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Water associated with gas production at Risha Gas Field

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ABSTRACT

Analyzed chemical and occurrence state of the formation water Risha Gas field based on geological features of reservoirs. It is necessary to determine the source of water, and depending on that to look for the proper solutions, either changing production strings, because of corrosion effect on the tubing, pumps or surface equipment. We have excluded most of the water samples analysis from the evaluation because of their variability in pH values and the wide difference between cations and anions values. Well logging tools interpretation for Risha gas wells show that the gas producing zone is at 2600 m where the formation water below 3200 m. The stratigraphic section between 2600 and 3200 m, the interval has no formation water. Interpretation results of water analyses associated with gas production after ten years of production by Stiff diagram shows that their water type is magnesium chloride and calcium chloride type, where their water patterns are more or less similar to the water pattern of (Campanian - Santonian formation) of water wells.

***Key words**: Risha Gas, Formation water, Stiff diagram, Interpretation results.*

Introduction

The water problems in most of all oil and gas wells, especially when the wells become older or because of leaks in casing or faulty cement. Main water problems in producing oil and gas wells because by water entering to the well, so as water enters the well, a detail study should be carried out for all available data about water conditions and history of the well concerning mechanical problems in completion procedure, to minimize operation cost (Parks, 1925). The flooding water causes a decrease in production or even stop production, and it may damage the production strings within the well, production pipe, gas station treatment units and compressors because of corrosion effect.

Therefore, it is necessary to find out the sources of water, either it comes from deep formations through deep faults, comes from the upper formations through faults or through the corrosion casing, or because of leaks of cementing. Water entering some of these wells might be a mixture of different waters from different formations.

The source of formation water either is that which was trapped during deposition of sediments and the content of water depend on depth and compaction of the sediments, so as increasing depth and compaction the water content decrease, another source is the rainfall in the outcrops formations which was depended on the petro-physical properties of the formations, porosity and permeability (Ostroff, 1967). The source of water flooding might be from the above formations, or from the deeper formations, or they associate it with gas, or water below the gas or oil within the same reservoir.

Stiff diagrams graphically illustrate the relative abundance of major ions, creating polygons with distinctive shapes. Cation and anion concentrations are first converted from mg/l to mill equivalents per liter (meq/l) to account for differences in the charge of different ions, and are then plotted on horizontal axes, with cations to the left of the zero point and anions to the right (Lee *et al.*, 2007).

The physical and chemical parameters of surface water play a significant role in classifying and assessing water quality (Lokhande and Mujawar, 2016) that water quality changes of the production wells, during pumping test duration. The water quality is excellent and acceptable for drinking purposes, according to the Jordanian water standard 2008, and EU drinking water standard 1998 (Mehaysen Ahmed Mahasneh, 2017). It is necessary to determine the source of water, and depending on that to look for the proper solutions, either changing production strings, because of corrosion effect on the tubing, pumps or surface equipment's, because casing corrosion will be opposite formation water, or water entering well through the bottom of the reservoir which can be stopped by changing method of production holding back pressure on the well (Ivan Barnes and Hem, 1973; Henry and Stiff, 1951), sometimes it might be useful to use soap sticks or plungers to remove water from the well.

The purpose of chemical water analysis is to provide a basis from which the source of any water produce with oil or gas could be determined and to detect and locate a leak in well and to help in solving a corrosion problem (Reistle, 1927; Van Everdingen, 1968).

In Risha gas wells, during drilling gas wells, there was no sign for formation water above 3200m, except the shallow aquifers from surface to depth about 600m. But when starting new techniques of horizontal drilling, and reaching the reservoir at depth 2600 m, there was a water phenomenon, later after production for ten years the quantity of water produced with gas has been increased and effects gas production was in other wells stopped gas production because of the increasing water columns in these wells, in other hands, water effect the gas station pumps, production strings. So various water samples have been collected from gas wells, water wells, gas station treatment units, and analyzed by the Ministry of energy and Royal scientific society labs. And have been interpreted by using Stiff pattern, to classify the water for different formation and trying to compare the gas water samples with them, to find out the source of that water. The aim of this study to determine the types of water in the Risha area, where their water patterns are more or less similar to the water pattern of (Campanian - Santonian formation) of water wells.

Study Area

Risha area located in the northeastern part of Jordan, occupies an area of approximately 7600 km^2, bounded in west by the Basalt plateau, in the north, east and south by Syria, Iraq, Saudi Arabia borders respectively Figure 1.

