

## BIOMARKER CHARACTERISATION OF OILS IN THE SALINA BASIN, MEXICO

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**ABSTRACT** – The Salina basin, Southeastern Mexico, was the first explored and one of the most productive petroliferous province of Mexico. Geochemical and biological markers analyses of oils were used to identify two major source-related oil families that were generated from source rocks deposited in: an anoxic marine carbonate environment associated with a silled-basin geometry (Tithonian age, Family 1), and a clay-rich suboxic/anoxic marine carbonate environment associated with isolated depressions in intraplatformal sags (Tithonian age, Family 2). Local source rock facies variations can explain the compositional differences in the geochemical features of these oils.

**RESUMEN** - La Cuenca Salina, ubicada en el sureste de México, fue la primera explorada y una de las provincias petrolíferas más productivas de México. Análisis geoquímicos y de marcadores biológicos de crudos fueron usados para identificar dos familias principales relacionadas a fuentes diferentes, que fueron generadas de rocas madres depositadas en: un ambiente marino carbonatado anóxico, asociado a una geometría de *silled-basin* (edad Tithotiana, Familia 1), y un ambiente marino carbonatado sub-óxico/anóxico rico en arcilla, con depresiones aisladas en sacos intraplataformaes (edad Tithotiana, Familia 2). Variaciones de facies locales en la roca madre pueden explicar las diferencias composicionales en las características geoquímicas de estos crudos.

### INTRODUCTION

In most Mexican sedimentary basins, exploration is far from being mature, since detailed multidisciplinary studies have not been carried out.

The Gulf of Mexico is one of the largest petroleum provinces of the world. The southern half of the Gulf of Mexico, in which the Salina basin is located, is highly oil prone (Fig. 1). Exploration started in late 1920, but the main discoveries occurred only in the 1950's (Santiago *et al.*, 1984).

This paper aims to classify the oil types present in the Salina basin, assessing the depositional environments of their source rocks. The purpose is to understand differences in their composition through molecular geochemistry using GC-MS techniques (e.g. Mackenzie *et al.*, 1984; Moldowan *et al.*, 1985; Mello *et al.*, 1988; Peters & Moldowan, 1993; Mello *et al.*, 1995).

Geochemical data from 12 oils, selected from 92 oil samples, recovered from reservoirs, ranging in age, from Miocene to Pleistocene (Table 1) were integrated with geological information and correlated to organic rich extracts from a Tithonian organic-rich section from the Tampico-Misantla

basin (Guzmán-Vega *et al.*, 1991). All the oil samples and organic extracts were analyzed by carbon isotopes, gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) techniques. The oils were also screened by API gravity and elemental analysis (Ni, V and S).

### EXPERIMENTAL AND ANALYTICAL PROCEDURES

All oil and organic extract samples were submitted to bulk, elemental and liquid chromatography analysis according procedures described previously (Mello, 1988).

Bitumen was extracted in a Soxhlet Apparatus by refluxing with dichloromethane. The organic extracts were fractionated via solid-liquid chromatography.

The GC analyses of alkanes were carried out using a Hewlett Packard 5890A equipped with a splitless injector and fitted with a 30m DB-5 column. The GC-MS analyses were performed using a HP-5890 spectrometer coupled to a Hewlett Packard 5890A GC equipped with on column injector, and fitted with a 25m SE-54 column.

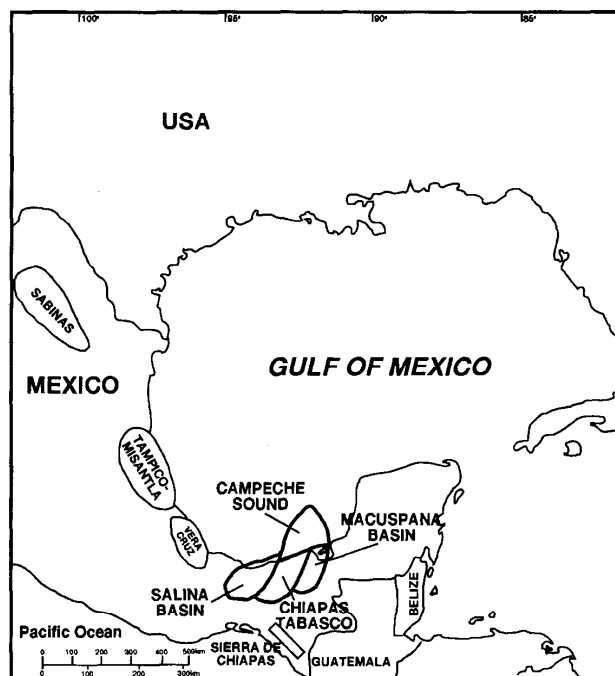


Fig. 1.- Location map of Salina basin, Southeastern Mexico.

The bitumen and oils were oxidized to CO<sub>2</sub> in a continuous oxygen flow preparation line; carbon isotope ratios of bitumen were measured in a Delta-E Finnigan mass spectrometer. The isotopic data were reported in the usual delta notation referenced to the PDB standard.

