

Petrophysical evaluation of the Asmari Reservoir Caprock using GR and Sonic Logs, The Parsi Oil field, SW Iran

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Abstract

In the present study, the cap rock of the Asmari reservoir in the Parsi Oil field, located at south west of Iran, were petrophysical evaluated using GR and Sonic logs and its thickness variations investigated. Cutting samples and well logs data from 28 drilled wells of the Asmari reservoir cap rock in this oil field, indicated that the cap rock consisted of anhydrite, halite, marl and a few thin beds limestone. So that it can be classified in the best cap rocks type. Meanwhile, during the drilling process and also on well logs, 6 thin beds with particular properties -named Key Beds- are recognizable. The entrance to the cap rock is clear with increasing in sonic wave velocity because of arrive to the compact anhydrite layer (the first key bed). High pore pressure and elasticity characteristic to gether with considerable thickness of evaporates, made it as a strong seal on the Asmari reservoir. Therefore the intensity of tectonic activities which were affected on the Parsi oil field could not prevent the hydrocarbon escape from the reservoir. Although in some area, these activities have removed upper parts of the cap rock and then the cap rock thickness is not comparable in southern and northern flanks. Very high thickness of the cap rock similar to southern flank of the Parsi oil field, seldom is reported in other oil fields of Iran and around the world. This matter can be related to tectonic events in the Zagros folded and thrust belt, folding mechanism and salt plasticity property.

Keywords: Cap rock, Key bed, Well logs, Zagros Fold-Thrust belt

1. Introduction

The Zagros fold-thrust belt, which extends for about 2000 kilometers from southeastern Turkey through northern Syria and Iraq to western and southern Iran, with its numerous supergiant hydrocarbon fields, is the most resource-prolific foldthrust belt of the world [1]. This orogenic belt is the result of the collision between the continental Arabian plate and the so-called Iranian block belonging to Eurasia [2]. Progressive post-Oligocene regression in the Zagros basin was favourable for deposition of the evaporitic and detrital sediments known as the Fars group. These consist of the Lower Fars (Gachsaran), the Middle Fars (Mishan), and the Upper Fars (Aghajari) Formations [3]. The Lower Fars is an important formation in the Middle East for two reasons: 1) It is the caprock to the major oil fields of Iraq and Iran, and 2) It contains reserves of sulphur [4]. It is comprised of 7 members as many cycles of the red and gray marl, limestone, gypsum and salt sequences [5]. In most Iranian oilfields (such as Parsi), member 1 of this formation acts as the caprock and distinguishes two different pressure area (Gachsaran and Asmari

formations). To predict the probable entrance depth, casing process, and prevent of blow out or mud loss is necessary to make sequential evaluation and depth determination of this part. Therefore, the present work using well log data (GR and Sonic logs) tends to focus on petrophysical characteristics of the Parsi oilfield cap rock.

2. Geological setting

The Parsi oilfield is located at 130 km southeast of Ahvaz (SW Iran) and placed in northern Dezful Embayment and surrounded by Paranj, Mamatin oilfields and Bangestan anticline. Meanwhile the Hendijan-Izeh strike-slip fault is divided it to two structural blocks and Main Front Fault (MFF) is passed through its right eastern part [2].

3. Methods

In the present study, to carry out the petrophysical evaluation of the caprock, GR and Sonic logs available for 28 drilled wells in the Parsi oilfield were investigated. The results correlated with the cutting samples data and then inputed data to Surfer software environment to evaluate the cap rock thickness variations.

4. Results and Discussion

A log, records one or more physical parameter(s) as a graph versus depth [6]. GR tool measures the strength of the natural radioactivity present in the formation [7]. Radioactive elements such as uranium, potassium and thorium tend to occur more in shales than in sands. As a result, the Gamma Ray log is a lithology log that identifies shales from sands [8].

The Sonic log measures the time, Δt , required for compressional sound wave to traverse one foot of formation. The interval transit time, Δt is the reciprocal of the velocity of the compressional sound wave. To avoid fractions, the interval transit time is scaled by 10^6 and reported in micro-seconds per ft ($\mu\text{sec}/\text{ft}$) [8].

