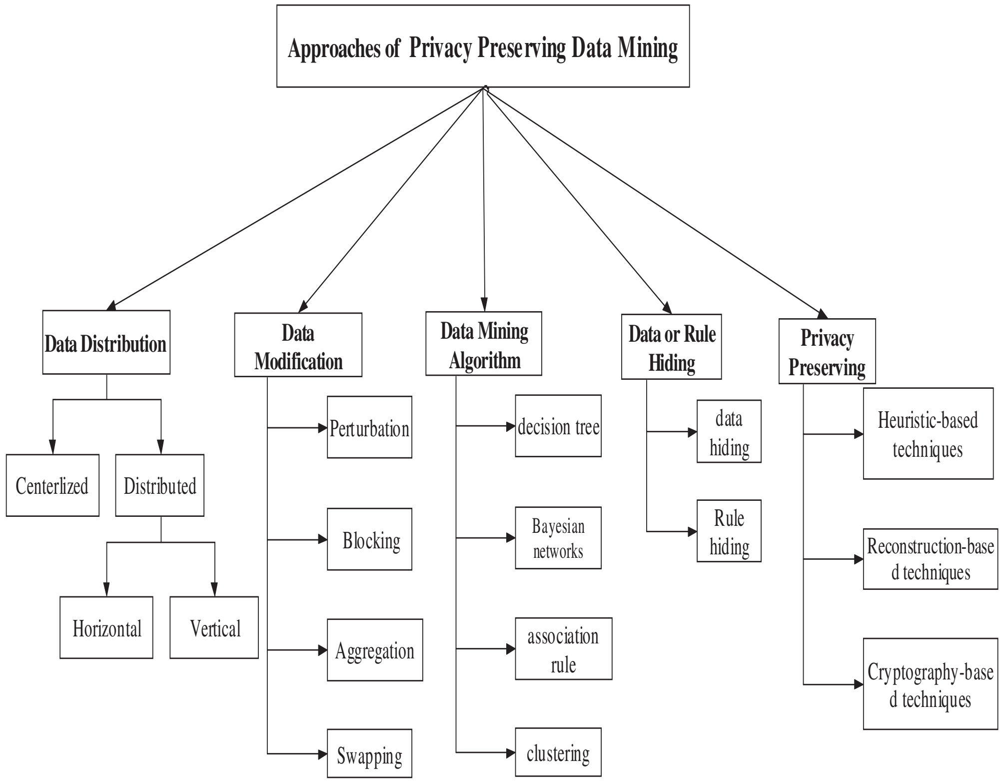

Figure 4. The approaches of privacy preserving data mining.

models into two categories based on their attack principles. Attack; refer to unauthorized access to this data. The victim refers to data owner targeted by the attacker. We can broadly classify privacy models into two categories based on their attack principles (Fung et al., 2010)

The first category considers that a privacy threat occurs when an attacker is able to link a record owner to a record in a published data table, to a sensitive attribute in a published data table, or to the published data table itself. We call these record linkage, attribute linkage, and table linkage, respectively. In all three types of linkages, we assume that the attacker knows the QID of the victim. In record and attribute linkages, we further assume that the attacker knows that the victim's record is in the released table, and seeks to identify the victim's record and/or sensitive information from the table. In table linkage, the attack seeks to determine the presence or absence of the victim's record in the released table. A data table is considered to be privacy preserving if it can effectively prevent the attacker from successfully performing these linkages (Fung et al., 2010). The second category aims at achieving the uninformative (not providing knowledge) principle: The published table should provide the attacker with little additional information beyond the background knowledge. If the attacker has a large variation between the prior and posterior beliefs, we call it the probabilistic attack (Machanavajjhala et al., 2007). Many privacy models in this family do not explicitly classify attributes in a data table into QID and sensitive attributes, but some of them could also thwart the sensitive linkages in the first category, so the two categories overlap (Machanavajjhala et al., 2007). The following Table 2 summarizes the attack models addressed by the privacy models.

TYPES OF LINKAGES

Record linkage

In the attack of record linkage, some value qid on QID identifies a small number of records in the released table T, called a group. If the victim's QID matches the value qid, the victim is vulnerable to being linked to the small number of records in the group. In this case, the attacker faces only a small number of possibilities for the victim's record, and with the help of additional knowledge, there is a chance that the attacker could uniquely identify the victim's record from the group (Fung et al., 2010).

Attribute linkage

According to Fung (2010) in the attack of attribute

Table 2. Privacy models in privacy preserving data publishing (Fung et al., 2010).

Privacy models	Attack models			
	Record linkage	Attribute linkage	Table linkage	Probabilistic attack
k-Anonymity	/			
Multi R k-Anonymity	/			
ℓ Diversity	/	/		
Confidence Bounding		/		
(a; k)-Anonymity	/	/		
(X; Y)-Privacy	/	/		
(k; e)-Anonymity		/		
(€;m)-Anonymity		/		
Personalized Privacy		/		
t-Closeness		/		/
£, Presence			/	
(c; t)-Isolation	/			/
E-Differential Privacy			/	/
(d; y)-Privacy			/	/
Distributional Privacy			/	/

linkage, the attacker may not precisely identify the record of the target victim, but could infer his/her sensitive values from the published data T, based on the set of sensitive values associated to the group that the victim belongs to. In case some sensitive values predominate in a group, a successful inference becomes relatively easy even if k-anonymity is satisfied. According to Clifton et al. (2002) suggested eliminating attribute linkages by limiting the released data size. Limiting data size may not be desirable if data records such as HIV patient data are valuable and are difficult to obtain (Clifton et al., 2002). Several other approaches have been proposed to address this type of threat. The general idea is to diminish the correlation between QID attributes and sensitive attributes.

Table linkage

Both record linkage and attribute linkage assume that the attacker already knows the victim's record is in the released table T. However, in some cases, the presence or the absence of the victim's record in T already reveals the victim's sensitive information. Suppose a hospital releases a data table with a particular type of disease. Identifying the presence of the victim's record in the table is already damaging. A table linkage occurs if an attacker can confidently infer the presence or the absence of the victim's record in the released table (Fung et al., 2010).

Probabilistic linkage

There is another family of privacy models that does not focus on exactly what records, attributes, and tables the attacker can link to a target victim, but focuses on how the attacker would change his/her probabilistic belief on the sensitive information of a victim after accessing the published data. In general, this group of privacy models aims at achieving the uninformative principle, whose goal is to ensure that the difference between the prior and posterior beliefs is small (Fung et al., 2010; Machanavajjhala et al., 2007). In sum, the privacy models in privacy preserving data publishing based on the linkage types.

RESULTS AND DISCUSSION

Privacy rights include the collection, storage and usage of personal data have only been partially protected under a variety of context-specific privacy laws, the protection of data privacy is an important problem that organizations must solve (LeFevre et al., 2006). As the frequency of identity theft continues to increase, there are increasing concerns about the competency of the organization's ability to protect the personally identifiable data the organization is entrusted with.

The problem has three main areas that are combined to create a Personally Identifiable Information Program (PIIP). The areas that must be considered are privacy, data security programs, and authentication of the requester. It is not so far behind as the privacy preserving topic is still a hot information technology and hinders the development of health information technology issue. From the findings of the literatures above, there were several gaps in the privacy preserving subject, in the form of: (a) when data are to be shared between parties, there could be some sensitive patterns which should not be disclosed to the other parties'. Many methods have been proposed for privacy preserving in various fields. They have monitored and analyze .the accuracy of the performance is still poor, because the methods not provide high level from privacy, efficiency, data quality, and negatively affects the accuracy of such methods performance. Moreover; sharing data will bring the problem of misuse. This is the main drawback of the privacy preserving of data. This research will address this main drawback through analyzing and evaluating the following sub-gaps.

