Résulté
Une analyse statistique de quelques paramètres pétrographiques : granulométrie, silice secondaire et argile totale du réservoir gréseux pétrolier d'âge cambrien d'Hassi-Messaoud a été entreprise en liaison avec les caractéristiques pétrophysiques de transfert de fluide (perméabilité) et de stockage (porosité). Le facteur principal de détérioration relative de la porosité est la silice secondaire tandis que l'argile totale et le grain maximum semblent jouer un rôle d'amélioration. Le grain moyen par contre n'a aucune influence sur la porosité. Le premier facteur de détérioration de la perméabilité est la silice secondaire (r = -0.924). La porosité et la perméabilité sont intimement liés. Le coefficient de corrélation entre ces deux paramètres est de 0.95.

Abstract
The statistical analysis of the granular parameters, of the secondary silica and of the total clay of cambrian sandstone reservoir of Hassi Messaoud is undertaken in link with the characteristics of the transfer of fluid (permeability and storage porosity). We show that the principal factor of relative deterioration of the porosity is the secondary silica while the total clay and the maximum grain seem to play a sensible positive part in this respect. The average grain doesn't have any influence on the porosity (r = 0.443). The first factor of deterioration of the permeability is the secondary silica (r = -0.924). The maximum grain and the total clay play a role in the amelioration of the permeability. The coefficient of interrelationship between the porosity and the permeability is of 0.950 which prove a good link between these two parameters. The structure of Hassi Messaoud appears like a vast flattened anticlinal of orientation SSW-NNE extending on more than 4 200 km² on the oriental termination of the triassic basin of the Algeria (Figure 1). The formations of the Paleozoic are eroded under the clayed and salted triassic formations. In this sector the Cambro-Ordovician formation subsists under the limit of the triassic erosion (Figure 2).

Four units constitute the main cambro-ordovician reservoir (Ri, Ra, R2 and R3) with a total thickness of the productive formations between 175 and 240 meters. The reservoir is constituted by some quartzitic beds of medium sandstone to coarse micaeous and feldspatic sandstones with silicic levels or micro-conglomerates (Figure 3). A network of 3W-NE faults and NW-SE cuts up the bearing.

We study separately in a first time the variables of porosity and of permeability, then we attempt to study the bond between them introducing from there other explanatory variables such as the granularity, the rate of clay and the silicification. The transmissivity and the indication of productivity will be presented only with comparative object.

Eighteen core-drills were sampled with a spacing on the vertical varying from 0.25 to 0.50 m. More than 2000 thin sections have been analyzed by microscope polarizing. Near 65 % of the porosity values were included into one slice from 6 to 12 % (Figure 4). The arithmetic average of the porosity is about 8.17 %.

The geographical distribution of the values of porosity indicates (Figure 5) :
— a first east sector having some improved porosities higher than 8 % situated along the line 12, where some porosities reach sometimes 10.3 % on Md 368 well and 9.6 % on Md 366 well.
— a second sector is situated on the West center, extended from the South toward the West-north. The values of the porosity decrease with the center toward the periphery of these sectors and from North toward the South of the field. We attempt to determine the factors having one major influence on the porosity : secondary silica, total clay and the maximum grain. The histogramm of the permeability is made with 3 228 measures achieved into 18 wells. The interval of the classes have a logarithmic gradation and about 85 % of the measures have some included values between 0.1 and 100 md (Figure 6). The distribution is unimodal and gaussian. The average of the permeability into the reservoir is near 17.6 rod. The variations of permeabilities is in relationship with some lateral changes of facies. The contour map permeability is drawn with the data of 112 wells, the equidistance of the lines have a logarithmic scale.

The lines of isopermeability describe two zones of which the permeability overtakes 10 md (Figure 7). The first of shape is transverse with a East-West extension, the second zone is situated along the line 12. where some porosities reach sometimes 10.3 % on Md 368 well, 9.6 % on Md 366 well.

— a second sector is situated on the West center, extended from the South toward the West-north. The values of the porosity decrease with the center toward the periphery of these sectors and from North toward the South of the field. We attempt to determine the factors having one major influence on the porosity : secondary silica, total clay and the maximum grain. The histogramm of the permeability is made with 3 228 measures achieved into 18 wells. The interval of the classes have a logarithmic gradation and about 85 % of the measures have some included values between 0.1 and 100 md (Figure 6). The distribution is unimodal and gaussian. The average of the permeability into the reservoir is near 17.6 md. The variations of permeabilities is in relationship with some lateral changes of facies. The contour map permeability is drawn with the data of 112 wells, the equidistance of the lines have a logarithmic scale.

