PLATE TECTONICS AND THE LOCATION OF OIL FIELDS

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ABSTRACT

From the present-day properties of plates of lithosphere we have developed a computer algorithm that reconstructs the continents in the past. The basic input data includes oceanic magnetic lineations and paleomagnetic observations. The addition of geological information allows one to reconstruct the major plate tectonic features in the past if this is desired. For this study we have plotted the position of major oil and gas fields, oil shales, and oil sands on these maps. Direct visual correlation with the latitude in the past shows that many petroleum deposits were formed within 35° of the paleoequator. The reconstruction is most promising in delineating broad exploration targets in the Paleozoic Era. In particular, Cambrian and Ordovician basins in North America and Asia should be explored because of their position on the equator during the lower Paleozoic. The tectonic activity and the pattern of continental grouping is important in the development of favorable basins.

INTRODUCTION

The relationship between the location of oil-fields and their geographical latitude at the time when the reservoir rocks were deposited has been studied by Irving and Gaskell (1962); Deutsch (1965); Irving, North and Couillard (1974). Advances in the reconstruction of plate tectonic models (Kanasewich, Havskov and Evans, 1978) for the whole of the Phanerozoic Era have made it worthwhile to examine the question again. North (1971) has emphasized the importance of the tectonic history in the formation of oil bearing basins. Therefore sedimentary basins should be studied in the context of their plate tectonic setting. This preliminary report includes major oil and gas fields as plotted on world maps on the basis of the age of the reservoirs. Strictly speaking the correlation should be based on the age of the source rock and the position of the basin with respect to the paleolatitude. Except for a few mature fields this information is not available or is in dispute. For many fields the geological age of the source rocks and the reservoir is similar. This is because barriers to vertical and horizontal migration are often very effective. Known exceptions will be discussed as each period is taken up.

A reconstruction of the major tectonic features of the earth during the past 600 million years is of interest to exploration geophysicists for three major reasons:

(1) Areas with favorable environmental conditions for the mass proliferation of biological life are identified. This is a precondition for the formation of coal, oil and gas. In particular, the generation of oil depends upon the primary production of plankton and this is controlled by water temperature, the action currents and the availability of nutrients.

(2) The metamorphic and tectonic history within a sedimentary basin should be known. There must be sufficient thermal activity so

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that oil and gas are formed and collected in reservoirs. The tectonic activity must not be so intense that the preservation of the hydrocarbons is endangered.

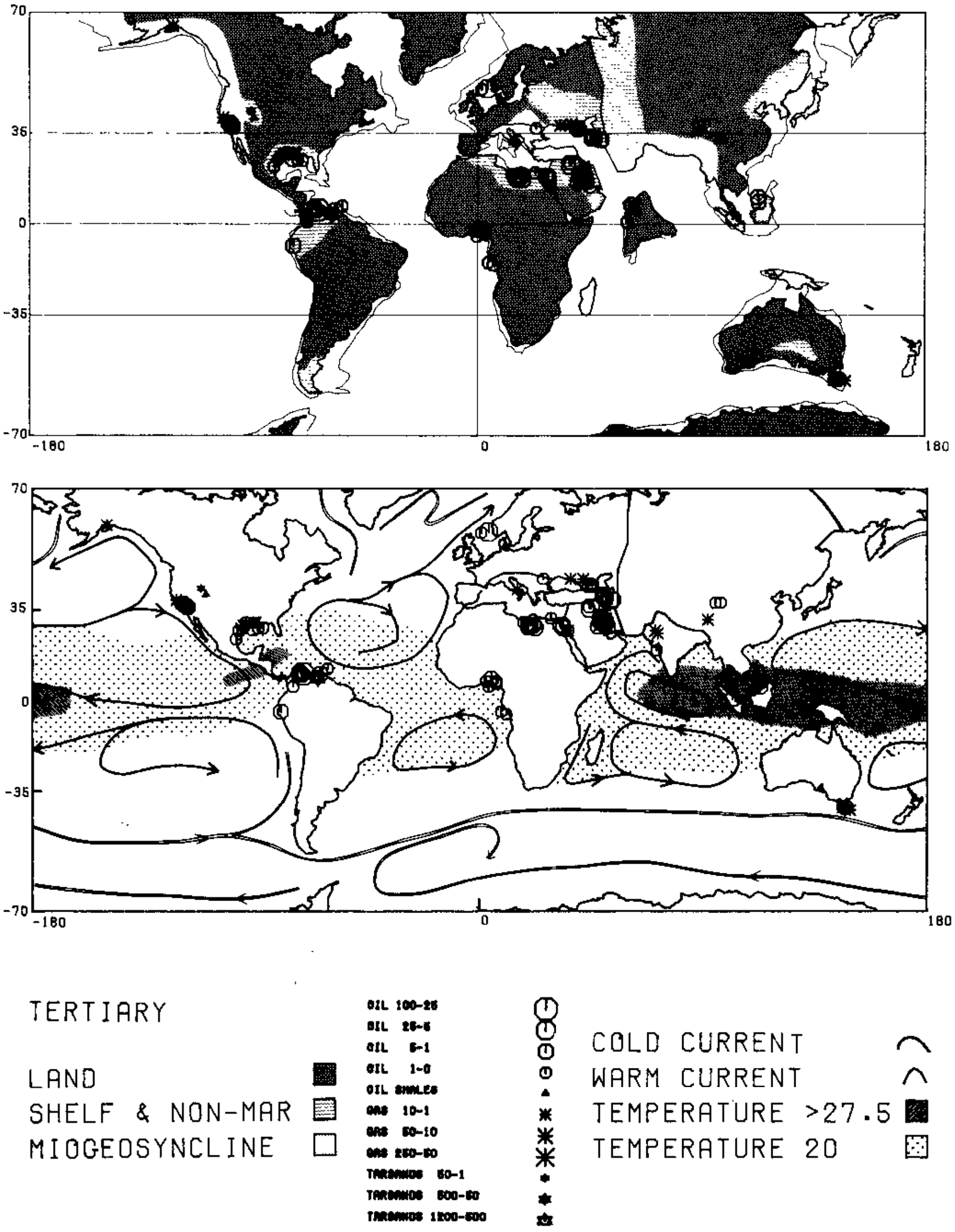
(3) Mineral deposits are associated with both spreading centers and subduction zones so exploration may be centered in the most probable areas.

The hypothesis of plate tectonics has been notable in accounting for present tectonic activity and for allowing reconstruction to be made on the basis of magnetic lineations up to the Cretaceous-Jurassic boundary. Making use of 10 principles which appear to define present-day plate tectonic activity, Kanasewich et al (1978) have used paleomagnetic observations to reconstruct continental fragments for six periods between the Cretaceous and the Cambrian. An interactive computer program was developed to rotate continental segments about any pole of rotation. The paleomagnetic results were used initially to position each continental segment on the appropriate latitude and in the correct orientation so that all averages of measured poles were exactly on the south pole. The interactive routine was used to eliminate overlap of continental margins while monitoring a display screen. An innovation, never used before, was the application of a least squares inversion procedure to determine a limiting absolute longitude. This is based on the principle that an absolute reference frame for plate tectonics is defined, to a good approximation, by minimizing the translational motion of plate boundaries. The velocity of plates, at the present time, is proportional to the amount of continental lithosphere they contain. Purely oceanic plates move about five times as fast as purely continental plates. When the relative longitude could not be obtained from magnetic lineations, the largest contiguous continental group was given priority since present evidence indicates that purely continental plates have the lowest velocity. The velocity was determined along a small circle, centered on the pole of relative motion from one period to the next. This procedure was applied, in order of continental area, to the remaining group of continental segments. The solution is not unique, but it is the most conservative estimate and is valuable in giving a quantitative estimate of the minimum velocity that satisfies paleomagnetic and geologic observations. Determination of the location of continents with a computer program reduces the effect of human bias in the reconstruction. When stratigraphic and structural geological data is added to the maps it becomes possible to deduce plate boundaries for periods when this is not given by oceanic magnetic lineations.

