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Fracture Analysis by Using Fractal in Nar Gas Reservoir Bushehr – Iran

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Abstract

One of the fundamental problems in the Structural Geology is fractured layers and fracture analysis by using fractal geometry is a good method . High gas production from the Dehram group (Kangan and Dalan formation) of Nar hydrocarbon field in Bushehr province, Iran, indicates the presence of natural fractured reservoir whose production potential is dominated by the structural fractures. The connectivity of fractured media depends upon the power–law exponent and the fracture density. Fracture pattern traces obtained from the outcrops of producing formations of nine different stations in Nar hydrocarbon field. 2D fracture network maps of Nar hydrocarbon field have been analyzed from their scaling properties. The fractal analysis of fracture intensity showed heterogeneous fractal structure characterized by generalized dimensions. Fracture distribution model and reservoir productivity can be estimated, which are of great interest in decision making to optimize gas production Fractal behavior has been observed in natural fracture patterns and fractal geometry provides a quantification of size scaling or scale dependency of the complex fracture systems. The fractal exponent could be attributed to the entire hydrocarbon reservoir. The management of data on a GIS could help to a better optimization of fault and big fracture prospecting of this region.

Keywords: Fractal, Fracture Network, Fractal Dimension, Reservoir, Nar Hydrocarbon Field.

Introduction

Fractal behavior has been observed in natural fracture patterns (Barton and Larson 1985; Barton and Hsieh 1989) and fractal geometry provides a quantification of size scaling or scale dependency of the complex fracture systems. Fractal analysis relies on the estimation of a non-integer number, i. e., fractal dimension, D. typically; box-counting technique is applied to measure the fractal dimension of the fracture network (Barton and Larson 1985). The main objective is to analyze the fractal dimension of fractures. (Mandelbrot 1982). Structural style and its relationship to morphology of Zagros fold–thrust belt is dominated by magnificent exposures of NWSE trending folds. These folds differ in their size and geometry in this area. One of the regions of this fold–thrust Belt is Nar anticline that located in the northeastern part of Kangan hydrocarbon field. High gas production from the some geology formations of Nar hydrocarbon field in Boushehr province, Iran indicates the presence of natural fractured reservoir whose production potential is dominated by the structural fracture where the gas flow occurs essentially along open fractures (Sarkheil et al. 2009a, b). The quantification and modeling of fracturing is thus of great interest for studying connectivity, transport properties, and production rate.

Geological Setting:

The area of study is located in South of Zagros in Boushehr province of Iran. (Fig 1)

Dehram group included (Up to Down) Kangan, Dalan & Faraghan Formations and are important seal interval in the Zagros basin. (Fig 2) Dalan Formation comprises of upper dalan, middle dalan (Nar member) & lower dalan . The Kangan, Dalan & Faraghan Formations

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consists of dolomite, anhydrite, shale , limestone & sandstone. The dehram group source rock is Sarchahan Formation & cap rock for this group is Aghar Shale.

It is necessary to identify the main processes responsible for fracturing. No straightforward answer exists as different processes may be dominant in various geological settings and is highly dependent on the various phases and characteristics of the local geological history (Sanders et al. 2002), fracturing also takes place in essentially undeformed regions (Price and Cosgrove 1990) and strongly related by lithology. Thus, structural assessment is very important to achieve natural fractured reservoir (Lyakhovsky 2001). Though traditional curvature analysis has often been used for fracture assessment (Price and Cosgrove 1990), curvature analysis on the present-day geological model gives limited insight for fracture purposes as it only analyses the geometry on the present-day model statically (Lisle 1994). The Nar anticline and these geological layers are characterized by simple fold within Cretaceous levels. These folds are asymmetric, verging southwest with a typical wavelength of about 10 km. Oligocene–Lower Miocene Asmari carbonates in this domain are shortened by folds wavelengths of 1–2 km on the flank of the main structures, which are locally breached by thrust faults. Our structural interpretation for the deeper horizons is based on information provided by seismic data, which indicate larger structures at depth. The Albian Kazhdumi and Eocene Pabdeh Formations separate three distinct sets of structures in the area simple fold with short wavelength in Oligocene carbonates that tend to out in Eocene marls, fold at Cretaceous level, which do not coincide with fold in deeper horizons, and finally fold in Early Cretaceous and older rocks.

