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The Tithonian (Upper Jurassic) Edzna Formation, An Important Hydrocarbon Reservoir of the Campeche Shelf, Gulf of Mexico

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ABSTRACT

The Upper Jurassic (Tithonian) Edzna Formation is considered to be the most important source rock in the southeastern Mexico Campeche shelf, Gulf of Mexico. The formation is penetrated by a number of wells, in which cumulative and test production show that the Edzna Formation also is an important hydrocarbon reservoir. The formation is composed of a condensed section of mudstone and bentonitic shale. Thicknesses vary between 62 m and 120 m in the northeastern area, thickening to 393 m in the central marine area. The structural top commonly reaches depths of 6100 m in the southwestern and western areas, with a minimum depth of 1600 m in the northeast. There is a distance of approximately 120 km between deepest and shallowest burial areas. There are three important structures in the Campeche shelf: the Ceeh-Cantarell anticlinorium in the northeast, the Sinan-Mison syncline in the central area, and the May-Oktan anticlinorium in the southern area of the marine region. The northeast-southwest-trending Edzna Formation reservoir is about 150 km long by 50 km wide. To date, cumulative oil production is about 45 million barrels.

INTRODUCTION

The Campeche shelf is located in the southeastern Gulf of Mexico, seaward of the states of Tabasco and Campeche, between geographical coordinates 91° 40′–90° 00′ W and 18° 30′–20° 00′ N. Physiographically, it forms a portion of the continental platform, extending to a depth of 500 m offshore. It has a surface area of about 15,000 km^2 (Figure 1). The Campeche shelf is considered an important oil-producing province, with very important Jurassic- and Cretaceous-age reservoirs.

Many authors have studied the Tithonian rocks of the Campeche shelf: Angeles-Aquino (1988, 1996a, b); Angeles-Aquino et al. (1994); Angeles-Aquino and Ortuño-Maldonado (1990); Angeles-Aquino and Cantú-Chapa (2001); Araujo et al. (1986); Basañez and Brito-Arias (1988); Bello and Guardado (1989); Bertrand

Figure 1. Location map of the Campeche shelf, showing the producing fields.

(1982); Cantú-Chapa (1977, 1982, 1989, 1999); Cantú-Chapa and Landeros-Flores (2001); Flores-Balbuena (1987); Holguín and Romero (1983); Landeros-Flores and Neri-León (1984); Lugo-Rivera et al. (1976); Olivas (1975); Ornelas-Sánchez et al. (1993); and Stanford-Bestt (1989).

These rocks were named the Edzna Formation and divided into three members by Angeles-Aquino and Cantú-Chapa (2001). The lower member is a clayey mudstone, clear gray to dark brown in color. The middle member consists of dark gray calcareous-sandy shales and black calcareous-sandy shales interspersed with dark-colored clayey limestones. The upper member consists of clayey and bentonitic lime mudstones, with a chalky appearance. These mudstones are dolomitized near the eastern portion of the Campeche shelf. The Caan-1 well (Figure 1) is considered the locality type of this formation (Angeles-Aquino and Cantú-Chapa, 2001).

For years, the Tithonian rocks were considered to be the only source rocks of the Jurassic section in the Campeche shelf and Tabasco state (cf., Angeles-Aquino and Cantú-Chapa, 2001). However, Tithonian rocks produce liquid hydrocarbons from a number of wells located in Jujo-Tecominoacan, Paredon, Chinchorro, Pijije, and Bellota fields from Tabasco state, southeastern Mexico. To date, more than 45 million barrels of oil have been produced, indicating that Tithonian rocks also are important hydrocarbon reservoir rocks in the Campeche shelf. A regional structural and stratigraphic study of the Edzna Formation was conducted using information from 50 wells; the wells form one cross section, one isopach map, and two structural maps. Oil production data were obtained from 21 wells located in this marine area.

