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Basin Analysis and Petroleum System Characterization and Modeling, Interior Salt Basins, Central and Eastern Gulf of Mexico*
Part 1: North Louisiana Salt Basin

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Editor's Note: Appreciation is expressed to Dr. Ernest A. Mancini, for making this report available to Search and Discovery for publication.
This article consists of three parts: **Part 1**--Abstract, Summary, and Data Compilation, along with illustrations (171) mainly for North Louisiana Salt Basin (NLSB); **Part 2**--illustrations for Mississippi Interior Salt Basin (MISB); **Part 3**--with interpretations of geologic history, basin evaluation, resource assessment, modeling, conclusions, and references.

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Abstract

The project consisted of two phases: Concept Development and Concept Demonstration. The principal research effort for Phase 1 (Concept Development) of the project has been data compilation; determination of the tectonic, depositional, burial, and thermal maturation histories of the North Louisiana Salt Basin; basin modeling (geohistory, thermal maturation, hydrocarbon expulsion); petroleum-system identification; comparative basin evaluation; and initial assessment of undiscovered and undeveloped reservoirs in the North Louisiana Salt Basin. Existing information on the North Louisiana Salt Basin has been evaluated, an electronic database has been developed, and regional cross sections have been prepared. Structure, isopach and formation lithology maps have been constructed, and burial-history, thermal-maturation-history, and hydrocarbon-expulsion profiles have been prepared. Seismic data, cross sections, subsurface maps and burial-history, thermal-maturation-history, and hydrocarbon-expulsion profiles have been used in evaluating the tectonic, depositional, burial and thermal-maturation histories of the basin. The principal research effort for Phase 2 (Concept Demonstration) of the project has been characterization of the Smackover petroleum system in the North Louisiana Salt Basin, characterization of the Upper Jurassic to Lower Cretaceous Bossier petroleum system, hydrocarbon-flow-pathway modeling in the North Louisiana Salt Basin, and refined assessment of the undiscovered and underdeveloped reservoirs in the North Louisiana Salt Basin. Presentations on the results of this work have been made at the annual meetings

of the American Association of Petroleum Geologists and Gulf Coast Association of Geological Societies. Technology transfer workshops have been conducted in Shreveport, Louisiana, Jackson, Mississippi, and Tuscaloosa, Alabama.

Introduction

The University of Alabama and Louisiana State University have undertaken a cooperative 5-year, fundamental research project involving sedimentary-basin analysis and petroleum-system characterization and modeling of the North Louisiana Salt Basin and Mississippi Interior Salt Basin. According to the USGS, the hydrocarbon volume of these basins ranks them in the top 8% of the most petroliferous basins of the world.

Executive Summary

The principal research efforts of the project have been the determination of the tectonic, depositional, burial and thermal-maturation histories of the North Louisiana Salt Basin, basin modeling (geohistory, thermal maturation, hydrocarbon expulsion, hydrocarbon-flow pathway), petroleum system study (identification, characterization, modeling), comparative basin evaluation, and assessment of the undiscovered and underdeveloped reservoirs in the North Louisiana Salt Basin.

Existing information, including 2-D seismic sections, on the North Louisiana Salt Basin has been evaluated, and an electronic database has been developed. Regional cross sections have been prepared. Structure, isopach, and formation-lithology maps have been constructed on key surfaces and of key intervals, respectively. Seismic data, well logs, cross sections, subsurface maps and burial-history, thermal-maturation history and hydrocarbon-expulsion profiles have been used in evaluating the tectonic history, depositional history, burial history and thermal-maturation history of the basin.

The origin of the North Louisiana Salt Basin is comparable to the origin of the Mississippi Interior Salt Basin. The geohistory of these basins is directly linked to the evolution of the Gulf of Mexico. The timing of tectonic events and the nature of the structural styles control the type and size of petroleum traps formed and the volume of hydrocarbons contained within these traps. The dominant structural styles are salt-supported anticlines, normal faults, and combination structural-stratigraphic features. Combination structural-stratigraphic features include large regional domal structures, such as the Sabine and Monroe uplifts.

The main difference in the geohistories of the North Louisiana Salt Basin and the Mississippi Interior Salt Basin is the elevated heat flow the strata in the North Louisiana Salt Basin experienced in the Cretaceous due primarily to reactivation upward movement, igneous activity, and erosion associated with the Monroe and Sabine Uplifts. The Jackson Dome in the Mississippi Interior Salt Basin is a similar phenomenon, but the effects of this igneous intrusion are on a much lower level geographically.

The Upper Jurassic Smackover petroleum system is the principal petroleum system in these basins. The underburden, source, overburden,

reservoir, and seal rocks associated with this petroleum system are a result of the rift-related geohistory. The generation of oil and gas from Smackover lime mudstone was initiated during the Early Cretaceous in the southern part of the basins and continued into the Tertiary. Hydrocarbon expulsion and migration commenced during the Early Cretaceous and continued into the Tertiary. Vertical and lateral migration is important to the productivity of these basins. In the North Louisiana Salt Basin, petroleum reservoirs include continental, coastal, and marine sandstone facies and nearshore marine, shelf, ramp, and reef carbonate facies. Seal rocks include Upper Jurassic and Lower Cretaceous anhydrite and shale, Upper Cretaceous chalk and shale, and Lower Tertiary shale.

The Upper Jurassic to Lower Cretaceous Bossier petroleum system had the potential to generate gas from thermally mature shale containing Type III kerogen, giving the Bossier high potential as a shale-gas reservoir in the North Louisiana Salt Basin. Potential undiscovered reservoirs in the North Louisiana Salt Basin are subsalt Triassic Eagle Mills sandstone and Upper Jurassic to Lower Cretaceous sandstone, shale, and limestone. Potential underdeveloped reservoirs include Lower Cretaceous sandstone and limestone and Upper Cretaceous sandstone.

Knowledge of basin geohistory and of the concepts of sequence stratigraphy and petroleum systems facilitates the design of new exploration strategies for the targeting of combination structural and stratigraphic traps and specific reservoir facies in a transgressive-regressive sequence. In the North Louisiana Salt Basin, Upper Cretaceous sandstone reservoirs are recognized as transgressive backstepping facies in transgressive-regressive sequences that onlap onto the Monroe Uplift that serves as a combination structural and stratigraphic trap, thermogenic gas is predicted to occur in Upper Jurassic to Lower Cretaceous transgressive and regressive, deeply buried (>20,000 ft) porous sandstone and carbonate facies, and the Bossier Formation is identified as a potential shale-gas reservoir as a result of petroleum system study.

Project Objectives

The principal objectives of the project were to develop through basin analysis and modeling the concept that petroleum systems acting in a basin can be identified through basin modeling and to demonstrate that the information and analysis resulting from characterizing and modeling of these petroleum systems in the North Louisiana Salt Basin and the Mississippi Interior Salt Basin can be used in providing a more reliable and advanced approach for targeting stratigraphic traps and specific reservoir facies within a geologic system and in providing a refined assessment of undiscovered and underdeveloped reservoirs and associated oil and gas resources.

Experimental

Work Accomplished

Data Compilation

Existing information on the North Louisiana Salt Basin (Figure 1) has been evaluated and an electronic database has been developed.

Representative oil and gas well logs (141) were utilized in the construction of 11 regional stratigraphic cross sections (Figure 2). The digitized logs have been used to construct cross sections (Figures 3-13) for the basin using PETRA software. Seismic reflection data have been studied for the basin. The well logs, cross sections and seismic profiles were used in making interpretations regarding the tectonic history and depositional history of the basin. Structure maps (Figures 14, 15, and 16), isopach maps (Figures 17, 18, and 19), an erosional thickness map for the Lower Cretaceous section (Figure 20), and formation-lithology maps (Figures 21-40) have been constructed on key surfaces and of key intervals, respectively. Cores from wells that penetrate Jurassic strata have been studied to assist with the interpretations of the tectonic and depositional histories of the basin. Samples taken from these cores were used in the characterization of the petroleum source rocks in the basin to assist with the determination as to the source rocks that generated the oil and gas occurring in the North Louisiana Salt Basin (Table 1).

Seismic profiles and well-log data have been used in constructing the cross sections (Figures 3- 13) and burial history (Figures 41-82) profiles. Present-day heat-flow values (Figure 83), lithospheric-stretching beta factors (Figure 84), measured and calculated vitrinite-reflectance values, and a transient heat-flow model (Figures 85 and 86) were used in preparing the thermal-maturation-history profiles (Figures 87-128) and hydrocarbon-expulsion profiles (Figures 129-170).

Burial-history, thermal-maturation history, and hydrocarbon-expulsion profiles were prepared for strata in the Mississippi Interior Salt Basin (Part 2 (4 mb)) using the same methodologies as was used for strata in the North Louisiana Salt Basin. Burial-history, thermal-maturation-history, and hydrocarbon-expulsion profiles were prepared for the North Louisiana Salt Basin, using a rift heat-flow model for comparison purposes (Part 3 (25 mb)).

Disclaimer

List of Illustrations

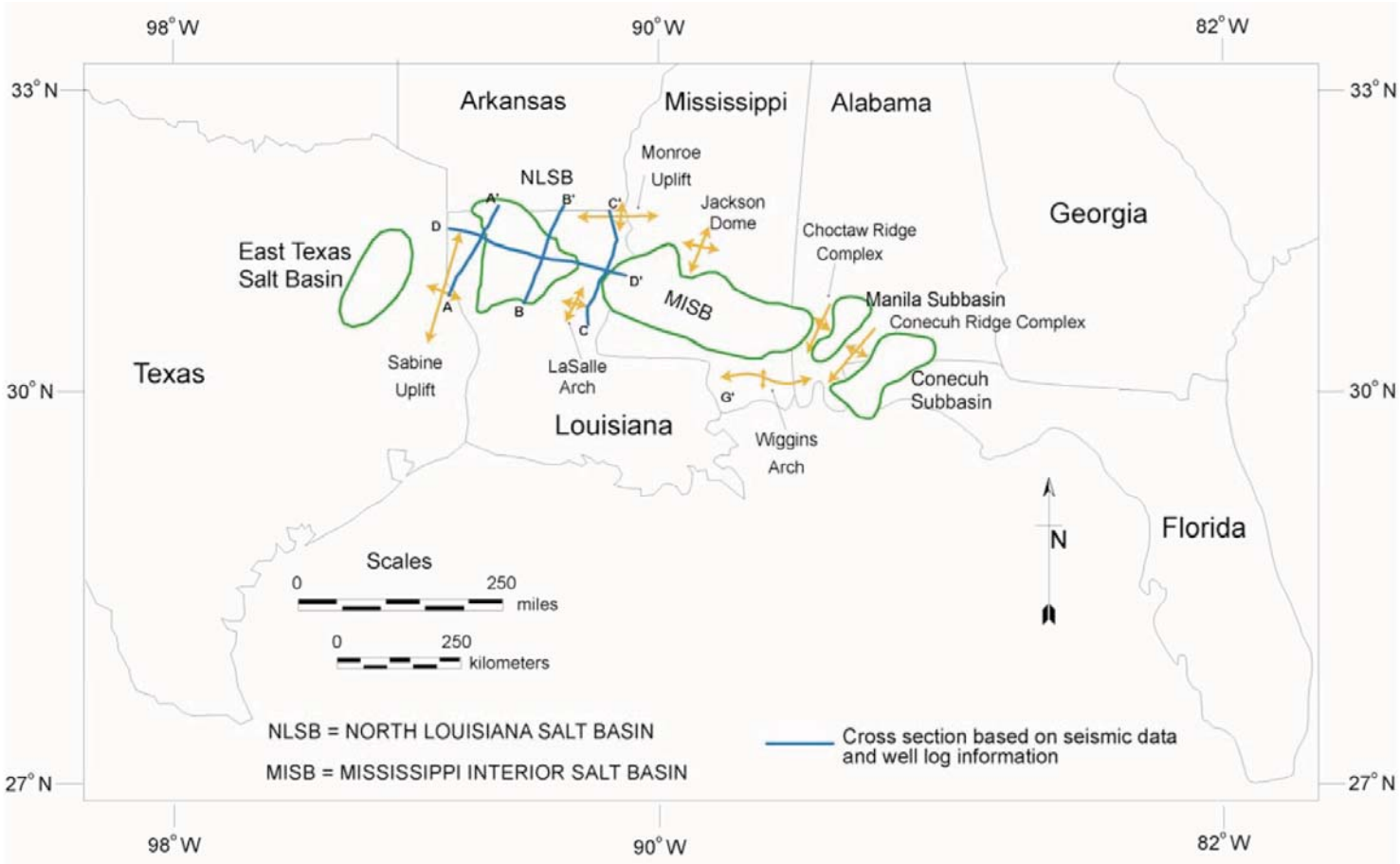
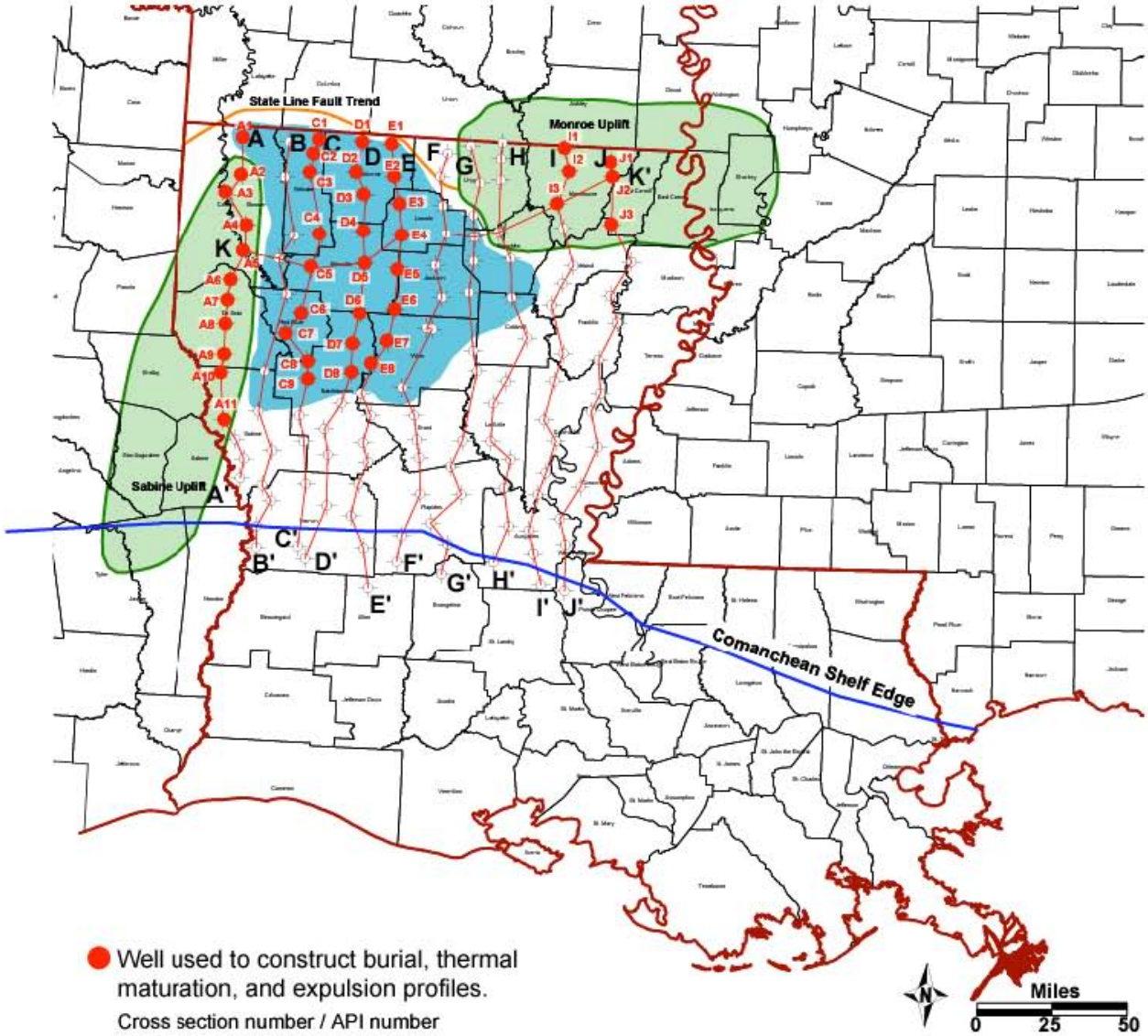


Figure 1. Location map of interior salt basins and subbasins in the north central and northeastern Gulf of Mexico area and regional seismic lines studied.



● Well used to construct burial, thermal maturation, and expulsion profiles.

Cross section number / API number

A1	1701521100	C4	1711901517	E1	1702720242
A2	1701500464	C5	1701320275	E2	1702700522
A3	1701521099	C6	1708120147	E3	1706100051
A4	1701500977	C7	1708120267	E4	1706100091
A5	1701501689	C8	1708100714	E5	1701300138
A6	1703120488	C9	1706920034	E6	1704920029
A7	1703120378	D1	1702701875	E7	1712720324
A8	1703100304	D2	1702701974	E8	1712701324
A9	1703100117	D3	1702720557	I1	1706700012
A10	1708520238	D4	1701320349	I2	1706700043
A11	1708520177	D5	1701320054	I3	1706700182
C1	1711920068	D6	1706920079	J1	1706700008
C2	1711900502	D7	1706900047	J2	1706700061
C3	1711920195	D8	1706900174	J3	1712300011

Figure 2. Index map showing line of cross sections and location of selected wells for the North Louisiana Salt Basin.

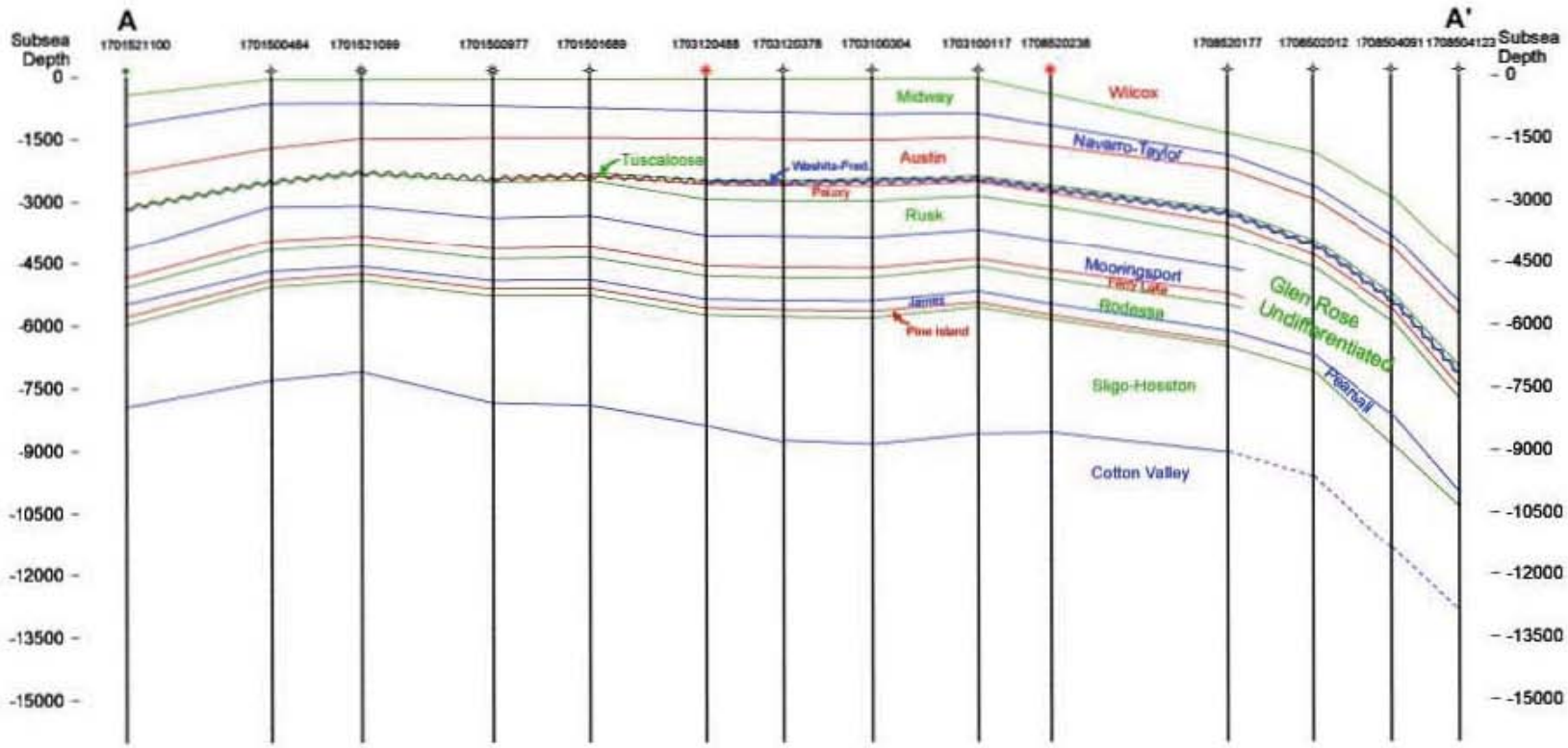


Figure 3. Cross section A-A' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:22X

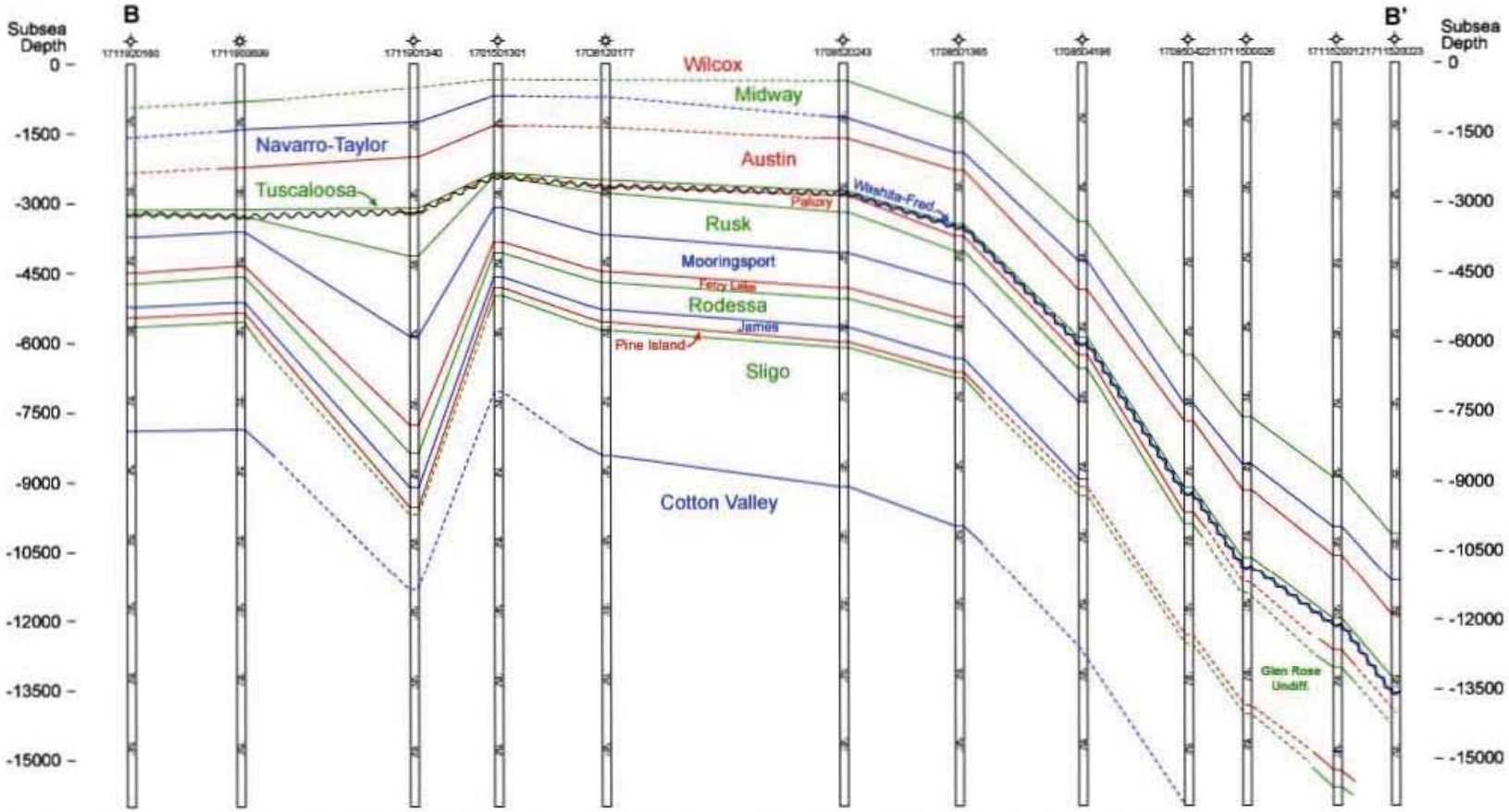


Figure 4. Cross section B-B' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

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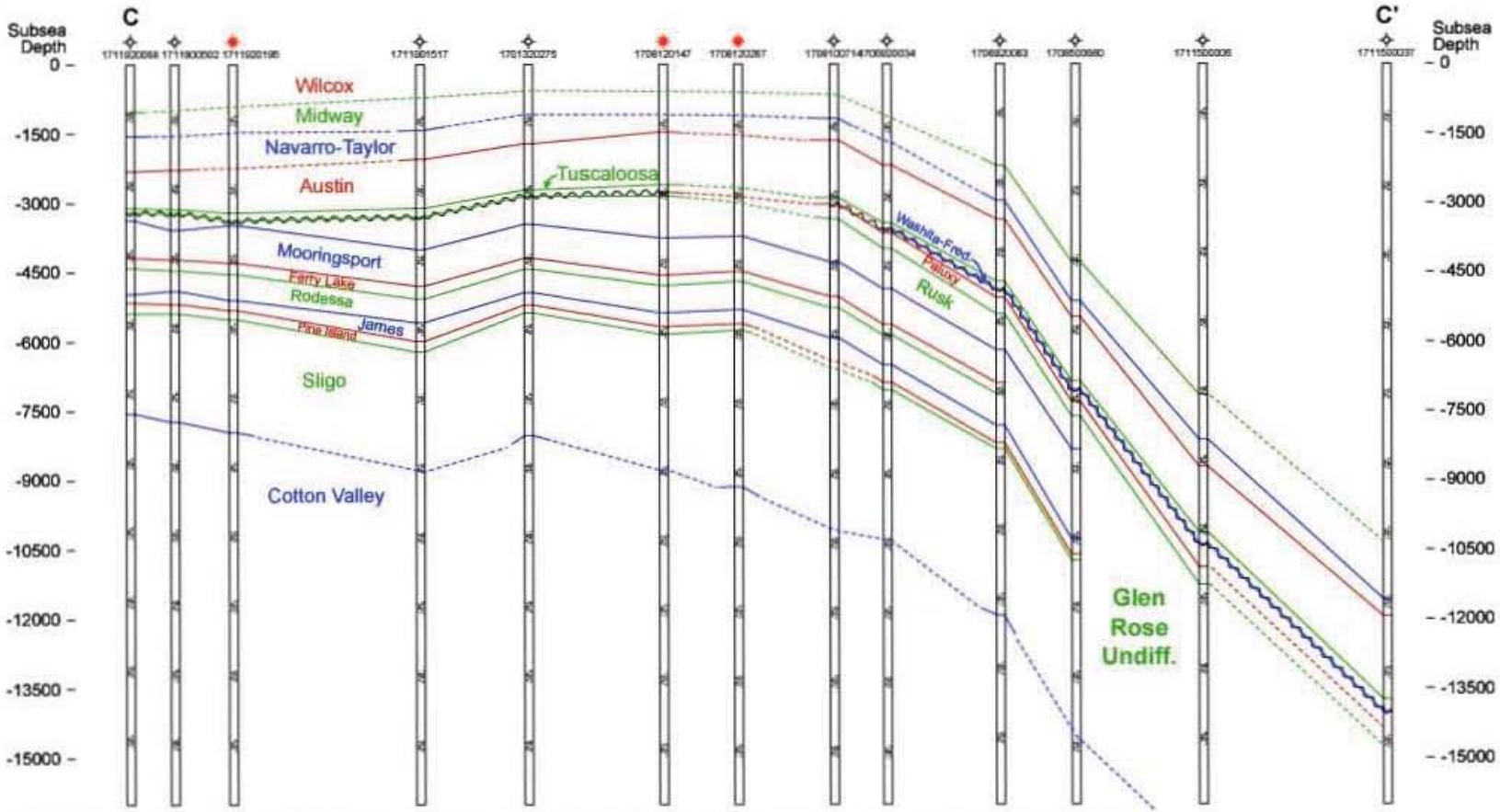

Figure 5. Cross section C-C' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:29X

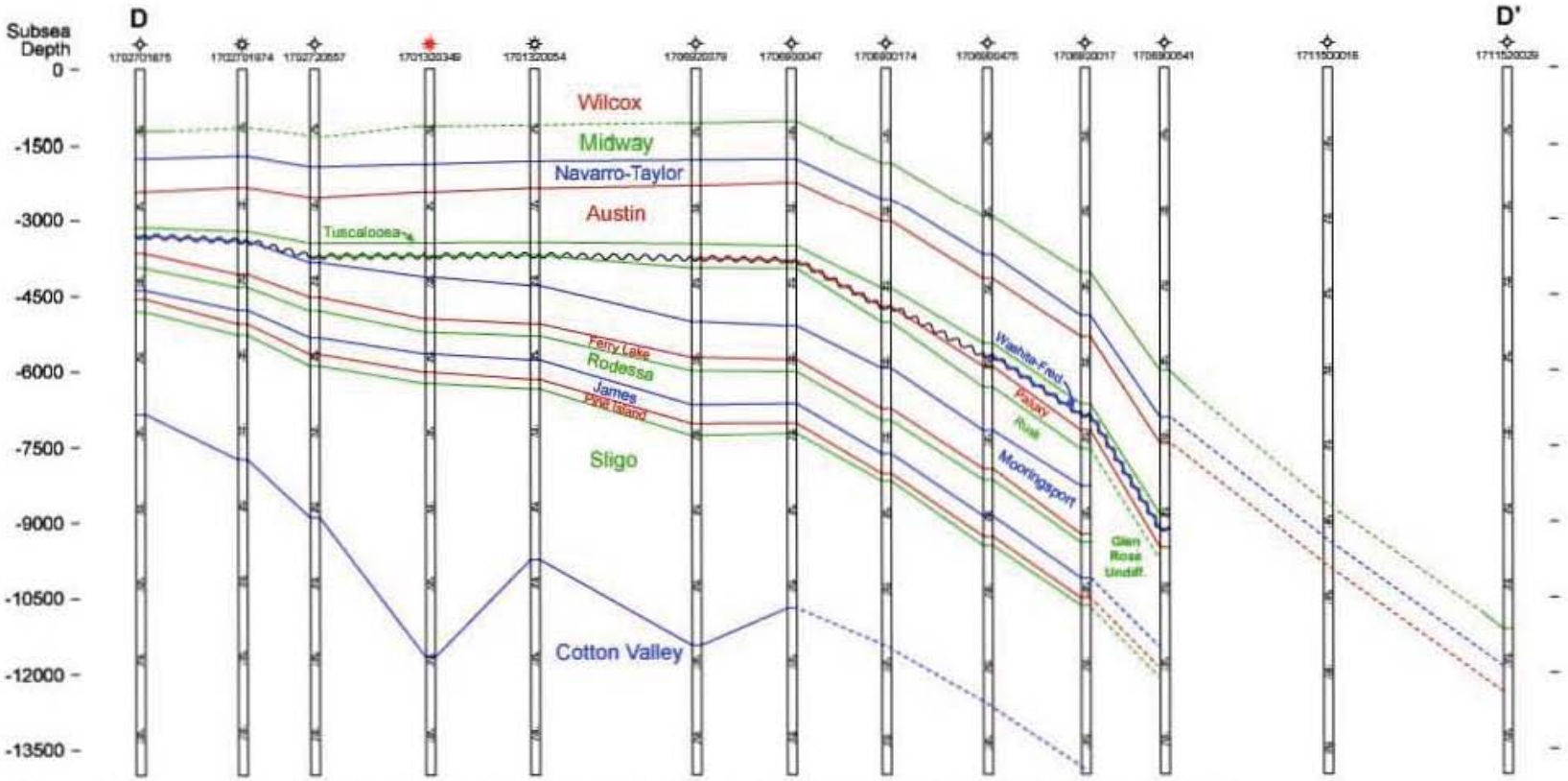

Figure 6. Cross section D-D' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:32X

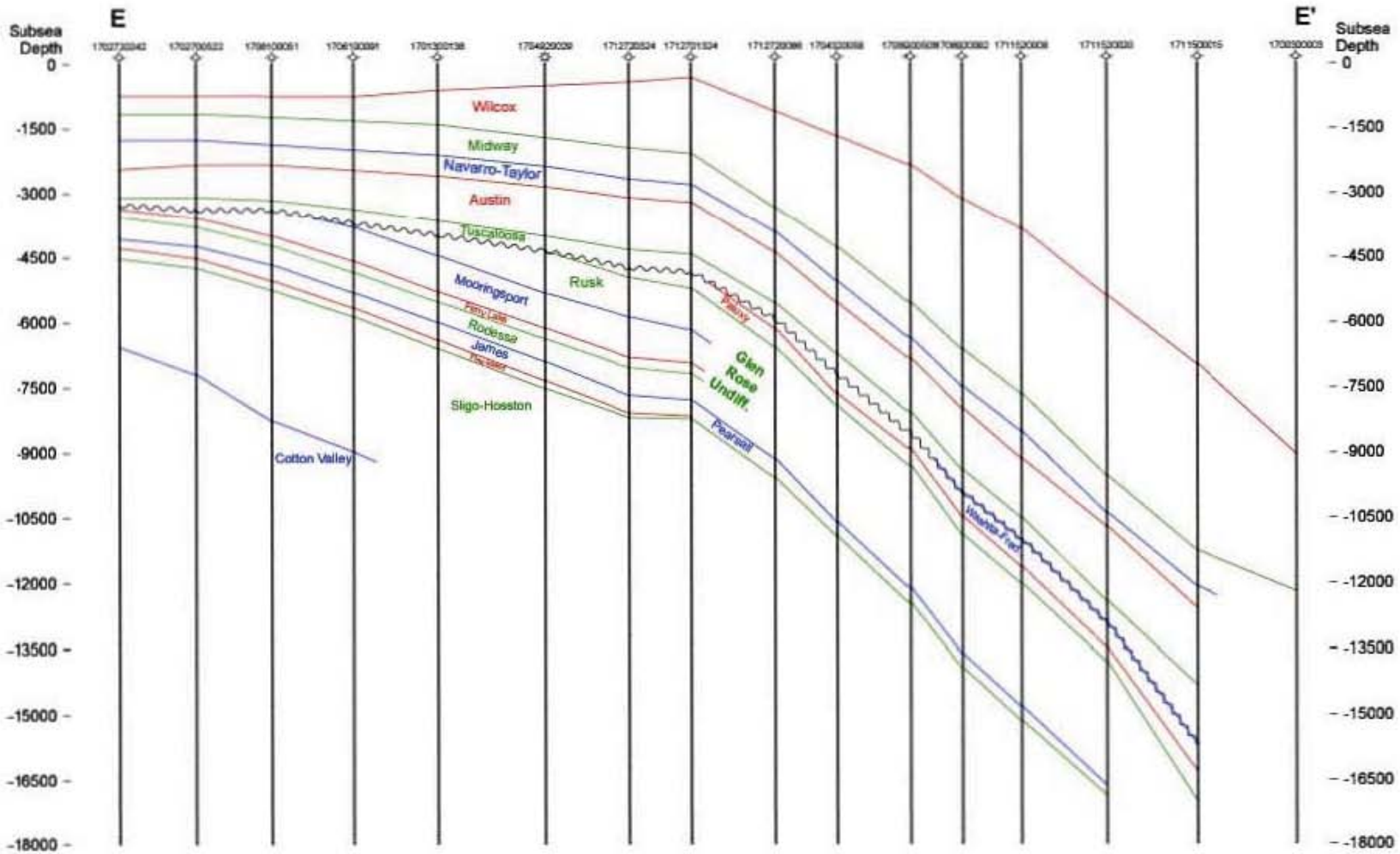

Figure 7. Cross section E-E' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:34X

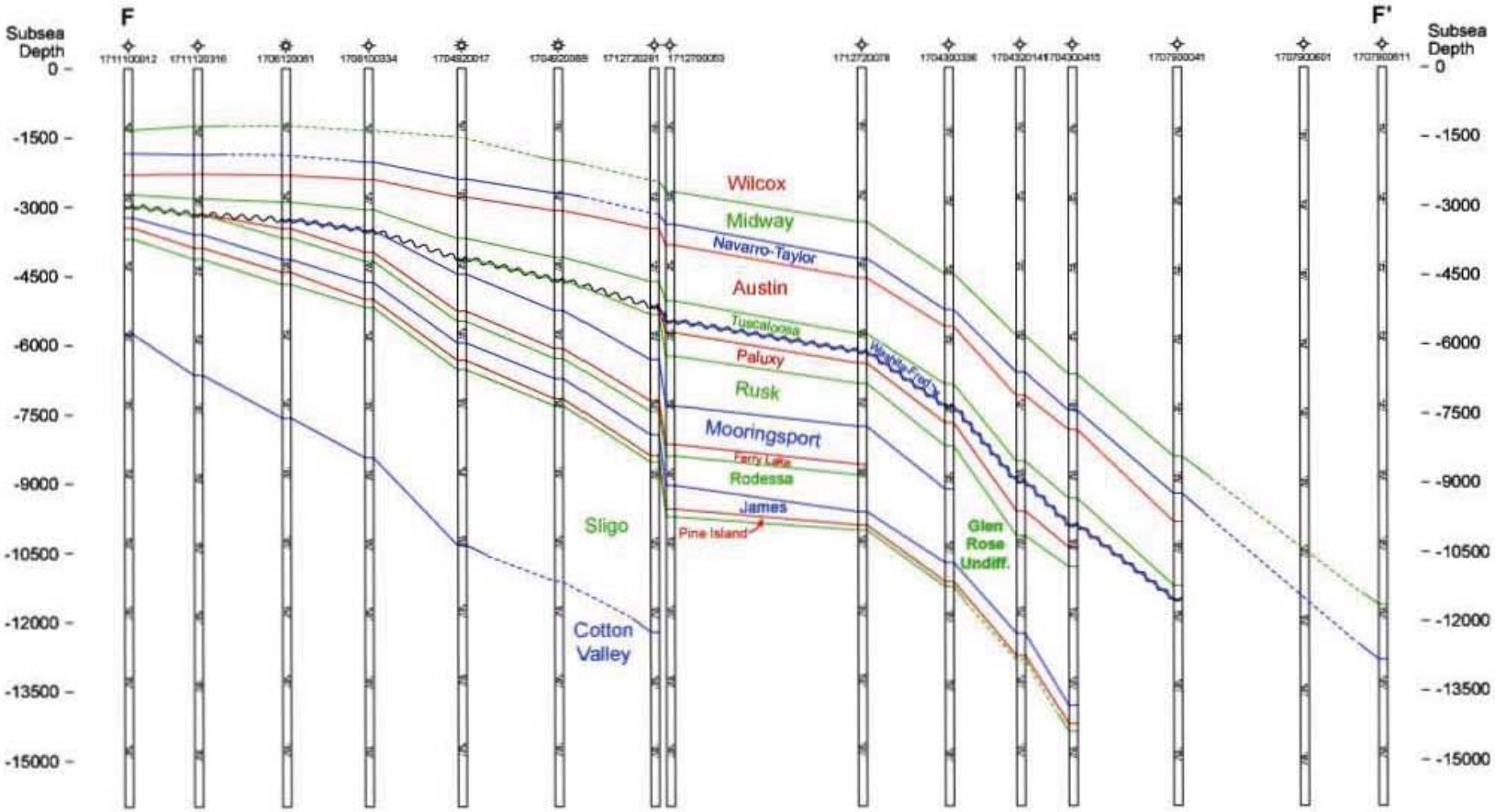

Figure 8. Cross section F-F' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:32X

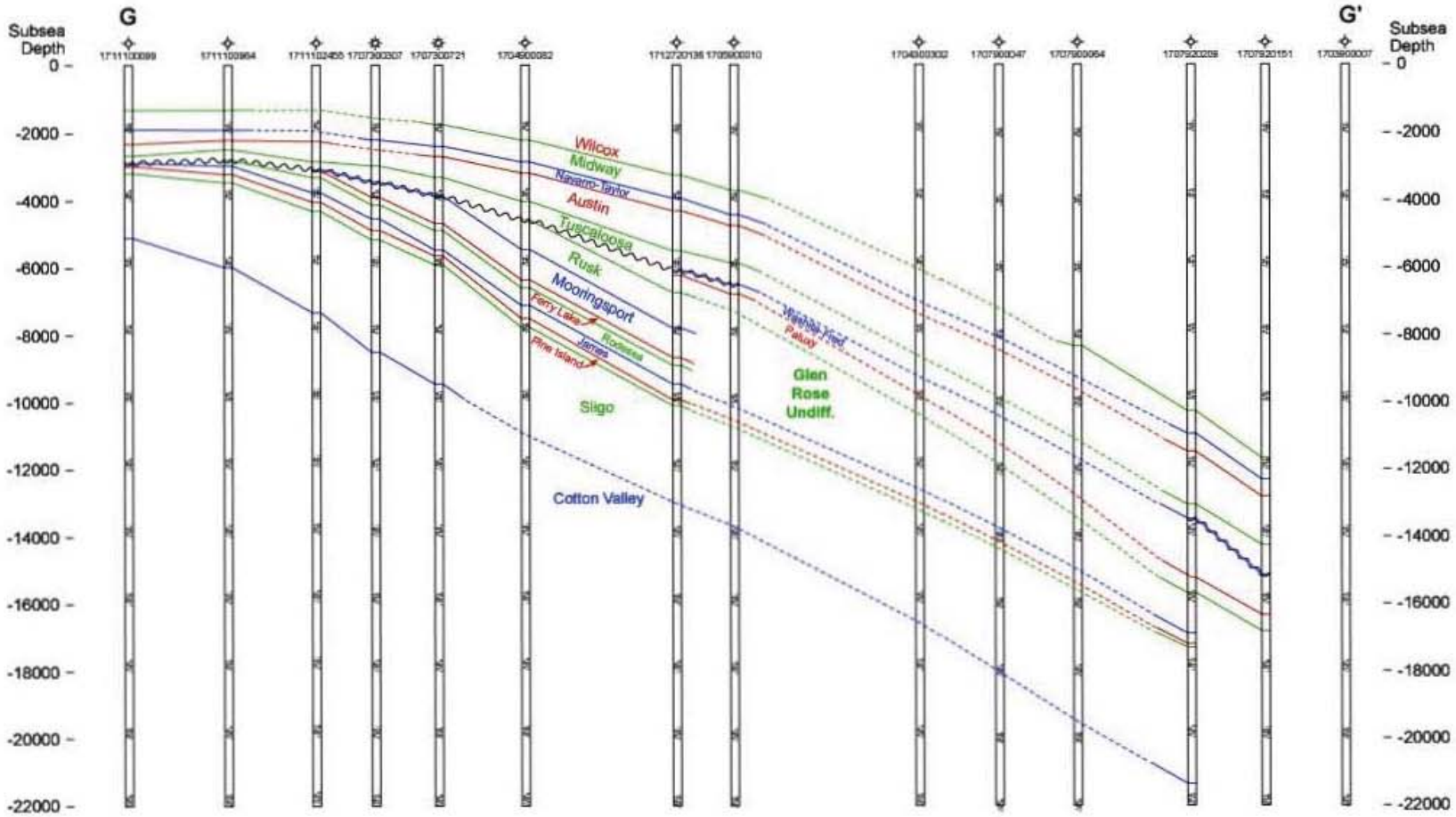

Figure 9. Cross section G-G' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

