APPENDIX 1

FLORIDA OIL FIELD DISCOVERY WELL DATA

FLORIDA OIL FIELD DISCOVERY WELL DATA

DISCOVERY DATE	PERMIT NO.	FIELD	COUNTY	DATUM FOR DEPTH MEASUREMENTS, FT. MSL (1)	PERFORATIONS OR OPEN HOLE DEPTH BELOW DATUM, FT.	TOTAL DEPTH BELOW DATUM, FT.	NAME OF PRODUCING FORMATION	DISCOVERY STATUS	OIL GRAVITY, DEGREES API
9-26-43	42	Sunniland	Collier	34 (DF)	11,602-11,626	11,626	Sunniland	Pumping	26
2-5-54	167	Forty Mile Bend	Dade	24 (DF)	11,322-11,339	11,557	Sunniland	Pumping	21
7-22-64	315	Sunoco Felda	Hendry	55	11,472-11,485	11,485	Sunniland	Pumping	25
8-2-66	371	West Felda	Hendry	49	11,486-11,489	11,675	Sunniland	Pumping	26
3-10-69	401	Lake Trafford	Collier	40	11,870-11,892	11,987	Sunniland	Pumping	26
6-15-70	417	Jay	Santa Rosa	206	15,470-15,524	15,984	Smackover	Flowing	51
12-19-71	504	Mt. Carmel	Santa Rosa	274	15,260-15,280	15,399	Smackover & Norphlet	Flowing	47
2-14-72	523	Blackjack Creek	Santa Rosa	157	15,790-15,900	16,235	Smackover	Flowing	51
12-5-72	563	Bear Island	Collier	31	11,589-11,595	11,817	Sunniland	Pumping	26
11-14-73	662	Seminole	Hendry	36	11,415-11,420	11,651	Sunniland	Pumping	25
7-30-74	712	Lehigh Park	Lee	40	11,389-11,394	11,630	Sunniland	Pumping	28
4-22-77	881	Sweetwater Creek	Santa Rosa	255	14,299-14,340	14,611	Smackover	Pumping	45
8-11-77	865	Baxter Island	Collier	30	11,512-11,515	11,823	Sunniland	Pumping	22
10-13-77	904	Mid-Felda	Hendry	59	11,492-11,496	11,686	Sunniland	Pumping	26
6-20-78	829	Raccoon Point	Collier	39	11,410-11,414	11,658	Sunniland	Pumping	23
9-28-78	897	Pepper Hammock	Collier	43	11,629-11,633	11,897	Sunniland	Pumping	27
6-27-82	1070	Townsend Canal	Hendry	53	11,416-11,421	11,462	Sunniland	Pumping	28
3-25-84	1125	Bluff Springs	Escambia	178	16,332-16,339	16,800	Smackover	Flowing	57
11-10-85	1170	Corkscrew	Collier	45	11,547-11,565	11,565	Sunniland	Pumping	26
2-19-86	1194	McLellan	Santa Rosa	245	14,072-14,090	14,475	Smackover	Flowing	41
6-4-88	1220	Coldwater Creek	Santa Rosa	166	15,150-15,170	15,407	Smackover	Flowing	47
6-14-88	1230	McDavid	Escambia	271	16,346-16,360	16,800	Smackover	Flowing	54

1. This is usually the kelly bushing elevation; where this was unavailable, drill floor (DF) elevation is given.

APPENDIX 2

1988, 1989 AND CUMULATIVE PRODUCTION DATA

1988, 1989 AND CUMULATIVE PRODUCTION DATA (1)

FIELD (2)	1988 PRODUCTION Oil (Bbls)	Gas (MCF)	Water (Bbls)	1989 PRODUCTION Oil (Bbls)	Gas (MCF)	Water (Bbls)	CUMULATIVE PRODUCTION Oil (MBbls)	Gas (MMCF)
NORTHWEST FLORIDA								
Bluff Springs	26,737	13,993	171,510	15,889	5,369	158,041	220	122
McDavid	38,417	12,478	7,536	82,789	35,886	33,566	121	48
Jay	4,729,067	7,443,364	46,050,785	4,814,354	7,595,813	51,452,328	365,479	466,858
Coldwater Creek	5,759	238	11,485	1,766	203	700	9	0
Blackjack Creek	462,464	740,047	6,252,039	517,142	1,016,557	9,581,475	54,482	51,989
Mt. Carmel	63,081	17,138	483,995	12,520	0	55,147	4,666	4,797
McLellan	64,107	29,549	17,981	44,541	20,302	15,313	174	77
Sweetwater Creek (3)	0	0	0	0	0	0	14	15
Subtotal	5,389,632	8,256,807	52,995,331	5,489,001	8,674,130	61,296,570	425,165	523,906
SOUTH FLORIDA								
Lehigh Park	168,605	16,493	1,297,670	104,109	8,956	1,510,456	5,165	519
Townsend Canal	30,283	0	156,898	46,590	0	216,085	406	0
West Felda	634,923	44,879	4,954,270	494,652	34,818	3,404,318	41,226	3,427
Mid-Felda	79,221	0	222,258	77,195	0	243,795	1,239	10
Sunoco Felda	82,636	4,513	1,046,974	36,591	1,308	404,823	11,529	980
Corkscrew	159,838	0	5,505	108,037	0	33,616	524	0
Lake Trafford	1,790	0	0	0	0	0	278	0
Seminole (3)	0	0	0	0	0	0	85	0
Sunniland	30,459	2,629	726,203	5,325	482	124,390	18,445	1,824
Bear Island	337,823	27,815	2,450,255	245,024	19,609	2,443,173	10,575	837
Pepper Hammock	0	0	0	0	0	0	0	0
Baxter Island (3)	0	0	0	0	0	0	2	0
Raccoon Point	830,838	99,863	643,621	682,866	81,989	626,993	4,444	529
Forty Mile Bend (3)	0	0	0	0	0	0	33	2
Subtotal	2,356,416	196,192	11,503,654	1,800,389	147,162	9,007,649	93,951	8,128
STATEWIDE TOTAL	7,746,048	8,452,999	64,498,985	7,289,390	8,821,292	70,304,219	519,116	532,034

1. Statistics compiled by Charles Tootle, Florida Geological Survey, Oil and Gas Section.
2. Fields are listed in approximate order from north to south and west to east.
3. Plugged and abandoned oil fields.

Abbreviations:
Bbls - Barrels (42 US Gallons)
MBbls - Thousand Barrels
MCF - Thousand Cubic Feet
MMCF - Million Cubic Feet

APPENDIX 3

1988 AND 1989 FIELD WELL STATISTICS

1988 AND 1989 FIELD WELL STATISTICS (1)

FIELD (2)	1988 Number of Wells					1989 Number of Wells				
	PRO	INJ	SI	TA	TOT	PRO	INJ	SI	TA	TOT
NORTHWEST FLORIDA										
Bluff Springs	0	0	1	0	1	1	0	0	0	1
McDavid	1	0	0	0	1	1	0	0	0	1
Jay	38	22	59	0	119	44	27	43	0	114
Coldwater Creek	0	0	1	0	1	1	0	0	0	1
Blackjack Creek	7	7	11	0	25	9	7	10	0	26
Mt. Carmel	1	0	1	0	1	1	0	1	0	2
McLellan	2	0	1	0	3	2	0	1	0	3
Sweetwater Creek (3)	0	0	0	0	0	0	0	0	0	0
Subtotal	49	29	74	0	152	59	34	55	0	148
SOUTH FLORIDA										
Lehigh Park	1	0	3	0	4	2	0	2	0	4
Townsend Canal	1	0	3	0	4	2	0	2	0	4
West Felda	13	0	27	0	40	11	0	21	0	32
Mid-Felda	1	0	1	0	2	2	0	0	0	2
Sunoco Felda	2	0	19	0	21	1	1	16	0	18
Corkscrew	3	0	0	0	3	3	0	0	0	3
Lake Trafford	0	0	1	0	1	0	0	1	0	1
Seminole (3)	0	0	0	0	0	0	0	0	0	0
Sunniland	0	0	13	0	13	0	0	8	0	8
Bear Island	10	0	17	0	27	7	2	17	0	26
Pepper Hammock	0	0	1	0	1	0	0	1	0	1
Baxter Island (3)	0	0	0	0	0	0	0	0	0	0
Raccoon Point	12	0	3	0	15	12	0	3	0	15
Forty Mile Bend (3)	0	0	0	0	0	0	0	0	0	0
Subtotal	27	0	54	0	81	23	3	46	0	72
STATEWIDE TOTAL	92	29	162	0	283	99	37	126	16	262

1. Statistics compiled by Charles Tootle, Florida Geological Survey, Oil and Gas Section.
2. Fields are listed in approximate order from north to south and west to east.
3. Plugged and abandoned oil fields.

Abbreviations:
PRO - Producing Wells
INJ - Injection Wells
SI - Shut In Wells
TA - Temporarily Abandoned Wells
TOT - Total No. Wells

APPENDIX 4

1988 AND 1989 FIELD WELLS DRILLED

1988 AND 1989 FIELD WELLS DRILLED

FIELD County	Well (1) and Permit No.	Operator-Well Name & No.	Location (2)	Completion Date	Drill Floor Elev., Ft. Above MSL	Total Depth, Ft. (3)	Status
MC DAVID FIELD							
Escambia	W-16368 P-1234	Hughes Eastern Corp.-Jones Estate No. 34-1	2420' FNL & 1637' FEL Sec. 34, T5N, R31W	6/13/89	20	16,750	Plugged and abandoned as a dry hole, 6/16/88.
JAY FIELD							
Santa Rosa	W-16369 P-1249	Exxon Corp.- Jones McDavid No. 7-8	2,337.66' FSL & 3,381.86' FEL Sec. 7, T5N, R29W	8/04/89	235	15,735	Injection well.
RACCOON POINT FIELD							
Collier	W-16121 P-1215	Exxon Corp.- Collier Land & Cattle Corp. No. 27-4	SHL: 2,651' FNL & 1,738' FEL BHL: 1,320' FSL & 1,320' FEL Sec. 27, T51S, R34E	1/07/89	34	MD: 11,796 TVD: 11,542	Completed as a potential producer.

1. Florida Geological Survey well number for samples (cuttings or core chips).
2. For directionally drilled wells, SHL is surface hole location, BHL is bottom hole location.
3. For directionally drilled wells, MD: measured depth; TVD: true vertical depth.

APPENDIX 5

1988 AND 1989 WILDCAT WELLS DRILLED

1988 AND 1989 WILDCAT WELLS DRILLED

County	Well (1) and Permit No.	Operator-Well Name & No.	Location (2)	Completion Date	Drill Floor Elev., Ft. Above MSL	Total Depth Ft. (3)	Status
NORTHWEST FLORIDA							
Calhoun	W-16298 P-1235	Zilkha Energy Co.- Donald Leonard No. 15-3	1049' FSL & 1330' FWL Sec. 15, T2S, R8W	08/26/88	141	9,758	Plugged & abandoned as a dry hole, 10/24/88.
Escambia	W-16126 P-1228	ARCO Oil & Gas Co.- R. H. Sherrill No. 34-3	1029' FSL & 1050' FWL Sec. 34, T5N, R33W	03/17/88	193	17,262	Plugged & abandoned as a dry hole, 3/17/88.
Escambia	W-16406 P-1230	Hughes Eastern Corp.-Walker-Boley No. 34-2	1500' FNL & 1050' FWL Sec. 34, T5N, R31W	07/14/88	269	16,800	Completed as a potential producer, 7/14/88. (McDavid Field)
Escambia	W-16506 P-1250	ARCO Oil & Gas Co.- A. Grimes No. 8-4	977' FSL & 976' FEL Sec. 8, T4N, R32W	08/11/89	30	17,500	Plugged and abandoned as a dry hole, 8/11/89.
Okaloosa	W-16503 P-1253	Hardy Oil & Gas U.S.A., Inc.- State of Florida No. 30-4	1320' FSL & 1650' FEL Sec. 30, T6N, R25W	10/12/89	22	14,105	Plugged & abandoned as a dry hole, 10/12/89.
Santa Rosa	W-16180 P-1232	Louisiana Land & Exploration Co.- Jeffreys No. 20-1	1600' FNL & 1100' FEL Sec. 20, T4N, R28W	06/24/88	183	16,080	Plugged & abandoned as a dry hole, 6/24/88.
Santa Rosa	W-16244 P-1244	Exxon Corp.- Exxon-Champion International No. 5-1	1330.75' FNL & 923.22' FEL Sec. 5, T2N, R29W	01/28/89	25	17,400	Plugged & abandoned as a dry hole, 1/28/89.
Santa Rosa	W-16301 P-1245	Hawkins & Co.- Champion No. 16-2	SHL: 1988.7' FSL & 186.7' FWL Sec. 15. BHL: 2220' FSL & 660' FEL Sec. 16, T5N, R30W	03/20/89	76	MD: 16,236 TVD: 16,123	Plugged & abandoned as a dry hole, 3/20/89.
Santa Rosa	W-16302 P-1246	Exxon Corp.- Shriners Hospital et al. No. 28-1	1600' FNL & 1100' FEL Sec. 28, T4N, R26W	04/26/89	25	15,519	Plugged & abandoned as a dry hole, 4/26/89.
Santa Rosa	No W# (4) P-1252	Hardy Oil & Gas U.S.A., Inc.- J.R. Miller Mill Co. No. 13-4	1200' FSL & 1200' FEL Sec. 13, T5N, R27W	10/12/89	25	14,970	Plugged & abandoned as a dry hole, 10/12/89.
Santa Rosa	W-16498 P-1257	Cation Petrol. Co.-B. Decker Ellis No. 18-4-3	859' FSL & 1,783' FEL Sec. 18, T4N, R28W	12/21/89	191	6,600	Plugged & abandoned as a dry hole, 12/21/89.

1988 AND 1989 WILDCAT WELLS DRILLED

County	Well (1) and Permit No.	Operator-Well Name & No.	Location (2)	Completion Date	Drill Floor Elev., Ft. Above MSL	Total Depth Ft. (3)	Status
SOUTH FLORIDA							
Collier	W-16122 P-1208	Sabine Corp.- Collier Co. No. 4-2	1320' FNL & 1600' FWL Sec. 4, T47S, R28E	01/28/88	43	11,850	Plugged & abandoned as a dry hole, 2/1/88.
Collier	W-16165 P-1216	Sabine Corp.- Collier Co. No. 18-2	1042.81' FNL & 1027.51' FWL Sec. 18, T50S, R33E	05/27/88	56	11,750	Plugged & abandoned as a dry hole, 6/13/88.
Collier	W-16195 P-1217	Sabine Corp.- Collier Co. No. 29-2	1584.97' FNL & 1644.89' FWL Sec. 29, T47S, R29E	07/09/88	46	12,000	Plugged & abandoned as a dry hole, 7/9/88.
Collier	W-16457 P-1238	Sabine Corp.- Alico Land Development No. 3-1	1081.92' FNL & 1398.02' FEL Sec. 3, T46S, R28E	11/13/89	51	11,620	Plugged & abandoned as a dry hole, 11/13/89.
Collier	W-16243 P-1240	Sabine Corp.- Collier Co. No. 5-5	SHL: 656' FNL & 868' FWL Sec. 9, BHL: 967' FSL & 967' FEL Sec. 5, T49S, R30E	12/10/88	38	MD: 12,345 TVD: 11,879	Plugged & abandoned as a dry hole, 12/10/88.

1. Florida Geological Survey well number for samples (cuttings or core chips).
2. For directionally drilled wells, SHL is surface hole location; BHL is bottom hole location.
3. MD: measured depth; TVD: true vertical depth (determined by directional survey).
4. Well samples have not been submitted yet.

APPENDIX 6

OIL EXPLORATION WELLS DRILLED IN FLORIDA STATE WATERS

OIL EXPLORATION WELLS DRILLED IN STATE WATERS

Year	Well (1) and Permit No.	Operator	Lease No. and Area	County	Rotary Table Elev. Ft. above MSL	Total Depth, Ft.	Geological Significance
1947	P-16 W-1413	Gulf Oil Corp.	State of Florida Lease 374 No. 1 Sugarloaf Key Area	offshore Monroe	23	6,100	Bottomed in Upper Cretaceous(?).
1947	P-22 W-972	Gulf Oil Corp.	State of Florida Lease 373 No. 1 Big Pine Key Area	offshore Monroe	23	15,455	No porosity in Sunniland Fm. Well bottomed in Pumpkin Bay (Late Coahuilan). Very difficult to correlate this well because of anhydrite development. Structurally very low.
1947	P-43 W-1502	Magnolia Petroleum Co.	State of Florida Block 5-B No. 1-A St. Vincent Sound	offshore Franklin	10	7,019	Bottomed in Lower Cretaceous.
1955	P-232 W-3510C	Gulf Oil Corp.	State of Florida Lease 826-G No. 1 Florida Bay	offshore Monroe	32	12,631	Well cored from 11,661-12,544' in Sunniland and Punta Gorda. Encountered some salt stringers in Punta Gorda. Only 60' of dark, dense calcilutite in Sunniland.
1956	P-251 W-4122	HORC	State of Florida Lease 833 No. 1 Pensacola Bay	offshore Santa Rosa	26	7,505	Bottomed in Lower Cretaceous.
1959	P-275 W-5094	Gulf Oil Corp.	State of Florida Lease 826-Y No. 1 Marquesas	offshore Monroe	56	15,478	Four drill stem tests: 12,474-12,533'(Lake Trafford?) 12,534-12,544'(Sunniland) 12,582-12,822'(Sunniland) 14,642-14,702'(Brown Dolomite) The 12,474-12,533' test recovered 15 barrels of 22 degree API gravity oil and 14.1 barrels of saltwater. Brown Dolomite from 14,650-15,036' was somewhat vuggy. This may be the principal target in this area. Net dolomite estimated at 400'.
1959	P-280 W-5152	California Coastal	State of Florida Lease 1011 No. 1 Big Pine Key Area	offshore Monroe	21	6,030	Bottomed in Lower Cretaceous.
1959	P-281 W-5103	California Coastal	State of Florida Lease 224-A No. 1 St. George Island Area	offshore Franklin	26	7,030	Bottomed in Lower Cretaceous.
1960	P-289 W-5574	California Coastal	State of Florida Lease 224-B No. 1 Boca Grande Area	offshore Lee	39	14,000	Brown Dolomite: 12,485-12,589'. Estimated net dolomite: 103'.
1961	P-292 W-5713	California Coastal	State of Florida Lease 1011 No. 2 Marquesas	offshore Monroe	36	7,722	Bottomed in Lower Cretaceous.
1961	P-293 W-5654	California Coastal	State of Florida Lease 224-A No. 2 South of Alligator Point	offshore Franklin	34	10,560	Did not encounter Smackover Fm. Bottomed in Eagle Mills Fm. of Triassic Age. Diabase found in Eagle Mills.
1961	P-297 W-5785	California Coastal	State of Florida Lease 224-B No. 2 Boca Grande Area	offshore Lee	40	12,600	There is an estimated 40' of dolomite in the 12,445-12,560' Brown Dolomite interval. No evidence of oil staining. Dolomite microcrystalline to finely crystalline. Core analysis from 11,255-11,625' Sunniland interval showed no permeability, extremely low porosity, and no oil.

OIL EXPLORATION WELLS DRILLED IN STATE WATERS

Year	Well (1) and Permit No.	Operator	Lease No. and Area	County	Rotary Table Elev. Ft. above MSL	Total Depth, Ft.	Geological Significance
1962	P-298 W-5970	California Coastal	State of Florida Lease 1011 No. 3 Marquesas	offshore Monroe	57	12,850	Bottomed in Punta Gorda. No shows of oil and no porosity reported. Drill stem test of the 12,521-12,600′ interval tested saltwater. Rebecca Shoals Reef (Paleocene and Upper Cretaceous) present.
1963	P-304 W-6278	California Coastal	State of Florida Lease 224-B No. 3 Honeymoon Island Area	offshore Pinellas	37	10,600	Bottomed in Lower Cretaceous. Very poor samples. No oil shows. Carbonates-clastics below 7,000′.
1967	P-375 W-8139	Mobil Oil Corp.	State of Florida Lease 224-B No. 1 Boca Grande Area	offshore Charlotte	21	12,931	This well drilled into Pumpkin Bay Fm. (Upper Coahuilan) at 12,230′. Drilled into basement (rhyolite porphyry) at 12,830′. No shows in Sunniland Fm. Brown Dolomite Zone: 11,920-12,000′. Estimated net dolomite: 70′. Poor samples.
1967	P-382 W-8304	Mobil Oil Corp.	State of Florida Lease 224-A No. 1-A W-SW of Crystal River	offshore Citrus	22	6,041	Mixed facies (carbonates, sandstones, and shales) at 4,325′; Triassic, Eagle Mills at 5,625′; Paleozoic at 5,920′. Very indurated shale and siltstone. Some quartzite. Bedding planes vertical in this core. No shows and no porosity.
1967	P-383 W-8305	Mobil Oil Corp.	State of Florida Lease 224-A No. 1-B Cedar Key Area	offshore Levy	25	4,735	Mixed facies (carbonates, sandstones, and shales) at 2,882′ in Cretaceous. Predominantly varicolored unconsolidated sandstone below 4,180′. Highly indurated quartzites and interbedded shales in core (Paleozoic) from 4,720-4,735′.
1968	P-387 W-8487	Mobil Oil Corp.	State of Florida Lease 224-A No. 1-C Little St. George Island Area	offshore Franklin	37	14,369	This well encountered Jurassic limestone. First indication of possible Smackover in Apalachicola area.
1983	P-1097 W-15391	Getty Oil Company	State of Florida Lease 2338 No. 1 East Bay	offshore Santa Rosa	30	18,011	Smackover tests at 17,405-17,411′ and 17,328-17,411′ produced only saltwater. Norphlet Ss. and Louann Salt were very thin.