The lines of isopermeability describe two zones of which the permeability overtakes 10 md (Figure 7). The first of shape is transverse with a East-West direction starting to the Eastern extends until the center, the second zone is wholly at the West with a North-South orientation. These two zones look strongly like the anomalies of the maximum grains and some observed porosities on their respective maps. The relation between porosity and permeability is done for the whole level Ra in the southerly part East of the field of Hassi Messaoud.

The quartzification and the compaction carry a discontinuity of the pores and are translated with a reduction of the values of the porosity and of the permeability. The figures 8 and 9 show a deterioration of the porosity and of the permeability with the increase of the content of silica. For best fear the factors having one major influence on the porosity and the permeability we have settled some interrelationships between the petrophysical parameters (porosity and permeability) and the petrographical parameters. We show that the porous and permeable zones are conditioned by a strong level of clay and a coarse granularity then that the silica fact goes on a decrease of their respective values. Although the fracturation plays a negative role rather...
on the production. It is difficult to define with precision the zones where this effect is predominant for they are not, in this case, associated to some mapped accidents and their present location therefore a qualitative character.

The totality of the productive capacity of the reservoir has a porosity higher than 5.5% and a storage capacity equal to 92.5%. We think that the data of some plugs are statistically representative in the Ra and that the value of the porosity cutting near 5.5% is reasonable (Figure 10).

The settled correlation between the average porosity per classes and the log of the average permeability has a polynomial regression such as:

\[ \ln(k) = -2.43 + 0.747 \phi - 0.0218 \phi^2 \]

and give for a porosity of 5.5% a value for \( \log(k) = 1.04 \) which represents a permeability of 2.82 md. We suggest therefore a minimal porosity of 5.5% and a minimal permeability of 2.4 md for the lower bounding of the useful reservoir (Figure 11).

The kaolinitisation of the illite and some feldspaths is a good illustration of the amelioration of the petrophysical characteristics. Nevertheless the kaolinitisation of some micas by gradual spacing of the leaflets lead to a reduction of the permeability by the mean of the largest specific surface.

The illite neoformation state is present under the shape of fibrous entanglements. So the phenomenon of illitisation of the kaolinite translates a deterioration of some petrophysical properties by increase of the occupied volume and consequently a reduction of the porosity and the permeability.

I. Introduction

Le gisement d’Hassi Messaoud apparaît comme un vaste anticlinal aplati d’orientation SSW-NNE s’étendant sur plus de 4 200 km² (Figure 1) près de la terminaison orientale du bassin triasique sud algérien. Les formations du Paléozoïque sont érodées sous les formations argilo-salifères du Trias qui constituent la couverture du gisement (Figure 2). Dans notre secteur seul le Cambro-Ordovicien subsiste sous la discordance triasique. Un réseau de failles SW-NE et NW-SE recoupe le gisement (Thouvenin et al., 1972).

La porosité dénommée porosité matricielle est définie par des formations productives oscillant entre 175 et 240 mètres. Une couche délimitée des différents niveaux est donnée en figure 3. Le réservoir est constitué par des quartzites, des grès moyens à grossiers micacés siltiphächtiques à niveaux silteux ou micro-conglomératiques (Mallenfer et al., 1963, Montadert, 1963, L’Homer, 1967).

II. Porosité

La porosité est dite matricielle lorsqu’elle est le résultat de vides intergranulaires, par opposition à la porosité résiduelle due aux seuls pores non reliés. La porosité totale (utilisable + résiduelle) est celle qui est appréhendée par les diagraphies électriques ou nucléaires.

La porosité dépend de la nature de la roche et des conditions de son dépôt, mais aussi des conditions qui ont prévalu après la sédimentation (compaction, cimentation, dissolution).

II.1. Prélèvement et préparation des échantillons

Des échantillons cylindriques sont prélevés dans les carottes à l’aide d’un outil diamanté au rythme de deux échantillons tous les 25 ou 50 cm, l’un suivant l’axe de la carotte (échantillon vertical), l’autre perpendiculaire à cet axe (échantillon horizontal). Leur diamètre est de 22 mm et leur longueur de 26 mm, leur volume total est de 10 cm³. Ces échantillons sont lavés dans un extracteur qui enlève l’eau et l’huile qu’ils contiennent, le liquide de lavage utilisé est le xylène (solvant) dont la température d’ébullition est de 140°C. Ils sont ensuite séchés dans une étuve à 80°C.

II.2. Méthodes de mesure de la porosité

Deux méthodes de mesure ont été utilisées : soit avec l’aide d’un porosimètre à immersion dans le mercure (typé Corelab), soit par la méthode pétrographique de mesure de la porosité (imprégnation préalable sous pression des échantillons par une résine colorée).