The study of these logs in the Parsi oilfield show that member 1 of the Gachsaran Formation (the Asmari reservoir caprock) is mainly consisted of anhydrite, halite, marl and a few thin beds limestone. So that it can be classified as the best cap rocks category. This matter is proved by means of the petrography study of microscopic thin sections, too. Meanwhile, during drilling Process and also on well logs, 6 thin beds with particular properties -named Key Beds- are recognizable.

Around the oilfield, the caprock underlies with a thick salt bed which is named "*Main Salt*", that is member 2 of Gachsaran Formation and the entrance to the cap rock is clear with increasing in sonic wave velocity because of arriving to the compact anhydrite layer (the first key bed: *key bed A*) (Fig. 2 A,B).

After drilling of this layer averaging thickness 2-3 meters, appearance of a sharp peak on GR log and decreasing in sound wave reveal a porous and high concentration of OM (organic matter) (Fig. 2 A,B). Its petrography study shows that this layer is a bitumenous bed which is named as "*key bed B*". It is most important key bed of the cap rock for its wide extension and special property (bitumenous) [9]. Then passing of a few marl and salt beds, an increasing in Δt and high GR reading indicate an another Index bed. It seems as fossiliferous Limestone with clay content which on thin sections is known "*key bed C*"

(Fig 2. A,B). In some area (northern flank and crest specially), tectonic activities have removed upper parts of the cap rock (A, B and C key beds) (Fig. 2 B). Therefore, the caprock thickness is less than its normal situation and this matter is caused a sudden thickness variations around the oilfield.

“*Key bed D*” is recognizable easily with petrophysic and petrography characteristics similar to C on GR and Sonic logs. This bed is first key bed in some area (specially in northern flank) and exists in whole studied wells.

Fifth key bed of the caprock (*Key bed E*) is a thin bed limestone and is reveal on both gamma ray and sonic logs, too. There is only a thin marl layer and anhydrite beneath E key bed around the oilfield (Fig 2. A,B). This anhydrite is suitable for casing point install [10].

Finally, lowstand key bed of the caprock is “*Key bed F*”. This can be recognized on GR log because of its high clay content and on sonic log due to high porosity. Usually, there are marl and anhydrite layers under this key bed and then appearance of porous and clay bearing limestones of the Asmari formation cause an intensive deviation on GR and sonic curves.

Based on the presence of anhydrite and salt their plastic properties in the caprock is caused to classify it in the best cap rocks type. High pore pressure and elasticity characteristic mid considerable thickness of evaporates, made it as a strong seal on the Asmari reservoir. Therefore the intensity of tectonic activities which were affected on the oilfield (such as Hendijan-Izeh Fault) could not prevent the hydrocarbons escape from the reservoir. These tectonic activities along with folding mechanism and salt plasticity property lead to a wide oscillations in caprock thickness. This matter reveals by sub surface maps examination. According to Isopach map (Fig. 3) caprock thickness is too low in northern flank, so that it is decreased to down 30 meters in southeast culmination. In crest, the thickness is more and in southern flank will be maximum. So that very high thickness of the cap rock similar to southern flank of the Parsi oil field, seldom is reported in other oil fields of Iran and around the world. Activity of contemporaneous faults with the Zagros orogeny is caused upper key beds to be removed at many wells in northern flank and crest. During the geological time and under high stresses salt rock can be mobile [11]. As a result of this matter, the salts belong to the caprock are migrated from NE to SW and led to considerable thickness of the caprock in southern flank (Fig 4). It seems disharmonic folding and evaporates migration are caused to key beds allegations phenomena not be clear.