1. Florida Geological Survey well number for samples (cuttings or core chips).

APPENDIX 7

1988 AND 1989 OIL EXPLORATION WELLS DRILLED IN FEDERAL WATERS, OFFSHORE FLORIDA

1988 AND 1989 OIL EXPLORATION WELLS DRILLED IN FEDERAL WATERS, OFFSHORE FLORIDA

AREA	WELL NO.	OPERATOR	LOCATION	DEPTH, FT. BELOW MSL	SPUD DATE	PLUGGED & ABANDONED DATE	COMMENTS
Destin Dome	OCS-G-6406	Chevron	Block 56	22,572	06/12/87	01/26/88	Temporarily abandoned Producible Norphlet discovery.
Pensacola	OCS-G-6391	Tenneco	Block 948	19,200	10/14/87	01/19/88	Temporarily abandoned.
Pensacola	OCS-G-6396	Texaco, Inc.	Block 996	17,910	04/08/88	09/07/88	
Destin Dome	OCS-G-6397	Gulfstar	Block 1	2,000	01/09/89	01/18/89	Temporarily abandoned.
Destin Dome	OCS-G-6398 No. 2	Gulfstar	Block 2	1,800	01/21/89	01/27/89	Temporarily abandoned.
Pensacola	OCS-G-6390	Gulfstar	Block 881	2,700	01/29/89	02/07/89	Temporarily abandoned.

Data from Gould, 1989.

APPENDIX 8

1988 AND 1989 GEOPHYSICAL EXPLORATION ACTIVITY

1988 AND 1989 GEOPHYSICAL EXPLORATION ACTIVITY

PERMIT	GEOPHYSICAL COMPANY	SURVEYED FOR	COUNTY	PERMIT APPROVED	EXPIRATION DATE	STATUS	ENERGY SOURCE	DEPTH, FEET	CHARGE SIZE, LBS	SHOT HOLE SPACING	SURVEY LENGTH,MI
G-98-88	Shell Western E&P	Shell Western E&P	DD,CL	N/A	N/A	Withdrawn	Seismic Gel	27	3	150	133.2
G-99-88	GFS	Harkins & Co.	SR,ES	14-Mar-88	14-Mar-89	Completed	Seismic Gel	100	20	440	6.3
G-100-88	Teledyne	First Seismic	SR,OK	27-May-88	27-May-89	Completed	Seis/Airgun	7.5	.5	110	113.8
G-101-88	Western	Western	SR,OK	20-Apr-88	20-Apr-89	Completed	Vibroseis	N/A	N/A	N/A	45.0
G-102-88	GFS	Davis Petroleum	SR	08-Apr-88	08-Apr-89	Completed	Seismic Gel	100	15	220	4.7
G-103-88	GFS	Union TX	SR	11-Apr-88	11-Apr-89	Completed	Seismic Gel	<10	.33	10	28.3
G-104-88	Dee Exploration	Exxon	ES	11-Apr-88	11-Apr-89	Completed	Seismic Gel	100	15	220	5.0
G-105-88	GFS	Pruet Oil	SR	27-May-88	27-May-89	Completed	Seismic Gel	100	5	330	1.6
G-106-88	IGC	Coastal Oil & Gas	SR	17-Aug-88	17-Aug-89	Completed	Seismic Gel	5	.33	220	9.4
G-107-88	Conoco	Conoco	BY,GA,HO,JK, LN,WK,WS	21-Jun-88	21-Jun-89	Completed	Vibroseis	N/A	N/A	N/A	140.0
G-108-88	GFS	Exxon	SR,ES	17-Aug-88	17-Aug-89	Completed	Seismic Gel	80	10	440	149.0
G-109-88	Teledyne	First Seismic	SR,OK	17-Aug-88	17-Aug-89	Completed	Seis/Airgun	7.5	.5	110	46.0
G-110-88	Teledyne	First Seismic	SR,OK,ES	30-Jun-88	30-Jun-89	Completed	Seis/Airgun	7.5	.5	110	18.0
G-111-88	Shell Western E&P	Shell Western E&P	DD	19-Sep-88	19-Sep-89	Completed	Vibrator	N/A	N/A	N/A	35.0
G-112-88	Shell Western E&P	Shell Western E&P	DD	19-Oct-88	19-Oct-90	Pending	Vibrator	N/A	N/A	N/A	90.5
G-113-88	Shell Western E&P	Shell Western E&P	DD,BR	02-Dec-88	02-Dec-89	Completed	Vibrator	N/A	N/A	N/A	55.5
G-114-88	Conoco	Conoco	HO	07-Sep-88	07-Sep-89	Cancelled	Vibroseis	N/A	N/A	N/A	19.2
G-115-88	Petty Ray	ARCO	ES	19-Sep-88	19-Sep-89	Completed	Seismic Gel	150	6	440	65.0
G-116-88	Shell Western E&P	Shell Western E&P	DD	02-Dec-88	02-Dec-89	Completed	Vibrator	N/A	N/A	N/A	24.1
G-117-88	Shell Western E&P	Shell Western E&P	DD,BR,HE	19-Dec-88	19-Dec-89	Completed	Vibrator	N/A	N/A	N/A	37.7
G-118-88	Shell Western E&P	Shell Western E&P	BR,HE,CL	27-Jan-89	27-Jan-90	Pending	Vibrator	N/A	N/A	N/A	26.0
G-119-88	Shell Western E&P	Shell Western E&P	DD	27-Jan-89	27-Jan-90	Completed	Vibrator	N/A	N/A	N/A	2.5
G-120-89	IGC	Coastal Oil & Gas	SR,OK	N/A	N/A	Cancelled	Seismic Gel	5	.33	220	46.0
G-121-89	Coastal Petroleum	Coastal Petroleum	GL,HE,MT,OE,PB	N/A	N/A	Withdrawn	Air/Watergun	N/A	N/A	N/A	225.0
G-122-89	GFS	Paramount	OK	13-Jul-89	13-Jul-90	Completed	Seismic Gel	60	15	165	4.3
G-123-89	GFS	First Seismic	SR	13-Jul-89	13-Jul-90	Completed	Seismic Gel	0.33	5	110	8.0
G-124-89	Shell Western E&P	Shell Western E&P	BR,PB			Pending	Seismic Gel	27	3	150	27.9
G-125-89	Halliburton	ARCO	ES	11-Aug-89	11-Aug-90	Expired	Seismic Gel	150	6	440	7.0
G-126-89	Halliburton	Exxon	ES	11-Aug-89	11-Aug-90	Completed	Seismic Gel	80-90	6	352	11.0
G-127-89	Shell Western E&P	Shell Western E&P	DD,BR			Pending	Seis/Vib	27	3	150	25.8
G-128-89	Halliburton	Exxon	SR,ES	26-Sep-89	26-Sep-90	Completed	Seismic Gel	30-90	.3-5	352	31.5
G-129-89	Digicon	Mobil	Offshore	09-Nov-89	09-Nov-90	Completed	Airgun	N/A	N/A	N/A	185.0
G-130-89	Halliburton	Chevron	ES	11-Oct-89	11-Oct-90	Completed	Seismic Gel	30-90	1-20	660	12.5
G-131-89	Shell Western E&P	Shell Western E&P	DD	05-Dec-89	05-Dec-90	Pending	Vibrator	N/A	N/A	N/A	70.8
G-132-89	GFS	Paramount	OK			Cancelled	Seismic Gel	60	15	165	4.6
G-133-89	Shell Western E&P	Shell Western E&P	DD	05-Dec-89	05-Dec-90	Pending	Vibrator	N/A	N/A	N/A	50.0
G-134-89	Shell Western E&P	Shell Western E&P	DD			Pending	Vibrator	N/A	N/A	N/A	8.5

County Abbreviations:

BR-Broward	GL-Glades	OE-Okeechobee
BY-Bay	HE-Hendry	OK-Okaloosa
CL-Collier	HO-Holmes	PB-Palm Beach
DD-Dade	JK-Jackson	SR-Santa Rosa
ES-Escambia	LN-Leon	WK-Wakulla
GA-Gadsden	MT-Martin	WS-Washington

	1988	1989	TOTAL
Total Miles in Applications:	1,055.8	717.8	1,773.6
Total Surveyed:	786.9	252.3	1,039.2
Surveyed Miles by Area:			
Panhandle Onshore:	632.1	67.3	699.4
Panhandle Offshore:	0.0	185.0	185.0
South Florida:	154.8	0.0	154.8
Surveyed Miles by Method:			
Vibrator:	339.8	0.0	339.8
Airgun:	0.0	185.0	185.0
Seismic Gel:	269.3	67.3	336.6
Seis.Gel/Airgun:	177.8	0.0	177.8
Total Pending:	116.5	183.0	299.5
Total Withdrawn, Cancelled, Expired:	152.4	282.6	435.0

APPENDIX 9

FLORIDA OIL AND GAS RESERVE ESTIMATES

By
Charles H. Tootle, P.E. #40,500

FLORIDA OIL AND GAS RESERVE ESTIMATES

FIELD (1)	OIL GRAVITY, A.P.I.	AVERAGE POROSITY, PERCENT	PRODUCTIVE ACRES	AVERAGE GAS-OIL RATIO, SCF/STB	ORIGINAL OIL IN PLACE, BARRELS	ESTIMATED RECOVERY FACTOR, FRACTION	ORIGINAL RECOVERABLE OIL IN PLACE, BARRELS	OIL PRODUCED THROUGH 1-1-90, BARRELS	REMAINING RECOVERABLE OIL RESERVES AS OF 1-1-90, BARRELS	ORIGINAL RECOVERABLE GAS IN PLACE, MCF	GAS PRODUCED THROUGH 1-1-90, MCF	REMAINING RECOVERABLE GAS RESERVES AS OF 1-1-90, MCF
NORTHWEST FLORIDA												
Bluff Springs	53	19.6	160.00	550	1,300,440	0.19	247,084	220,111	26,973	135,795	120,791	15,004
McDavid	53	12.8	160.00	400	4,987,347	0.10	498,736	121,206	377,530	199,494	48,364	151,130
Jay (FL & AL)	51	14.0	14,414.50	1,277	820,569,503	0.60	492,341,702	395,356,327	96,985,375	628,720,354	505,468,642	123,251,712
Jay (FL only)	51	14.0	13,021.14	1,277	763,129,638	0.60	457,877,783	365,479,210	92,398,573	584,709,929	466,858,558	117,851,371
Coldwater Creek	47	12.1	160.00	500	2,080,107	0.15	312,016	8,802	303,214	156,008	537	155,471
Blackjack Creek	48	16.5	5,719.98	954	100,500,000	0.60	60,300,000	54,482,137	5,817,863	57,526,200	51,989,890	5,536,310
Mt. Carmel	43	9.1	481.28	1,028	17,500,000	0.29	5,075,000	4,665,696	409,304	5,218,140	4,797,292	420,848
McLellan	43	9.0	480.00	430	2,915,540	0.14	412,686	174,289	238,397	177,455	74,905	102,550
Sweetwater Creek (2)	44	11.0	160.00	1,070	624,000	0.10	62,400	13,695	48,705	66,768	14,655	52,113
Subtotal (3)			20,342.40		893,037,072		524,785,705	425,165,146	99,620,559	648,189,789	523,904,992	124,284,797
SOUTH FLORIDA												
Lehigh Park	28	17.7	800.00	100	8,211,707	0.65	5,337,609	5,164,594	173,015	533,761	518,448	15,313
Townsend Canal	28	13.7	640.00	0	4,504,699	0.20	900,940	406,117	494,823	0	0	0
West Felda	26	15.0	7,500.00	80	125,802,366	0.35	44,030,828	41,225,828	2,805,000	3,522,466	3,221,145	301,321
Mid-Felda	26	11.9	480.00	10	5,090,419	0.30	1,527,126	1,239,166	287,960	12,726	10,094	2,632
Sunoco Felda	25	15.0	3,840.00	85	28,946,578	0.40	11,578,631	11,528,631	50,000	984,184	981,329	2,855
Corkscrew	26	6.9	480.00	0	1,667,806	0.40	667,122	524,462	142,660	0	0	0
Lake Trafford	26	7.9	160.00	0	7,690,293	0.04	307,612	277,746	29,866	0	0	0
Seminole (2)	25	14.1	480.00	0	2,366,565	0.10	236,657	84,755	151,902	0	0	0
Sunniland	26	15.0	2,080.00	100	37,685,118	0.50	18,842,559	18,444,812	397,747	1,884,256	1,824,628	59,628
Bear Island	26	11.9	2,880.00	80	42,811,959	0.35	14,984,184	10,575,398	4,408,786	1,198,735	836,093	362,642
Pepper Hammock	27	15.3	160.00	0	976,713	0.10	97,671	323	97,348	0	0	0
Baxter Island (2)	22	19.6	160.00	0	1,276,617	0.10	127,662	1,859	125,803	0	0	0
Raccoon Point	23	13.9	2,400.00	120	42,437,790	0.25	10,609,448	4,443,959	6,165,489	1,273,134	530,070	743,064
Forty Mile Bend (2)	21	10.0	320.00	50	1,112,701	0.07	77,889	32,888	45,001	3,894	1,656	2,238
Subtotal			22,380.00		310,581,331		109,325,938	93,950,538	15,375,400	9,413,156	7,923,463	1,489,693
STATEWIDE TOTAL			42,722.40		1,203,618,403		634,111,643	519,115,684	114,995,959	657,602,945	531,828,455	125,774,490

1. Fields are listed in approximate order from northwest to southeast.
2. Plugged and abandoned oil fields.
3. Northwest Florida subtotals use Jay (FL only) data.

UNITS:
MCF - Thousand Cubic Feet
SCF - Standard Cubic Feet
STB - Stock Tank Barrels

METHODS USED TO DETERMINE RESERVE ESTIMATES:
Archie's Equation was used to estimate the oil saturation in two feet increments. The formation water resistivities used were 0.018 ohm-meters for the Smackover Fm. (northwest Florida) and 0.022 ohm-meters for the Sunniland Fm. (south Florida). Formation temperatures were estimated SST = 76 + depth/80 for northwest Florida and SST = 76 + depth/100 for south Florida. SST is subsurface formation temperature in degrees Fahrenheit, and the depth is the distance in feet below ground surface. The volumetric calculation procedure was used to estimate the reserves for all of the oil fields except Sunniland, Sunoco Felda, and West Felda fields. Decline curve analysis was used to estimate the reserves for these three oil fields. This type of analysis will give credible results for these fields because they are well into the decline part of their production curves. In addition, few porosity logs were available for these three fields and resistivity logs yield anomalous values because the wells were drilled with water.

DISCLAIMER:
An attempt was made to present realistic estimates; however, no guarantee or warranty is expressed or implied. Anyone who uses this information does so at their own risk.

PART II

PETROLEUM EXPLORATION AND DEVELOPMENT POLICIES IN FLORIDA: RESPONSE TO PUBLIC CONCERN FOR SENSITIVE ENVIRONMENTS

By
Jacqueline M. Lloyd, P.G. 74
and
Joan M. Ragland, P.G. 298

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ABSTRACT

Florida's oil and gas policies have evolved in response to its increased awareness of the economic and aesthetic value of its other natural resources. The history of state oil and gas regulations and policy in Florida can be divided into three phases. The first phase encouraged exploration with no stated concern for other natural resources. This phase culminated in the legislative offer of an award for petroleum discovery. The second phase began in 1945 with the passage of the conservation law and spanned the mid-1940's to -60's. This period was characterized by economic concern for tourist trade and commercial fisheries. Finally, environmental concerns became an issue in the early 1970's. The effects of these concerns are especially apparent in the development of recent offshore policies and regulations. The following text describes the history of oil and gas development and regulation in Florida as it relates to concerns for the economic and aesthetic value of Florida's other (non-petroleum) natural resources.

ACKNOWLEDGEMENTS

Walt Schmidt, Tom Scott, Steve Spencer, David Curry, Ed Lane, and Frank Rupert, all staff members of the Florida Geological Survey, reviewed this report and suggested improvements. Debbie Tucker (Office of the Governor, Environmental Policy, Community and Economic Development Unit, Tallahassee, Florida) reviewed the section on offshore activity and policy development and suggested clarifications. Jim Jones and Ted Kiper drafted and photographed the figures.

PETROLEUM EXPLORATION AND DEVELOPMENT POLICIES IN FLORIDA: RESPONSE TO PUBLIC CONCERN FOR SENSITIVE ENVIRONMENTS

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INTRODUCTION

Florida currently produces oil from two areas (Figures 1 and 2). One is in south Florida, the other is in the western panhandle area. The south Florida area includes 14 oil fields; the western panhandle area includes seven.

South Florida production began with Florida's first oil discovery at Sunniland field in September, 1943 (Gunter, 1949) (Figure 1). The south Florida fields are oriented along a northwest-southeast trend through Lee, Hendry, Collier, and Dade counties (Figure 1). The trend is the Sunniland trend and is approximately 12-miles wide by 145-miles long and happens to lie within some of south Florida's most sensitive wetland environments.

Production in the western panhandle began with the discovery of Jay field in June, 1970 (Babcock, 1972). Although Jay field straddles the Escambia River, most of the field is within less sensitive upland environments (Figure 2). Even though ecological and environmental concerns affected development at Jay field (Oil and Gas Journal, 1972), most of Florida's environmental regulations have evolved in response to development in south Florida.

PHASE I: ENCOURAGING EXPLORATION AND PETROLEUM LEGISLATION

Early Exploration

The years 1900 to 1939 were characterized by sporadic, shallow wildcat exploration in Florida. Florida's "first phase" (1900 to 1945) policies concerning petroleum exploration somewhat parallels this same period. Until Florida's first commercial oil field discovery in 1943, emphasis was on encouraging exploration. The only petroleum legislation passed prior to this discovery was the reward bill, which was passed in 1941. Attempts to pass petroleum conservation legislation began after the state's first deep oil test was drilled in 1939. These attempts were not successful until 1945. The attempt to pass this legislation and the history leading up to the passage of the conservation law in 1945 are described in detail by Fields (1959). The following discussion of this history is summarized from his report.

The first test for oil in Florida was in 1900 at Pensacola in Escambia County (Gunter, 1949). This well was drilled to only 1320 feet. An additional 79 exploratory wells were drilled between 1900 and 1939; however, many of these were very shallow and may have been more "promotional" than serious oil tests (Gunter, 1949). In 1939, the first significant deep oil test was completed near Pinecrest, in Monroe County, at a depth of 10,006 feet (Gunter, 1949). Information yielded by this deep test drew the attention of major oil companies to Florida and marked the beginning of more "serious" oil exploration in Florida.

Early Legislation

The interest shown by these major oil companies prompted the first attempt to pass conservation legislation in Florida in 1939. The bill was supported by the petroleum industry and proposed to make "waste" in production, storage, and transportation of oil or gas unlawful. The bill briefly:

1. Prohibited waste of oil and gas.
2. Defined waste.
3. Set up the State Board of Conservation.

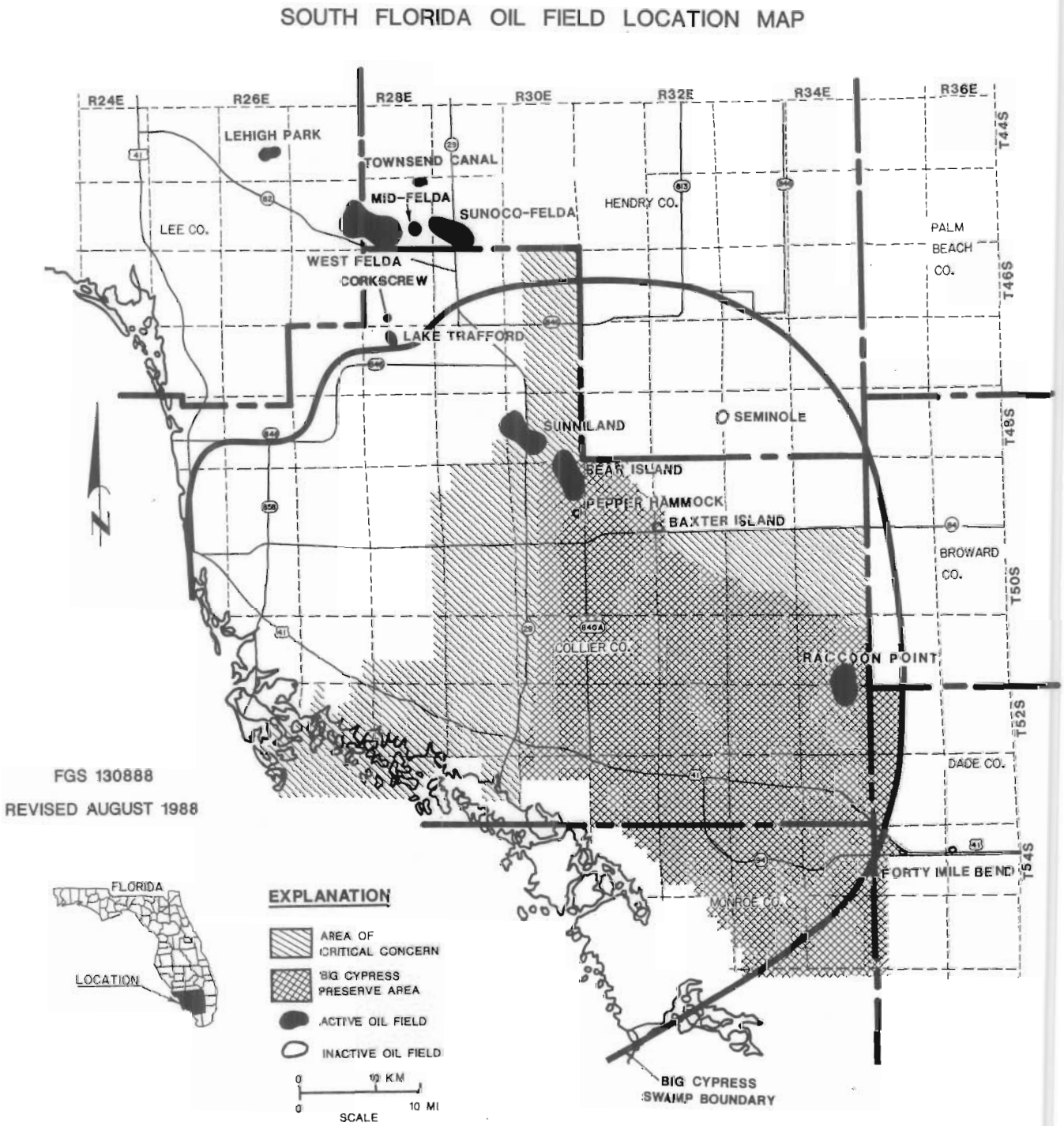

Figure 1. South Florida oil field location map showing boundaries of Big Cypress Swamp drainage area, Big Cypress Swamp Area of Critical State Concern, and Big Cypress Swamp National Preserve.