Surface Fracture and Methodology:

The present investigation measures the fractures specification (e.g., dip, strike, and density) of measurement in nine different stations along various location in Nar hydrocarbon field, using the result for fractal analysis. Data were collected from nine stations along the 28-km transect in an area of approximately 5-8 km. A total of 987 fracture plane measurements from nine stations were recorded for evaluation to facilitate analyzing data on the scale of Nar hydrocarbon field, the stations were divided into nine sectors based on regional structures and topographic expression.

Data within each sector was summarized for interpretation. Therefore, Rose diagrams may be used to conduction with 1% counter plots for interpretation at a larger scale. When the fracture data from each of these regions is compiled into a plot which covers the study area, two orientations of strike dominate: a set which strikes northeast at NW-SE, sets striking NE-SW and E-W also appears throughout the Nar hydrocarbon field. The only substantial set which trends to the central division in the Nar hydrocarbon field fracture system is oriented at NE-SW

Fractal analysis

Fractures exist over a wide range of scales, from microfractures to largest faults. Fracture patterns in nature display a self-similar geometry, at least at statistical sense, that repeat over various scales. This scaling behavior is described by a non-integer (or fractal) dimension varying in 2D from 1 to 2. The box-counting method (Giorgilli et al. 1986; Liebovitch and Toth 1989; Lovejoy et al. 1987; Matsumoto et al. 1992) is generally used to measure the fractal dimension of the spatial distribute on and scaling of fractures. A sequence of grids of different cell size, r, is placed over the fracture map, the number of cells intersected or containing a fracture is counted. The fractal relation is:

$$N \sim ri^{-D}$$

$$\log (N) = a + D \log 1/r$$

The fractal dimension is:

$$D ¼ \mathrm{LogN}$$

$$D = \log (N) / \log 1/r$$

N , is the number of cells containing fractures, r , is the length of the side of the cell, and the fractal dimension D is the slope of straight line segments fitted to the N, (1/r) plotted on logarithmic axes (Barton 1995). D is the so called box-counting dimension or capacity dimension, generally noted D0. The application analysis to a fracture traces from Nar region map.

Nar anticline divided to nine box and by using box counting method calculation N & r then determine Fractal dimension for all boxes. (Fig.: 5)

After the fractal dimension calculation , you see that max dimension related to C , F & I boxes (Table 1) , this subject means that in this boxes have high fracture density . therefore these points are the best places for digging wells But all wells are in the F box , because F box is the crest of Nar anticline and gas have a low density , therefore emigrated to the highest point .(F point)

Conclusions

The power–law fracture length distribution shows scale invariance. The fractal exponent could be attributed to the entire hydrocarbon reservoir. The fracture connectivity seems to be independent of investigation scale. The extrapolation to 3D analysis based on fractal mathematics and percolation theory will constitute an interesting field of research for a better understanding of fracture geometry and reservoir conductivity properties. The management of data on a GIS could help to a better optimization of fault and big fracture prospecting of this region, focusing in fractured connected media to reduce low hydrocarbon producer wells.

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Table 1 : Fractal dimension for all boxes

Box	Fractal Dimension
A	1/3694
B	1/1854
C	1/613
D	1/0799
E	1/4571
F	1/8477
G	1/5419
H	0/8451
I	1/738