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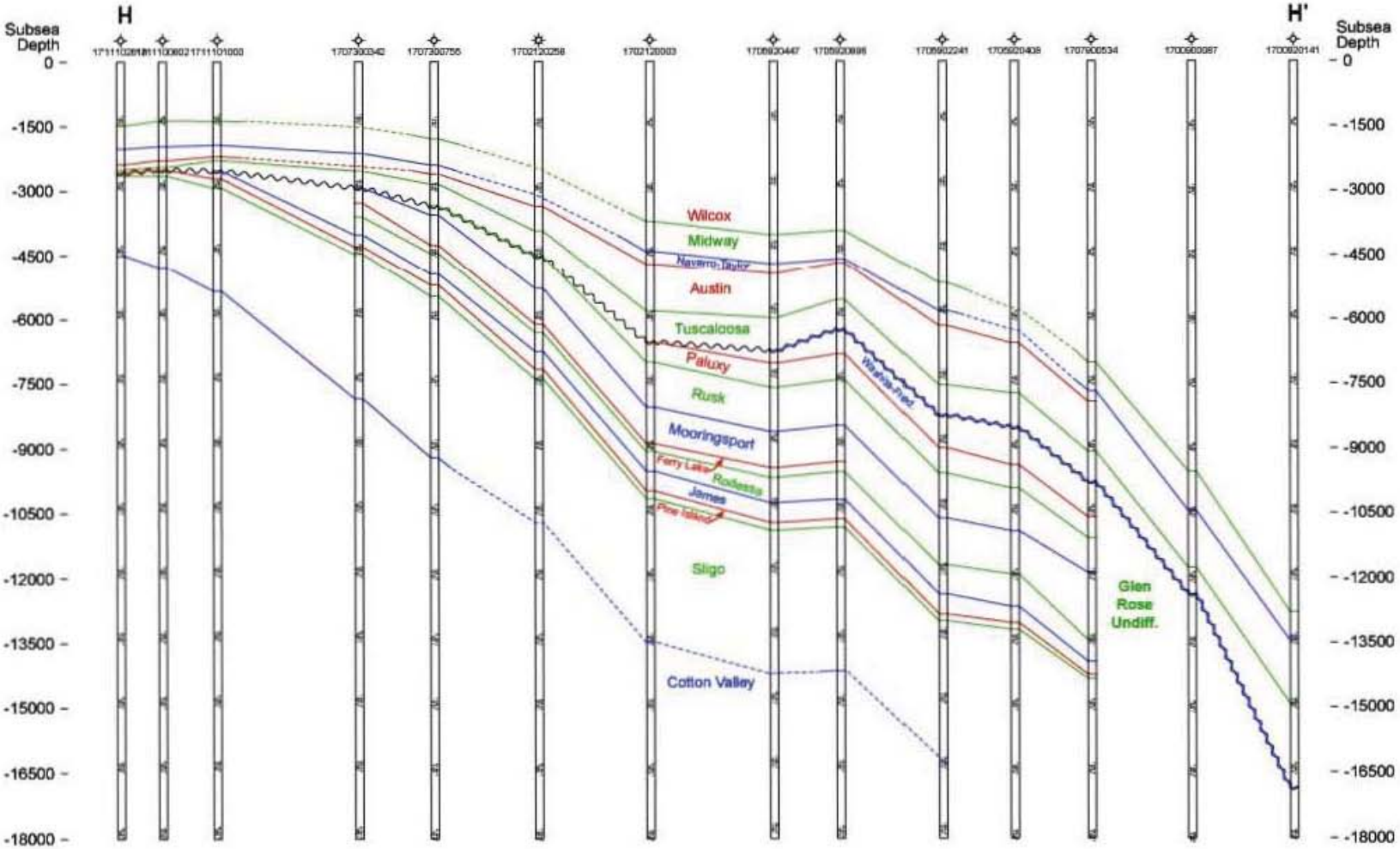

Figure 10. Cross section H-H' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

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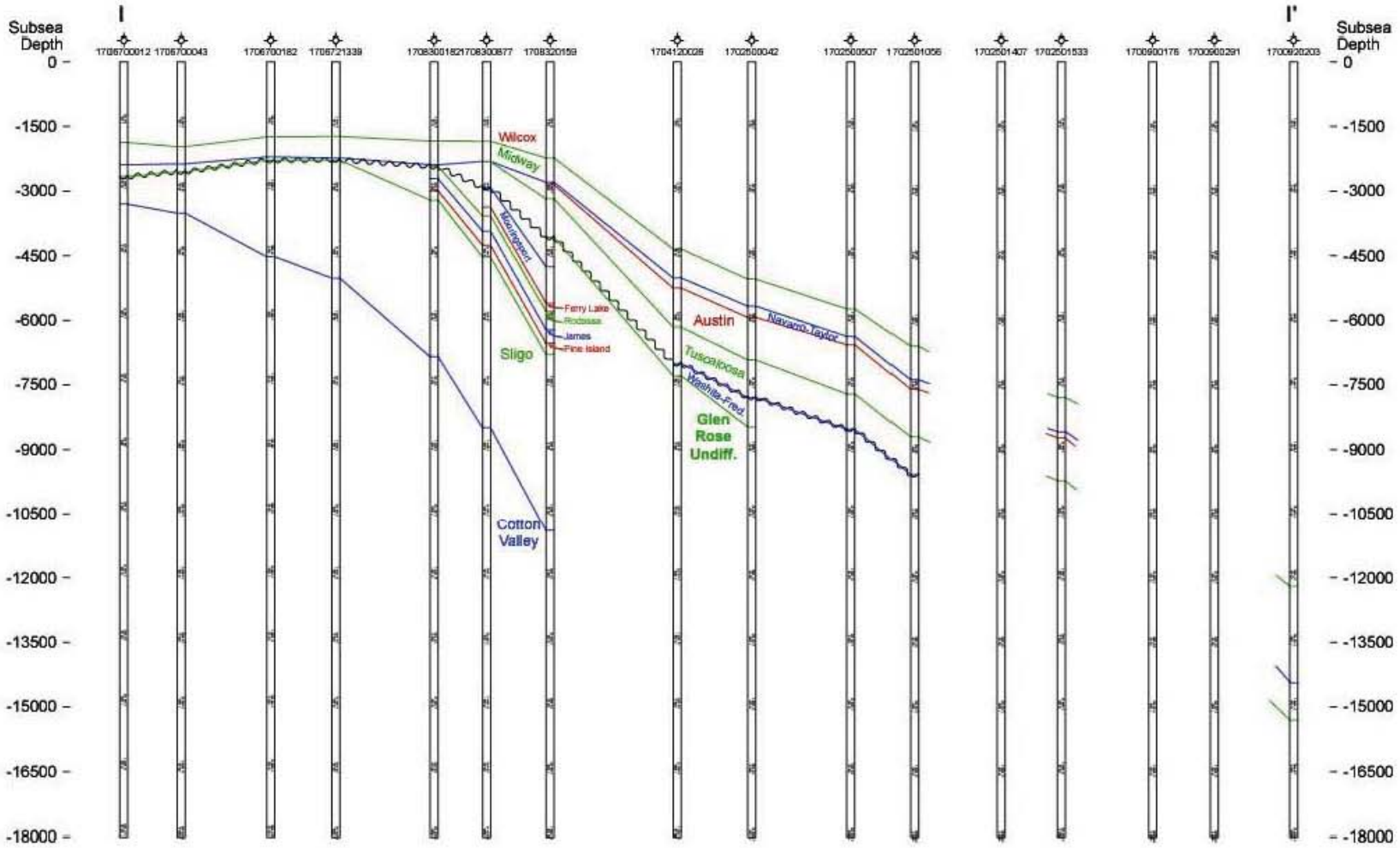

Figure 11. Cross section I-I' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:31X

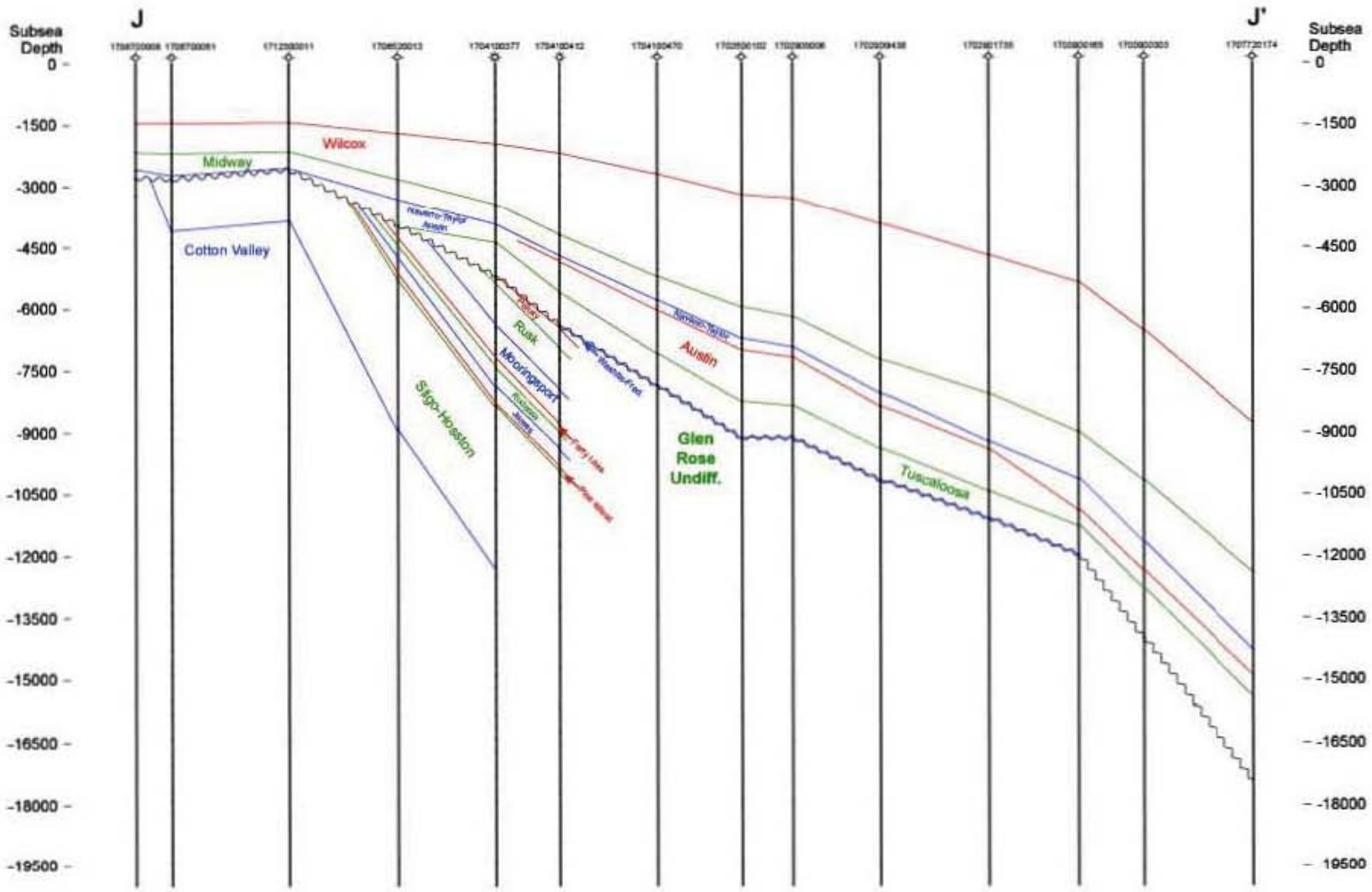

Figure 12. Cross section J-J' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

VE:30X

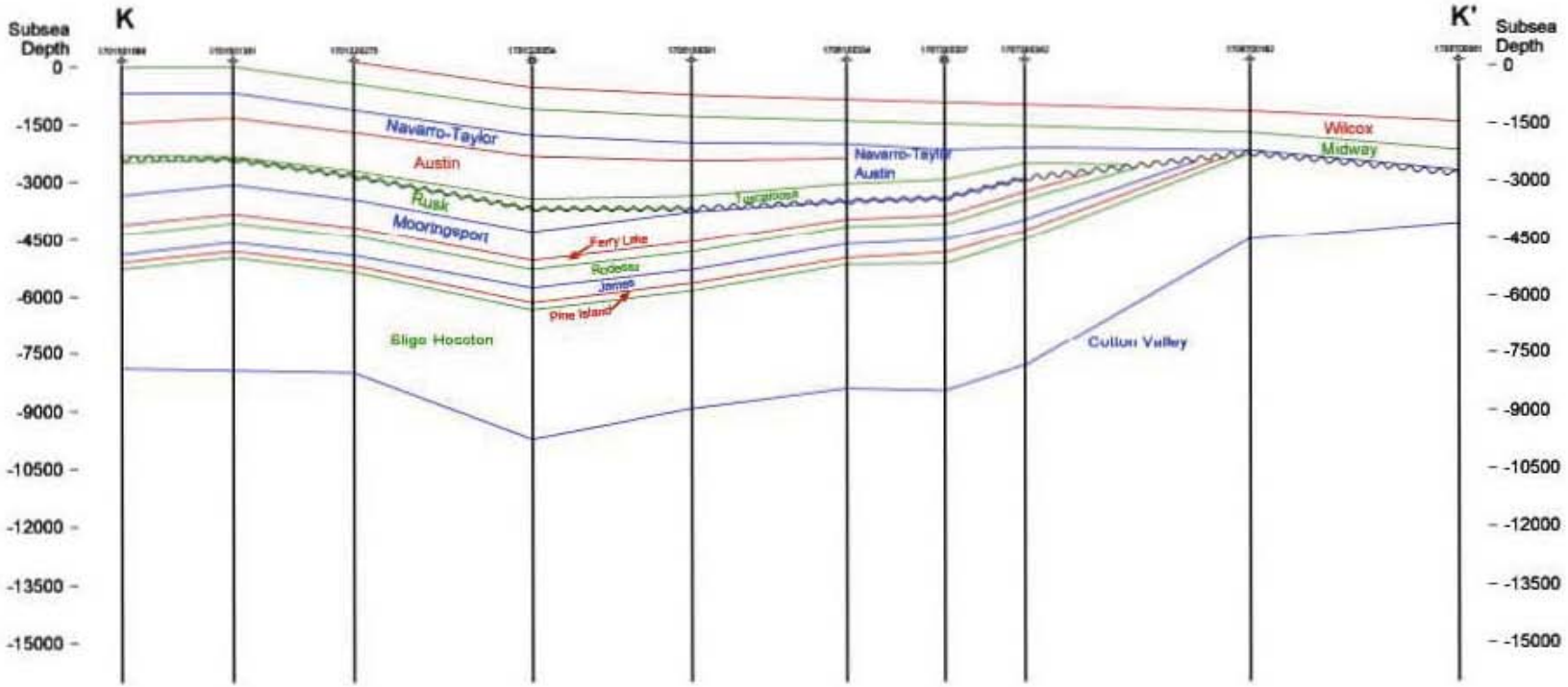

Figure 13. Cross section K-K' for the North Louisiana Salt Basin. See Figure 2 for location of cross section.

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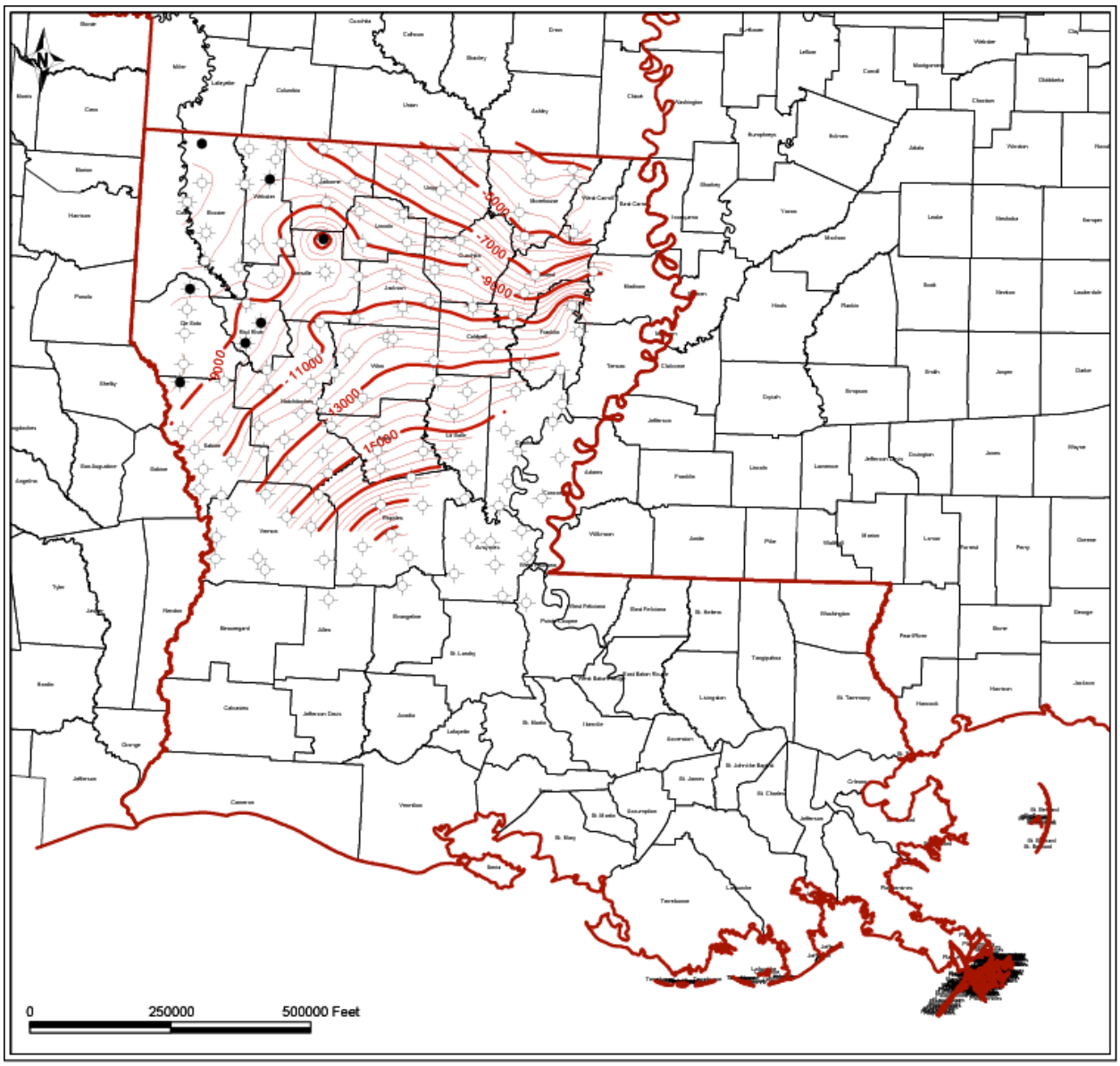


Figure 14. Structure map on the top of the Cotton Valley.
Contour interval = 500 feet

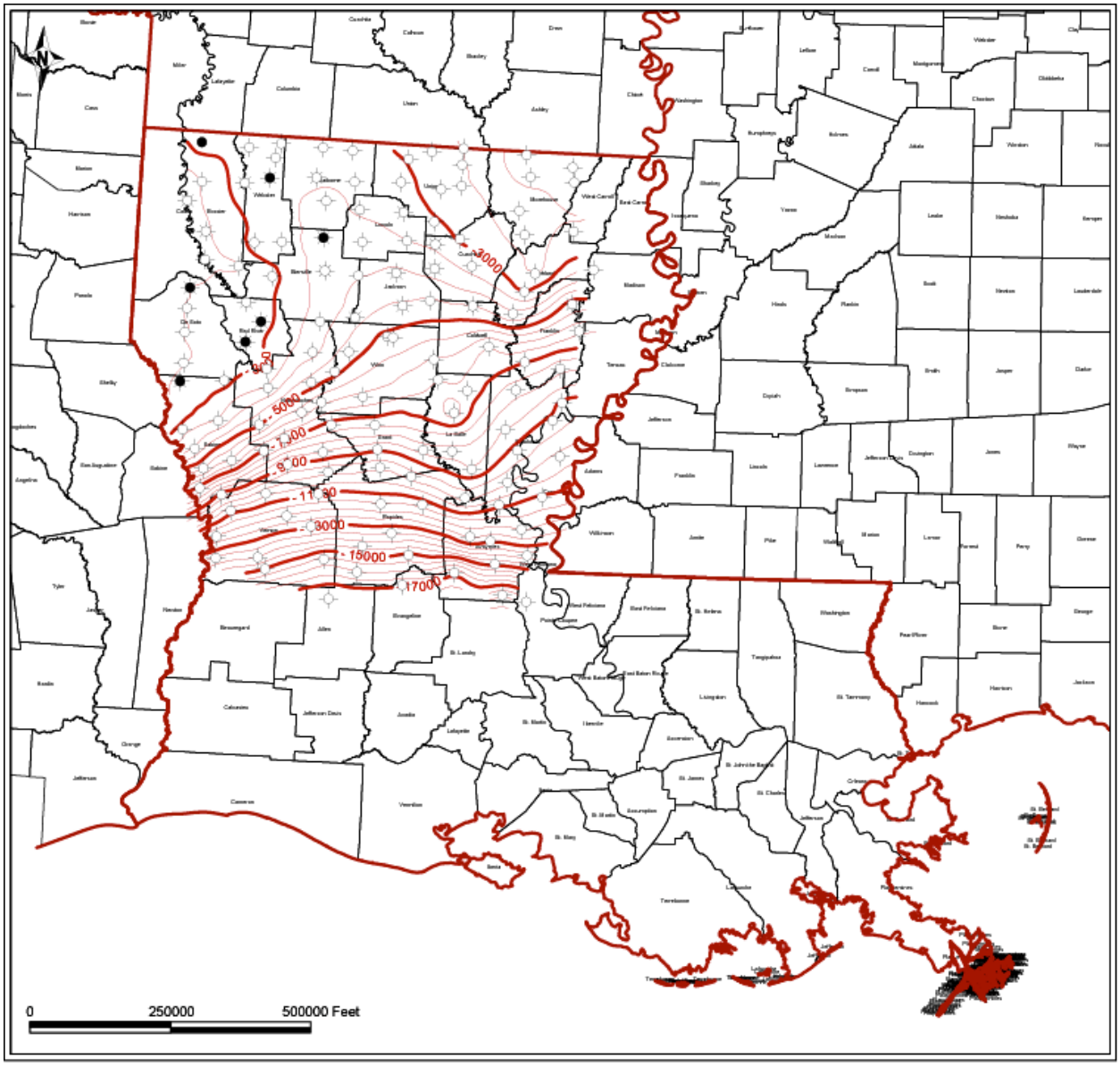


Figure 15. Structure map on the top of the Lower Cretaceous.
Contour interval = 500 feet

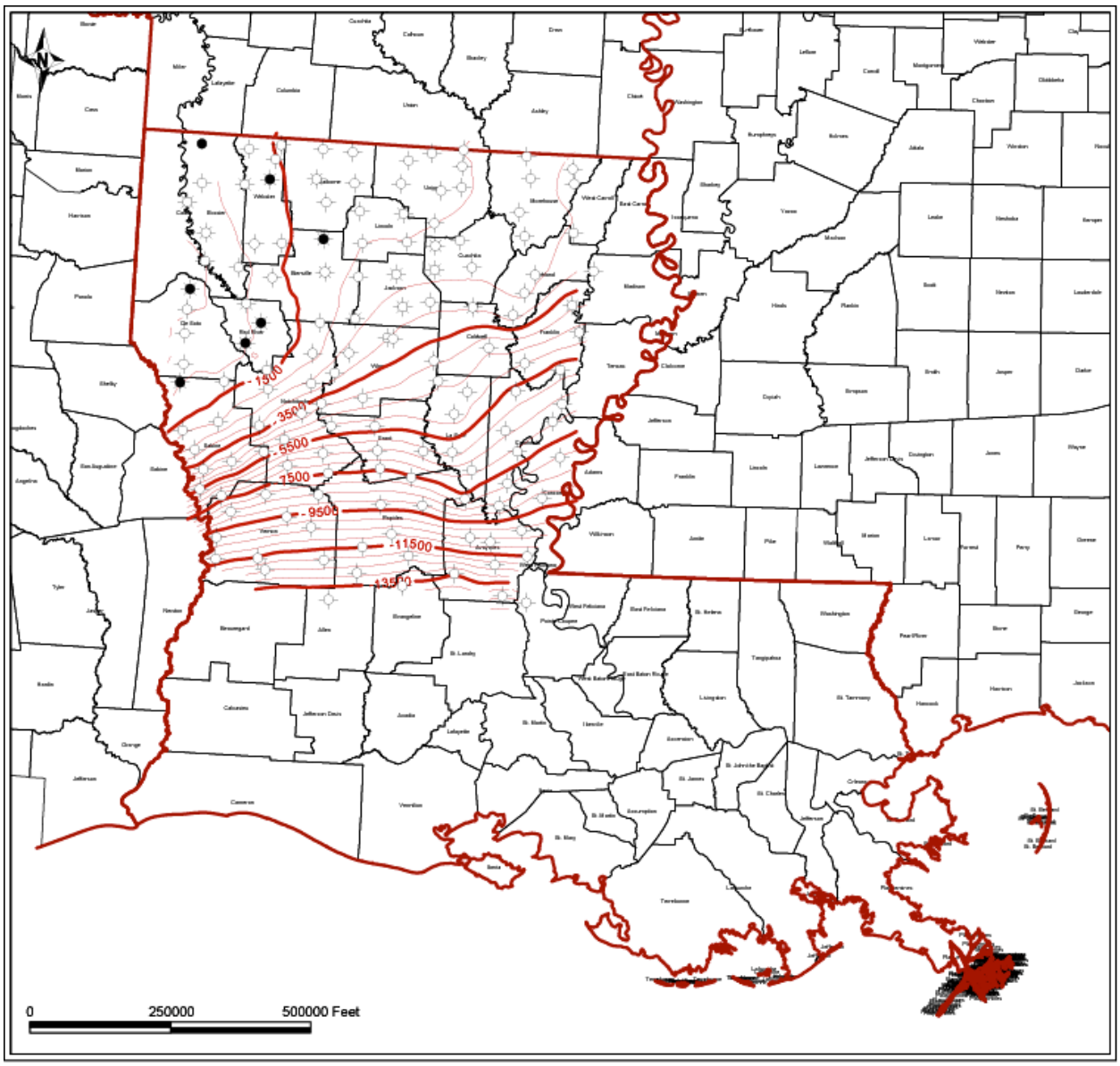


Figure 16. Structure map on the top of the Upper Cretaceous.
Contour interval = 500 feet

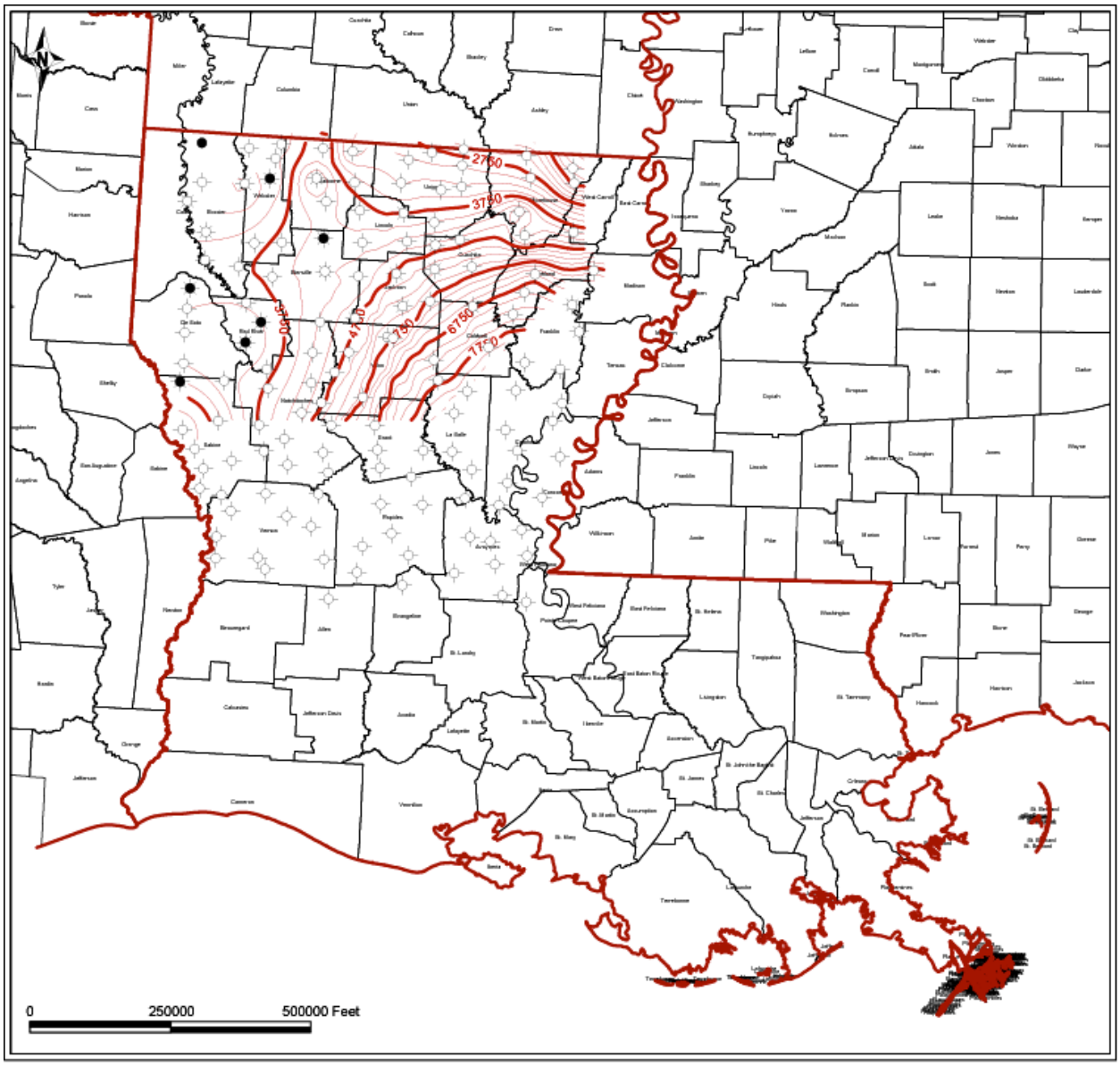


Figure 17. Isopach map of Cotton Valley strata, from the top of the Smackover to the top of the Cotton Valley.

Contour Interval = 250 feet

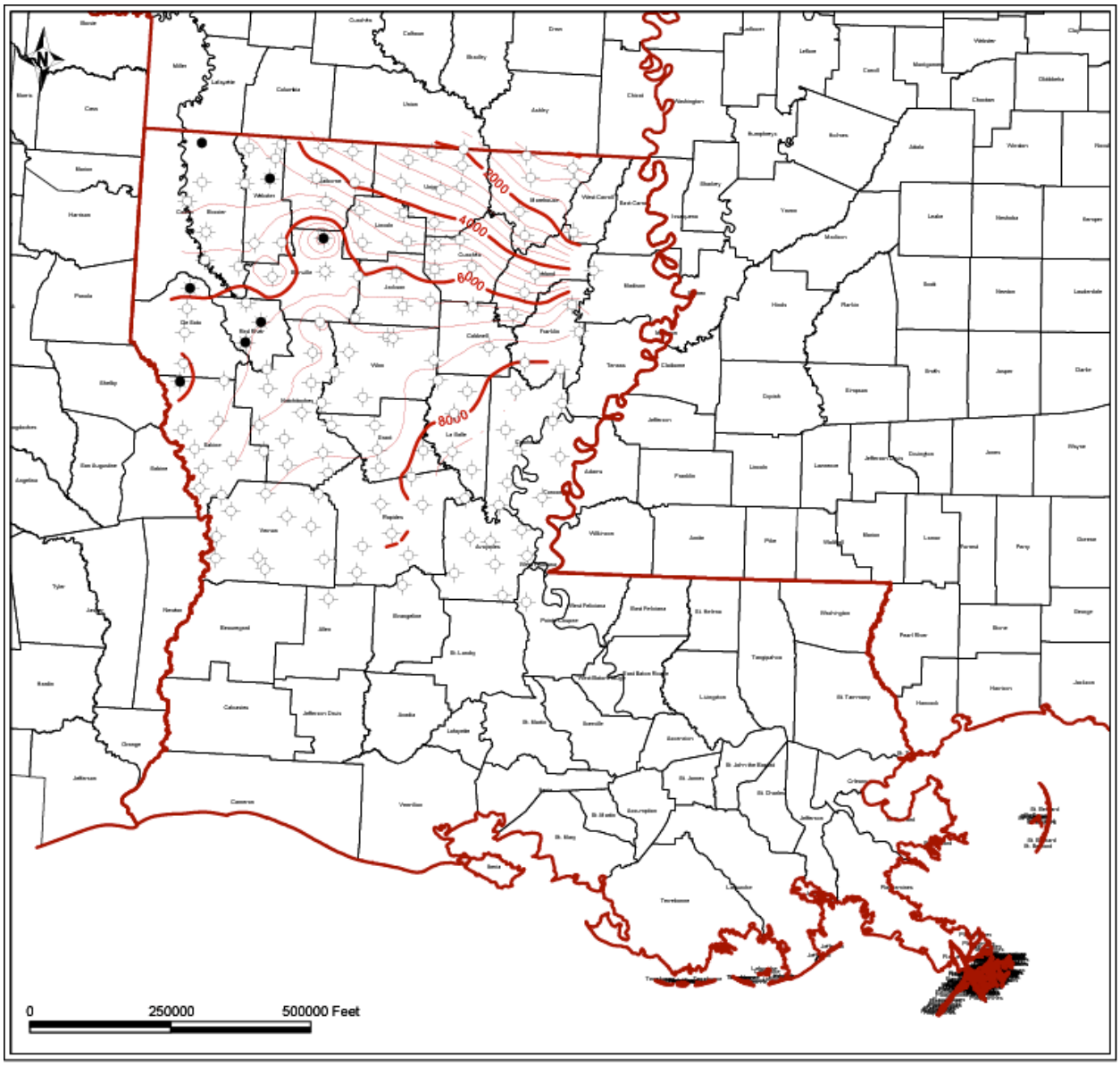


Figure 18. Isopach map of Lower Cretaceous strata, from the top of the Cotton Valley to the top of the Lower Cretaceous.

Contour Interval = 500 feet

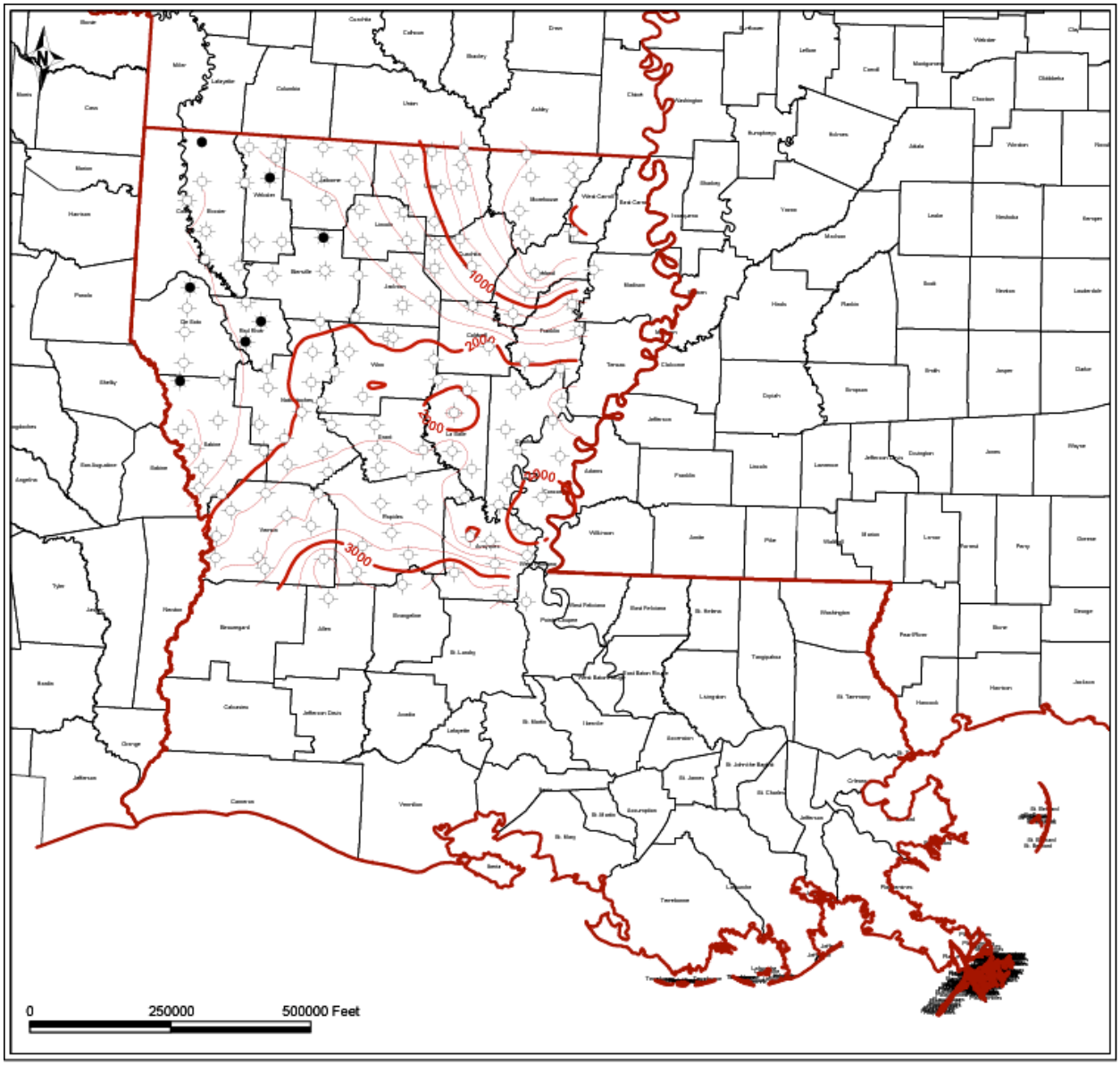


Figure 19. Isopach map of Upper Cretaceous strata, from the top of the Lower Cretaceous to the top of the Upper Cretaceous.

Contour Interval = 250 feet

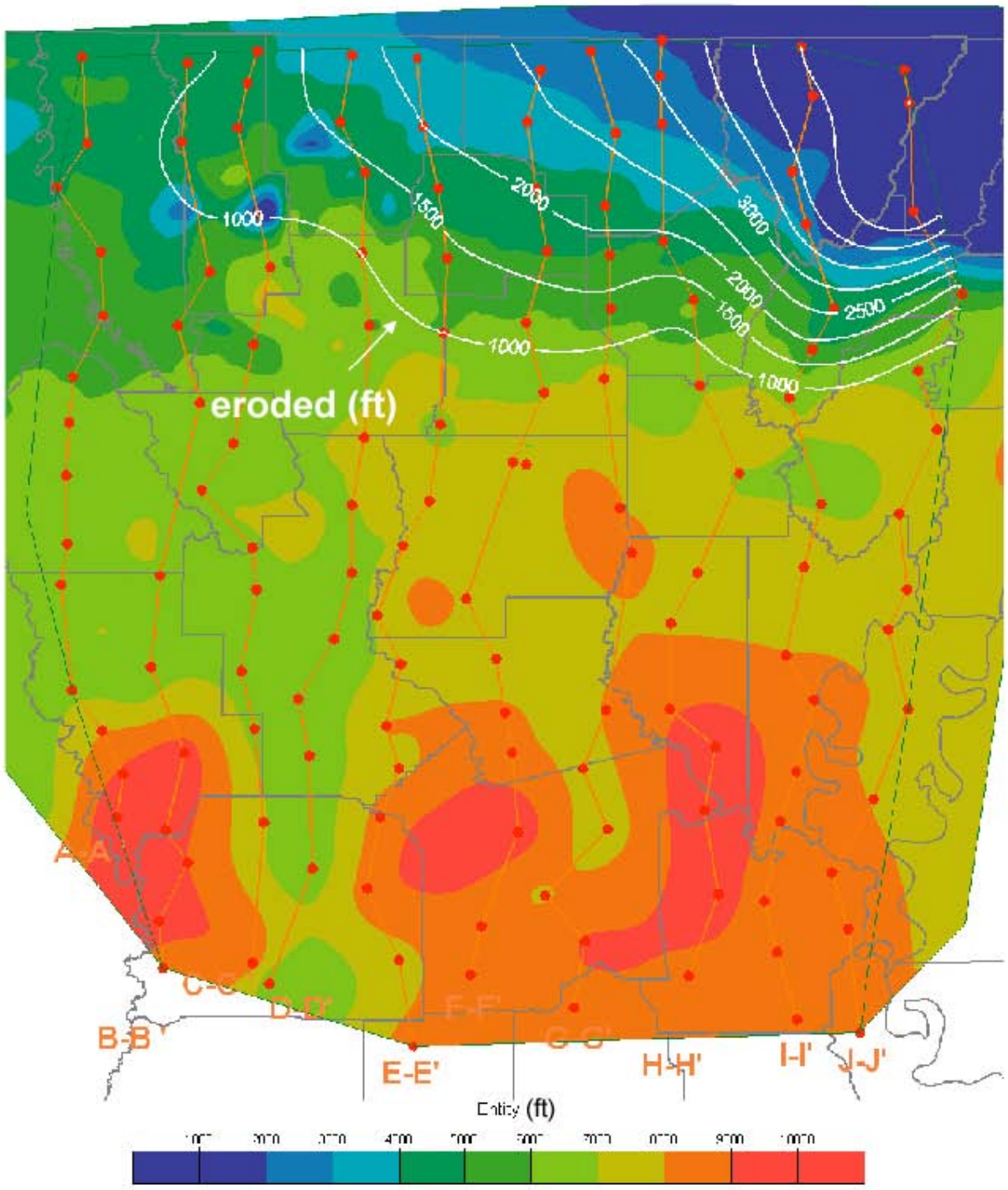


Figure 20. Erosion thickness of total Lower Cretaceous section. Prepared by Roger Barnaby.

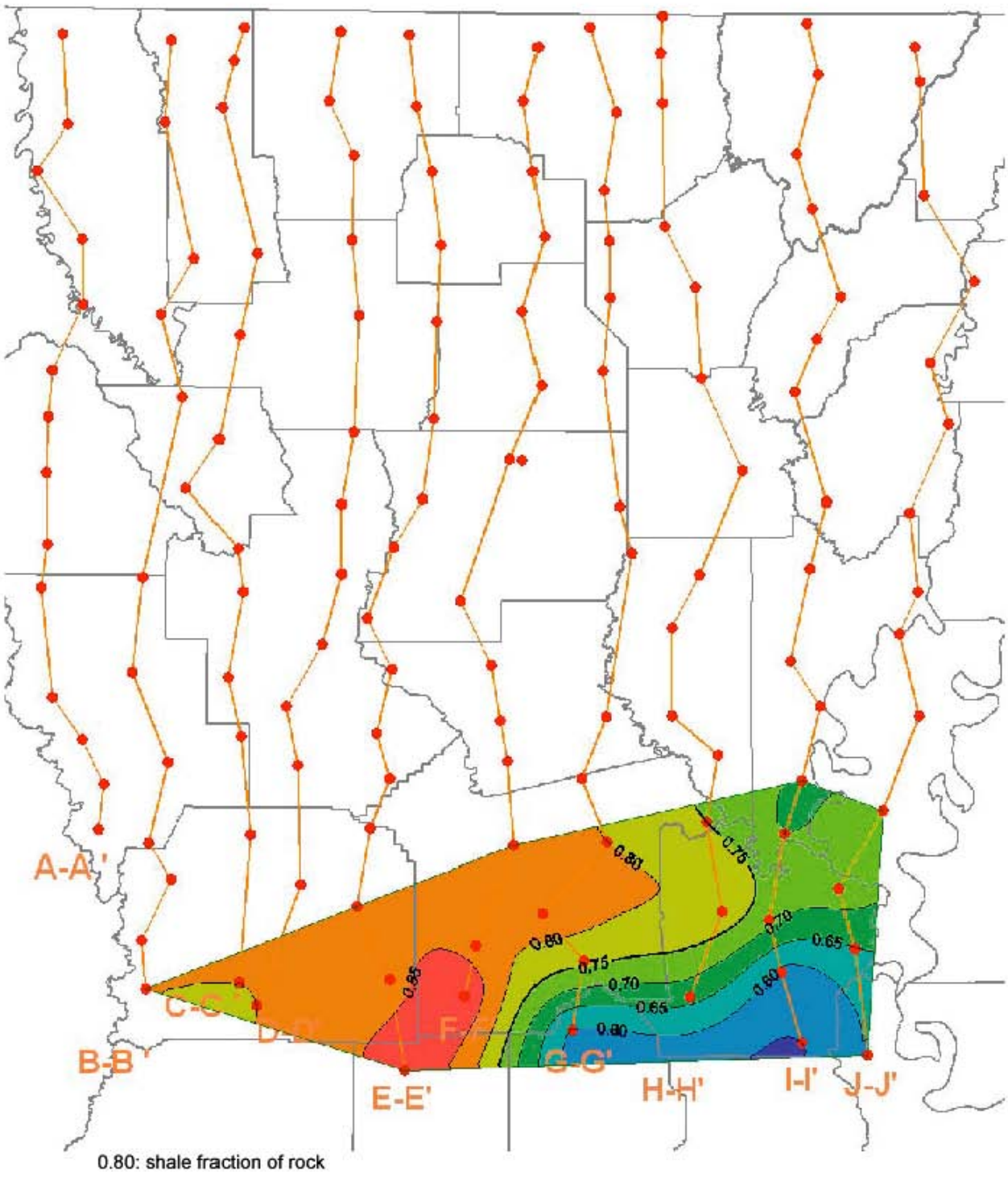


Figure 21. Lithology map of Miocene strata. Prepared by Roger Barnaby.