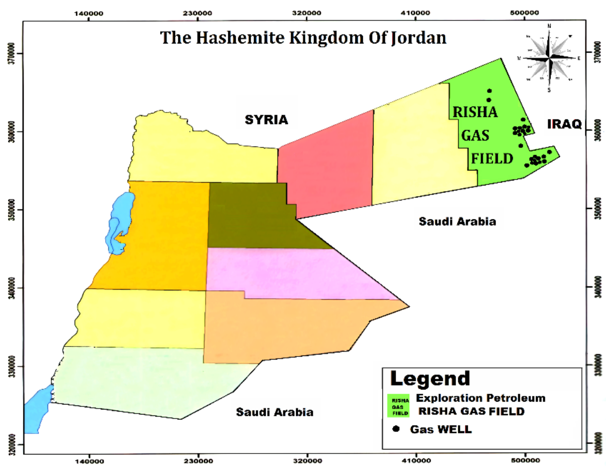

Fig. 1. The study area Risha Gas field (NPC, http://www.npc.com.jo/index.php?lang=en)

Stratigraphy

Risha area represents the northeastern plateau of Jordan, which is part of the unstable shelf, that lies between stable Nubo Arabian platform and the Asian branches of the Alpine mobile geosynclines, in this region sedimentary sequence over 5Km, ranging in age from Paleozoic to Eocene Figure 2.

The important features in the Risha stratigraphic sequence is the occurrence of a thick Mesozoic wedge (thickening and dipping towards the west) of clastic/ Carbonate Sediments overlying a thick Paleozoic wedge (thickening and dipping towards the east) of clastic Sediments with angular unconformity, while the Mesozoic wedge thickens and dip to the west, the Paleozoic wedge thickens and dip dips to the east.