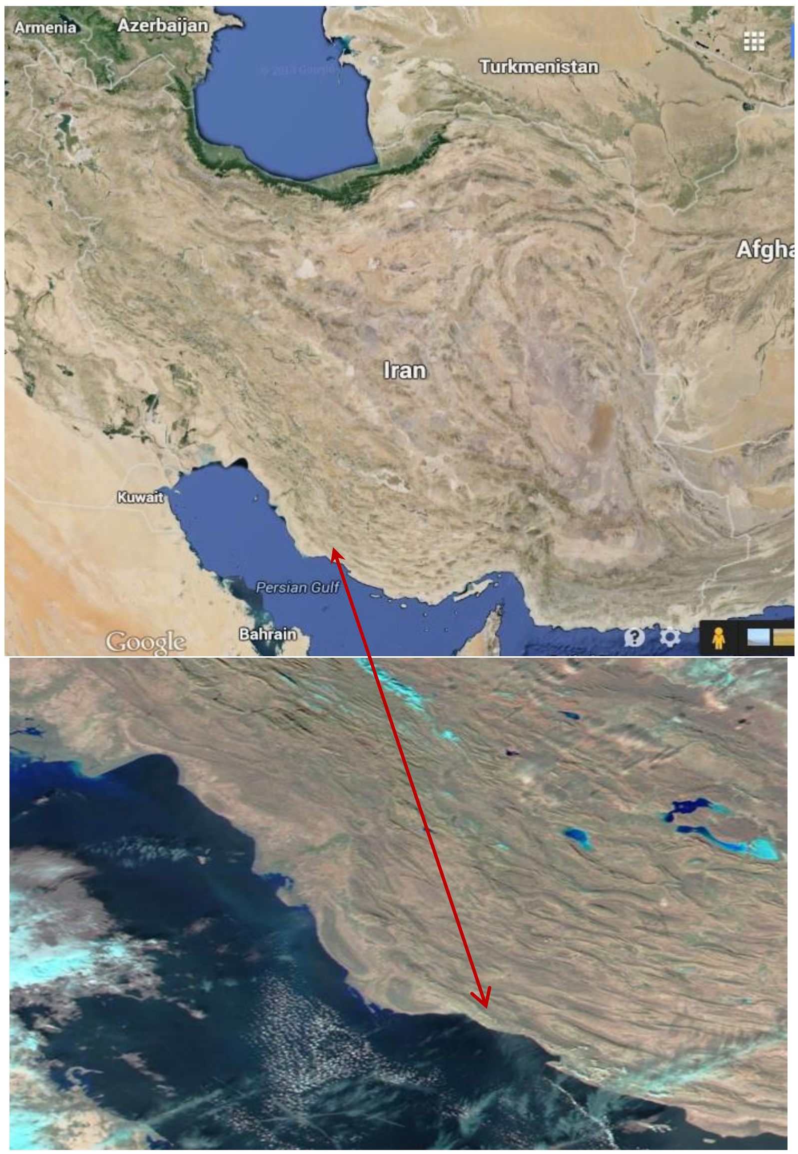


Fig. 1: A satellite image south of Iran that shows the location of the study area (Nar Anticline)

OLD NOMENCLATURE	PRESENT NOMENCLATURE			REZERVOIR ZONATION: OLD ZONE	REZERVOIR ZONATION: NEW ZONE		AGE
KHUFF	DEHRAM GROUP	KANGAN FORMATION		ZONE A	A	A1	TRIAS
						A2	
				ZONE B	B	B1	
						B2	
				ZONE C	C		PERMIAN
		DALAN FORMATION	UPPER DALAN FORMATION	ZONE D	D		
					E	E1	
						E2	
			MIDDLE DALAN FORMATION (NAR MEMBER)	NOT ZONED	F	F1	
						F2	
			LOWER DALAN FORMATION		G	G1	
						G2	
						G3	
						G4	
						G5	
PRE KHUFF CLASTICS		FARAGHAN & OLDER			NOT ZONED		PRE-PERMIAN