BASIC DATA

TERTIARY PERIOD, ANOMALY 13-38 Ma

The models for each period have been generated by a digital computer and a Calcomp plotter on a mercator projection. More specifically the projection is a Miller-modified mercator one in which the map ordinate is $y = c \ln \tan (45+0.4\phi)$ where ϕ is the latitude in degrees and c is a scaling constant. This modification allows one to depict the earth with less distortion at extreme latitudes. The Tertiary period at the time of formation of magnetic anomaly 13 (Pitman et al, 1974) is shown in Figure 1. The petroleum deposits that are plotted are given in the table in the Appendix. The references for the data are extensive but rely heavily on Halbouty et al (1970), Demaison (1977), North (1971), Irving et al (1974), Rigassi (1976) and Gillen (1976) and other reports in World Oil. Many oil fields have production from several systems and, although the principal producing horizon is generally well known, the reserves are not well documented for secondary horizons. For cases where the distribution was not known, secondary horizons were arbitrarily assigned one-third of the known total. The Tertiary fields have been plotted on present day coordinates and also the coordinates that were found for the Tertiary period. The present day map shows the distribution of warm and cold oceanic currents and warm ocean water. It is seen that some warm currents traverse high latitudes and this may explain the occurrence of fields north and south of a latitude of 35°. On the geologic map it is seen that most major fields are within ± 35° and that they are also associated with mildly active tectonic areas. The Ekofisk field in the North Sea is an exception but the basin has much Cretaceous and Triassic production when the area was at a latitude of 35° and more directly in contact with warm oceanic currents.



Note: Oil in billions of barrels; gas in trillion of Cubic ft.

Fig. 1. Top. The position of the continents and some stratigraphic data at the Eocene-Oligocene boundary (magnetic anomaly 13, 38 ma) on a Miller-modified mercator projection. The positions of oil and gas field with production in Tertiary sediments are shown. Bottom: Tertiary oil and gas fields are plotted with the present-day position of continents. Mean annual surface ocean water temperatures and currents are also shown.

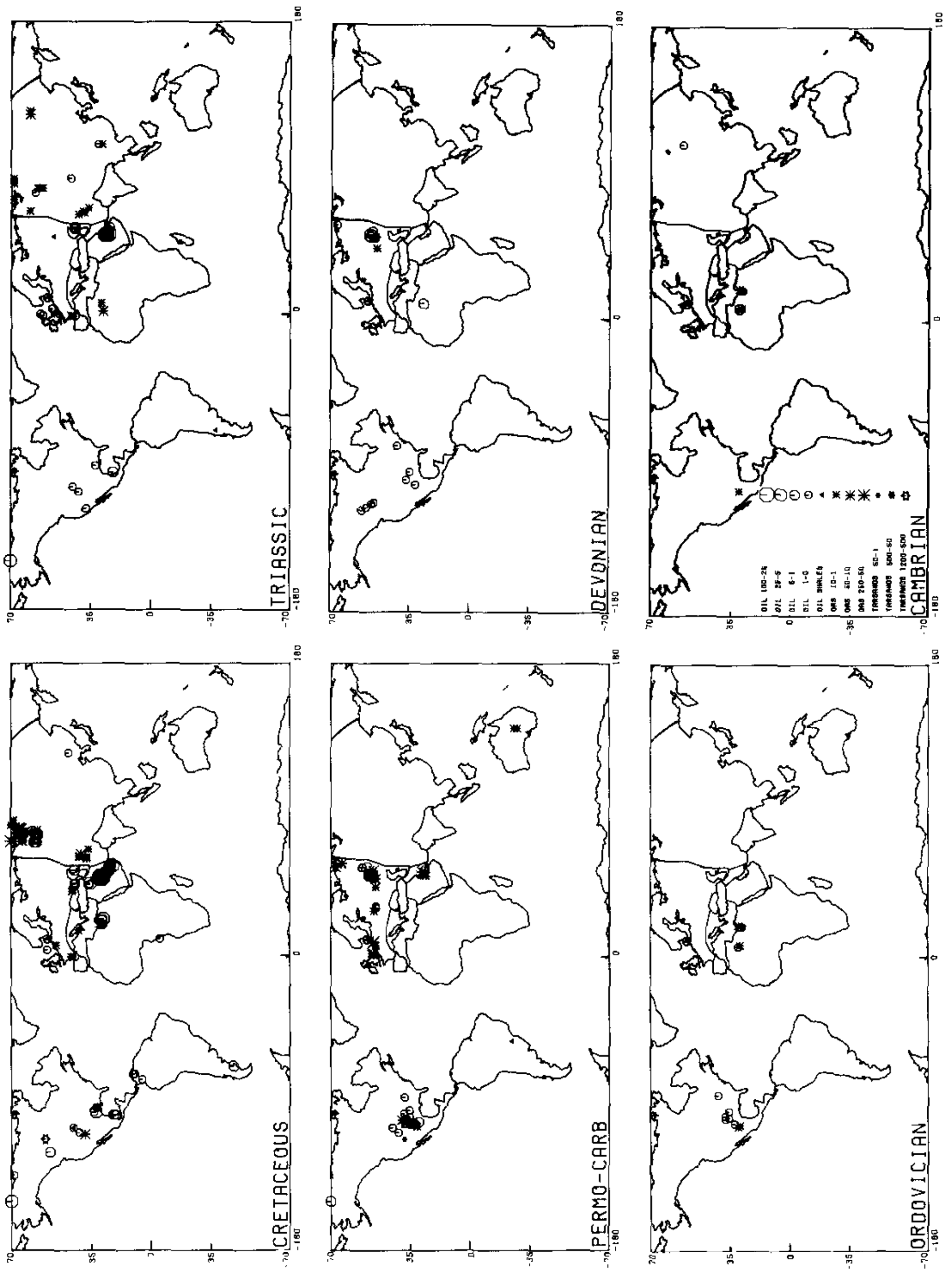


Fig. 2. Oil and gas fields for six periods in the Phanerozoic Era plotted with the present-day position of the continents.

CRETACEOUS (110 Ma) AND TRIASSIC (190 Ma) PERIODS

Figure 2 shows all the Mesozoic and Paleozoic fields on a series of 6 maps with the continents in their present day coordinates. A comparison of figures 2, 3 and 4 shows that plotting fields in their Mesozoic coordinate system places more fields in the equatorial zone. However, there were many widespread shallow seas in Asia and North America that extended far north. A notable exceptional case is the Prudhoe Bay Field in northern Alaska. Most of the production is in Mississippian to Jurassic rocks when Alaska was at a latitude of 50°N as compared to its present 70°N. However, the most important source rocks are thought to be Cretaceous

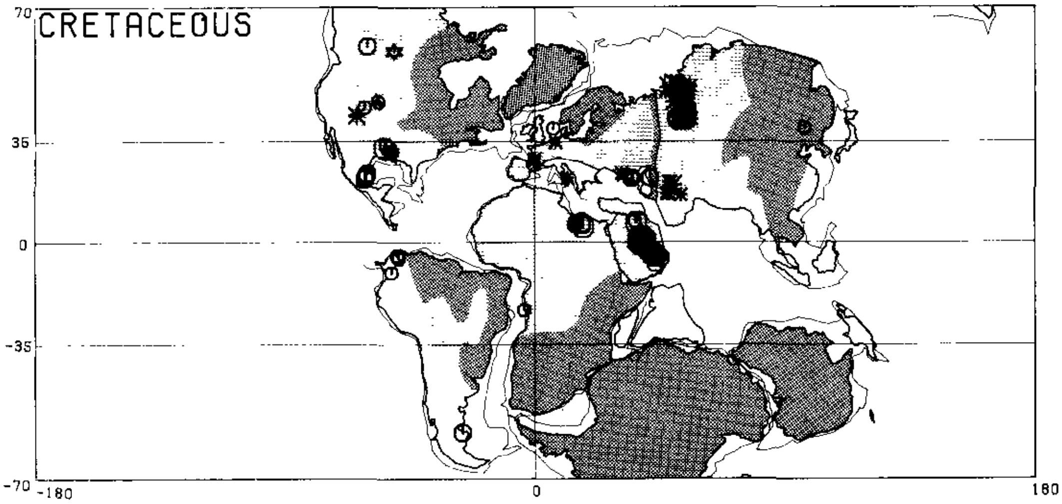


Fig. 3. The position of the continent and some stratigraphic data in the middle Cretaceous (magnetic anomaly M1, 110 ma). The longitude is not absolutely determined but was obtained from a least squares minimization of continental velocities between the Cretaceous and Tertiary periods. The position of oil and gas fields with production in Cretaceous sediments is shown.