## RESULTS AND DISCUSSION

Sedimentary organic matter and oils contain complex assemblages of biological markers, and it is well established that such components can reflect the distribution of precursor compounds in organisms which contributed organic matter at the time of sediment deposition. Biological marker distributions in oils can, therefore, serve as diagnostic fingerprints carrying information about the prevailing environmental paleo-conditions. Thus, biomarkers can assist in ascertaining the depositional environment of petroleum source rocks via the types of contributing organisms (e.g. Mello, 1988; Mello *et al.*, 1988; Peters & Moldowan, 1993; Mello *et al.*, 1993 and 1995).

Although the oils studied share most of their geochemical characteristics, they can be subdivided

based on their specific molecular features into two distinct oil families (Fig. 2).

### Family 1 oils

These oils are associated with marine siliciclastic reservoirs, ranging in age from Miocene to Pliocene, with almost 90% pooled in Upper Miocene reservoirs (Table 1).

Among the bulk and GC data of the oils, the sulfur content and pristane/phytane ratio distinguish this family from the oils classified as Family 2 (e.g. Fig. 3-6 and Table 1). Their geochemical features include saturated HC contents ranging from 21% to 63% (Table 1), low to high API gravity ranging from 15° to 37°, sulfur content from 0.1 to 6.0%, and V/Ni ratios ranging from 1-5.0% (Fig. 3-6 and Table 1). The broad variation in the above geochemical features is explained not only by slight source rock facies variation, but also by a narrow range of thermal evolution (oils ranging from early to peak generation stages).

The oils present whole oil carbon isotope data ranging from -25.6‰ to -27.8‰ (Table 1 and Fig. 3) that do not allow separation between the two families. Integration of these data suggest a

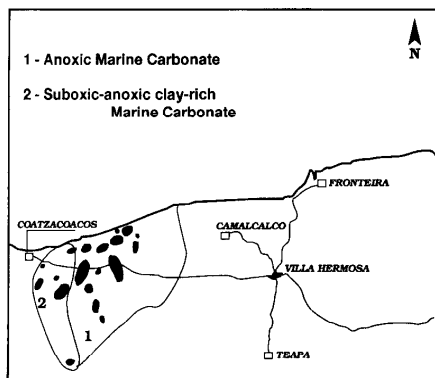


Fig. 2. Geographical distribution of oil families in the Salina basin.

marine carbonate environment for Families 1 and 2 source rocks with variable input of siliciclastic material (Palacas *et al.*, 1984; Mello *et al.*, 1988; Guzmán-Vega *et al.*, 1991; Peters & Moldowan, 1993; Mello *et al.*, 1995).

Figures 4 and 5 show key molecular features that allow the characterization and differentiation of Family 1 from Family 2 oils. The most important are: presence in Family 1 oils of 28,30-bisnorhopane, C35/C34 ratios  $\gg 1$ , Ts/Tm  $\ll 1$ , C29/C30 ab-hopanes ratios  $> 1$ , low to very low relative abundances of a series of C28-C34 17a(H)-diahopanes, presence of C30 steranes and very low relative abundance of diasteranes (Figs. 4-9). These biological marker features have been reported as diagnostic of marine carbonate oils with very little input of siliciclastic material in the Gulf Coast (Sofer, 1988; Sassen, 1990;

Moldowan *et al.*, 1990; Wenger *et al.*, 1991; and Comet *et al.*, 1993).

The low Ts/Tm ratios and high relative abundance of extended homohopanes associated with very high C35/ C34 ratios are quite distinctive, since hypersaline conditions appear to increase bacterial contributions to the sediments. Thus, the concentrations of the bacterially-derived extended hopanes and Tm in these oils are extremely high, perhaps reflecting the importance of bacterial lipids in a more carbonate setting. In particular, the low 17a (H)-diahopane/C29Ts ratios observed in the Family 1 oils when compared with the Family 2 oils (Figs. 8-9), corroborates the marine carbonate anoxic environment with low siliciclastic input for the Family 1 source rocks. The origin of this compound would be discussed in more detail below.

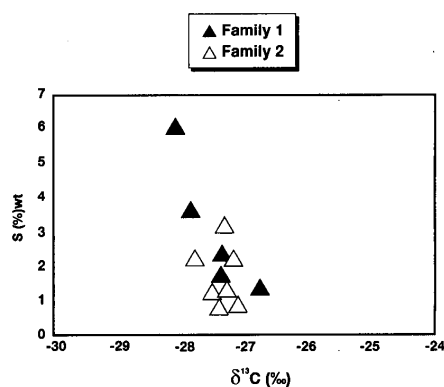


Fig. 3. Sulfur content (% wt) vs. whole oil carbon isotope composition (‰).