(1) There is no model that can identify the number of quasi identifier attributes in such a way that protect the privacy of original data and keep the new version of data usable.
(2) There is a lack of connectivity between providers the health care.
(3) Beside the lack of performing centralized database to keep the confidentiality and privacy of data or to collect data, the problem of case indexing still not solved.
(4) The lack of high quality of data and the possibility of errors that adversely affect the results of researches and studies, which depend on the new version data.

CONCLUSION

The information sharing has become part of the routine activity of many individuals, companies, organizations, and government agencies. Privacy-preserving data publishing is a promising approach to information sharing, while preserving individual privacy and protecting sensitive information. Recent developments have helped improve decision making especially in the fields of medical information, research, and public health organization. Privacy protection is a complex social issue, which involves policy-making, technology, psychology, and politics. Finally, we emphasize that privacy-preserving technology solves only one side of the problem. It is equally important to identify and overcome the nontechnical difficulties faced by decision makers when they deploy a privacy-preserving technology. Their typical concerns include the degradation of data/service quality, loss of valuable information, increased costs, and increased complexity. The findings and reviews outlined in this chapter have indeed contributed to the researcher's study and in depth understanding of the subject matter. This has served as the impetus needed to further the research and ultimately meet the research objectives stated in the beginning.

Conflict of Interest

The authors have not declared any conflict of interest.

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Full Length Research Paper

Development of an approach for mapping of features thermal and hydric of watersheds: Case of the watershed of Brezina (Northwest of Algeria)

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The objective of the present study is to present the parameters of the hydrological assessment of a steppe area from the data of remote sensing. Adopted methodology rests on the cartography of the various parameters of the hydrous and energy balance on one year scale. Several methods are used. Thus, for cartography of precipitations, one uses in a combined way the relief, the distance of the sea and the exposure. The second method is used for the cartography of the streaming on an each pixel scale. This method utilizes a matrix which calls upon the information contained in space variability and information resulting from the first method. The combination of information of precipitation and the streaming allow the development of the chart of infiltration. The third method consists with the estimate of the evapotranspiration on broad scale. This last method uses images AVHRR and the model of assessment of energy Surface Energy Balance Algorithm for Land (SEBAL). The quality and the space precision of these cartographies using imagery NOAA AVHRR open a broad hydrological field of application and can be extended for the exploration of all the Algerian steppe area.

Key words: Balance of water, Brézina, mapping, surface energy balance algorithm for land (SEBAL), energy balance.

INTRODUCTION

The arid regions cover approximately 40% of the surface of the grounds world (Dregne et al., 1991; Standish-Lee et al., 2005; Bridget et al., 2006) and accommodate 2 billion people, of which 90% live in the developing countries. These zones receive small and irregular quantities (in space and time) of precipitations (Goudie, 1987; Thornes, 1994â; Unganai and Mason, 2002; Lange and Leinbundgut, 2003). They are characterized in particular by frequent, drying winds and violent ones which accelerate the evaporation of water and activate the perspiration of the plants (FAO, 2008). The arid regions correspond to territories characterized by the

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presence of a cover degraded vegetable (Le Houerou, 1995) and by an imbalance marked between the quantity of water available and the evaporating capacity of the climate (CNULD, 2009). These zones are the object of significant environmental tensions, because of their great ecological brittleness and of the scarcity of the water resources (Qadir et al., 2007). The growth and the transformation of the needs for the populations accentuate the pressure on the natural resources and can generate phenomenon of degradation of the medium, often amplified by the climatic changes (Simonneaux et al., 2009).

Algeria is classified as being a semi arid zone to arid because of importance of the evapotranspiration compared to precipitations. According to Halitim (1988) and Haddouche (2009) the arid region covers nearly 95% of the own territory, including 80% of which the hyper arid field (Saharan) (Nedjraoui, 2003). In Algeria, the arid areas are characterized in particular by steppe zones. These last represent a space and privileged course of the extensive ovine breeding (Hirche et al., 2007). They play a fundamental role in the agricultural economics of the country. However, these areas are subjected to recurring drynesses and an increasing anthropic pressure: overgrazing, exploitation of unsuitable grounds to the cultures (Nedjraoui and Bedrani, 2008). Since more than one about thirty years, they know an increasingly accentuated degradation of all the components of the ecosystem (flora, vegetable cover, ground and its elements, fauna and its habitat). This degradation, result of a hydrological imbalance, is due in particular to the turning into a desert. This tendency to the degradation of the steppe vegetation is attested by a whole of research tasks on these mediums (Le Houerou, 1993, 1995, 2005; Bouchetata and Bouchetata, 2005; Haddouche et al., 2007; Hirche et al., 2007; Haddouche, 2009). This appeared by a deterioration of the grounds and hydrous resources. What led to a reduction in the potentialities of the ecological systems, socio-economic and by the reduction of the biological potential (Le Houérou, 1995; Aidoud, 1993; Bedrani, 1996; Senoussi and Bensemaoune, 2009).

The problems of the availability of water in this part of Algeria were treated by several work (Bessaoud, 2008; Lambs and Labiod, 2009; Benblidia and Thivet, 2010). The need for bringing up to date and for following regularly its evolution, remains paramount. The country underwent one period of very severe drynesses with increases in the annual average temperature varying from 0,65 with 1.45°C between 1970 and 2004, an average comparable with the planetary average rise observed over the period 1906-2005 (Bessaoud, 2008).

Thus, Algeria has passed for the 30 last years to a severe and persistent hydrous deficit over several years, resulting from an evaluated pluviometric deficit with 30% (FAO, 2008). Another factor comes in its turn to accentuate the imbalance of the water resource: it is about the increase in the Algerian population which knows rates varying of 1.5%/year in 2003 (Kaci and Sassi, 2003) and 1.2% in 2011 according to world statistics' (http://www.statistiques-mondiales.com/algerie.htm). The total renewable water resource of the country was estimated at 11 300 × 106 m^3 whose 7900 × 106 m^3 are exploitable. The total taking away in 2000 were evaluated with 6074 × 106 m^3 of which 65% were intended for agriculture, 22% with the domestic use and 13% with the industrial sector (Bakreti et al., 2013). The two combined factors, rate/rhythm of exploitation and climatic change, were negatively reflected on the water resource in Algeria. The impact was very quickly noted on the mode of the flows, in particular that of the surface waters which underwent progressive reductions, become increasingly permanent and thus threatening the aptitude to meet the requirements of water of all the sectors (industrial, agriculture, AEP, etc.) (Kettab, 2001; Benblidia and Thivet, 2010). For the assumption of responsibility of this problem, Algeria granted a particular interest to the valorization of the hydrous potential, these last years (Kettab, 2001).The purpose of this vision is to adapt to the changes born of the climatic upheavals (Kettab et al., 2008). In addition to the dryness which touches in particular the steppe areas, the problem of failing management of these resources worsens the situation, (Kadi, 1997; Benterki et al., 2009; Mebarki, 2009; Ciheam, 2010). The characterization and the quantification of the various contributions out of water thus remain a concern of foreground. Annual volumes of the rains which the slopes basins receive must be well considered and mobilized.

The engineering methods of characterization and quantification of the various contributions of water, requires multicriteria assessment of information on the geomorphology, lithology, climatology, the hydrology of the various slopes basins (Terra, 2006).

The modern techniques of investigation and exploration such as the teledetection and the satellite imagery give the access to this information in several layers (Haddouche, 2009). Taking into account of the various sources of information requires a combination of these various layers. Several hydrological techniques founded on the GIS were reported to improve space modeling of water (Schumann and Geyer, 2000; Jain et al., 2004; Zhan and Huang, 2004; Li and Zhang, 2008; Van Dijkn and Renzullo, 2010). Thus, the coupling GIS-remote sensing allows the quantification of incoming and outgoing volumes of water and the number of parameters which intervene (Saleh and Christopher, 2011). The methodology used is founded on the analysis of the satellite imagery, the integration and the analysis of the data of the physical environment. The evaluation of the various parameters of the assessments of water and energy give charts of identifications of the zones presenting sensitive conditions to the degradation of ground and desertification (Nejraoui, 2008). For the

Table 1. Somme **studies** scientific related to the question of GIS and remote sensing.