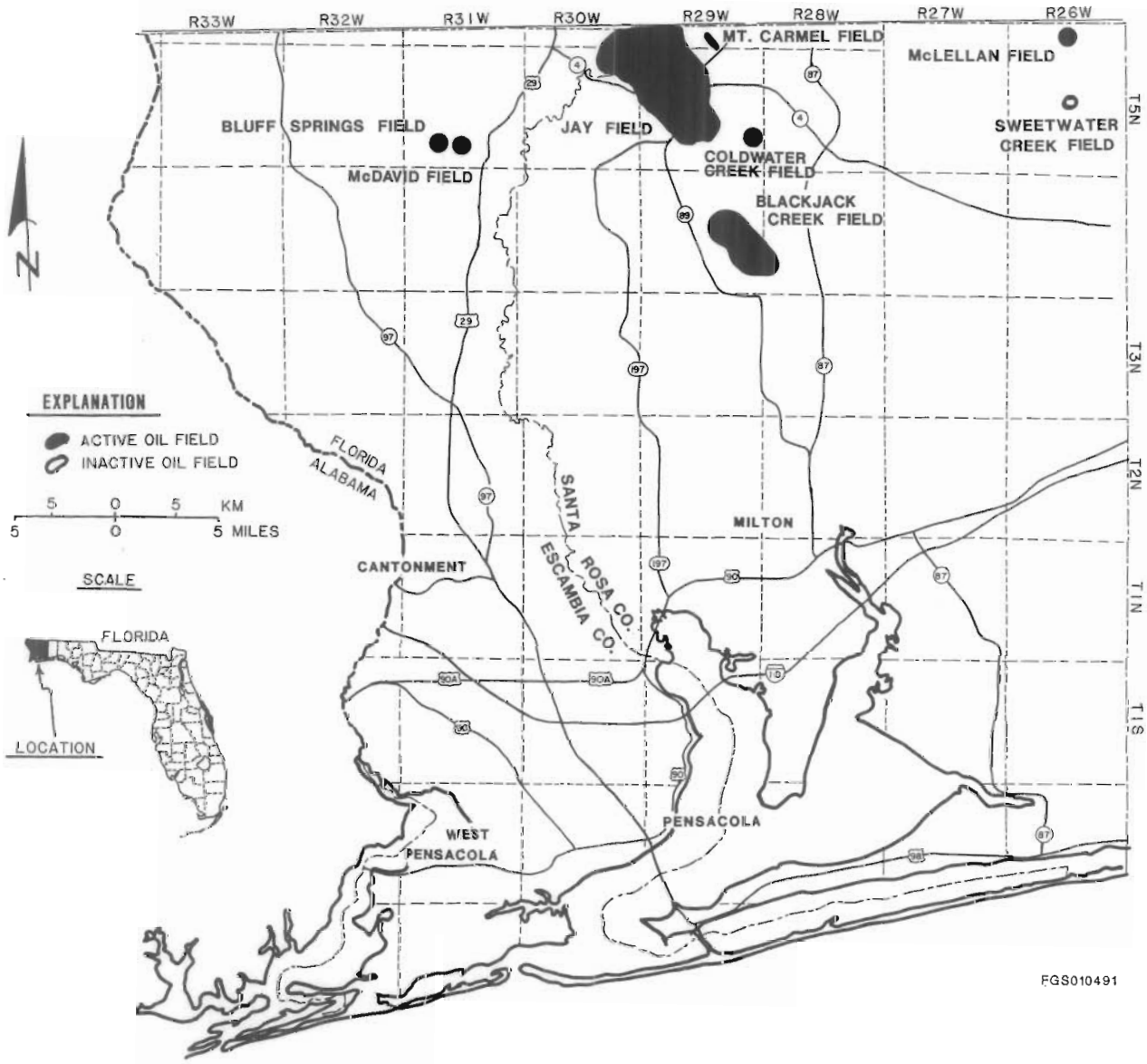

Figure 2. Northwest Florida oil field location map.

4. Required notice of intention to drill, deepen or plug a well.
5. Required that log and plugging records be filed with the State Board of Conservation.
6. Authorized the State Board of Conservation to promulgate and enforce rules and regulations and prescribe necessary forms.
7. Prescribed penalties for violations.

Opponents to the legislation argued that such a law would deter rather than encourage exploration. A quote from one of the opposition leaders states: " . . . as long as the state has no production . . . there is about as much necessity for legislation to regulate or control production as there would be to require paupers to rent lock boxes in banking institutions." This first effort to pass legislation failed.

Florida's legislature only met every two years so the next attempt to pass a conservation bill was not made until 1941. The proponents had enlisted petroleum industry lawyers to prepare a much more detailed bill than the previous one. The opposition revised the bill to the extent that it dealt more with ground-water pollution concerns than with conservation of oil and gas. The original proponents, therefore, fought the passage of the bill in the House of Representatives after it passed the Senate. It died on the House calendar at the end of the session. Efforts to pass a conservation law were again delayed by two years.

1941 was also the year that the discovery award bill (Chapter 20667-No. 459, Laws of Florida, 1941) was passed to encourage exploration for oil and gas. The bill offered an award to the explorer and operator of the first commercial oil or gas discovery. The award included $50,000 and a five-year oil and gas lease covering four tracts of land up to 10,000 acres each "free of any bonus, rental or lease charges except the reservation of one-eighth royalty usually retained in such leases." This act became law without the Governor's approval and was filed in the Office of Secretary on June 4, 1941.

In 1943, the conservation bill was introduced again. A briefer, simpler version was proposed to avoid the alteration by the opposition that had occurred in 1941. The bill had stronger backing but failed to be voted on during this session. The session closed with the bill on the calendar. A separate bill, which sought to protect ground water by regulating drilling practices, was also introduced in 1943. This bill passed the Senate, but died in the House, primarily due to a lack of interest by its sponsors.

The 1943 legislature adjourned in June; just three months before the first oil discovery. If the discovery had been made before the end of the session, the conservation law may have passed. By the end of 1943, more than 15 major oil companies and numerous independents were buying leases in the state. Major newspapers began publishing oil news and discussing conservation issues.

The September 1943 discovery, named the Sunniland field, was made by Humble Oil and Refining Company (HORC) in Collier County, Florida (Figure 1). In 1944, after proven commercial production, HORC was awarded the $50,000 for finding the first oil production in Florida. HORC donated the award to the University of Florida and Florida State College for Women (now Florida State University) and added $10,000 as a gift (Elliot, 1945).

PHASE II: ECONOMIC CONCERNS AND PETROLEUM LEGISLATION

The second phase of Florida's petroleum legislative history began in 1945 with the passage of the conservation law and spanned the mid-1940's to -60's. The public began to show concern for the value of Florida's other natural resources. This concern was prompted primarily by potential economic impact on tourist trade and commercial fisheries.

In 1945, due to the Sunniland discovery and the resulting increase in exploration, Governor Millard F. Caldwell appointed an Oil Advisory Committee to study the petroleum laws and practices of other states. The State Bar Association also appointed an oil and gas

committee to study legislation of other states. The two committees worked together, with advice from the Interstate Oil Compact Commission, to prepare what was to become the first conservation law. The 1945 legislature saw the introduction of this conservation law and several other related oil bills. The bills included:

1. The conservation law.
2. A bill to ratify the Interstate Oil Compact and to make Florida a member of the Interstate Oil Compact Commission.
3. A bill for taxation of oil and gas produced in Florida.
4. A state lease law.

Unexpected opposition arose to all of the oil bills; this time from the cities along the west coast of Florida. They were not opposed to the subject matter of the oil legislation, but wanted provisions to be inserted in all the proposed bills that would ensure protection of the Florida west coast beaches from pollution and "unsightly operations." Their concerns were not environmental but rather economic. They contended that oil operations might "destroy the beauty of the west coast and do irreparable damage to the tourist trade."

Newspapers of these cities "clamored" for beach protection. Amendments were adopted which addressed this issue and were made a part of Florida's conservation bill. After six years of effort, a law providing for the conservation of oil and gas in Florida was finally passed and signed by the Governor on June 5, 1945 (Chapter 22819-No. 305, Laws of Florida, 1945). The bill to ratify the Interstate Oil Compact and make Florida a member of the Interstate Oil Compact Commission (Chapter 22823-No. 270, Laws of Florida, 1945) and the state lease law (Chapter 22824-No. 310, Law of Florida, 1945) were also passed by the 1945 legislature.

The conservation law:

1. Prohibited the waste of oil or gas.
2. Set up the State Board of Conservation and gave them the authority to:
   a. administer and enforce the Conservation Act,
   b. adopt necessary rules and regulations,
   c. establish drilling units, and
   d. regulate production procedures as necessary to prevent waste.
3. Set penalties for violations.
4. Restricted drilling on or near improved beaches or municipalities.

A taxation law was not passed until the next legislative session. The oil and gas taxation act (Chapter 22784-No. 270, Laws of Florida, 1947) became law without the Governor's approval and was filed in the Secretary of State's office June 3, 1947.

Early Rules and Regulations

The first rules regulating oil and gas exploration and production were adopted in 1946 (Section 115-B-2.05, Florida Administrative Code (F.A.C.)). There was no mention in the rules of environmental concerns. As discussed previously, the statutory protection for improved beaches was enacted in response to an economic issue. Primarily, the rules were written to " . . . prevent waste of oil or gas . . . "

Rule revisions in 1949 (Gunter, 1950), 1962 and 1963 (Babcock, 1964) were procedural in nature and did not include environmental concerns. The 1949 and 1962 revisions added provisions for the temporary abandonment of wells and defined an abandoned well. The 1963 revision changed the time for supplying the Oil and Gas Section of the Division of Geology with electrical logs and other surveys made in the drilling of a well from six months to ninety days. It also provided that the State Board of Conservation would keep information confidential for a period not exceeding one year from the date the information is filed, unless exceptional hardship was proven.

Early Offshore Geophysical Permitting

In 1963, the first five offshore geophysical permits were granted by the State Board of Conservation (Babcock, 1964). In 1965, a

statement of policy outlining rules and regulations to be observed in performing offshore geological and/or geophysical work was prepared by the State Board of Conservation (Babcock, 1966). These covered "submerged lands, other than inland waters of Florida and applicable to federal lands seaward of Florida's boundary." The rules were supposedly "pursuant to authorization of the Department of the Interior of the United States dated April 3, 1965, and published in the federal register (Federal Register Document 56-2450, Volume 21, No. 64)."

Approximately 100 offshore geophysical permits were issued. In the early 1970's, it was determined that there was no statutory authority to issue these permits and geophysical permitting was discontinued (David Curry, Florida Geological Survey Oil and Gas Section Administrator, personal communication, 1989).

These rules expressed concern for natural resources other than oil and gas, primarily for commercial fisheries; thus, the concern was again prompted by economics. They included; however, a brief reference which indicates an aesthetic or environmental concern (Babcock, 1966):

> "All operators conducting seismic operations shall use reasonable precaution in accordance with approved and accepted methods to prevent destruction of, or injury to, fish, oyster, shrimp and other aquatic life, wildlife, or other natural resources."

PHASE III: PETROLEUM POLICY DEVELOPMENT IN RESPONSE TO ENVIRONMENTAL CONCERN

South Florida Development History

The minimal legislative activity and apparent lack of environmental concern between the time of the passage of the conservation law and the early 1970's may have been partly due to the slow development and limited success in south Florida following the opening of the Sunniland field. During the years between Sunniland field discovery (1943) and the first rule revision to include extensive environmental concerns (1972), only 92 exploratory wells were drilled in south Florida. The Sunniland discovery was not followed by the usually rapid successes seen when new production areas are opened. Forty Mile Bend field was discovered in 1954, but showed disappointing production from only two wells and was abandoned in 1955 (Gunter, 1955 and 1956). The second really successful oil field was not discovered until 1964, 21 years after the Sunniland discovery. This was the Sunoco Felda field (Babcock, 1966). Discoveries of West Felda field in 1966 (Babcock, 1968), Lake Trafford field in 1969 (Applegate and Lloyd, 1985), and Bear Island in 1972 (Applegate and Lloyd, 1985) followed.

Policy Development in Response to South Florida's Sensitive Environments

The rule revision of 1972 included the first statutory evidence of serious environmental concerns and the first mention of concern for onshore native and sensitive environmental resources. These rules incorporated the concerns that developed through the years with the recognition of the importance of wetland environments, especially as it related to oil exploration and development in south Florida.

South Florida oil production is partially within the Big Cypress Swamp and is adjacent to the Everglades (Figure 1). The wetlands of these areas provide important feeding, nesting, and wintering grounds for migrating and several endangered and threatened species are dependent upon the wetland ecosystem for subsistence (Big Cypress Area Management Task Force, 1984).

The Big Cypress Swamp Advisory Committee was created by the Governor and Cabinet in 1971 in response to pressures exerted on the Big Cypress ecosystem by many external factors, not

solely by oil and gas exploration. This Committee provides a forum for industry, various regulatory agencies, and environmental groups to allow oil exploration and development while ensuring the protection of sensitive environmental and wildlife resources (Big Cypress Area Management Task Force, 1984).

In 1974, Congress set aside about 40 percent of the Big Cypress Swamp (570,000 acres) as the Big Cypress National Preserve (Figure 1). In the legislation creating the Preserve, the National Park Service acquired the surface land rights, but, in most cases, not the mineral rights. This legislation (Public Law 93-440) allows oil and gas exploration as long as it is not detrimental to the purpose of the preserve, which is to: " . . . ensure the preservation, conservation and protection of the natural, scenic, hydrologic, floral, faunal and recreational values of the Big Cypress watershed, and to provide the enhancement and public enjoyment thereof."

The rule revisions of 1981 through 1986 incorporated additional environmental concerns. These rules and the interagency cooperation of the Big Cypress Swamp Advisory Committee allow oil production and exploration to take place while minimizing damage to the environment.

Current Regulation of Geophysical Exploration

An amendment in 1980 gave the Florida Geological Survey the statutory authority to regulate geophysical activity, both onshore and offshore in state waters (Chapter 377, Part 1, Florida Statutes). Rules were adopted in 1984 (Chapter 16C-26.07, F.A.C.) to implement this authority and legitimate permitting began in July 1984. The rules state:

> "It is the intent of the department to permit geophysical operations . . . in Florida provided that this activity is conducted in a manner which minimizes or prevents the destruction of or injury to the environment and the natural resources of the State of Florida."

There were major revisions to the geophysical rules in 1985 and 1986 that resulted from safety violations by some geophysical companies and from additional concerns about wildlife habitat and sensitive environments.

Offshore Activity and Policy Development

JURISDICTIONAL BOUNDARIES

State ownership of the continental shelf off Florida extends three miles into the Atlantic Ocean and about 10.5 miles (three marine leagues) into the Gulf of Mexico. The federal government controls resources beyond these state boundaries out to 200 miles. The Outer Continental Shelf (OCS) is a jurisdictional term that describes the offshore area that is under the control of the federal government. The federal government divides the OCS into planning areas. Three federal OCS planning areas surround Florida: the Eastern Planning Area, the Straits of Florida Planning Area, and the South Atlantic Planning area (Figure 3) (Johnson and Tucker, 1987).

OFFSHORE – STATE WATERS

There has been no leasing of tracts within Florida state waters since the early 1980's. At this time, the only known active leases within Florida state waters are held by Coastal Petroleum Company. Three leases were obtained by Coastal Petroleum in the late 1940's. Two of these leases cover state land in the Gulf of Mexico, from the coastline to about 10 miles offshore, between Apalachicola and Naples, Florida and the submerged land of rivers and lakes that feed this area. A third lease covers Lake Okeechobee.

Between 1947 and 1983, a total of 19 wells were drilled in Florida state waters (Figure 4).

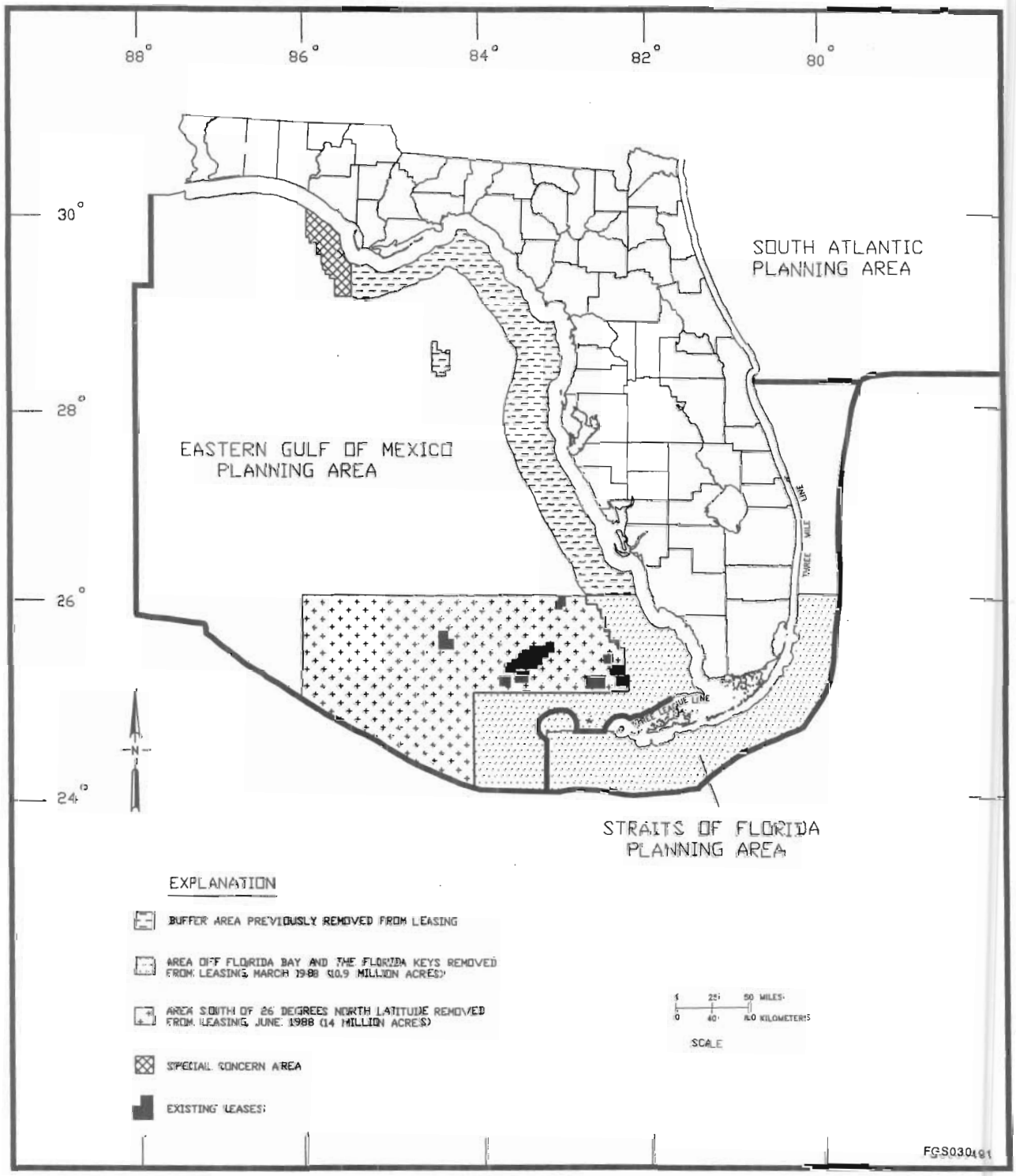

Figure 3. Florida portion of the 1987-1992 federal Outer Continental Shelf oil and gas leasing program (after Johnson and Tucker, 1987). The areas off Florida Bay and the Florida Keys were removed from the 5-year plan. The area south of 26° North latitude was removed from the November 1988 lease sale. President Bush later canceled Sale 116, Part II in this area until after the year 2000.

Detailed information on these wells is tabulated in Part I, Appendix 6, of this publication. One of these wells, drilled in 1959 in the Marquesas Keys area (Florida permit 275, Figure 4), had a significant oil show in the Lake Trafford (?) Formation (Applegate and Lloyd, 1985; also Part I, Appendix 6 of this publication).

Recognition of environmental sensitivity, as well as dependence of many commercial enterprises on the vitality of these areas, has led state government to place all state waters under a no-lease protection policy. This policy was enacted by the legislature in two steps: effective July 1, 1989, drilling was prohibited in Florida state waters south of 26° north latitude off the west coast and south of 27° north latitude off the east coast; effective July 31, 1990, drilling was prohibited in the remainder of Florida's territorial seas, i.e., north of 26° north latitude off Florida's west coast to the western boundary of the state bordering Alabama and north of 27° north latitude off Florida's east coast to the northern boundary of the state bordering Georgia (Section 377.242, Florida Statutes).