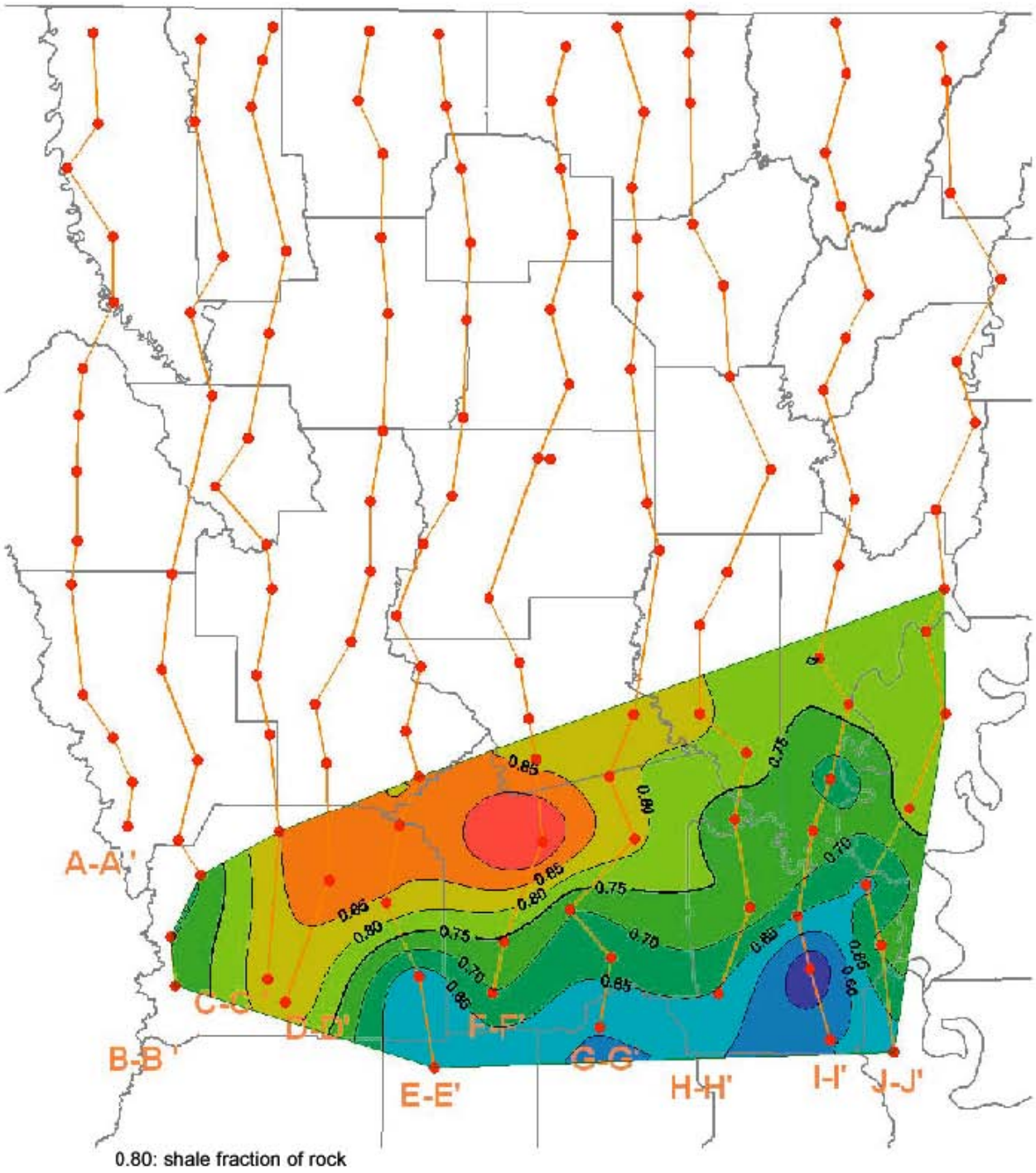


Figure 22. Lithology map of Oligocene strata. Prepared by Roger Barnaby.

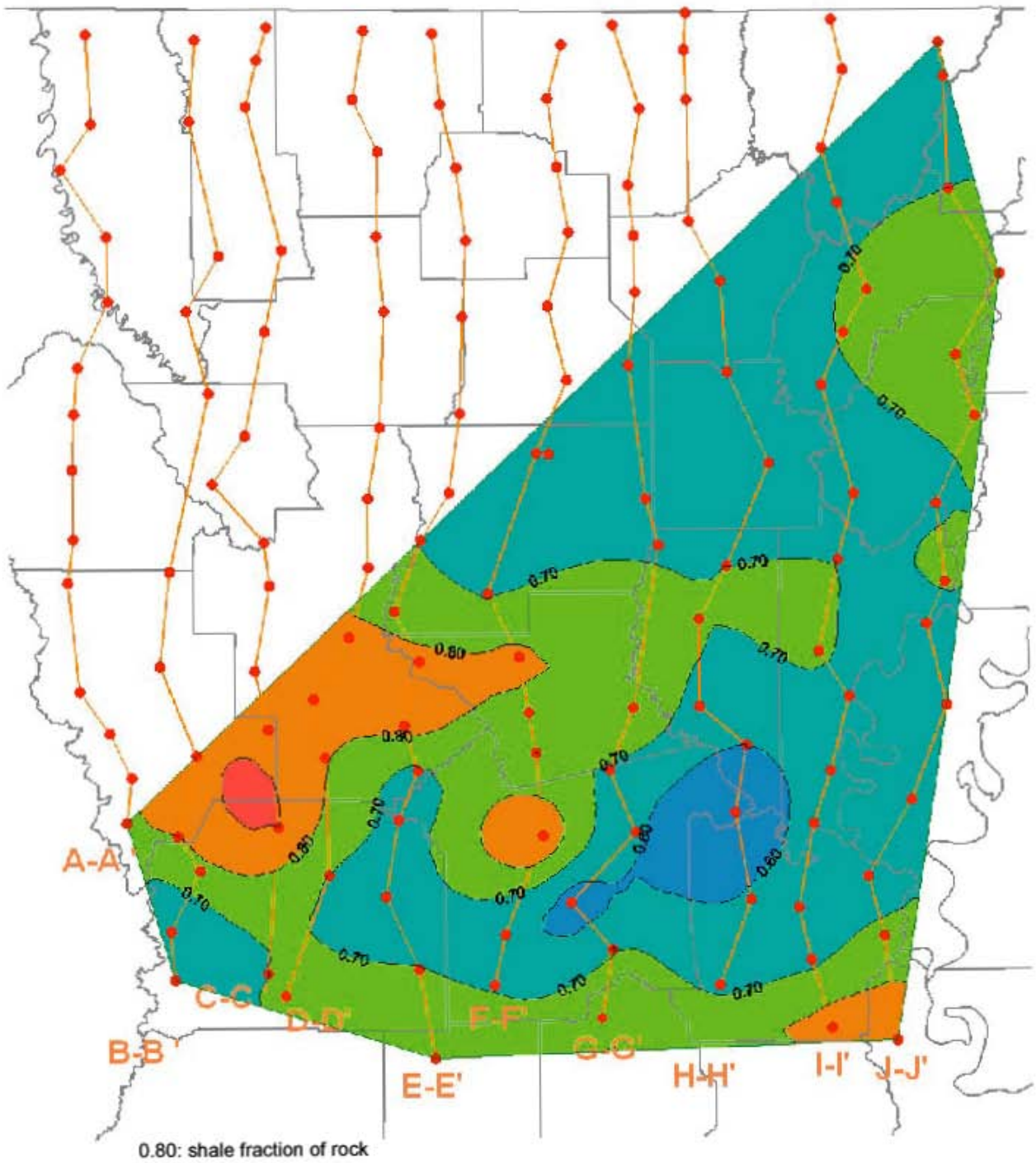


Figure 23. Lithology map of Cockfield. Prepared by Roger Barnaby.

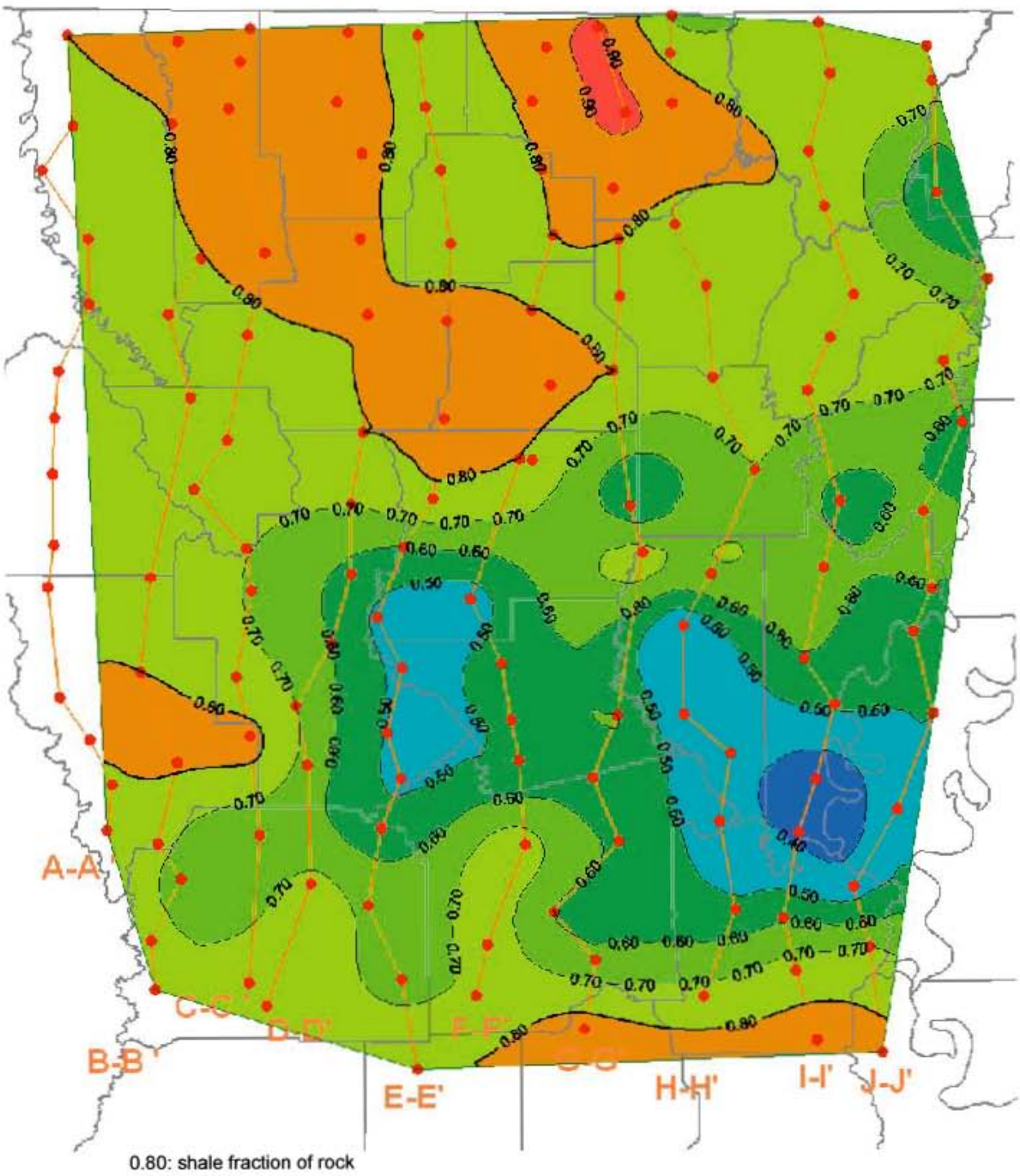


Figure 24. Lithology map of Sparta. Prepared by Roger Barnaby.

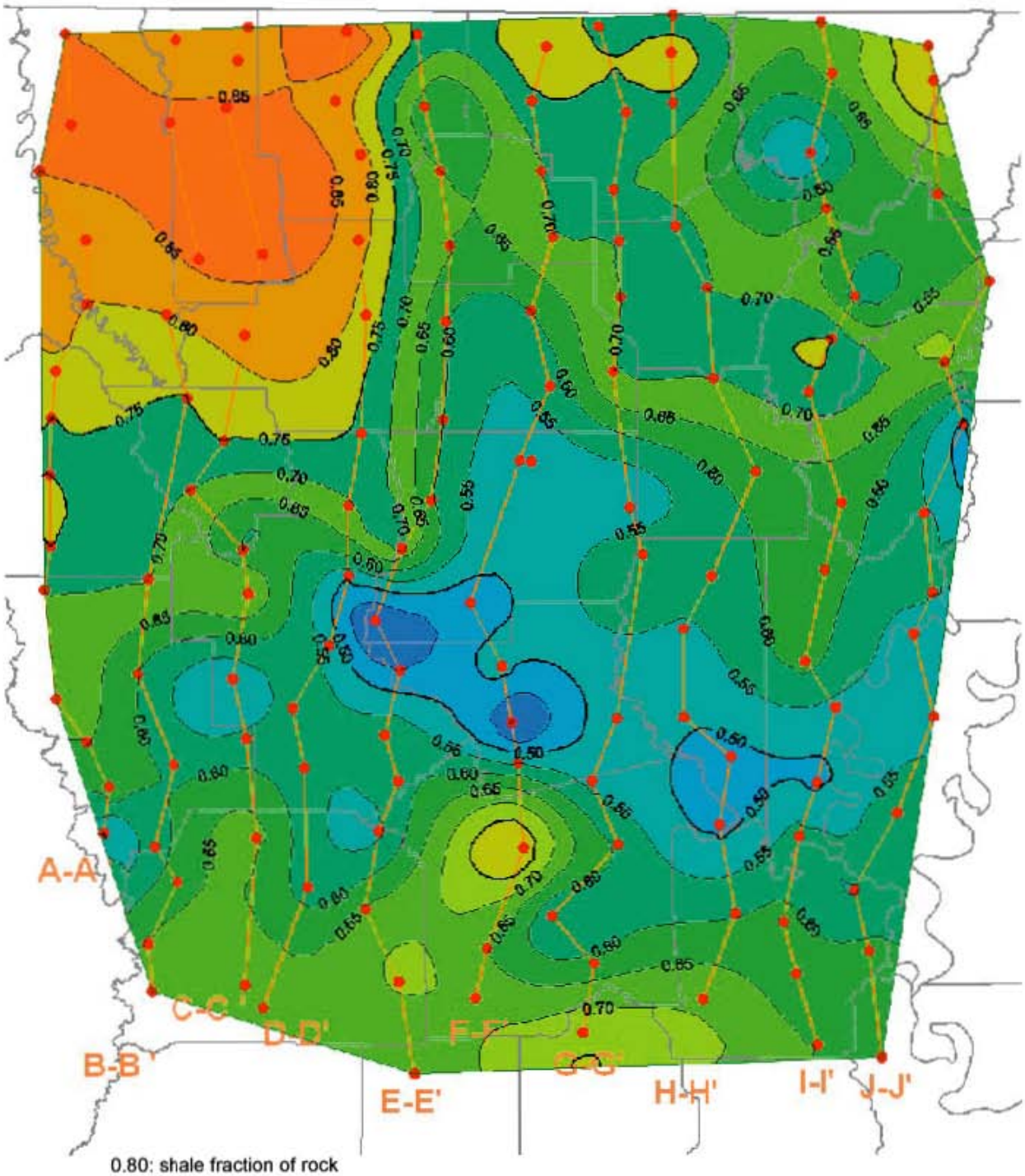


Figure 25. Lithology map of Wilcox. Prepared by Roger Barnaby.

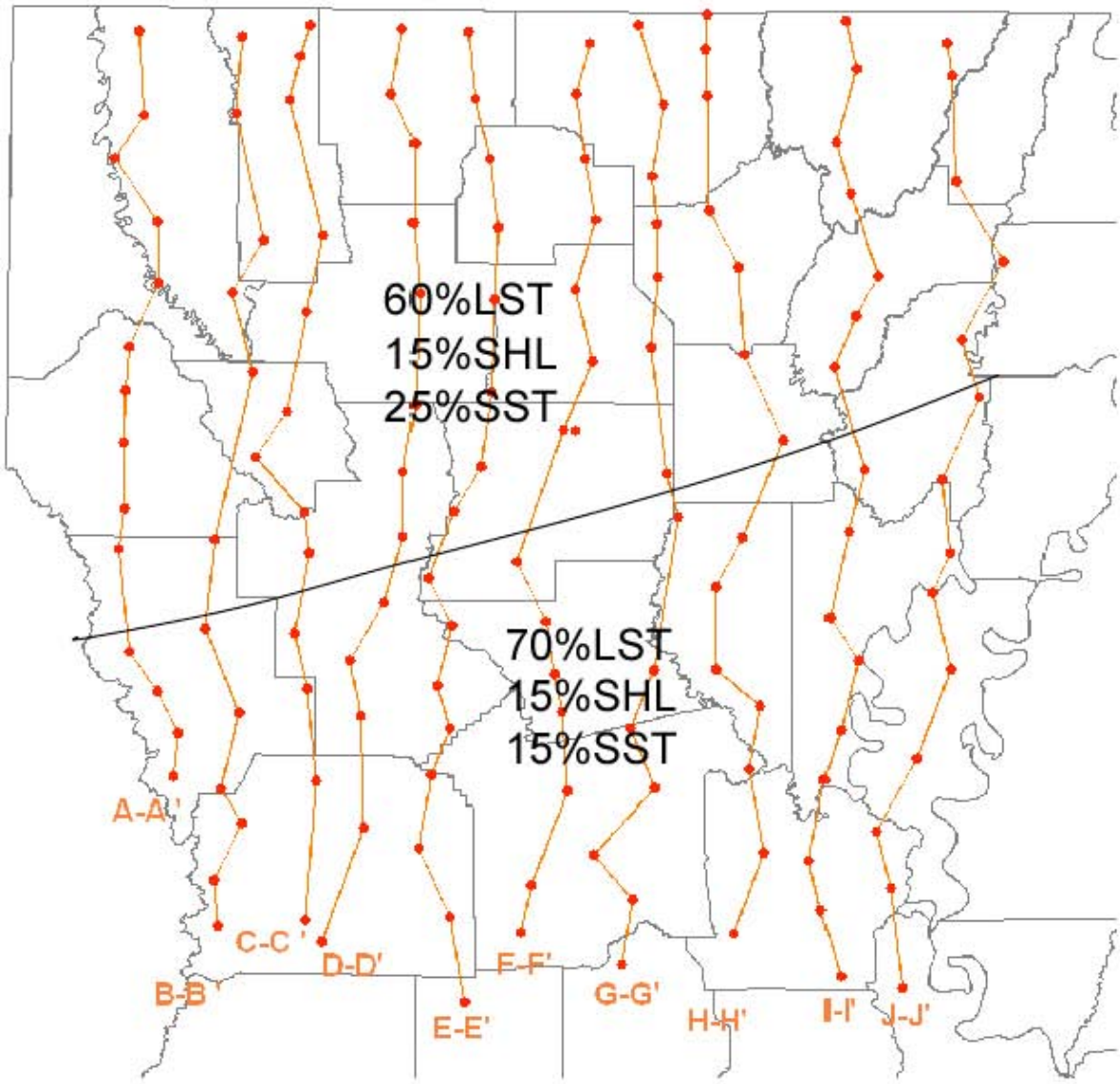


Figure 26. Lithology map of Upper Cretaceous strata. Prepared by Roger Barnaby.

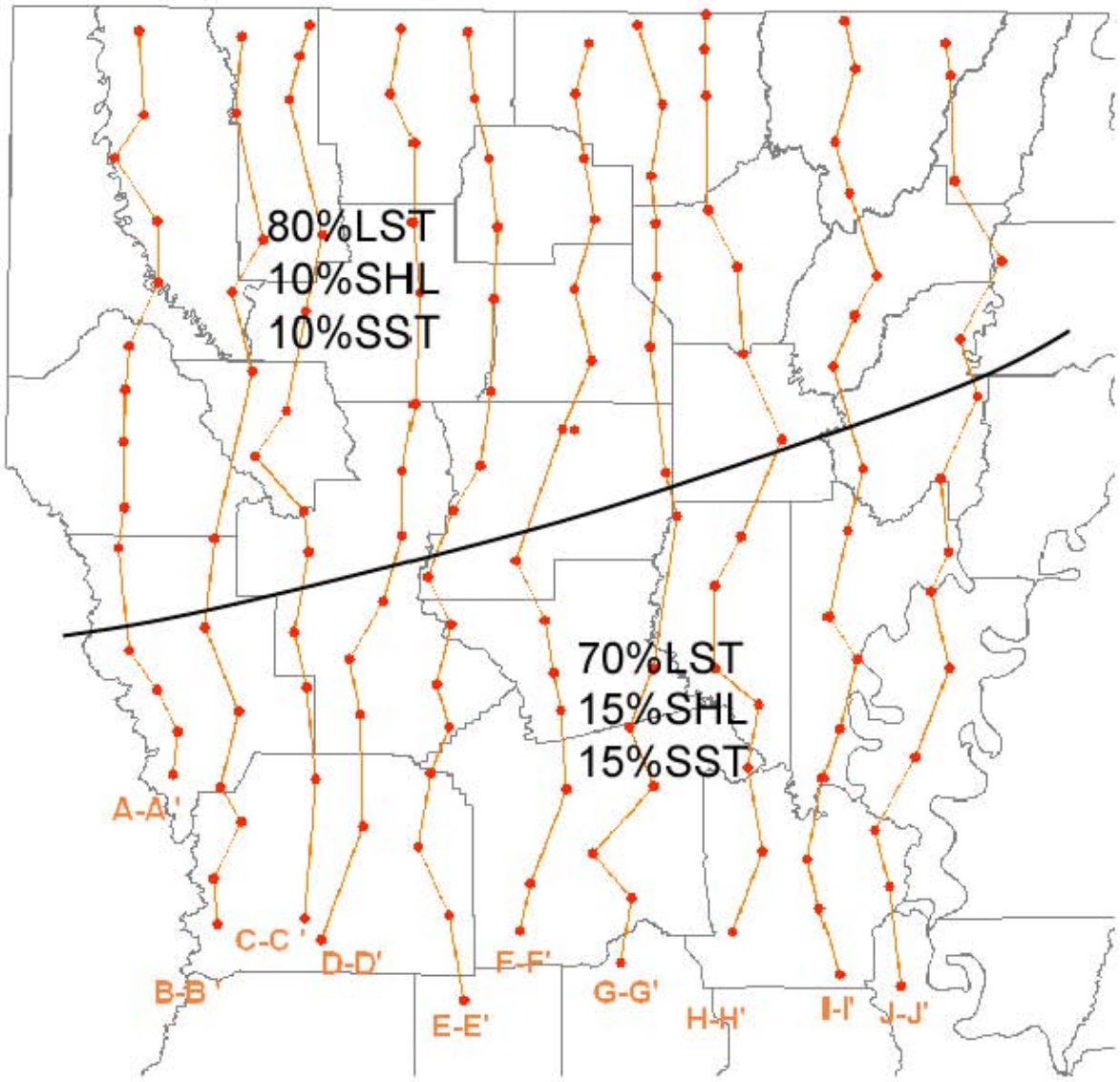
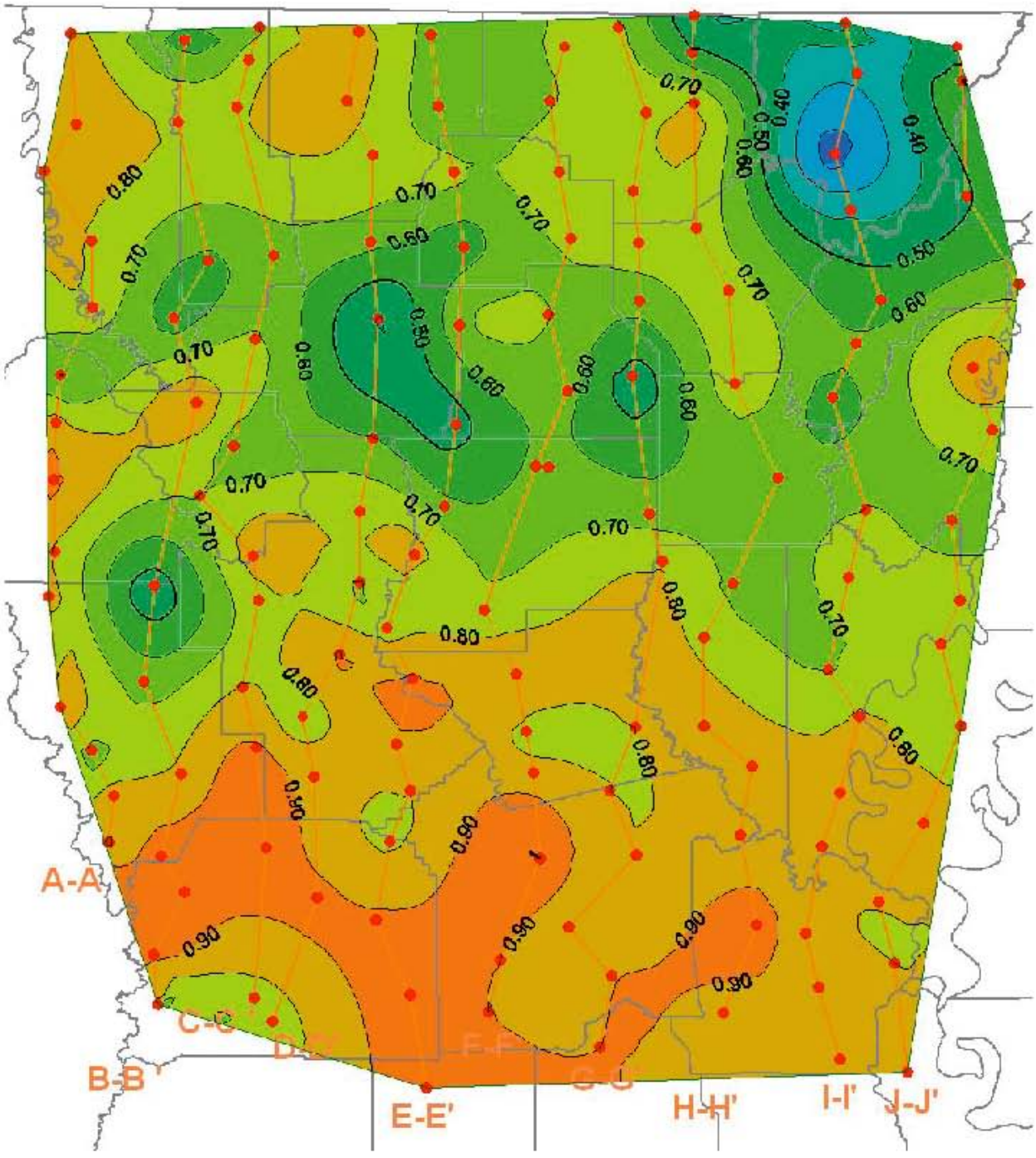


Figure 27. Lithology map of Austin. Prepared by Roger Barnaby.



0.80: shale fraction of rock

Figure 28. Lithology map of Tuscaloosa. Prepared by Roger Barnaby.

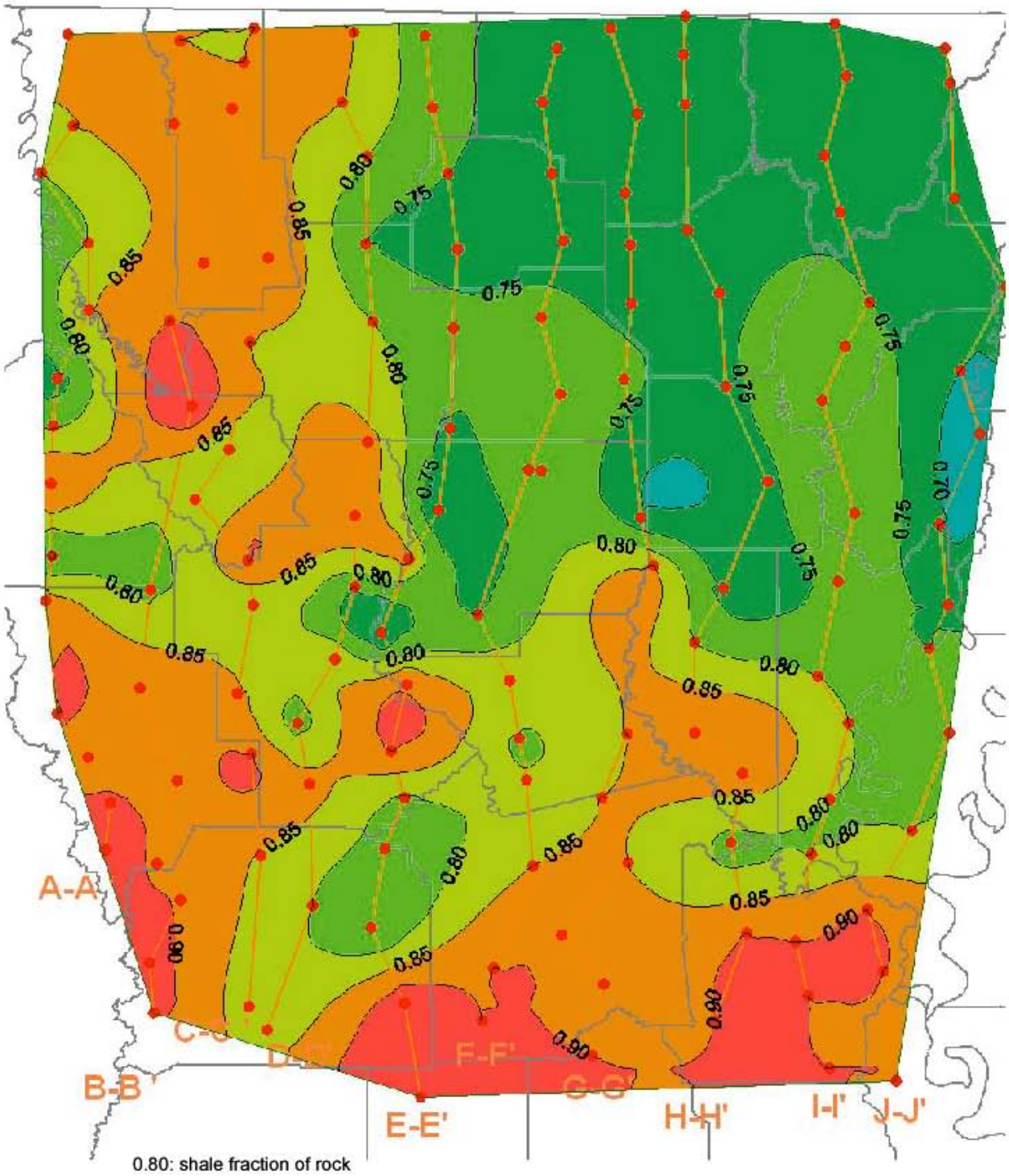


Figure 29. Lithology map of Paluxy. Prepared by Roger Barnaby.

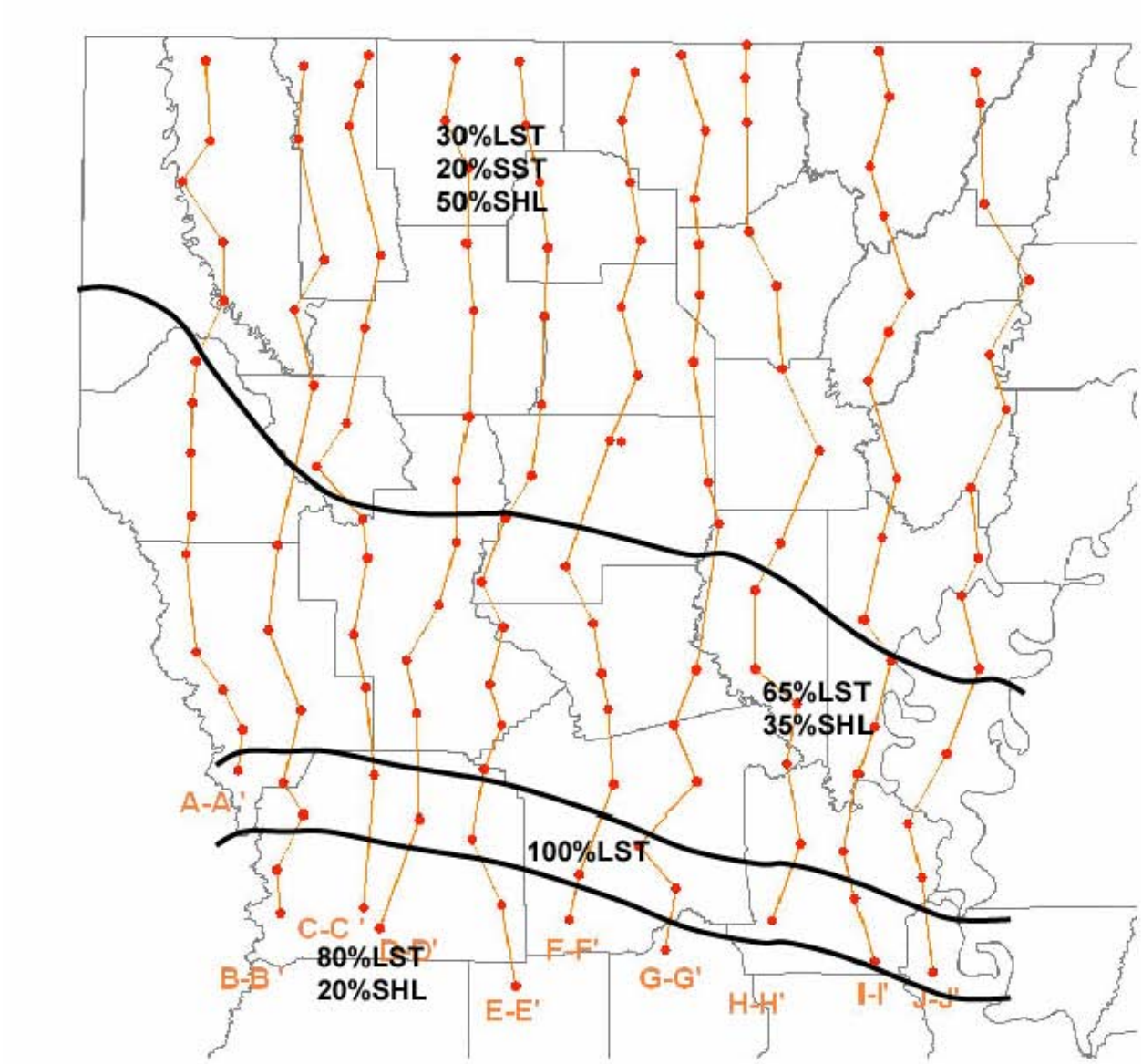


Figure 30. Lithology map of Upper Glen Rose. Prepared by Roger Barnaby.

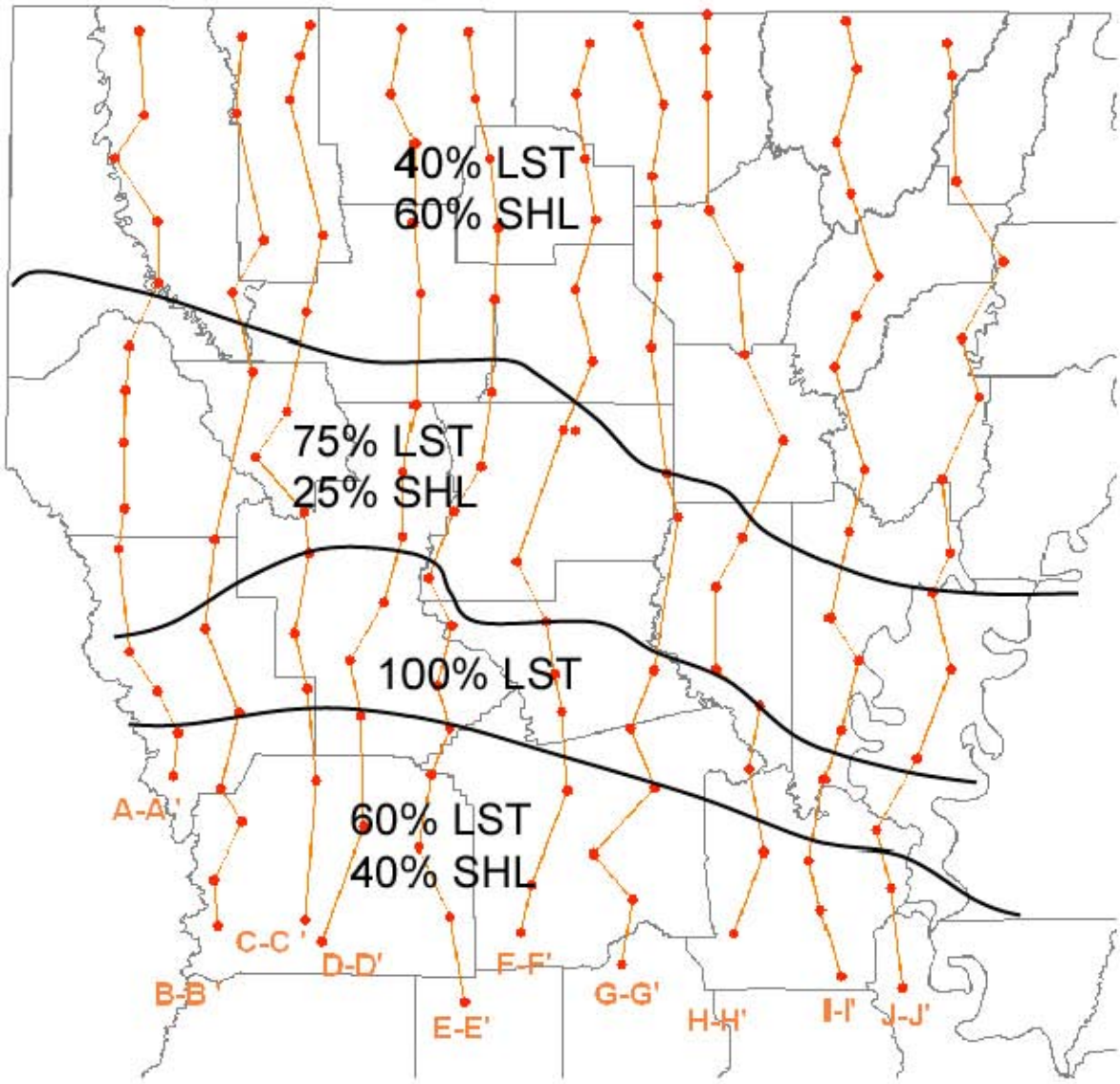


Figure 31. Lithology map of Mooringsport. Prepared by Roger Barnaby.

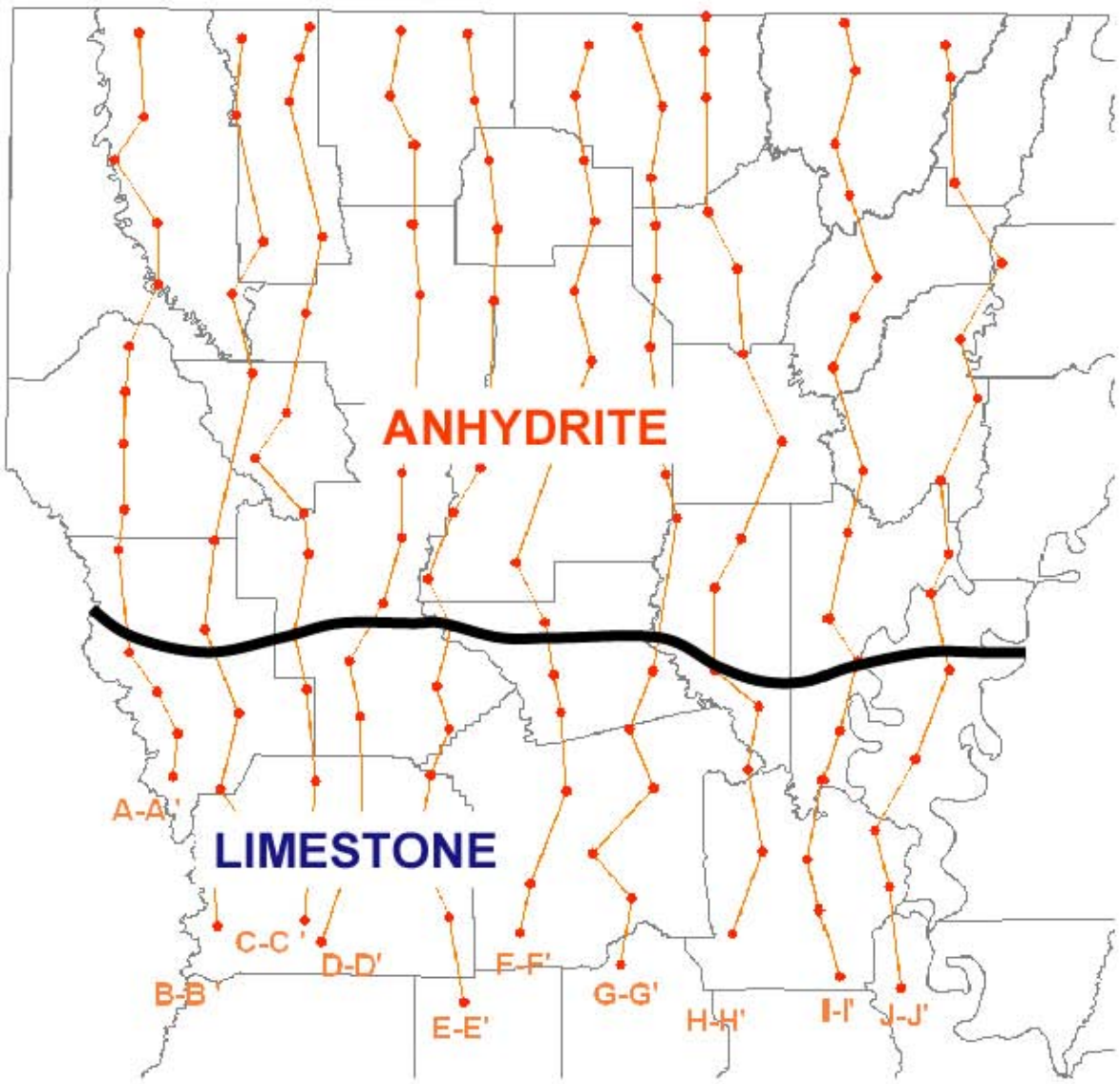


Figure 32. Lithology map of Ferry Lake. Prepared by Roger Barnaby.

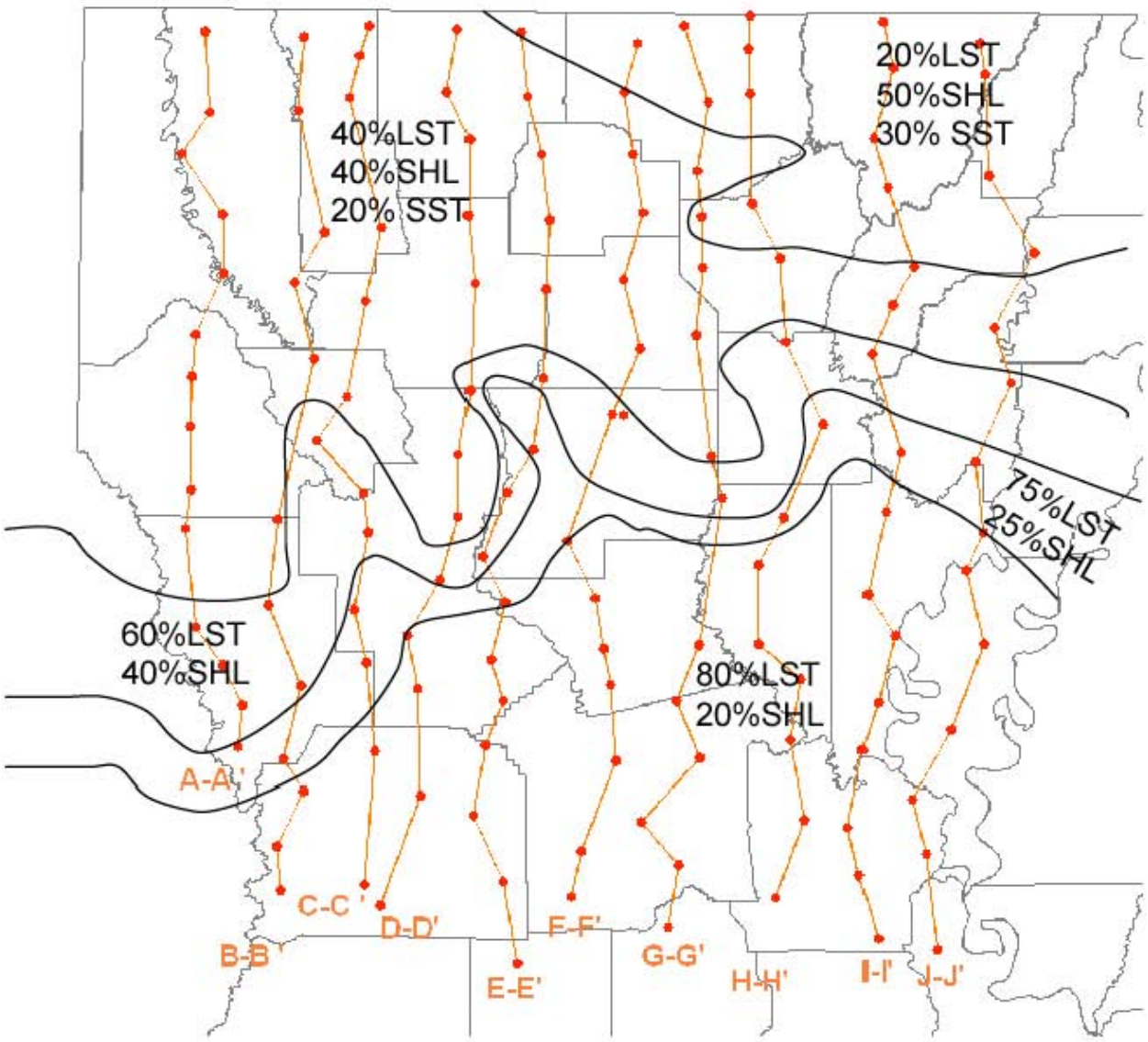


Figure 33. Lithology map of Rodessa. Prepared by Roger Barnaby.