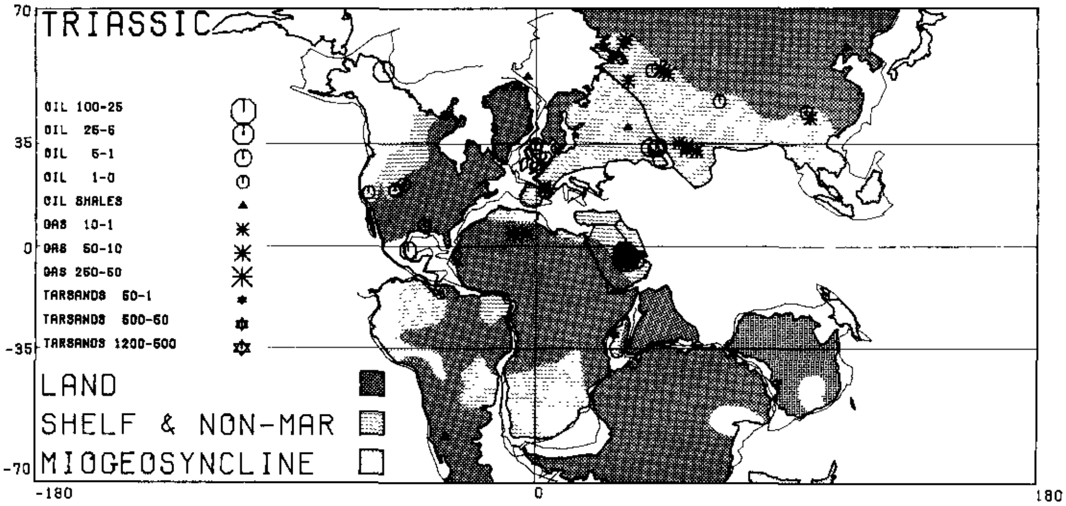


Fig. 4. The position of the continents and some stratigraphic data in the Triassic period (190 ma). The longitude was obtained by a least squares minimization of the Laurasian and Gondwanaland continental velocities between the Triassic and the Cretaceous periods. The positions of the oil and gas fields with production in the Triassic and Jurassic sediments is shown.

marine shales because they contain 5.4% of organic carbon as compared to 1.9% for Jurassic marine shale and 1.1% for basal Mississippian shale (Morgridge and Smith, 1972). According to our paleomagnetic reconstruction the latitude of Prudhoe Bay was 81°N in the Cretaceous. It was 50°N in the Carboniferous and 35°N in the Devonian. North (1971) believed "that the oil on the Arctic slope will prove to be of Devono-Mississippian origin (the age of the Ellesmerian orogeny)." However, little is known of the Devonian sedimentation in the area between Brook's Range and Barrow Arch. The question of source rocks for Prudhoe Bay cannot be answered definitively at present.

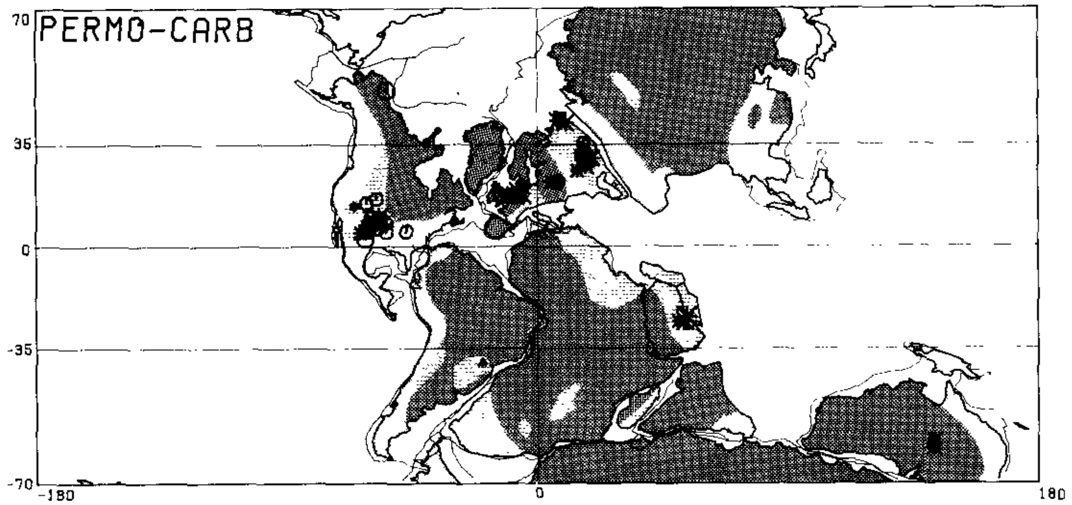


Fig. 5. The position of the continents and some stratigraphic data in the Permo-Carboniferous periods (280 ma). The longitude was obtained by a least squares minimization of Laurasian and Gondwanaland velocities between the Carboniferous and the Triassic periods. The position of the oil fields with production in Permian, Pennsylvanian or Mississippian sediments is shown.

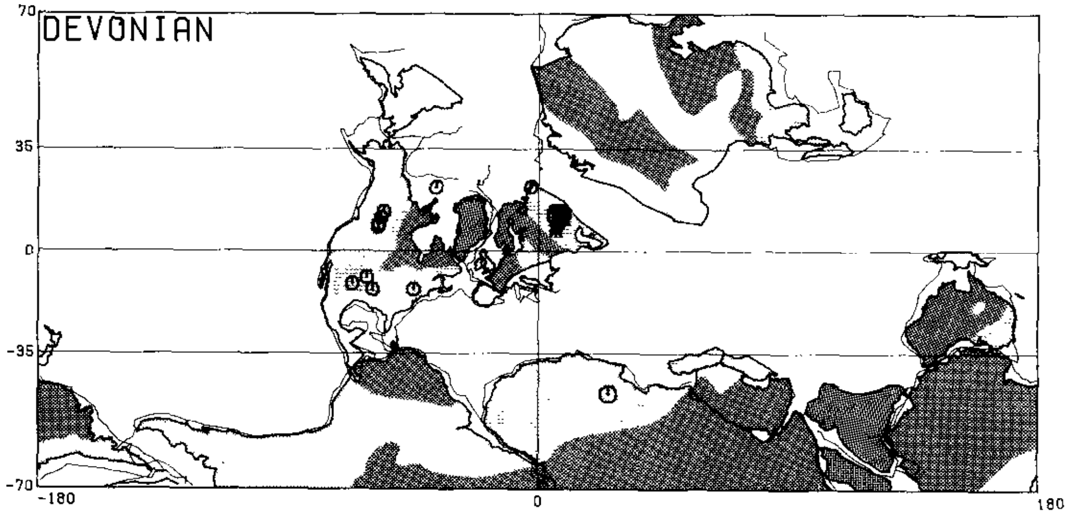


Fig. 6. The position of the continents and some stratigraphic data in the Devonian period (370 ma). The longitude was obtained by a least squares minimization of continental velocities between the Devonian and Permian periods. The position of the oil fields with production in Devonian sediments is shown.

In general it is found that oil deposits in the Mesozoic are distributed over a wide range of paleolatitudes. This may reflect the high ocean temperatures that were present in the Cretaceous. From 0^{18} isotope studies on calcareous fossils (Urey et al, 1951, Emiliani, 1966) it is found that sea temperatures were as much as 10°C higher than now. Therefore these plate tectonic reconstructions for the Mesozoic are only useful insofar as they give tectonic information. To keep the maps from being too cluttered, information on model spreading centers, subduction zones and eugeosynclinal deposits have been omitted from the figures here but they may be seen in Kanasewich et al (1978).