OFFSHORE – FEDERAL WATERS

Activity

A total of 53 wells have been drilled in federal waters offshore Florida; 43 wells in the Eastern Planning Area, 3 in the Straits of Florida Planning Area near the Marquesas Keys, and 7 in the South Atlantic Planning Area off northern Florida and southern Georgia (through February, 1989) (Figure 5). This relatively small number of offshore wells has not resulted in any development in Florida's offshore to date. However, two Destin Dome area wells (Amoco-8338 and Chevron-6406, Figure 5) off Florida are Norphlet discoveries and are described as producible fields by Gould (1989).

The Amoco-8338 well, completed in Destin Dome block 111 in 1987, was the first commercial discovery in the Eastern Gulf of Mexico Planning Area (Gould, 1989). The Oil and Gas Journal (1989) discusses the Chevron-6406 well and quotes Chevron USA Inc. as stating that "the well was not tested due to safety and cost considerations. However, analysis of cores and wireline logs indicates the presence of gas in the Norphlet sandstone." These two discoveries extend the offshore Norphlet gas trend seaward and eastward from the Mobile map area of the Central Gulf of Mexico Planning Area, offshore Alabama, into the Eastern Gulf of Mexico Planning Area, offshore Florida.

In addition to the potential indicated by these Destin Dome discoveries, an offshore south Florida well (Florida permit 284, Figure 5), drilled in the Marquesas Keys area in 1960, had potential for low volume oil production from the Lake Trafford and Sunniland Formations (Applegate and Lloyd, 1985).

Policy

Former Florida Governor Bob Martinez negotiated with the federal government concerning the current five-year (1987-1992) federal OCS Oil and Gas Leasing program (Figure 3). His negotiations reflected his belief that "oil and gas activities must not be allowed at the expense of our unique and sensitive resources" (Governor Martinez, March 3, 1987 letter to Secretary of the Interior, Donald Hodel).

When the five-year oil and gas leasing plan was first proposed by the Secretary of the Interior, Donald Hodel, Governor Martinez expressed his concerns to both Secretary Hodel and to President Reagan. He requested that sensitive areas off Apalachicola Bay in northwest Florida, Florida Bay and the Florida Keys be removed from the plan. In August 1987, the Governor filed a petition for judicial review in federal court of the Department of the Interior's five-year leasing plan because these areas were not removed (Press Release, Office of the Governor, August 14, 1987).

In January 1988, Secretary Hodel accompanied Governor Martinez on a snorkeling

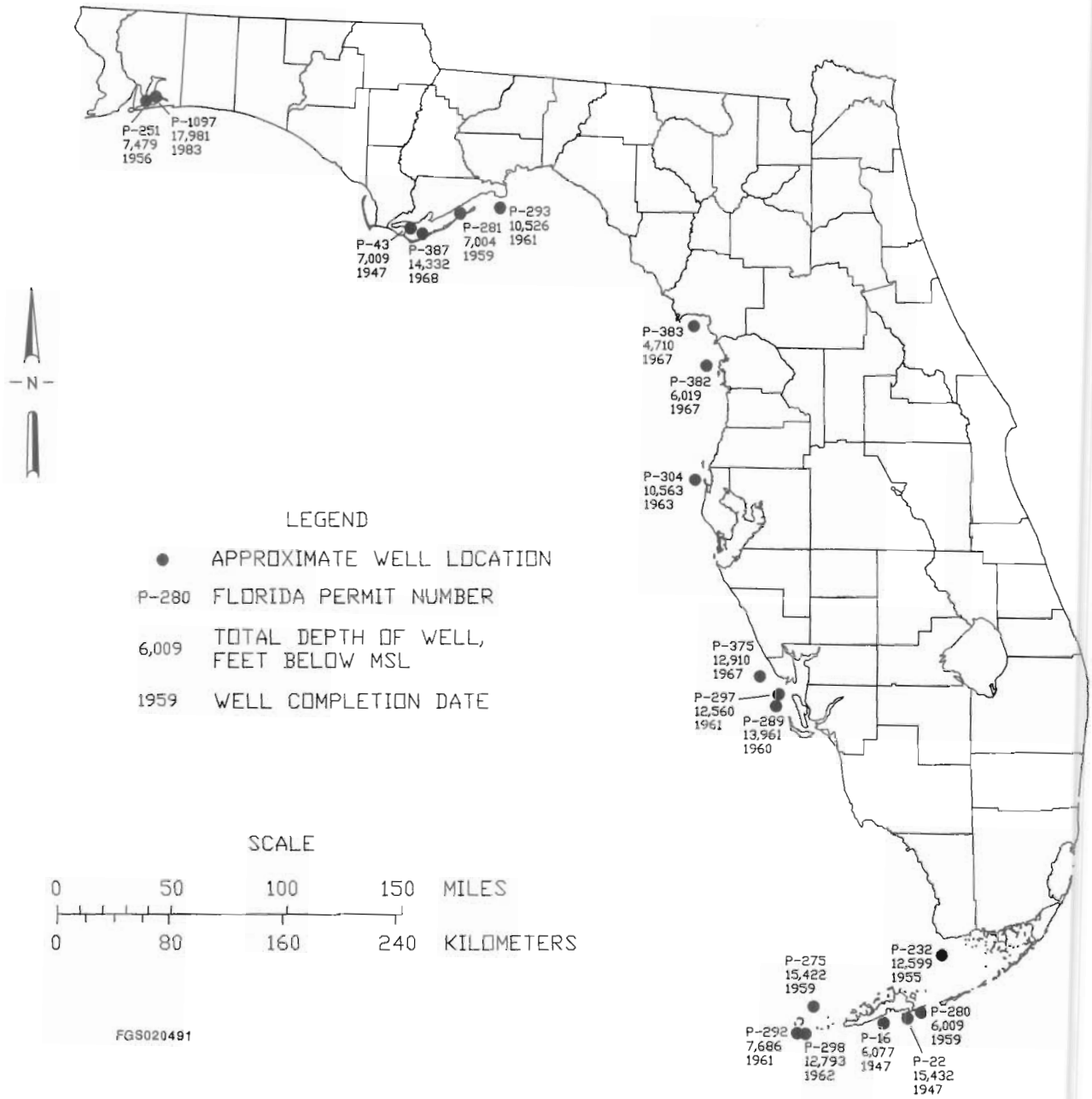

Figure 4. Oil exploration wells, Florida state waters.

trip to the Florida Keys. The Governor was able to show Secretary Hodel "exactly what it is that we in Florida are fighting to protect." The following March, the Secretary of the Interior agreed to remove 11 million acres of sensitive habitat around Florida Bay and the Keys from further consideration for leasing under the five-year plan (Figure 3). The Secretary further agreed to require a one-year study before any drilling could take place in an area of "special concern" off northwest Florida (Figure 3). The study would verify that the exploration would be for gas and not oil. The Department of the Interior would also establish an emergency response team to deal with possible accidents. As a result of this agreement, the petition for judicial review of the five-year plan was dropped (Press Release, Office of the Governor, March 24, 1988).

In May, 1988, the Governor requested that the federal government delay exploratory drilling for oil and gas off southwest Florida. The request specifically referred to leases which were sold off southwest Florida during 1984 and 1985. The leases are in an area south of Naples to just north of the Dry Tortugas, Marquesas Islands, and the Florida Keys (south of 26° north latitude, Figure 3). Congress had required a three-year environmental study before exploratory drilling would be permitted in this area. A panel of scientists was assembled by Governor Martinez to review the federal environmental study. The panel concluded that the federal study was not extensive enough to ensure protection of sensitive environmental resources. Specifically, there was not enough information to determine the potential effects of an oil spill. Subsequently, the Governor supported and Congress imposed a one-year drilling moratorium on the area south of 26° north latitude (Press Releases, Office of the Governor, May 26, 1988, and June 16, 1988).

In June 1988, Hodel agreed to remove 14 million acres in the same area (south of 26° north latitude) from the November 1988 lease sale (Figure 3). Martinez and Hodel appointed two task forces to assess the environmental impact of proposed drilling in previously leased areas. One task force assessed the risk posed by oil spills and the directions spilled oil would be carried by winds and currents. The second task force assessed the impact of drilling on marine and coastal resources (Press Release, Office of the Governor, June 16, 1988). President George Bush established an additional federal task force to review drilling and leasing in this area. As a result of this task force, President Bush canceled, until after the year 2000, Gulf of Mexico Sale 116, Part II, which covered this area. He also ordered the Minerals Management Service to begin procedures to cancel the leases that oil companies hold in this sale area and begin discussions with Florida on a joint federal-state repurchase of the leases costing $100-$200 million (Oil and Gas Journal, 1990).

The House Appropriations Committee voted in June 1990 to delay lease sale 137 (scheduled for November 1991), which includes the area from Naples to Pensacola. Also in June 1990, President Bush proposed a 12-year moratorium on drilling off the southwest coast near the Florida Keys, but this was not supported by the same House panel that delayed lease sale 137. The panel said they did not want to lock up the area for that long a time.

Florida's current Governor Lawton Chiles has begun discussion with President George Bush concerning the draft proposed 5-year OCS oil and gas leasing program for mid-1992 through mid-1997. The 5-year program includes oil and gas lease sales off Florida's panhandle in 1994 and 1997. In a letter to the president dated February 18, 1991, the governor stated that:

> "The west Florida coast contains many sensitive marine and coastal resources which are vital to our State's well-being. The economy of Florida is directly tied to these resources through such industries as tourism and recreational and commercial fishing. We cannot afford to place these marine and coastal resources at unnecessary risk, simply because this

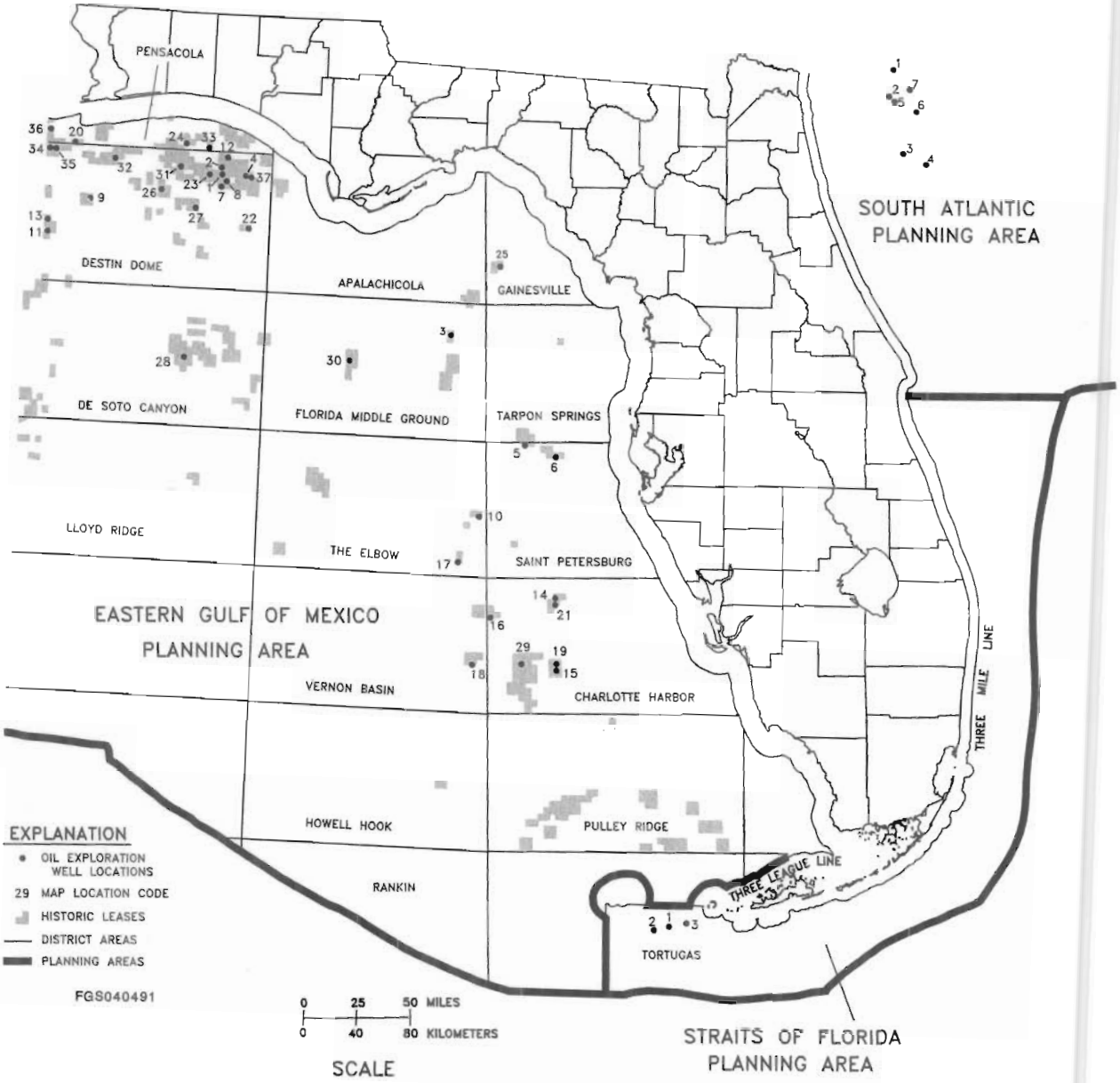

Figure 5. Oil exploration wells, federal waters, offshore Florida. Well locations are plotted at the center of their three-square mile lease block. If two or more wells have been drilled in the same lease block, they are represented by the same location point and code on the map and in the map location code and well data table.

MAP LOCATION CODES AND WELL DATA

PLANNING AREA	MAP LOCATION CODE	MAP AREA	BLOCK NUMBER	LEASE NO. OR FLORIDA PERMIT NO. (P-)	OPERATOR	WELL NO. (1)	PLUGGED & ABANDONED DATE	TOTAL DEPTH (FT.)
EASTERN GULF OF MEXICO PLANNING AREA (2)	1	Destin Dome	162	2486	Exxon	1	1974	10,930
	2	Destin Dome	118	2492	Exxon	1	1974	7,075
	3	Florida Middle Ground	252	2516	Texaco	1	1975	15,663
	4	Destin Dome	166	2490	Fina	1	1975	17,608
	5	St. Petersburg	7	2527	Shell	1	1975	18,443
	1	Destin Dome	162	2486	Exxon	2	1975	10,418
	2	Destin Dome	118	2492	Exxon	2	1975	7,507
	6	St. Petersburg	100	2523	Texaco	1	1975	17,388
	7	Destin Dome	250	2472	Exxon	1	1975	6,634
	8	Destin Dome	207	2480	Exxon	1	1975	4,800
	1	Destin Dome	162	2486	Exxon	3	1975	17,938
	9	Destin Dome	360	2468	Gulf	1	1975	20,988
	10	The Elbow	566	3344	Mobil	1	1977	15,865
	11	Destin Dome	617	2463	Chevron	1	1977	10,513
	12	Destin Dome	31	2502	Amoco	1	1977	18,338
	13	Destin Dome	529	3888	Shell	1	1980	20,450
	14	Charlotte Harbor	144	3906	Gulf	1	1981	11,362
	15	Charlotte Harbor	672	3917	Tenneco	1	1981	11,302
	16	Charlotte Harbor	265	3912	Shell	1	1981	12,362
	17	The Elbow	915	3341	Mobil	1	1981	18,128
	18	Vernon Basin	654	3903	Mobil	1	1981	10,768
	19	Charlotte Harbor	628	3915	Mobil	1	1981	1,270
	20	Pensacola	973	3886	Mobil	1	1981	23,264
	21	Charlotte Harbor	188	3909	Odeco	1	1981	11,360
	22	Destin Dome	563	3890	Sohio	1	1982	21,068
	23	Destin Dome	160	6417	Shell	1 TA	1985	7,764
	24	Pensacola	948	6391	Sohio	1	1985	18,958
	23	Destin Dome	160	6417	Shell	2	1985	16,953
	25	Gainseville	707	6456	Sohio	1	1985	15,941
	26	Destin Dome	284	6428	Exxon	1	1985	17,500
	27	Destin Dome	422	6438	Chevron	1	1985	22,222
	28	DeSoto Canyon	512	6472	Shell	1	1986	12,300
	29	Charlotte Harbor	622	4950	Shell	1	1986	10,550
	30	Florida Middle Ground	455	8363	Tenneco	1	1986	12,401
	24	Pensacola	948	6391	Tenneco	2 ST	1987	19,200
	31	Destin Dome	111	8338	Amoco	1	1987	19,240
	32	Destin Dome	56	6406	Chevron	1 TA	1988	22,572
	24	Pensacola	948	6391	Tenneco	2 TA	1988	19,200
	33	Pensacola	996	6396	Texaco	1	1988	17,910
	34	Destin Dome	1	6397	Gulfstar	1 TA	1989	2,000
	35	Destin Dome	2	6398	Gulfstar	2 TA	1989	1,800
	36	Pensacola	881	6390	Gulfstar	1 TA	1989	2,700
	37	Destin Dome	167	6420	Chevron	1	Drilling	17,259
SOUTH ATLANTIC PLANNING AREA (3)	1	NH 17-5	208	3686	Tenneco	1	1979	7,754
	2	NH 17-5	427	3695	Tenneco	1	1979	7,472
	3	NH 17-2	913	3664	Getty	1	1979	7,000
	4	NH 17-2	1005	3671	Transco	1	1979	11,635
	5	NH 17-5	472	3699	Exxon	1	1979	7,578
	6	NH 17-5	564	3705	Exxon	1	1980	12,863
	7	NH 17-5	387		Ocean Production	GE-1	1977	13,254
STRAITS OF FLORIDA PLANNING AREA (3)	1	NG 17-10	44	P-296	Gulf	1	1961	4,686
	2	NG 17-10	46	P-290	Gulf	1	1961	7,871
	3	NG 17-10	28	P-284	Gulf	1	1960	15,294

1. TA = Temporarily Abandoned; ST = Sidetrack Well.
2. Data from Gould, 1989.
3. Data from Karpas and Gould, 1990.

Nation continues its strong dependence on fossil fuels and fails to implement a comprehensive energy policy. Therefore, it is in the national, as well as the State's best interest to ban all oil and gas activities within 100 miles of Florida's coast."

The governor feels that a comprehensive, national energy policy is essential. Only within such a policy can the risks associated with coastal oil and gas development be wisely assessed. He concluded his letter to the president with:

"This Nation, with your leadership, should develop a strong national energy program which includes the development of alternative energy sources, fuel efficiency, conservation and the rapid decrease in the dependency on fossil fuels. Without such a program, interest in oil and gas drilling offshore Florida and the associated risks to the resources of our State will remain; and I will continue to oppose short-sighted approaches to such monumental and long-term problems."

SUMMARY

Florida petroleum regulations have evolved from simple to the complex, from encouragement for exploration to concern for economic and then aesthetic value of Florida's other natural resources. There were no laws regulating oil and gas activities before 1945. Early legislation responded to the need for petroleum resource conservation and to the need to protect the economic value of other resources. Later legislation responded to environmental concerns, especially due to development within the wetland environments of south Florida.

Petroleum exploration eventually extended into areas offshore from the panhandle and southwest Florida. Other natural and economic resources in these areas include commercial and recreational fisheries, coastal and barrier island environments, Florida Bay, the Florida Keys, and the only living coral reef in the conterminous United States. This juxtaposition of potential petroleum resources and existing natural resources has yielded strong state environmental policies. Florida's concerns influenced the federal 1987-1992 OCS oil and gas leasing program. Florida's Governor Chiles has begun discussion with the President which may influence the next 5-year OCS oil and gas leasing program as well.

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PART III

PETROLOGY AND PROVENANCE OF THE NORPHLET FORMATION PANHANDLE, FLORIDA

By
Greg W. Scott

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ABSTRACT

The Norphlet Formation of the Florida Panhandle is primarily a sandstone that underlies the Smackover Formation and overlies the Louann and Werner Formations. Three lithofacies of Norphlet strata have been identified in the Florida Panhandle: an updip conglomerate, red beds, and an upper quartzose sandstone (Denkman Member).

The Denkman Member consists of an upper gray and a lower brown to reddish-brown quartzose sandstone. Generally, these sandstones are fine- to medium-grained and well sorted with rounded to subrounded grains. The upper Denkman is massively bedded to faintly horizontally or wavy laminated; the lower Denkman is either horizontally laminated or has low to high-angle cross- stratification. The average composition of the member is 62 percent quartz, 26 percent feldspar, and 12 percent rock fragments.

The red bed lithofacies has fine- to coarse-grained, moderately sorted sandstones with subrounded to rounded grains. The most distinctive feature of the lithofacies is its closely spaced horizontal to slightly inclined (1° - 5°) laminae. The average composition of the facies is 35 percent quartz, 16 percent feldspar, and 49 percent rock fragments.

The conglomeratic lithofacies is a multilayered section of gray conglomerates and red, coarse-grained sandstones. The conglomerate consists of poorly sorted, subangular to subrounded, cobble- to pebble-size plutonic and metamorphic rock fragments.

Principal source areas for Norphlet sediments in the Florida Panhandle were the basement rock of the Conecuh Ridge (Talledega Slate Belt) to the north and the Pensacola Arch (Piedmont Belt) to the south and east. Additionally, contributions from the Eagle Mills, Werner, and Louann Formations probably were significant.

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PETROLOGY AND PROVENANCE OF THE NORPHLET FORMATION, PANHANDLE, FLORIDA

By
Greg W. Scott

INTRODUCTION

Several authors have published data on the petrologic character of the Upper Jurassic Norphlet Formation in Mississippi and Alabama (Hartman, 1968; Badon, 1975; McBride, 1981; Mancini et al, 1984). This study is primarily confined to areas of Norphlet deposition previously undocumented, namely Escambia, Santa Rosa, and Okaloosa Counties, Florida (Figure 1, Table 1). Throughout panhandle Florida, the Norphlet Formation is encountered at depths usually greater than 13,000 feet below mean sea level. The formation underlies most of the study area except eastern-most Okaloosa County, where it wedges out. The Norphlet unconformably overlies the Louann, Werner, or Eagle Mills Formations (Oxley et al, 1967; Mancini et al, 1984). Lying above the Norphlet Formation sandstones and making an abrupt lithologic break are carbonates of the Smackover Formation (Sigsby, 1976) (Figure 2).