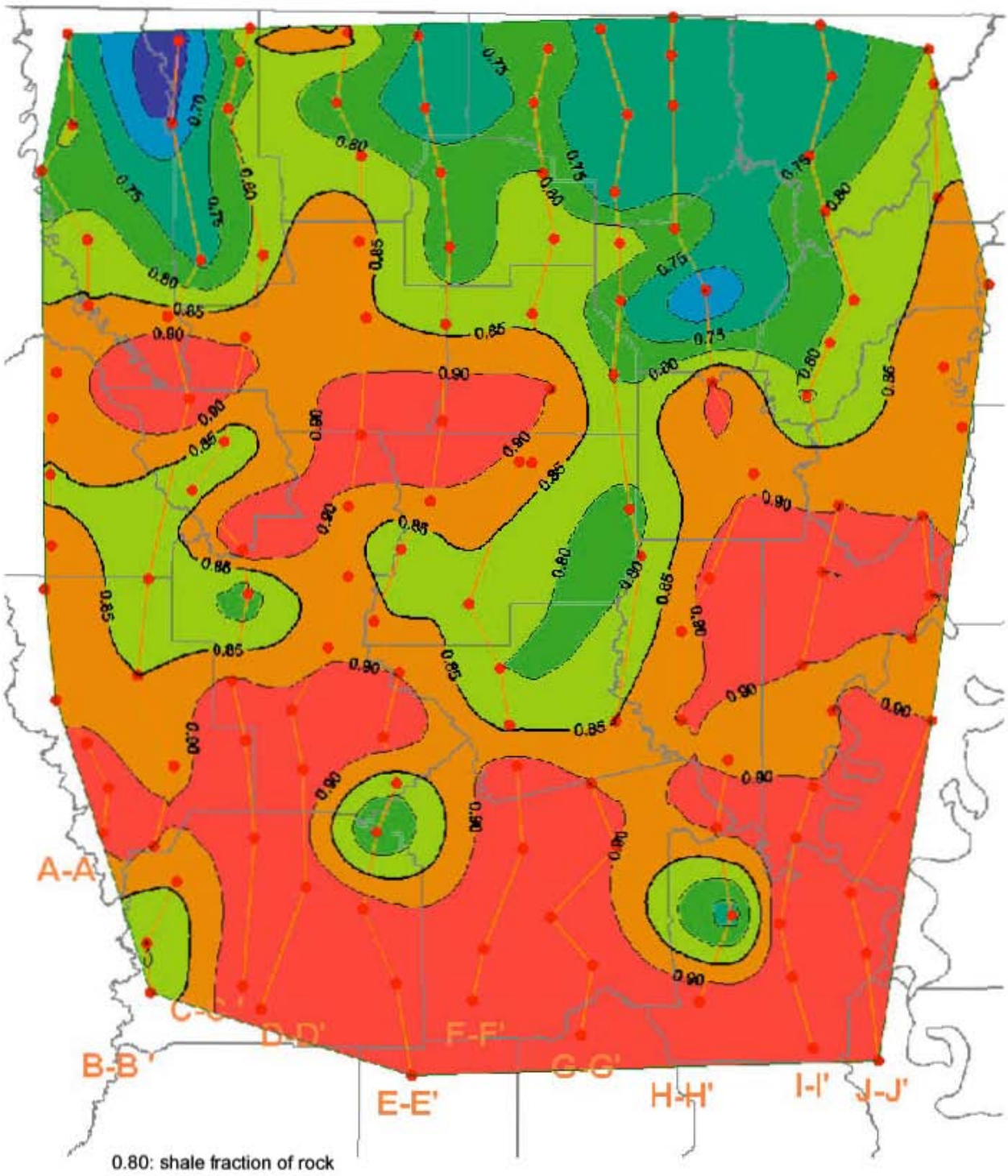


Figure 34. Lithology map of Bexar. Prepared by Roger Barnaby.

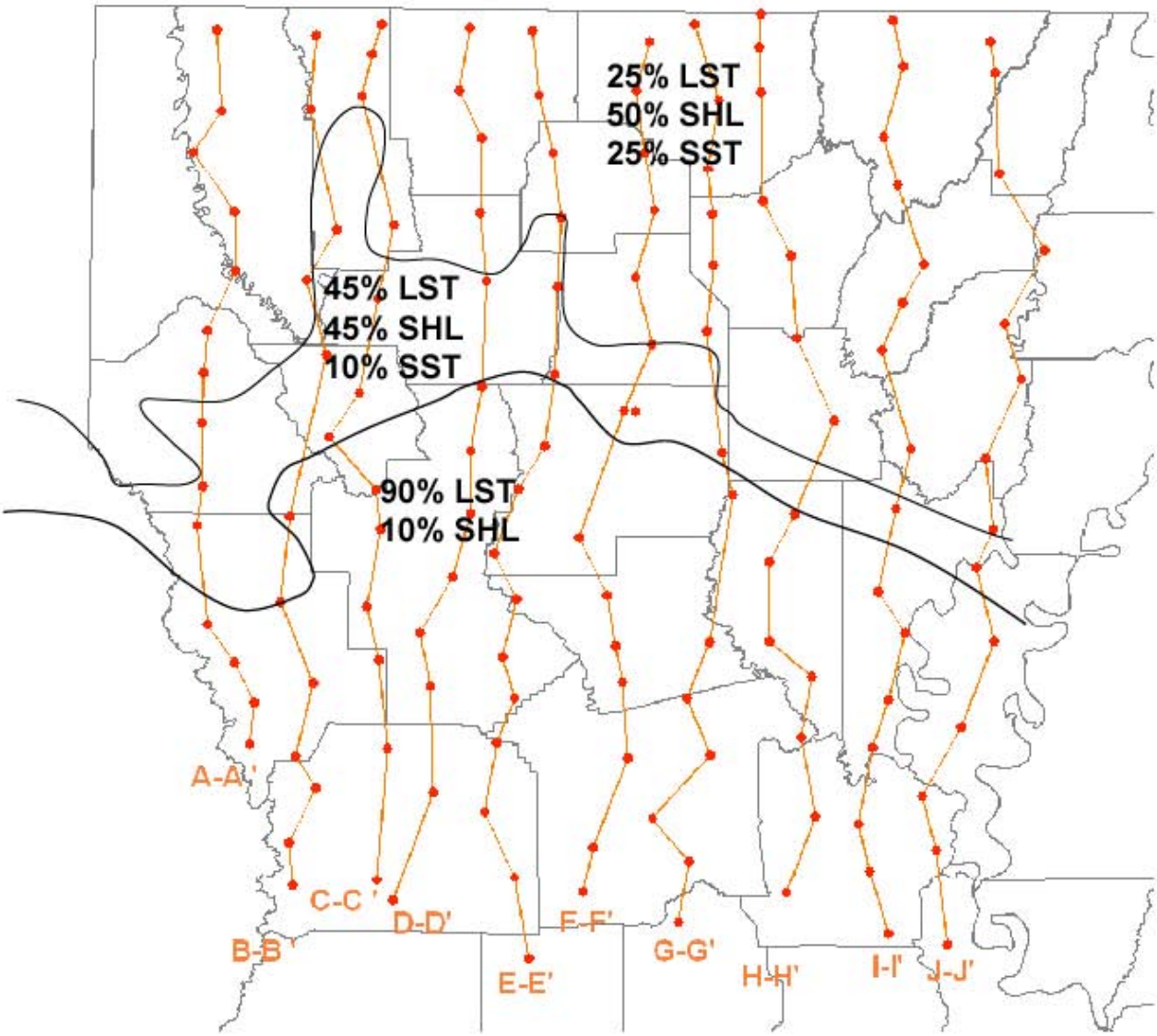


Figure 35. Lithology map of James. Prepared by Roger Barnaby.

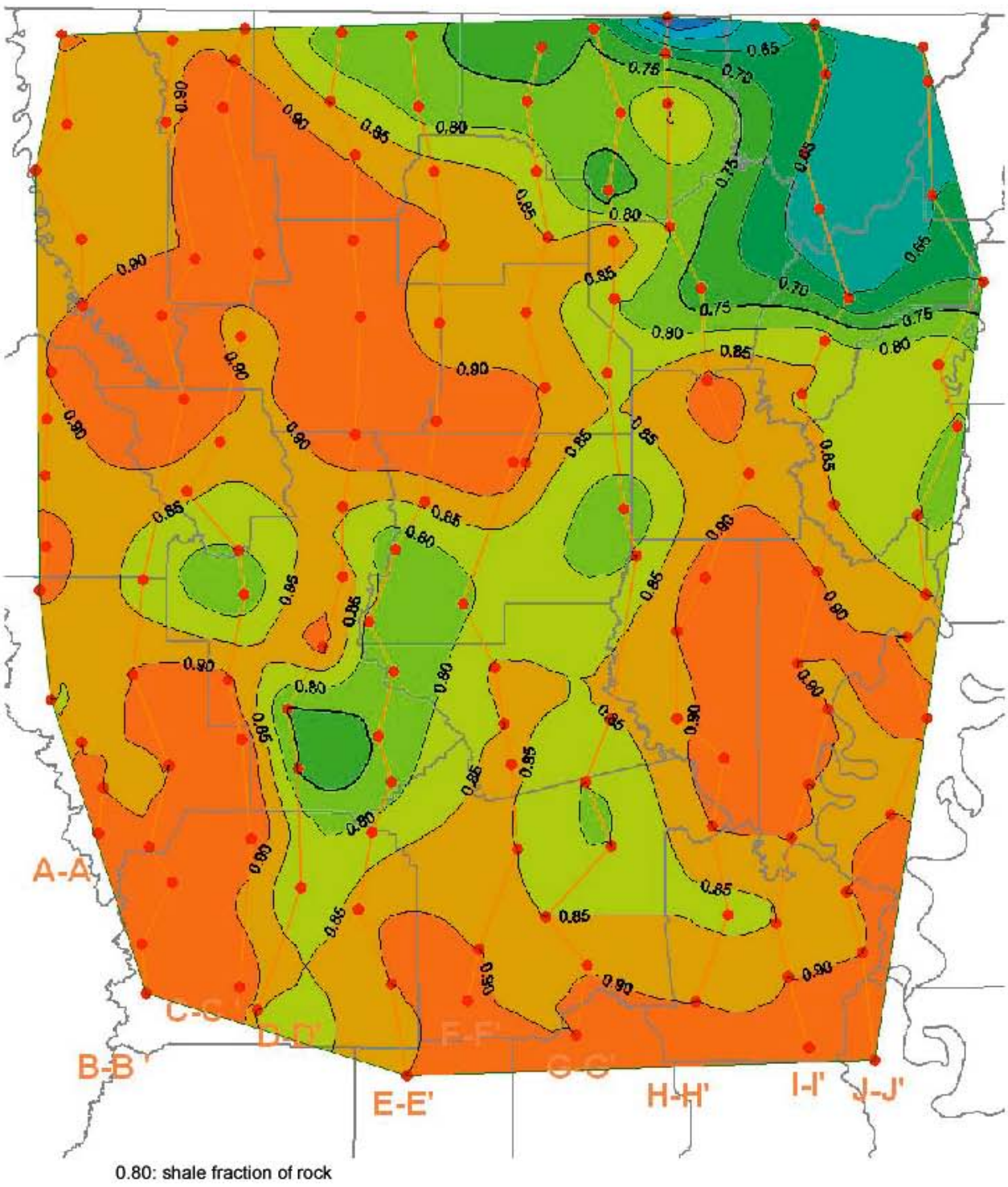


Figure 36. Lithology map of Pine Island. Prepared by Roger Barnaby.

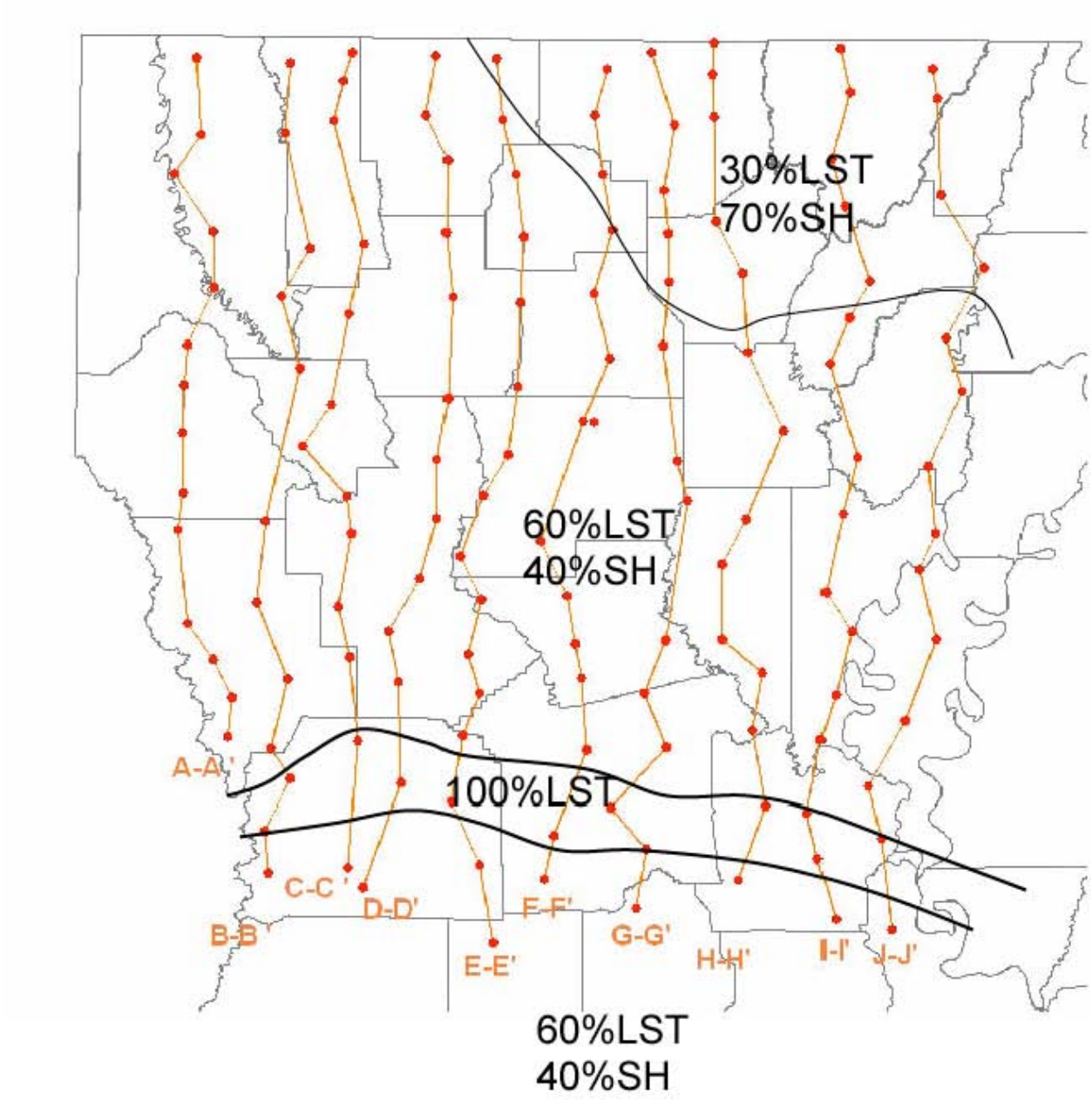


Figure 37. Lithology map of Sligo. Prepared by Roger Barnaby.

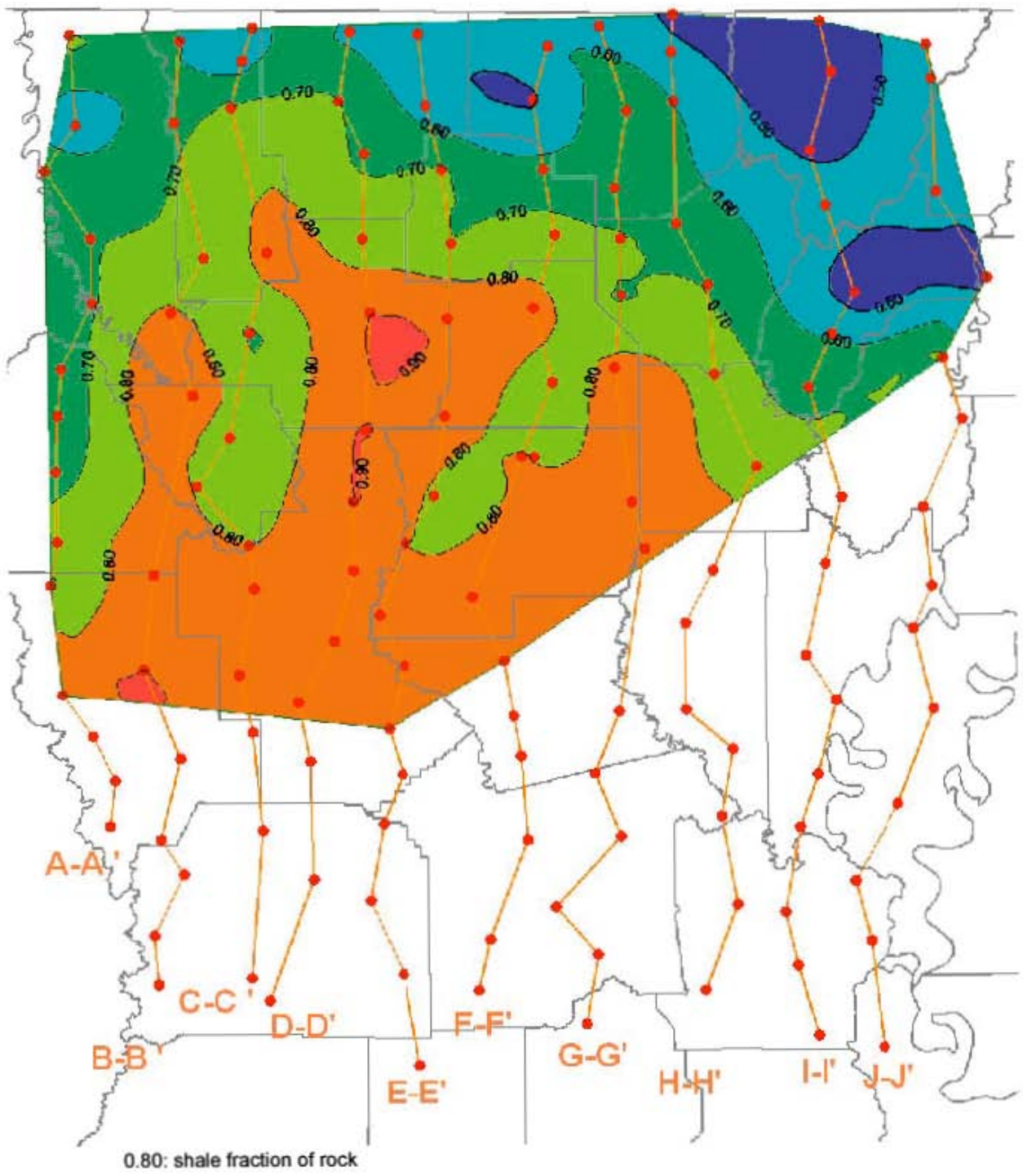


Figure 38. Lithology map of Hosston. Prepared by Roger Barnaby.

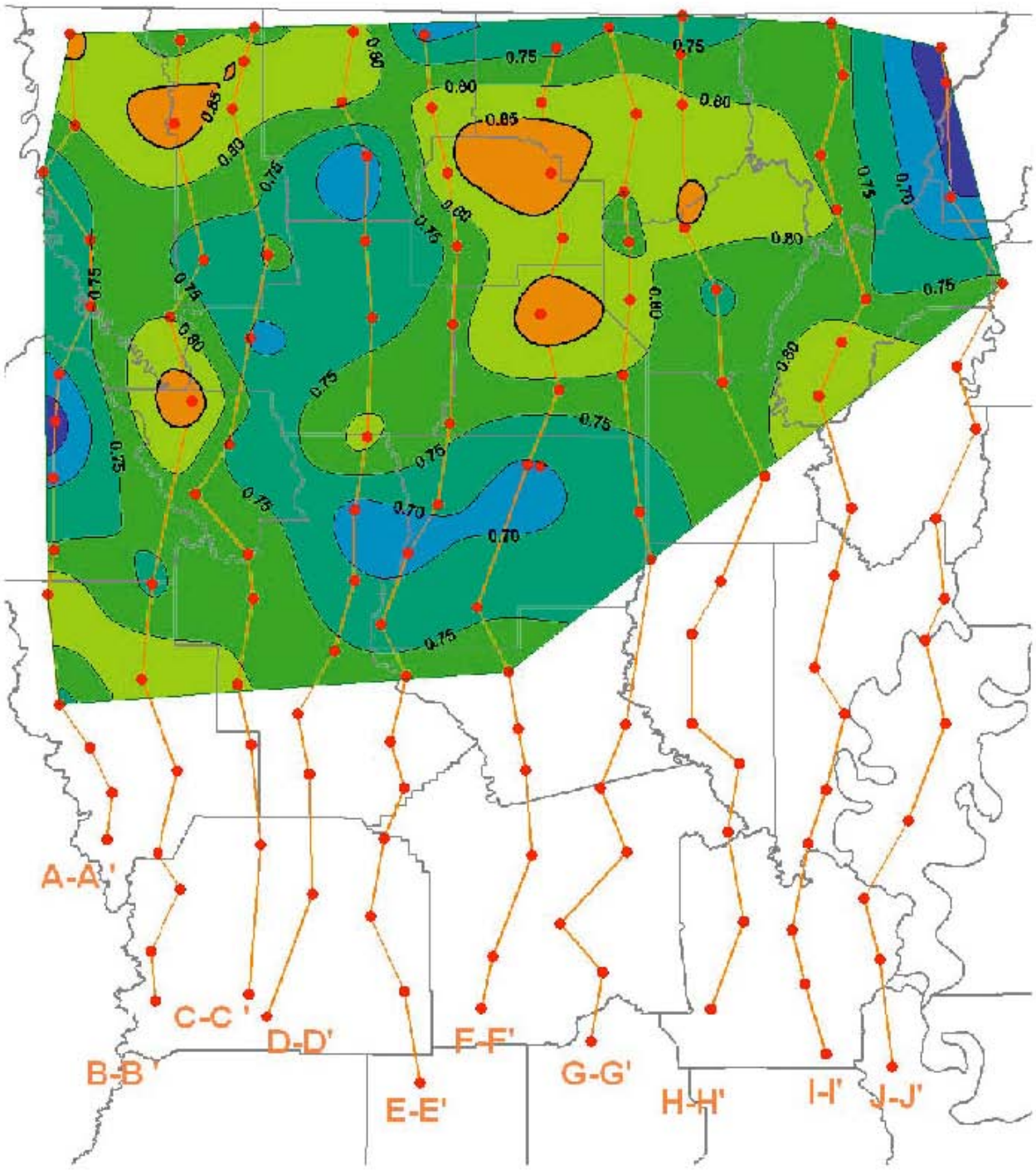


Figure 39. Lithology map of Cotton Valley. Prepared by Roger Barnaby.

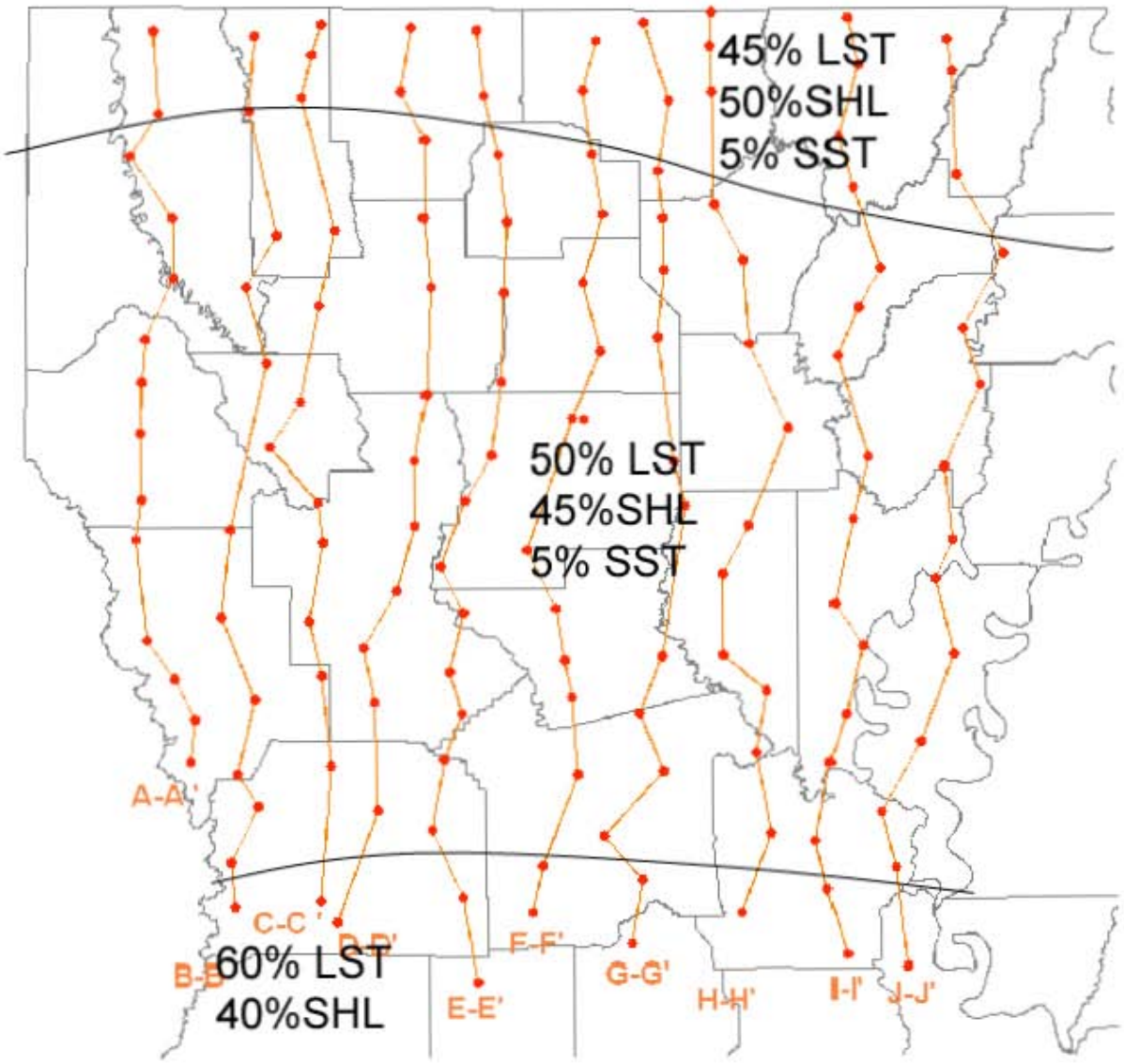


Figure 40. Lithology map of Smackover. Prepared by Roger Barnaby.

Table 1. Comparison of North Louisiana Salt Basin and Mississippi Interior Salt Basin.

Petroleum system characteristics (Smackover)	North Louisiana Salt Basin				Mississippi Interior Salt Basin	
Thickness (m)	396				116	
Kerogen type	Type IIS (Microbial/Amorphous)				Type IIS (Microbial/Amorphous)	
TOC (wt%) range	0.06 – 8.42				0.24 – 4.55	
TOC (wt%) average	0.58 (measured) - 1.0 (calculated for modeling)				0.85 (measured) – 1.5 (calculated for modeling)	
Depth to generate oil, m (ft)	1829 – 2591 (6,000-8,500)				2438 – 3353 (8,000-11,000)	
Depth to generate gas, m (ft)	3658 – 4877 (12,000-16,000)				5029 – 6401 (16,500-21,000)	
	Basin proper		Monroe Uplift	Sabine Uplift	Updip/Margin	Downdip/Center
	Updip/Margin	Downdip/Center				
Maturity (R_o%)	0.8-1.3	1.3->2.6	<0.5-1.3	0.8-1.5	<0.5-1	1-2.5
Time to generate oil (Ma)	115-135	125-140	105-125	115-125	35-90	90-135
Time to generate gas (Ma)	Present-50	50-105	No gas	20-50	No gas	12-80
Time of expulsion (Ma)	50-110	100-125	100–120*	90-105	30-50	60-110
Time of peak expulsion (Ma)	40-105	80-120	90-110*	60-100	Present-45	50-100
Heat flow (HFU)	1.25				1.09	

* Only in the southwest portion of Monroe Uplift

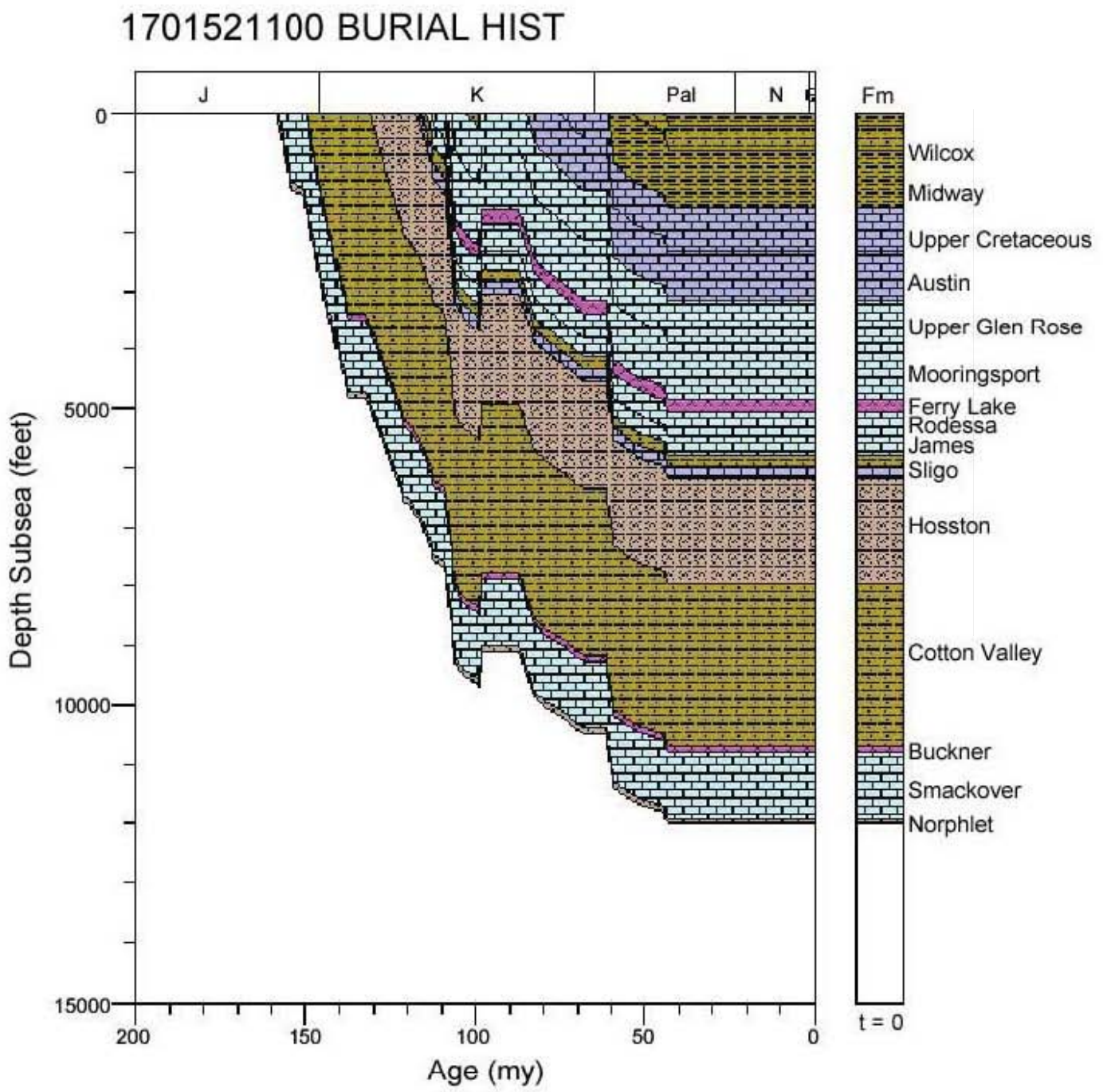


Figure 41. Burial history for well 1701521100, North Louisiana Salt Basin.

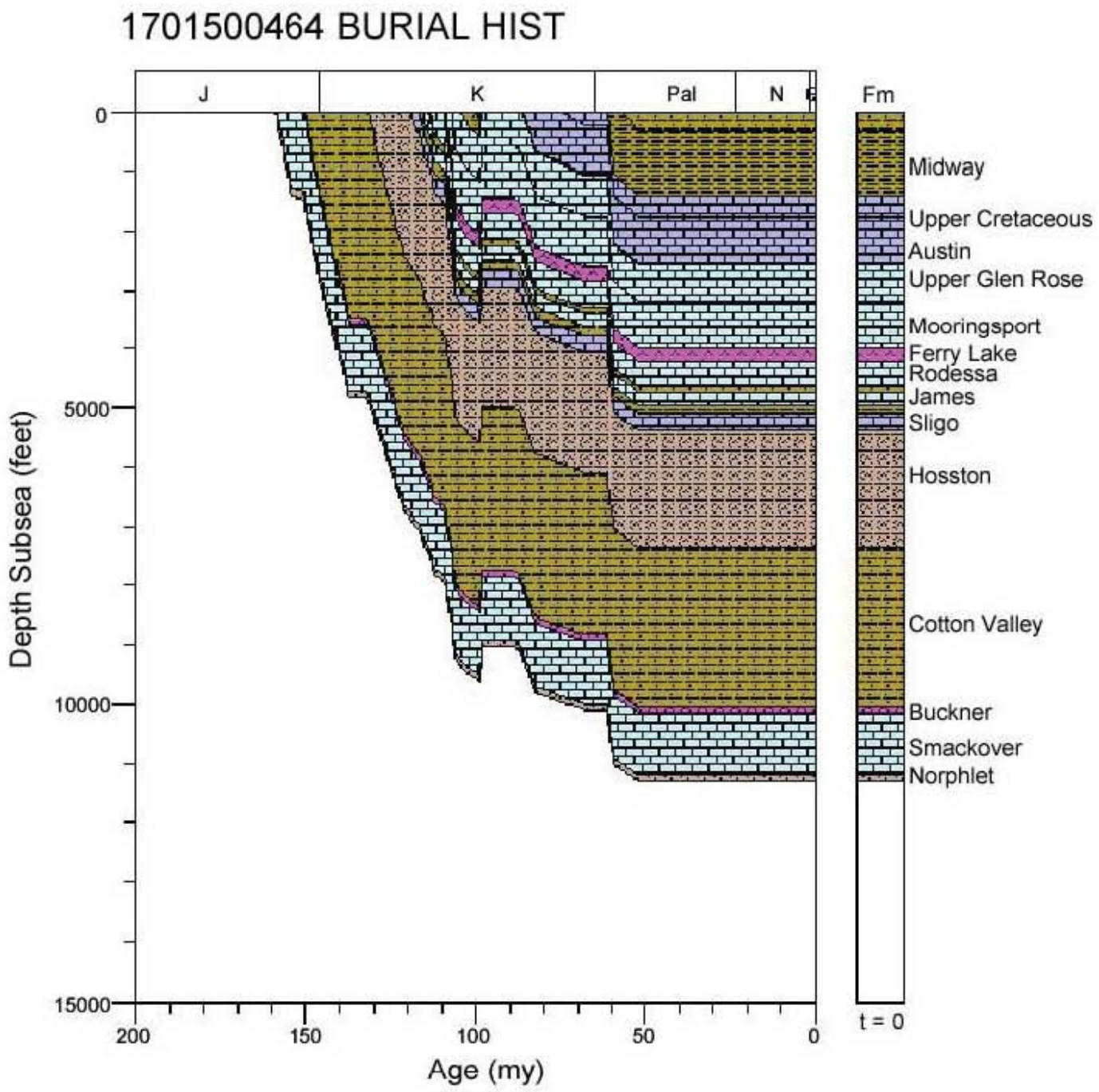


Figure 42. Burial history for well 1701500464, North Louisiana Salt Basin.

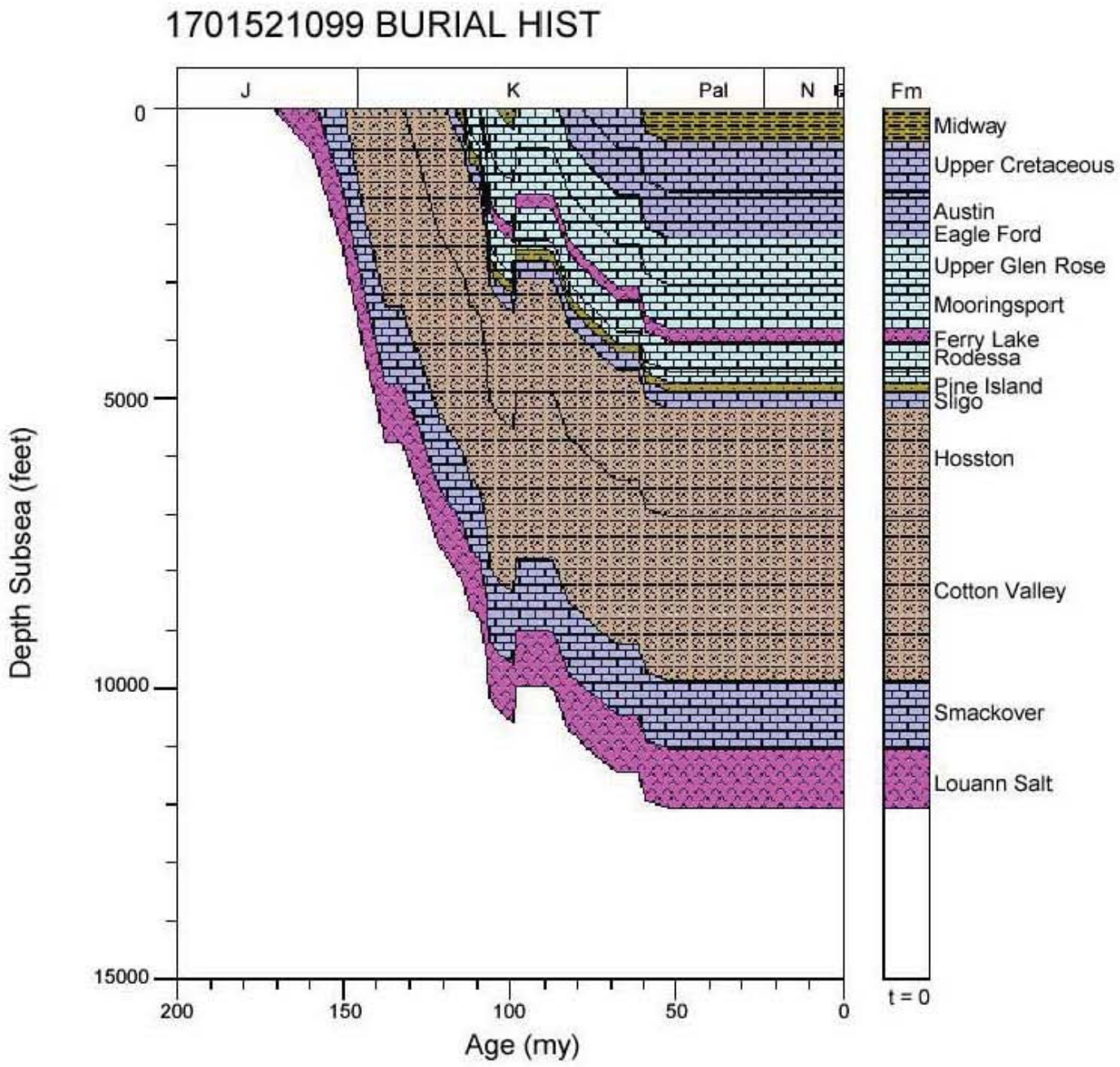


Figure 43. Burial history for well 1701521099, North Louisiana Salt Basin.

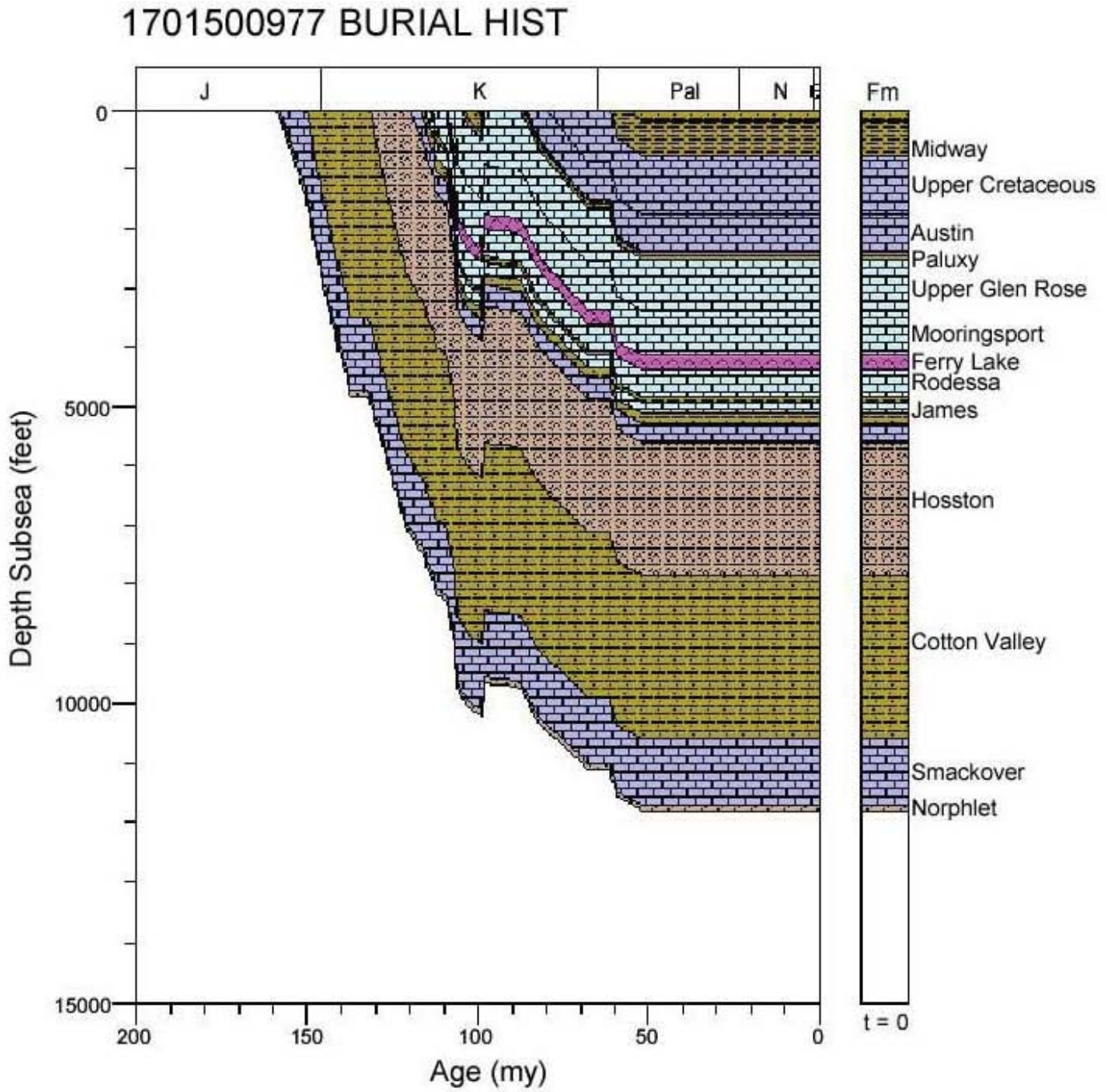


Figure 44. Burial history for well 1701500977, North Louisiana Salt Basin.

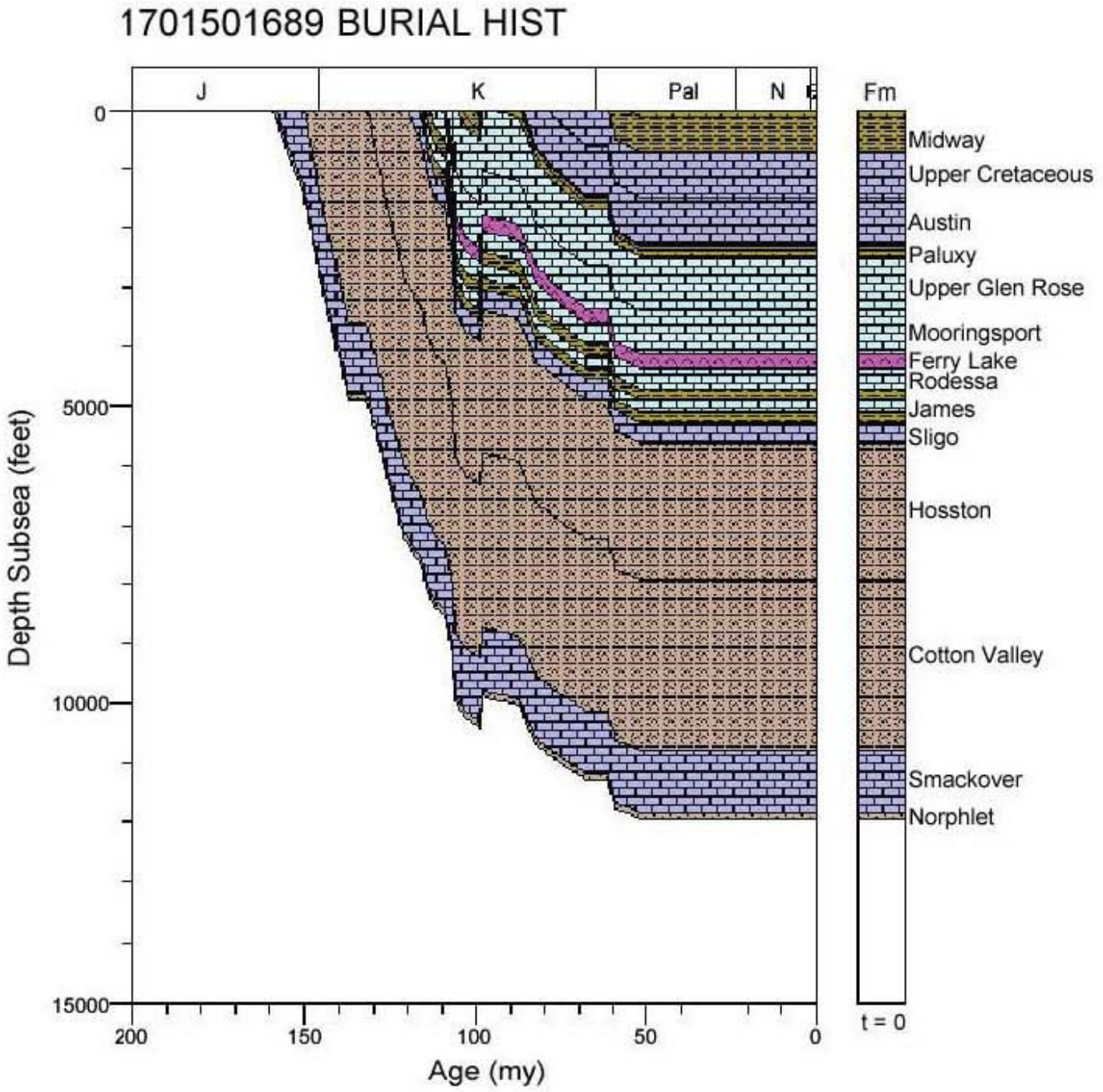


Figure 45. Burial history for well 1701501689, North Louisiana Salt Basin.