OIL FAMILY	WELL	DEPTH (m)	RESERVOIR AGE	LITHOLOGY	API GRAVITY	CARBON 13	S (%)	V (ppm)	N (ppm)	V/N1	% SATURATES
1	SAL-1	1539 - 1549	Upper Miocene	Sandstones	15.2	-27.9	3.6	110.0	31.0	3.5	23.5
1	SAL-2	1540 - 1543	Upper Miocene	Sandstones	16.3	-28.1	6.0	i**	i**	i**	39.9
1	SAL-3	385 - 390	Upper Miocene	Sandstones	23.9	-27.3	2.2	49.0	23.0	2.1	43.7
1	SAL-4	1805 - 1830	Upper Miocene	Sandstones	25.0	-27.4	1.7	20.0	7.0	2.9	45.0
1	SAL-5	550 - 569	Upper Cretaceous	Limestones	33.6	-26.8	1.3	16.0	4.0	4.0	59.4
1	SAL-6	490 - 500	Middle Cretaceous	Limestones	33.8	-26.8	1.3	16.0	4.0	4.0	62.3
2	SAL-7	2591 - 2596	Upper Miocene	Sandstones	12.9	-27.5	1.2	30.0	21.0	1.4	38.1
2	SAL-8	620 - 627	Upper Pliocene	Sandstones	15.5	-27.2	2.1	38.0	19.0	2.0	37.1
2	SAL-9	3383 - 3397	Upper Miocene	Sandstones	27.0	-27.8	2.1	i**	i**	i**	39.3
2	SAL-10	2685 - 2717	Upper Miocene	Sandstones	27.2	-27.3	1.3	33.0	21.0	1.6	45.8
2	SAL-11	2997 - 3017	Upper Miocene	Sandstones	36.4	-27.1	0.9	7.0	4.0	1.8	58.7
2	SAL-12	1250 - 1260	Lower Pliocene	Sandstones	37.2	-27.4	0.8	11.0	5.0	2.2	63.2

Table 1. Identification and Bulk Data for oils from Mexican Southeastern Basins

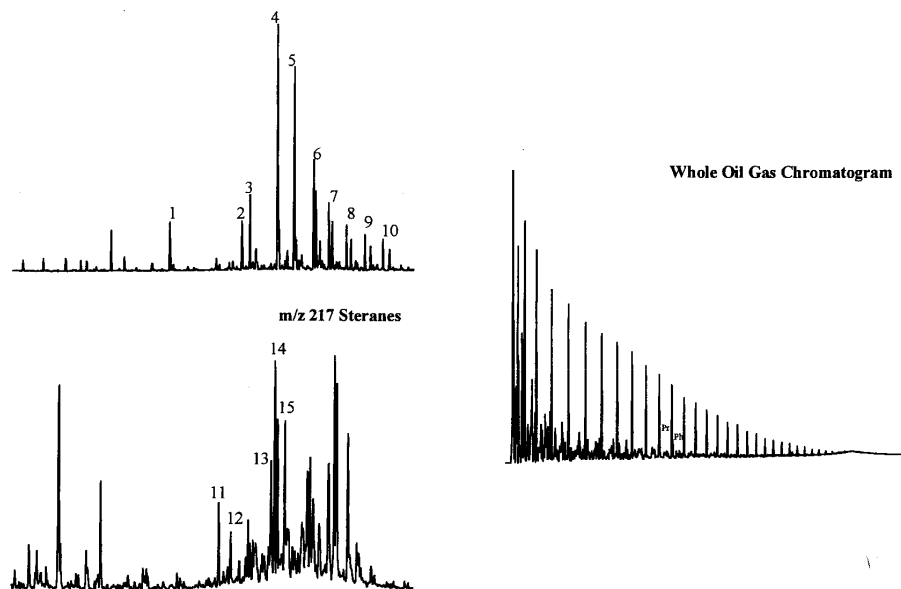


Fig. 4. Whole oil gas chromatograms and M/Z 191 and M/Z 217 fragmentograms for a typical Family 1 oil.

Figure 10 illustrates the oil-source rock correlation using biomarker ratios and features related to gas chromatograms and m/z 191 and m/z 217 mass chromatograms. As can be observed, there is a good correlation between the biological marker features arising from a representative oil from Family 1 and an organic-rich Tithonian marl recovered from a well of the Tampico-Misantla basin. These rocks were deposited in a restricted basin under upper to middle neritic conditions (Guzmán-Vega *et al.*, 1991). Such correlation allow to speculate on the presence of as yet undrilled Tithonian source rocks in the Salina Basin, as observed in the Tampico-Misantla basin.

#### Family 2 oils

These oils are associated with Upper Miocene marine siliciclastic reservoirs in the West part of Salina Basin (Fig. 3).

They show bulk geochemical features typical of oils derived from marine carbonate environments, similar to Family 1, although suggesting a clay-rich facies. These include compositional and elemental data such as low sulfur contents and V/Ni ratios, medium content of saturates, pristane/phytane > 1 and isotopic values of oils ranging from -26.3‰ to -27.8‰ (Figs. 3-6 and Table 1). Some of these data are

typically observed with oils derived from clay-rich marine carbonate environments (Sofer, 1988; Talukdar *et al.*, 1986; Mello *et al.*, 1988; Mello *et al.*, 1995).