Structure

The surface structural pattern of the area has been

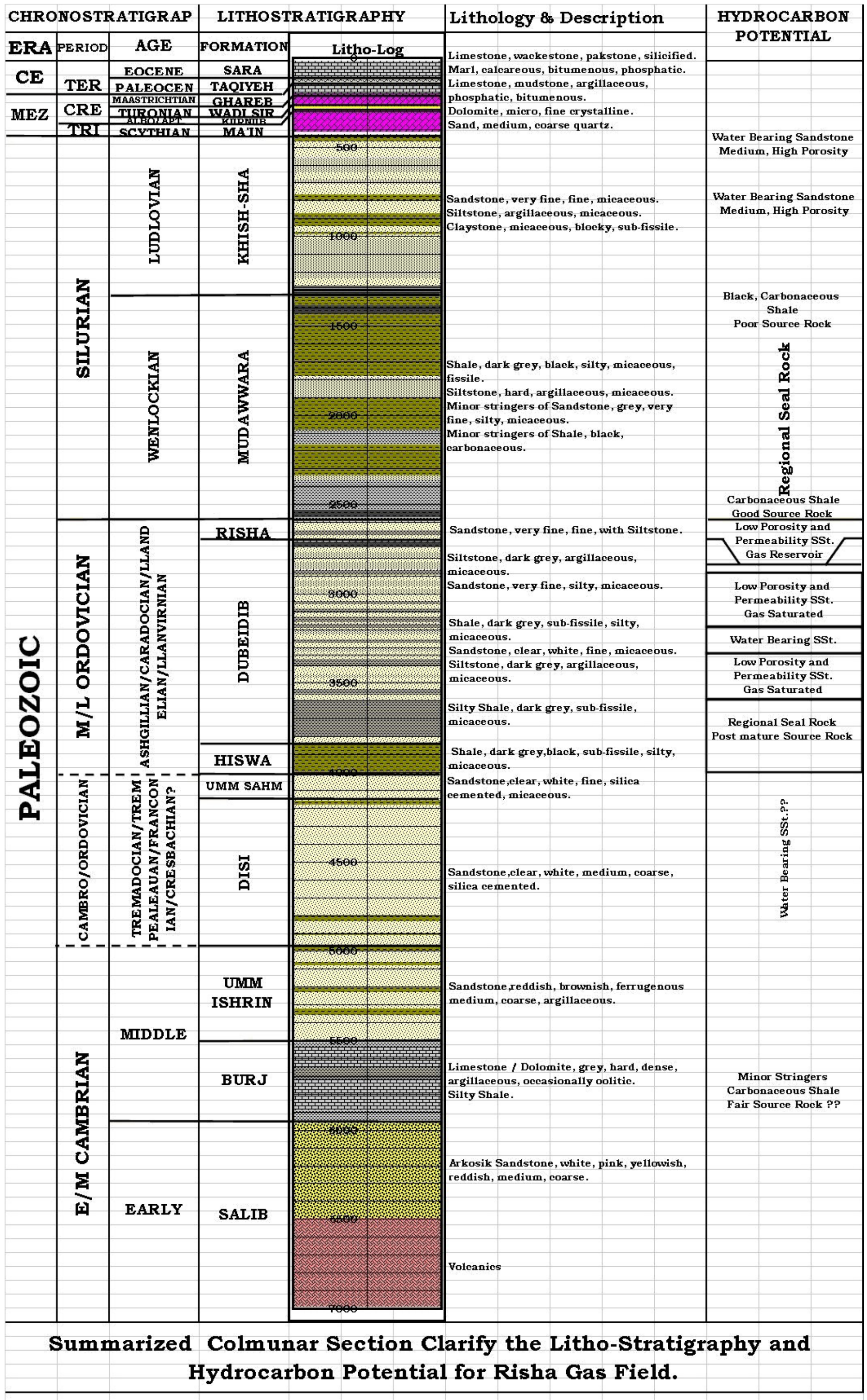

Fig. 2. Lithostratigraphy cross-section and hydrocarbon potential for Risha Gas field ((NPC, http://www.npc.com.jo/index.php?lang=en).

described by Heimbach, 1970 and he noted that the occurrence of Wadi and mudflats reflect the dominant trends of tensional joints and faults. The structures in the north-east have a dominant (north, west, south, east) tend and to the west, these same trends are intersected by a structure trending in a north-south direction Figure 3.

There is as far the close relationship between surface observation and seismic interpretation as the faults are concerned, these faults are characterized by small throw, they could be recent in age and we could relate them with regional deformation. The structure of the Risha formation is relatively simple, the upper shows a gentle dip to the west and north with gentle anticlinal fractures present over the Risha area.

Seismic markers dip to the northeast and southwest, resulting in large but very gentle structures. Many faults and fractures observed on seismic extended from Cambro-Ordovician through the overlying Silurian shale which influences the reservoir Figure 4.

Methdology and Procedure

Stiff diagrams graphically illustrate the relative abundance of major ions, creating polygons with distinctive shapes. Cation and anion concentrations are first converted from mg/l to mill equivalents per liter (meq/l) to account for differences in the charge of different ions, and are then plotted on horizontal