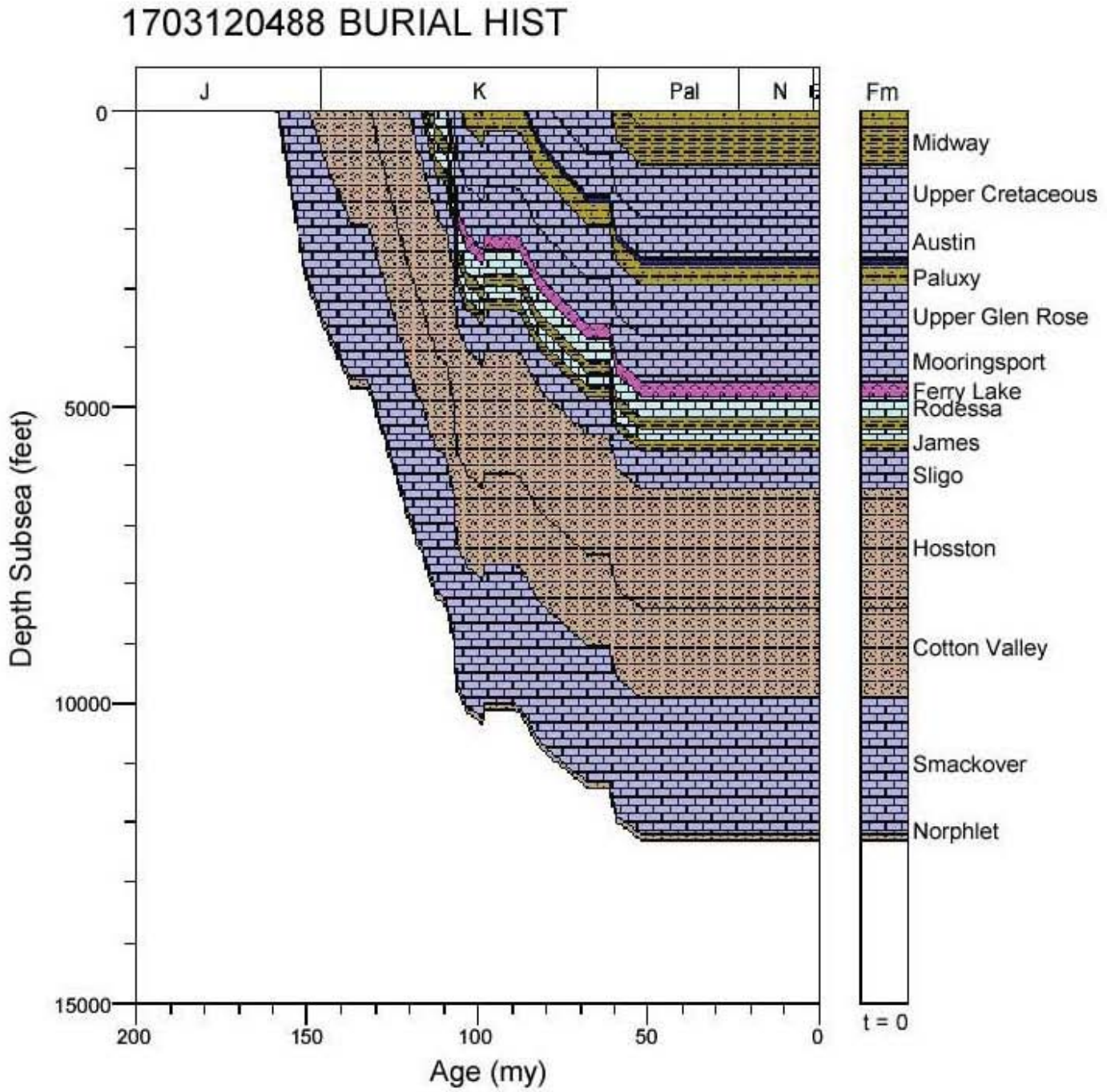


Figure 46. Burial history for well 1703120488, North Louisiana Salt Basin.

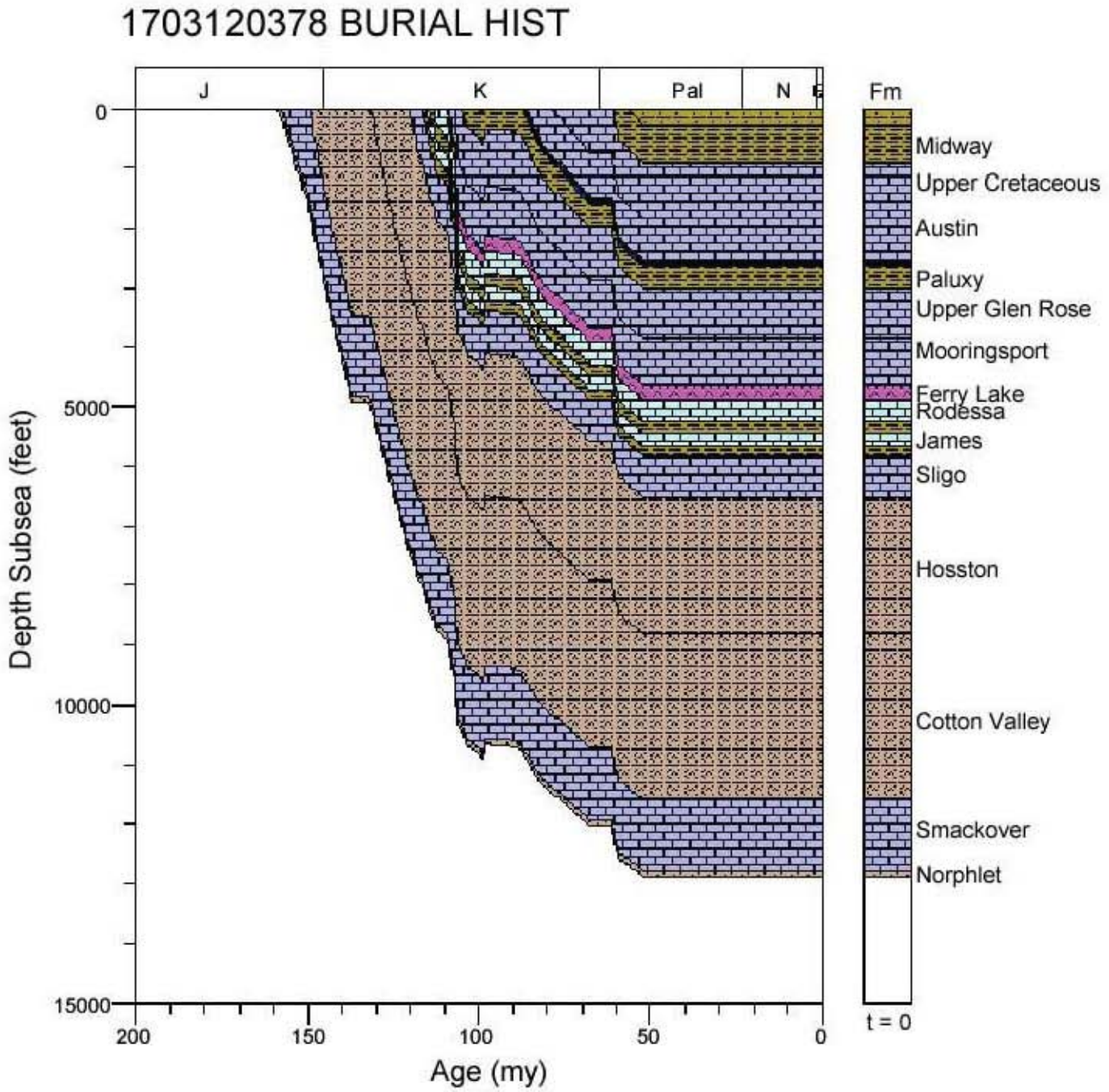


Figure 47. Burial history for well 1703120378, North Louisiana Salt Basin.

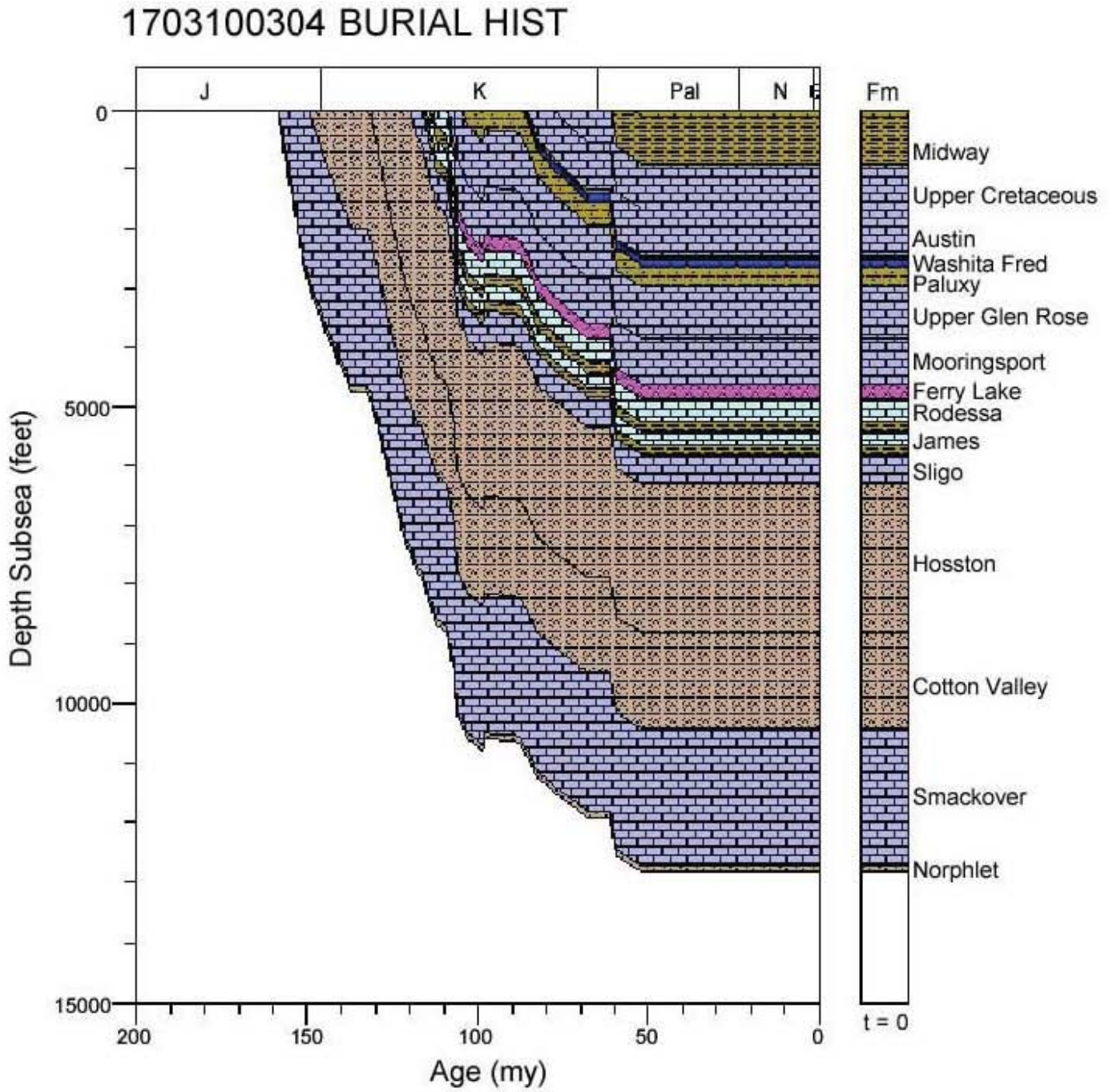


Figure 48. Burial history for well 1703100304, North Louisiana Salt Basin.

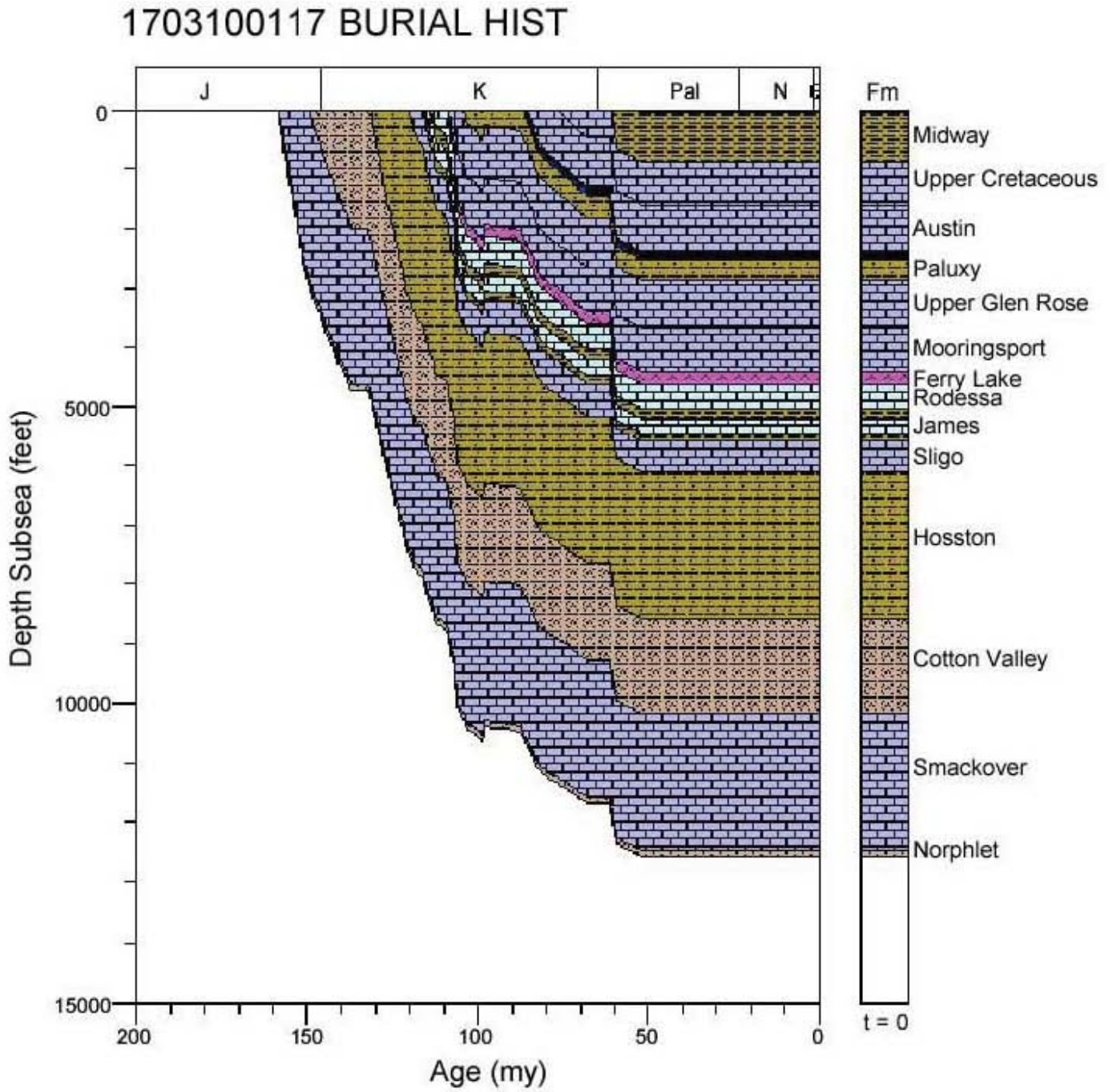


Figure 49. Burial history for well 1703100117, North Louisiana Salt Basin.

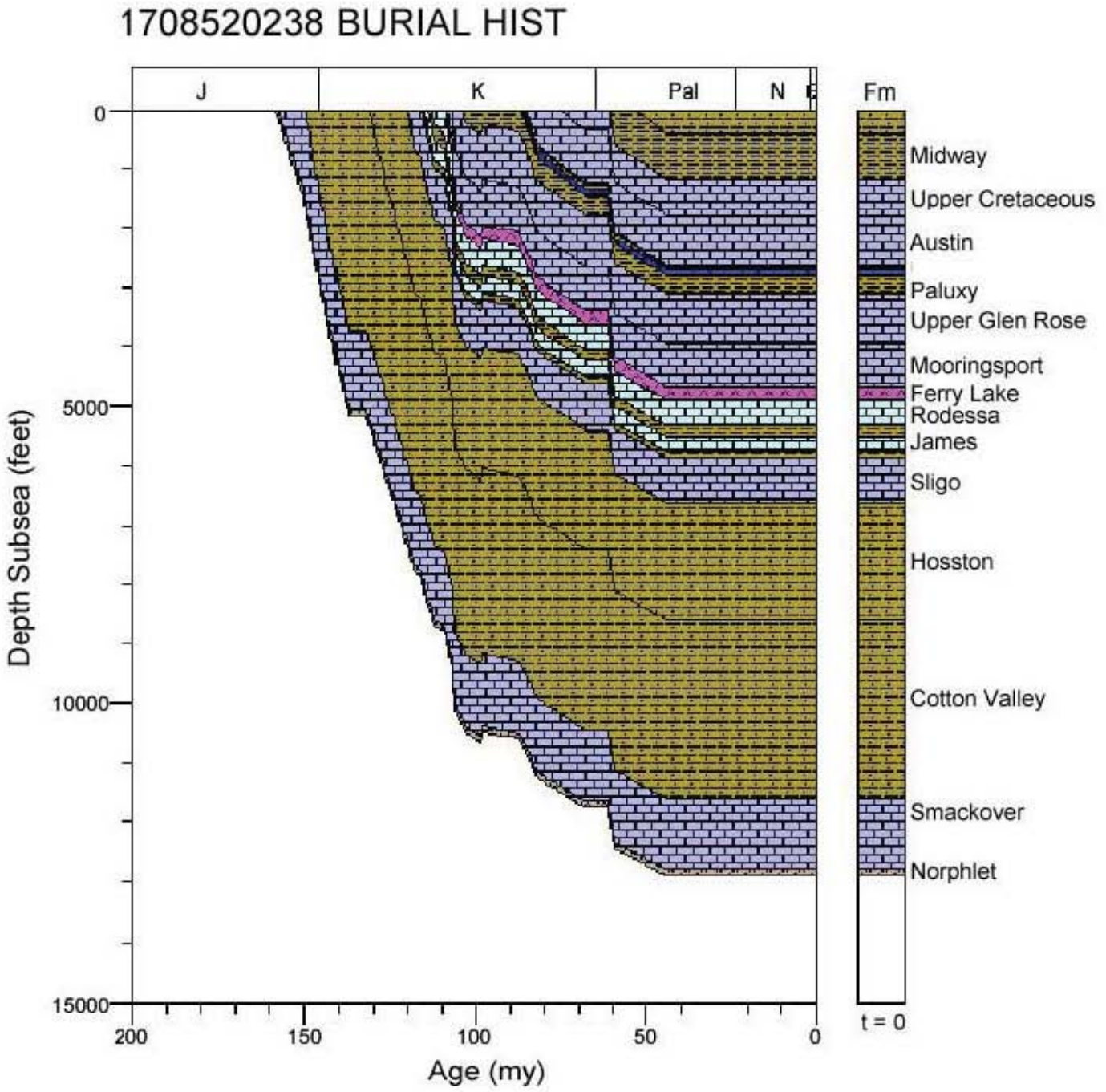


Figure 50. Burial history for well 1708520238, North Louisiana Salt Basin.

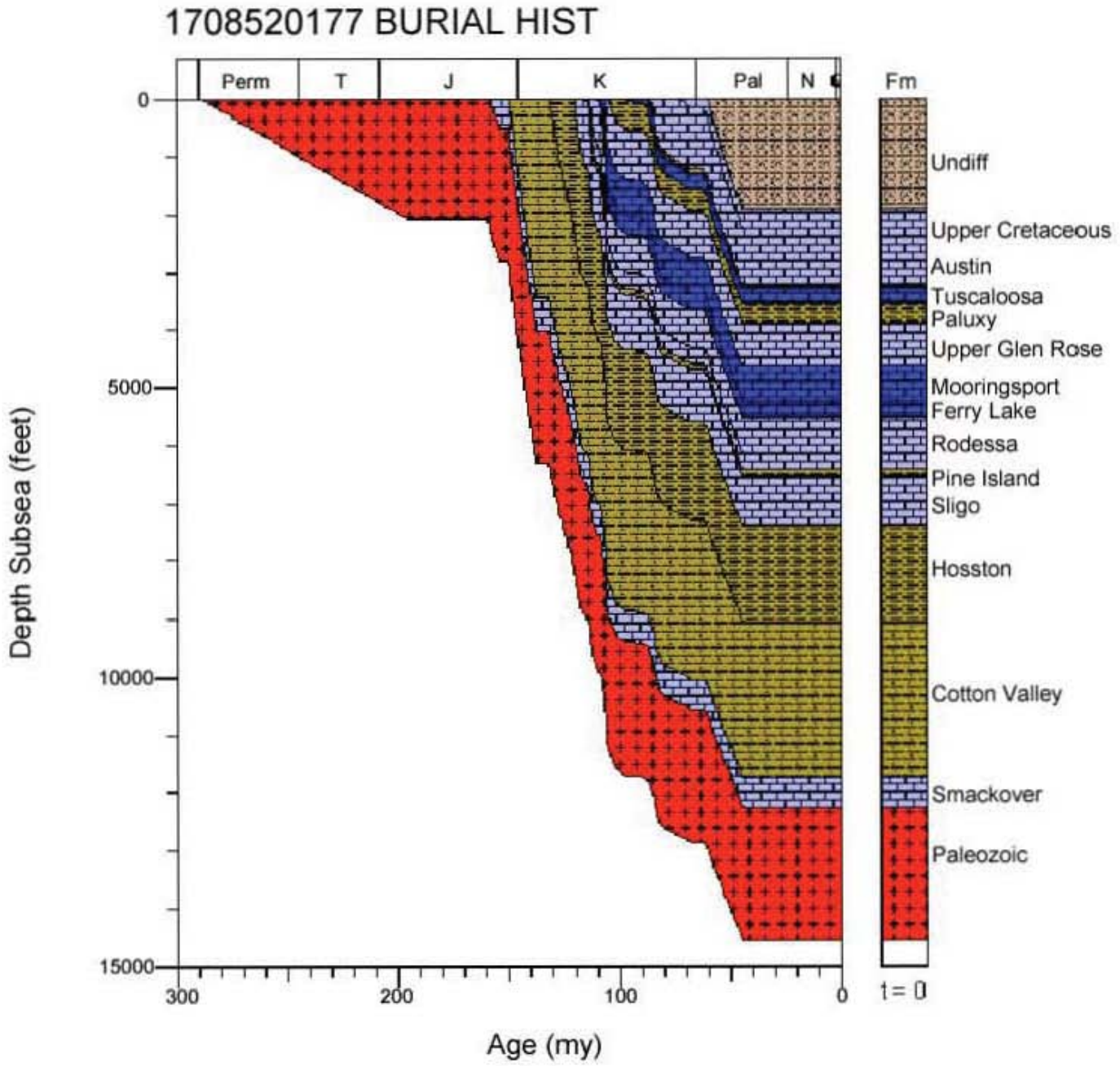


Figure 51. Burial history for well 1708520177, North Louisiana Salt Basin.

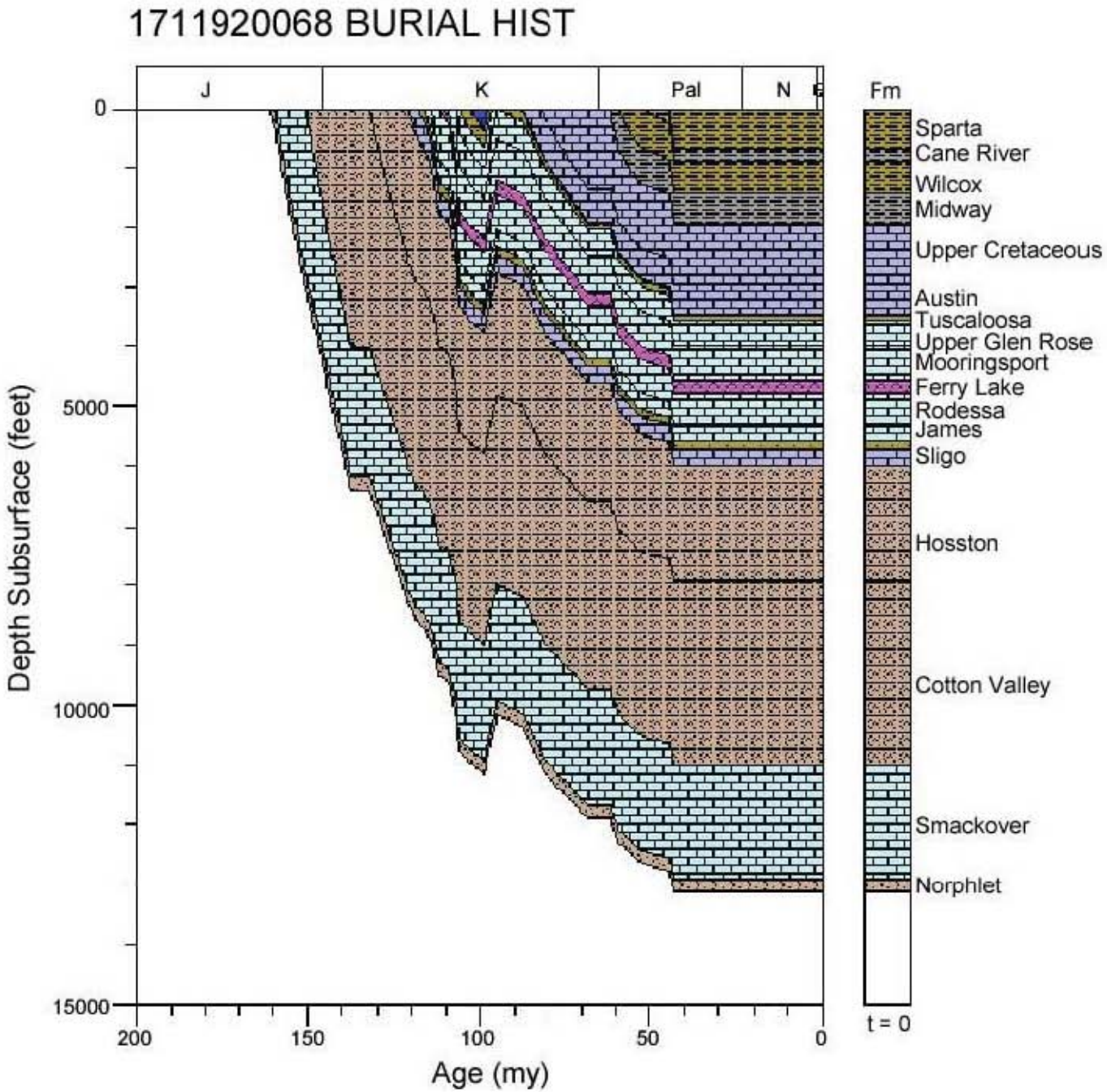


Figure 52. Burial history for well 1711920068, North Louisiana Salt Basin.

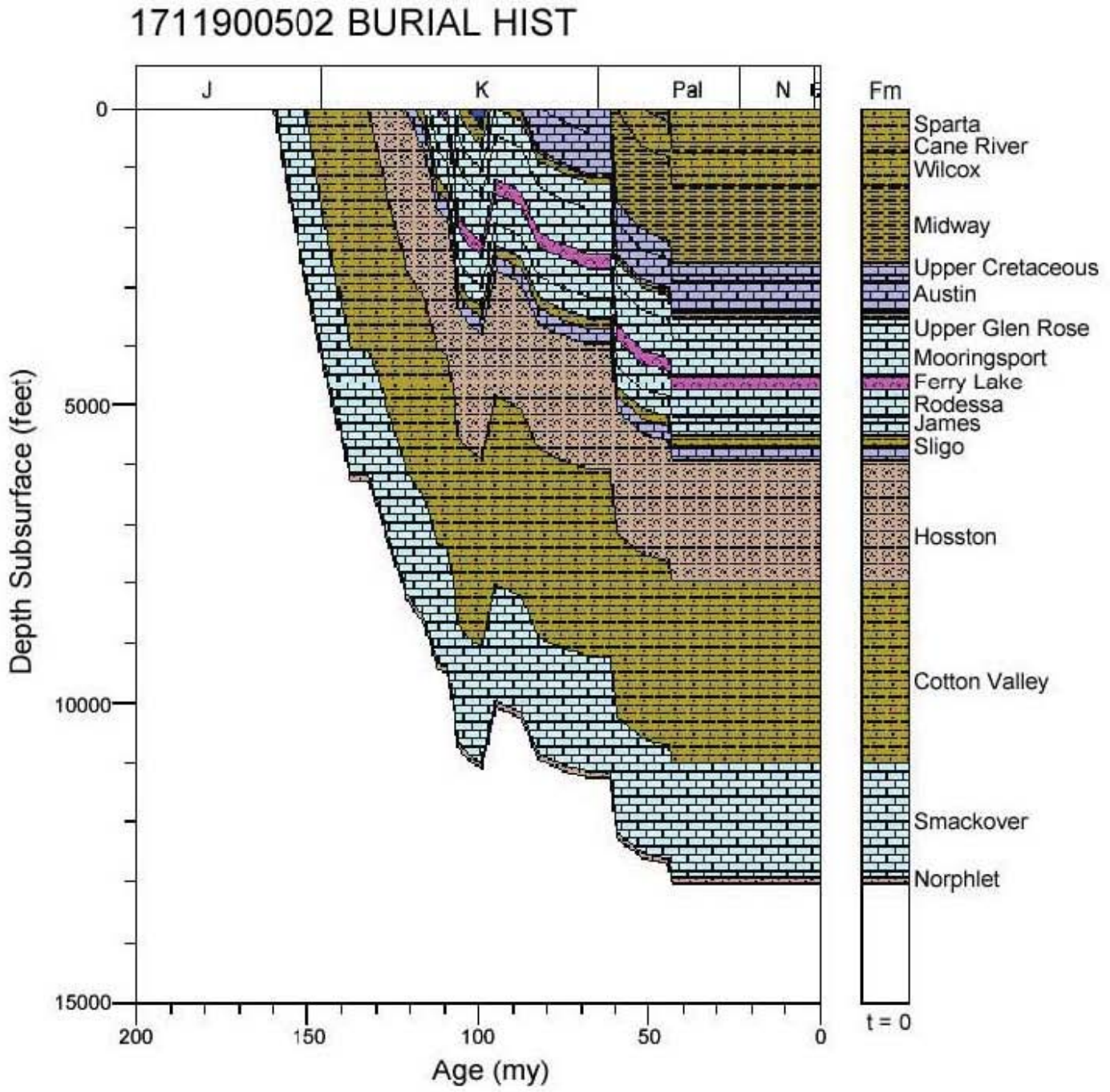


Figure 53. Burial history for well 1711900502, North Louisiana Salt Basin.

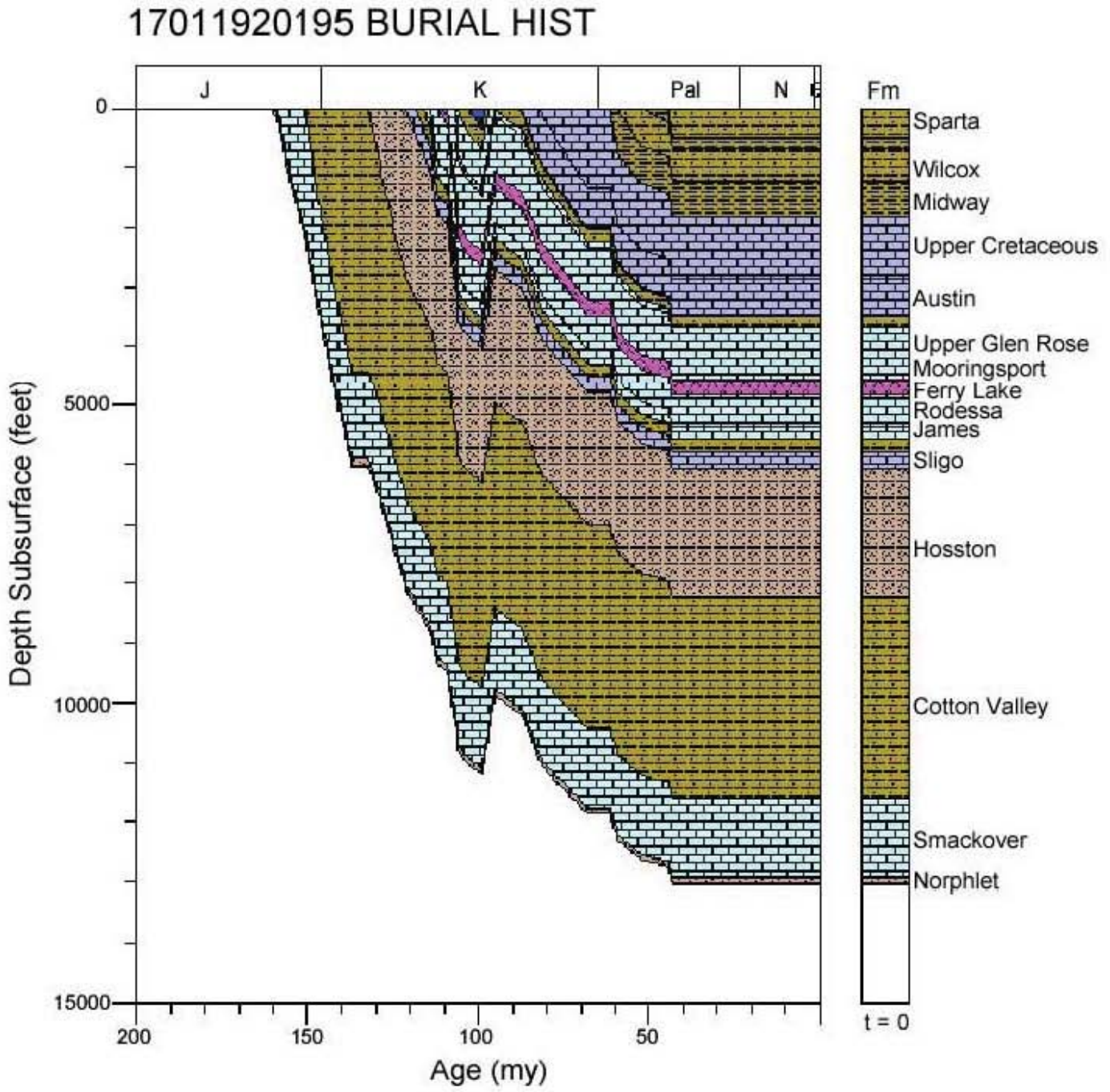


Figure 54. Burial history for well 1711920195, North Louisiana Salt Basin.

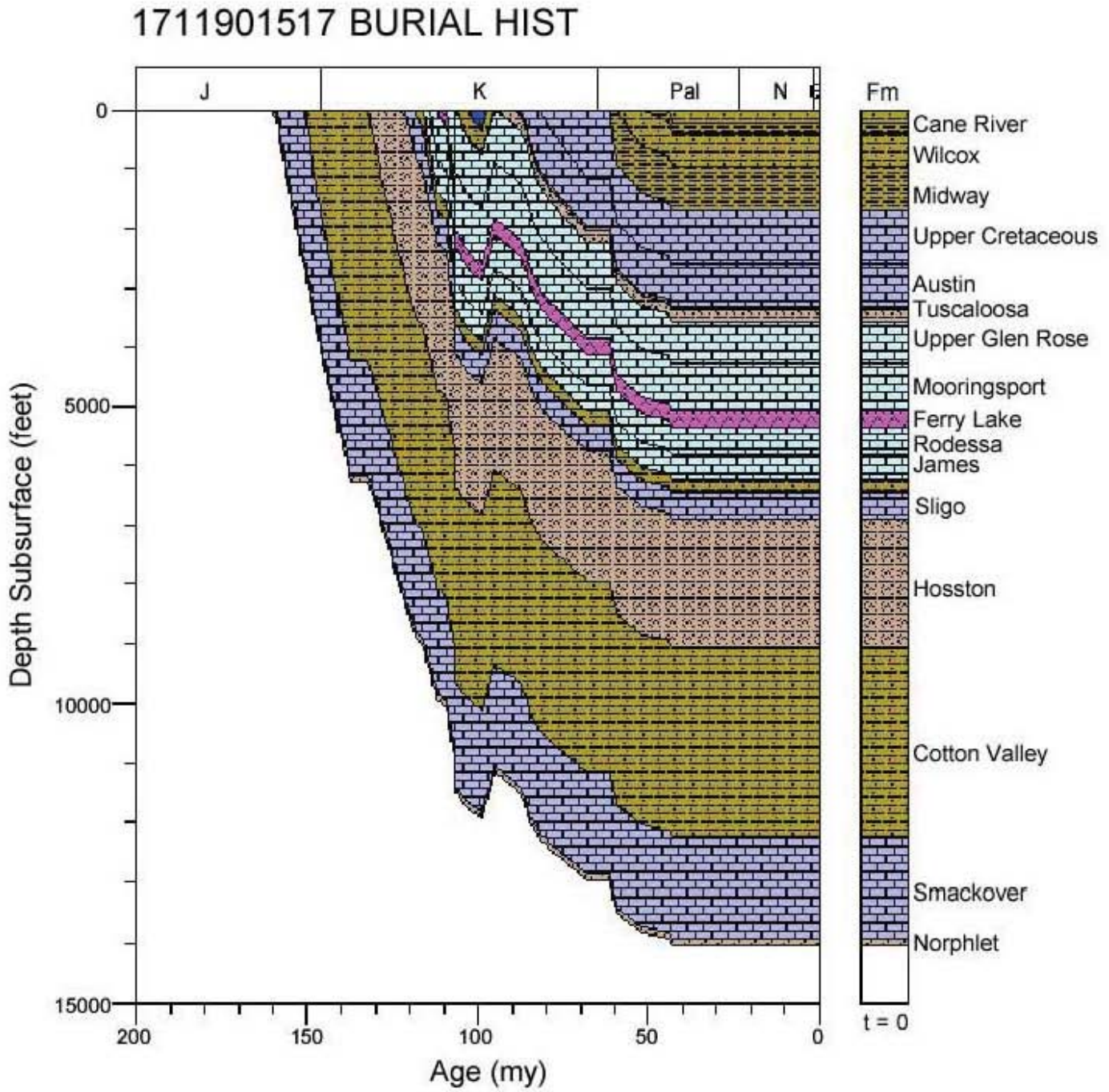


Figure 55. Burial history for well 1711901517, North Louisiana Salt Basin.

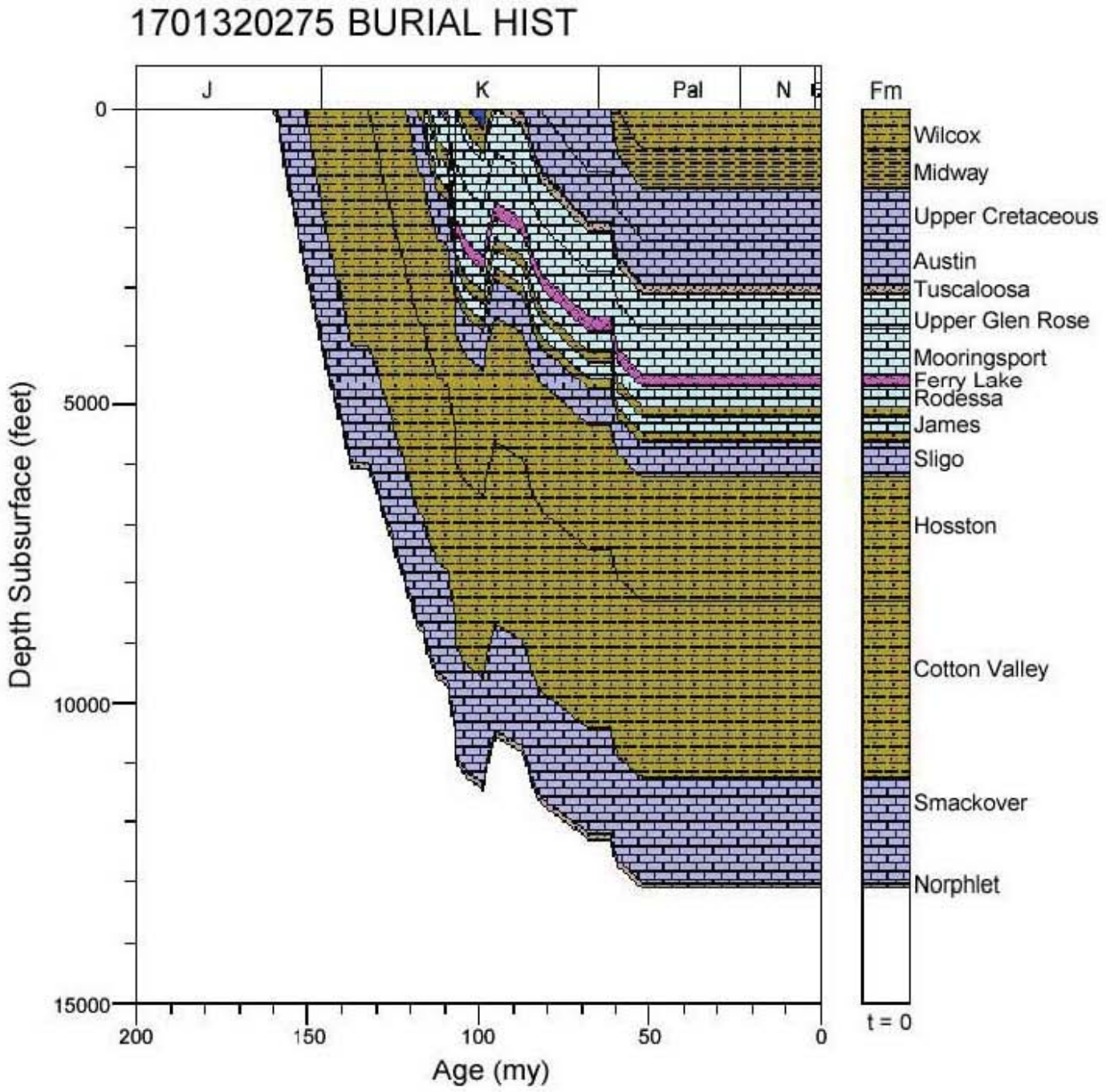


Figure 56. Burial history for well 1701320275, North Louisiana Salt Basin.