Figure 5 shows GC and GC-MS data of a typical Family 2 oil. Although oils of this family share several molecular features with Family 1 oils, they present some biomarker features that distinguish and characterize them as sourced by marine carbonate sediments deposited under siliciclastic influence (Figs. 4-9; for peak identification see appendix 1). The most important includes: C35/C34 ratios < 1, Ts/Tm > 1, high to very high relative abundances of a series of C28-C34 17a(H)-diahopanes, presence of C30 steranes and high relative abundance of diasteranes relative to the steranes. These biological markers have been reported as associated with marine carbonate oils derived from clay-rich source rocks (Northam, 1985; Schou *et al.*, 1985; Mello *et al.*, 1988; Moldowan *et al.*, 1990; Sassen, 1990; Peters & Moldowan, 1993; Mello *et al.*, 1995).

The compound 17a(H)-diahopane (C30\* compound) has been named sometimes as compound 'X' (Philp & Gilbert, 1986) and it has been regarded as a possible terrestrial marker because of its presence in coals and terrestrially sourced oils (Volkman *et al.*, 1983; Philp & Gilbert,

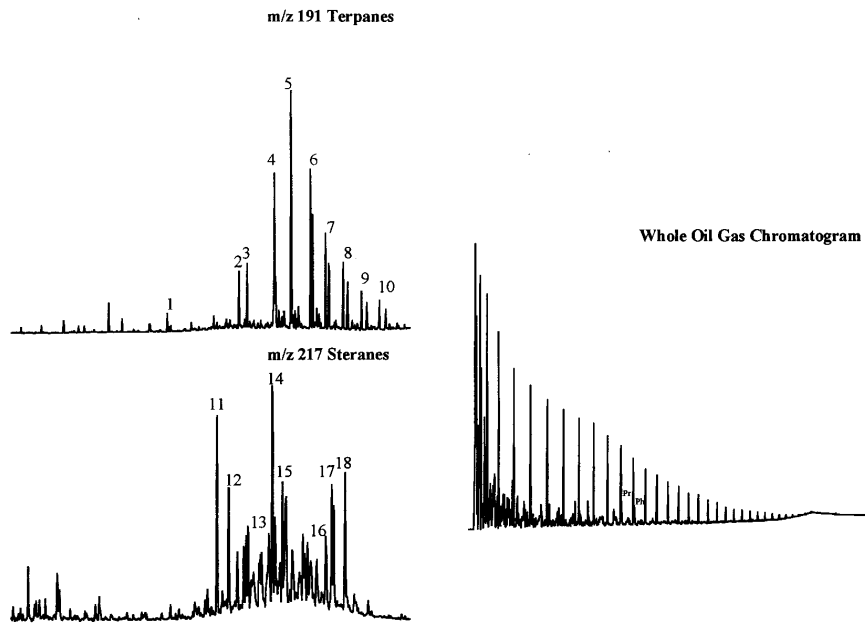


Fig. 5. Whole oil gas chromatograms and M/Z 191 and M/Z 217 fragmentograms for a typical Family 2 oil.

1986). However, Moldovan *et al.*, (1991) determined its structure and showed it to be derived from bacteriohopane precursors. Peter & Moldovan (1993) suggested that a high relative concentrations of C30\* could be associated to an bacterial input deposited in a clay-rich sedimentary environment under oxic or suboxic conditions and proposed the C30\*/C29Ts ratio as an indicator of

clay content and/ or oxygen depletion level for environmental interpretation. As can be observed, in Figures 8-9, there are good correlations between the C30\*/C29Ts ratio and other indicators of clay content and salinity/redox conditions (eg. low C29/C30 hopanes, high diasterane index, high Ts/Tm,

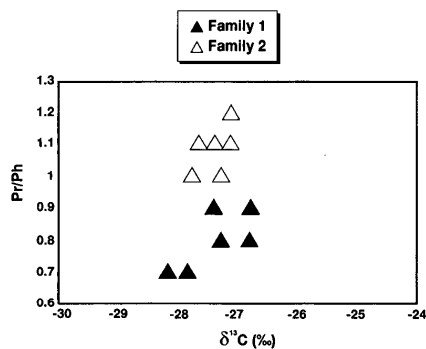


Fig. 6. Pristane/Phytane ratio vs. whole oil carbon isotope composition.

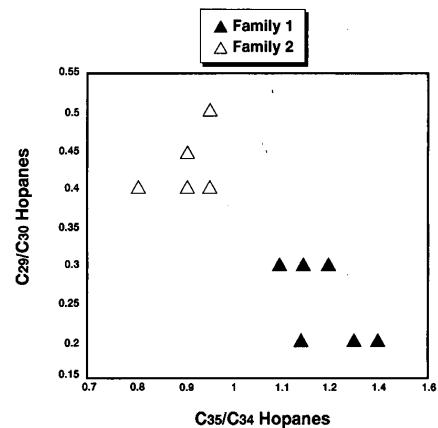


Fig. 7. C<sub>29</sub>/C<sub>30</sub> pentacyclic terpanes vs. C<sub>35</sub>/C<sub>34</sub> hopanes ratios of oils.