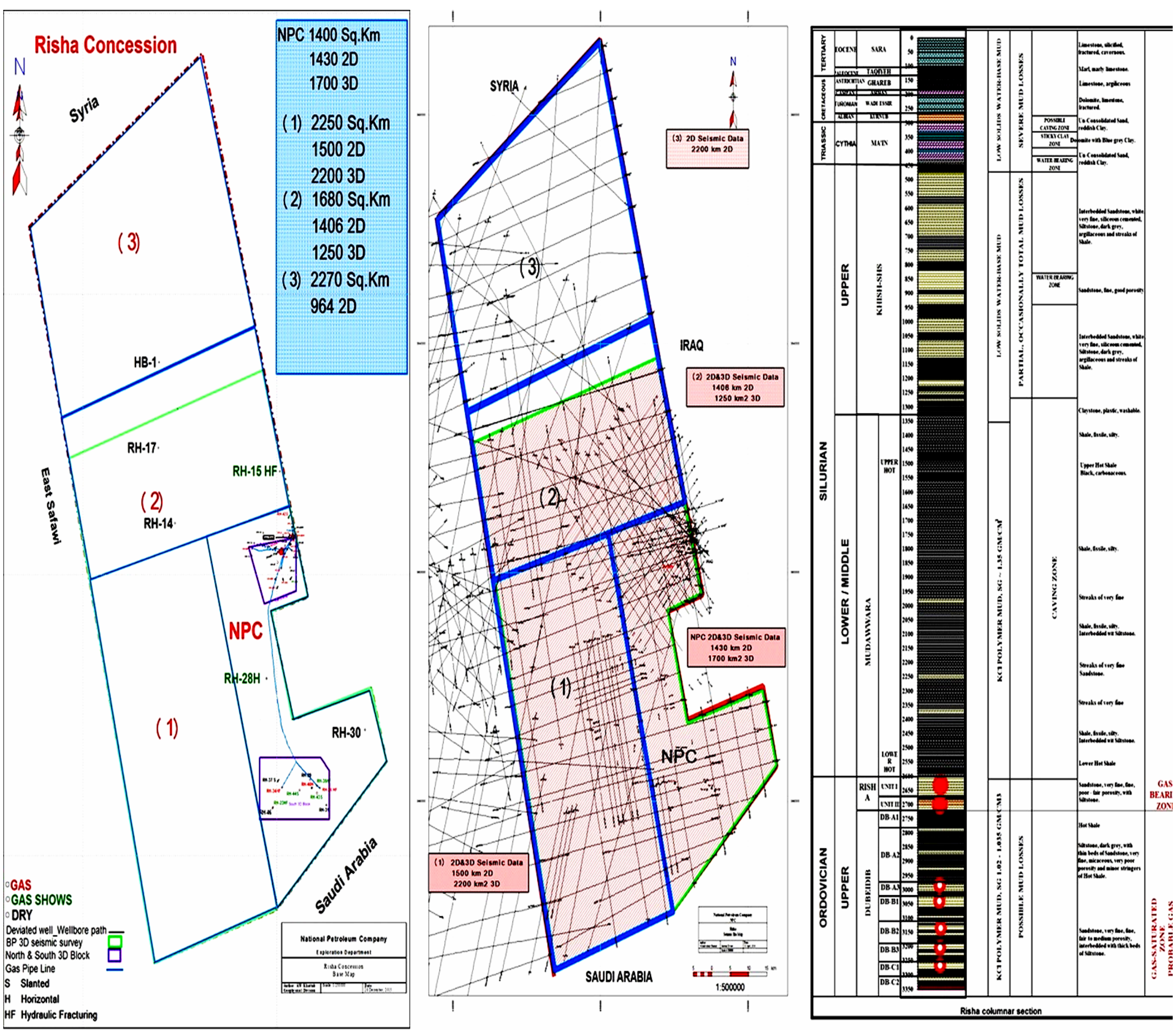

Fig. 3. Structures Map Risha Area ((NPC, http://www.npc.com.jo/index.php?lang=en).

axes, with cations to the left of the zero point and anions to the right. Most commonly, sodium and potassium are plotted across from chloride, calcium is plotted opposite carbonate and bicarbonate, and magnesium is plotted opposite sulfate. This arrangement reflects potential or expected mineralogical sources of each of these dissolved ions in groundwater. The points are then connected to form a polygon, the size and shape of which visually indicate the total ionic concentration and the relative importance of the individual ionic species.

Water Analysis Application

Application of water samples Laboratory analysis is varied, the stiff application of water samples. laboratory analysis is varied, the stiff diagram could show the effects of the mixing of waters, as contamination of formation water with drilling mud, and it is an important factor during well electrical logging tools interpretation or to find out the source of water, also its important factor to distinguish different formation water, and sometimes water appearing after fracturing or acidizing of well is doubtful.

Water from an unknown source can be compared with the analyses of previously known water and distinguished from the production of water with gas or oil because of the leak of casing or cement failure, a stiff method by graphical water from an unknown source can be compared with the analyses of previously known water and distinguished from the production of water with gas or oil because of the leak of casing or cement failure, Stiff method by graphical the presentation could distinguish water of various formations.

In plotting water composition on maps, it is convenient to show the analyses in the form of patterns. One of the most commonly used patterns was devised by Stiff. The cations are plotted to the left on three or four lines, and the anions are plotted to the right. Milli equivalents are usually plotted on a logarithmic scale (Stiff, 1951).

Sample from Risha field

Each formation watercontains water with different chemical properties from the water of other formation, chemical laboratory analysis will quid from which formation it is coming and identification source of that water, so it will be the first step to put