STRATIGRAPHIC DESCRIPTION

The Edzna Formation has a wide distribution in southeastern Mexico. It forms a characteristic interval of mudstone and bentonitic shale in the subsurface between two dolomitized limestone units. The stratigraphic section shows the distinctive well log response of the Edzna Formation, which is divided into the lower, middle, and upper members as proposed

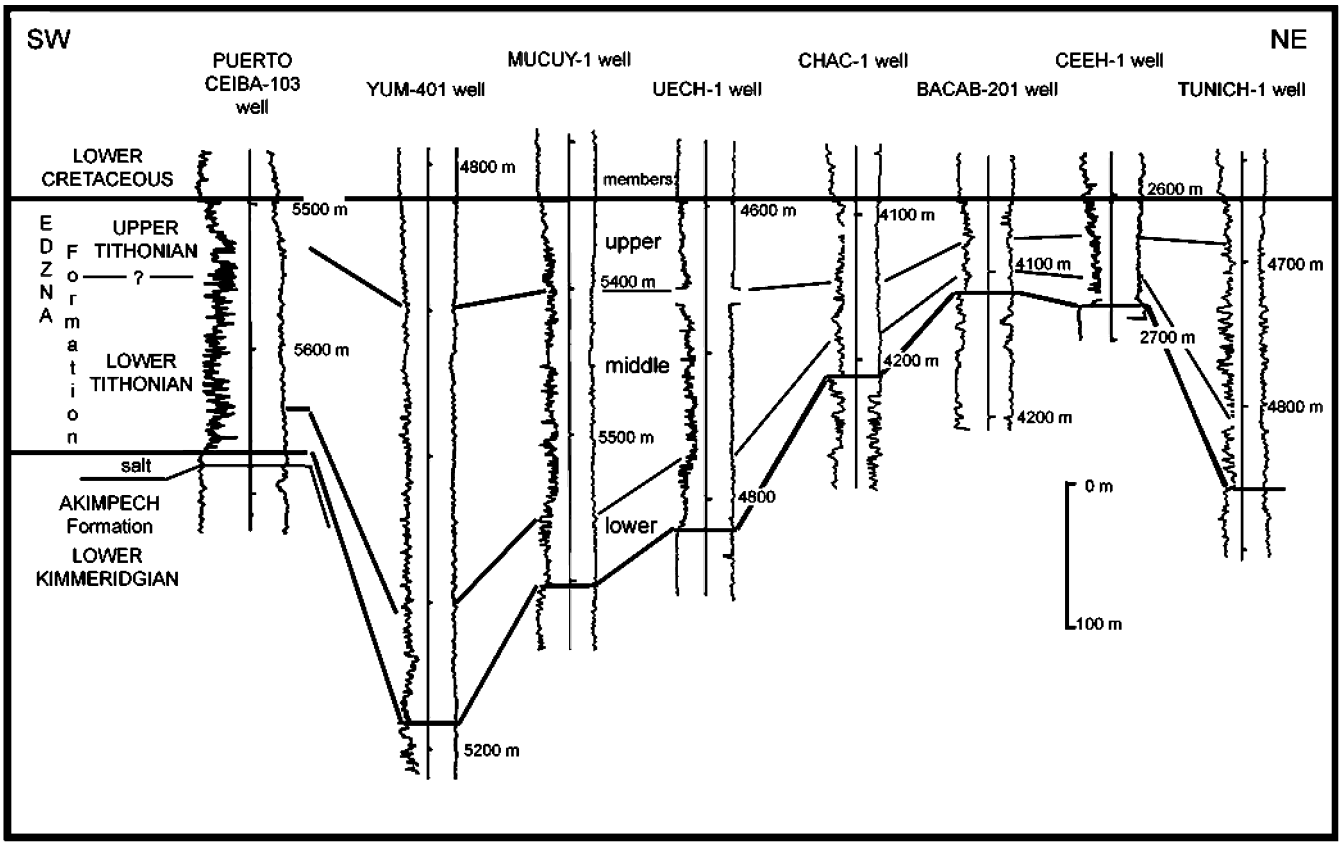

Figure 2. **Stratigraphic cross section of the Edzna Formation in the Campeche shelf. Datum is the Jurassic-Cretaceous boundary; location is shown in Figure 1. Well logs are gamma-ray (left) and resistivity (right).**

by Angeles-Aquino and Cantú-Chapa (2001). These members are present almost everywhere, which makes it possible to correlate them within the formation across long distances.