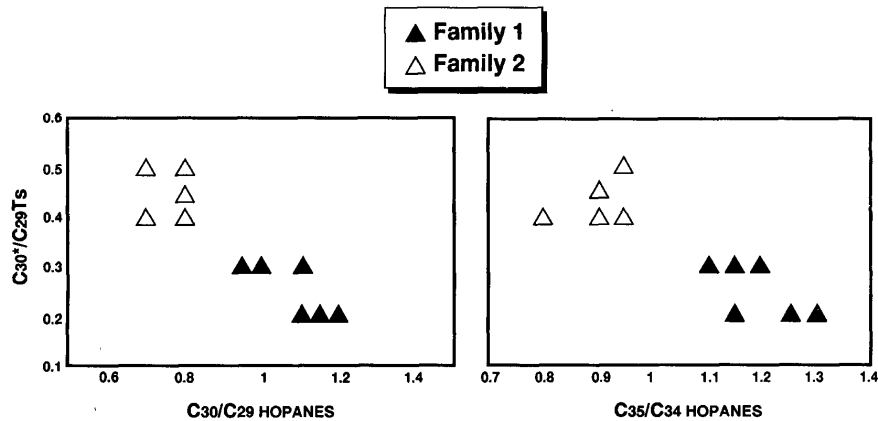


Fig. 8.  $C_{30^*}/C_{29}Ts$  ratio vs.  $C_{29}/C_{30}$  and  $C_{35}/C_{34}$  hopanes ratios of oil.

high pristane/phytane and low  $C_{35}/C_{34}$  hopanes ratios). These biological marker features, suggest an origin from a source rock deposited in a clay-rich suboxic/anoxic marine carbonate semirestricted environment.

In summary, the biomarker differences of oils from the Salina basin can be interpreted in terms of salinity, clay-content and oxygen depletion variations associated with facies changes within a Tithonian marine carbonate depositional environment, during the Upper Jurassic anoxic event that occurred in the Gulf of Mexico (Guzmán-Vega *et al.*, 1995).

The block diagram in Figure 11 is an idealized illustration of the paleoenvironment of deposition proposed to have existed during Tithonian times in the Salina basin. This model assumes, for the source rocks of the Family 1 oils, that the Tithonian ocean was a narrow and shallow semi-restricted sea, under a semi-arid climate. Such conditions are favored by a silled-basin geometry in an extensional tectonic setting. In this situation, vertical mixing is restricted and enhanced water stratification, leading the development of anoxia and organic preservation (e.g. Tampico-Tuxpan basin; Guzmán-Vega, 1991 ; Guzmán-Vega *et al.*,

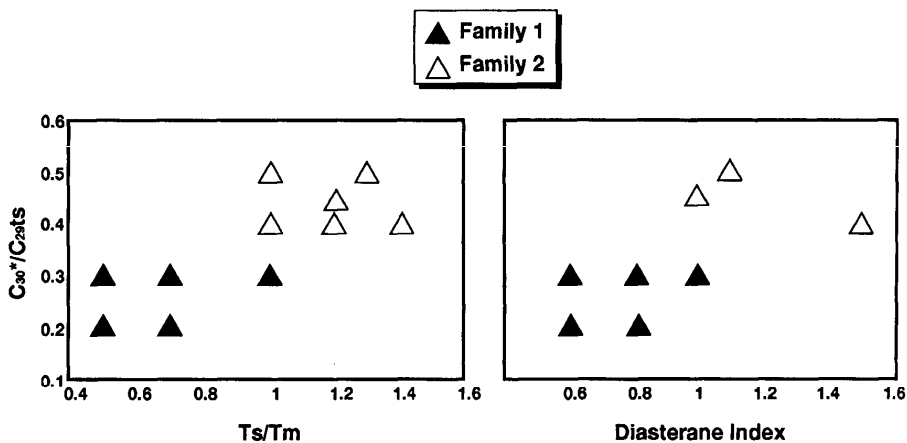
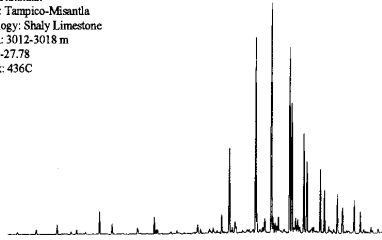


Fig. 9.  $C_{30^*}/C_{29}Ts$  ratio vs. diasterane index and  $Ts/Tm$  ratios of oil.