Fig. 2: Nar nomenclature & reservoir zonation

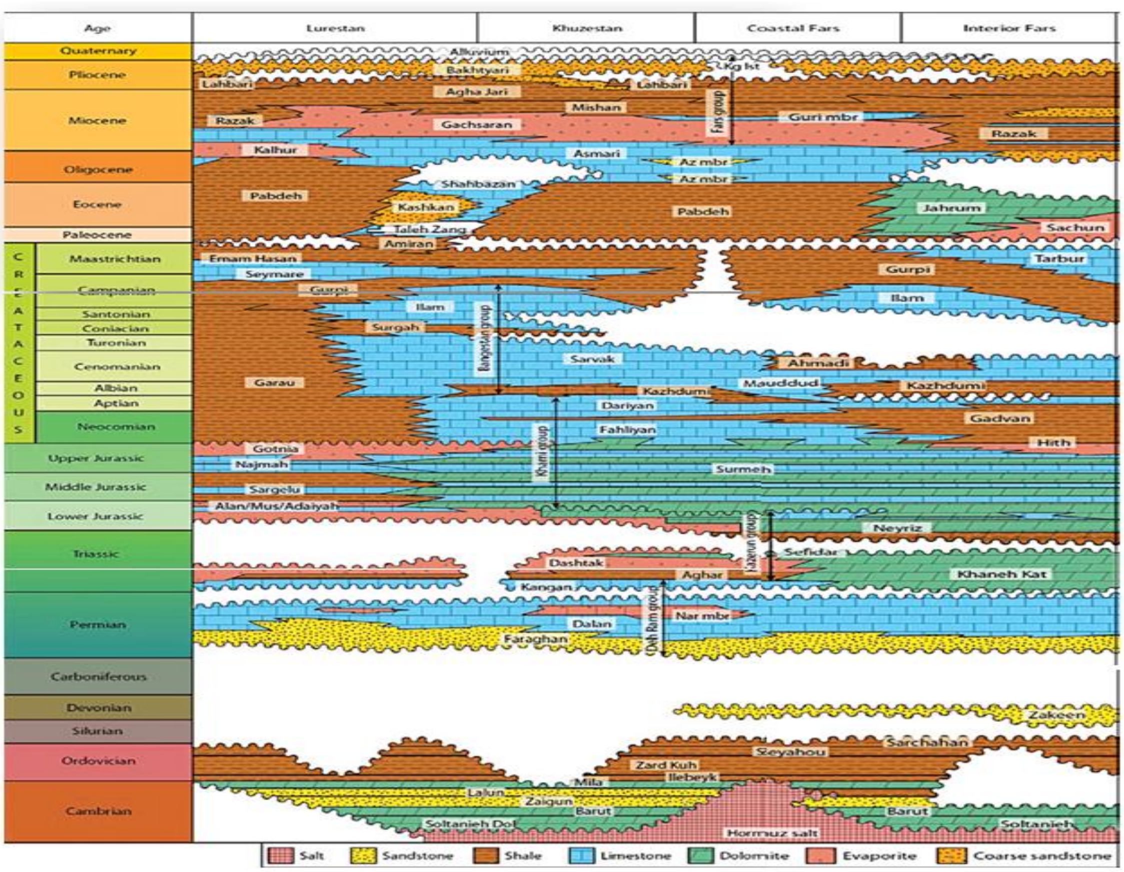


Fig. 3: Zagros Stratigraphy (From National Iranian Oil Company Archives)

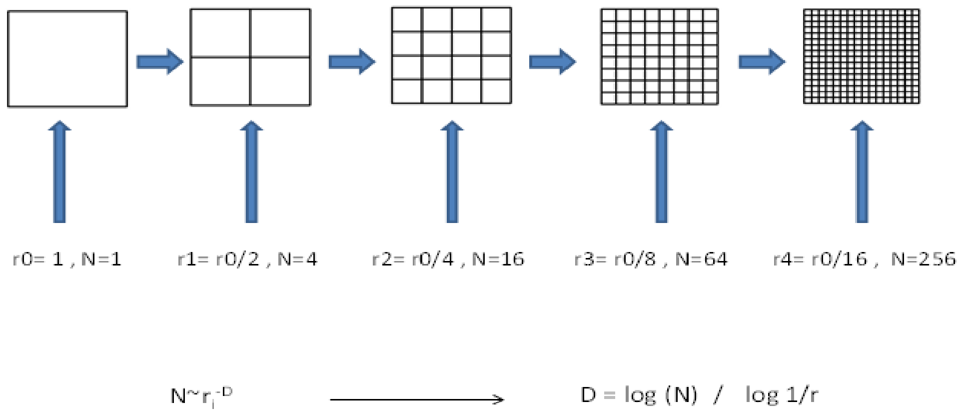


Fig. 4 : Box counting & Calculation method N & r for determine a from of Fractal dimension Jami 2011