References	Study area	Climate Type	parameter mapping	GIS or remote sensing
Seguin (1980)	plain of Crau, north of Marseille	dry zone	Real evaporation in the water balances	remote sensing in infrared thermography
Ottlé (2001)	three sub-basins of the Seine	very wetlands	water balances	Remote Sensing
Khaldi (2005)	the West Algerian Macta and Tafna	Mediterranean to the north and the South continental	precipitations	GIS
Mebarki (2007)	Eastern Algerian	Saharan arid- wet Mediterranean	Precipitation, flow, shortfall	GIS
Bensaid (2006)	wilaya of Naama (West Algeria).	arid area	the study of the silting up	GIS and Remote Sensing
Simonneaux et al. (2009).	Marrakech, Morocco	semi-arid	management of irrigation	Remote Sensing
Haddouche (2009)	Nâama, Algeria	semi-arid to arid	landscape dynamics in arid mid	Remote Sensing
Souidi et al. (2010)	Mountains of Béni Chougrane, Algéria	semi-arid	evapotranspiration	Remote Sensing

estimate of the assessment mass and energy, various methodological approaches were applied (Jacob, 1999; Bastiaanssen, 2000). These applications concern in their majority of particular cases (Seguin, 1980; Servat and Mahé, 2009). Thus, the direct methods of the estimation of the various parameters of water assessment take much time and in materials and are not very representative on the scale of the area (Souidi et al., 2010) (Table 1).

This present work concerns the application of the Remote Sensing coupled with the Geographical Information System (GIS) for the cartography of the components of the hydrological assessment. One is interested in the area of *Brézina* (*Wilaya of' El Bayadh*) which belongs to steppe space. It is characterized by a weak pluviometry (ANRH, 2003). The rainy events are at limited duration and of strong intensity. What gives a weak a cover vegetable. The abrasion of the ground is remarkable (Remini et al., 2009). The area shelters a significant dam called Brézina dam. However, failures in the quantity of stored water were raised on the level of this dam (ANB, 1999). Importance of the dam on the level of the area of Brézina, its localization in the steppe zone, the influence of the steppe aspect on the water resources, the significant solid contribution, the significant annual evapotranspiration, the considerable infiltration justify the choice of the site.

Thus we propose to evaluate the possibilities offered by satellite data AVHRR of NOAA and the multi-source data for the quantification of the quantity of the incoming and outgoing water on the scale of the slope basin of Brézina. Also, it is a question of understanding the behavior of its hydrological mode with respect to the physical constraints. It is thus a question of a contribution to a strongly multi-field gasoline approach in order to provide an aid tool to decision.

The method used appears likely to provide satisfactory information to a space scale of and time. It can be compatible with the models of the water assessments. The followed step seeks to make the combination between two methodological options which are an associated specific study that has a total space-time vision which utilizes the multispectral Remote Sensing and the techniques of GIS. It calls upon various methods of measurement of flows, models (SEBAL, SPLIT WINDOW) and with an approach of spatialization of the results based on the concept of layers of information.

GENERAL CHARACTERISTICS OF THE ZONE OF STUDY

The territory of El Bayadh framework in a space delimited by longitude by 0°(méridien de Greenwich) à 2°E and latitude by 31°à 34°N. (El Zerey et al., 2009). It is divided into three geographical bands parallel to the Mediterranean Sea, is successively from the North to the South: the High Plains steppe area, the area of the Saharan Atlas and the pre-Saharan area. The site retained for this study is localised in steppe space extending from synclinal of El Bayadh located at western north of Algeria (Figure 1). It forms the side in the north,

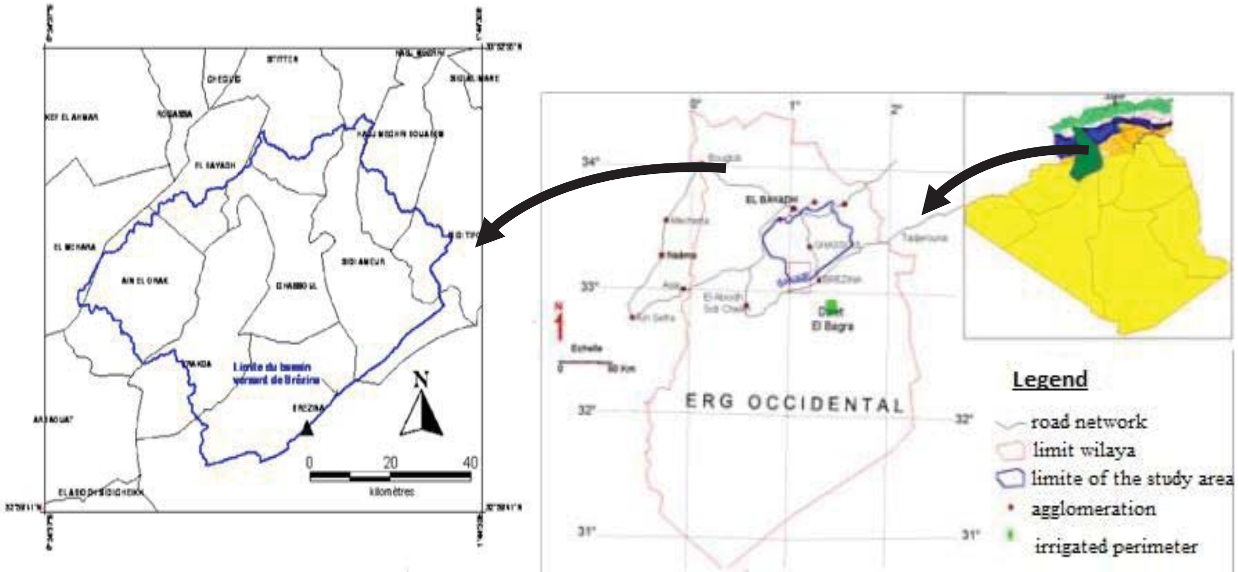


Figure 1. Location of the zone of study.

Kheneg Larouia and the Southern side. The site which is a genuine physical barrier in extreme of the Sahara represents a hydrological unit upstream dam Kheneg Larouia. This last is with ten km in the North of the "oasis city" of Brézina. It is characterized by, a broken relief, a varied lithological mosaic (Regagba et al., 2006). The geodesic coordinates system used for the elaboration of the different maps used in this work is UTM Nord Sahara.

The relief is notched by a hydrographic network which is strongly arranged hierarchically with rivers and gullies (Figure 2). The hydrographic network map has been established by using the DEM of the region by using the software MAPINFO, Vertical Mapper.

The zone of study is very little sprinkled. Precipitation is weak and irregular (El Zerey et al., 2009). The variations in temperatures are very marked. The area is characterized by one cold winter and a very hot summer. 30 years the maximum average temperature recorded (1965-1995) in August is of 31°C, whereas the weakest is recorded in January with 9°C (Figure 3). The bioclimat is of the semi arid type to arid, alternative fresh with cold (*sensu* Emberger) with an average annual pluviometry varying from 250 with less than 100 mm/an (Southern) (ANRH, 2003). The zone of study is classified as a very sensitive zone to desertification because of the importance of the climatic aridity, the unequal distribution of water, a strong sensitivity of the grounds to hydrous and wind erosion (Regagba, 1999). These last decades knew a notable reduction in the annual rainfall, with sometimes several consecutive years of persistent dryness. The reduction in precipitations is about 18 to 27% and the dry season increased 2 months during last century. The ork of Hirche in 2007 (Nedjraoui, 2008) bearing on a statistical analysis of the evolution of the rainfall of several steppe stations. Among these stations those of El Bayadh. The ork shows that this steppe zone is characterized by an increasing aridity. The climatic disturbances are a significant cause of the brittleness of these mediums, already very significant and causing ecological crises reflecting itself on the whole of the ecosystem.