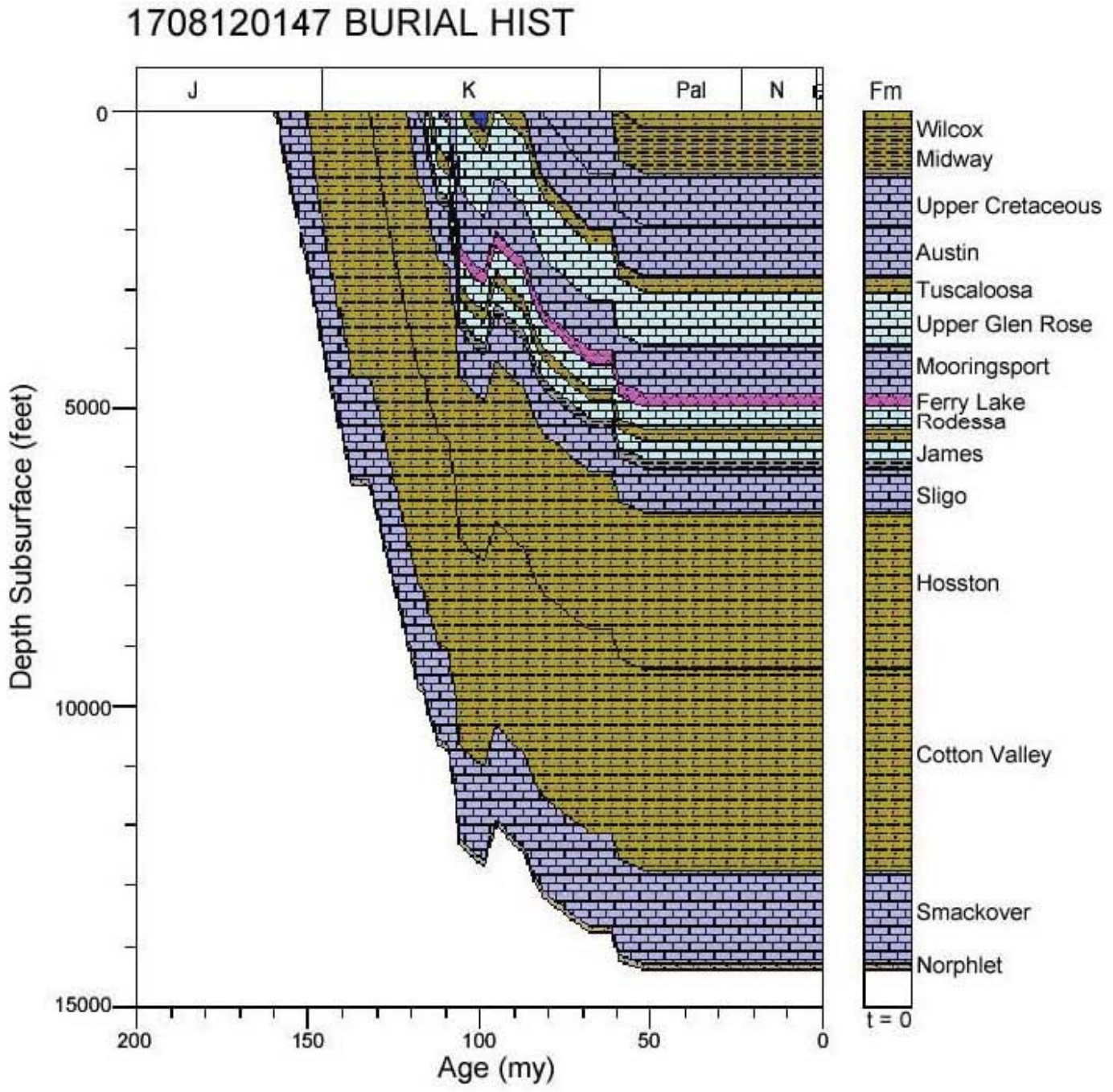


Figure 57. Burial history for well 1708120147, North Louisiana Salt Basin.

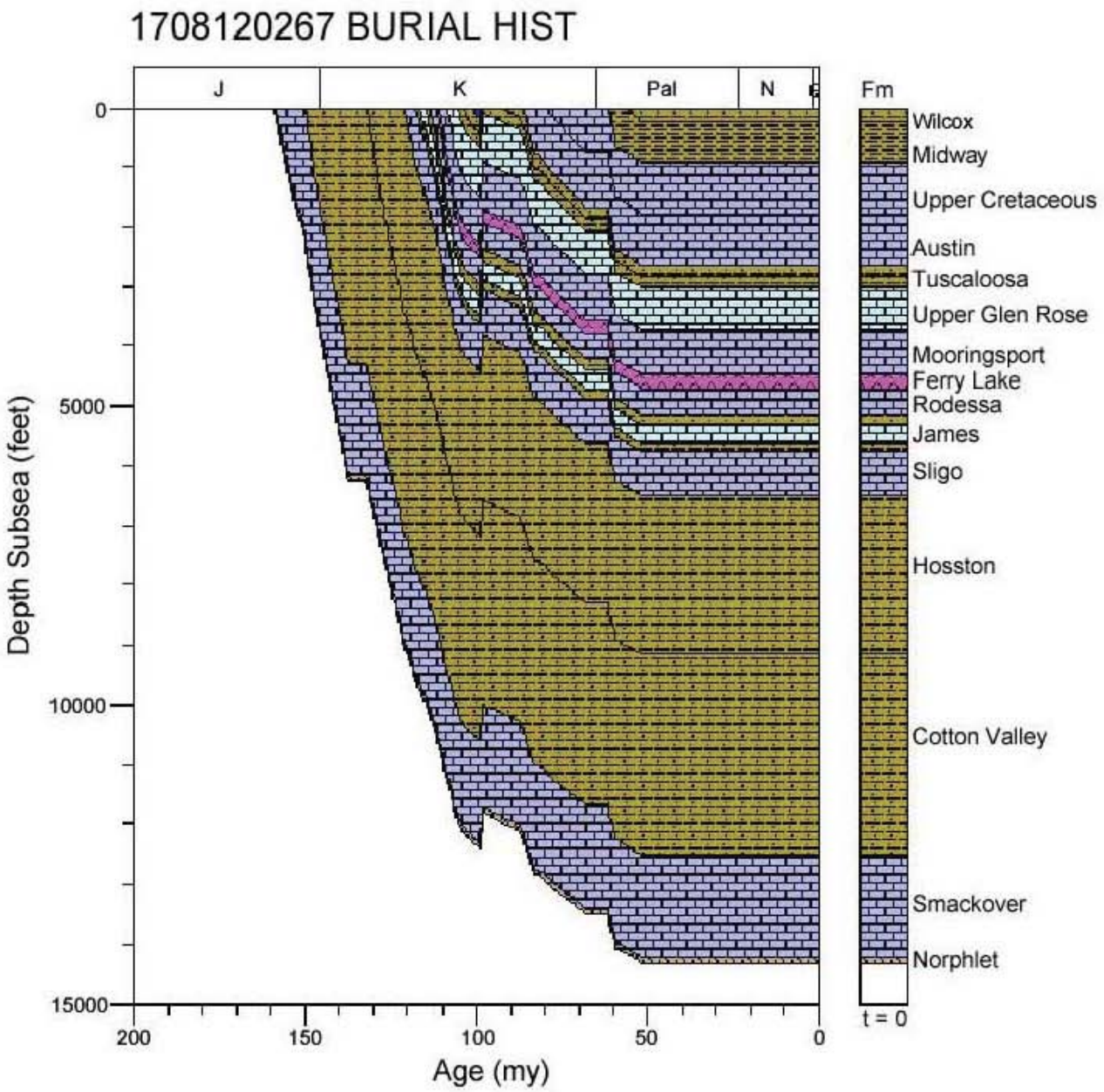


Figure 58. Burial history for well 1708120267, North Louisiana Salt Basin.

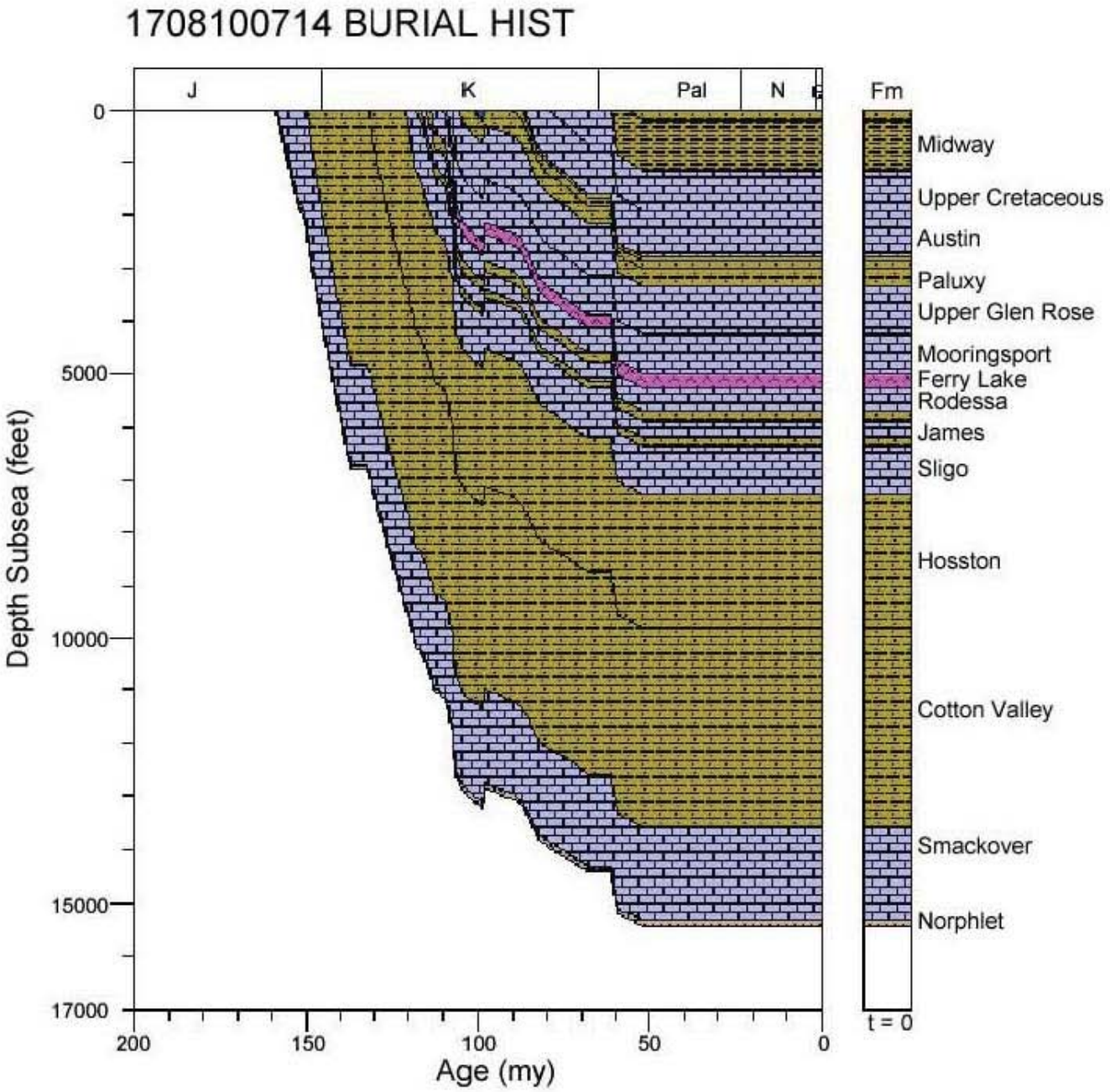


Figure 59. Burial history for well 1708100714, North Louisiana Salt Basin.

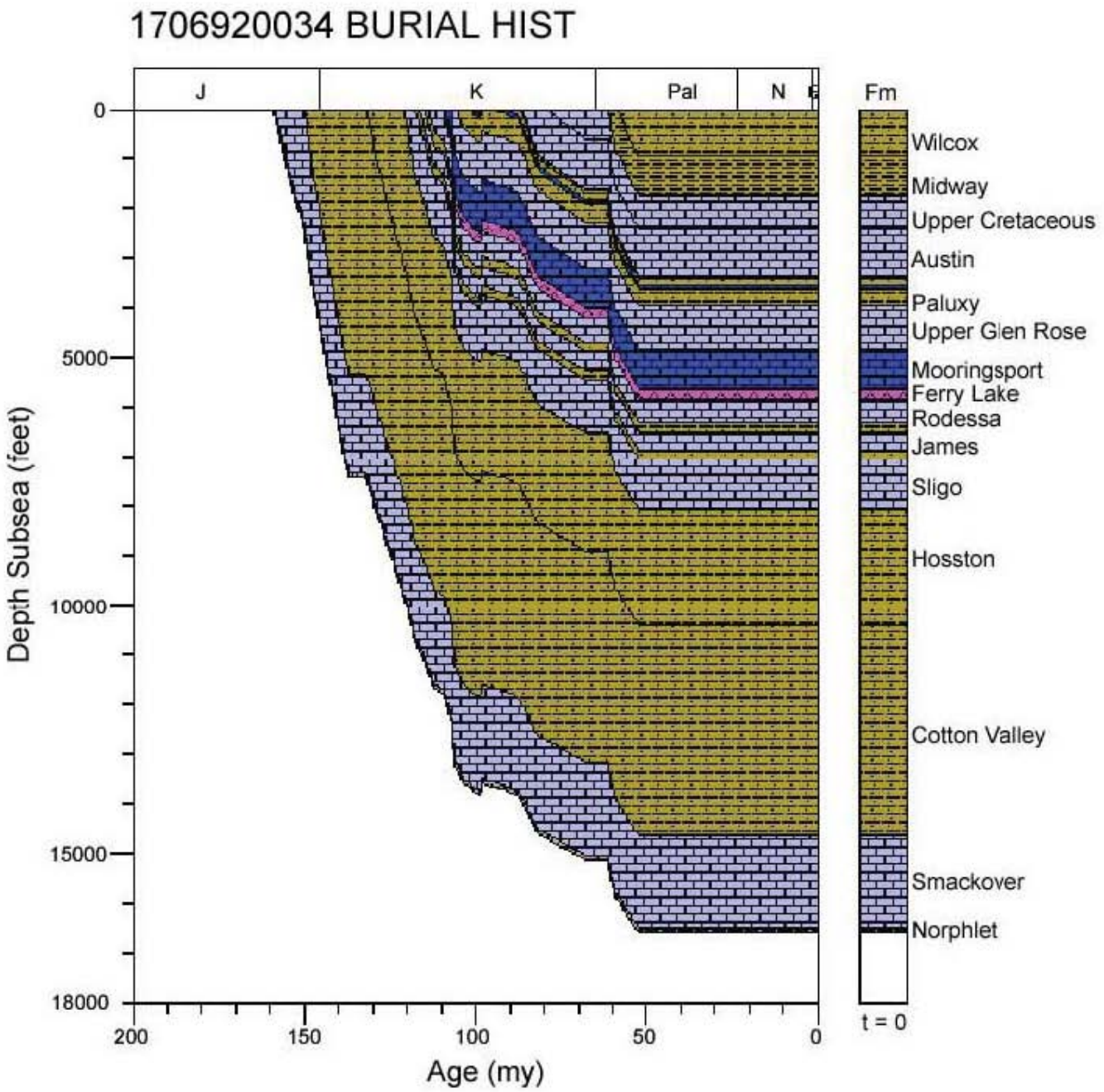


Figure 60. Burial history for well 1706920034, North Louisiana Salt Basin.

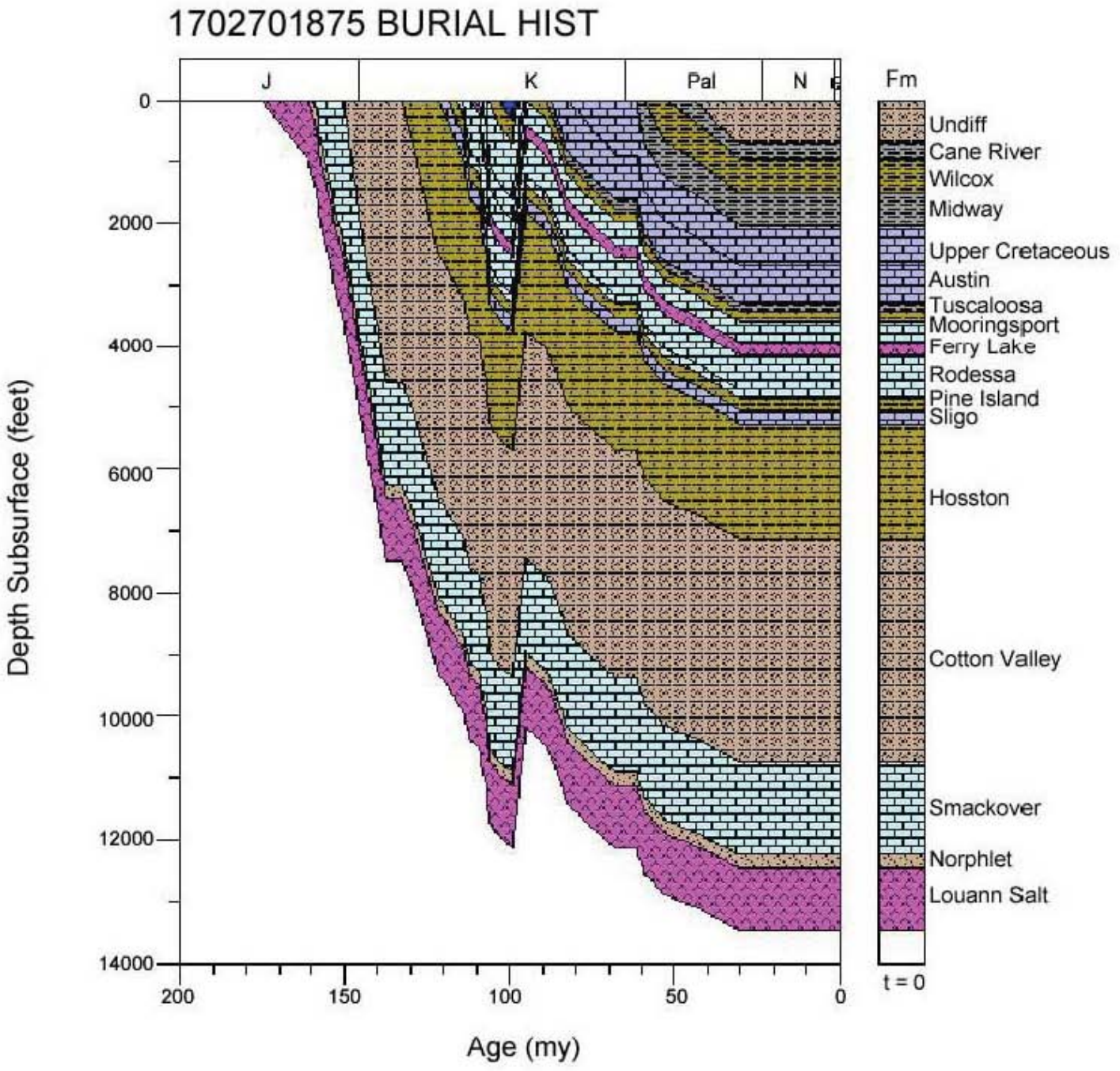


Figure 61. Burial history for well 1702701875, North Louisiana Salt Basin.

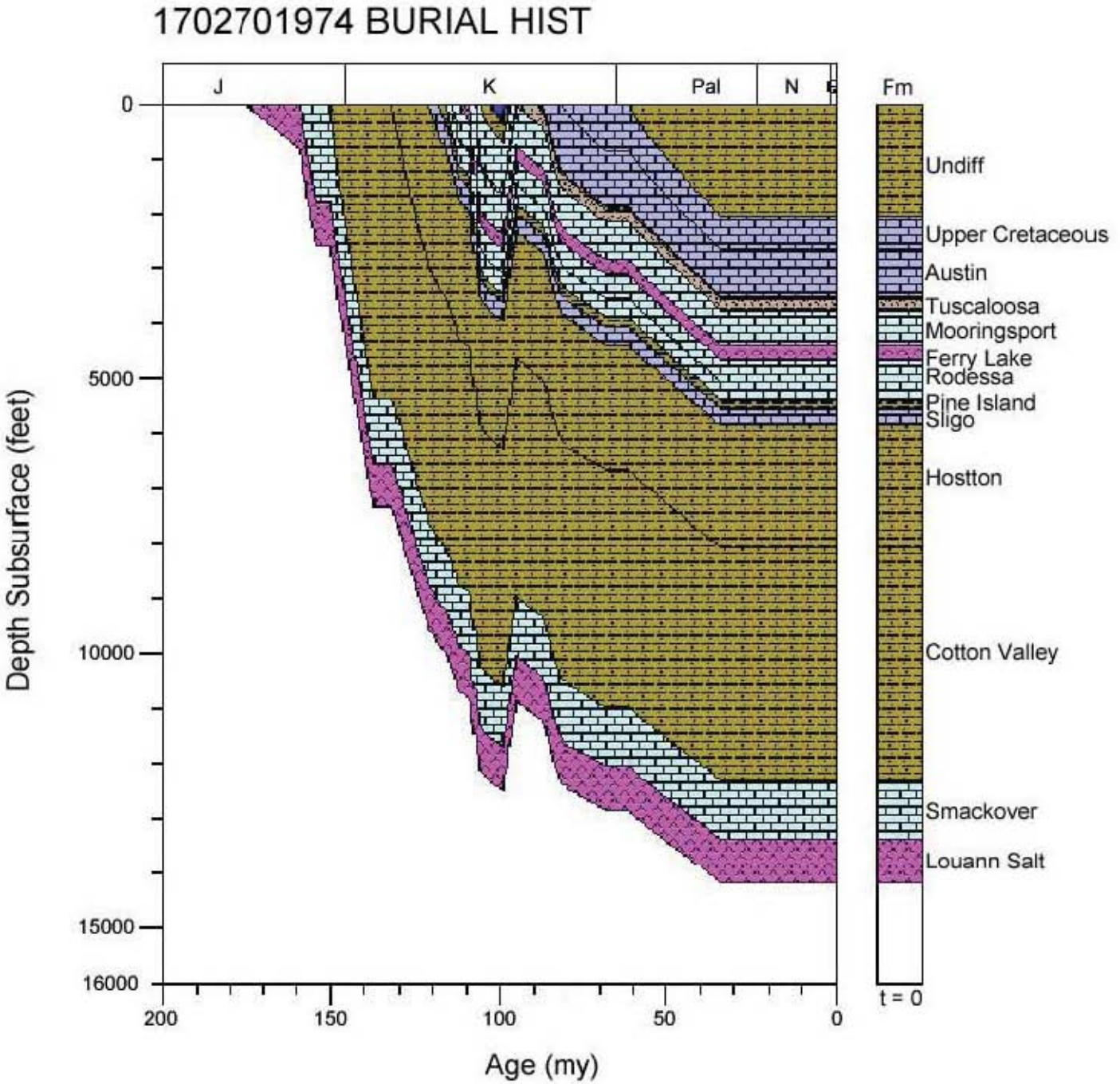


Figure 62. Burial history for well 1702701974, North Louisiana Salt Basin.

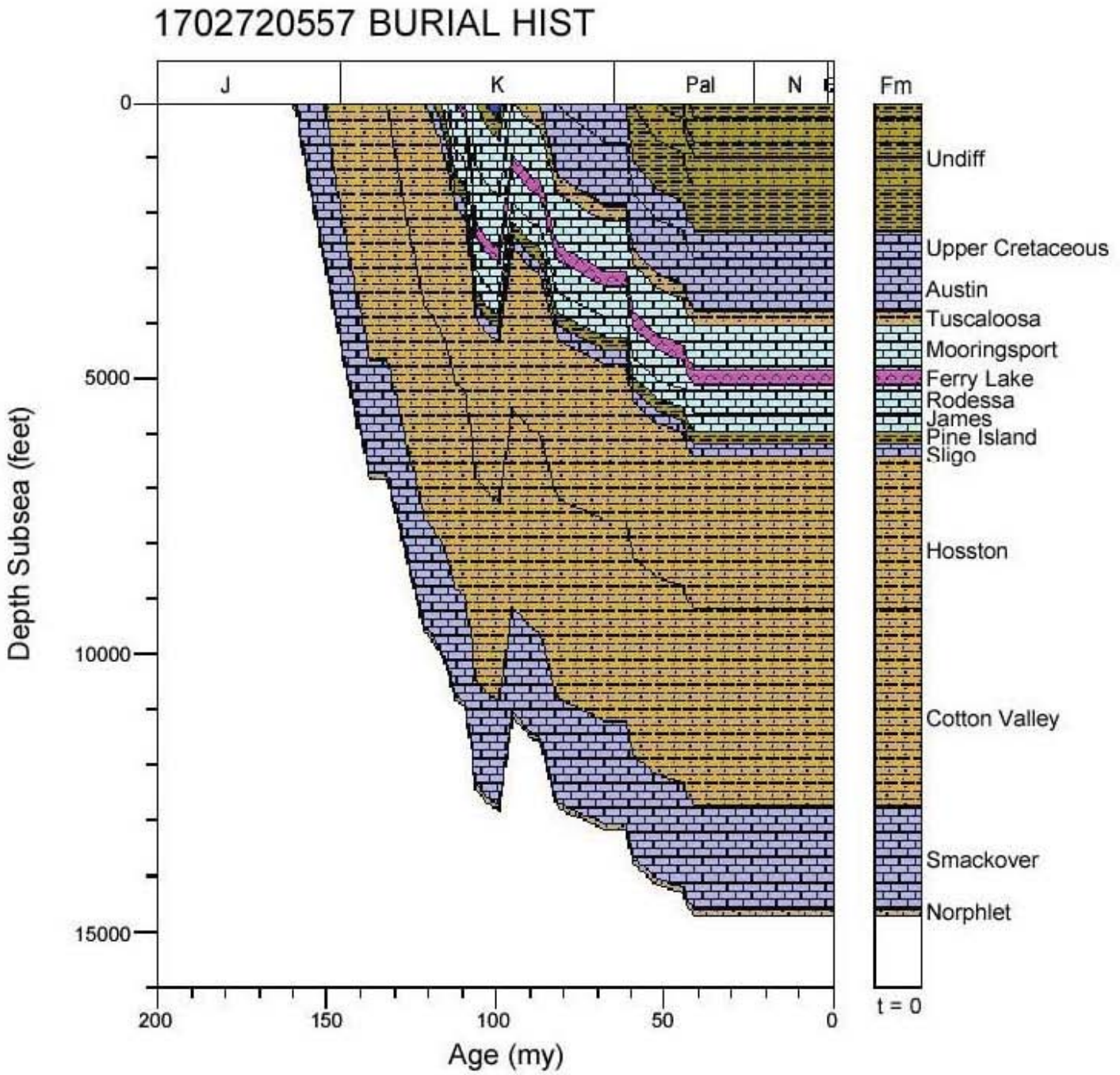


Figure 63. Burial history for well 1702720557, North Louisiana Salt Basin.

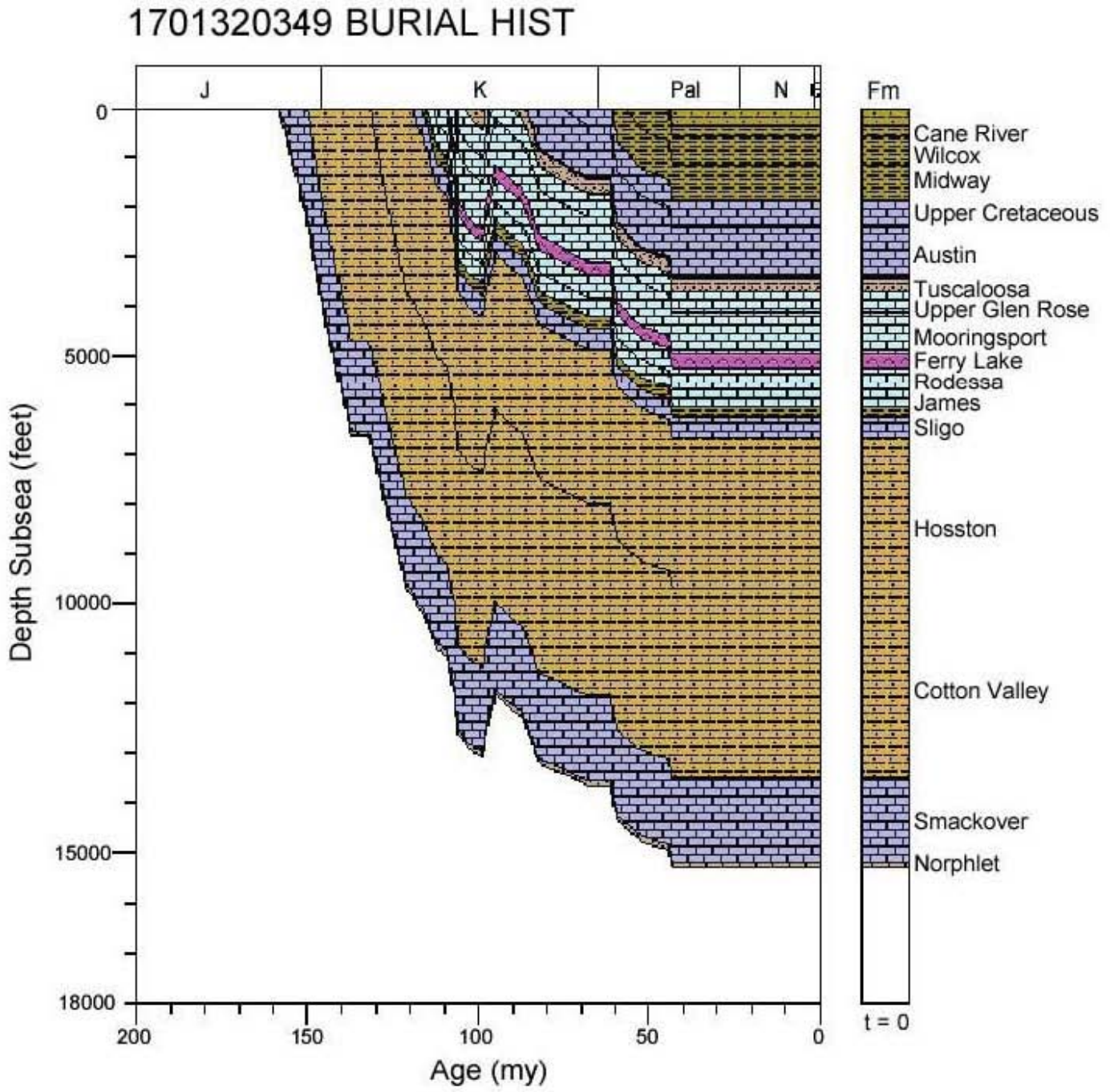


Figure 64. Burial history for well 1701320349, North Louisiana Salt Basin.

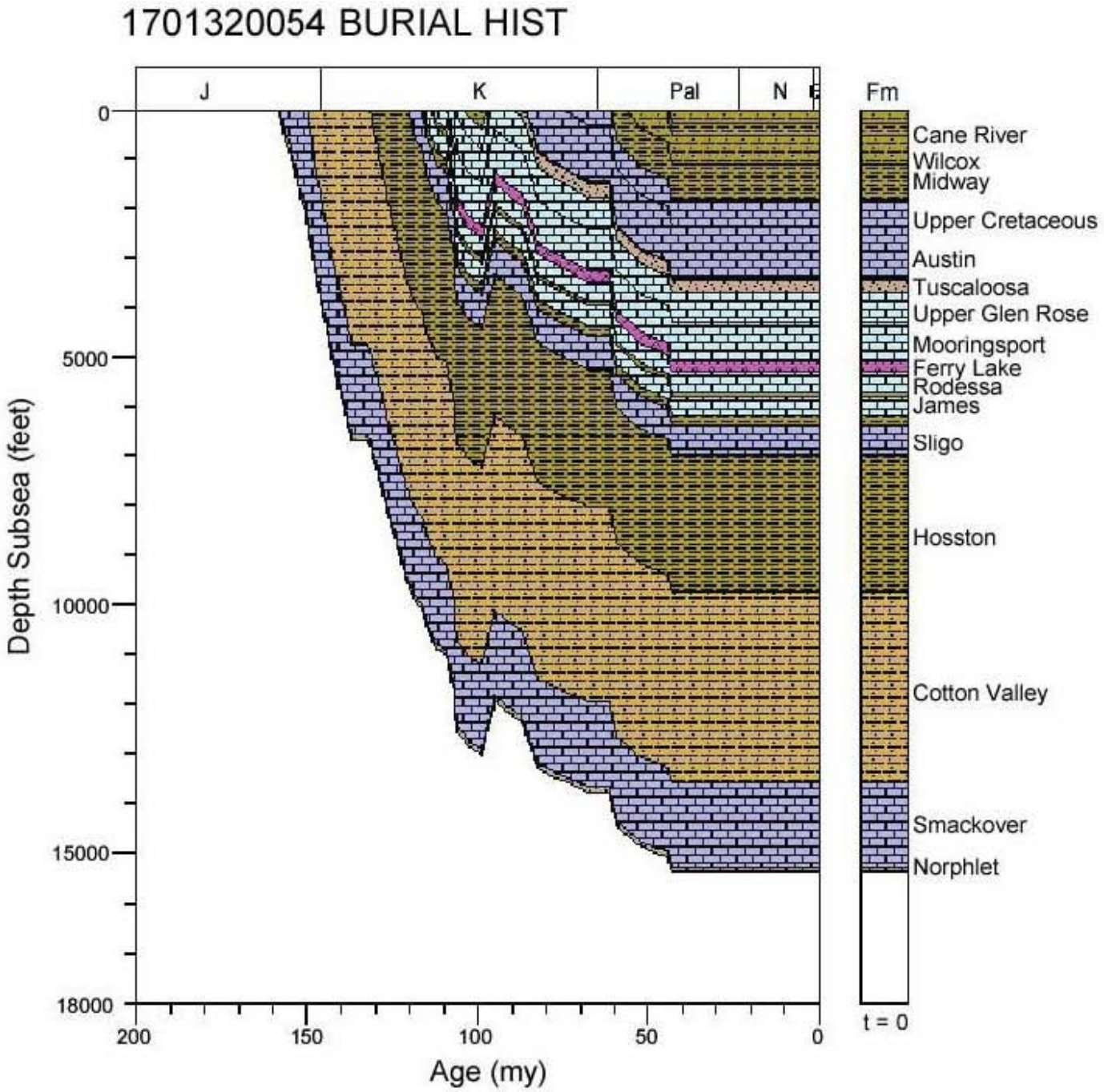


Figure 65. Burial history for well 1701320054, North Louisiana Salt Basin.

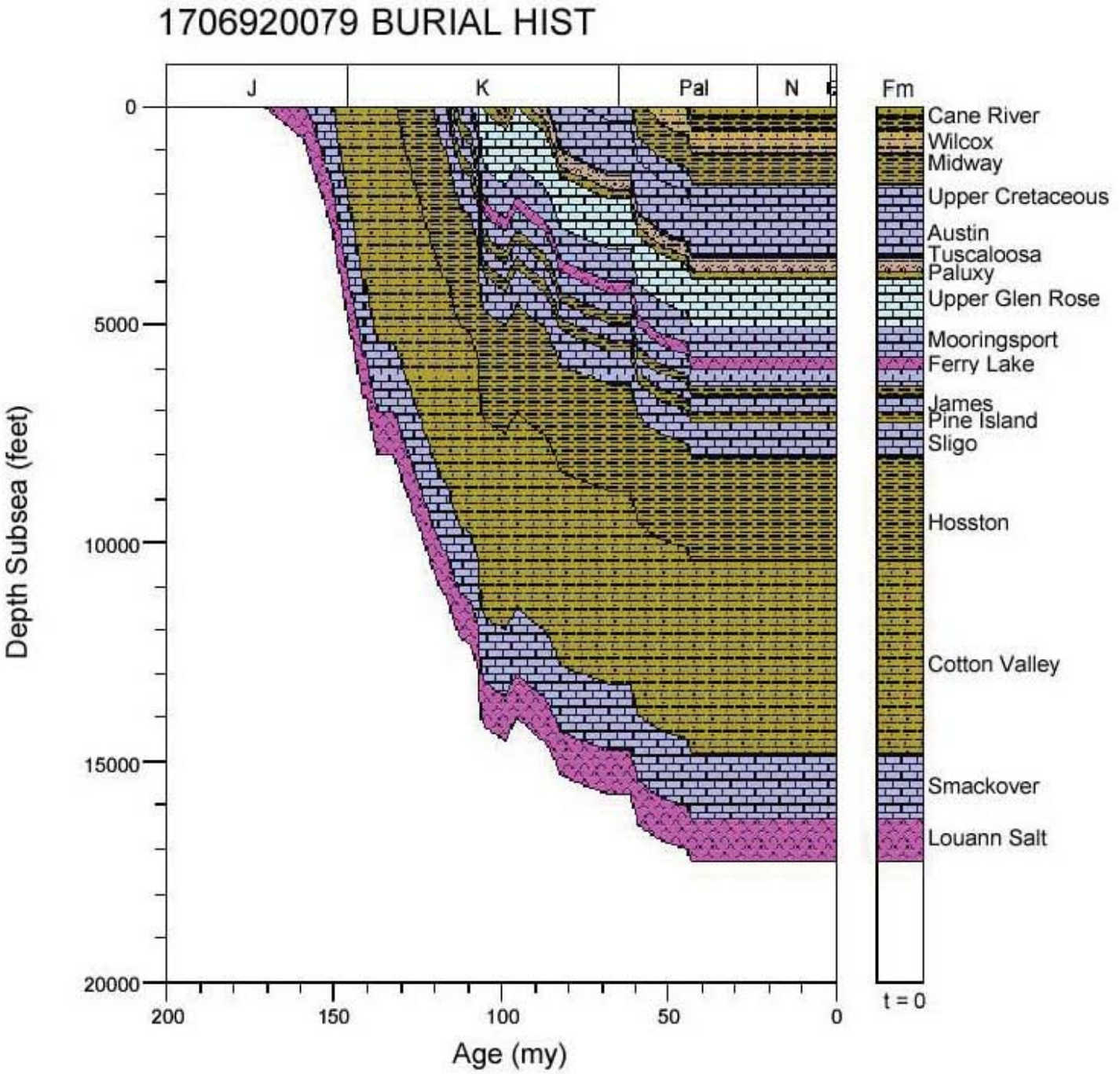


Figure 66. Burial history for well 1706920079, North Louisiana Salt Basin.

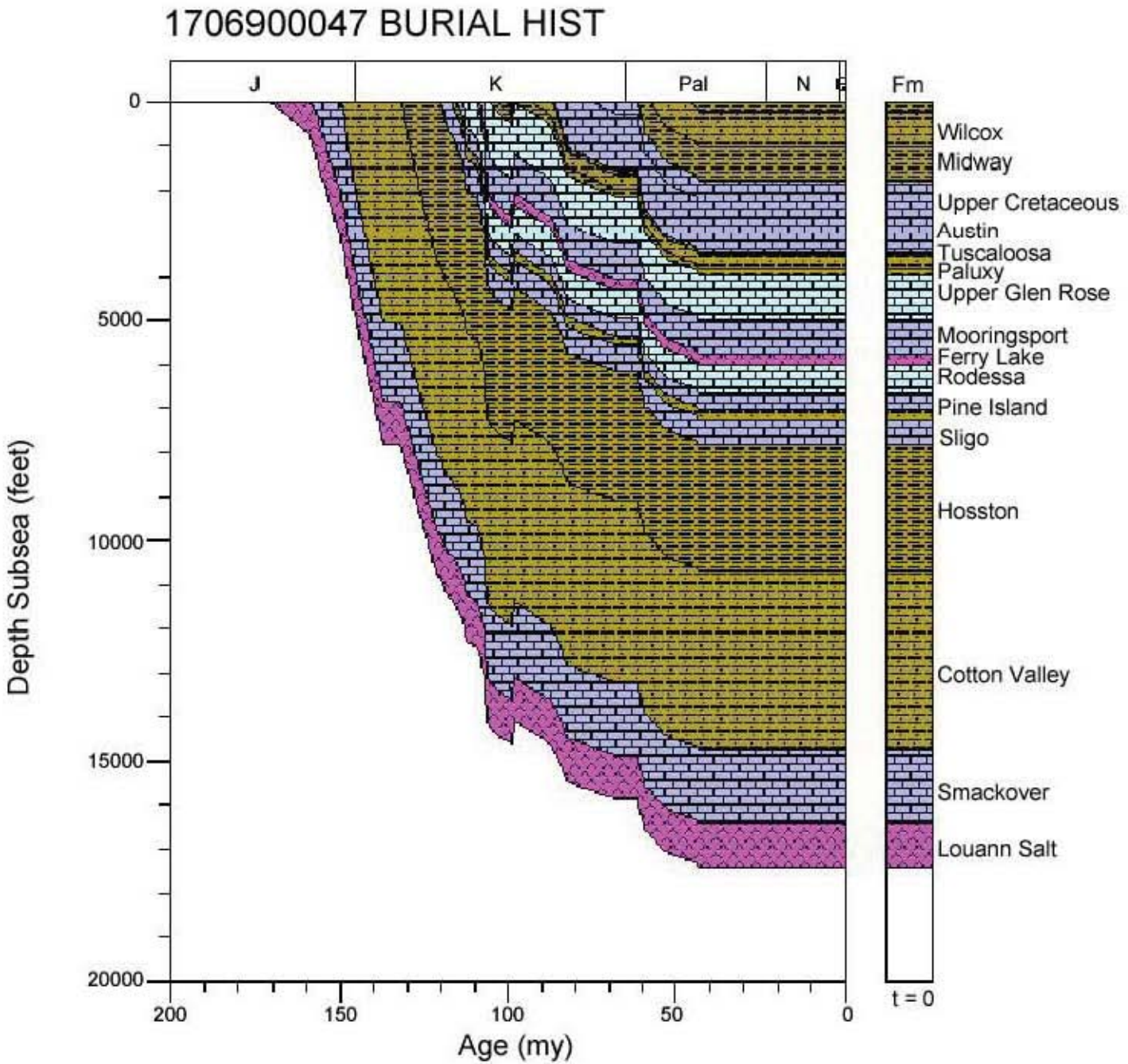


Figure 67. Burial history for well 1706900047, North Louisiana Salt Basin.

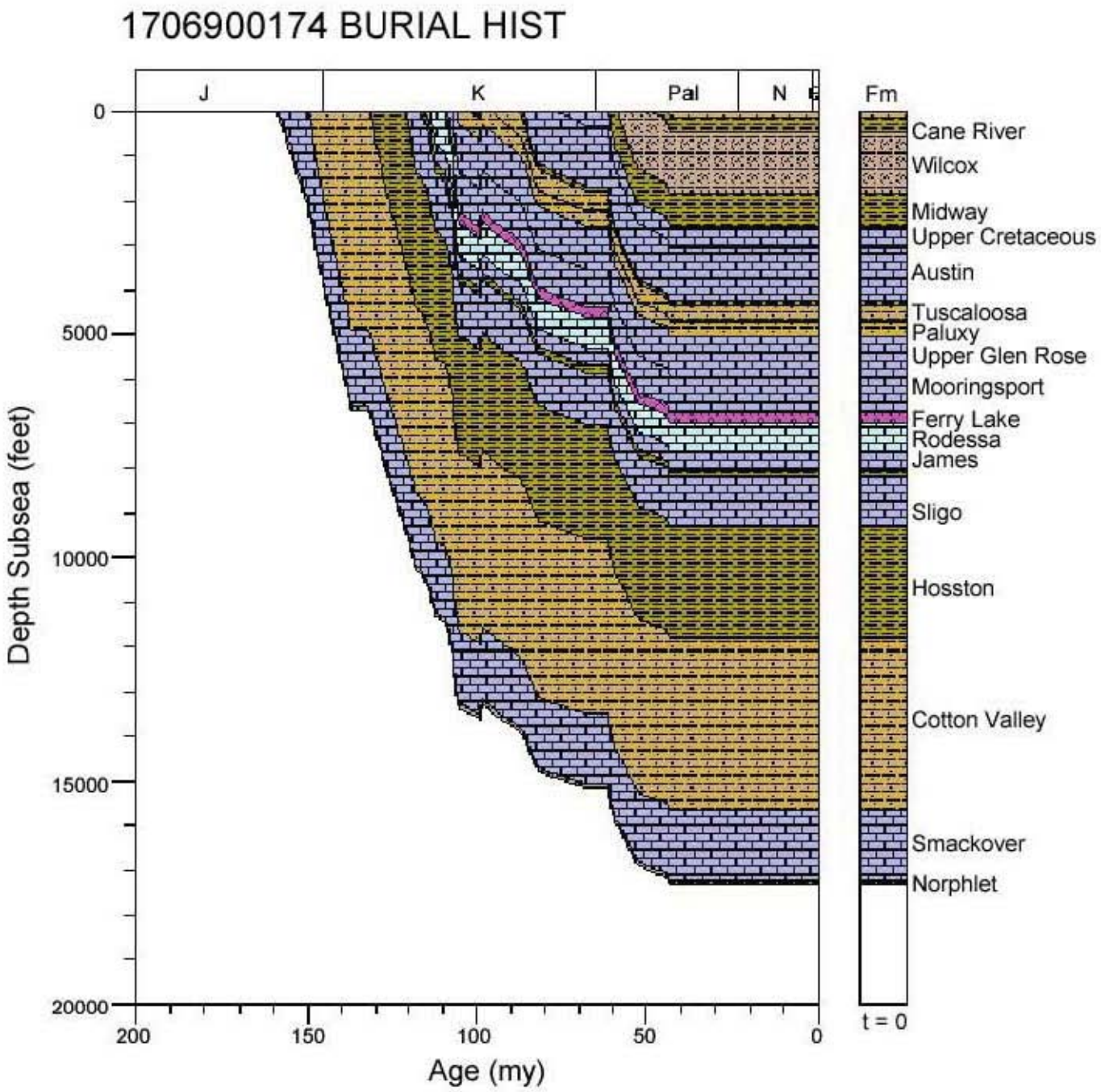


Figure 68. Burial history for well 1706900174, North Louisiana Salt Basin.