THE PERMO-CARBONIFEROUS AND DEVONIAN PERIODS

From figures 5 and 6 and the tables in the appendix it is seen that except for two gas fields in Australia and one oil shale in South America, the petroleum deposits in the Permo Carboniferous are all north of present-day latitude 26°. All major Devonian oil and gas fields lie between present-day latitudes of 28°N and 77°N. When plotted as in figures 5 and 6 on reconstructed paleolatitudes for the Permo-Carboniferous and the Devonian periods, the fields are within 40° of the equator. Note that the reefs in the Alberta basin all lie within 15° of equator in Devonian times. The results are consistent with the migration of reef belts as tabulated by Schwarzbach (1963).

ORDOVICIAN AND CAMBRIAN PERIODS

There are only a small number of oil and gas fields which produce from the lower Paleozoic. On the paleo-reconstruction of figures 7 and 8 the Ordovician and Cambrian fields in Oklahoma and Texas are found within 20° of the equator.

There is a considerable body of paleomagnetic data for the lower Paleozoic which indicates that there was a major reorganization of continental segments between the lower and upper Paleozoic. This probably coincides with the various episodes of the Caledonian Orogeny. The evidence from paleomagnetism also indicates that rather high velocities (5-7 cm/year) of continental plate segments must have occurred. North Africa is placed in the south polar region and this is supported by various glacial indicators (Beuf et al, 1968, Fairbridge, 1969, 1971) in the geological outcrops. The unusual occurrence of several oil and gas fields in Libya and Algeria at paleolatitudes of 77°S to 85°S in the Ordovician and 56°S to 65°S in the

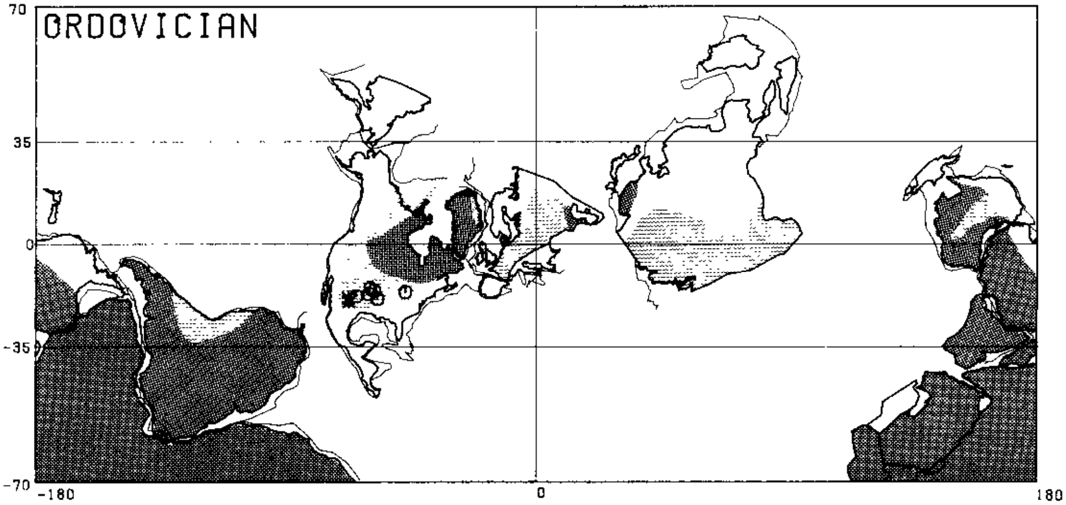


Fig. 7. The position of the continents and some stratigraphic data in the Ordovician period (470 ma). The longitude was obtained by a least squares minimization of continental velocities between the Ordovician and Devonian periods. The position of the oil fields with production in Ordovician and Silurian sediments is shown.

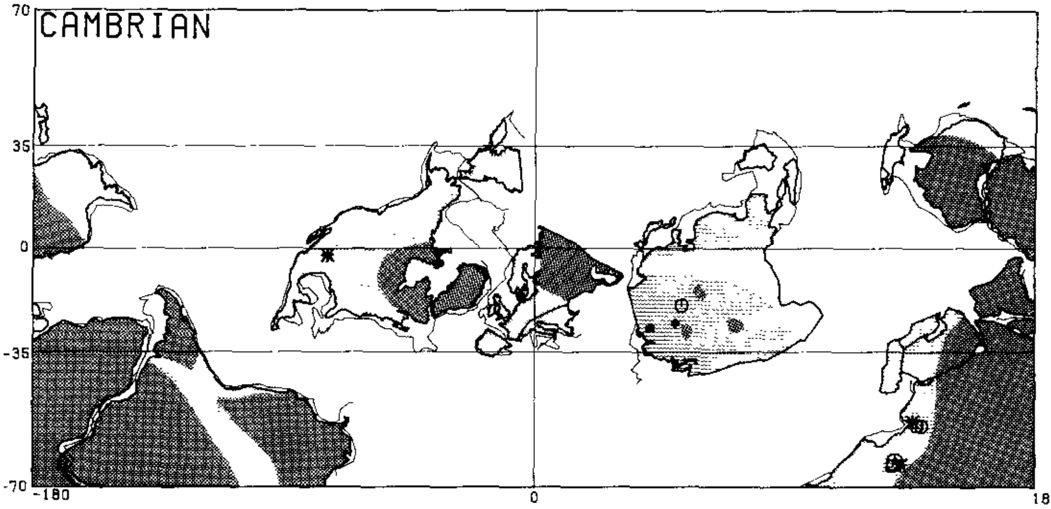


Fig. 8. *The position of the continents and some stratigraphic data in the Cambrian period (550 ma). The longitude was obtained by a least squares minimization of continental velocities between the Cambrian and the Ordovician periods. The position of the oil fields with production in Cambrian sediments is shown.*

Cambrian indicates that the source rocks are higher stratigraphically than the reservoir rocks. The source rocks for the Hassi Messaoud field (Balducci and Pommier, 1970) are thought to be Triassic or Silurian shales. The source rocks for the Amal and other related fields in Libya (Roberts, 1970) are thought to be the Rakb formation of Cretaceous age.

CONCLUSIONS

The influence of continental geometry, climate and tectonic activity on the generation of petroleum can only be evaluated by obtained accurate plate tectonic reconstruction. Future work should incorporate models of ocean currents and data on paleotemperatures. More paleomagnetic data is needed in many critical areas, particularly in China, South America and the Arctic of North America. The results of studies such as these are best applied to Paleozoic basins. The maps of the Ordovician and Cambrian should be of particular value in considering broad exploration targets. In particular it would appear that because of the equatorial position of North America and Asia during the lower Paleozoic, basins with Ordovician and Cambrian sediment should be explored more intensely.

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Appendix - Data on Hydrocarbon Deposits