The stratigraphic cross section of the Edzna Formation was made using eight radioactivity logs along a 240-km transect. Three wells are located in the northeastern area and five wells are in the central-southwestern area of the Campeche shelf. The extreme southwest of the section is correlated with the onshore Puerto Ceiba-103 well from the State of Tabasco (Figure 2).

The section shows that the greatest thickness of the Edzna Formation is in the Yum-401 well (355 m) in the central area. Condensed sections were penetrated in the wells Bacab-201 (62 m) and Ceeh-1 (74 m) in the northeastern area. Moreover, thinning of the three members is related to condensation, not to erosion or onlap (Figure 2).

The upper contact between the Edzna Formation and the Lower Cretaceous dolomitized limestone is sharp, as shown by the gamma-ray curve of the logs. A strong lithologic change noticeable in radioactive logs characterizes the lower contact between the Edzna Formation and the Kimmeridgian Akimpech Formation. The upper part of the latter formation includes Member E, which consists of mesocrystalline (Uech-1 well) and microcrystalline dolomites (Chac-1 well) (Angeles-Aquino and Cantú-Chapa, 2001). The Edzna Formation overlies a thin salt body of 10 m in the Puerto Ceiba-103 well, which is located in the southwestern area (Figure 2).

Figure 3 shows two structures in the isopach map of the Edzna Formation indicated by changes in thickness. The structures are located in the northeastern area and in the central area of the Campeche shelf. A prominent thin trend 45-km long is aligned northwest to southeast in the northeastern area. Thin intervals of about 70 m were drilled in wells of the northeastern area (Figure 3A).

The second structure is located in the central region of the Campeche shelf. It is perpendicular in orientation to the previously described structure. The central structure has a northeast-to-southwest