Most of panhandle Florida is located within the Conecuh Embayment which, in turn, is situated within the Alabama Interior Salt Basin. The Conecuh Embayment, as defined by Sigsby (1976), lies between the pre-Jurassic Conecuh Ridge to the north and the Pensacola Arch to the southeast, both of which probably served as source areas for Norphlet sediments (Figure 3).

NORPHLET FORMATION OF PANHANDLE FLORIDA

The Norphlet Formation varies considerably in lithologic character across panhandle Florida. In central Escambia and Santa Rosa Counties, the upper Norphlet Denkman Member (informally subdivided into upper and lower units) is characterized by relatively clean, light-colored sandstones (Tyrrell, 1973). Core material available for this study is concentrated within this quartzose lithofacies because the member lies just below the more productive Smackover Formation and therefore is more frequently cored than other lithofacies.

The Pensacola Arch trends southwest through Okaloosa County and across southern Santa Rosa and Escambia Counties (Figure 3). Placement of the arch this far west is based upon the overall subsurface trend of structural features and stratigraphic sequences and geophysical well logs interpreted for this project. It is against this arch that the relatively clean sandstones of the Denkman Member thin and grade into medium- to coarse-grained and gravelly sandstones.

In southern Santa Rosa County, the formation is represented by a 14.6-foot section of conglomerates and coarse grained sandstones (Getty Oil Company, Florida permit 1097), interpreted to lie on top of or adjacent to the Pensacola Arch. The conglomeratic sands contain granule- to cobble-sized igneous and metamorphic clasts. Mancini et al, (1985) identified chert, granite, rhyolite, quartzite, and shale pebbles within this conglomerate lithofacies in southern Alabama.

In western Okaloosa County (Champlin Petroleum Company well, Florida permit 518), the Norphlet Formation is characterized by coarse, red, lithic sandstones (red beds), which probably represent a transition from the conglomerate deposits over the Pensacola Arch. The formation thins dramatically east of this well and wedges out completely within approximately 16 miles. In southern Santa Rosa County, the Norphlet Formation represented within the Belco Petroleum Corporation well core (Florida permit 692) exhibits a red bed lithofacies at its base.

A discontinuous basal shale sequence has been identified within Norphlet cored sections in

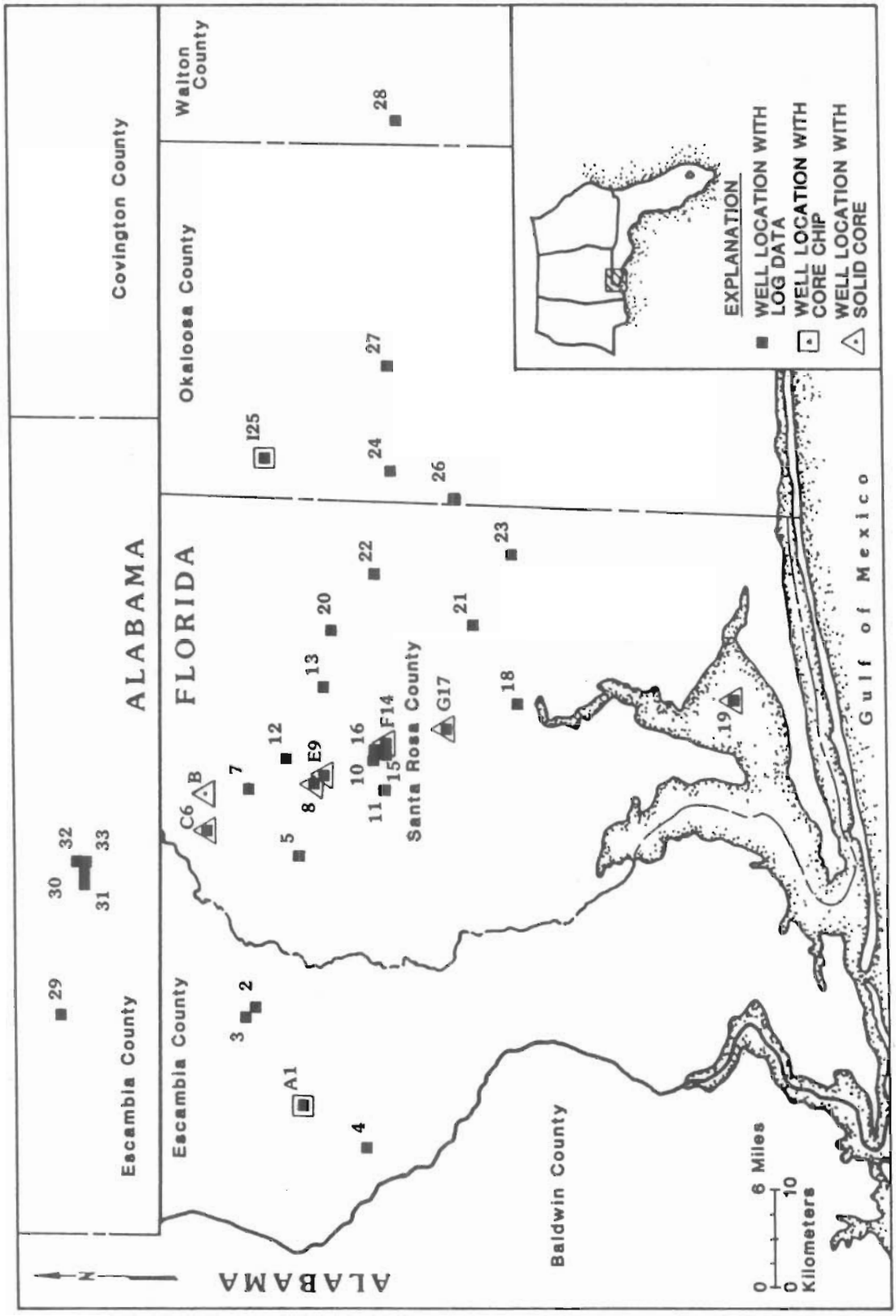

Figure 1. Area of study and location of core, chip, and log data.

Table 1. Well Names, Locations, and Permit Numbers for all Wells Used in this Study[1]

Well/Name/Location	Florida State Permit	Data	Core Interval[2] ft blkb
Escambia County, Florida			
A. 1. Shell Oil Company No. 1 Schneider Section 18, T4N, R32W	647	Core Chip, Log	17132 - 17331
2. Stone Petroleum Corporation No. 1 St. Regis Paper Co. 29-4	1125	Log	None
3. Stone Petroleum Corporation St. Regis Paper Co. 29-3 Section 29, T3N, R33W	1136	Log	None
4. Chevron USA, Inc. No. 1 Lafloresta 2-1 Section 2, T3N, R33W	1027	Log	None
Santa Rosa County, Florida			
B. Smackco Ltd. No. 13-4 L.W. Roberts] Section 13, T5N, R29W	1096	Solid Core, Log	15220 - 15257
5. Miami Oil Products, Inc., Pennzoil United Inc., and Signal Oil & Gas Company No. 1 Ethel Shivers, et al Section 7, T4N, R29N	497	Log	None
C. 6. Exxon Corporation Martha Murphy, 10-6 Section 10, T5N, R29W	1004	Solid Core, Log	15766 - 15787
7. Southeastern Exploration, Ltd., Rudman Resources and Co., No. 1 St. Regis Paper Company Section 28, T5N, R29W	476	Log	None
D. 8. Exxon Corporation St. Regis Paper Company 13-S Section 13, T4N, R29W	1080	Solid Core, Log	16100 - 16153.5

Table 1. (Continued)

Well/Name/Location		Florida State Permit	Data	Core Interval[2] ft blkb
E. 9.	Exxon Corporation St. Regis Paper Company 24-5 Section 24, T4N, R29W	1110	Solid Core, Log	16098 - 16125
10.	Conoco, Inc. No. 1 Charlie Windhorst 12-3 Section 12, T3N, R29W	1123	Log	None
11.	C & K Petroleum and Florida Gas Exploration Co. No. 1 I.L. Ward 6-2 Section 6, T3N, R28W	657	Log	None
12.	Franks Petroleum, Inc. No. 1 Donald Boutwell Section 7, T4N, R28W	1045	Log	None
13.	Samedan Oil Corporation No. 1 W.S. Rosasco Section 24, T4N, R28W	929	Log	None
F. 14.	Jenkins Oil & Gas, Inc. No. 1 Haynes 8-1 Section 8, T3N, R28W	1128	Solid Core, Log	16596 - 16619
15.	Jenkins Oil & Gas, Inc. No. 1 Jenkins-Lee 8-2 Section 8, T3N, R28W	1148	Log	None
16.	Spooner Petroleum Co. No. 1 Champion International 5-4 Section 5, T3N, R28W	1178	Log	None
G. 17	Mesa Petroleum Company Rolin D. Davis T.R. Miller Mill 33-1 Section 33, T3N, R28W	551	Solid Core, Log	16806 - 16879
18.	Belco Petroleum Corporation No. 1 W.S. Mitchum Unit 23-4 Section 23, T2N, R28W	692	Log	None
H. 19	Getty Oil Company Florida State Lease 2338 East Bay Location	1097	Solid Core, Log	17657 - 17749

Table 1. (Continued)

Well/Name/Location	Florida State Permit	Data	Core Interval[2] ft blkb
20. Tenneco Oil Company 16-4 USA-FL State Lease 3128-F Section 16, T4N, R27W	1114	Log	None
21. Conoco, Inc. No. 1 Estes Timber Company Unit 11-2 Section 11, T2N R27W	610	Log	None
22. Pennzoil Production Company No. 1 USA State Forest, No 5-2 Section 5, T3N, R26W	911	Log	None
23. Phillips Petroleum Company No. 1 St. Regis Paper Company "B" Section 21, T2N, R26W	534	Log	None
Okaloosa County, Florida			
24. Cabot Corporation No. 1-9 USA Section 9, T3N, R25W	731	Log	None
I. 25 Champlin Petroleum Company No. 1 USA & State of Florida Section 28, T5N, R25W	518	Core Chip, Log	14549
26. Tenneco Oil Company USA-FL State Lease 3229 Unit 31-3 Section 31, T3N, R25W	1105	Log	None
27. Sonat Exploration Company No. 1 James G. Moore Unit 3-11 Section 3, T3N, R24W	590	Log	None
28. Coastal Production Company No. 1 Brady Belcher Section 9, T3N, R21W	519	Log	None

Table 1. (Continued)

Well/Name/Location		Florida State Permit	Data	Core Interval[2] ft blkb
		Alabama State Permit		
Escambia County, Alabama				
29.	Hughes Eastern Petroleum, Ltd. No. 1 A.T.I.C. 33-2 Section 33, T2N, R7E	4299	Log	None
30.	Inexco Oil Company No. 1 Cogel 1-8 Section 1, T1N, R8E	3895	Log	None
31.	Inexco Oil Company No. 1 Tocumen et al Unit 1-3 Section 1, T1N, R8E	4060	Log	None
32.	Pruet & Hughes Company St. Regis Paper Co. Unit 6-3 No. 1 Section 6, T1N, R9E	1902	Log	None
33.	Inexco Oil Company No. 1 Steward Estates 6-5 Section 6, T1N, R9E	4347	Log	None

Notes:
(1) - Refer to Figure 1.
(2) - To convert feet to meters: ft x 0.3048 = meters
A-I - Refers to wells whether either solid core or core chips were analyzed.
1-33 - Refers to wells of which geophysical well logs were analyzed.
None - No core or chip material was analyzed.
ft blkb - Feet below kelly bushing.
Log - Geophysical well log.
Solid Core - Solid core material.
Core Chip - Solid core chip material.

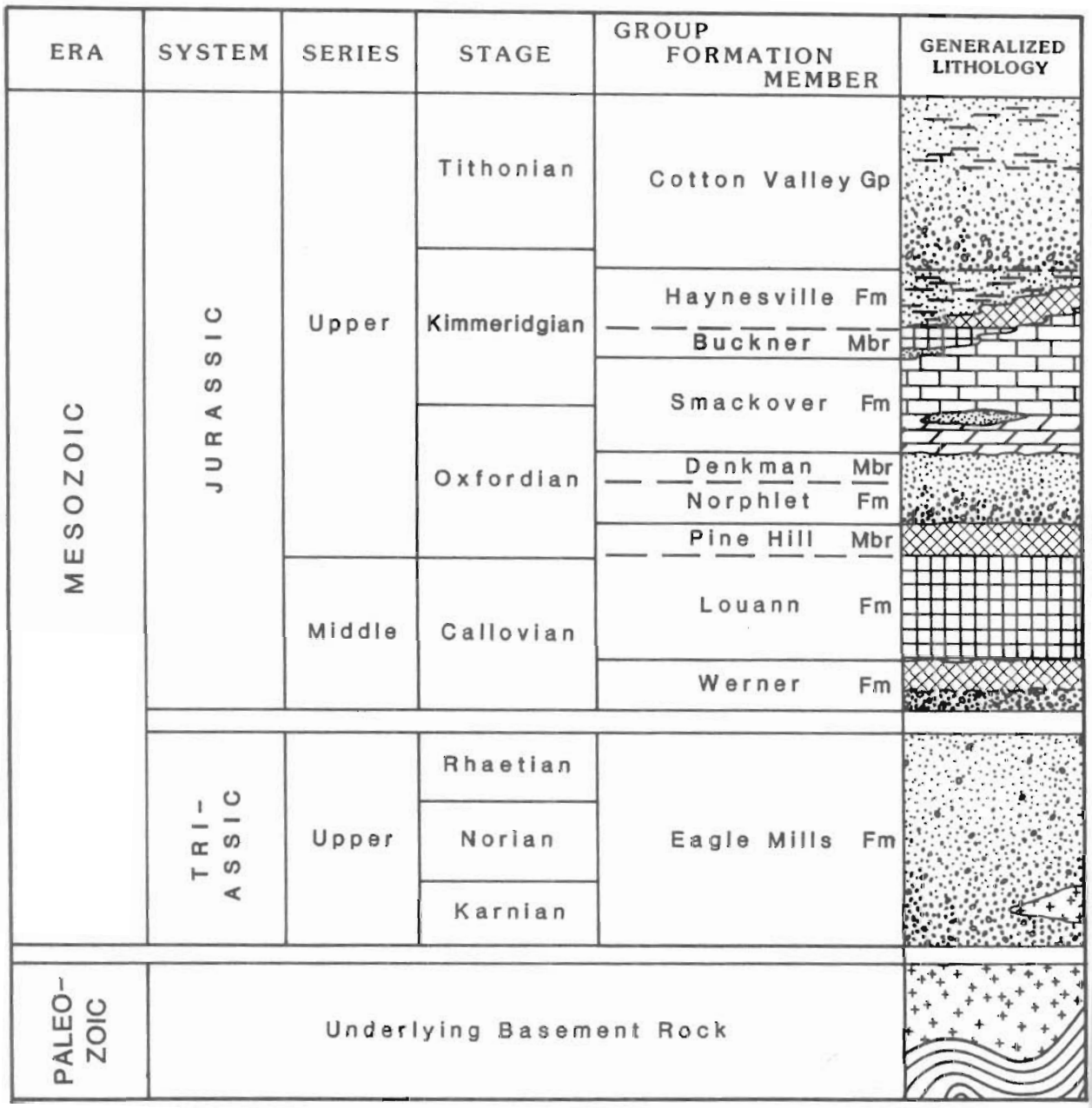

Figure 2. Stratigraphic column, of Mesozoic and older units of the North Central Gulf Coast.

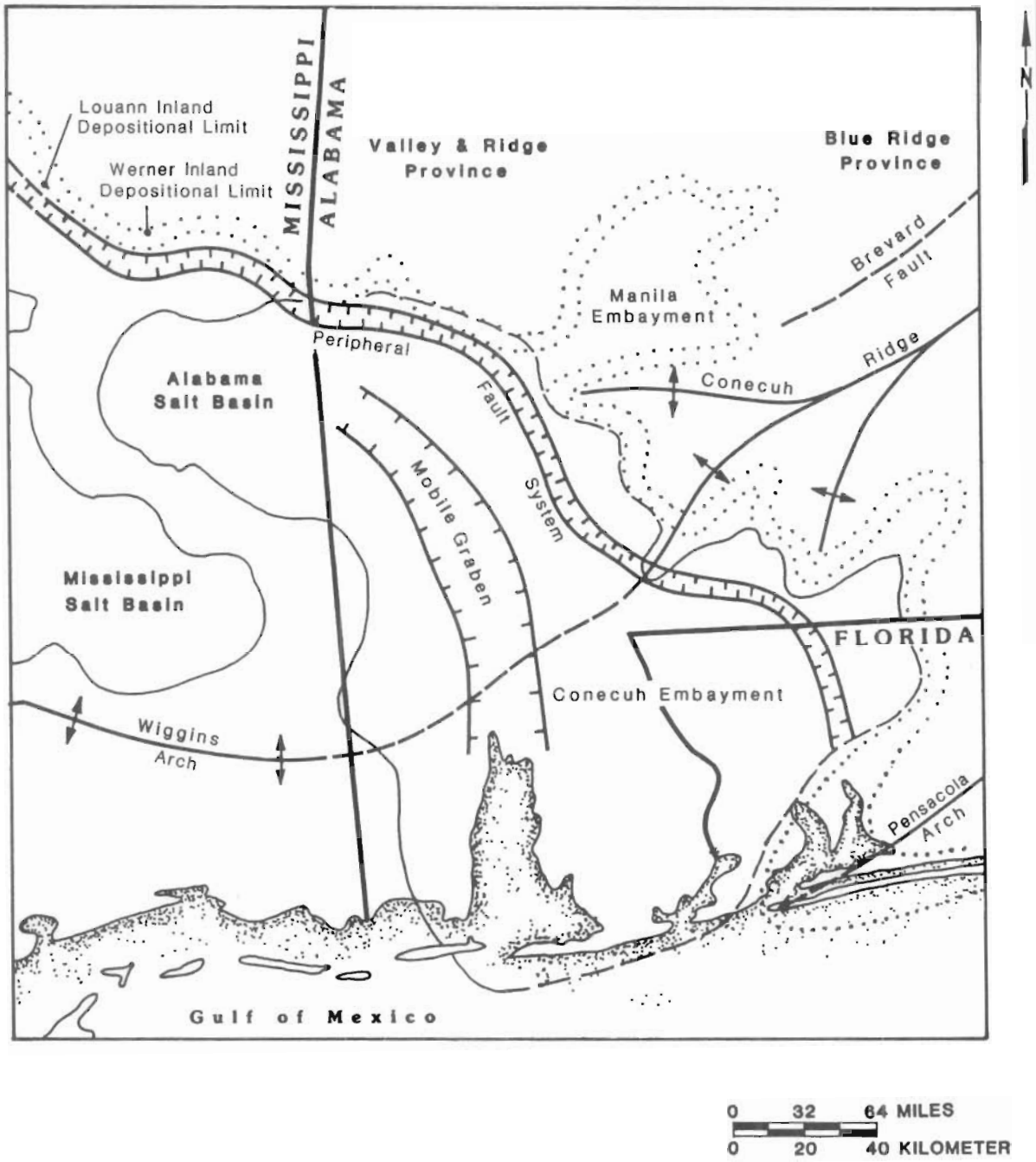

Figure 3. Tectonic map of South Central Gulf Coast.

southern Escambia County, Alabama (Hughes Eastern, Alabama permit 4299). Portions of the shale sequence most likely occur in parts of Florida as well. However, due to the limited scope of this project, a thorough study of the shale lithofacies was not undertaken.

The most complete section of Norphlet examined for this study is found in the core from the Mesa Petroleum well (Florida permit 551) where 73 feet of continuous Norphlet strata were examined. The core contains the entire Denkman Member and a portion of the underlying red bed sequence. With the exception of a slight increase in volcanic rock fragments with depth, the core does not show much vertical variation in composition. The core consists of interbedded fine- to medium-grained sandstones in which the bedding dips range from horizontal to 5°, with 1° to 4° dips common.

At the top of the Mesa core (-16806.5 feet below kelly bushing (ft blkb)) is an interval of 7.8 feet of light-gray, massively bedded, and well-cemented sandstone (upper Denkman). Below the upper Denkman, the unit changes to a light-brown sandstone (lower Denkman) with widely spaced, wavy to slightly inclined (1° to 5°) laminae. At approximately -16837 ft blkb, the Denkman grades into red beds.

An isopach map across panhandle Florida shows the variable thicknesses of the formation (Figure 4). The average thickness of the unit in panhandle Florida is 122.9 feet. However, this figure may be misleading since most completely penetrated Norphlet sections are believed to lie on structural highs (J. Files, Inexco Oil Company, 1986, personal communication). The Champlin Petroleum well (Florida permit 518) exhibits a thick section of Norphlet of 410 feet, as determined by geophysical log data, whereas the Getty Petroleum Company well (Florida permit 1097) exhibits an abnormally thin section of only 14.6 feet.

Denkman Member

In all cores examined, the Smackover-Norphlet contact is relatively sharp, with dense dolomite overlying quartzose sandstone of the upper Denkman member. The upper and lower Denkman cannot be distinguished from one another by geophysical log characteristics, due to gross lithologic and sedimentary similarities (Wilkerson, 1981). However, the two units can readily be distinguished in hand specimens where color and sedimentary characteristics differ. Generally, the Denkman Member is light- to medium-gray in color at the top and becomes brown at depth.