Field	Country	Reserves	Type	Year	Present Lat.	Present Long.	Paleo Lat.	Paleo Long.	Ref.
TERTIARY									
AFRICA									
MORGAN	EGYPT	2.5	O	1965	29	33	19	28	H50
AMAL	EGYPT	2.5	O	1968	28	34	18	28	H51
ZELTEN	LIBYA	2.2	O	1959	29	20	19	16	H55
GIALO	LIBYA	2.0	O	1961	29	22	19	18	H60
INTISAR 'A'	LIBYA	1.5	O	1967	29	21	19	17	H76
DEFA	LIBYA	>1.4	O	1960	28	20	18	16	H62
BELAYIM +	EGYPT	1.4	O	1955	29	34	19	29	H80
INTISAR 'D'	LIBYA	1.2	O	1967	29	21	19	17	H91
JONES CREEK	NIGERIA	1.0	O	1967	8	5	-2	1	H119
AMAL-N-A	LIBYA	>0.9	O	1959	28	23	18	18	H27
DAHRA HOFRA	LIBYA	0.7	O	1959	30	18	20	14	H137
WAHA	LIBYA	>0.6	O	1960	29	20	19	16	H97
IMO RIVER	NIGERIA	0.6	O	1959	7	7	-3	3	H160
BOMU	NIGERIA	0.6	O	1958	6	7	-4	3	H164
EBBEN	NIGERIA	0.5	O	1965	7	3	-3	-1	H178
OKAN	NIGERIA	0.5	O	1964	5	4	-5	-0	H179
EMERAUDEM	CONGO(B)	0.5	O	1969	-5	9	-15	4	H180
CABINDA'B'	ANGOLA	0.4	O	1966	-6	11	-16	6	H89
ARABIA									
MARUN	IRAN	10.5	O	1963	31	49	19	42	H12
KIRKUK	IRAN	>10.	O	1927	35	45	23	38	H7
AGHA JARI	IRAN	>6.4	O	1938	31	50	18	42	H14
GACH SARAN	IRAN	>5.3	O	1928	30	51	18	43	H16
AHWAZ	IRAN	>4.0	O	1958	31	49	19	41	H23
PAZAN	IRAN	3.5	O	1961	30	50	18	42	H39
BIBI HAKIMEH	IRAN	>3.0	O	1961	30	51	18	43	H29
RAG-E-SAFID	IRAN	>3.0	O	1964	30	50	18	42	H31
PARIS	IRAN	3.0	O	1964	31	50	19	42	H43
MASJID-I-S/M	IRAN	1.9	O	1908	32	49	20	42	H69
WAFRA	NEUTRAL Z	>1.5	O	1953	29	48	17	41	H30
HAFT KEL	IRAN	>1.3	O	1928	31	49	20	42	H58
MANSURI	IRAN	>1.3	O	1963	31	49	19	41	H63
KARANJ	IRAN	1.3	O	1963	31	50	19	42	H84
BUSHGAN	IRAN	1.0	O	1963	29	52	17	44	H116

Field	Country	Reserves	Type	Year	Present Lat.	Present Long.	Paleo Lat.	Paleo Long.	Ref
BAI HASSAN	IRAQ	>0.8	O	1953	35	44	24	37	H92
BINAK	IRAN	>0.7	O	1959	29	50	18	43	H105
NAFT-I-SAFID	IRAN	>0.7	O	1935	32	29	20	23	H106
BARQAN	SAUDI AR	0.5	O	1969	27	36	15	29	H182
DARIUS KHARG	IRAN	>0.4	O	1961	29	50	17	42	H87
PAZANAN	IRAN	50.0	G	1938	30	50	18	42	G16
SUI	PAKISTAN	6.0	G	1952	27	71	8	63	G38
MARI	PAKISTAN	5.0	G	1957	26	72	6	64	G45
SARADJEH	IRAN	5.0	G	1958	35	51	23	43	G47
BARQAN	S.ARABIA	3.5	G	1969	27	36	15	29	G61
ASIA									
MINAS	INDONESIA	4.0	O	1944	0	102	2	103	H34
SERIA	BRUNEI	1.7	O	1929	5	113	9	113	H71
AMPA S/W	BRUNEI	1.0	O	1963	7	113	11	113	H111
YA-ERH-HSIA	CHINA	0.5	O	1950	37	97	38	91	H168
LENG-HU	CHINA	0.5	O	1958	37	95	38	89	H165
EUROPE									
EKOFISK	NORWAY	7.0	O	1969	59	4	50	4	H19
KOTUR-TEPE	USSR	4.0	O	1956	38	54	32	50	H36
NEFTYANYYE - K	USSR	2.5	O	1949	39	51	33	47	H49
BALAKHANY S-R	USSR	2.4	O	1896	40	50	34	46	H53
BIBI EYBAT	USSR	2.0	O	1871	39	50	33	46	H66
M/V/ALIYURT	USSR	>1.0	O	1915	43	45	36	40	H45
S/DUVANNYY	USSR	0.9	O	1963	39	50	33	46	H124
M/G/OCNITEI	ROMANIA	0.8	O	1900	45	26	37	24	H129
CHILEKEN	USSR	0.6	O	1956	39	52	33	48	H145
KARACHU/K/Z	USSR	0.6	O	1928	39	50	33	46	H157
OKTYABRI-SHOYE	USSR	0.5	O	1913	43	46	36	42	H169
STARO-GROZNYY	USSR	>0.2	O	1893	43	45	36	41	H144
SSP	USSR	7.3	G	1950	45	42	38	38	G31
ANAST-TROIT	USSR	2.4	G	1953	45	37	38	33	G78