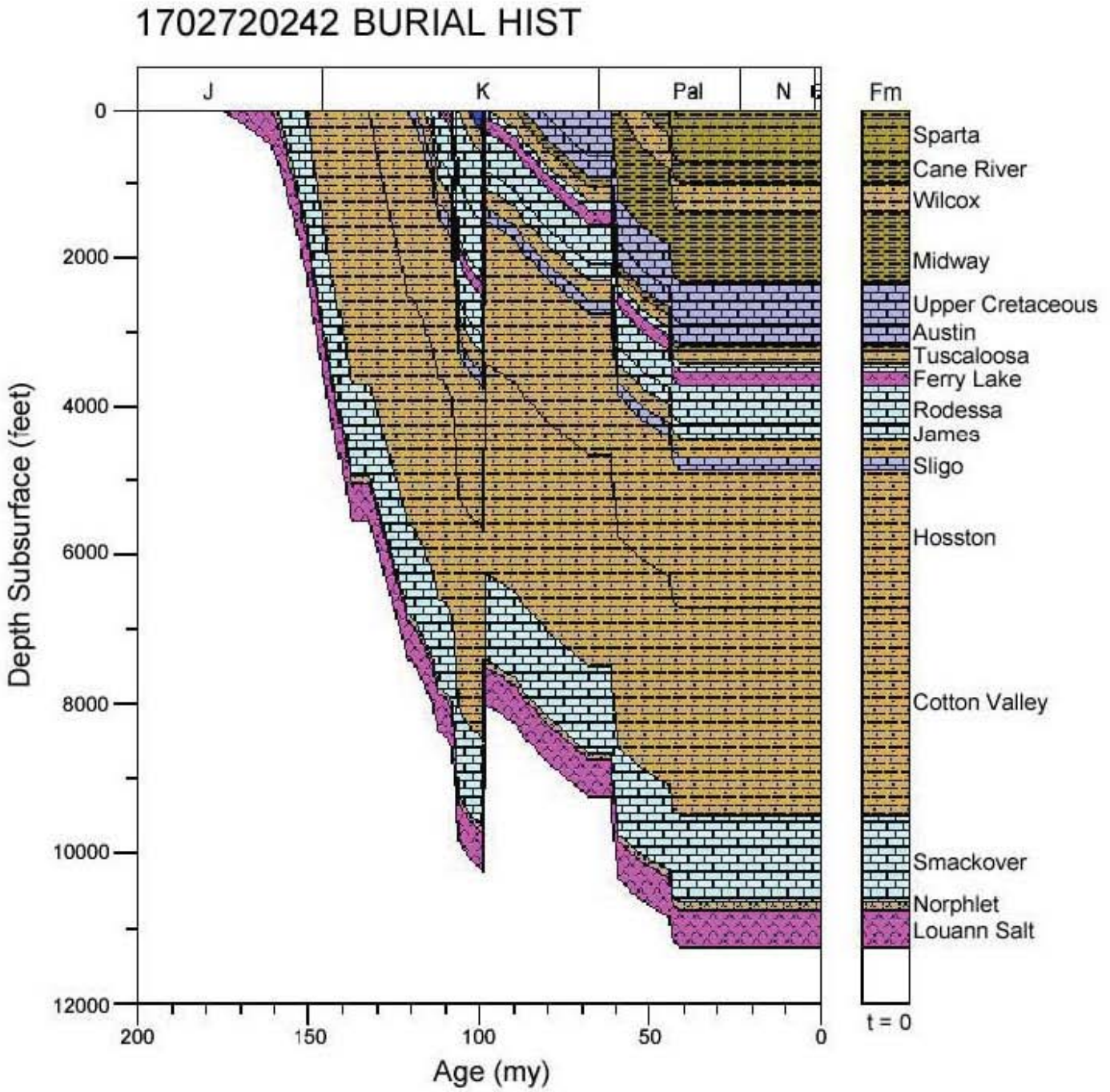


Figure 69. Burial history for well 1702720242, North Louisiana Salt Basin.

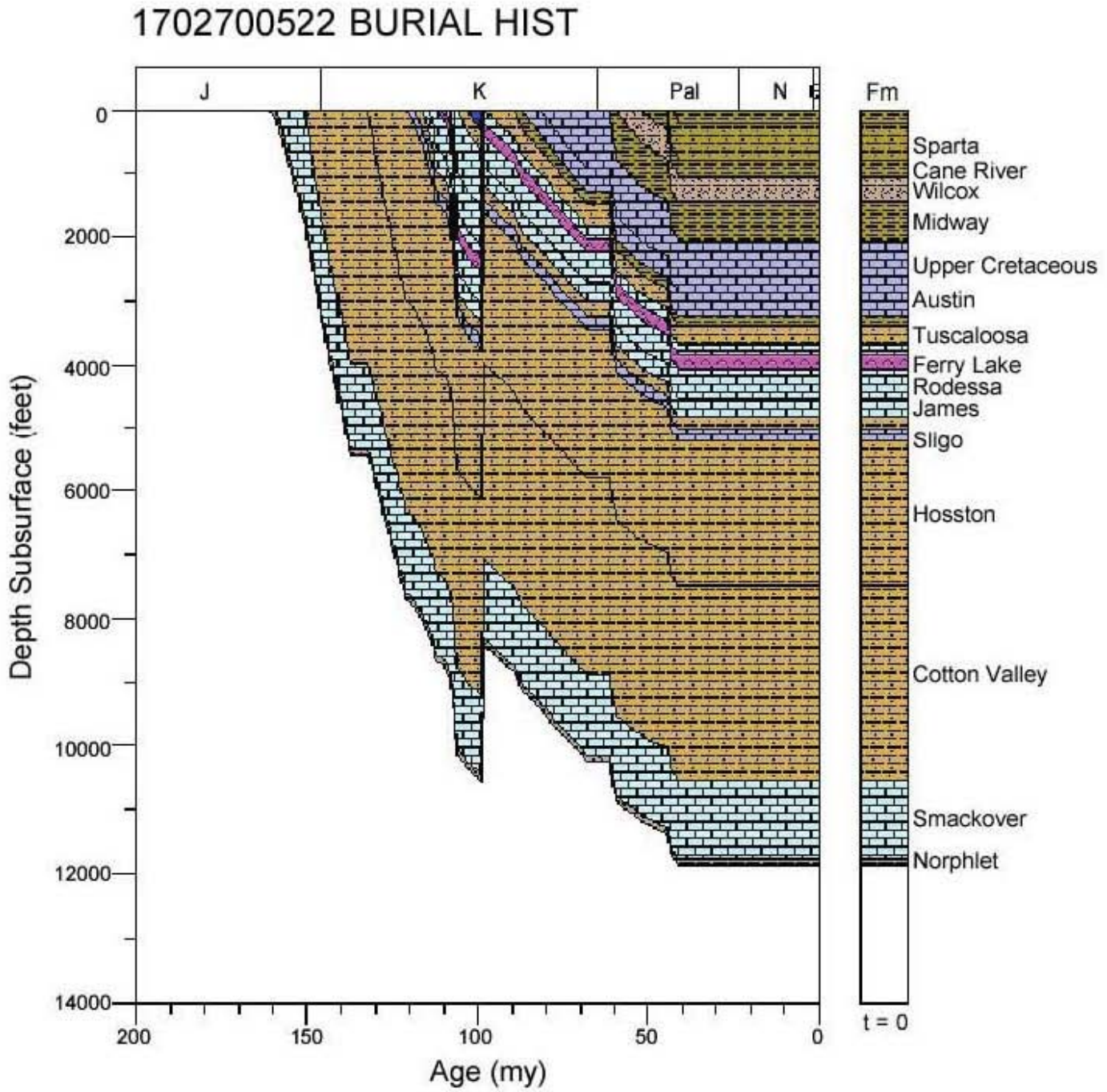


Figure 70. Burial history for well 1702700522, North Louisiana Salt Basin.

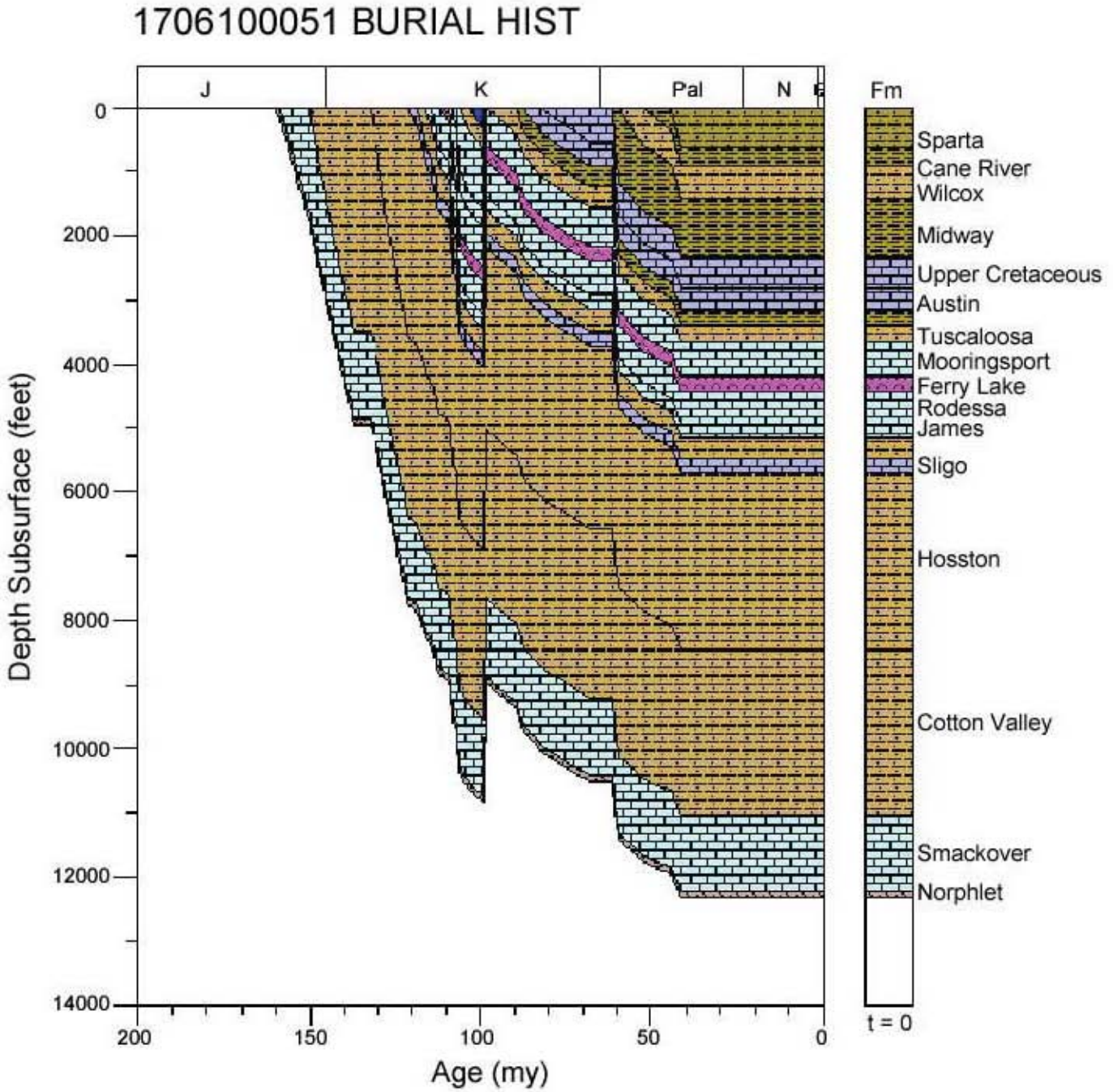


Figure 71. Burial history for well 1706100051, North Louisiana Salt Basin.

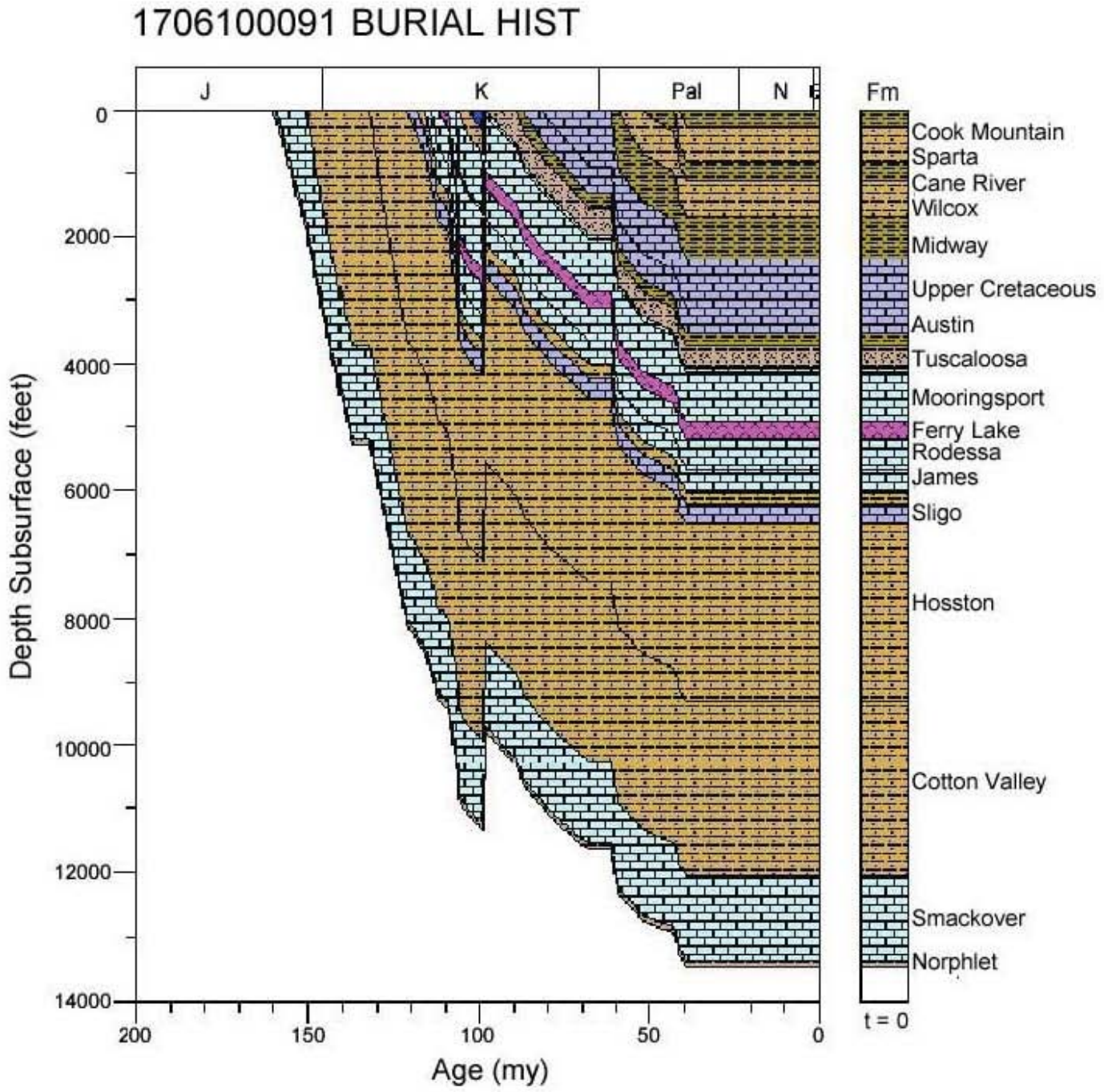


Figure 72. Burial history for well 1706100091, North Louisiana Salt Basin.

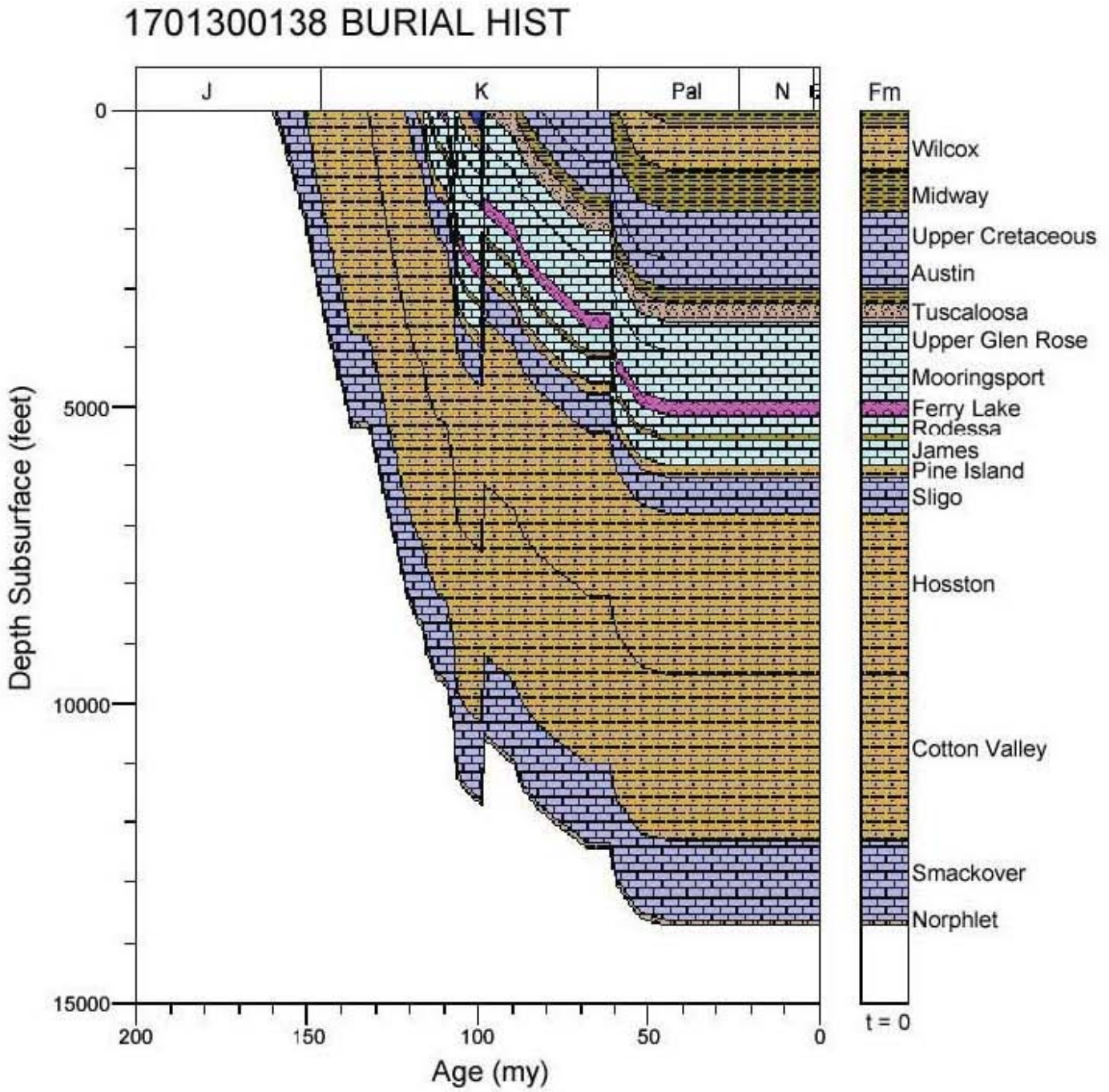


Figure 73. Burial history for well 1701300138, North Louisiana Salt Basin.

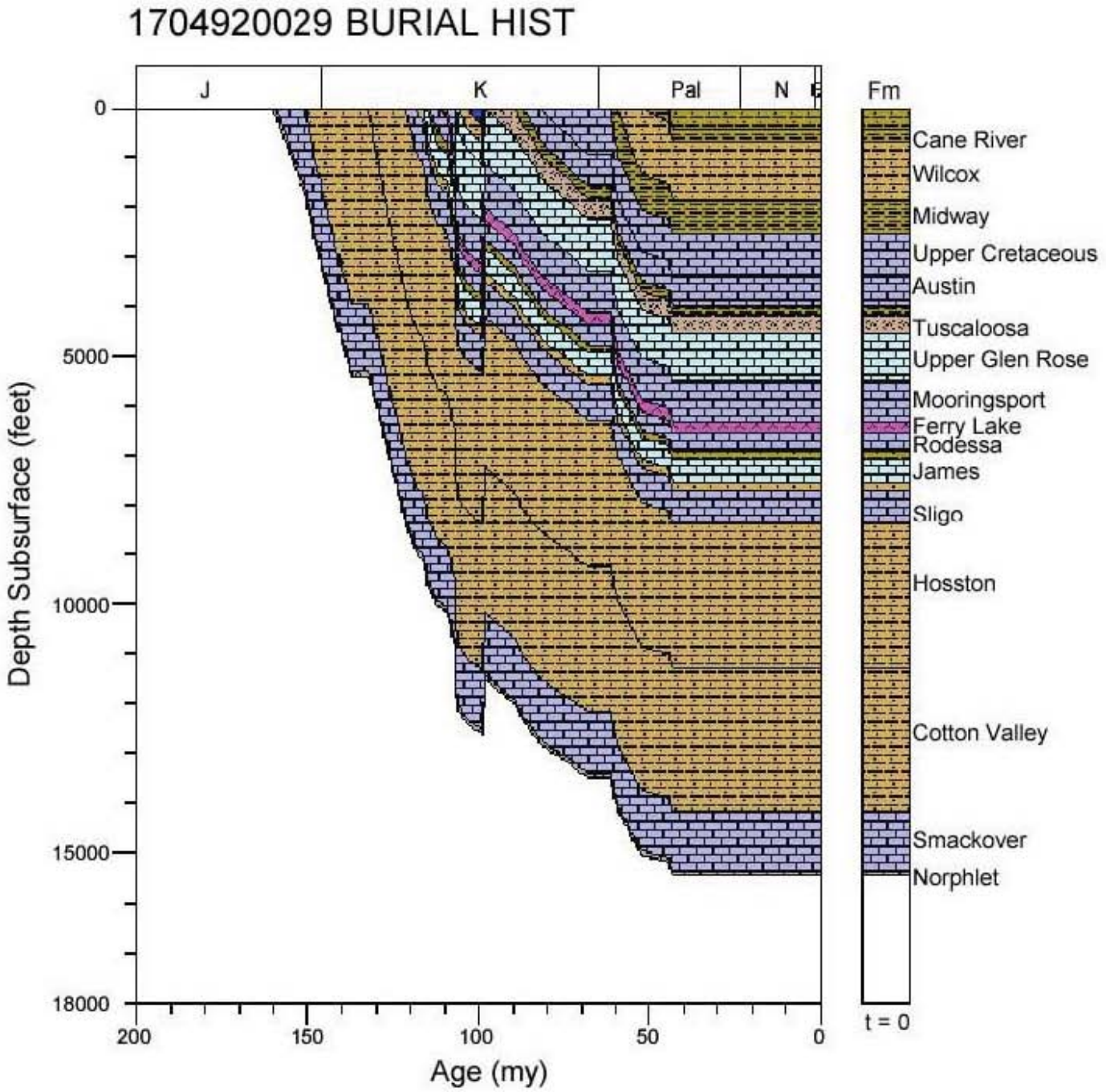


Figure 74. Burial history for well 1704920029, North Louisiana Salt Basin.

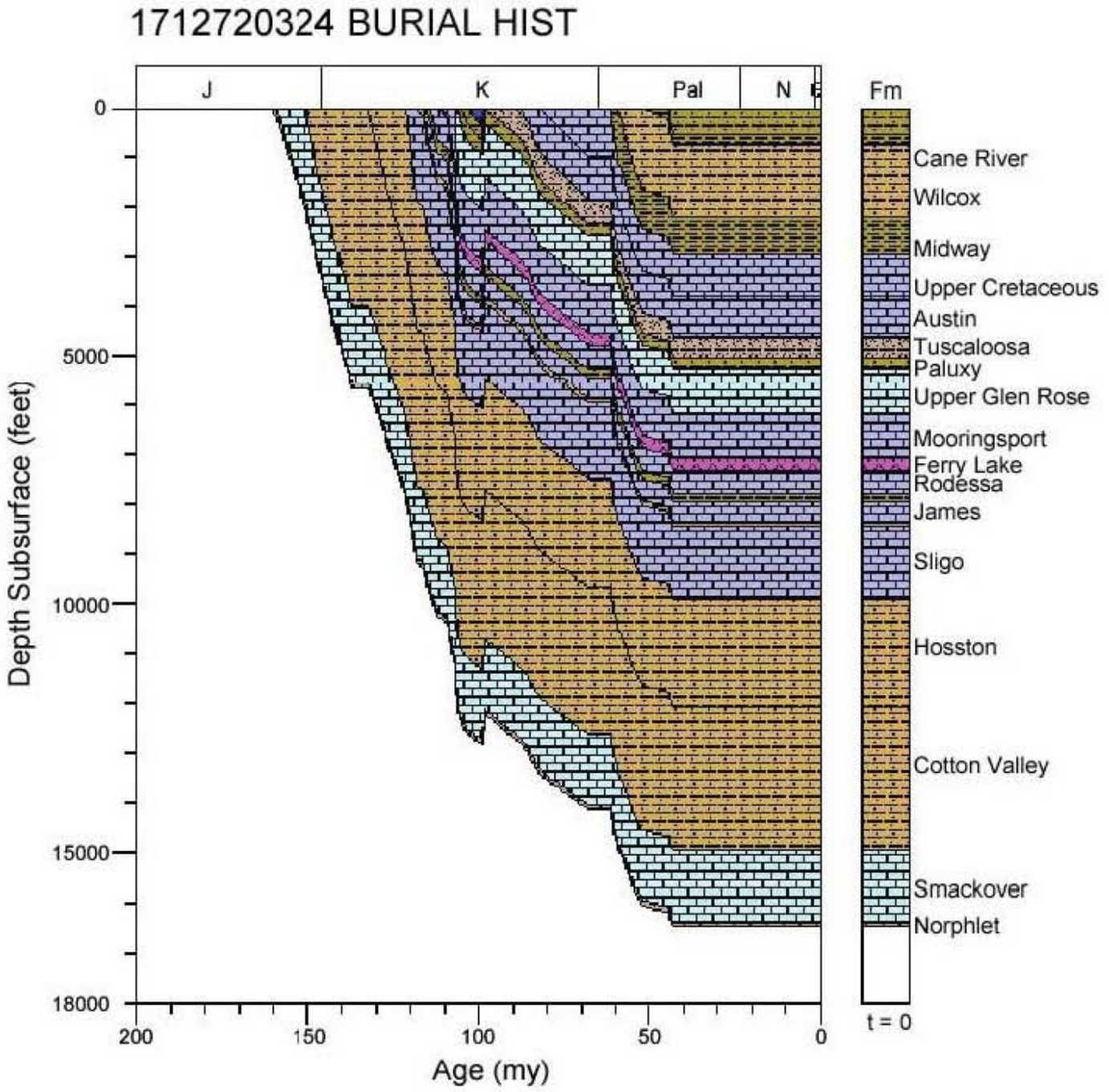


Figure 75. Burial history for well 1712720324, North Louisiana Salt Basin.

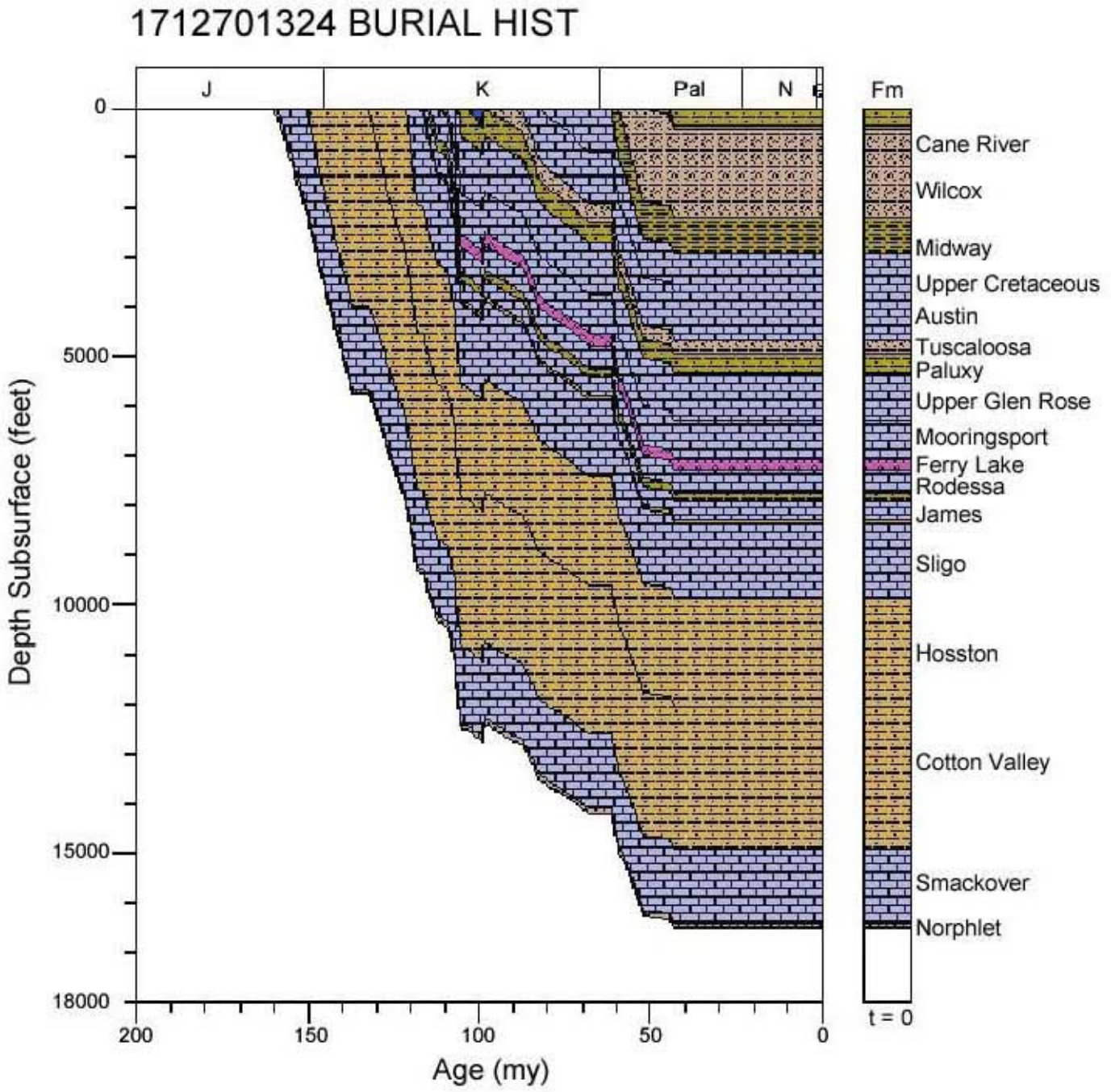


Figure 76. Burial history for well 1712701324, North Louisiana Salt Basin.

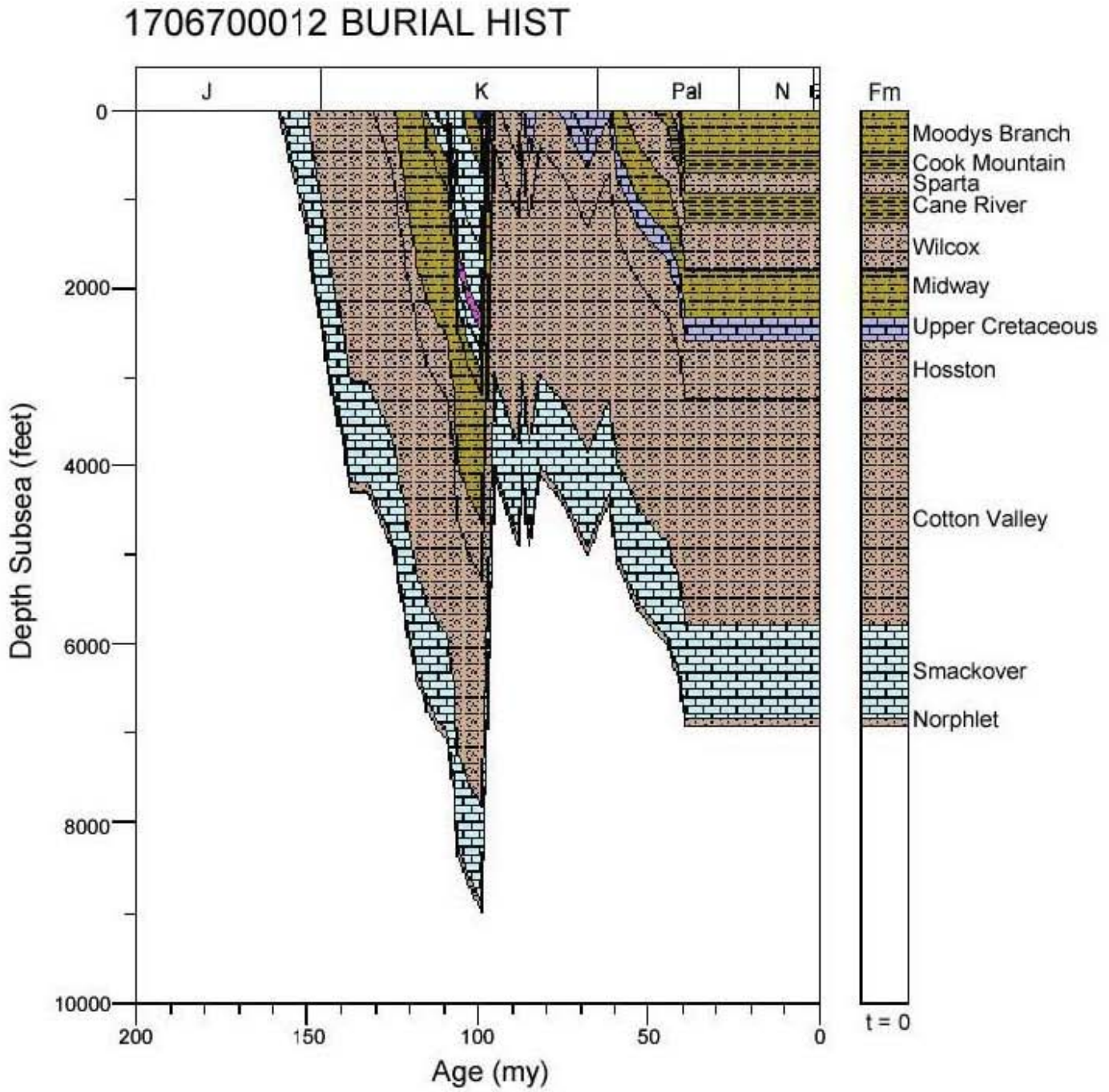


Figure 77. Burial history for well 1706700012, North Louisiana Salt Basin.

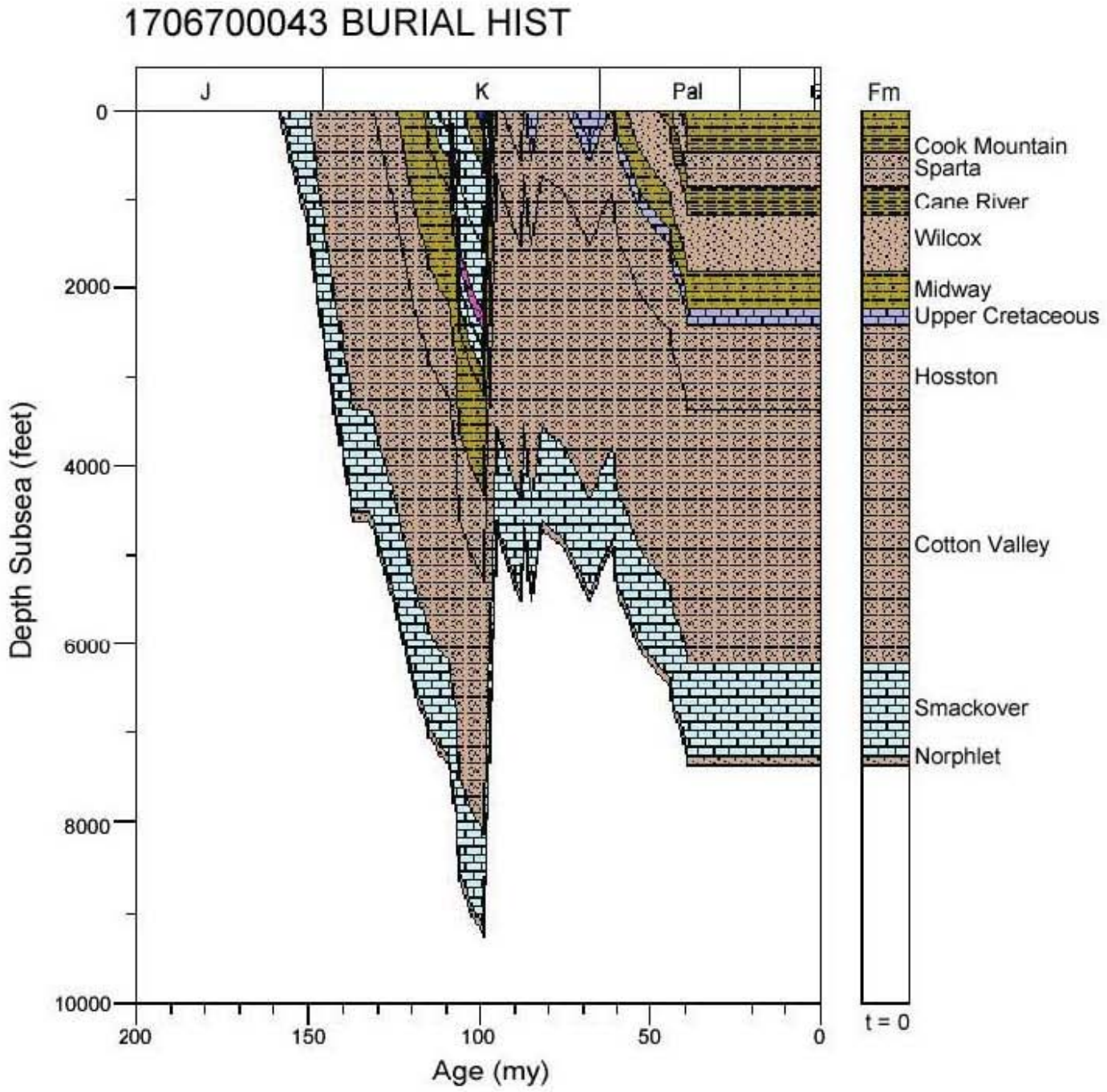


Figure 78. Burial history for well 1706700043, North Louisiana Salt Basin.

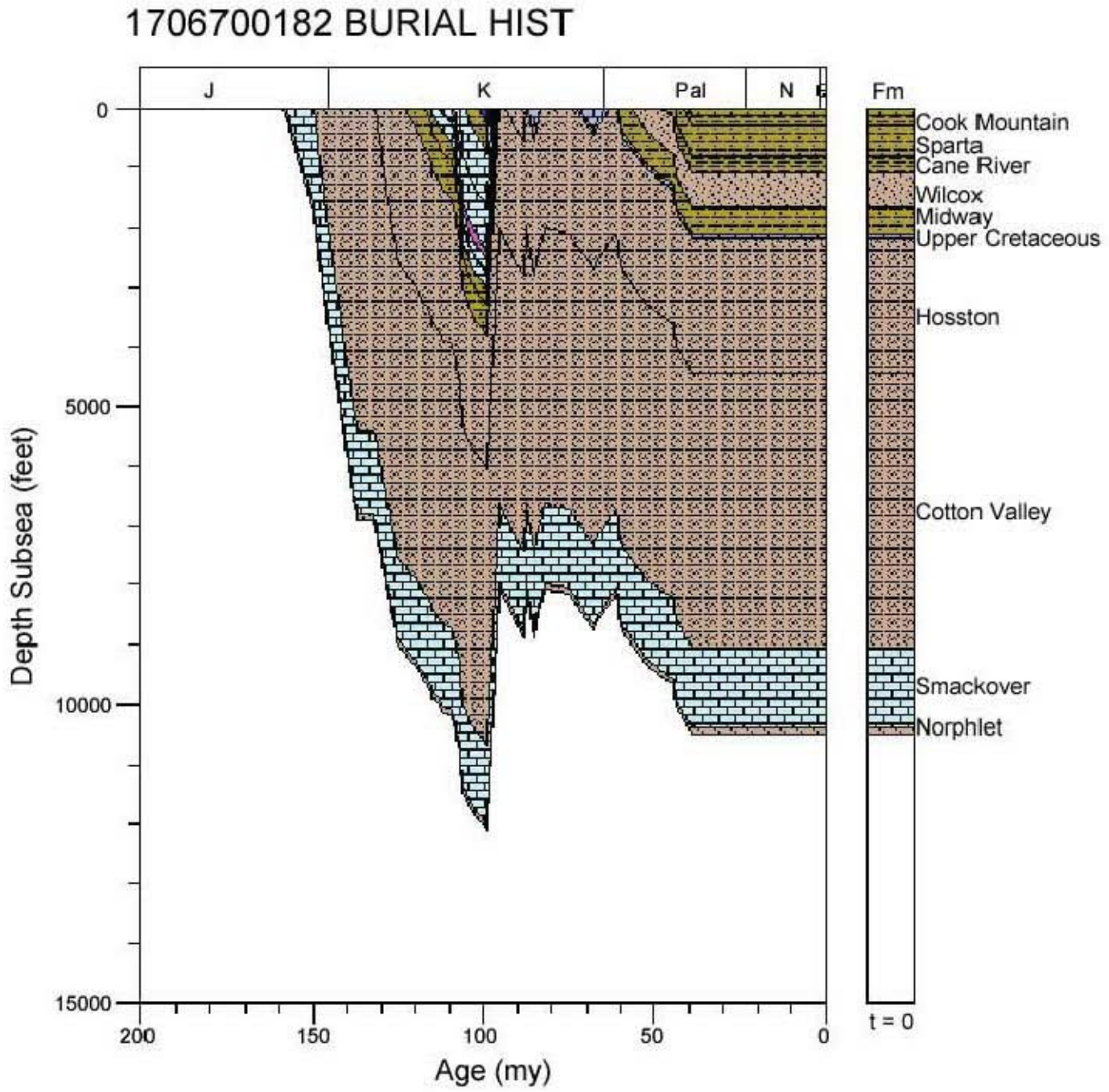


Figure 79. Burial history for well 1706700182, North Louisiana Salt Basin.

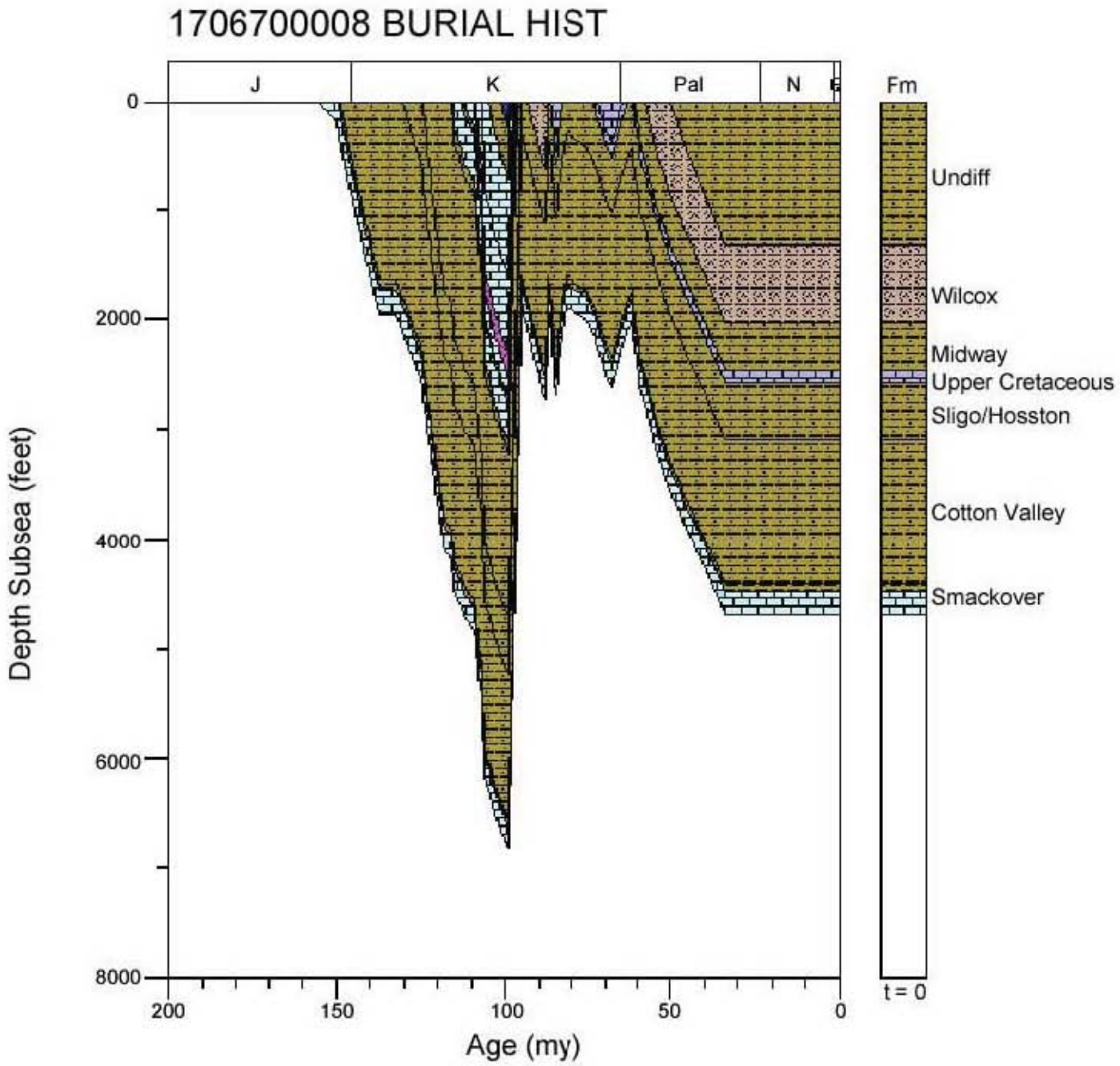


Figure 80. Burial history for well 1706700008, North Louisiana Salt Basin.