The Map of the slope has been developed from the DEM of the of the study area by using the software MAPINFO. The slopes of the basin are classified in four classes. One notes that the strong slope is remarkable in the North of the basin where altitudes can go to 1200 m (more than 10%). This slope becomes weak in Southern extreme of the basin area (lower than 0.5%). An average slope characterizes the remained basin (from 5 to 10%) (Figure 4).

The ground of the area of study breaks up into five classes. Hard limestones which outcrop in the shape of directed furrows from West to East. These formations are thus in the interface with the South where the stopping rests. The gypseous marly formations drowned in the calcareous solid mass are overflowing along the hydrographic network. The filling sedimentary covering the other formed surface is of argilo-gypseous nature, it is remarkable in the center of the basin. The limestone grounds are condensed in the North of the basin and the area of El Ghassoul (Figure 5).

DATA USED

The data used are those of the ONM (National office of Meteorology) and of the ANRH (National Agency of the Hydrous Resources).They are a weather data which were

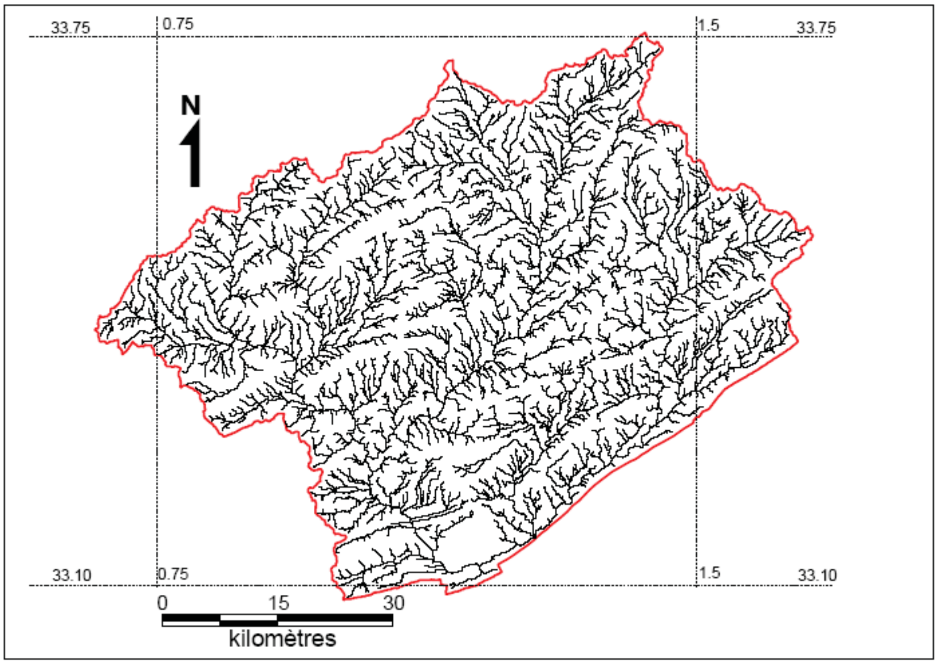
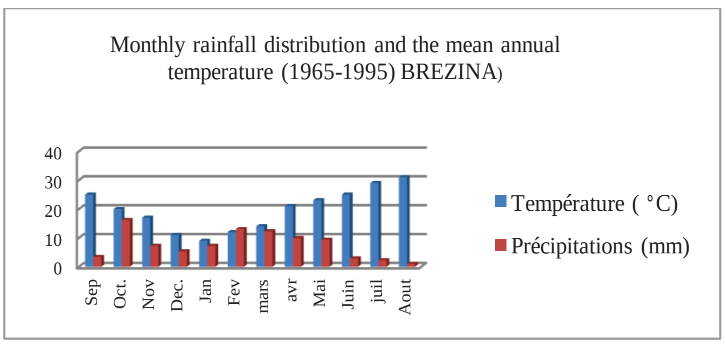


Figure 2. Hydrographic network of the zone of study.



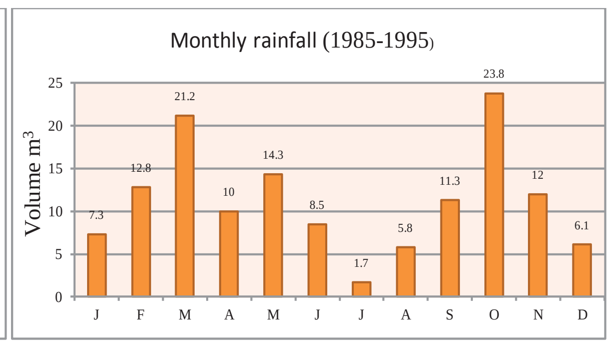


Figure 3. Representation of volumes precipitated and temperatures of catchment of Brézina (ANRH, 2003).

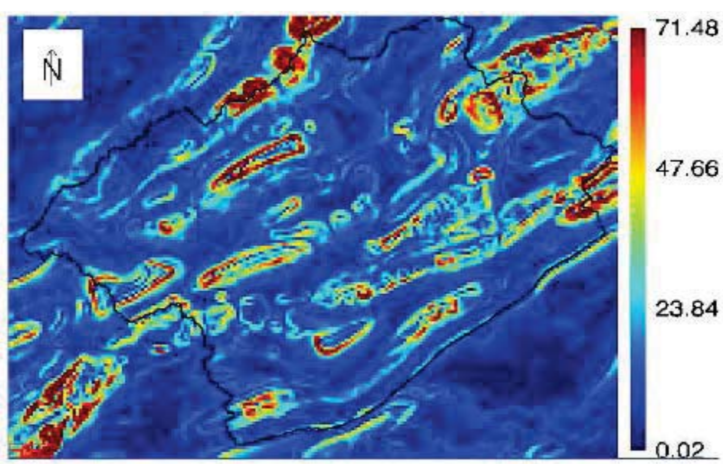


Figure 4. The slope classes of the zone of study.

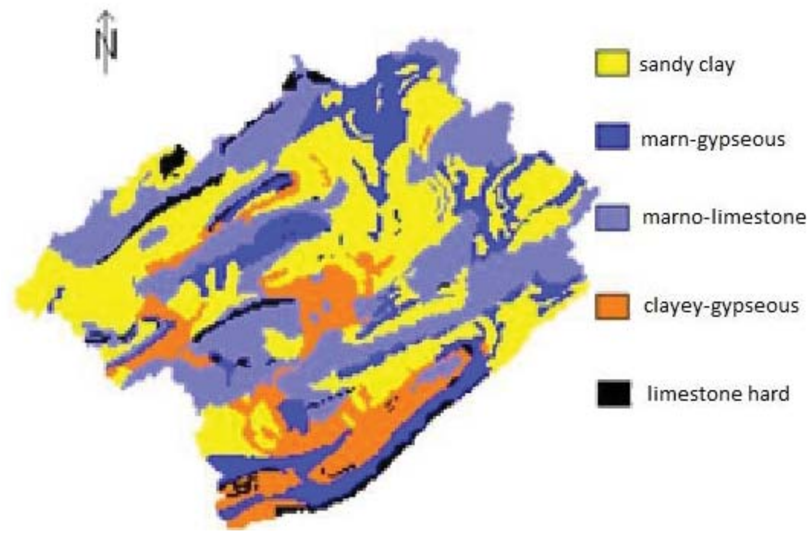


Figure 5. Different classes of sol of the study area.

Table 2. Reference weather stations.

