Geodynamic evolution of the Algerian offshore and its impact on the structural framework and play types

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The Algerian offshore extends for over 1200 km from east to west and forms the margin of the Algéro-Provençal basin in its eastern part and the margin of the Alboran Sea in its western part. Parallel to this margin, there is a development of the Maghrebides which corresponds to the southern section of the Alpine thrust-belt. The structural polarity of these mountain belts is outward, away from the Mediterranean (south-verging). The offshore area includes two elements of the Maghrebides: the thrust belt (inner zones, Petite and Grande Kabylie), and the outer zones west of Algiers and in the far eastern part of the Algerian offshore.

Analysis of magnetic maps and seismic sections shows the existence of two different structural zones. The eastern domain shows NW-SE lineaments which accommodate the south-verging thrust of the inner zones over the foreland. These lineaments also accommodate the opening of the South Balearic basin. The western domain is characterised by E-W to NE-SW trends which have allowed the westward displacement of the Alboran block during the middle Miocene. These faults are seismically active at the present time and are associated with Plio-Quaternary volcanism.

This difference in structural style is interpreted to have a direct influence on the petroleum play types. In the eastern part, plays occur within the front and back thrust belts, (e.g. Oued Gueterini field). The western zone is characterized by plays associated with strike-slip basins (e.g. Cheliff Basin).

The Algerian offshore belongs to the southern margin of the Algéro-Provençal and Alboran Basins (Fig. 1). In spite of the existence of seismic data dating from 1969-77, no previous study enabled us to get a clear structural image integrated within the general geologic framework of the Western Mediterranean sea. The acquisition of new seismic data in the Algerian offshore has justified a new structural reinterpretation using more up to date concepts. The main objective was to define the hydrocarbon potential of this offshore area.

Structural framework

The Algerian offshore shows the presence of two basins (Fig. 2):

- The Algéro-Provençal basin is characterized by two zones with different structural styles. To the east, there is a zone showing NW-SE alignments, to the north of ‘La grande and La Petite Kabylie’. To the west, there is a zone characterized by E-W to NE-SW trends which have allowed the westward displacement of the Alboran bloc during the middle Miocene (Kheidri & Ziou, 2003). These faults are seismically active at the present time and are associated with Plio-Quaternary volcanism. The Algerian western offshore shows the presence of an extensive depositional system, which may be subdivided into two systems separated by an evaporitic formation (Fig. 3). On the basis of the established structural model and examination of gravimetric, magnetic, and seismic maps, this area can be subdivided laterally into three geographical areas (parallel with the axis of the basin). From south to north, they are

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Figure 1 Geographical and geological schematic map of the Algerian offshore in the context of the Western Mediterranean Sea (modified after Dewey et al., 1989).

Figure 2 Schematic palinspastic map of the Algerian offshore.
successively the zone of block tectonics, the roll-over zone and the anticlinal zone (Fig. 3).

The South Alboran basin (Habibas) can be represented by a trans-tensional model developed for the South East Alboran basin (Kheidri et al., 2000). This latter is characterized by a low rate of structuration, with vertical synsedimentary movements that induce the appearance of onlap on the edges of the basin (Fig. 4). A well-developed Messinian evaporite (thick salt) sequence is absent in this area, in contrast with the neighbouring Mediterranean basins to the east.

Geodynamic evolution
The structural framework of the Algerian offshore is explained as resulting from the aftermath of two consecutive phases of extensional (early–late Miocene) and contractional (Late Miocene to Holocene) tectonics (Fig. 5) (Comas et al., 1999; Chalouan & Andre, 2000). Due to the diachronism in the opening of the Mediterranean basins, the earliest extensional structures present in the Algerian western offshore are middle Miocene in age.

Middle–late Miocene rifting: During this phase a dramatic extension was initiated and a great thickness of Neogene sediments was deposited over the whole of the western Mediterranean area. During this period, the western part of the Algero-Provençal basin behaved as a back arc basin (Kheidri & Ziou., 2004) and the Alboran basin was trans-tensional (Kheidri et al., 2000).

Post-Messinian compressional evolution. During the late Miocene until now, all the Algerian western offshore has been affected by a compressional/contractional regime (Comas et al., 1999, Chalouan & Andre, 2000). Compressional structures developed, induced by north-south contraction. An east-west trans-tension was initiated in the marine basin; coevaly, general uplift and emersion took place at the basin margins. The subsidence history at these times has been considered either thermal or flexural (Comas et al., 1999).

Hydrocarbon potential
In the western Algerian offshore just one exploration well (HBB-1) has been drilled; the definition of the petroleum system remains uncertain. Therefore, the structural data and analogy with similar zones were used as a basis to try to define the hydrocarbon potential of the region (definition of the plays and structures, size and distribution of the traps and evaluation of the state of maturity of the sedimentary section). Differences in the structural style may have a direct impact on the type of plays present. Thus we can have several petroleum systems in the two previously defined basins (Khedri et al., 2003).

The Algero-Provençal basin may show two types of plays. Type I, in front of the inner zones of the chain, is associated with ramp anticlines which develop during the southward thrust phases. It is the most promising type of play because it causes structuration in all the sedimentary series.
Type II is associated with the tilted block systems that develop behind the inner zones. This particularly involves Oligo-Miocene to Quaternary formations, and is associated with the back arc basin which developed at this location. Similar to the Eastern Algerian offshore (Kheidri & Ziou, 2004), this type is subdivided vertically into two systems:

- A deep 'subsalt' system of middle Miocene age, present under the Messinian saliferous layers. This latter is related to the half-grabens developed during the opening of the Mediterranean.
- A shallow 'post salt' system of Plio-Quaternary age above the Messinian salt, related to gravitational and salt tectonics.

In the South Alboran basin (Habibas), the western part of the margin is characterized by plays associated with the trans-tensional basin system which developed in the Habibas area. Onshore and in its continuation into the Alboran basin, the Cheliff basin has always been considered as a thrust basin, and is very poorly evaluated at the present time, though the potential is proven by many outcrops and subsurface indicators and the small field of Ain Zefz located in the Cheliff basin.

**Geodynamic impact**

The impact of geodynamics on the petroleum system is direct on the type and the age of the traps and the state of maturity of the sedimentary section. The Algéro-Provençal basin is affected only by the latest stage of the synrift tectonics, and the South Alboran basin behaves as a trans-tensional structure. In these types of basin only some stratigraphic traps are typically found. The earliest structures identified in the Algerian offshore are late Miocene in age. This requires a later timing of generation and expulsion (Plio-Quaternary).

The analysis of graphs of isotherms shows that in the Algerian offshore, the beginning of oil generation (vitrinite reflectance $R_0 = 0.70\%$) is situated at a depth of 2150 m, the maximum of oil generation (1.00\%) at 2760 m, the end of oil generation (1.30\%) at 3000 m, and the beginning of gas generation (> 2.0\%) at 3500 m (Fig. 6).

Analysis of the base of the deep and the shallow systems in terms of depth shows that the first is largely mature over the whole of the Algerian offshore, whereas the second is immature except for some small zones. The timing of generation and expulsion is favourable, since it began in the Pliocene and continued until the present.

**Conclusion**

The interpretation of seismic data, according to new concepts and the most recent models defined in other similar areas, has produced a new structural image of the Algerian offshore integrated within the regional tectonic framework. The resulting structural configuration information makes possible a better identification of the possible plays.

**Bibliography**