Overall, the upper Denkman is slightly coarser-grained than the lower Denkman. However, the average grain size (0.21 mm) of the Denkman Member is finer than the red bed lithofacies. Framework packing densities average 79.0 percent. This value indicates a relatively high framework packing density for panhandle Florida. Honda (1981) reported an average packing density of 81.3 percent from the Hatters Pond Area, Alabama, an abnormally high value. Extensive pressure solution and grain rearrangement characterize this high packing density in Alabama (Honda, 1981), but are not found extensively in Florida sediments.

The Denkman Member of panhandle Florida is a lithic arkose (Folk, 1980). The average composition of framework grains is 61.5 percent quartz, 26.3 percent feldspar, and 12.2 percent rock fragments. This average composition differs slightly from that cited in other studies of the region, presumably because all samples used in this study are closer to their source areas and thus richer in feldspars and lithic grains.

FRAMEWORK GRAINS

Quartz is the most abundant detrital mineral in the Denkman Member. Quartz content throughout the Denkman Member ranges from 50.5 percent to 75.2 percent, averaging 61.7 percent of framework grains. The most common quartz type present, making up 47.5 percent of the total quartz population, is monocrystalline quartz with little to no undulatory extinction (Figure 5). Some of these grains have mineral

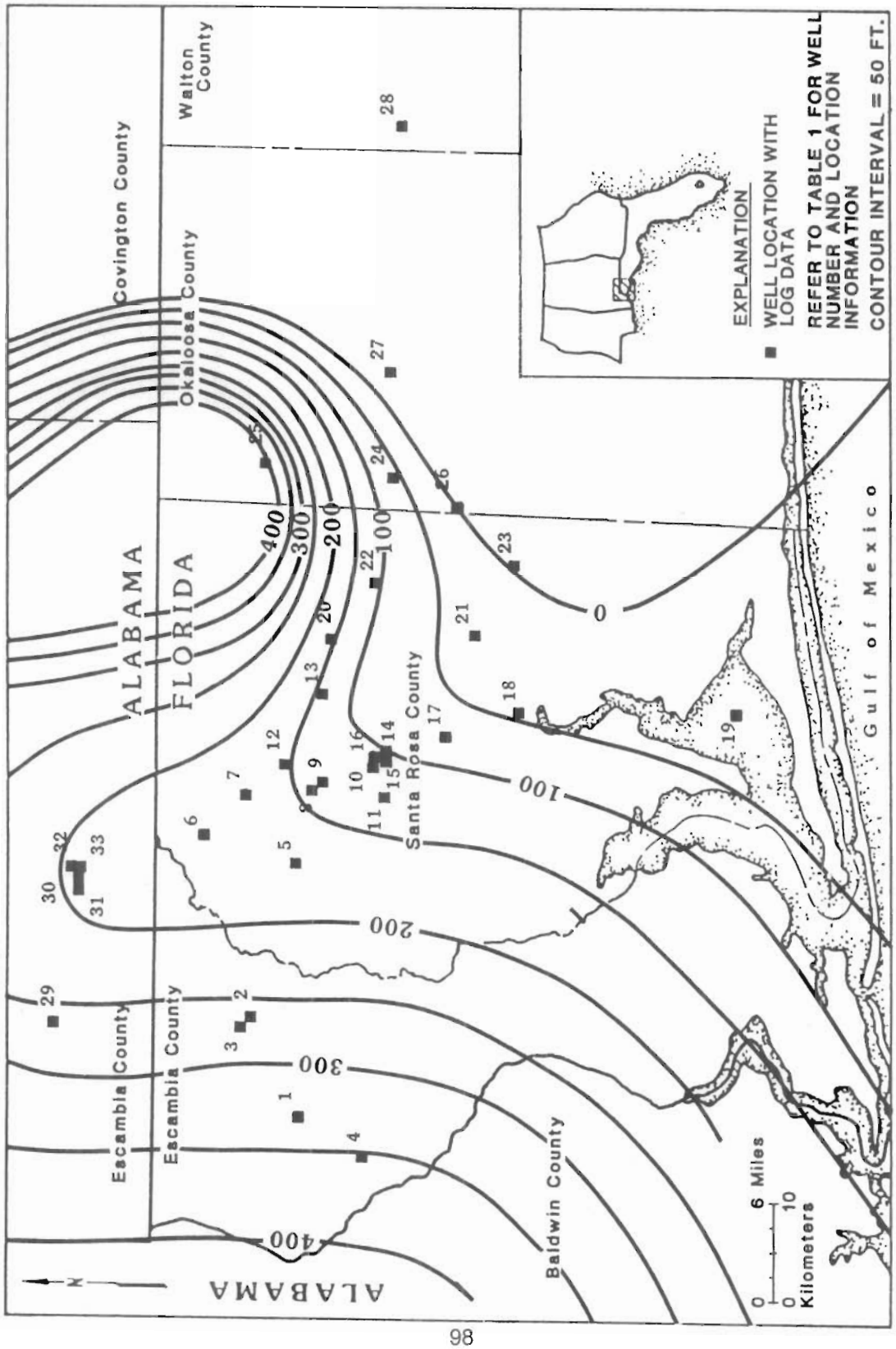

Figure 4. Isopach map, Norphlet Formation, panhandle Florida.

inclusions and small vacuole trains which suggest a plutonic origin, whereas others exhibit abundant vacuoles and have vermicular inclusions of chlorite suggesting a hydrothermal origin (Folk, 1980).

The second most abundant quartz type present is monocrystalline, undulose quartz, making up 42.8 percent of the total, followed by semi-composite, 5.6 percent, and fully-composite grains, 3.6 percent. Semi-composite grains are composed of two or more subcrystals having very close optical orientation with a distinct break between subcrystals; however, the extinction shadow is not observed to sweep smoothly across the grain during petrographic analysis. Fully-composite grains have two or more subcrystals with strongly undulose extinction and distinct crenulate boundaries (Young, 1976; Folk, 1980). Semi-composite grains are more numerous than fully-composite grains in all core material examined, except the Shell Oil Company core (Florida permit 647) where a slight reversal in frequency occurs. Small, needle-like inclusions of rutile are seen in all types of quartz.

Most of the quartz grains examined in this study are subrounded to rounded. Additionally, many grains have overgrowths, some being abraded indicating recycling.

The second most abundant detrital mineral of the Denkman Member is feldspar, which ranges from 15.9 percent to 46.5 percent and averages 26.3 percent throughout the study area. Potassium feldspars (orthoclase and minor amounts of microcline) are the most abundant, ranging from 55.0 percent to 100 percent and averaging 87 percent of the feldspar fraction (Figure 6). Plagioclase feldspar ranges from 0 percent to 32.0 percent, averaging 13.0 percent of the total feldspar population. In order of decreasing abundance, the feldspars are orthoclase, plagioclase, and microcline, with untwinned orthoclase making up the largest fraction. Most grains appear similar to quartz in size and rounding. Many feldspars are sericitized, possess mineral inclusions, and have quartz intergrowths in graphic patterns. Overgrowths are common on both potassium and plagioclase feldspars.

Feldspar grains have been subjected to a variety of weathering processes, with many showing signs of multiple processes. Most appear to be related to dissolution and replacement of grains (Figure 7). The most common form of weathering is vacuolization, of which the magnitude ranges from slight to extreme. About 45.0 percent of all feldspars show some sign of vacuolization. The author makes a distinction between degrees of weathering. In the case of "slight" vacuolization, weathered grains appear cloudy due to pin-point dissolution. Severely weathered grains on the other hand, are seen as partially or totally dissolved grains and make up about 8.0 percent of the total feldspar population. A few grains, generally less than 2.0 percent of the total feldspar population, appear unaltered.

Other forms of feldspar alteration were observed, but all were secondary to vacuolization in frequency of occurrence. Limonitization was the next most abundant form observed in all samples followed by phyllosilicate replacement. The dominant form of phyllosilicate replacement is chloritization, but kaolinitization and illitization also occur. In the Smackco Ltd. well (Florida permit 1096), considerable chloritization of feldspars is present of which the magnitude appears to increase with depth. Dolomitization of feldspars was the next most often observed form of feldspar weathering followed by calcitization, anhydritization, and pyritization.

Rock fragments within the Denkman range from 3.0 percent to 26.0 percent, averaging 12.2 percent. Metamorphic rock fragments (MRFs) are the most abundant averaging 80.0 percent of the total rock fragment population. The next abundant fragments are volcanic rock fragments (VRFs), 15.0 percent, followed by sedimentary rock fragments (SRFs) at 5.0 percent.

An aphanitic grain type of varying composition and texture is the most abundant rock fragment present (Figure 8). Initially, some difficulty developed in identifying these grains because of their resemblance to chert. The grains were

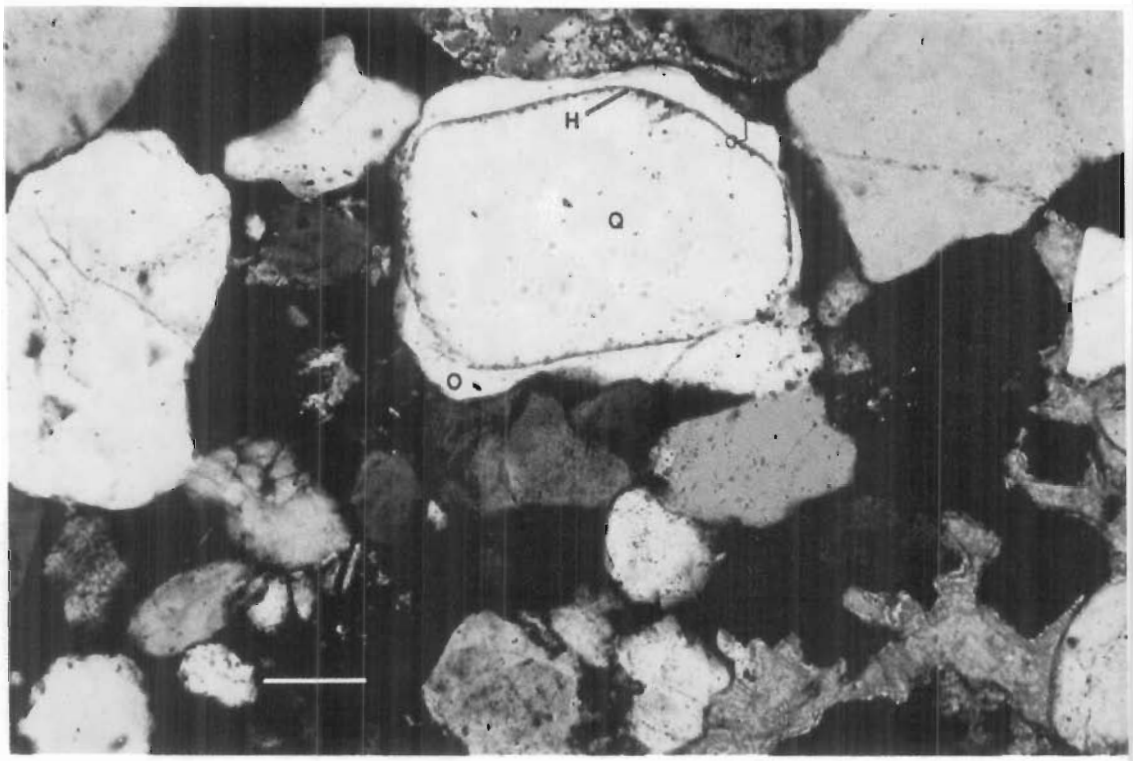

Figure 5. The most abundant detrital grains present within both the Denkman Member and red bed lithofacies are monocrystalline quartz grains (Q), which can exhibit a rounded to subrounded shape, hematite coatings (H) and secondary overgrowths (O). Crossed-nicols; upper Denkman Member; 16617.0 feet; Jenkins Oil & Gas Inc., No. 1 Haynes 8-1; Florida permit 1128; Bar scale = 0.1 mm.

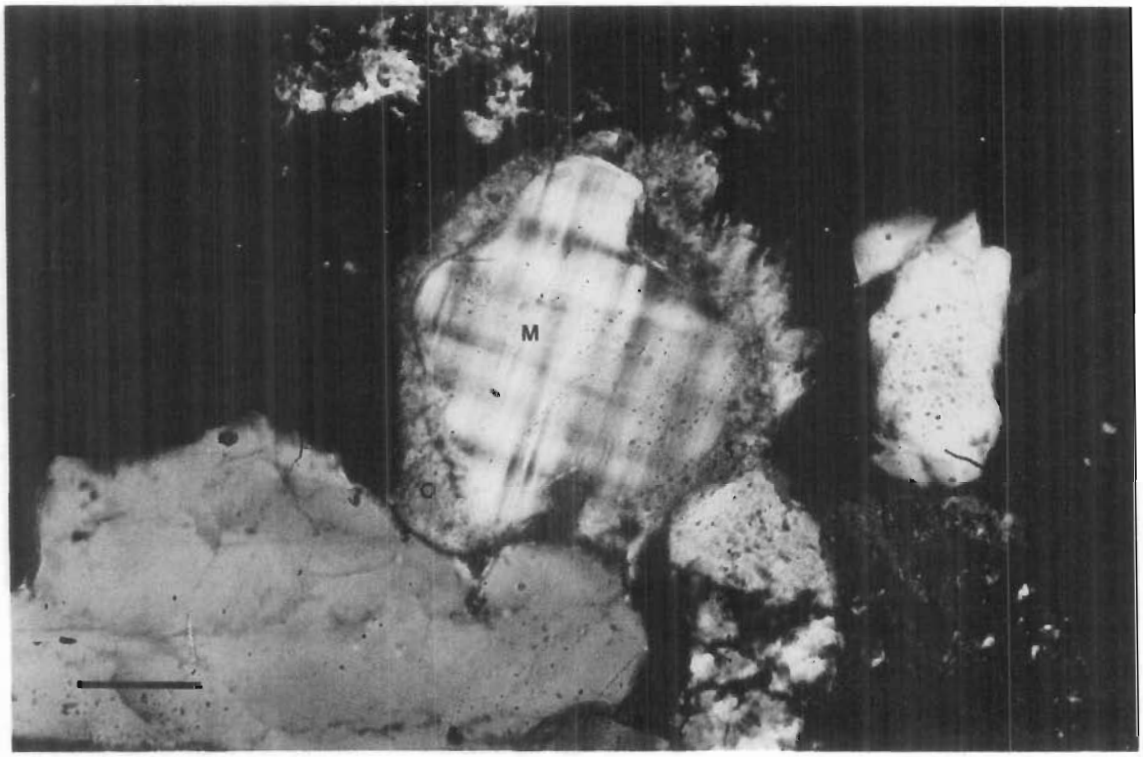

Figure 6. Potassium feldspar grain (microcline) (M) exhibiting authigenic overgrowth (O). Crossed-nicols; upper Denkman Member; 17297.0 feet; Shell Oil Company, Schneider No. 1; Florida permit 647; Bar scale = 0.05 mm.

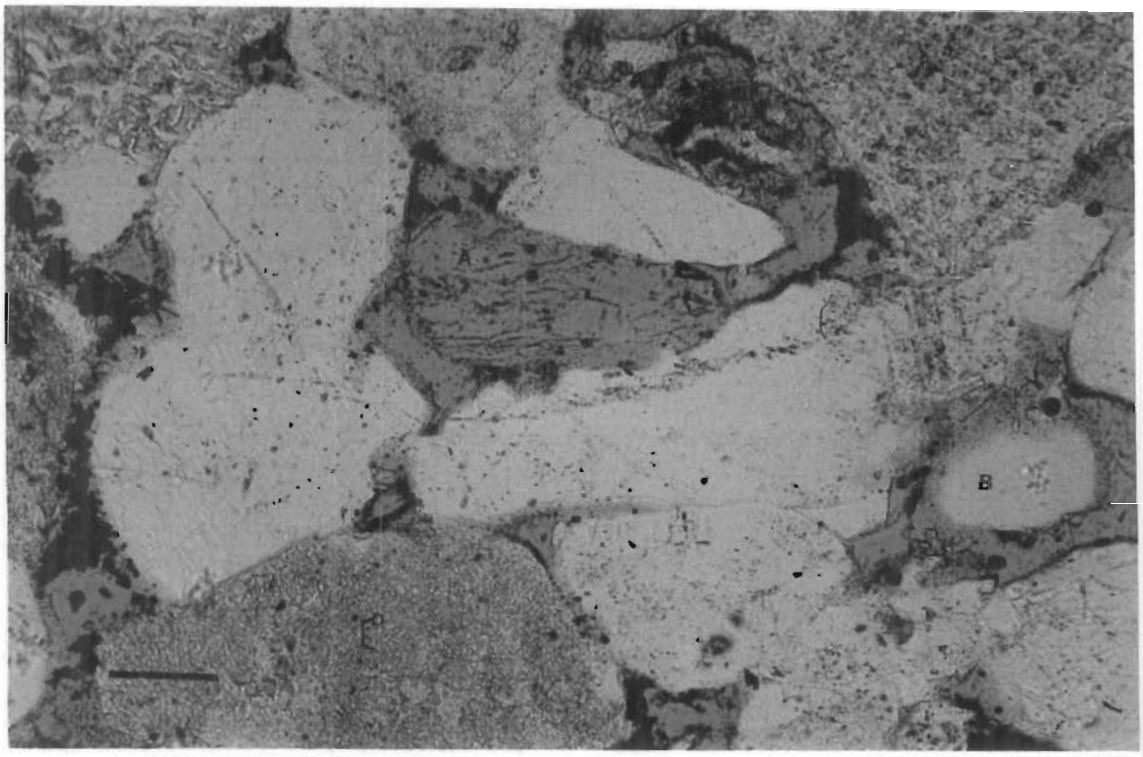

Figure 7. Dissolution of feldspars. (A) advanced stage of dissolution, all that remains is probable residual clay skeleton and (B) central part remaining of grain dissolved from margin to center. Plane-polarized light; upper Denkman Member; 16121.0 feet; Exxon Corporation, St. Regis Paper Company, No. 13-S; Florida permit 1080; Bar scale = 0.1 mm.

grouped together as low-rank MRFs on the basis of their unifying characteristics. The grains usually appear dark-colored, resistant to deformation, and silicified. A possible clue to their origin is suggested by some of these grains possessing small, highly birefringent, phyllosilicate inclusions and microlayers, which may suggest an originally argillaceous texture. Another possible source is indicated by several grains examined from the Mesa Petroleum Company core (Florida permit 551). Within the Mesa core, many silicified VRFs closely resemble some of the low-rank metamorphic grains. This resemblance is increased where no phenocrysts appear within the VRFs (Figure 9). However, because of the pervasive alteration of original grain fabrics, the author prefers to group these aphanitic grains as low-rank MRFs.

The second most abundant type of rock fragment present is high-rank metamorphic grains with a fabric of stretched and sutured quartz subcrystals separated by thin mica plates [Folk's (1980) schistose metamorphic] (Figure 10). The remaining rock fragments (in decreasing order of abundance) are: VRFs, slate/phyllite, another type of high-rank metamorphic rock fragment [Folk's (1980) stretched metamorphic], and traces of chert, dolomite, and shale.

MATRIX AND CEMENTS

As a whole, the Denkman Member of panhandle Florida is virtually matrix-free except as observed in the Smackco Ltd. well core (Florida permit 1096). X-ray diffraction data from samples of this core indicates that chlorite and illite comprise the majority of the matrix. Minor amounts of euhedral dolomite are also present within the matrix.

Quartz overgrowths are the most abundant cement type present within the Denkman. The overgrowths can be subhedral to euhedral, multiple in occurrence, with some being abraded and recycled (Figure 5).

The second most abundant cement present is feldspar, occurring as overgrowths. Authigenic phyllosilicate cements follow in abundance consisting of pore-lining chlorite, illite, and kaolinite. Clay content increases with depth and is most abundant in the Smackco Ltd. well (Florida permit 1096).

Carbonate cement occurs most often at the top of the section, just below the Smackover-Norphlet contact. Calcite occurs 15.0 percent of the time as opposed to dolomite occurring 11.0 percent of the time. Locally, dolomite may be more abundant than calcite. Calcite is usually seen as a pore-filling cement surrounding framework grains. Calcite also occurs as poikilotopic patches where framework grains appear to float within the cement crystal. Dolomite is usually seen as isolated or interlocked mosaics of euhedral rhombs.

Anhydrite cement is minor throughout the section and usually seen as poikilotopic masses which may form visible spots in the sandstone. In at least one sample from the Smackco Ltd. well, doubly terminated quartz crystals occur within an anhydrite nodule. Hematite and pyrite are both minor constituents of the cement fraction, with hematite occurring as coatings on some grains (Figure 10). Pyrite occurs as blebs, euhedral crystals, and rosettas of probable replacement origin within many framework grains. The presence of pyrite within tightly cemented quartz sandstones suggests that sour gas (H_2S-saturated gas) invaded the capillary pores of the sandstone, converting the hematite grain coatings to pyrite (McBride, 1981).

Red Bed Lithofacies

The relatively clean sandstones of the Denkman Member become reddish-brown with depth and grade into underlying red beds. These red beds which include sandstones, siltstones, and shales, become the dominant Norphlet lithology in parts of Alabama (Mancini et al, 1985).

Two wells containing red bed lithofacies were examined for this study: the Champlin Petroleum well (Florida permit 518) and the Mesa Petroleum Company well (Florida permit 551).