Stations	ALT	EXP	LONG	LAT
EL BAYADH	1209.34	283.53	869.97	3748.51
STITTEN	1347.61	338.18	890.25	3751.66
AIN EL -ORAK	1312.20	74.03	347.41	3702.34
GHASSOUL	1139.61	212.55	890.68	3701.06
S-A-BEL ABBES	1243.82	182.14	918.95	3717.17
BREZINA	849.71	184.69	899.36	3669.37
ARBA-TAHTANI	1038.91	294.09	834.42	3665.95

collected from the localized stations in the basin considered (Table 2). These data relate in particular the measurements temperature of the air (minimal, maximum and average), the temperature in the ground (0.5 and 1 m), monthly precipitations , the moisture of the air and the speed of the wind. The satellite data are collected using the AVHRR (improved radiometer with very high resolution) which equips the satellite 14 with the National Oceanic and Atmospheric Administration (NOAA). These data illustrate measurements which concern the average of three images per week taken in the middle of the days between 13 and 15 h from January 1 to December 31 of the year 1998 (Table 3).

MATERIALS AND METHODS

Cartography of the properties in the Vis-PIR and the IRT

The sizes of the energy balance make it possible to extract the sizes from the hydrological assessment (Makhlouf and Michel, 1994; Allen et al., 2007). These sizes are: albedo, the index of vegetation [Normalised Difference Vegetation Index (NDVI)], and the temperature of surface (Vidal and Durand, 1993; Bastiaanssen et al., 1998; Jacob, 1999). The planetary albedo is the integration on the solar spectral field (0.3 - 3 µm) of planetary hemispherical reflectance (Taconet et al., 1986). The NDVI is calculated starting from the planetary reflectance in the red and the infra-red close relation. For the extraction of the surface temperature starting from the satellite images we use the Split window method. The latter is largely used for cartography of the surface temperature under the arid conditions (Hamimed et al., 2001; Balaji and Raghavan, 2000).

Méthode of cartography of the annual evapotranspiration on the scale of the watershed

To cartografy the evapotranspiration, the equation of the assessment of energy on the surface is applied. The latter is solved in this case by the means of model Surface Energy Balance Algorithm for Land (SEBAL). Several researchers confirmed the reliability of the use of this model (Bastiaanssen, 2000; Teixeira et al., 2009, Souidi et al., 2010; Yan et al., 2012). The extraction of the latent heat flow (the energy equivalent of the real evapotranspiration) is given by residual equation of the assessment of energy. This step leads to the cartography of the density flux of latent heat on the scale of the pixel. The office plurality gives thereafter the annual evapotranspiration on the scale of the studied basin.

Table 3. Data used of NOAA-AVHRR during the year 1998.

01 January	22 February	14 April	17 June	30 July	14 October
09 January	02 March	16 April	19 June	02 August	15 October
15 January	03 March	25 April	29 June	05 August	21 October
19 January	04 March	29 April	05 July	29 August	26 October
23 January	06 March	05 May	09 July	05 September	30 October
13 February	10 March	15 May	16 July	09 September	18 November
14 February	20 March	31 May	17 July	14 September	25 November
15 February	21 March	01 June	19 July	15 September	09 Décember
16 February	31 March	03 June	25 July	30 September	13 Décember
20 February	01 April	04 June	26 July	02 October	19 Décember
21 February	05 April	10 June	29 July	12 October	24 Décember

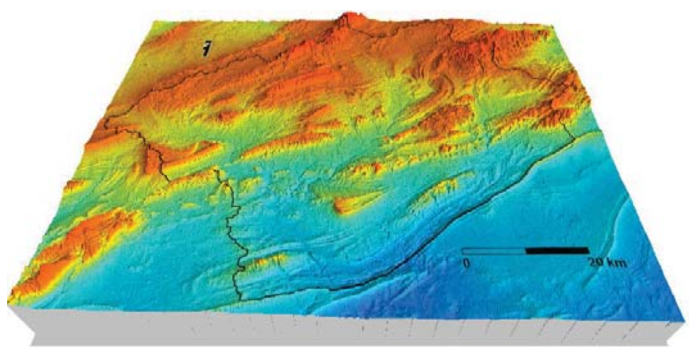


Figure 6. Representation in 3D of the study site.

Cartography method of the rainfall map

The space estimation of the rain rests on two approaches. First is called geostatistic approach. It is applied after having to identify the space structure starting from the values measured at the pluviometric stations (Hevesi et al., 1992). Second is based on the relations between precipitations and the characteristics of relief (altitude, smoothed altitude, the exposure, effects of site, the distance to the sea), (Mebarki, 2007; Meddi and Meddi, 2009; Mariam, 2010). In Algeria, Seltzer (1946) showed that the distribution of the rains evolves according to three configurations: It notes that the height of rain increases with altitude. It is higher on the slopes exposed to the wet winds than on the slopes under the winds. Of another dimension, the author notes that pluviometry increases from west to the east and decreases as one moves away from the littoral (Bouanani, 2004). The cartography of the precipitation of the zone of study is obtained by a mathematical model worked out by the combination of the sizes of relief (altitude, longitude, altitude and the exposure).

$$P = 0{,}19045.ALT + 0{,}20079.EXP + 0{,}0539.LOG + 0{,}9613.LAT - 3636{,}4604$$

Method of cartography of the streaming and the contribution of water

The coefficient of streaming is a function of the slope (Figure 4), of the vegetable cover and the classes of the ground of the zone study (Figure 5). Maps of synthesis of the type "evaluation of the coefficient of streaming" are elaborated starting from the MNT (Figure 6) (Bonn, 2005). Thus, the combination of the maps of the slope and the ground gives the values of the coefficient of streaming of the zone of Brézina (Table 4). The latter are calculated starting from the indications given by Mallants and Feyen (1990) and Bonn (2005).

For the calculation of the drained areas we utilize in entry the hydrographic network map (Figure 2). Each pixel is affected by number of pixels located upstream according to directions' of flow. For a pixel given, the blade of stream water equal to the rain fallen on the considered pixel by the coefficient from streaming of the considered pixel. A calculation matrix of the streamed strip water is used for all the pixels composing the basin of Brézina (Figure 7). For the development of the map of the liquid contribution of the catchment area, a combination of the layers of information is used. This combination is established by multiplying each pixel of water strip obtained by its surface. That is done by using a program in C++ which utilizes in entry the image of the streamed water strip. This program was created by the author to facilitate the calculation which involves precipitation and evapotranspiration data as input as to indicate the figures (Figures 7and 8). The calculation is repeated over the entire surface of the watershed which is composed of 5934 pixels.

Cartography of the infiltration

The quantity of water infiltrated on the level of the basin is calculated starting from a calculation program. This program utilizes two images in entry, that of the rain and that of the streamed water strip. A matrix of calculation of the quantity infiltrated for each pixel is thus worked out (Figure 8).

Table 4. Runoff coefficient for different geographical conditions of the study area established from methodology of BONN.