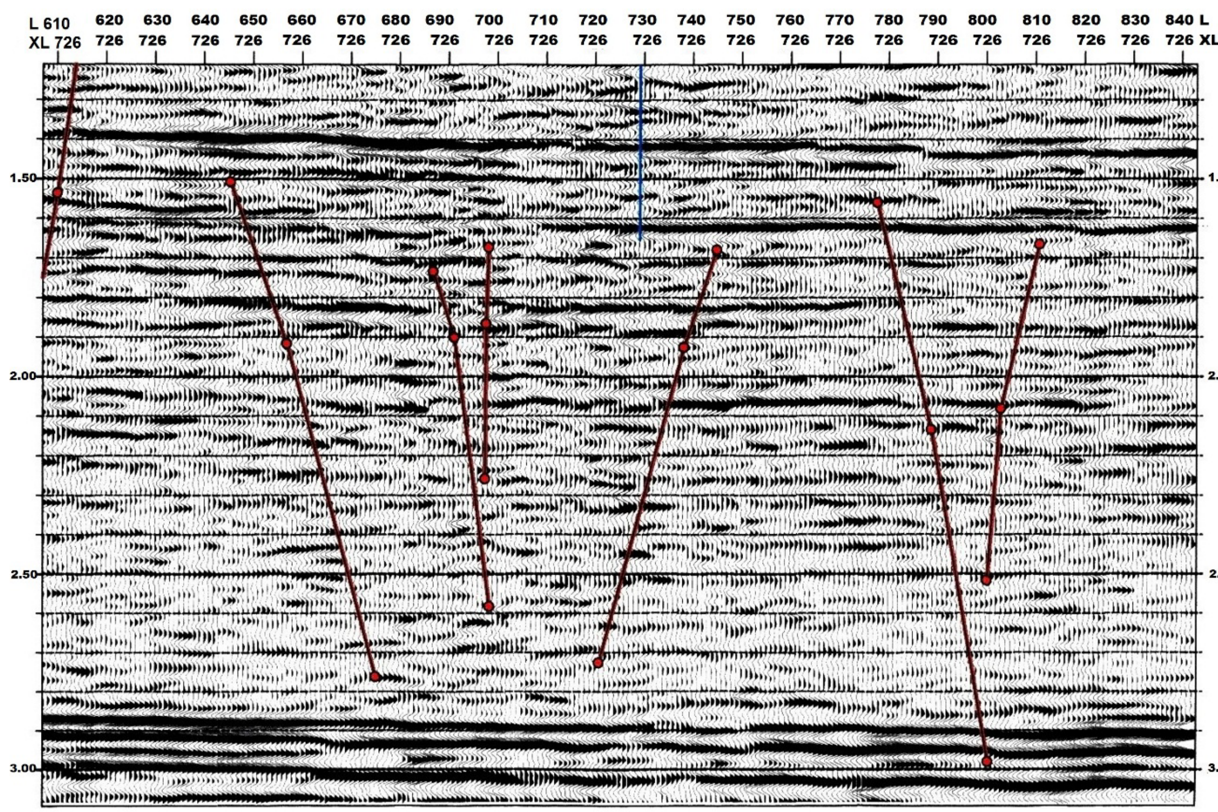

Fig. 4. Seismic Cross Line Risha Area ((NPC, http://www.npc.com.jo/index.php?lang=en)

a plane for repairing the well.

In Risha area, several water samples from water wells and gas station treatment plant have been analyzed by Robertson Research center (UK) Water authority laboratories and Royal society laboratories (Jordan). And compare between them based on the values of their chemical constituents to understand either the water samples are a formation water, gas condensate water, or contaminated water because of the leaks of casing (high corrosive) or faulty cement.

Results and Discussion

Interpretation of water samples analysis

Stiff diagram has been done for representative samples of water wells such, RH water well A, water well B, and Semica water wells, Risha well, and gas station treatment plant water to see their formation pattern and to compare between them to find out the source of water which was produced with gas and to find the proper treatment solution to stop water flooding. So the interpretation water samples analysis are as below:

Water wells samples

Water wells are producing from limestone and dolomite formation of Campanian - Santonian, and interpretation of analysis result by Stiff diagram show that the type of water is chloride magnesium, $\frac{rCl^- - rNa^+}{rMg^{2+}}$ (2.48, 3.12, 3.32) and this type of water is a direct indicator for the presence of oil.

These waters, however, are sometimes found in petroleum collectors. and this water is characteristic of the transition zone between a hydrodynamic area which becomes more hydrostatic in the deeper part of the basin Table 1, Figure 4.

Table 1. Results of water samples analysis.

	Analysis of water wells		
	RHWLLA	WLLB	Smeca Well
TDS	1800	865	1014
pH	7.8	7.7	7.15
SP.GR.		1.006	
Na	207	230	112
K	8	30	7.5
Ca	90	180	110
Mg	68	100	41.5
Cl	376	542	250
HCO_3	353		170
SO_4	160	422	220

pH is of major importance in determining the corrosively of water. The value of pH ranges between 7.15 to 7.8, it means that is basic, the pH value of most field water increase due to the taking apart of HCO_3^- into CO_3^-.

The total dissolved solids (TDS) between 865 to 1800 mg/l in the water measure of the total amount of minerals dissolved in water, therefore a very useful parameter in the evaluation of the quality water for drinking. Sodium (Na^+) with a concentration