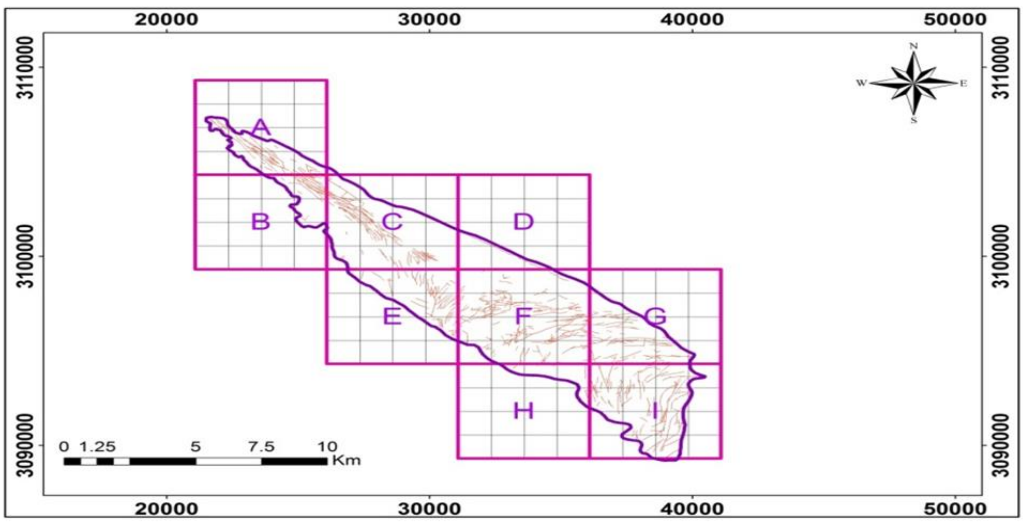


Fig. 5 : Box Counting Method

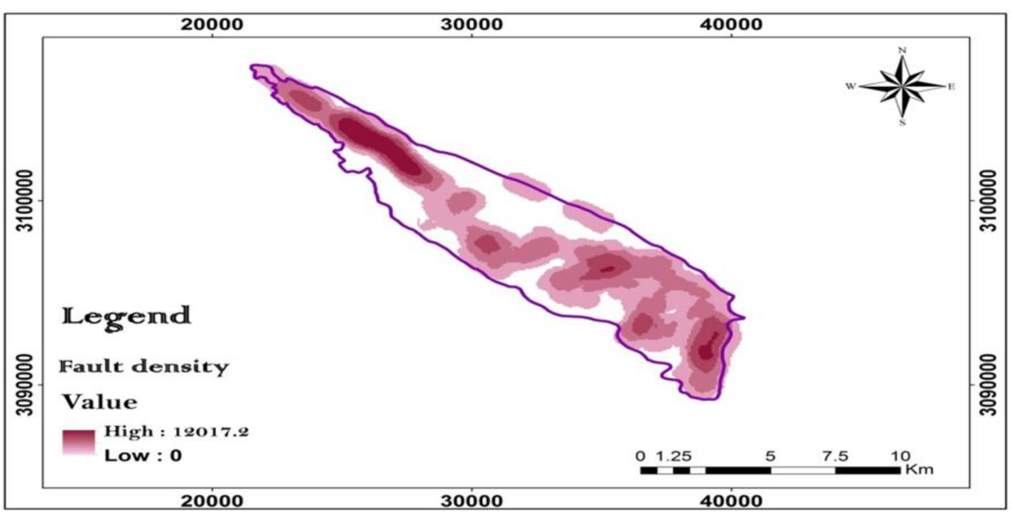
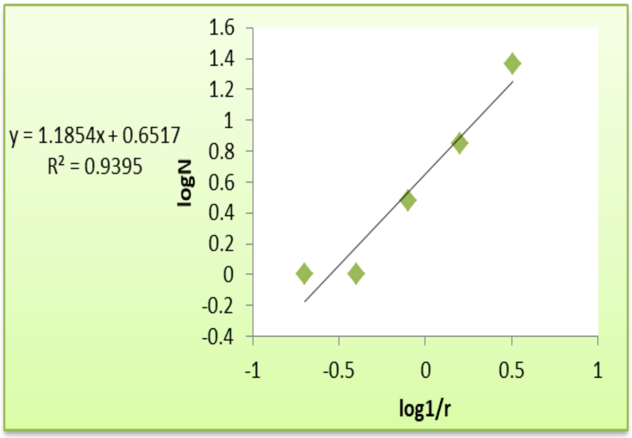
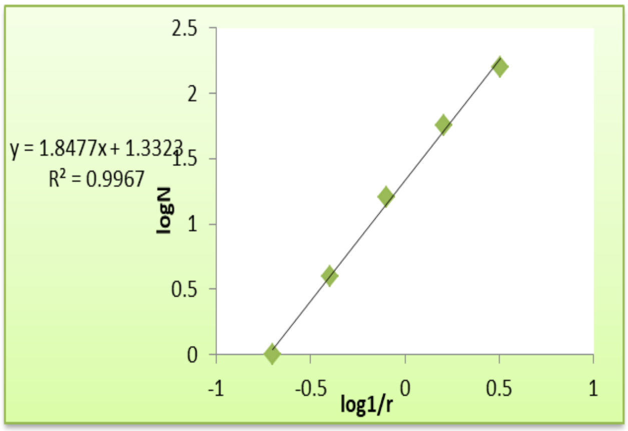