Field	Country	Reserves	Type	Year	Present Lat.	Present Long.	Paleo Lat.	Paleo Long.	Ref.
TERTIARY CONTD.									
AUSTRALIA									
KINGFISH	AUSTRLA.	1.1	O	1967	-41	147	-56	145	H95
HALIBUT	AUSTRLA.	0.6	O	1967	-41	148	-55	146	H162
BARRA COUTA	AUSTRLA.	0.5	O	1965	-41	147	-56	144	H184
MARLIN	AUSTRLA.	3.6	G	1966	-42	149	-56	148	G57
BARRA COUTA	AUSTRLA.	1.8	G	1965	-41	146	-56	144	G79
COAL MEASURES	N.Z.	0.1	S		-38	175	-45	175	S12
NORTH AMERICA									
BAY M-T/C-I	LOUISIANA	3.4	O	1930	28	-91	25	-74	H40
WILMINGTON	CALIF	2.6	O	1932	36	-118	37	-99	H48
ELK HILLS	CALIF	1.3	O	1919	37	-119	38	-100	H83
MIDWAY SUNSET	CALIF	1.2	C	1894	37	-120	39	-100	H90
HUNTINGTON B	CALIF	1.0	O	1920	36	-118	37	-98	H121
LONG BEACH	CALIF	0.9	O	1921	36	-118	38	-99	H125
VENTURA AV	CALIF	0.8	O	1916	36	-119	38	-100	H128
SEELIGSON	TEXAS	0.8	C	1937	24	-98	23	-82	H132
SOUTH P BKL 24	LOUISIANA	0.8	O	1950	28	-87	25	-70	H133
COALINGA	CALIF	0.6	C	1887	37	-121	39	-101	H140
HASTINGS	TEXAS	0.6	O	1934	30	-94	28	-77	H146
W DELTA BLK 73	LOUISIANA	0.6	O	1962	28	-89	25	-72	H147
BUENA VISTA HS	CALIF	0.6	O	1909	37	-119	39	-100	H149
SANTA FE SPS	CALIF	0.6	C	1919	36	-118	38	-98	H150
CONROE	TEXAS	0.6	O	1931	30	-94	28	-77	H155
COALINGA NOSE	CALIF	0.5	O	1938	37	-120	39	-100	H170
TOM O'CONNOR	TEXAS	0.5	O	1934	27	-97	25	-80	H185
KERN RIVER	CALIF	¬0.4	O	1899	37	-119	39	-99	H151
KATY	TEXAS	6.0	G	1934	29	-95	27	-78	G37
KENAI	ALASKA	5.0	G	1959	61	-150	67	-122	G44
OLD OCEAN	TEXAS	5.0	G	1934	28	-96	26	-79	G46
K.MAN N DOME	CALIF	3.6	G	1928	37	-120	39	-101	G58
MONROE	LOUISIANA	¬3.5	G	1916	31	-92	33	98	G32
RIO VISTA	CALIF	3.5	G	1936	38	-122	40	-102	G59
BAYOU SALE	LOUISIANA	3.5	G	1940	30	-91	27	-74	G71
BASTIAN BAY	LOUISIANA	3.3	G	1941	30	-90	27	-73	G74
CIRCLE CLIFFS	UTAH	11	T		40	-112	43	-91	T7
GREEN RIVER	UTAH	0.1	S		40	-110	40	-90	S11
SOUTH AMERICA									
BOLIVAR CSTL	VENEZUELA	30.	C	1917	10	-71	6	-64	H3
LAMA	VENEZUELA	¬1.4	O	1957	10	-72	6	-65	H61
BOSCAN	VENEZUELA	1.0	O	1946	10	-72	6	-65	H98
QUIRIQUIRE	VENEZUELA	1.0	O	1928	10	-64	5	-57	H100
LA BREA P-T	PERU	1.0	O	1868	-5	-80	-9	-74	H101
LAMAR	VENEZUELA	¬0.8	O	1958	10	-72	5	-65	H85
OFICINA	VENEZUELA	0.6	C	1937	9	-66	4	-59	H153
MENE GRANDE	VENEZUELA	0.6	C	1914	10	-71	5	-64	H159
FYZABAD GR	TRINIDAD	0.5	O	1913	12	-61	7	-54	H174
INF LA CIRA	COLOMBIA	¬0.4	O	1918	5	-75	3	-58	H141
LA PAZ	VENEZUELA	0.3	C	1925	11	-72	6	-65	H99
ORINOCO	VENEZUELA	50	T		8	-65	3	-56	T1
CRETACEOUS									
AFRICA									
SARIR	LIBYA	8.0	O	1961	28	23	5	18	H17
AMAL-N-A	LIBYA	3.4	O	1959	29	22	7	17	H27
A-100	LIBYA	1.0	O	1968	29	22	6	17	H112
CABINDA 'B'	ANGOLA	0.8	O	1966	-6	11	-24	-4	H89
RAGUBA	LIBYA	¬0.7	O	1961	29	19	7	14	H107
DEFA	LIBYA	¬0.6	O	1960	28	20	6	15	H62
SAMAH	LIBYA	¬0.4	O	1962	28	17	6	14	H81
WAHA	LIBYA	¬0.3	O	1960	29	20	7	15	H97
HATEIBA	LIBYA	¬6.0	G	1963	30	20	8	16	G23
ARABIA									
BURGAN	KUWAIT	66.	O	1938	29	48	1	48	H2
SAF-/KHAJI	NEUTRAL Z	25.	O	1953	28	49	0	39	H4
RUMALIA	IRAQ	13.6	O	1953	20	47	2	38	H9
RAUDHATAIN	KUWAIT	7.7	O	1955	30	47	2	38	H18
MANIFA	SAUDI A	¬7.4	O	1957	28	49	0	39	H11
FERE/MARJAN	IRAN/S-A	¬6.7	O	1966	28	50	0	40	H13
KIRKUK	IRAQ	¬5.0	O	1927	35	45	7	37	H7
GACH SARAN	IRAN	2.7	O	1928	30	51	2	40	H16
RUMALIA N	IRAQ	5.0	O	1961	30	47	2	38	H28
SABRIYA	KUWAIT	4.0	O	1958	30	48	1	38	H35
AGHA JARI	IRAN	¬3.2	O	1938	31	50	2	40	H14
MURBAN BU HASA	ABU DHABI	3.0	O	1962	24	53	-5	42	H44
WAFRA	NEUTRAL Z	¬3.0	O	1953	29	48	0	39	H30
UMM SHAIF	ABU DHABI	2.2	O	1958	25	53	-4	41	H56
MURBAN BAB	ABU DHABI	2.0	O	1954	24	54	-5	43	H59
MINAGISH	KUWAIT	2.0	O	1959	29	48	1	38	H64
AHWAZ	IRAN	¬2.0	O	1958	31	49	3	39	H23
ZUBAIR	IRAQ	1.9	O	1948	30	48	2	38	H68
BAG-E-SAFID	IRAN	1.5	O	1964	30	50	2	40	H31
DAMMAM	SAUDI A	¬1.5	O	1938	30	51	1	40	H29
BAHRAIN	BAHRAIN	1.1	O	1931	26	51	-2	40	H96
SASSAN	IRAN	¬1.0	O	1967	26	53	-3	42	H75
FAHUD	OMAN	1.0	O	1964	24	57	-6	45	H102
FATEH	DUBAI	1.0	O	1966	25	55	-4	43	H103
BOSTAN	IRAN	1.0	O	1967	26	53	-3	42	H104
SHAYBAH	SAUDI A	1.0	O	1968	22	55	-7	43	H109
ABU JIDU	ABU DHABI	1.0	O	1966	24	54	-5	43	H110
UMM GUDAIR	KUWAIT/NZ	1.0	O	1962	29	48	1	38	H115
DARIUS KHARG	IRAN	¬0.8	O	1961	29	50	1	40	H87
IDD-EL-SHARGI	QATAR	¬0.7	O	1960	25	51	-3	40	H57