Soil classification	Slope %	Clay-sandy	MARN-gypseous	Marno-limestone	Clayey gypseous	Limestone hard
Dense canopy	<0.5	0.215	0.6	0..685	0.7	1
	0.5-5	0.285	0.61	0.7	0.725	1
	5-10	0.365	0.635	0.72	0.75	1
	>10	0.44	0.7	0.785	0.8	1
Cover little dense (herb)	<0.5	0.215	0.6	0.685	0.7	1
	0.5-5	0.26	0.605	0.7	0.725	1
	5-10	0.35	0.615	0.74	0.775	1
	>10	0.4	0.615	0.765	0.8	1
Bare soil	<0.5	0.515	0.75	0.835	0.85	1
	0.5-5	0.555	0.77	0.855	0.87	1
	5-10	0.615	0.8	0.885	0.9	1
	>10	0.735	0.86	0.945	096	1

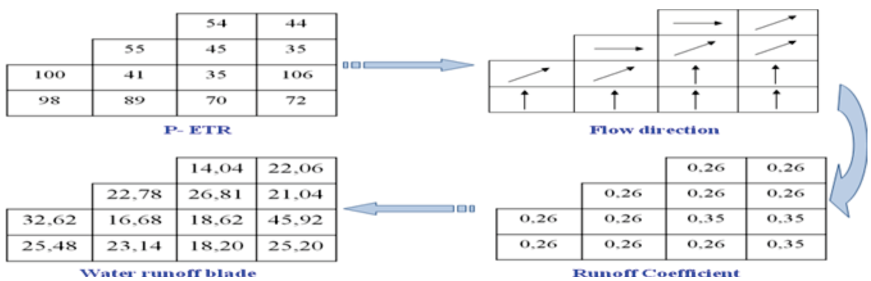


Figure 7. Extract of the matrix of calculation of the blade of runoff water of the watershed of brézina on the basis on images NOAA-AVHRR (1998).

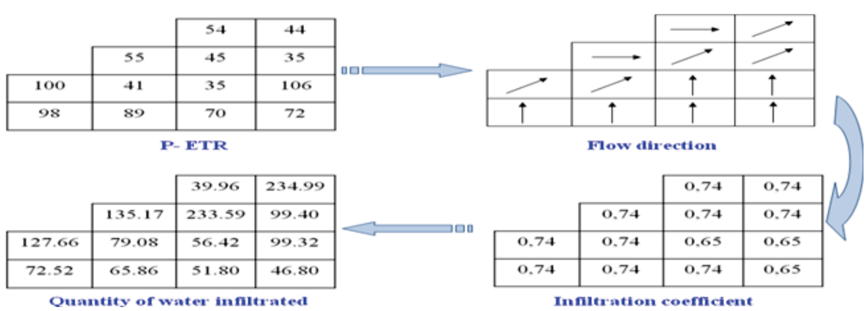


Figure 8. Extract of the matrix of calculation of lthe infiltration using the images NOAA-AVHRR (1998).

RESULTS AND DISCUSSION

While being based on the various data in the visible, the infra-red close relation several maps are elaborated: The maps of the index of vegetation show that the vegetable cover of the catchment area of Brézina is relatively weak. This much degraded cover present bad quality of density of covering and generation. Three types of cover thus characterize the catchment area as shown in Table 5.

The weakness of vegetable cover in this steppe zone is confirmed per M (Benslimane et al., 2008). The image of temperature of average surface of the basin of Brezina

Table 5. NDVI of the basin studied.

The values of NDVI	Type of Cover	Positions
NDVI> 0.25	Coverage relatively dense	North of Basin
0.15-NDVI-0.25	Medium coverage	The center of the basin
NDVI< 0.15	Low coverage	South of Basin

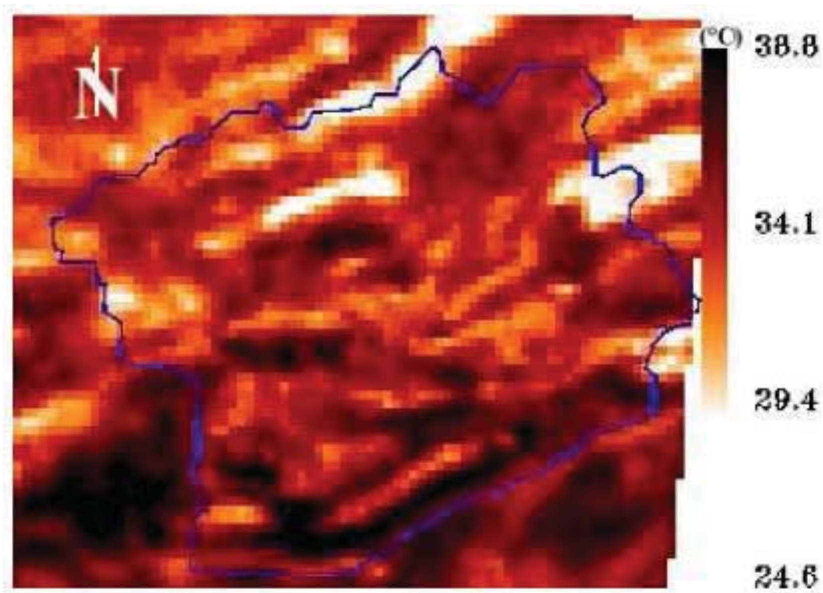


Figure 9. Average annual temperature of area by using the Split Window method.

is illustrated in the Figure 9. Compared to the little covered grounds, the average temperature is more significant on the naked ground. This temperature also varies according to altitude; it is weak in the mountains that on flat surfaces. Validation of the Split Window method for the estimate of the temperature of surface is given by several researchers.

The application of model SEBEL to the level of the site of the study makes it possible to note that the evapotranspiration is a function of the vegetable cover and the geographical position (Figure 10). A strong evapotranspiration is observed in the dense zones and reached 68 mm / year. However, it decreases by North to the South (South-western of the basin) where are the naked zones, where it does not exceed 10 mm / year. As for the influence of the geographical position, the data point out that the evapotranspiration increases in the North-western part of the basin to reach the 40 mm / year value. However it decreases in the South-eastern zones, and does not exceed 20 mm / year. The average value of the evapotranspiration thus deduced (68 mm/year) approaches with that founded by the Turc model (72 mm/year). The validity of model SEBAL is thus confirmed.

This model gives similar results found to those for the ground of experimentation (Bolle et al., 1993; Goutorbe et al., 1994; Van den Hurk et al., 1997; Bastiaanssen et al., 2000, 2005; Souidi et al., 2010; Yan et al., 2012).

The approach based on the relations between precipitations and the characteristics of relief gives the pluviometric map of the area of Brézina (Figure 11). This map shows that the three laws of Seltzer are respected. The height of the rain increases with altitude. The pluviometric gradient of altitude is significant in the majority of the basin. The zones in relief are sprinkled than the plane zones. Moreover, one clear pluviometric degradation from North to the South is remarkable. The station of El bayadh located at the North of the catchment area and of which altitude is 1209 m, receives more than 150 mm, whereas to 47 km in the South, the station of El Ghassoul receives just 110 mm .The difference becomes more significant as one approaches the southern areas of the basin. The station of Brézina which is in Southern extreme of the basin, the records just 30 mm. One also notes a sensitive degradation of rain from the West to the East. The station of Aïn Orak receives an average height of 100 mm, whereas in extreme east of the basin, the station of Sidi Ahmed Bel-Abbes records only 80 m for

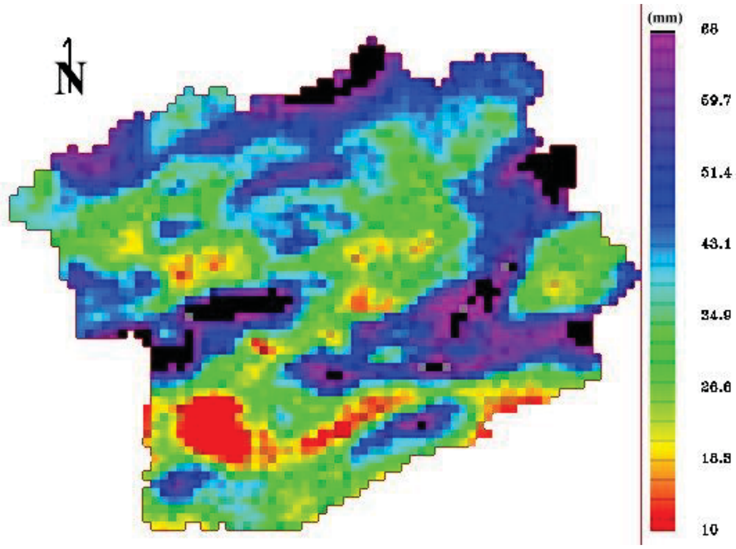


Figure 10. Map of evapotranspiration of Brézina after application of the model SEBAL.