5. Conclusion

The caprock of the Asmari reservoir in the Parsi oilfield consisted of anhydrite, marl, salt, a few thin beds of limestone and a bituminous shale layer with 6 key beds including of A, B, C, D, E, and F to depth. High pore pressure and elasticity characteristic mid considerable thickness of evaporates, made it as a strong seal on the Asmari reservoir. Various tectonic activities are affected on the Parsi oilfield and led to be different the caprock thickness and entrance depth to the reservoir. So that from NE to SW it is observed that the thickness increases. This matter is related to salt plasticity and effective stresses in the Zagros folded and thrust belt.

6. References

- [1] Alavi, M., Regional stratigraphy of the Zagros fold-thrust belt of Iran and proforland evolution, *American Journal of Sciences*, v.304, p.1-20, (2004).
- [2] Sherkati, S., and Letouzey, J., Variation of structural style and basin evolution in the central Zagros Izeh zone and Dezful Embayment, Iran, *Marine and Petroleum Geology*, v. 21, p. 535–554, (2004).
- [3] Bahroudi, A., and Koyi, H.A., Tectono-sedimentary framework of the Gachsaran Formation in the Zagros foreland basin, *Marine and Petroleum Geology*, v. 21, p. 1295-1310, (2004).
- [4] Tucker, M.E., Sabkha cycles, stacking and controls, Gachsaran (Lower Fars/Fata) Formation, Miocen, Mesopotamian basin, Iraq, *Neues jahrbuch Geologisch und Plaonatologisch Abhandlung*, v. 124, p. 45-69, (1999).
- [5] Motiei, H. Stratigraphy of Zagros. Geological Survey of Iran Publications, (1994) (In persian).
- [6] Luccia ,F.J., Carbonate Reservoir Characterization, 2nd Edition, Springer Publications, 336 p, (2007).
- [7] Darling, T., Well Logging and Formation Evaluation, Elsevier publications, p. 326, (2005).
- [8] Crain, E.R., Petrophysical Handbook, Alberta, Canada, 55 Chapters on CD ROM, (2002).
- [9] Moradi, M., Soleimani, B., Amiri Bakhtiar, H., Jaffari, A., Identification and Correlation of Key Beds of Asmari Reservoir Cap Rock in Parsi Oil Field Using Microfossils and Well-Log Data, 3th Symposium of paleontology, Mashhad, (2009) (In Persian).
- [10] Moradi, M., Soleimani, B., Amiri Bakhtiar, Casing Point determination in Cap rock of the Asmari Reservoir, Parsi oilfield using GR and Sonic logs, 27th symposium of Geoscinces, Tehran, Iran, (2010) (In Persian).
- [11] Richard, H., Groshong, Jr., 3-D Structural Geology, A Practical Guide to Quantitative Surface and Subsurface Map Interpretation, Second Edition, Springer publications, 399 p, (2006).

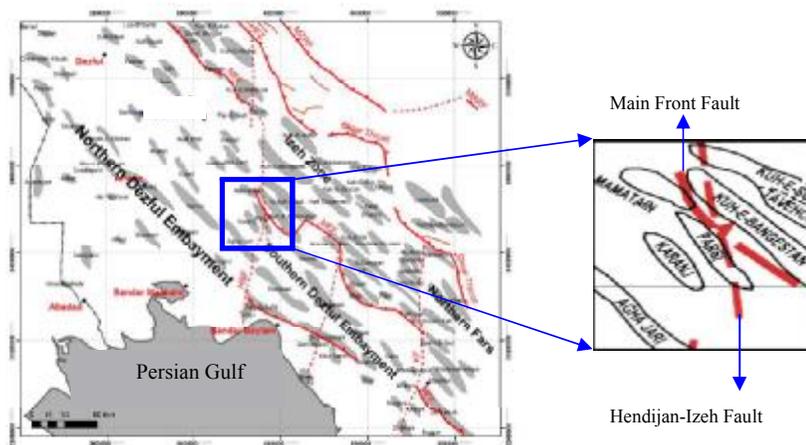


Fig. 1- Study area in Dezful Embayment, Khuzestan province, SW Iran [2].