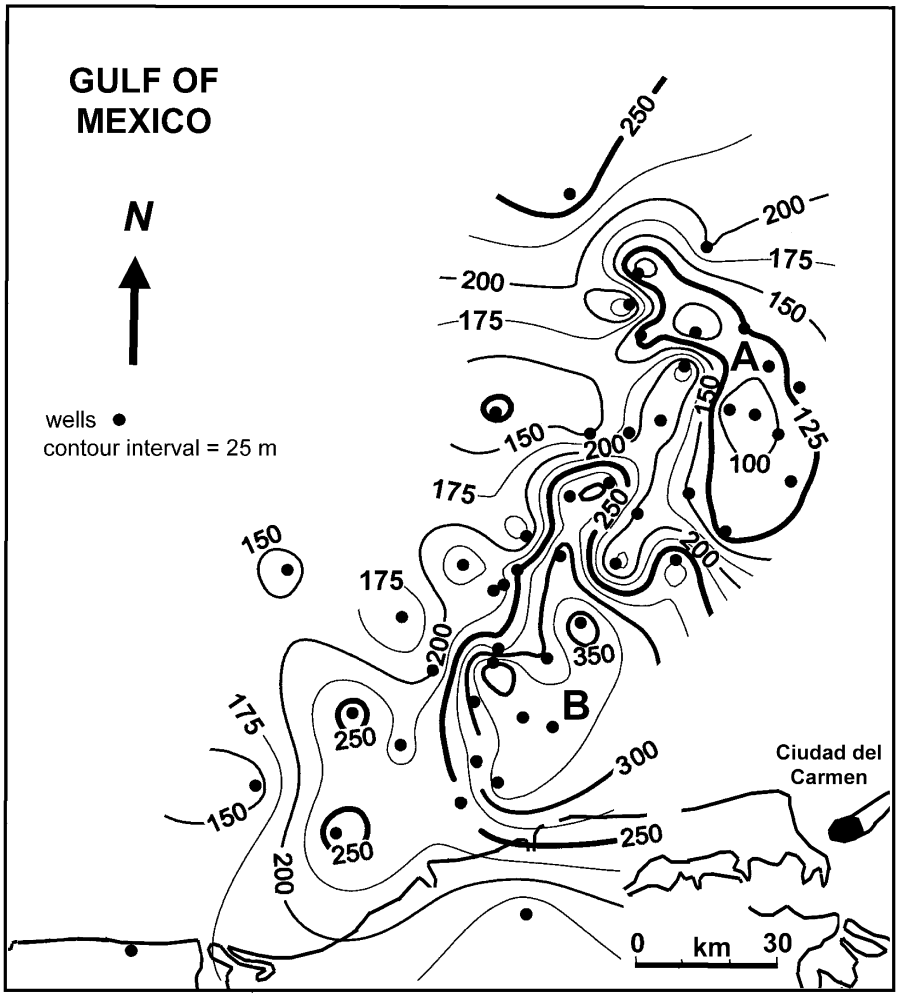

Figure 3. Isopach map of the Edzna Formation in the Campeche shelf. Isopach is in meters. Contour interval = 25 m.

orientation and is 125-km long. Its thickness varies from 130 m to 390 m (Figure 3B).

SEDIMENTOLOGY

Tithonian strata deposited in southeastern Mexico are characterized by bathyal facies. The most notable sedimentological feature of the Edzna Formation is the abruptness of lateral-thickness changes in areas very close to one another, such as in the Cantarell oilfield complex, and the Taratunich, Abkatun, Caan, Pol, and Chuc oil fields.

The deposits of different thicknesses of the Edzna Formation were probably influenced by the irregular relief of the underlying Kimmeridgian Akimpech Formation on which they were deposed. Thin sections of the Edzna Formation may have accumulated by slow deposition over structurally high areas of open sea. In contrast, the thick sections of this formation may indicate more basinal areas or structural lows on the Akimpech Formation.

On the other hand, the upper member of the Akimpech Formation is characterized by dolomitized oolitic limestone that probably influenced the irregular deposition of the overlying Edzna Formation.

Toward the southwest of the Campeche shelf, the Edzna Formation (middle member) changes from argillaceous carbonate and shale to pore carbonate rocks. It is inferred here that the cleanest facies in this carbonate rocks were dolomitized and fractured as a result of tectonic events, leading to secondary porosity development. These processes transformed the formation into a reservoir.

AGE

Ammonites found at the top of the Edzna Formation, specifically in the upper member, include *Durangites* sp. in the Chac-1 well (core 4) and *Salinites* sp. and *Protancyloceras* sp. in the Chac-2 well (core 14). The middle member provided a specimen of *Suarites* sp. in the Tunich-1 well (core 7). These fossils characterize the upper Tithonian and are known in northeastern and eastern Mexico (Cantú-Chapa, 1977, 1982, 1989, 1999) and Cuba (Myczynski, 1999). A specimen of *Mazapilites* sp. was obtained from the lower member in the Puerto Ceiba 101A-well (core 1, 5439–5440 m); this ammonite is characteristic of the lower Tithonian (Cantú-Chapa, 2001). These fossils establish a Tithonian age for the Edzna Formation. Calpionellids (*Calpionella*) (*alpina*, *Crasicollaria massutiniana*), saccocomas, and calcified radiolarians predominate in the upper member.

STRUCTURAL GEOLOGY

The structural map of the top of the Edzna Formation in the subsurface of the Campeche shelf is based on 50 well penetrations (Figure 4). Its study