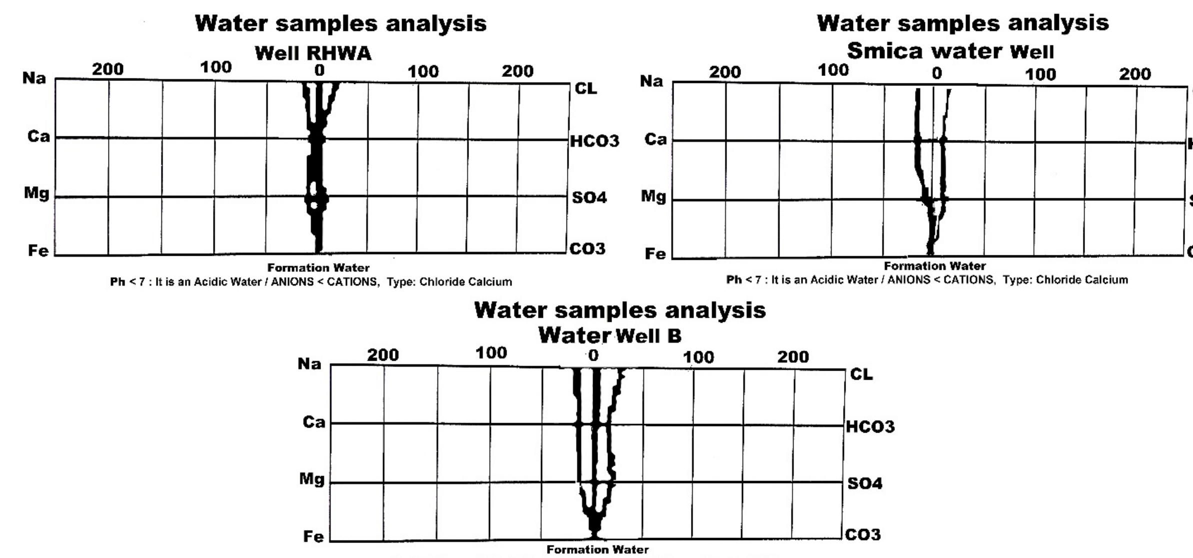

Fig. 4. Stiff diagram water samples analysis.

range 112 to 230 mg/l. Ratio between Ca^{+2}/ Na^{+} was 0.43 to 0.982, the type of water is Chloride Magnesium.

Calcium (Ca^{+2}) with a concentration between 90 to110 mg/l and magnesium (Mg^{+2}) 68 to 180 mg/l, the major natural sources are soils and rocks containing limestone and dolomite and gypsum ($Caso_4^{-2}$).

The main causes of hardness and of boiler scale and deposits in hot water heaters.

Bicarbonate (HCO_3^{-}) with a concentration in range 170 to 353 mg/l and CO_2 products of the solution of carbonate rocks, mainly limestone ($CaCO_3$) and dolomite ($CaMgCO_3$) by water containing Carbone dioxide (CO_2) may affect to control the capacity of water to neutralize strong acids.

Bicarbonate of calcium and magnesium decompose in steam boilers and water heaters to form scale and release corrosive carbonate dioxide gas. In combination with magnesium and calcium, it causes carbonate hardness.

Sulfate (SO_4^{-2}), gypsum and other rocks containing sulfur (S) compound range between 160 to 422 mg/l. In a certain concentration gives a water a better taste and, at higher concentrations, has a laxative effect. In combination with Calcium forms a hard calcium carbonate scale.

R-1 Well Samples

Interpretation of analysis result by a Stiff diagram for collected Sample from the Triassic formation during drilling (R-1 well at depth 1400 m) shows that the water type is a chloride of calcium type and this water mostly occurs in deeper zones, which are isolated from the infiltration water and are hydrostatic. Table 2, Figure 5.

Table 2. shows that the pH is of major importance in determining the corrosivity of water. The value of PH ranges at 7.2, it means that is basic.