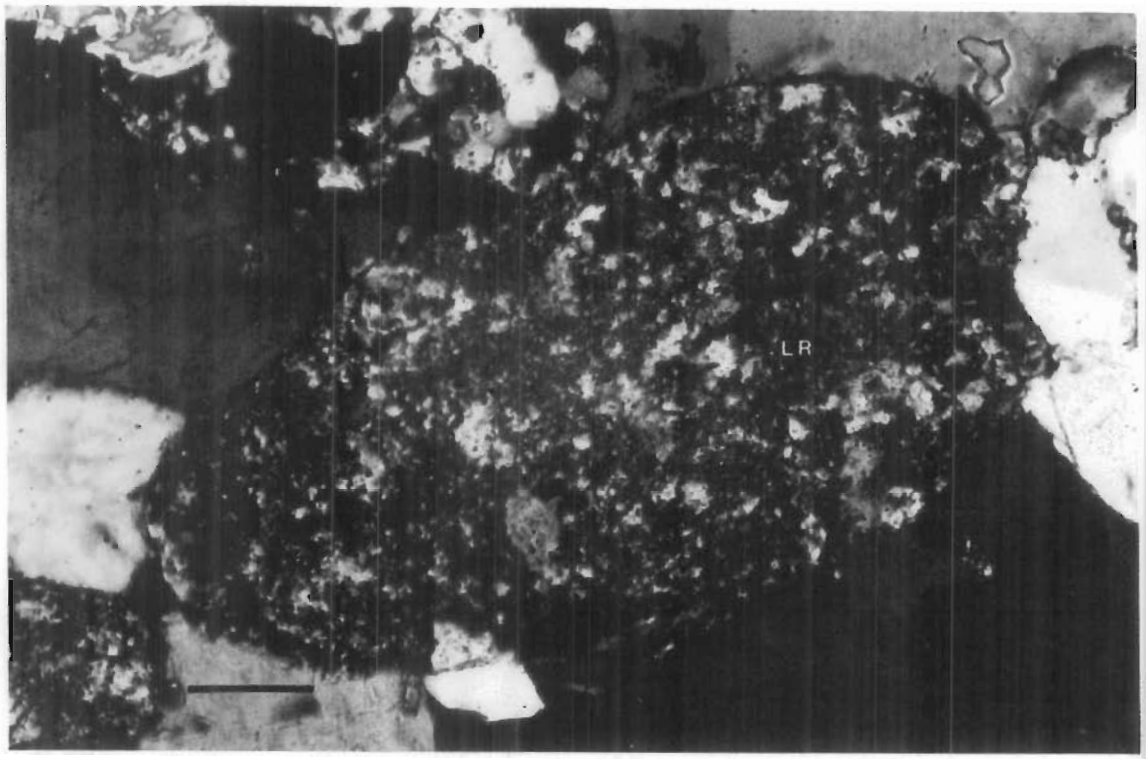

Figure 8. The most abundant rock fragments present within both the Denkman Member and red bed lithofacies are low-rank metamorphic grains (LR) possibly having several different origins. Crossed-nicols; upper Denkman Member; 16617.0 feet; Jenkins Oil & Gas Inc., Haynes 8-1; Florida permit 1128; Bar scale = 0.1 mm.

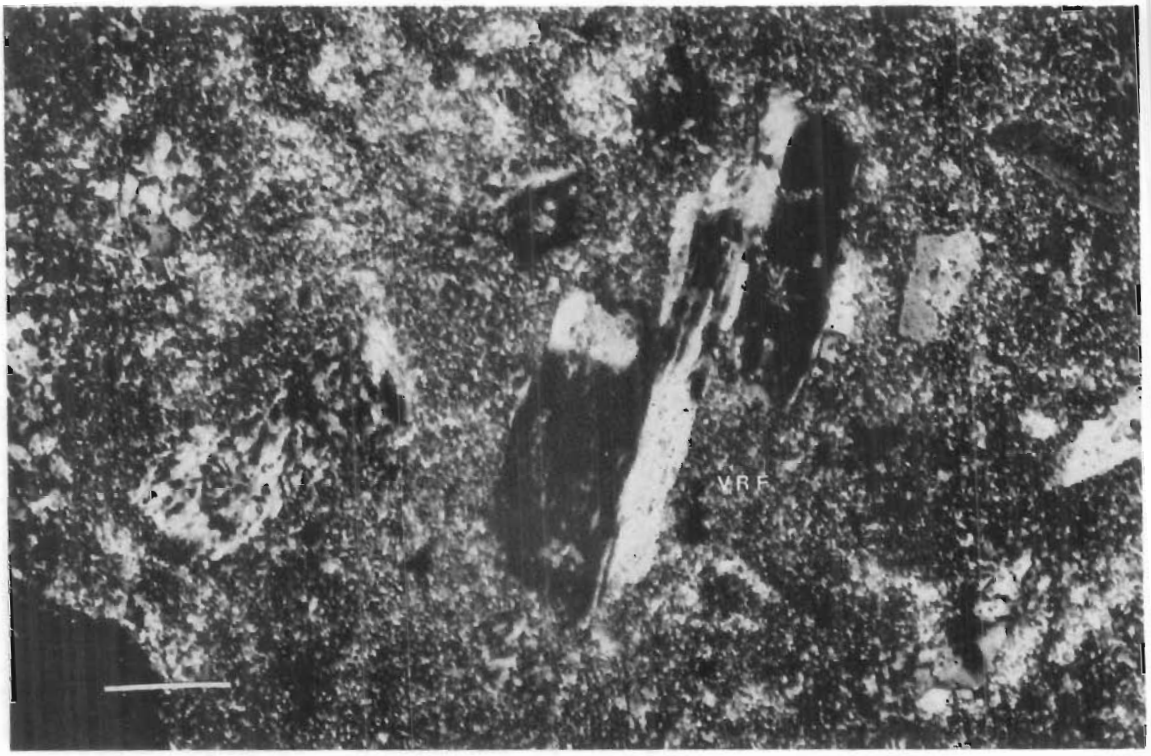

Figure 9. Volcanic rock fragment (VRF) which has been partially silicified. Crossed-nicols; red bed lithofacies; 15549.0 feet; Champlin Petroleum Company, USA & State of Florida, No. 1; Florida permit 518; Bar scale = 0.1 mm.

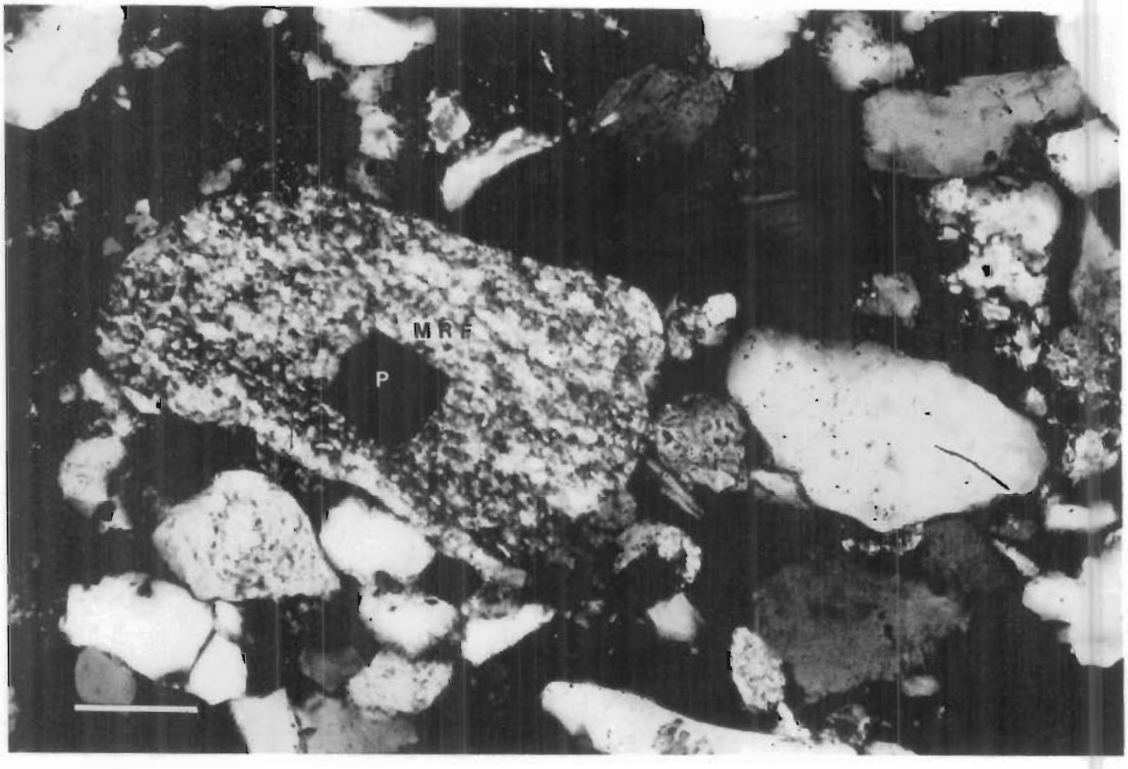

Figure 10. High-rank metamorphic rock fragment (MRF) with a fabric of stretched and sutured quartz subcrystals separated by thin mica plates. A euhedral pyrite crystal (P) appears in the center of the grain. Crossed-nicols; lower Denkman Member; 16145.5 feet; Exxon Corporation, Martha Murphy 10-6; Florida permit 1004; Bar scale = 0.1 mm.

The Champlin Petroleum well (Florida permit 518) is located in extreme northwest Okaloosa County. This well lies adjacent to the Pensacola Arch, which accounts for the coarser and more lithic nature of its red beds. Fourteen and one-half feet of Norphlet material were cored within this well (-14403.6 to -14481.3 ft blkb), of which only the upper three feet were recovered. From this three-foot interval, a single chip of red, coarse-grained sandstone was analyzed for this project. This would place the sample approximately 4.9 feet below the Smackover-Norphlet contact as determined by geophysical logs. This stratigraphic relationship would effectively limit the Denkman Member to the overlying 4.9 feet interval, if present at all. A geophysical well log from Champlin Petroleum Corporation well (Florida permit 518) shows a serrated spontaneous potential (SP) pattern (Figure 11) believed to be representative of the red bed lithofacies (Wilkerson, 1981). In the author's opinion, the Norphlet section within this well is comprised almost entirely of red beds perhaps formed by stacking of wadi-type deposits on the flanks of the Pensacola Arch (Mancini et al, 1985). If the sequence in this well is typical of the Norphlet, a conglomeratic lithofacies may be expected in the lower part of this well. However, at the present time, the author is not able to recognize a conglomeratic lithofacies from the geophysical log data.

The Mesa Petroleum Company well is located in south-central Santa Rosa County, farther out in the Conecuh Embayment than the Champlin well. Within this well, the transition from Denkman to red beds is subtle and cannot be identified on geophysical logs. The lower portion of the core from this well exhibits a red bed section approximately 33-feet thick. The red bed portion of the core consists of a red, poorly- to moderately well-sorted, fine- to medium-grained sandstone with subrounded to subangular grains. The most distinctive feature of this lithofacies is the closely spaced horizontal to slightly inclined (1° to 5°) laminae. These laminae are composed of alternating fine and medium- to coarse- grain sizes. The coarse layers contain more rounded grains and more feldspars and rock fragments than the finer-sized layers.

Framework packing densities of the red bed lithofacies average 81.4 percent. Packing densities within the red bed lithofacies were found to be higher than those within the quartzose lithofacies (79.0 percent average). Red bed packing densities are very similar to Norphlet packing densities reported from the Hatters Pond Area, Alabama (81.4 percent average (Honda, 1981)). However, grain rearrangement and extensive pressure solution reported by Honda (1981) for the Hatters Pond Area do not occur extensively within the red bed lithofacies in panhandle Florida.

The red bed lithofacies is a feldspathic litharenite (Folk, 1980). The average composition of framework grains is 61.3 percent quartz, 23.1 percent rock fragments, and 15.6 percent feldspars.

FRAMEWORK GRAINS

The most abundant detrital grain found in the red bed lithofacies is quartz. Quartz content averages 61.3 percent of framework grains. This value is similar to those from Denkman samples, thus reflecting the consistent lithology of the formation. In a sample from the Champlin well (Florida permit 518), rock fragments are more abundant than quartz, possibly due to the relative closeness of the sample to its source areas. The most common quartz type present, making up to 48.0 percent of the total quartz population, is monocrystalline quartz with little to no undulatory extinction. Approximately 16.0 percent of all quartz grains contain mineral inclusions and/or small vacuole trains, suggesting a plutonic origin (Folk, 1980).

The second most abundant quartz type is monocrystalline, undulose quartz, making up 44.5 percent of the total quartz fraction. Semi-composite quartz grains average 5.6 percent, while fully-composite quartz grains average 2.0

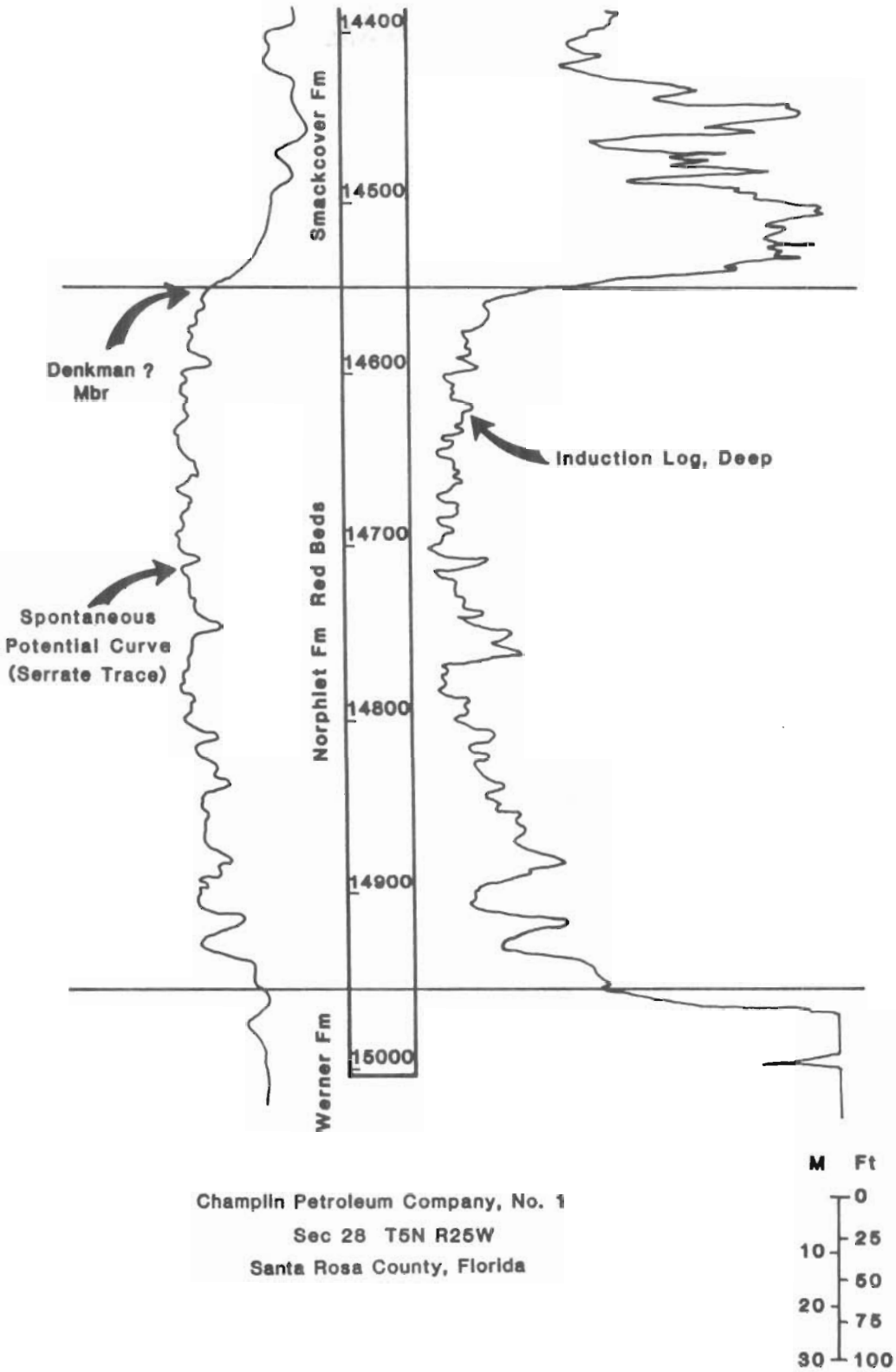

Figure 11. Induction log and spontaneous potential curve illustrating serrate pattern associated with red beds.

percent of all quartz examined. The quartz grains of the red bed lithofacies are very similar to those seen in the Denkman Member.

The second most abundant detrital framework grains of the red bed lithofacies are rock fragments. Their abundance is the major difference between red bed and quartzose lithofacies. Rock fragments average 23.1 percent of all framework grains within this lithofacies. Metamorphic rock fragments are the most abundant of these, averaging 74.2 percent of the total rock fragment population. Like those in Denkman Member samples, these MRFs mostly consist of the same low-rank metamorphic grains of various compositions and microtextures. Similarities do exist between some silicified VRFs and SRFs and these abundant low-rank MRFs; however, their alteration prevents any clear determination of an original volcanic or sedimentary texture for these grains.

Volcanic rock fragments are second only to MRFs in abundance within the red bed lithofacies and average 24.9 percent of all rock fragments. These VRFs show two types of texture: a dark, fine-grained matrix enclosing feldspar laths and a mostly silicified grain with relict phenocrysts (Figures 9 and 12).

Other than being coarser, feldspars of the red bed lithofacies are very similar in appearance, composition, and roundness to the feldspars of the Denkman Member. Feldspars within the red bed lithofacies average 15.6 percent of all framework grains. Potassium feldspars (untwinned orthoclase and minor amounts of microcline) are more abundant than plagioclase feldspars, averaging 85.4 percent compared with 15 percent of all feldspars in the red bed lithofacies. Several lath clusters and individual feldspar laths were observed within the samples. Such clusterings probably are deformed and deteriorated VRFs.

Vacuolization is the dominant diagenetic alteration affecting red bed feldspars. Chloritization, kaolinitization, and illitization are the second most abundant diagenetic alterations, followed by hematization, anhydritization, and pyritization. Approximately 18.0 percent of all feldspars show no signs of alteration. However, numerous grains show seritization, mineral inclusions, and quartz intergrowths.

CEMENTS

The most abundant type of cement present is quartz overgrowths (Figures 4 and 13). Phyllosilicate grain coatings are the second most common cement type seen in the red bed lithology (Figure 14). Chlorite, illite, and kaolinite were all identified by x-ray diffraction. Scanning electron microscopy shows that an irregular, platy, chlorite rim cement dominates. In decreasing order of abundance, feldspar, calcite, anhydrite, and dolomite cements also occur throughout the lithofacies.

Conglomeratic Lithofacies

Wilkerson (1981) and Pepper (1982) identified a conglomeratic lithofacies in several wells along the updip limit of the Norphlet Formation in southern Alabama. Geophysical logs from the Getty Oil Company well (Florida permit 1097) located in East Bay (southern Santa Rosa County) indicate a Norphlet section up to 14.6-feet thick probably lying on top of Werner and Eagle Mills sediments (Figure 15). Approximately 7.9 feet of cored conglomeratic (Norphlet Formation conglomeratic lithofacies) and anhydritic material (Werner Formation) from the Getty well were examined for this project.

The examined core consists of three feet of conglomeratic material lying above a 4.9-feet thick interval of "dirty," white, laminated anhydrite. The contact between the conglomerate and the anhydrite is gradational over a one to two inch section. The upper Norphlet part of the core, along with the Norphlet-Smackover contact, is missing.

Geopetal infilling of cavities within the Werner Formation anhydrite by coarse-grained Norphlet sediments can be seen in the Getty well core

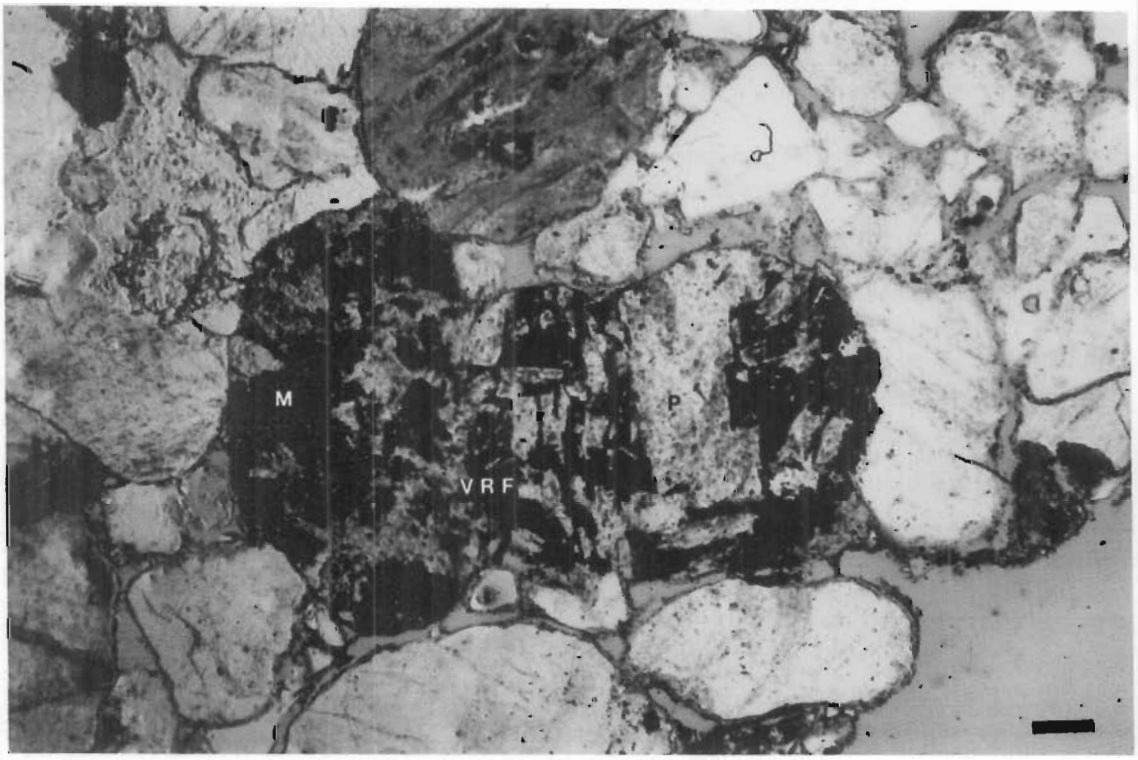

Figure 12. Volcanic rock fragment (VRF) in the red bed lithofacies exhibiting a dark, fine-grained matrix (M) enclosing probable plagioclase phenocrysts (P). Plane-polarized light; red bed lithofacies; 15549.0 feet; Champlin Petroleum Company, USA & State of Florida, No. 1; Florida permit 518; Bar scale = 0.1 mm.