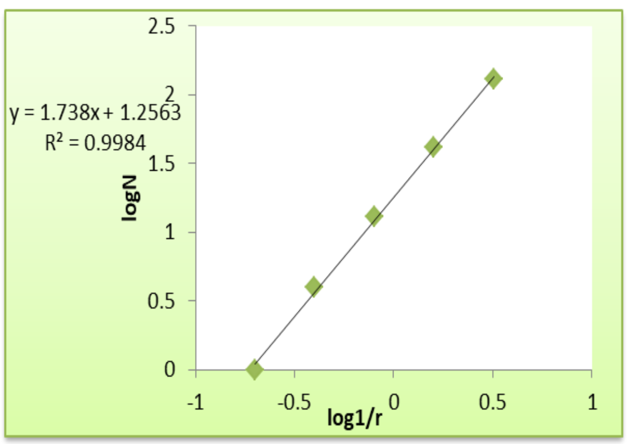
Fig. 6 : Nar anticline fracture density



log N-log 1/r for B box



log N-log 1/r for F box



log N-log 1/r for I box

Fig 7: Fractal dimension curves for B , F & I Boxes

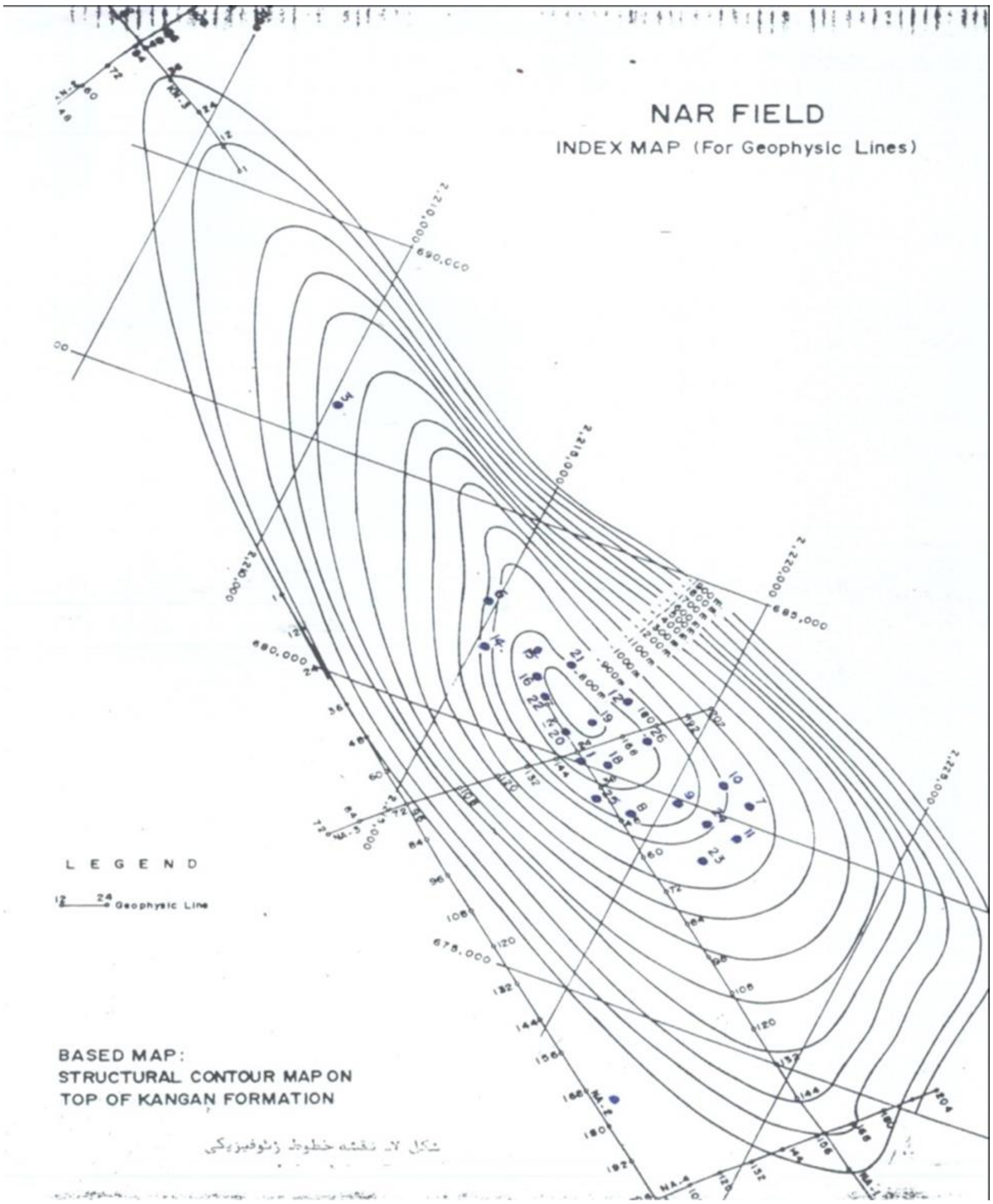


Fig. 8: Wells position on the Nar anticline map