The total dissolved solids (TDS) range 2690mg/

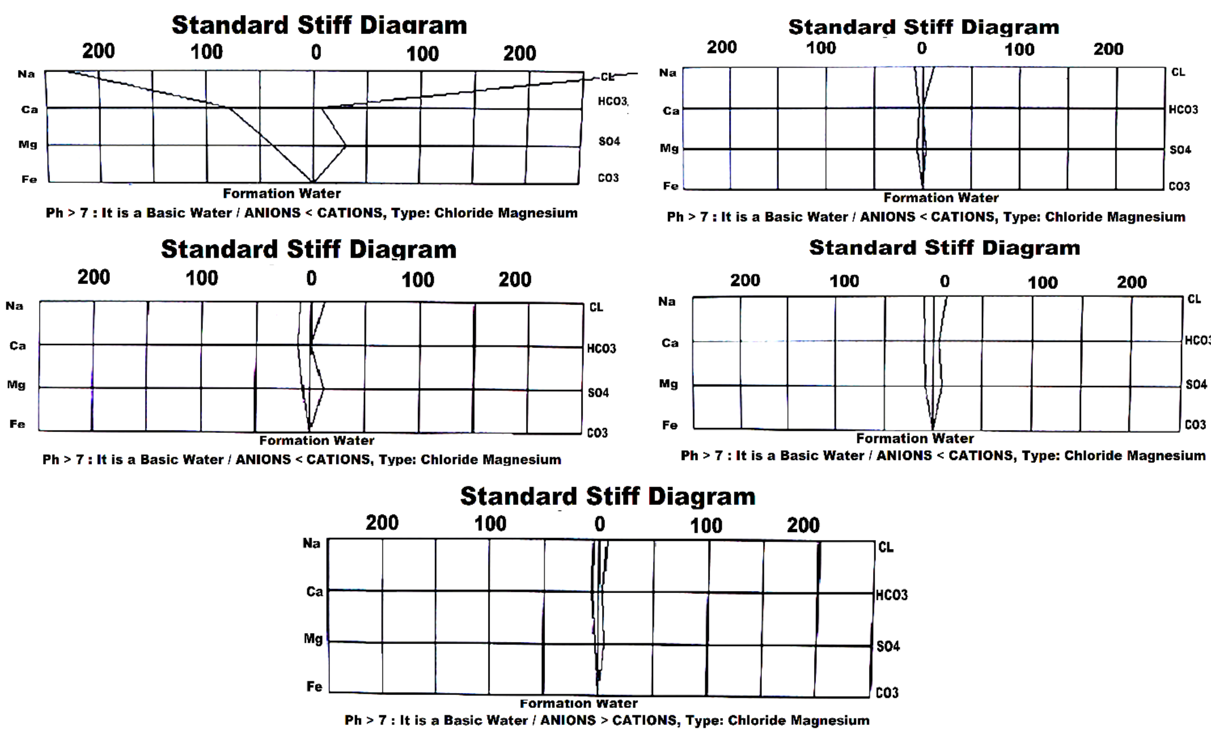

Fig. 5. Stiff diagram for Different wells in Risha Area.

Table 2. Results of water samples analysis.

No. Sample	TDS (mg/l)	pH	SP.GR. (gr/cm³)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	HCO_3 (mg/L)	SO_4 (mg/L)
1	2690	7.2	1.0218	75.70	27.5	208	122	533	393	125

l in the water measure of total amount of minerals dissolved in water, therefore a very useful parameter in the evaluation the quality. Sodium ($Na^{+)}$ with a concentration range 75.7 mg/l Na^+ K^+, HCo_3^-, CO_3, contents gradually increase with depth.

Calcium (Ca^{+2}) with a concentration 208 mg/l and (CL^-) 533 mg/l, Mg^{+2} 122 mg/l the concentration decrease with depth. The major natural sources are soils and rocks containing limestone and dolomite of water, Bicarbonate (HCO_3^-) with a concentration in range 393 mg/l.

The $HCO3^-$ content in mg-equ does not exceed the Cl^- content, and CO_2 products of the solution of carbonate rocks, mainly limestone ($CaCO_3$) and dolomite ($CaMgCO_3$) by water containing Carbone dioxide (CO_2) may affect to control the capacity of water to neutralize strong acids. The ratio of Ca^{+2}/Na^+ is 2.74.

Interpretation of analysis result by a Stiff diagram for collected Sample from Triassic formation during drilling (R-1 well) at depth 1400 m, show that the water type is Calcium-Bicarbonate/Chloride/Sulfate groundwater type and this water mostly occur in deeper zones. Groundwater with calcium as the dominant cation and bicarbonate the dominant anion, but with relatively elevated chloride and sulfate concentrations. This water type consistently has higher levels of TDS than the other two types.

Water associated with gas production

Interpretation result of water analyses associated with gas production during the first ten years of