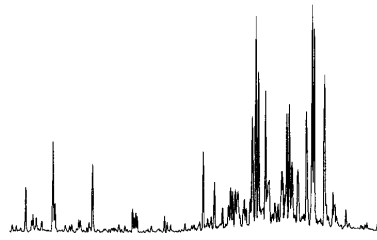
**JABONERA 1 EXTRACT**  
m/z 191 Terpanes

Age: Tithonian  
Basin: Tampico-Misantla  
Lithology: Shaly Limestone  
Depth: 3012-3018 m  
δ13C -27.78  
T max: 436C



(a)

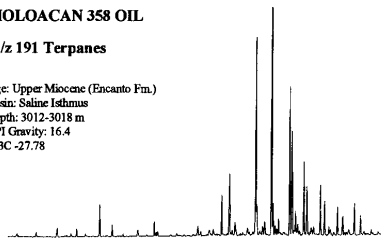
m/z 217 Steranes



**MOLOACAN 358 OIL**

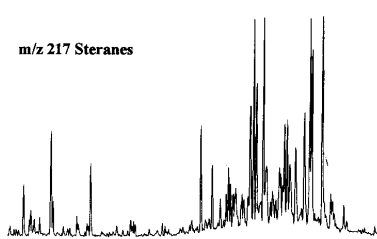
m/z 191 Terpanes

Age: Upper Miocene (Encanto Fm.)  
Basin: Salina Isthmus  
Depth: 3012-3018 m  
API Gravity: 16.4  
δ13C -27.78



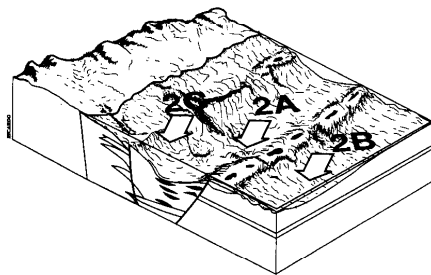
(b)

m/z 217 Steranes



**Fig.10.** Oil-source rock correlation using a typical Family 1 oil and an organic extract from a Tithonian marl of Tampico-Misantla basin.

1991). By contrast, the deposition of the source rocks for the Family 2 oils occurred in a more proximal position, in intraplatformal sags, under shallow to middle neritic conditions at time of a global transgression period and a worldwide anoxic event (Aguayo *et al.*, 1985; Michaud, 1987).



**Fig. 11.** Schematic block diagram showing the postulated depositional environment in which the source rocks for families 1 and 2 oils were deposited.

**CONCLUSIONS**

The oils in the Salina basin, Southeastern Mexico, are associated with marine carbonate environments with variable siliciclastic input. They show differences in key biomarker ratios and isotopic signatures that distinguish the sources for these oil types as: an anoxic marine carbonate environment associated with a silled-basin geometry (Family 1 oils) and a clay-rich suboxic/anoxic marine carbonate environment associated with isolated depressions in intraplatformal sags (Family 2 oils).

The oil-source rock correlation allows to propose the Tithonian organic-rich calcareous shales as the source rocks for the oils recovered in the Salina basin.

Regional geochemical variations of the oils could be explained by differences in the source rock facies all throughout the area, reflecting the Tithonian paleogeography in this part of the Gulf of Mexico.

These oils are accumulated onshore throughout the stratigraphic column from Miocene

to Pliocene reservoirs, which, in view of these results can only be explained by an origin from deep Tithonian source rock associated with a vertical migration pathway.