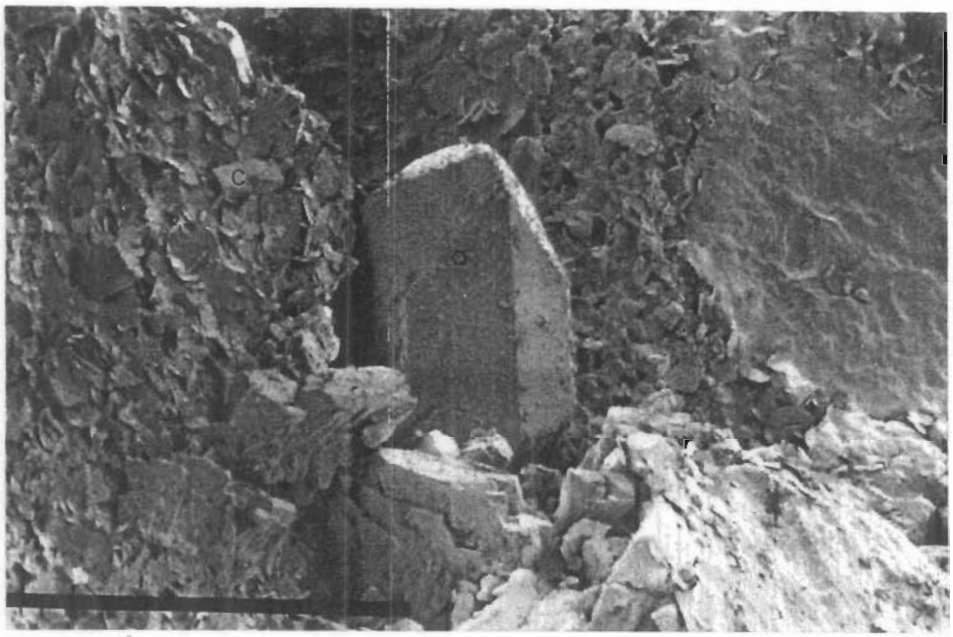

Figure 13. Scanning electron micrograph of red bed lithofacies pore, exhibiting euhedral quartz overgrowths (Q) and chloritic clay coatings (C). Red bed lithofacies; 16847.5 feet; Mesa Petroleum Company, T.R. Miller Mill Company, No. 1; Florida permit 551; Bar scale = 0.1 mm.

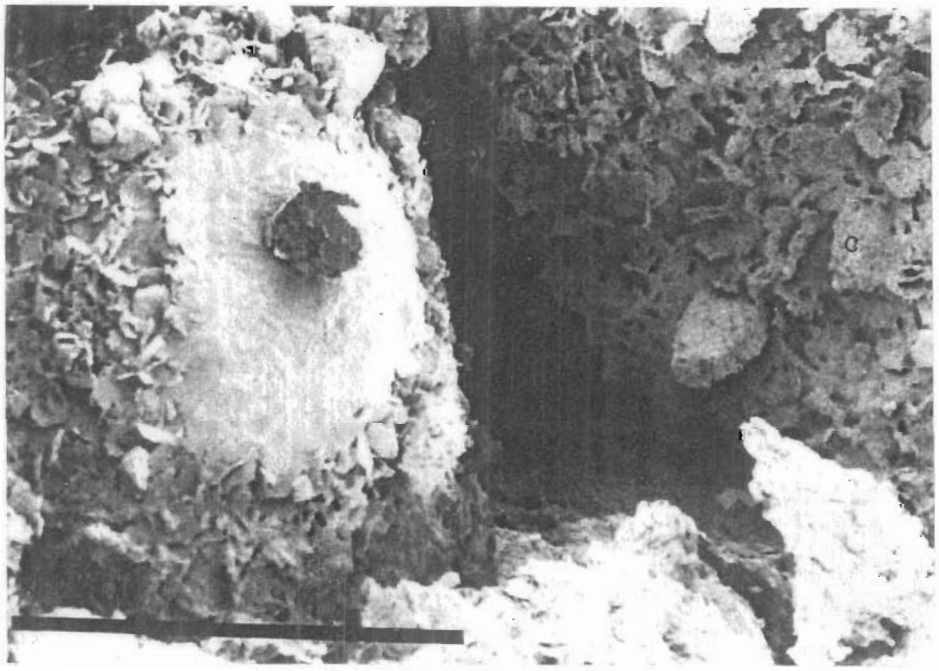

Figure 14. Scanning electron micrograph of red bed lithofacies exhibiting porosity reducing chloritic clay coats (C). Red bed lithofacies; 16847.5 feet; Mesa Petroleum Company, T.R. Miller Mill Company, No. 1; Florida permit 551; Bar scale = 0.1 mm.

(Figure 15). Geopetal infilling by Norphlet sediments probably occurred after meteoric leaching of the then-exposed anhydrite. Finally, calcite-saturated waters infiltrated the cavities and precipitated the calcite caps.

The preserved lower Norphlet portion of the core is an interlayered section of conglomeratic and coarse-grained sandstones. At the top of the core is a two-inch zone of coarse-grained sandstone overlying approximately three feet of conglomerate. The sandstones are red and the grains are moderately sorted and subangular to subrounded. The conglomeratic material is dark gray in color, poorly sorted, with angular to rounded grain shapes. Large rock fragments within the conglomerate consist of pebble- to cobble-sized grains, some up to three inches across. These large rock fragments are dark green, white, and dark gray, subangular to subrounded, and appear to be plutonic and metamorphic in origin. Mancini et al, (1984) identified pebbles of shale, chert, quartzite, granite, and rhyolite in conglomerates from Escambia County, Alabama, farther to the north than these Florida conglomerates. Differences in composition between these Pensacola Arch conglomerates and their northern counterparts are believed to be due to the proximity and type of source materials available to each. Lying directly below the three-foot zone of gray conglomerate is another interval of coarse, red sandstone about one- to two-inches thick. Below this sand the lithology again changes to a 2.0- to 2.5-inch thick conglomerate lying on a "dirty" white, crystalline, coarse-grained, wavy-laminated anhydrite.

PROVENANCE OF NORPHLET SEDIMENTS

Interpretation of petrographic and stratigraphic data can give a general indication of source areas for Norphlet sediments. Mineral composition of Norphlet sediments varies moderately across panhandle Florida. Although compositional differences do exist, essentially the same constituents are present throughout all cores, including quartz, feldspars, and sedimentary, igneous, and metamorphic rock fragments. The similarity in mineralogy in all lithofacies of the formation indicates that the source areas remained constant throughout Norphlet deposition (Wilkerson, 1981).

Walls (1985) used locations of samples which had the highest amount of labile grains to indicate source areas of the Norphlet Formation of southern Alabama. He noted that MRFs dominate updip Alabama Norphlet sediments, but diminish to the south. The labile nature of the fragments suggests that the nearby southern Appalachian uplands served as a source area for these MRFs. Compositional variation maps, constructed by Walls (1985), indicate a southwesterly dispersal pattern for these sediments. This direction would imply significant deposition of MRFs in the Manila Embayment, separated from panhandle Florida by the Conecuh Ridge (Figure 3). Both the Manila Embayment and the Conecuh Ridge probably restricted much of this debris from panhandle Florida. Additionally, Walls (1985) noted a significant compositional difference between samples from northern counties and samples from Mobile, Escambia, and Conecuh Counties, Alabama. Samples from the southern counties have a higher lithic content, higher feldspar concentration, and appear to have accumulated from several directions, indicating at the very least a southern source (Walls, 1985).

Ottman et al, (1973) and Sigsby (1976) suggested that the Conecuh Ridge and Pensacola Arch were topographic highs during much of Norphlet deposition, outlining the Conecuh Embayment. All Norphlet sediments of panhandle Florida are located within this basin, which is bordered to the north by the Conecuh Ridge, to the east and south by the Pensacola Arch, and to the southwest by the Wiggins Arch. The Conecuh Ridge and Pensacola Arch probably served as source areas for Florida Norphlet sediments (Sigsby, 1976). It is the author's opinion that sediments derived from the

Figure 15. Norphlet Formation-Werner Formation contact exhibiting Norphlet conglomeratic lithofacies, red, coarse-grained sandstone (S), conglomerate (C), Werner anhydrite (A), and geopetal sediment infilling of cavities within the upper Werner Formation (G). 17739.9 feet; Getty Oil Company; Florida permit 1097, East Bay location.

Wiggins Arch probably did not contribute significantly to deposits in Florida, primarily due to the downdip location of the arch.

Neathery and Thomas (1975; Figure 1) suggested that basement rocks of panhandle Florida probably are southern extensions of the Southern Appalachian Piedmont Belt. Dominant rock types of the Piedmont are mica schist, granite gneiss, and granite. Evidence for a Pensacola Arch (Piedmont Belt) source for Norphlet sediments in panhandle Florida is provided by the presence of conglomeratic and red bed lithofacies. Pebble- to cobble-size, matrix-supported conglomerates are similar to updip Norphlet conglomerates observed in southern Alabama wells (Wilkerson, 1981; Pepper, 1982; Walls, 1985). The restricted updip distribution of these conglomerates apparently reflects proximity to, as well as the composition of, the Pensacola Arch. These conglomerates are composed dominantly of plutonic and metamorphic rock fragments.

Southwestern Alabama red bed lithofacies probably represent distal portions of conglomeratic sequences (Mancini et al, 1984). The locations of Florida red beds, which all lie further out into the basin than the conglomerates, suggest a Pensacola Arch source for Norphlet sediments of panhandle Florida. Supporting evidence for this claim is a pronounced fining of grain sizes within the quartzose and red bed lithofacies toward the center of the Conecuh Embayment.

Evidence for a Conecuh Ridge (Talledega Slate Belt) source is less dramatic (Neathery and Thomas, 1975; Figure 1). However, higher feldspar and sedimentary rock fragment concentrations in samples from wells located in northern Santa Rosa County may indicate that the Conecuh Ridge was a supplier of sediments to panhandle Florida.

Sediments that originated from the Eagle Mills, Werner, and Louann Formations also are indicated by stratigraphic location and composition (Figures 16 and 17). Scott et al, (1961) believed the Eagle Mills was initially deposited in deep, relatively narrow troughs, bounded by steep faults and cut by volcanic intrusives. The Conecuh Embayment apparently lies within one of these troughs (Woods and Addington, 1973; Figure 3).

After initial deposition of continental-derived Eagle Mills sediments within the trough, the formation was subjected to an extended period of subaerial weathering (Anderson, 1979). Following this weathering and subsequent erosion of some of the Eagle Mills, deposition of Werner Formation sediments began with these beds eventually onlapping the paleo-Gulf Coast (Imlay, 1980). The Werner Formation covered all of the embayment and apparently much of the southern end of the Pensacola Arch. The author believes that the Getty Oil Company well (Florida permit 1097) lies near the crest of the arch. Whether the Conecuh Ridge was completely buried or not by the Werner Formation is unclear. However, during Werner deposition, updip Eagle Mills sediments were probably still being shed and deposited from surrounding highlands. This can be interpreted from the cross-sections which shows Eagle Mills sediments capped by lower Haynesville sediments, indicating exposure of the Eagle Mills during much of the Jurassic. Consequently, Eagle Mills sediments were probably incorporated into lower Werner sediments (Figures 16 and 17).

Following Werner Formation deposition, deposition of the Louann Formation began within the Conecuh Embayment. The Louann Formation does not now lie as far inland as the Werner Formation, apparently due to post-depositional dissolution and erosion of the salt during Norphlet deposition. Perhaps the Louann originally did overlap the Werner, but it has since been eroded back to a more basinward position (Anderson, 1979).

Following the retreat of the Louann Sea from the Conecuh Embayment, stream gradients were again increased to the point where continental erosion could take place (Pepper, 1982). It was during this time that Norphlet deposition began. Norphlet sediments thus began burying Louann

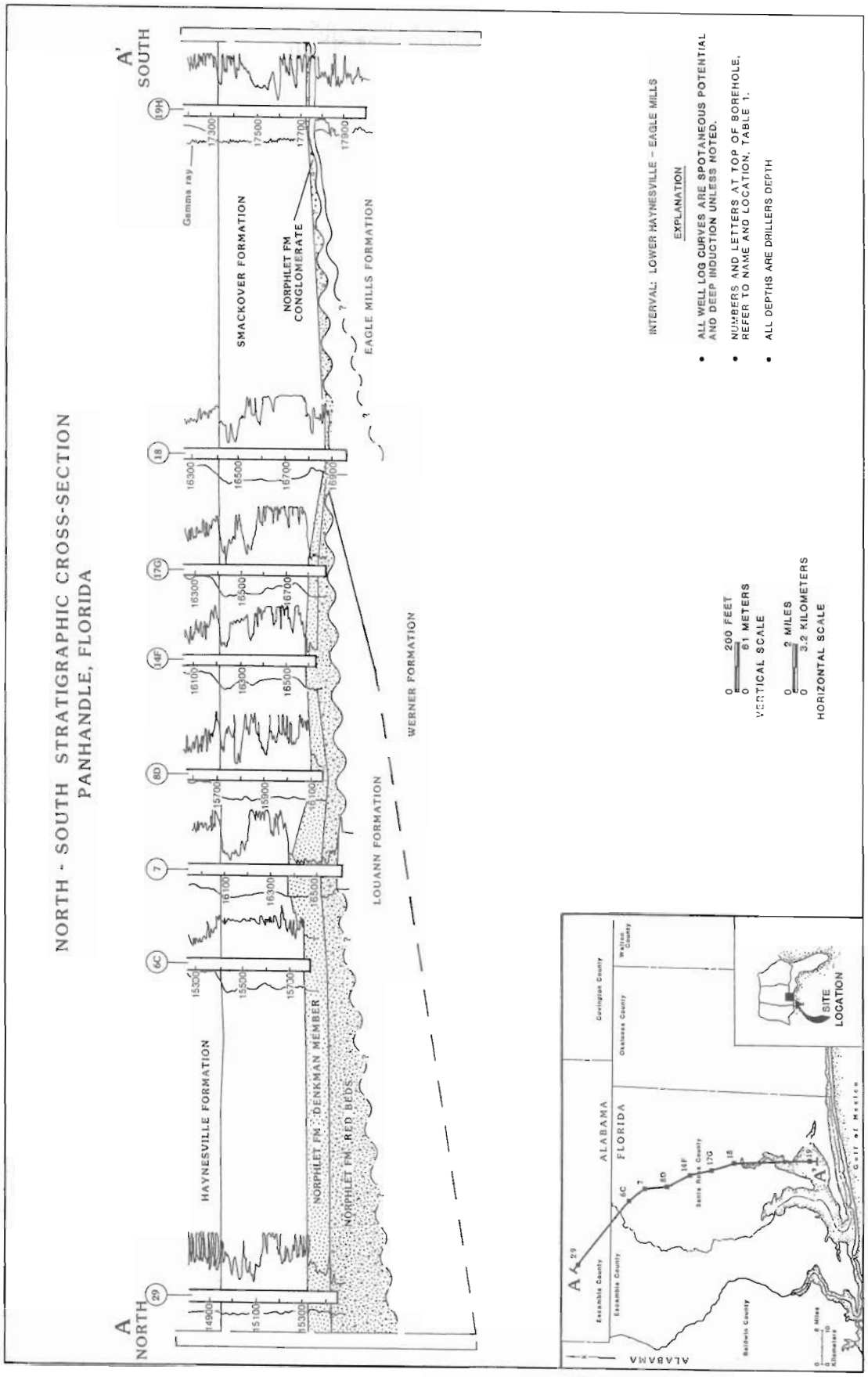

Figure 16. North-south stratigraphic cross section, panhandle, Florida.

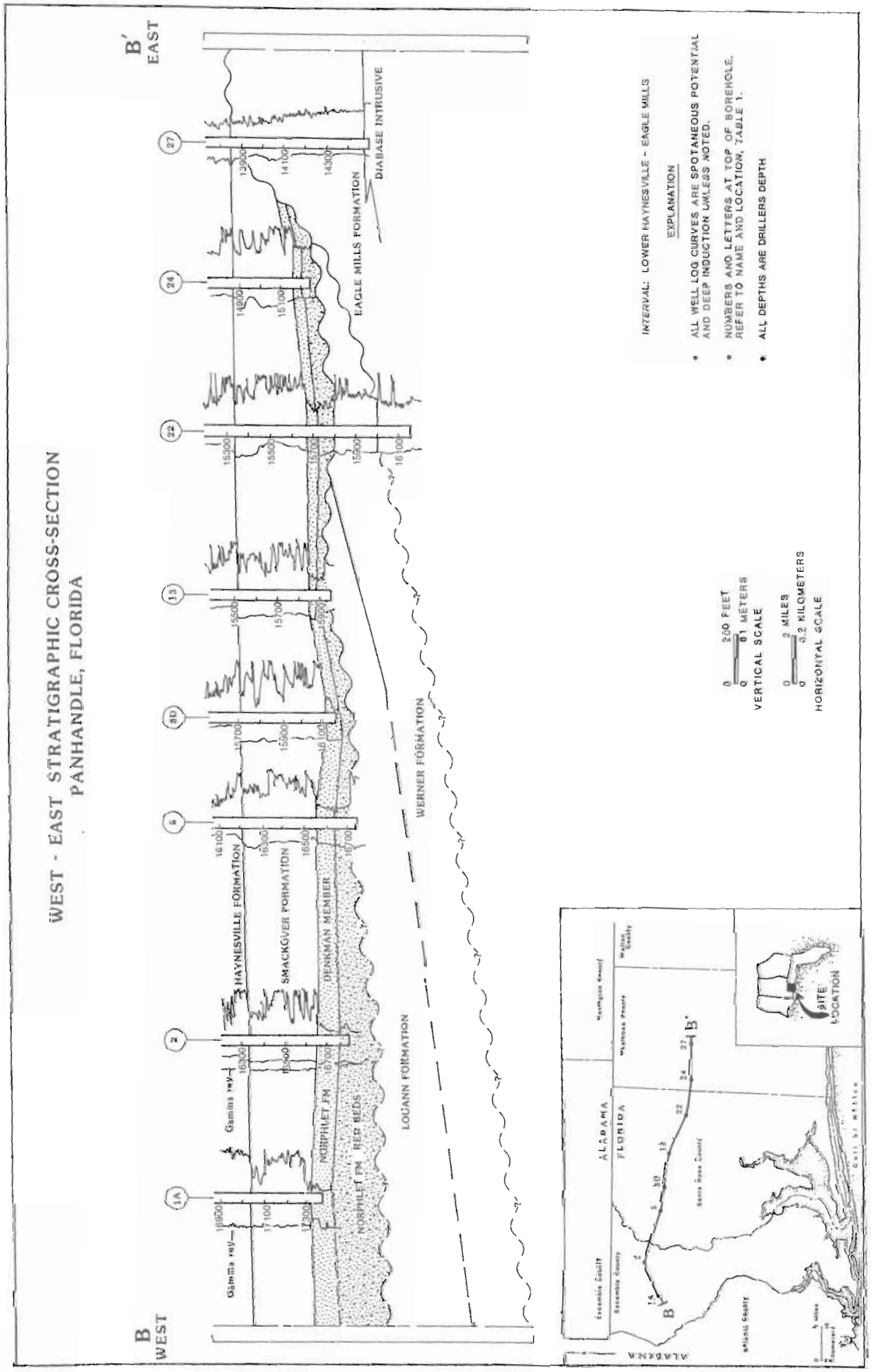

Figure 17. West-east stratigraphic cross section, panhandle, Florida.

sediments, overstepping both the Louann and Werner Formations. Examination of the cross-section shows that outside the embayment, the Eagle Mills Formation was never completely buried by Norphlet sediments (Figure 17). Since the Eagle Mills apparently was exposed throughout Norphlet deposition in panhandle Florida, the author assumes it was a source for Norphlet sediments. The Eagle Mills in panhandle Florida was not completely covered until middle Kimmeridgian time, when anhydrite of the lower Haynesville Formation completely covered the embayment.

Diabase dikes and sills are known to cut Eagle Mills sediments throughout the Gulf Coast and are believed to be present in the bottom of the Sonat Exploration well (Florida permit 590) Scott et al, 1961; A. Applegate, Florida Geological Survey, 1986, personal communication). Some VRFs in the quartzose and red bed Norphlet facies appear to be diabase. Thus, a contribution to Norphlet sediments from erosion of the Eagle Mills appears very likely.

CONCLUSIONS

1. Three distinct lithofacies of the Norphlet Formation have been identified in panhandle Florida: an updip conglomerate, red beds, and an uppermost quartzose lithofacies (Denkman Sandstone Member).
2. This study demonstrates that panhandle Florida Norphlet sediments are more lithic in composition than are Norphlet sediments from southern Alabama. Metamorphic rock fragments are the most abundant rock fragments present within the lithic suite. A partially silicified low-rank type of metamorphic rock fragment of possible argillaceous and/or volcanic origin dominates the suite. Volcanic rock fragments are present in all samples and are most abundant in the south and east, nearest the Pensacola Arch. Sedimentary rock fragments account for only 4.7 percent of the lithic fraction and are most abundant in central Santa Rosa County, nearest the Conecuh Arch.
3. Panhandle Florida Norphlet sediments were derived from the basement rock of the Conecuh Ridge (Talledega Slate Belt) to the north and the Pensacola Arch (Piedmont Belt) to the south and east. Additionally, sediment contribution from the Eagle Mills, Werner, and Louann Formations probably was significant.

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