HAFT KEL	IRAN	¬0.7	C	1928	31	49	3	40	H58
MANSURI	IRAN	¬0.7	O	1963	31	49	2	39	H63
NATIH	OMAN	0.6	O	1963	24	56	-5	45	H161
HOUT	S-A/NZ	0.5	O	1963	29	49	0	39	H183
BAI HASSAN	IRAQ	¬0.4	O	1953	35	44	8	36	H92
BINAK	IRAN	¬0.3	O	1959	29	50	1	40	H105
NAFT-I-SAFID	IRAN	¬0.3	O	1935	32	49	3	39	H106
ASIA									
SAMOTLOR	USSR	15.1	O	1966	61	75	42	54	H6
S/S -MEDVEDEV	USSR	4.2	O	1962	62	77	44	55	H32
UST'-BALYK	USSR	3.1	O	1961	62	70	43	51	H42
MAMONTOVO	USSR	3.0	O	1965	61	73	42	53	H46
ZAPADNO-S/T	USSR	2.0	O	1962	61	72	42	52	H67
PRAVDINSK	USSR	1.5	O	1964	61	70	42	51	H77
YUZHNO-C/C	USSR	1.4	O	1969	60	75	42	54	H78
SALYM	USSR	1.0	O	1963	61	70	42	51	H117
TA-CH'ING	CHINA	0.6	O	1959	46	125	39	97	H148
MEGION	USSR	¬0.3	O	1961	61	75	43	54	H126
URENGOY	USSR	210.	G	1966	67	78	49	54	G1
YUBILEYNYY	USSR	70.	G	1968	67	75	48	52	G2
ARKTICHESKOYE	USSR	63.	G	1968	70	71	51	49	G4
ZAPOLYARNOYE	USSR	54.3	G	1965	67	79	49	54	G5
TAZ	USSR	40.4	G	1962	68	79	49	54	G7
MEDVEZH'YE	USSR	35.3	G	1967	66	71	47	50	G9
YAMBURG	USSR	30.0	G	1969	68	76	49	52	G12
GAZLI	USSR	17.0	G	1956	40	63	21	50	G17
GUBKIN	USSR	12.3	G	1965	66	76	48	53	G21
VYNGAPUR	USSR	10.6	G	1968	64	76	46	54	G25
RUSSKOYE	USSR	10.6	G	1968	66	79	48	55	G26
MESSOYAKHA	USSR	¬9.4	G	1967	69	84	51	56	G20
SHEKEITLI	USSR	7.7	G	1968	37	61	17	48	G30
ACHAK	USSR	5.0	G	1966	41	61	21	48	G41
BOYERDESHIK	USSR	3.6	G	1969	37	60	17	48	G55
KOMSOMO	USSR	3.5	G	1966	65	77	47	54	G56
NYDA	USSR	3.5	G	1967	66	72	47	51	G68
SOLENAYA	USSR	3.5	G	1969	70	81	52	54	G70
NOVYY PORT	USSR	¬3.4	G	1964	69	71	50	49	G40
GUGURTLI	USSR	2.3	G	1965	41	62	22	49	G72
YEFREMOVKA	USSR	¬1.6	G	1964	60	78	42	56	G49
SHIBARGHAN	USSR	¬1.2	G	1959	36	66	17	53	G56
EUROPE									
M-V/ALIYURT	USSR	¬2.0	O	1915	43	45	23	97	H45
UZEN'	USSR	¬1.8	O	1961	43	53	23	41	H37
STAROGROZNYY	USSR	¬ .4	O	1893	43	45	23	35	H144
NORTH SEA	UK	.1	O		56	4	39	7	K3
AMPOSTA	SPAIN	.1	O		43	0	27	-1	K4
LACQ	FRANCE	¬ .5	G	1951	45	0	29	0	G33
MAYKOP	USSR	.2	G	1909	45	40	24	31	G75
TUL'SKIY	USSR	.2	G	1969	44	41	24	32	G76
MEILLON ROUGE	FRANCE	.7	G	1965	44	0	28	0	G62
BERGEN	N.LANDS	¬ .2	G	1964	52	7	35	7	G60
REGGENTE	ITALY	.0	G		41	16	23	12	RG5
NORTH AMERICA									
EAST TEXAS	TEXAS	.0	O	1930	32	-95	33	-54	H24
PRUDHOE BAY	ALASKA	¬ .7	O	1967	70	-150	81	-44	H5
POZA RICA	MEXICO	.7	O	1930	20	-97	22	-61	H47
PEMBINA	ALBERTA	.8	O	1953	55	-120	61	-60	H70
NARANJOS C/A	MEXICO	.4	O	1909	21	-97	23	-61	H79
EBANO PANUCO	MEXICO	.0	C	1901	22	-97	24	-60	H120
HAWKINS	TEXAS	.5	O	1940	33	-95	34	-54	H166
SALT CREEK	WYOMING	¬ .3	O	1906	44	-105	47	-56	H175
RANGELY	COLORADO	.2	O	1902	41	-108	45	-61	H158
SMACKOVER	ARKANSAS	¬ .2	O	1922	32	-92	32	-51	H167
BLANCO BASIN	N MEXICO	11.	G	1927	38	-109	43	-64	G64
CARTHAGE	TEXAS	6.0	G	1936	31	-93	31	-53	G36
MONROE	LOUISIANA	¬3.5	G	1916	31	-92	31	-52	G32
ATHABASCA	CANADA	892	T		57	-112	60	-50	T2
FRONTIER	WYOMING	0.1	S		44	-105	47	-56	S10
SOUTH AMERICA									
C-RIVADAVIA	ARGENTINA	2.0	O	1907	-47	-67	-60	-26	H65
LAMA	VENEZEULA	¬0.6	O	1957	10	-72	-5	-49	H61
LA PAZ	VENEZEULA	¬0.6	C	1925	11	-72	-5	-49	H99
LAMAR	VENEZEULA	¬0.4	C	1958	10	-72	-6	-49	H85
INF LA CIRA	COLOMBIA	¬0.2	O	1918	5	-75	-11	-51	H141
TRIASSIC									
AFRICA									
HASSI ER R'MEL	ALGERIA	35.	G	1956	28	3	5	-8	G10
RHOURDE NOUSS	ALGERIA	2.5	G	1962	29	8	5	-3	G48
BEMOLANGA	M.GASCAR	2	T		-18	45	-30	28	T8
ARABIA									
GHAWAR	S.ARABIA	75.	O	1948	25	50	-4	32	H1
ABQAIQ	S.ARABIA	12.	O	1941	26	50	-3	32	H10
QATIF	S.ARABIA	9.	O	1945	27	50	-2	32	H15
KHURSANIYA	S.ARABIA	6.5	O	1956	27	49	-2	31	H20
ABU SAFAH	S.ARABIA	6.5	O	1963	27	50	-2	32	H21
KHURAIS	S.ARABIA	6.4	O	1957	26	49	-4	31	H22
BERRI	S.ARABIA	5.9	O	1964	27	49	-2	31	H25
DAMMAM	S.ARABIA	5.5	O	1938	27	50	-3	32	H26
MANIFA	S.ARABIA	3.6	O	1957	28	49	-1	31	H11
F-MARJAN	S.ARABIA	3.3	O	1966	28	50	-1	32	H13
DUKHAN	S.ARABIA	2.4	O	1940	25	51	-4	33	H52
IDD-EL-SHARGI	S.ARABIA	¬1.4	O	1963	25	51	-4	33	H57
MAYDAN MAHZAM	S.ARABIA	1.1	O	1963	26	52	-4	34	H94
ZAKUM	S.ARABIA	1.0	O	1964	25	54	-5	36	H108
ABU HADRIYA	S.ARABIA	1.0	O	1940	28	49	-2	31	H113
FADHILI	S.ARABIA	1.0	O	1949	29	49	-2	31	H114
SASSAN	IRAN	¬0.5	O	1967	26	53	-4	35	H75
BAHRAIN	BAHRAIN	¬14.4	G	1931	26	50	-3	32	G14