#### ACKNOWLEDGMENTS

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#### REFERENCES

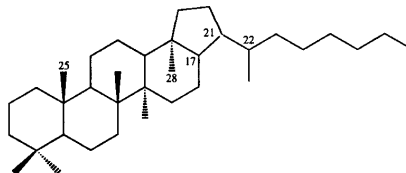
- AGUAYO, E.; BELLO, R. & M. BASA, E.Z. 1985 Evolución sedimentaria del Mesozoico del area de Chiapas-Tabasco. *Revista del Instituto Mexicano del Petróleo*, 40: 123-138
- COMET, P.; ALCALA-HERRERA, J.A.; MORELOS-GARCIA, J.A.; SASSEN, R. & BROOKS, J. 1993 Classification and Origin of Petroleum from the Northern Gulf of México. In: MELLO, M.R. & TRINDADE, L.A.F. Eds. *Extended Abstracts from Third Latin American Congress on Organic Geochemistry*, Manaus, Brazil. p.30-31
- GUZMÁN-VEGA, M.A. 1991 *Géodynamique sédimentaire du bassin de Tampico-Tuxpan, est du México: Sédimentation, Subsidence, Évolution de la Matière Organique*. Ph.D. Thesis, University of Pau, France
- GUZMÁN-VEGA, M.A.; MARTINEZ-CONCHA, F.J.; ARAUJO, C.V. & MELLO, M.R. 1991 Evaluación geoquímica de la Cuenca de Tampico-Tuxpan, Este de México. IMP/Petrobrás internal publication, p. 1-32.
- GUZMÁN-VEGA, M. A.; MELLO, M.R.; LEÓN, C. & HOLGUIN, N. 1995 Tithonian oils from the Sureste basin, Mexico: The facies variability of their source rocks. In: GRIMALT, J.O. & DORRONSORO, C. Eds. *Organic Geochemistry: developments and applications to energy, climate, environment and human history*. Selected papers from the 17th International Meeting on Organic Geochemistry, 1995. Donostia-San Sebastián, Spain, p. 229-231.
- MACKENZIE, A. S.; MAXWELL, J. R.; COLEMAN, M.L. & DEEGAN, C.E. 1984 Biological marker and isotope studies of North Sea crude oils and sediments. 11th World Petroleum Congress *Proceedings*, "Geology Exploration Reserves", 2:45-56.
- MELLO, M.R. 1988 *Geochemical and molecular studies of the deposition environments of source rocks and their derived oils from the Brazilian marginal basins*. Ph.D. Thesis, University of Bristol, 240pp.
- MELLO, M.R.; GAGLIANONE, P.C.; BRASSELL, S.C.; & MAXWELL, J.R. 1988 Geochemical and biological marker assessment of depositional environment using Brazilian offshore oils. *Marine and Petroleum Geology*, 5:205-203.
- MELLO, M.R.; KOUTSOUKOS, E.A.; SANTOS NETO, E.V. & SILVA TELLES JR., A. 1993 Geochemical and micropaleontological characterization of lacustrine and marine hypersaline environments from Brazilian basins. In: KATZ, B.J. & PRATT, L. Eds. *Source Rocks in a Sequence Stratigraphic Framework*, AAPG Memoir, 68:17-34.
- MELLO, M.R.; TELNAES, N. & MAXWELL, J. R. 1995 The hydrocarbon source potential in the Brazilian marginal basins: a geochemical and paleoenvironmental assessment. HUC, A.Y. Ed., *AAPG Studies in Geology*, 40:233-273.
- MICHAUD, M. 1987 *Étude Paléogéographique du Mésozoïque du Chiapas*. Ph.D. Thesis, University of Paris VI, p.210
- MOLDOWAN, J.M.; SEIFERT, W.K. & GALLEGOS, E.J. 1985 Relationship between petroleum composition and depositional environment of petroleum source rocks. *AAPG Bulletin*, 69:1255-1268.
- MOLDOWAN, J.M.; FAGO, F.J.; LEE, C.Y.; JACOBSON, S.R.; WATT, D.S.; SLOUGUI, N.; JEGANATHAN, A. & YOUNG, D.C. 1990 Sedimentary 24-n-propylcholestanes, molecular fossils diagnostic of marine algae. *Science*, 247:309-312.
- MOLDOWAN, J.M.; FAGO, F.J.; CARLSON, R.M.K.; YOUNG, D.C.; DUYNE, G.V.; CLARDY, J.; SCHOELL, M.; PILLINGER, C.T. & WATT, D.S. 1991 Rearranged hopanes in sediments and petroleum. *Geochimica Cosmochimica Acta*, 55:1065-1081.
- NORTHAM, M.A. 1985 Correlation of northern North Sea oils: the different facies of their Jurassic source. In: THOMAS, B.M.; DORE, A.G.; EGGEN, S.S.; HOME, P.C. & LARSEN, R.M. Eds. *Petroleum geochemistry in exploration of the Norwegian Shelf*, p. 93-99.
- PALACAS, J.G.; ANDERS, D.E. & KING, J.D.



- 1984 South Florida Basin- A prime example of carbonate source rocks of petroleum. In: PALACAS, J.G., Ed. Petroleum geochemistry and source rock potential of carbonate rocks. *AAPG Studies in Geology*, 18:71-96.
- PETERS K. E. & MOLDOWAN, J.M. 1993 *The biomarker guide: Interpreting molecular fossils in petroleum and ancient sediments*. Prentice Hall, p.363.
- PHILP, R.P. & GILBERT, T.D. 1986 Biomarker distributions in Australian oils predominantly derived from terrigenous source material. In: LEYTHAEUSER, D. & RULLKÖTTER, J. Eds. *Advances in Organic Geochemistry 1985*, pp. 73-84.
- SANTIAGO, J.; CARRILLO, J. & MARTELL, B. 1984 Geología petrolera de Mexico, 1984 In: SCHLUMBERGER Ed. *Evaluación de formaciones en Mexico*, p. 1-36.
- SASSEN, R. 1990 Lower Tertiary and Upper Cretaceous source rocks in Louisiana and Mississippi: Implications to Gulf of Mexico crude oils. *AAPG Bulletin*, 74:857-878.
- SCHOU, L.; EGGEN, S.S. & SCHOELL, M. 1985 Oil-oil and oil-source rock correlation, northern North Sea. In: THOMAS, B.M.; DORE, A.G.; EGGEN, S.S.; HOME, P.C. & LARSEN, R.M. Eds. *Petroleum geochemistry in exploration of the Norwegian Shelf*, p. 101-117.
- SOFER, Z. 1988 Biomarkers and carbon isotopes of oils in the Jurassic Smackover Trend of the Gulf Coast States, U.S.A. *Organic Geochemistry*, 12:421-432.
- TALUKDAR, S.; GALLANGO, O. & CHIN-A-UEN, M. 1986 Generation and migration of hydrocarbons in the Maracaibo Basin, Venezuela: An integrated basin study. In: LEYTHAEUSER, D. & RULLKÖTTER, J. *Advances in Organic Geochemistry 1985*. PP. 261-280.
- VOLKMAN, J.K.; ALEXANDER, R.; KAGI, R.I.; NOBLE, R.A. & WOODHOUSE, G.W. 1983 Demethylated hopanes in crude oils and their application in petroleum geochemistry. *Geochimica Cosmochimica Acta*, 47:785-794.
- WENGER, L.M.; SASSEN, R. & SCHUMACHER, D. 1991 Molecular characterization of Smackover, Wilcox, and Tuscaloosa-reservoired oils in the eastern Gulf Coast. In: SCHUMACHER, D. & PERKINS, B. Eds. Gulf Coast oils and gases, their characteristics, origin, distribution, and exploration and production significance. 9th Annual Research Conference Gulf Coast Section, Society of Economic Paleontologists and Mineralogists Foundation, *Proceedings*, pp.37-57.