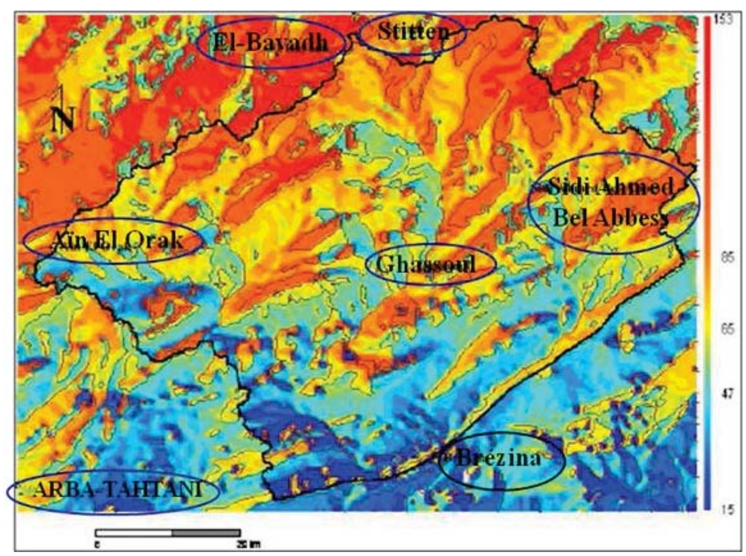


Figure 11. Map of rainfall in the study area of the year (1998).

the same altitude. The quantity of rain precipitated on the West side is thus more significant than on East side .The basin of Brézina thus presents various quite distinct pluviometric zones.This is with the diversity of the relief just like that of the conditions of the organization of the hydrographic network and valley and orographical provision. For the year of study, the results are consistent with data of ANRH (ANRH, 2003). On the other hand, the work of Hirche in 2007, (Nedjraoui, 2008) relating to the same region gave similar results. The character of drought during the year study is indicated by ANB (1999) and (El Zerey et al., 2009).

The map of the coefficient of runoff (Figure 12) makes it possible to note that this parameter is very high on the level of the calcareous bar in the North and the Southern interface of the basin. The permeability of the ground where is the dam is reduced. The value of the coefficient of streaming is very low for the sandy grounds (about 0.26). What generates thereafter a strong infiltration on these grounds. In the rest of the basin the value of the coefficient of streaming is moderate (from 0.3 to 0.6).

The irregularities of precipitation, the diversity of the types of ground, the strong slopes, disturb the distribution of the streamed water strip on the catchment area (Figure

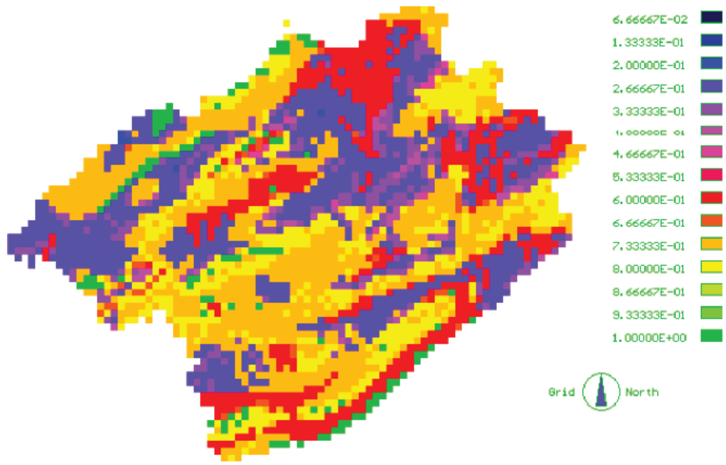


Figure 12. Runoff coefficient of the study area.

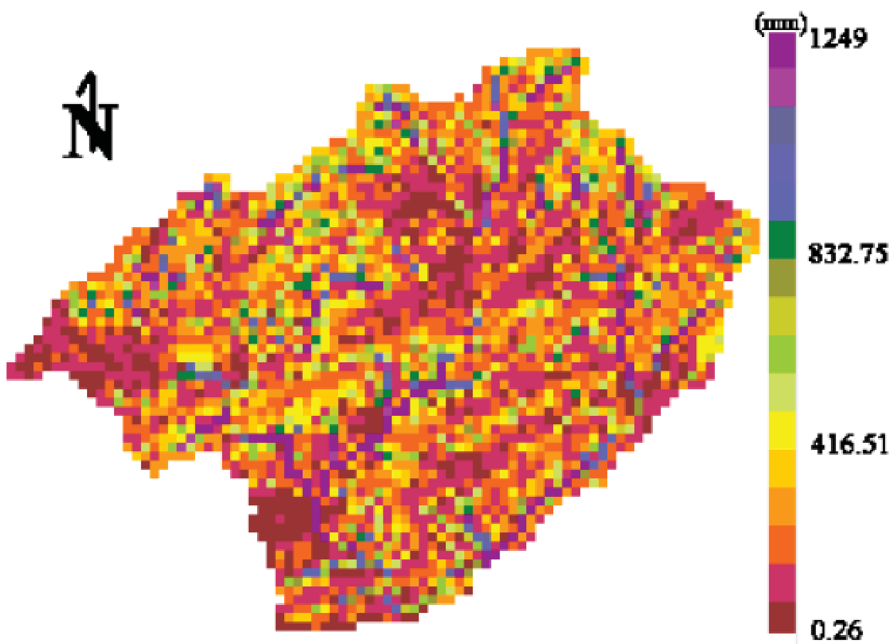


Figure 13. Map blade of runoff during the year.

13). This disturbance is remarkable on the pixels having a stronger precipitation and a coefficient of higher streaming. The water strip decreases by North to the South and by the West to the East where precipitations are higher. With the discharge system, the cumulated value of the received water strip reached 784 mm / year. It is about a small quantity compared to the surface of the basin. What explains the importance of the infiltration in the basin. The volume of water stored in the dam is thus systematically weak.

During the year 1998, the calculated contribution, by extraction of the parameters of surface starting from the satellite images, has the scale of the catchment area of Brézina is of 0.05 m^3 / S. the same value was recorded during year 1982/1983 (ANRH, 2003). The average of the flows measured by the services of the ANB, during a series of observation of 30 years , being spread out between 1948 and 1986, gives an average of 0.91 m^3 / year (ANB, 1999). The year of study (1998) seems thus an overdrawn year. Indeed, Nejrauoi (2008) confirms the tendency of dryness during these last decades.

Regularized volume by the dam Brézina, with the downstream, is evaluated at 6.5 mm^3 / year (ANB, 1999) distributed between the water needs for the AEP for

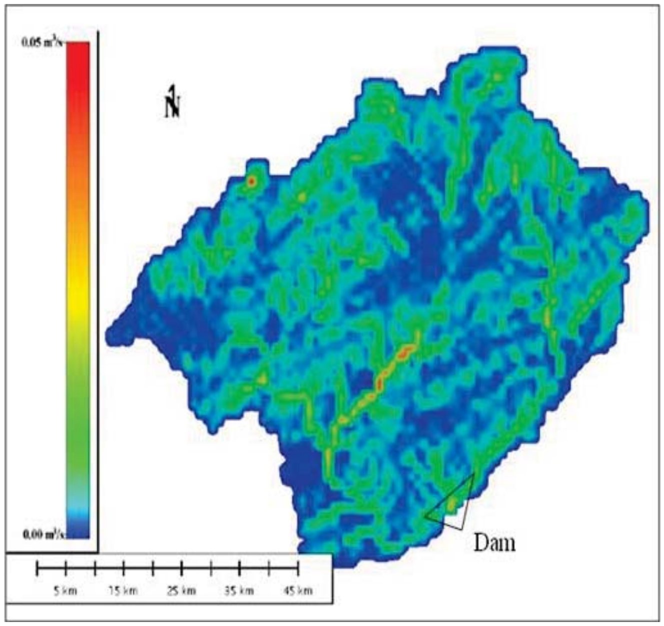


Figure 14. Map of liquid supply in the study area.