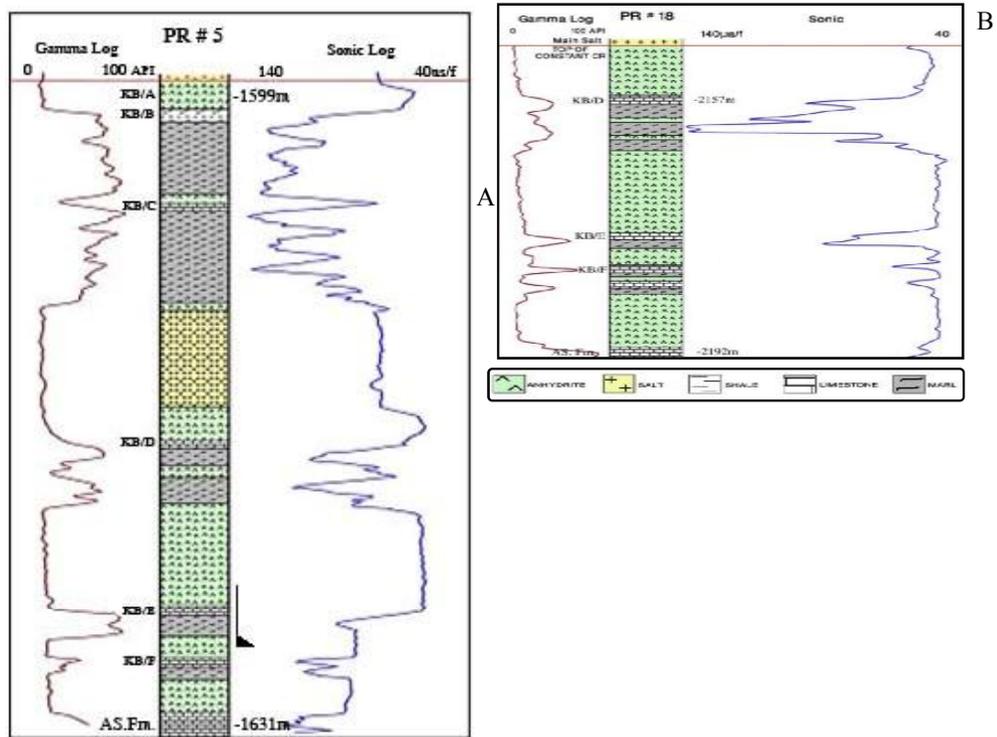


Fig. 2- A) Variation of GR and Sonic logs, key beds position, lower and upper contact of the caprock in well # 5, and B) Remove of upper key beds due to tectonic activities in well # 18.

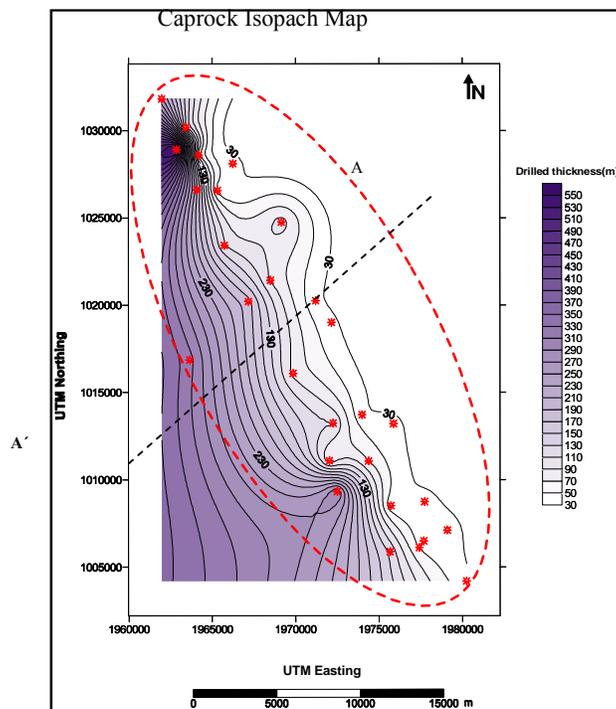


Fig. 3- The caprock Isopach map along with the position of the studied wells.