## APENDIX 1

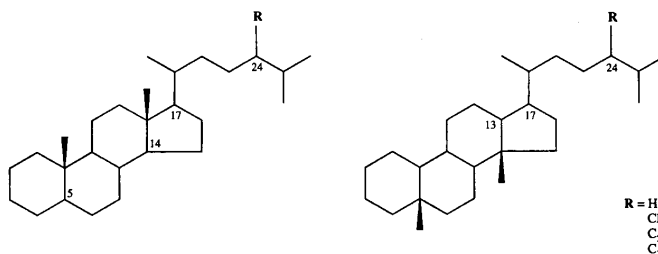
### Terpanes



#### Terpanes

	Mol.F.	M.W.
1 - C <sub>24</sub> Tetracyclic terpane (des-E-hopane)	C <sub>24</sub> H <sub>42</sub>	330
2 - 18α(H),22,29,30-Trisnorhopane (Ts)	C <sub>27</sub> H <sub>46</sub>	370
3 - 17α(H),22,29,30-Trisnorhopane (Tm)	C <sub>27</sub> H <sub>46</sub>	370
4 - 17α(H),21β(H),30-Norhopane	C <sub>29</sub> H <sub>50</sub>	398
5 - 17α(H),21β(H)-Hopane	C <sub>30</sub> H <sub>52</sub>	412
6 - 17α(H),21β(H)-Homohopane (22S) + 17α(H),21β(H)-Homohopane (22R)	C <sub>31</sub> H <sub>54</sub> C <sub>31</sub> H <sub>54</sub>	426 426
7 - 17α(H),21β(H)-Bishomohopane (22S) + 17α(H),21β(H)-Bishomohopane (22R)	C <sub>32</sub> H <sub>56</sub> C <sub>32</sub> H <sub>56</sub>	440 440
8 - 17α(H),21β(H)-Trishomohopane (22S) + 17α(H),21β(H)-Trishomohopane (22R)	C <sub>33</sub> H <sub>58</sub> C <sub>33</sub> H <sub>58</sub>	454 454
9 - 17α(H),21β(H)-Tetrakishomohopane (22S) + 17α(H),21β(H)-Tetrakishomohopane (22R)	C <sub>34</sub> H <sub>60</sub> C <sub>34</sub> H <sub>60</sub>	468 468
10 - 17α(H),21β(H)-Pentakishomohopane (22S) + 17α(H),21β(H)-Pentakishomohopane (22R)	C <sub>35</sub> H <sub>62</sub> C <sub>35</sub> H <sub>62</sub>	482 482

### Steranes



#### Steranes

	Mol.F.	M.W.
11 - 13β(H),17α(H)-Diacholestane (20S)	C <sub>27</sub> H <sub>48</sub>	372
12 - 13β(H),17α(H)-Diacholestane (20R)	C <sub>27</sub> H <sub>48</sub>	372
13 - 5α(H),14α(H),17α(H)-Cholestane (20S)	C <sub>27</sub> H <sub>48</sub>	372
14 - 5α(H),14β(H),17β(H)-Cholestane (20R) + 5α(H),14β(H),17β(H)-Cholestane (20S) + 13α(H),17β(H),24-methyl-Diacholestane (20R) + 13β(H),17α(H),24-ethyl-Diacholestane (20S)	C <sub>27</sub> H <sub>48</sub> C <sub>27</sub> H <sub>48</sub> C <sub>28</sub> H <sub>50</sub> C <sub>29</sub> H <sub>52</sub>	372 372 386 400
15 - 5α(H),14α(H),17α(H)-Cholestane (20R)	C <sub>27</sub> H <sub>48</sub>	372
16 - 5α(H),14α(H),17α(H),24-Ethyl-cholestane (20S)	C <sub>27</sub> H <sub>48</sub>	400
17 - 5α(H),14β(H),17β(H),24-Ethyl-cholestane (20R) + 5α(H),14β(H),17β(H),24-Ethyl-cholestane (20S)	C <sub>27</sub> H <sub>48</sub> C <sub>27</sub> H <sub>48</sub>	400 400
18 - 5α(H),14α(H),17α(H),24-Ethyl-cholestane (20R)	C <sub>27</sub> H <sub>48</sub>	400