Field	Country	Reserves	Type	Year	Present Lat.	Present Long.	Paleo Lat.	Paleo Long.	Ref.
TRIASSIC CONTD.									
ASIA									
KARAMAI	CHINA	0.7	O	1955	45	84	48	66	H134
LUNG-NUSSU	CHINA	0.6	O	1956	31	105	45	97	H154
MEGION	USSR	¬0.3	O	1961	61	75	56	42	H126
SREDNE-VILYUY	USSR	15.9	G	1963	63	123	76	65	G19
SHEKEITLI	USSR	7.8	G	1955	29	105	45	98	G 29
MAASTAKH	USSR	6.4	G	1967	63	125	77	67	G35
URTABULAK	USSR	5.4	G	1963	38	63	33	54	G39
MESSOYAKHA	USSR	¬4.6	G	1967	69	84	64	32	G20
SAMANTEPE	USSR	3.7	G	1967	38	54	33	54	G63
KANDYM	USSR	3.5	G	1967	39	64	35	54	G63
KAZANSKOYE	USSR	3.5	G	1967	58	78	55	47	G64
LUGINETS	USSR	3.5	G	1967	59	78	56	46	G67
PELYATA	USSR	3.5	G	1969	69	81	63	31	G69
PUNGA	USSR	3.4	G	1961	63	64	54	33	G73
MYL'DZHINO	USSR	¬3.3	G	1964	60	78	56	45	G49
NOVYY PORT	USSR	¬1.7	G	1964	69	71	59	28	G40
SHIBARGHAN	AFGHANSTN	¬1.2	G	1959	36	66	33	58	G56
GUGURTLI	USSR	1.2	G	1965	41	62	36	51	G72
FUSHUN	CHINA	0.1	S		42	124	62	112	S7
EUROPE									
UZEN	USSR	¬1.8	O	1961	43	53	34	43	H37
ZHETYBAY	USSR	1.1	O	1961	43	54	34	44	H93
NORTH SEA	UK	0.1	O		59	1	35	0	K1
NORTH SEA	UK	0.1	O		58	0	34	0	K2
NORTH SEA	N.LANDS	0.1	O		54	4	31	3	K3
LACQ	FRANCE	3.5	G	1951	45	0	21	3	G33
HEWETT	UK	¬2.7	G	1966	53	1	29	2	G52
MEILLON ROUSSE	FRANCE	¬1.7	G	1965	44	0	20	3	G62
KASHPIRIAN	USSR	0.1	S		53	48	40	33	S8
SVALBARD	NORWAY	0.1	S		78	15	55	-3	S6
NORTH AMERICA									
PRUDHOE BAY	ALASKA	¬11.	O	1967	70	-150	56	-55	H5
ARENQUE	MEXICO	1.0	O	1967	22	-96	-1	-46	H118
KERN RIVER	CALIF	¬0.2	O	1899	37	-119	19	-60	H151
SMACKOVER	ARKANSAS	¬0.2	O	1922	32	-92	8	-41	H167
RANGELY	COLORADO	¬0.1	O	1902	41	-108	20	-51	H158
SALT CREEK	WYOMING	¬0.1	O	1906	44	-105	22	-48	H157
SOUTH AMERICA									
NEUQUEN	ARGENTINA	0.1	S		-38	-70	-60	-32	S9
CARBONIFEROUS									
ARABIA									
BAHRAIN	BAHRAIN	¬6.6	G	1931	26	50	-26	51	G14
AUSTRALIA									
GIDGEALPA	AUSTRALIA	5.0	G	1964	-26	140	-60	143	G42
MOOMBA	AUSTRALIA	5.0	G	1964	-28	140	-62	143	G43
EUROPE									
ROMASHKINO	USSR	¬4.7	O	1948	55	51	31	17	H8
ARLAN	USSR	4.1	O	1955	56	55	34	18	H33
NOVOYEL/TASH	USSR	¬1.1	O	1955	55	50	31	16	H41
TUYMAZY	USSR	¬1.1	O	1937	54	51	31	18	H54
MUKHANOVO	USSR	¬1.0	O	1945	53	49	29	17	H74
KULESHOVKA	USSR	0.8	O	1958	53	51	30	18	H131
PRILUKI	USSR	0.7	O	1959	52	30	22	7	H142
YARINO-K-LOG	USSR	0.5	O	1954	58	55	35	17	H173
GLYNSKO -R	USSR	0.3	O	1958	52	31	22	8	H187
USA	USSR	¬0.4	O	1963	68	57	43	8	H152
GRONINGEN	NL/W.GER	65.3	G	1959	53	9	19	-6	G3
ORENBURG	USSR	26.3	G	1966	53	53	31	19	G13
VUKYTL	USSR	17.7	G	1964	66	57	41	10	G15
LAYAVOZH	USSR	17.5	G	1965	68	55	42	7	G16
SHEBELINKA	USSR	16.3	G	1950	52	48	28	17	G18
LEMAN	UK	12.0	G	1966	53	2	18	-10	G22
INDEFATIGABLE	UK	8.0	G	1966	54	2	19	-11	G28
YEFREMOVKA	USSR	4.6	G	1965	52	48	28	17	G50
ZAPADNO-K	USSR	3.5	G	1968	53	28	23	5	G66
BERGEN	N.LANDS	¬2.3	G	1964	52	7	17	-7	G60
KOROBKI	USSR	2.1	G	1949	52	43	26	15	G17
HEWITT	UK	¬1.3	G	1966	53	1	18	-11	G52
MELEKESS	USSR	¬ 61	T		52	50	29	18	T3
MIDLOTHIAN	UK		S		56	-5	20	-15	S3
NORTH AMERICA									
PRUDHOE BAY	ALASKA	¬3.6	O	1967	70	-150	51	-54	H5
K-S-DIAMOND M	TEXAS	1.7	O	1948	33	-102	6	-61	H72
PANHANDLE	TEXAS	1.7	O	1918	37	-102	9	-59	H73
YATES	TEXAS	1.3	O	1926	30	-101	3	-62	H86
SHO-VEL-TUM	OKLAHOMA	¬0.8	O	1914	35	-98	6	-57	H123
ILLINOIS OLD/P	ILLINOIS	0.7	O	1905	38	-86	5	-47	H139
WASSON	TEXAS	0.6	O	1936	33	-103	6	-62	H156
COWDEN	TEXAS	0.6	O	1930	32	-102	5	-61	H163
SLAUGHTER	TEXAS	0.5	O	1936	35	-103	8	-61	H171
BURBANK	OKLAHOMA	0.5	O	1920	38	-96	8	-54	H176
GOLDSMITH	TEXAS	¬0.4	O	1935	33	-102	6	-61	H138
RANGELY	COLORADO	¬0.3	O	1902	41	-108	15	-61	H158
GOLDEN TREND	OKLAHOMA	¬0.3	O	1946	37	-99	8	-57	
SEMINOLE GR	OKLAHOMA	¬0.1	O	1926	35	-94	5	-54	H127
SALT CREEK	WYOMING	¬0.1	O	1906	44	-105	17	-58	H175
HUGOTON	KY/OK/TXS	39.5	G	1926	39	-100	10	-57	G8
PANHANDLE	TEXAS	30.5	G	1918	37	-102	9	-59	G11
JALMAT	N. MEXICO	8.1	G	1929	31	-104	5	-63	G27
MOCANE-LAVERNE	OKLAHOMA	3.8	G	1952	38	-99	9	-57	G53
ALBERT	NEW-BRSWK	0.1	S		46	-65	9	-30	S4
TAR TRIANGLE	UTAH	16	T		38	-112	14	-66	T6
SOUTH AMERICA									
IRATI	BRAZIL	0.1	S		-25	-52	-40	-20	T5
DEVONIAN									
AFRICA									
ZARZAITINE	ALGERIA	1.3	O	1958	28	9	-47	25	H82
EUROPE									
ROMASHKINO	USSR	¬9.6	O	1948	55	51	13	7	H8
NOVOYELKHOV-A.	USSR	¬2.2	O	1955	55	50	12	7	H41
TUYMAZY	USSR	¬1.1	O	1937	54	51	12	8	H54
MUKHANOVO	USSR	¬0.5	O	1945	53	49	11	8	H74
SHKAPOVO	USSR	1.3	O	1944	54	53	13	9	H88
KOROBKI	USSR	¬1.0	G	1949	52	43	7	6	H77
USA	USSR	¬0.2	O	1963	68	57	23	-3	G182
MELEKESS	USSR	61	T		52	50	11	9	T3
NORTH AMERICA									
SWAN HILLS	ALBERTA	0.9	O	1957	56	-116	12	-56	H122
RAINBOW	ALBERTA	0.7	O	1965	58	-118	14	-56	H135
REDWATER	ALBERTA	0.7	O	1948	54	-114	10	-57	H136
BRADFORD	PENN.	0.7	O	1871	42	-78	-14	-45	H143
LEDUC-WOODBEND	ALBERTA	0.5	O	1947	53	-113	-9	-58	H177
SEMINOLE GR.	OKLAHOMA	¬0.2	O	1926	35	-94	-14	-60	H127
GOLDSMITH AND.	TEXAS	¬0.2	O	1935	32	-102	-12	-67	H138
GOLDEN TREND	OKLAHOMA	¬0.1	O	1946	37	-99	-10	-62	H186
ORDOVICIAN									
AFRICA									
RHOURDE EL B.	ALGERIA	¬0.3	O	1962	30	7	-85	-136	H181
RAGUBA	LIBYA	¬0.2	O	1961	29	19	-78	16	H107
SAMAH	LIBYA	¬0.2	O	1962	28	19	-77	164	H81
HATEIBA	LIBYA	¬3.0	G	1963	30	20	-78	154	G23
RHOURDE-NOUSS	ALGERIA	¬1.3	G	1962	29	8	-84	-144	H48
EUROPE									
KUKKERSITE	ESTHONIA	0.1	S		60	25	9	-8	S2
NORTH AMERICA									
SEMINOLE GR	OKLAHOMA	¬0.5	O	1926	35	-94	-19	-57	H127
OKLAHOMA CITY	OKLAHOMA	¬0.5	O	1928	37	-97	-16	-58	H130
LIMA	INDIANA	¬0.5	O	1885	41	-84	-17	-47	H172
SHO-VEL-TUM	OKLAHOMA	¬0.1	O	1914	35	-98	-18	-60	H123
GOLDSMITH-AND.	TEXAS	¬0.1	O	1935	32	-102	-18	-65	H138
GOLDEN TREND	OKLAHOMA	¬0.1	O	1946	37	-99	-15	-60	H106
PUCKETT	TEXAS	6.5	G	1952	29	-103	-20	-67	G34
GOMEZ	TEXAS	¬2.0	G	1963	30	-104	-19	-68	G51
CAMBRIAN									
AFRICA									
AMAL-N-A	LIBYA	¬0.9	O	1959	29	2 2	-56	135	H27
H-MESSAAOUD	ALGERIA	3.5	O	1956	30	8	-65	130	H38
SAMAH	LIBYA	¬0.2	O	1962	28	1 9	-56	139	H81
RAGUBA	LIBYA	¬0.2	O	1961	29	1 9	-56	138	H107
RHOURDE-EL-B	ALGERIA	¬0.3	O	1962	30	7	-66	129	H181
HABIETA	LIBYA	¬3.0	G	1963	30	2 0	-55	136	H23
RHOURDE NOUSS	ALGERIA	¬1.3	G	1962	29	8	-65	132	H48
ASIA									
SILIGIR	USSR	13	T		64	0 4	-26	51	T4
OLENEK	USSR	8	T		70	1 9	-27	41	T5
EUROPE									
KOLM	SWEDEN	0.1	S	1974	58	15	-14	-4	S1
NORTH AMERICA									
GOMEZ	TEXAS	¬2.0	G	1963	30	-104	-2	-74	H51

Reserves: oil in billions of barrels, gas in Trillion cubic feet.
Type: O = oil, G = gas, T = tar sands, S = oil shale.
Year: year of discovery.
Present = present-day location; Paleo = location in a past period.
Ref. H, G. Halbouty et al, 1970; S = Balducci and Pommier. 1970;
I = Irving et al, 1974; T = Demaison, 1977; K = World Oil issues.

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