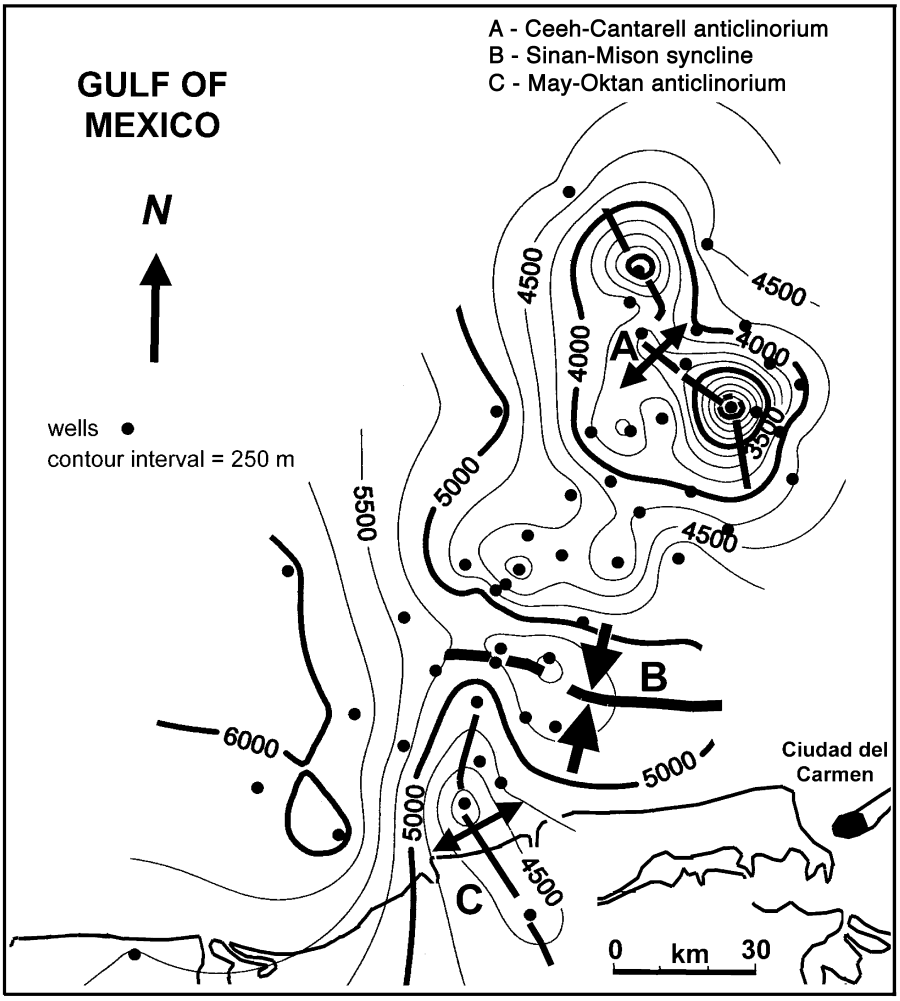

Figure 4. Structural map of the top of the Edzna Formation. Isobath is in meters.

permits an understanding of hydrocarbon accumulation in this formation. The most conspicuous features of the structural map are represented by three important regional structures and five minor structural traps. The first ones are named here the Ceeh-Cantarell anticlinorium in the northeastern area, the Sinan-Mison syncline in the central area, and the May-Oktan anticline in the southern area of the Campeche shelf (Figure 4).

1) The Ceeh-Cantarell anticlinorium consists of two segments or domains and is approximately 80-km long by 25-km wide; it has a northwest-to-southeast orientation. The structural closure of the domains in the axis of the anticline varies from 1601 m (Cantarell-94A well) to 2605 m (Ceeh-1 well). The name refers to the Ceeh and Cantarell fields, which are located in the extremes of this anticline (Figure 4A).

   The same structural behavior of the Tithonian Edzna Formation is observed in the Campanian-Maastrichtian Cantarell Formation from the Campeche shelf. The top of the latter formation is between 1800 m (Cantarell-57 well) and 3360 m (Abkatun-74 well) in a short distance of approximately 25 km in the northeastern area studied (Cantú-Chapa and Landeros-Flores, 2001, Figure 4).

2) The Sinan-Mison syncline has a west-to-east orientation and is approximately 70-km long in the central area of the Campeche shelf. The top of the Edzna Formation was penetrated at 5283 m in the Sinan-101 well and at 5594 m in the Mison-1A well. Both wells penetrated the syncline axis and provide the name of this structure (Figure 4B).

3) The May-Oktan anticlinorium is present in the southern area of the Campeche shelf. It has a northwest-to-southeast orientation and is 50-km long by 15-km wide. Its axis was drilled at 4020 m and 4430 m in the May and Oktan wells, respectively. The depths cited above correspond to the top of the Edzna Formation (Figure 4C).

All these structures also are present in the structural map of the base of the Edzna Formation, which confirms their presence (Figure 5). Detailed geological studies of some oil fields show these structures, which are cut by several faults (Cabrera-Cuervo, 2000; Pérez-Aldana, 2000).