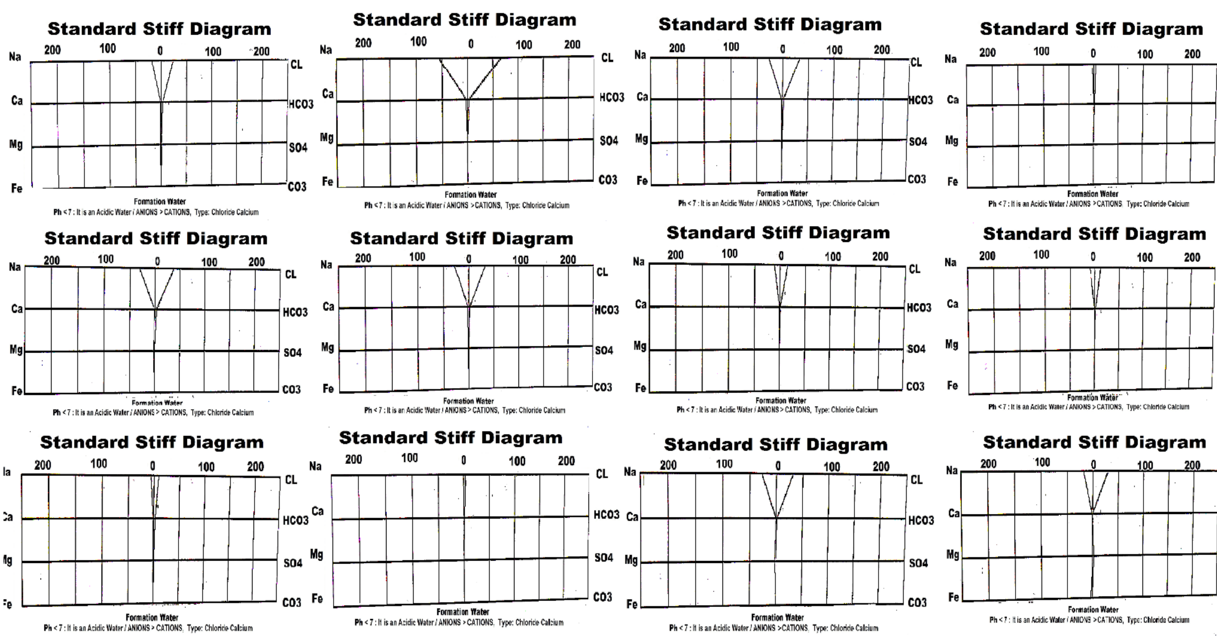

Fig. 6. Stiff diagram of water analyses associated with gas production.

Table 3. Physical and Chemical of water analyses associated with gas production

Sample No	1	2	3	4	5	6	7	8	9	10	11	12
TDS	1712	4460	2450	2120	2220	306	1372	890	1026	2400	2120	720
pH	5.7	5.99			5.5	5.6	5.5	5.6	5.5	5.7	5.63	6.4
SP.GR.	1.01	1.016	1.002	1.0018	1.01	1.01	1.01	1	1.0017	1.004	1.002	
Na	420	1320	740	660	650	53	425	230	240	740	644	60
K	29.3	126	39	20	40	3.9	24.5	8	18	56	47	6
Ca	12	60	33	38	32	3.18	28	10	12	31	28	130
Mg	12	17	28	7,5	12	1.2	1.8	6	7	16.8	19.2	9
Cl	852	2382	1342	1172	1182	128	703	426	554	1278	1145	227
HCO3	192	159	171	134	145	100	110	110	160	124	148	
SO4	67	5	12	10	4.3	0	0	3	28	85	5	

production by Stiff diagram shows that the type is a Chloride Calcium type, but their water patterns do not show any similarity with the chloride of calcium water type of Triassic (R-1 well), this means that it might be brought about by the drying effect of escaping gas because of its low concentration. Figure 6, Table 3.

From the chemical composition of formation water can be used as indicator the presence of petroleum. The total salinity of formation waters decreases with stratigraphic depth (Samedov and Buryakovsky, 1966; Rieke and Chillingarian, 1974).

According to Chilingarian *et al.* (1994), the chemistry of pore water is determined mainly by the compaction of argillaceous rocks and squeezing –out of pore water. The formation water chemistry, in turn, influencesthe diagenetic and catagenetic transformation (of clay minerals) processes. Table 3 shows the analysis of waters in Risha Gas Field.

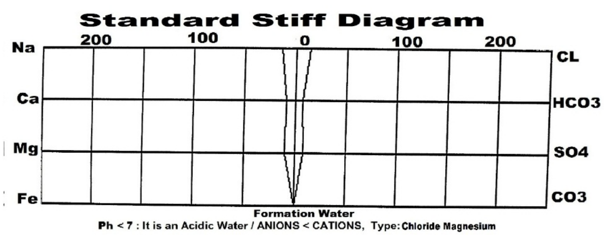

Fig. 7. Standard stiff diagram.

The contents of Cl^-, Ca^{+2} and Mg^{+2} decreases with depth, the contents of (Na^+K^+ and HCO_3^- + CO_3^- +H^++K^+) gradually increase with depth.

Interpretation result of water analyses associated with gas production after ten years of production by Stiff diagram indicate that their water type is Chloride Magnesium type, where their water patterns are more or less similar to the water pattern of (Campanian - Santonian formation) of water well B, RH well A and Semica water wells, so it's most probably due leaks in casing or faulty cement. Table 4, Figure 7.

Conclusion

- We have excluded most of the water samples analysis from the evaluation because of their variability in pH values and the wide difference between cations and anions values.
- Well electrical logging tools interpretation for Risha gas wells show that the gas producing zone is at 2600 m where the formation water below 3200 m.
- The stratigraphic section between 2600 to 3200 m, the interval has no formation water.
- Water Wells A, B and SMEICA shows the type of water was magnesium chloride with pH 7.2 it means that is basic.
- Water which was produced during the first eight years of production shows a calcium chloride water type and the pH around 5.5 it means that is acid, but its water patterns does not show any similarity with calcium chloride of the Triassic formation (R-1 well), which means it is most probably brought about by a drying effect of escaping gas low concentration.
- Water which was produced after eight years of production shows a pattern similar to Campanian - Santonian formation water patterns, so it's most probably due leaks in casing or faulty cement.

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Table 4. Result of water analyses associated with gas production.

Sample No.	TDS	pH	SP.GR.	Na	K	Ca	Mg	Cl	HCO_3	SO_4
1	2690	7.2	1.0218	990	27.5	208	122	533	393	125

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