Brézina: 0.62 Million m^3/year, for 9 429 inhabitants; the requirements of water for palm grove:1.47 Million m^3 / year (174 ha); and the needs for the new perimeter of Daiet El Bagra:4.41 year/m^3 Million (330 ha).

In addition, it is to be announced that the data relating to the solid contributions, quantified by the services of the ANB, are estimated at 1.2 tonnes/m^3 (ANB, 1999). Brittleness of the lithological context of the catchment area of Brézina thus the strong socio-economic pressure of this area with agropastoral vocation is the principal factors of the impoverishment of the soil. With these constraints, the irregularities of the exceptional climatic parameters are added (Figure 14).

The crossing of the various maps (type of ground, vegetable cover and relief) of the zone of study gives the map of infiltration (Figure 15). The map obtained makes it possible to note that the infiltrability is related to the permeability of the ground. A strong infiltration characterizes the majority of the pixels of the catchment area going to 300 mm. This quantity of water is considerable compared to the quantity of stored water each year. This report is directly related to the type of the ground, which can be fissured, and to the presence of the caves to a low depth.

The phenomenon of the infiltration is thus posed like a major concern for the managers of the dam of Brézina. One finds oneself in front of a critical situation, where the management of surface waters in steppe medium by this type of work, is little adapted compared to the hydrological assessment recorded with the discharge system of the catchment area. Such a situation challenges a priori on the utility of such an investment in a similar site.

ANALYZE OF SENSITIVITY AND CONCLUSION

At the end of this work, the various parameters of the hydrological assessment are cartographies. Infact, rain, streaming, the infiltration and the evapotranspiration. For the analysis of the sensitivity one based on the average values of the various values on the scale of the catchment area. With regard to pluviometry, a good correlation between the latter and the characteristics of the stations are observed and this in spite of a low density of the pluviometric network (coefficient of correlation reaches 95%). This justifies the validity of the selected method.

In what concerns the evapotranspiration, the value deduced starting from model SEBAL (68 mm) approaches with that found by the model Turc (72 mm) (TURC, 1954). The recourse to the application of this model is justified by the fact of nonavailability of measurements on the ground of the evapotranspiration. The choice of the Turc model is justified by the fact that in keeping a hydrological approach, it adapts to slopes basins to calculate the ETR. Evaporation is calculated starting from this equation utilizing the average value of the annual rain and the annual temperature of the average air estimated starting from the satellite data. The error is 5%.The error value is low. That what justified the validity of the choice of model SEBAL for the cartography of the evapotranspiration on the scale of the catchment area.

The method of estimation of the two key parameters of the hydrological assessment the evapotranspiration and pluviometry is validated. This validity extends to the values from the infiltration and the streaming. These last

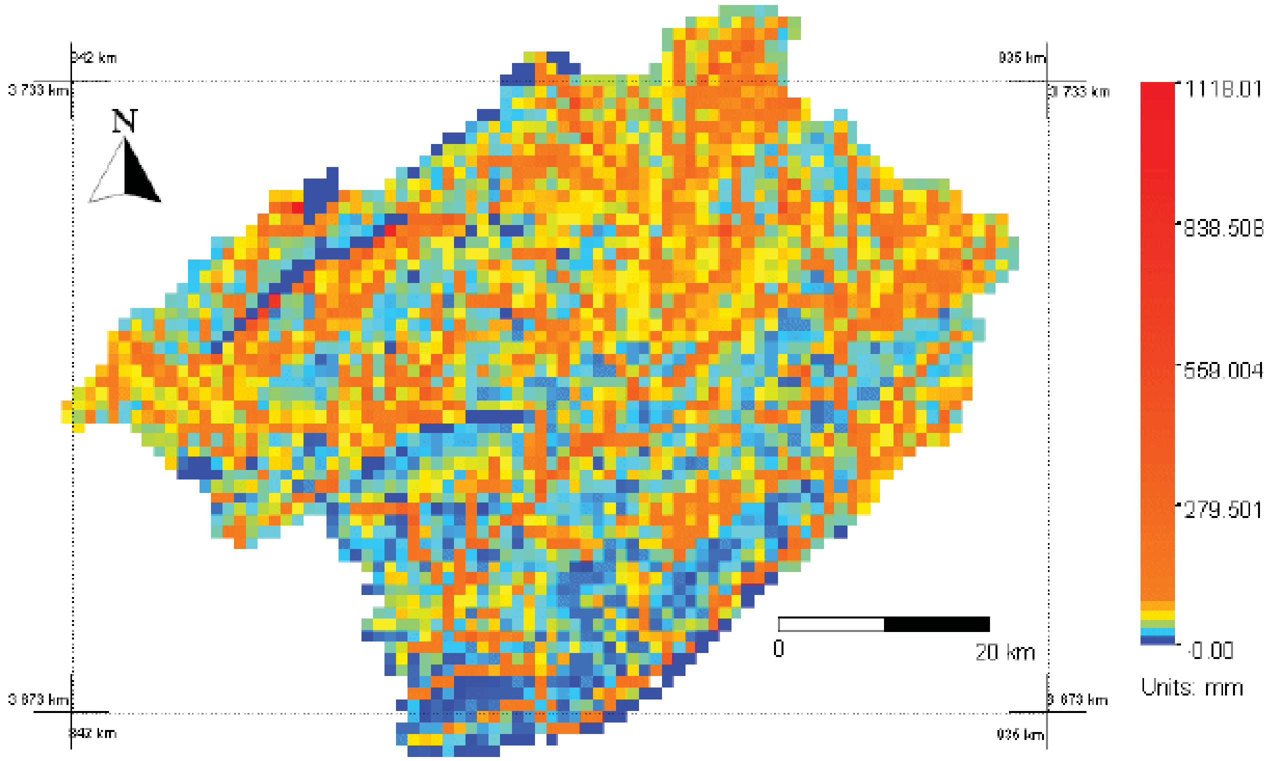


Figure 15. Map of infiltration of study area.

are deduced starting from pluviometry and from the evapotranspiration. The cumulated value of streaming on the scale of the pixel exceeds the value (600 mm). Whereas that cumulated relating to the infiltration on the scale of the pixel reaches (500 mm).

The same remark can be associated with the methodology of estimation of the liquid contribution. The value of this last is of 0.05 m^3 / S. This value is comparable with the data collected by ANB (1999) whose average over the period 1974-1984 is equal 0.05 m^3 / S. The catchment area belongs to an area slightly sprinkled, located between the zones at desert tendency. The occasional appearance of violent downpours cause significant streamings where the major part of water is concentrated in the first twenty hours. The risings have place in autumn and in spring but there are also those appeared in summer.

The purpose of this contribution was to contribute to a development of methodologies making it possible to integrate the teledetection and the GIS into the approaches used to improve the estimates of flows of energy and mass on a regional scale. Consequently, to estimate the evolution of a steppe area in terms of resources water. The data resulting from NOAA-AVHRR allow the follow-up of the annual variations of the hydrological assessment. The satellite observations convey rich information. It is starting from this study relating to a simple and paramount interrogation "How this potential of information can it be used for the evaluation of the water resources of a steppe area?".

In prospect, it is considered to have a continuous follow-up of the hydrological assessment. That by approaching the quantification of solid transport in the area catchment of dam of Brézina which reveals an extremely worrying aspect. The managers of the dam and consequently safeguards the water resources which become more in rarer in this steppe area and oasis of the Algerian south west.

Conflict of Interest

The authors have not declared any conflict of interest.

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