PRODUCING AREA

One of the more remarkable features of the Edzna Formation is its potential as a hydrocarbon reservoir rock. Its cumulative oil production is about 45 million barrels; the production data were obtained for 21 wells. The hydrocarbon-producing area at the Edzna

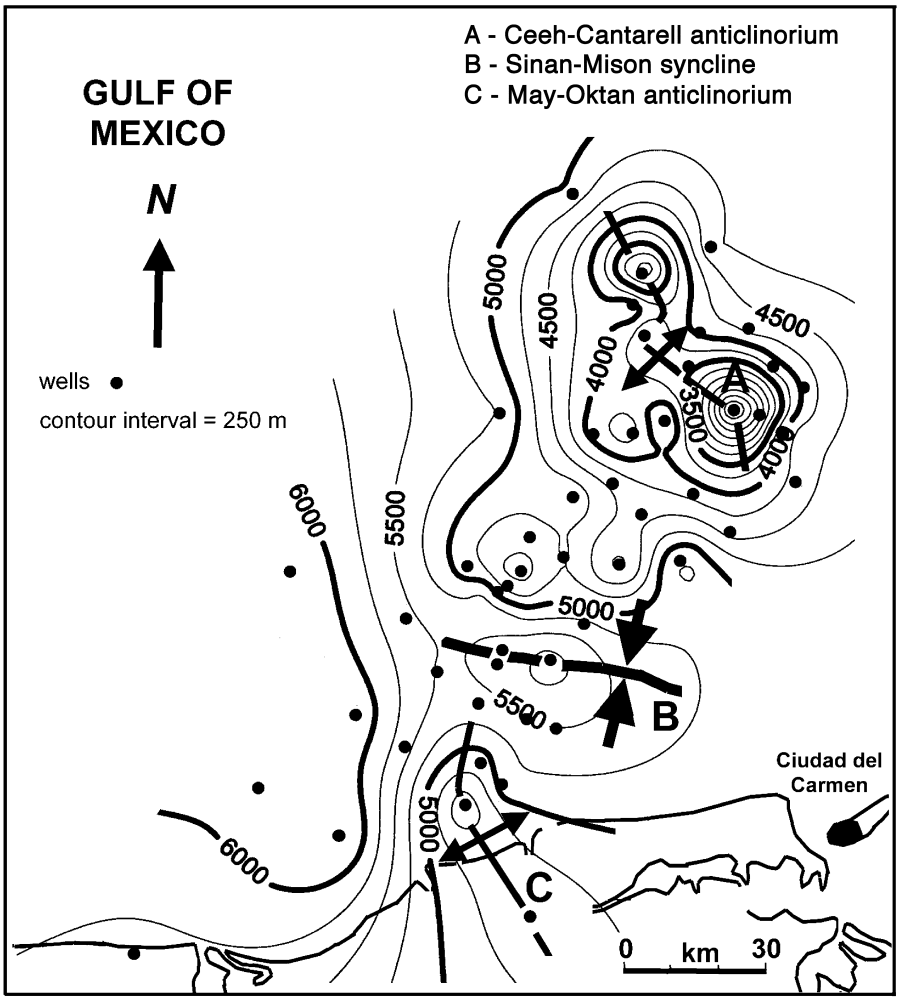

Figure 5. Structural map of the base of the Edzna Formation. Isobath is in meters.

Formation is located in a structure about 150-km long by 50-km wide. It is oriented approximately northeast-to-southwest in the central region of the Campeche shelf (Figure 4). A review of the cumulative production of the Edzna Formation wells shows that its range of oil production for the scattered oil fields is so great that production trends are not meaningful. Practically all of the traps in the Edzna Formation are of the structural type.

CONCLUSION

The present study is made only with drilled-well data. The stratigraphic study of the Edzna Formation shows it to be a condensed section. Its structural study, in a regional level, characterizes the scattered oil fields, and it shows the importance of the Edzna Formation as a significant reservoir in the Campeche shelf. Oil fields are related mainly to structures.

The cumulative production of the Edzna Formation wells shows that its range of oil production is great. Its productive trends are not apparent. Reservoirs must be evaluated and considered on an individual basis. Tectonic events fractured and transformed the Tithonian formation into reservoir rocks. The location and orientation of the producing area may have been influenced by the Cenozoic origin of the platform of the Yucatan Peninsula, whose western margin is parallel to the producing area of the Campeche shelf.

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