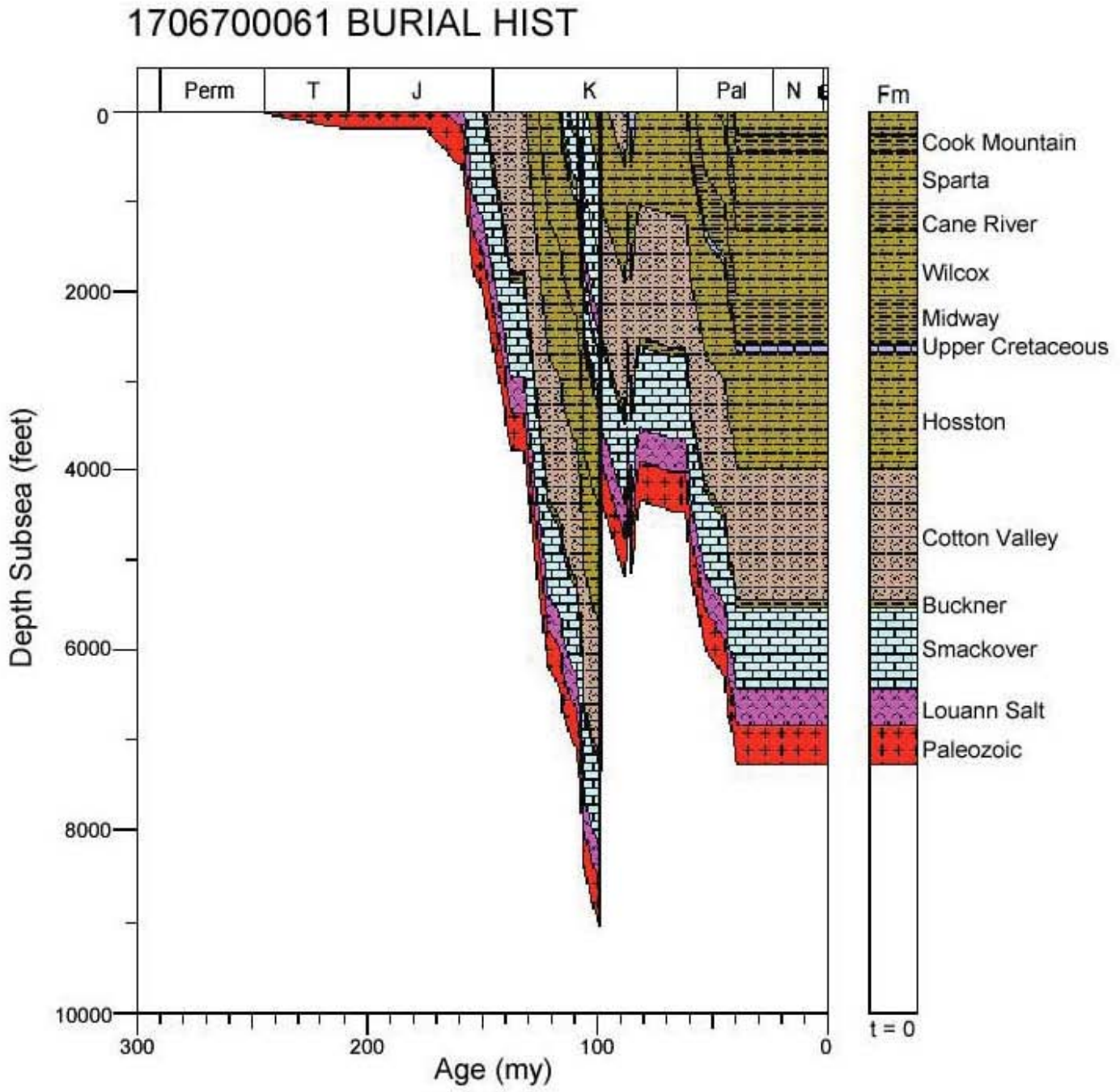


Figure 81. Burial history for well 1706700061, North Louisiana Salt Basin.

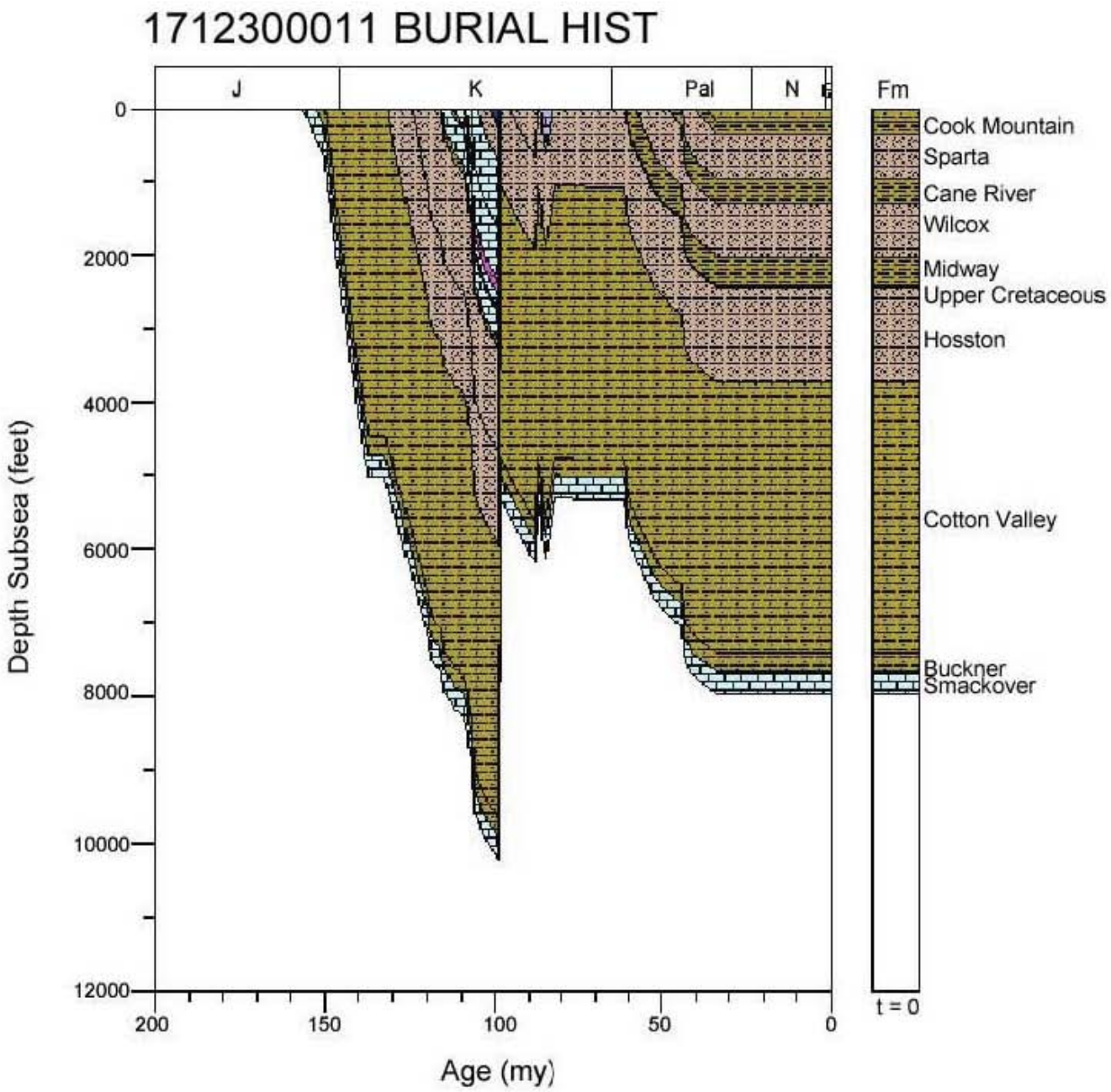
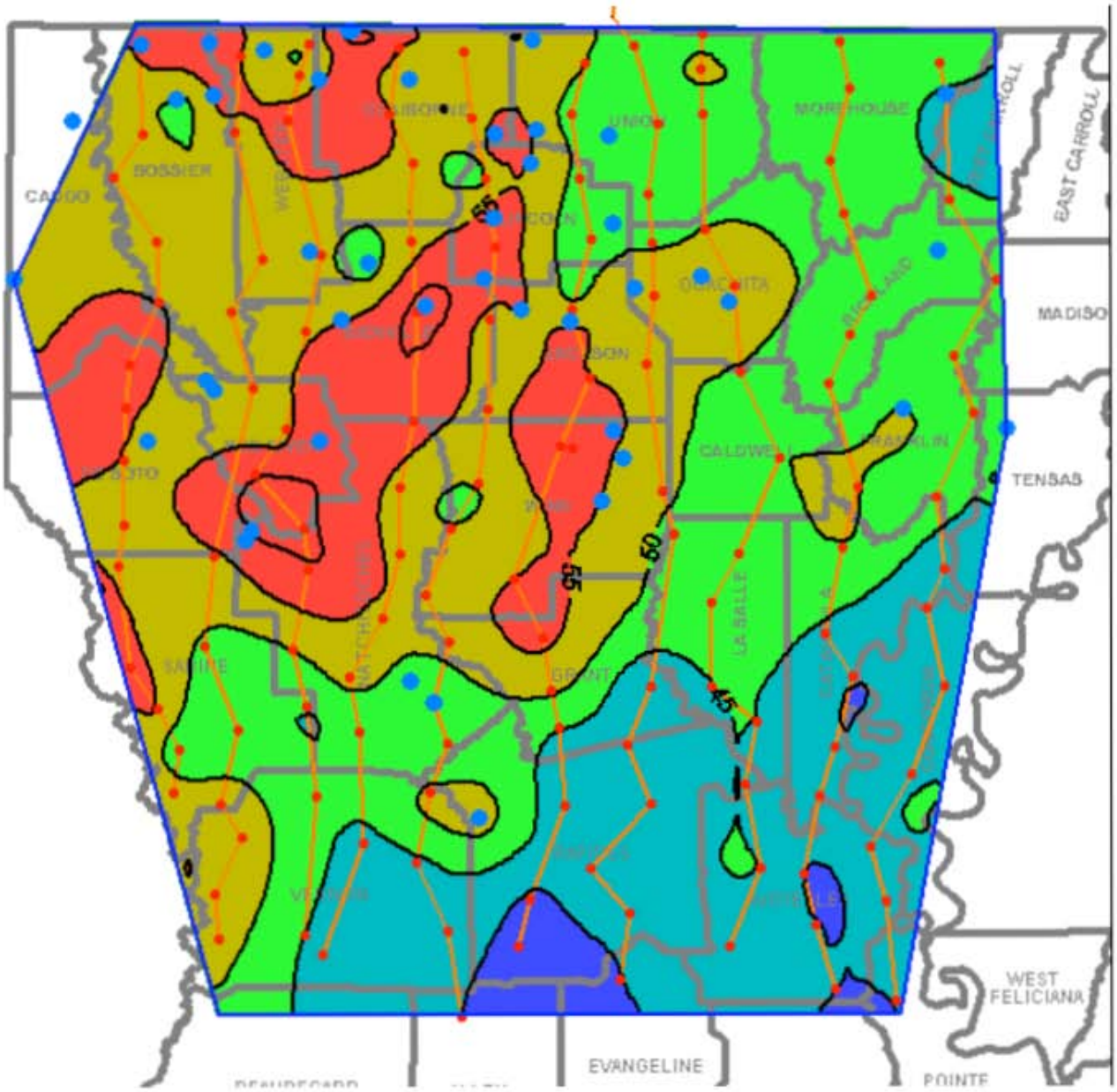


Figure 82. Burial history for well 1712300011, North Louisiana Salt Basin.



- wells w/ BHTs
- wells w/ BHTs & %Ro

55: heat flow value (mW/m^2)

Figure 83. Present-day heat flow values. Prepared by Roger Barnaby.

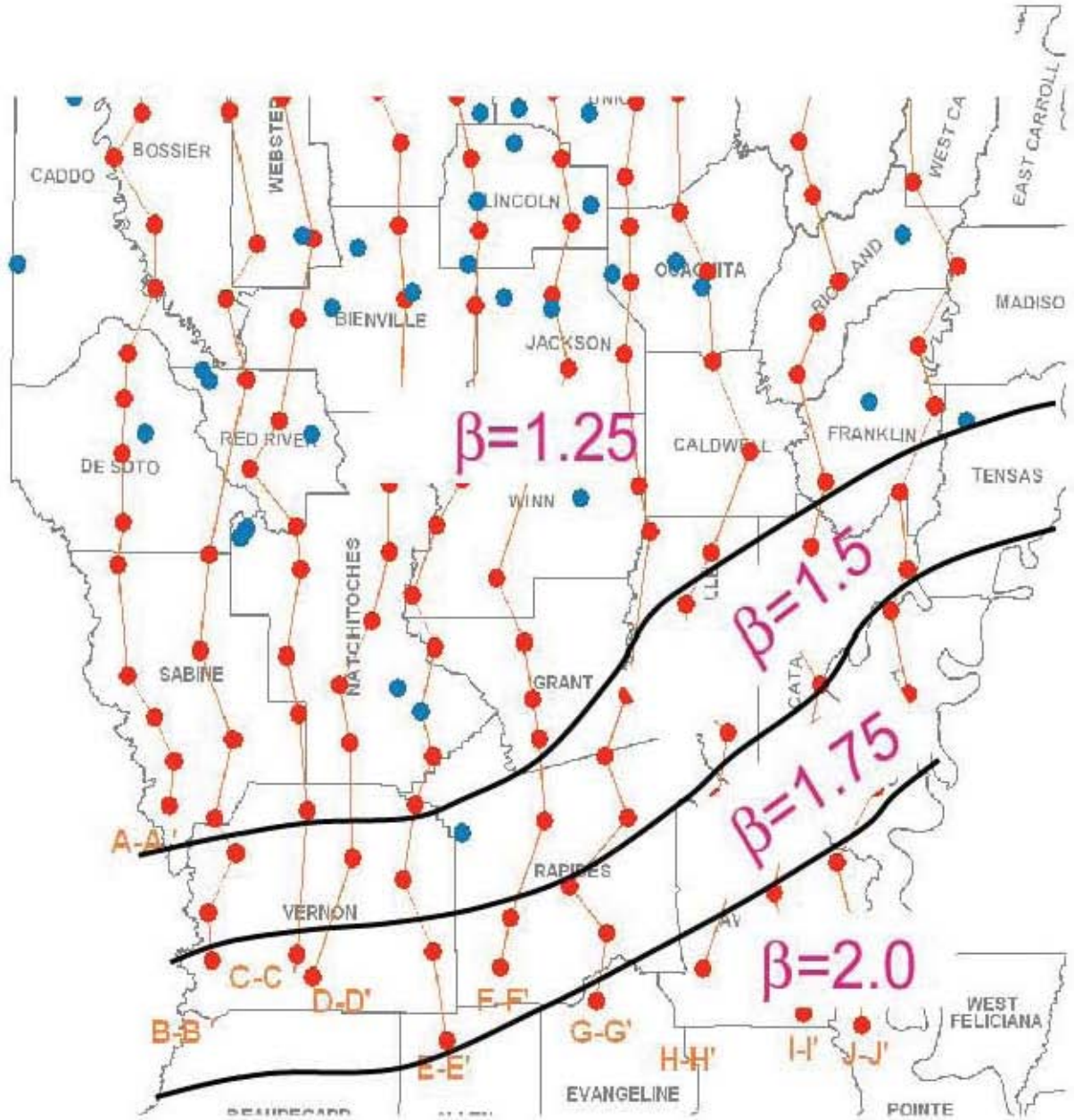


Figure 84. Lithospheric stretching beta factors. Prepared by Roger Barnaby.

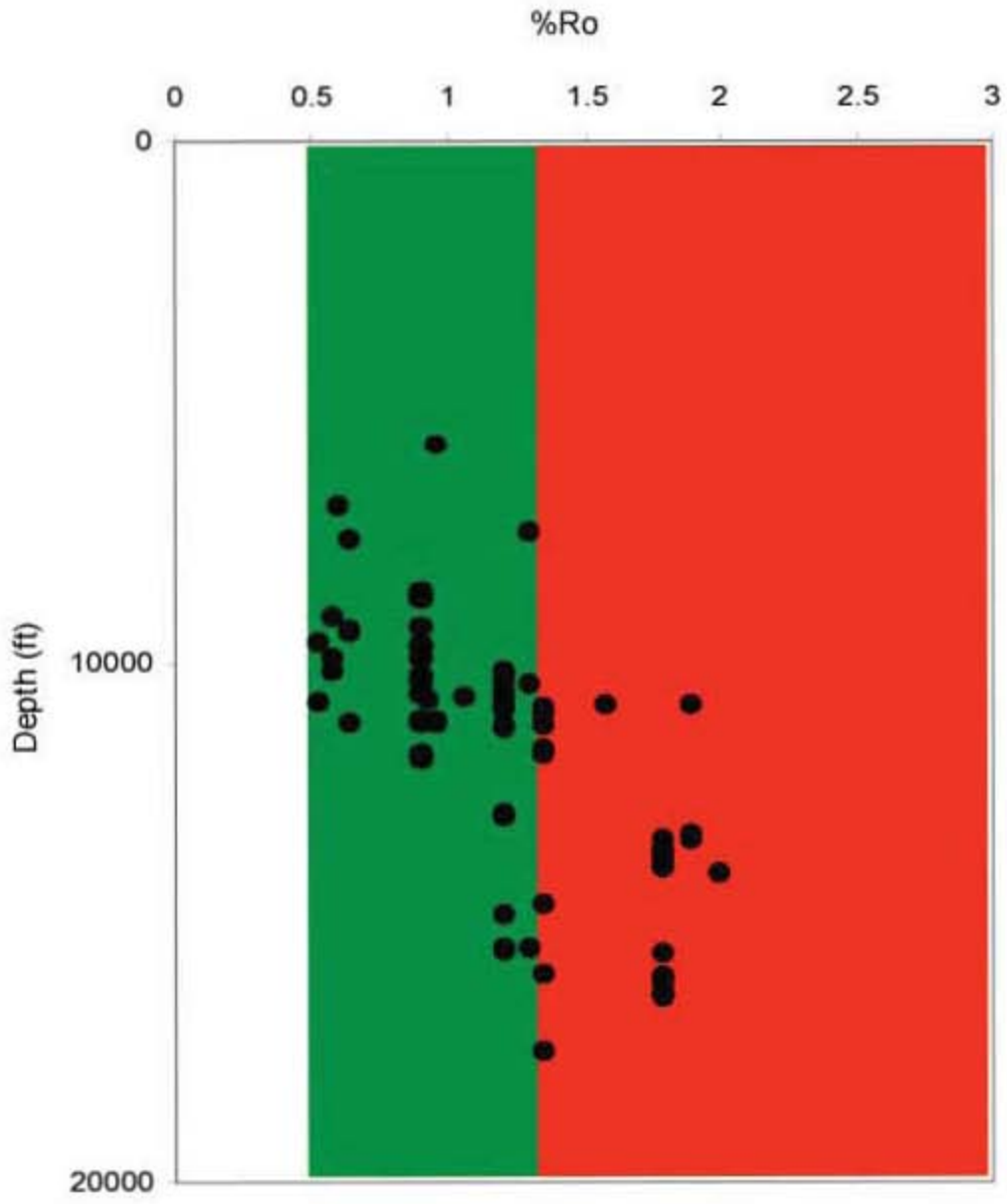


Figure 85. The relationship of vitrinite reflectance and depth. Prepared by Roger Barnaby.

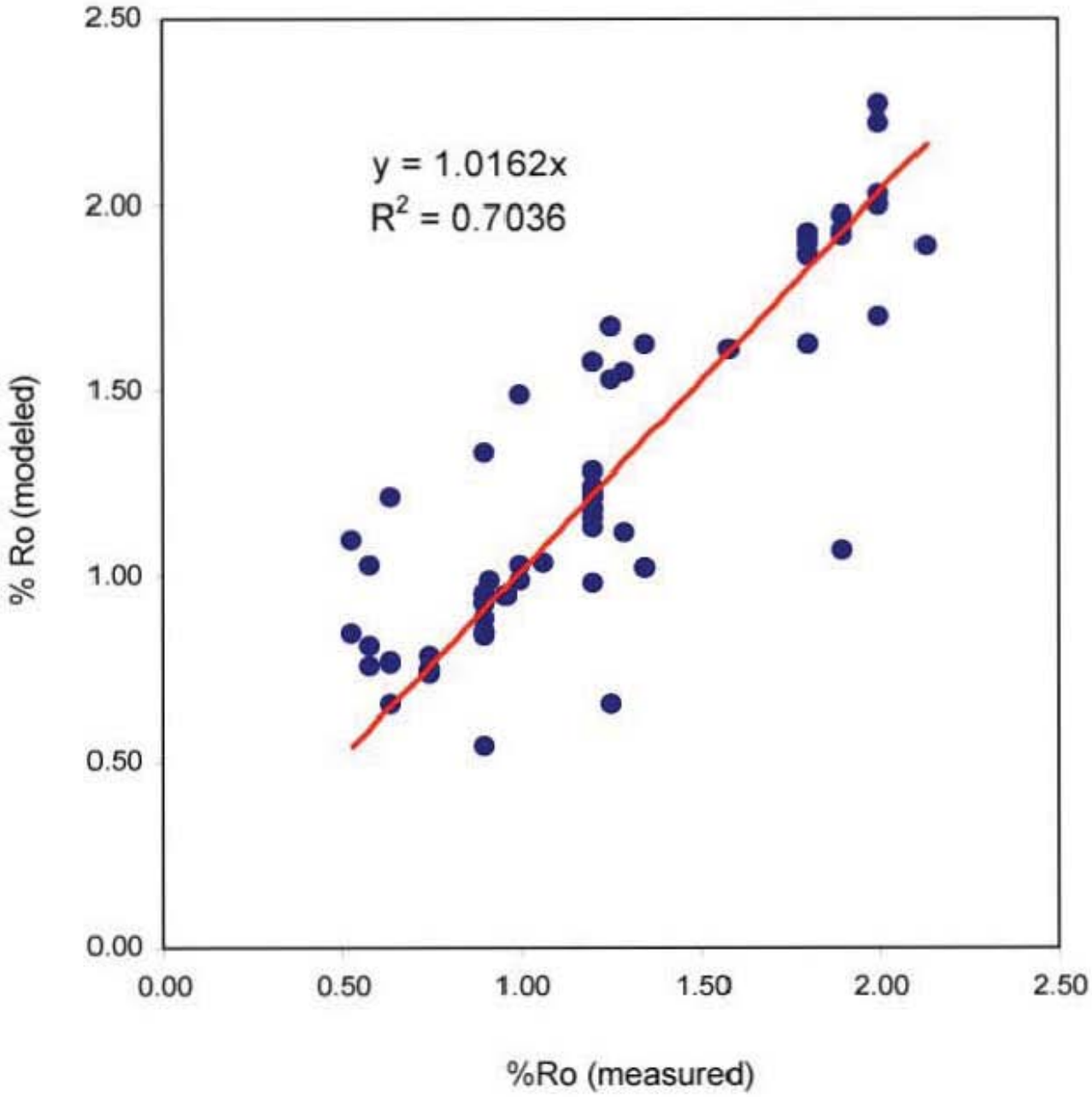


Figure 86. Comparison of the modeled %Ro with measured %Ro.
Prepared by Roger Barnaby.

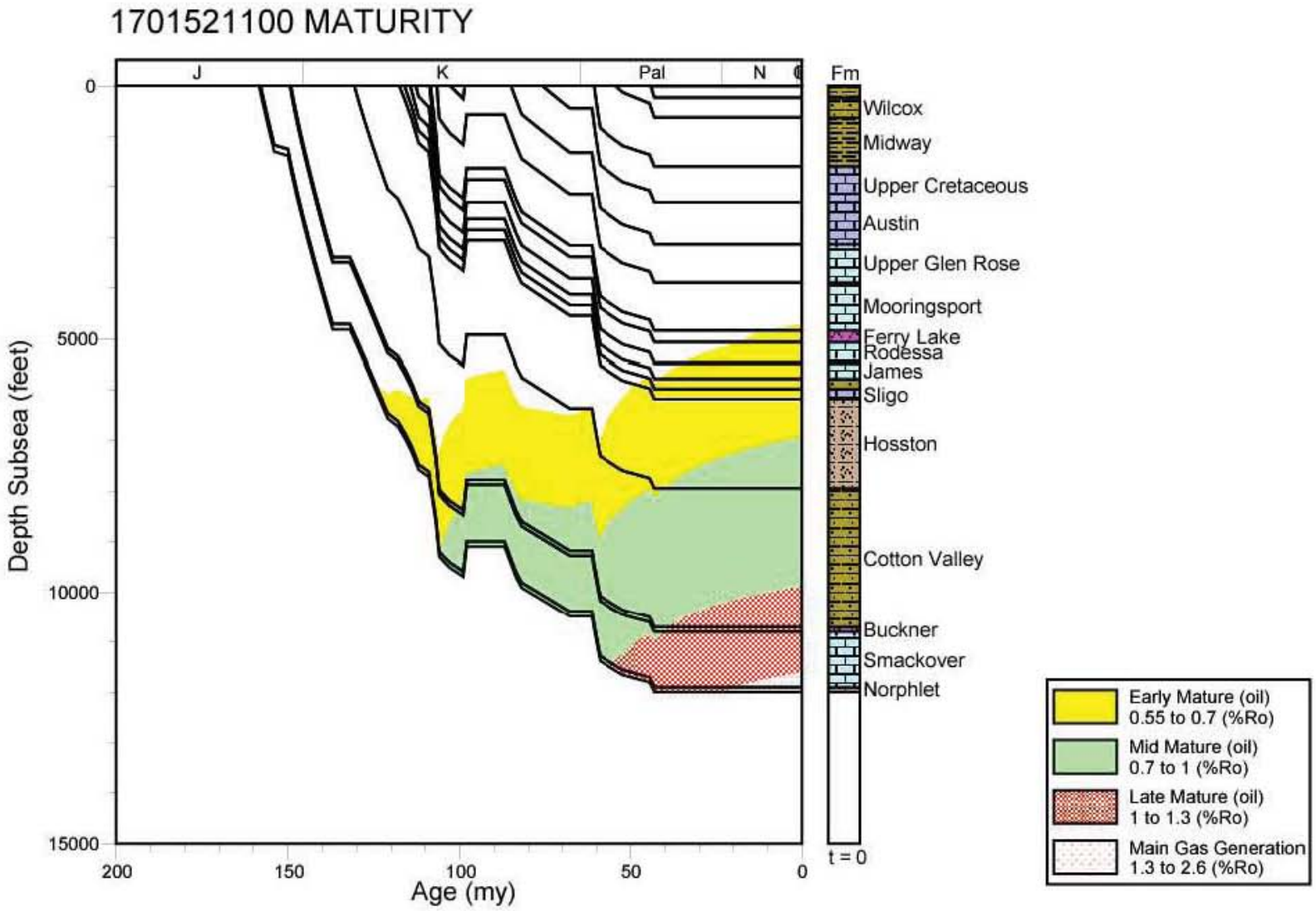


Figure 87. Thermal maturation profile for well 1701521100, North Louisiana Salt Basin.

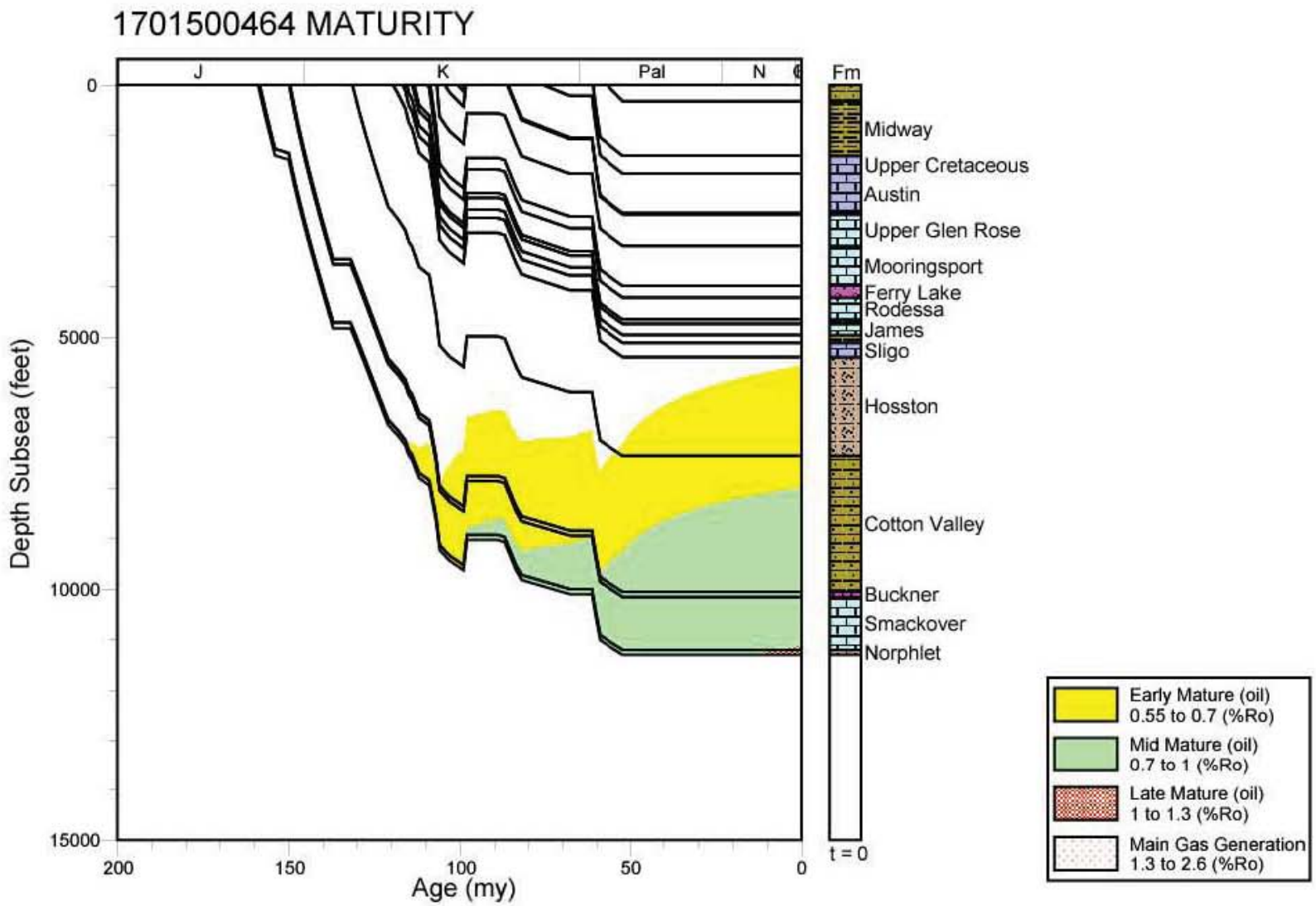


Figure 88. Thermal maturation profile for well 1701500464, North Louisiana Salt Basin.

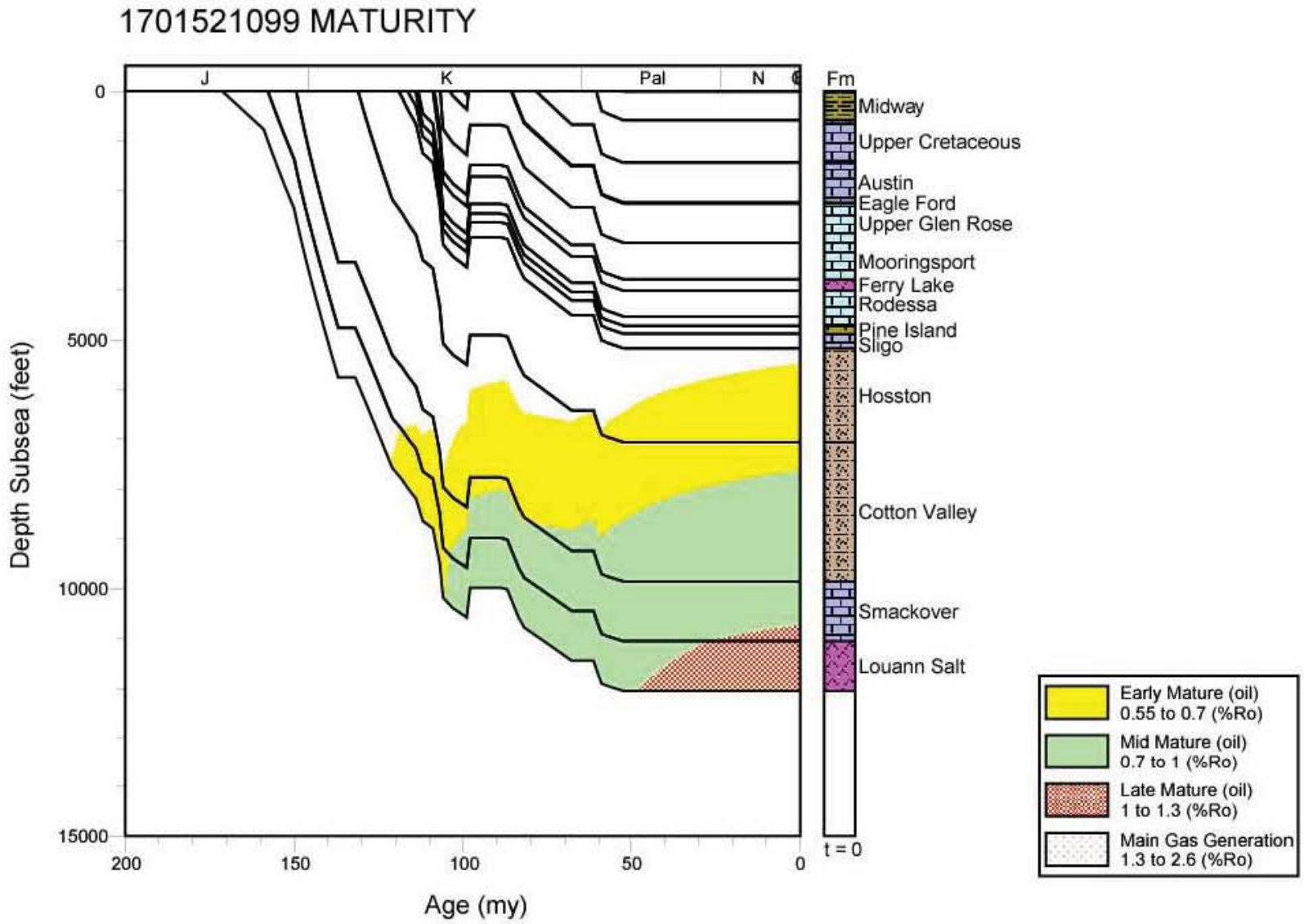


Figure 89. Thermal maturation profile for well 1701521099, North Louisiana Salt Basin.

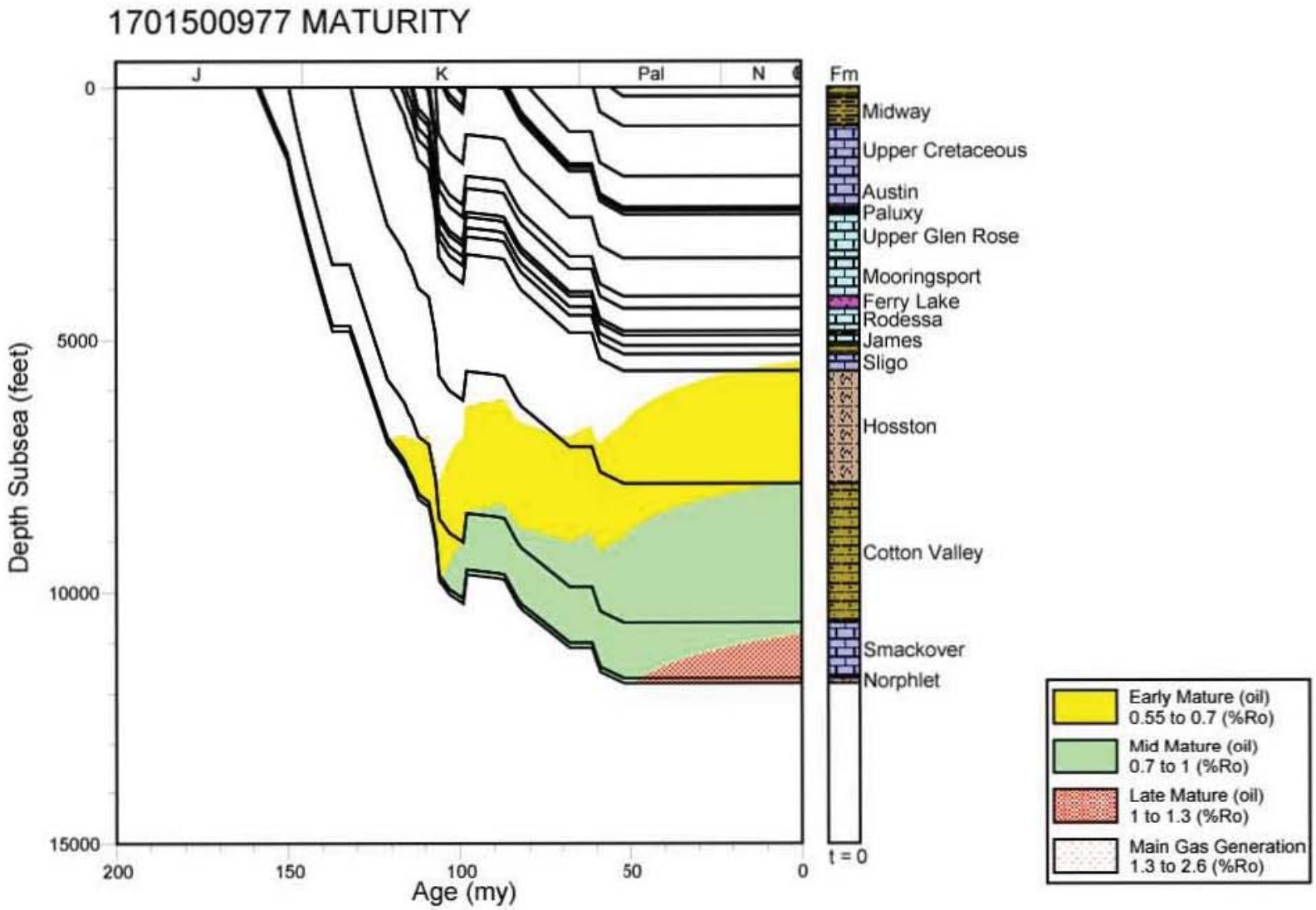


Figure 90. Thermal maturation profile for well 1701500977, North Louisiana Salt Basin.

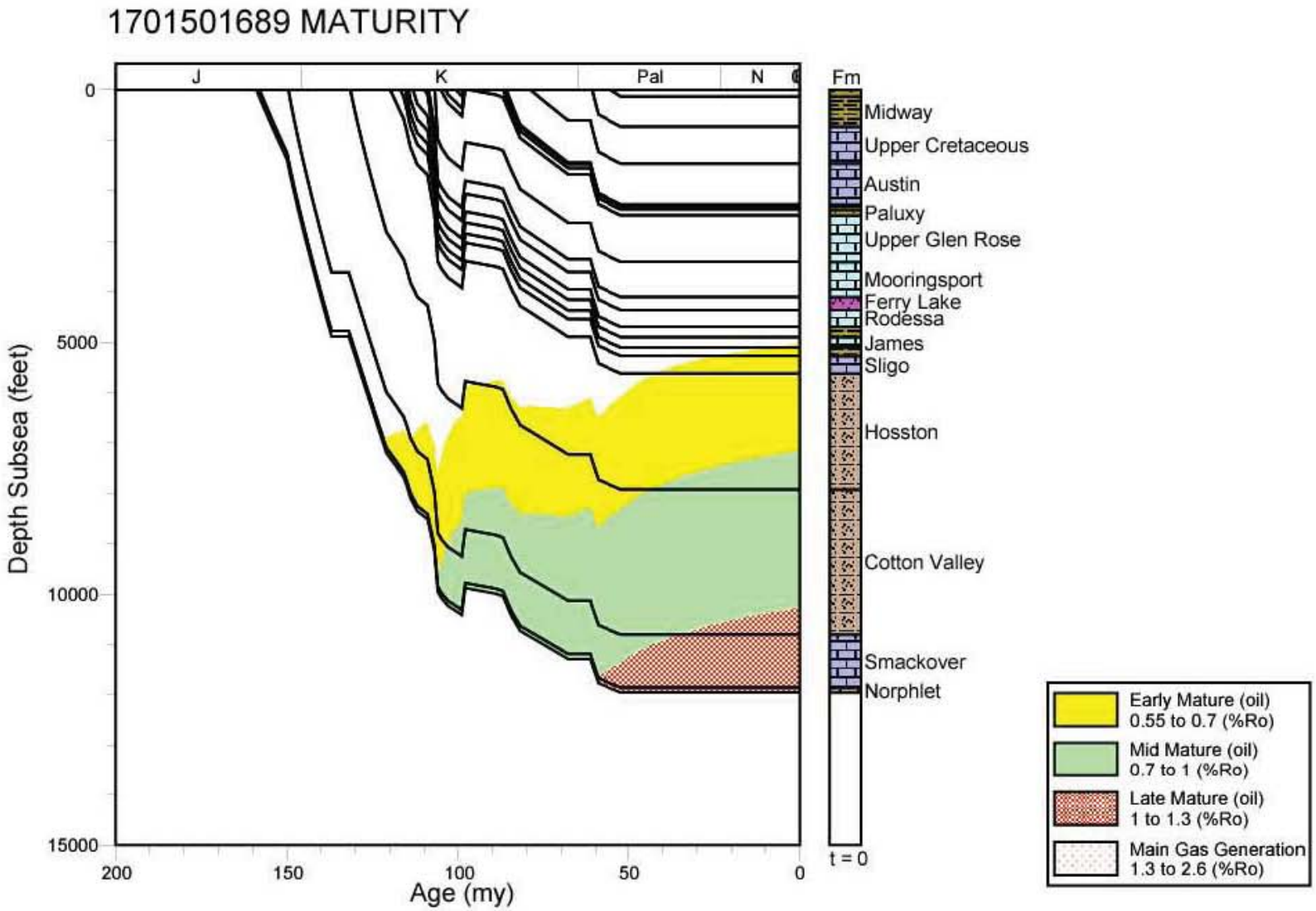


Figure 91. Thermal maturation profile for well 1701501689, North Louisiana Salt Basin.

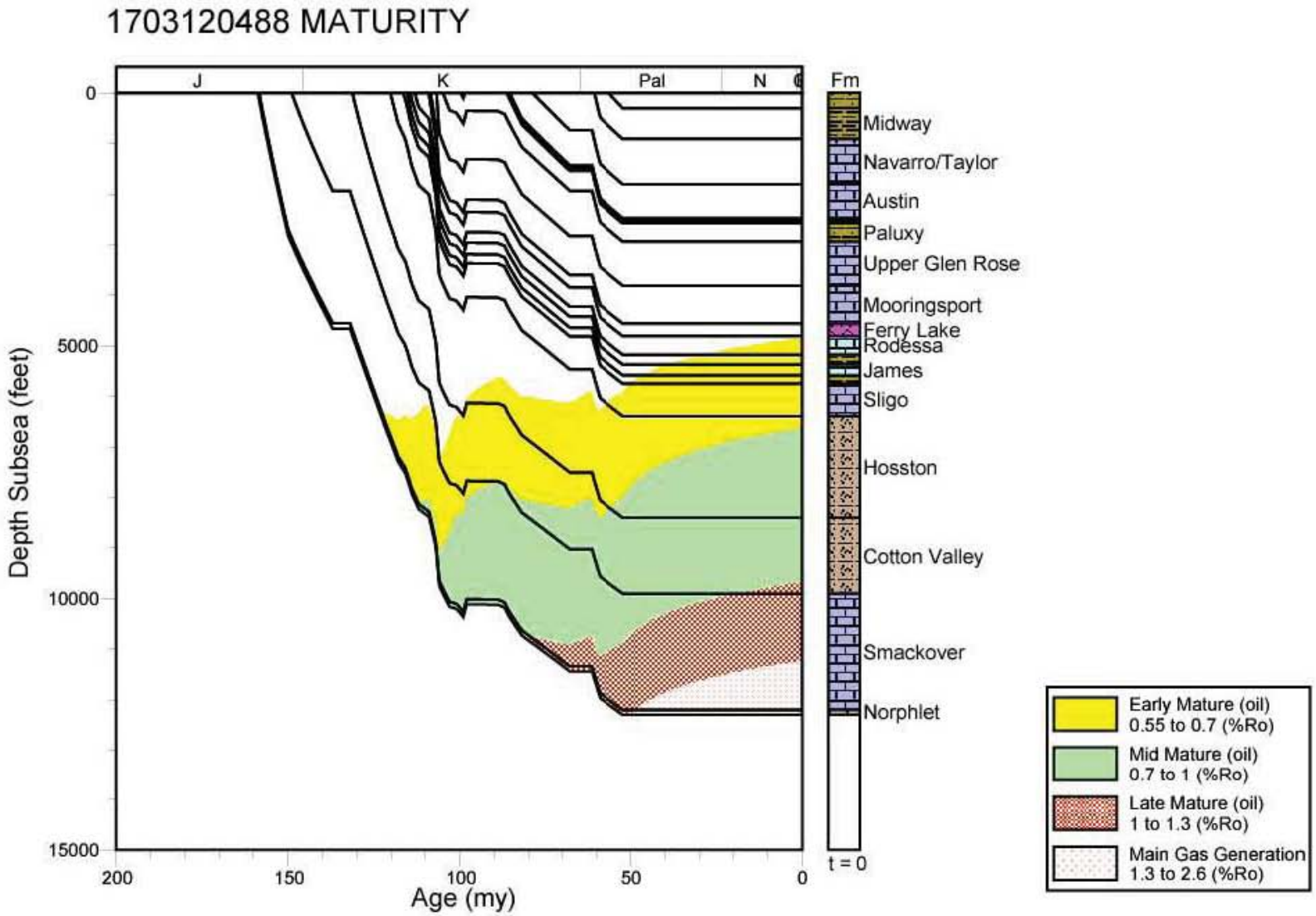


Figure 92. Thermal maturation profile for well 1703120488, North Louisiana Salt Basin.

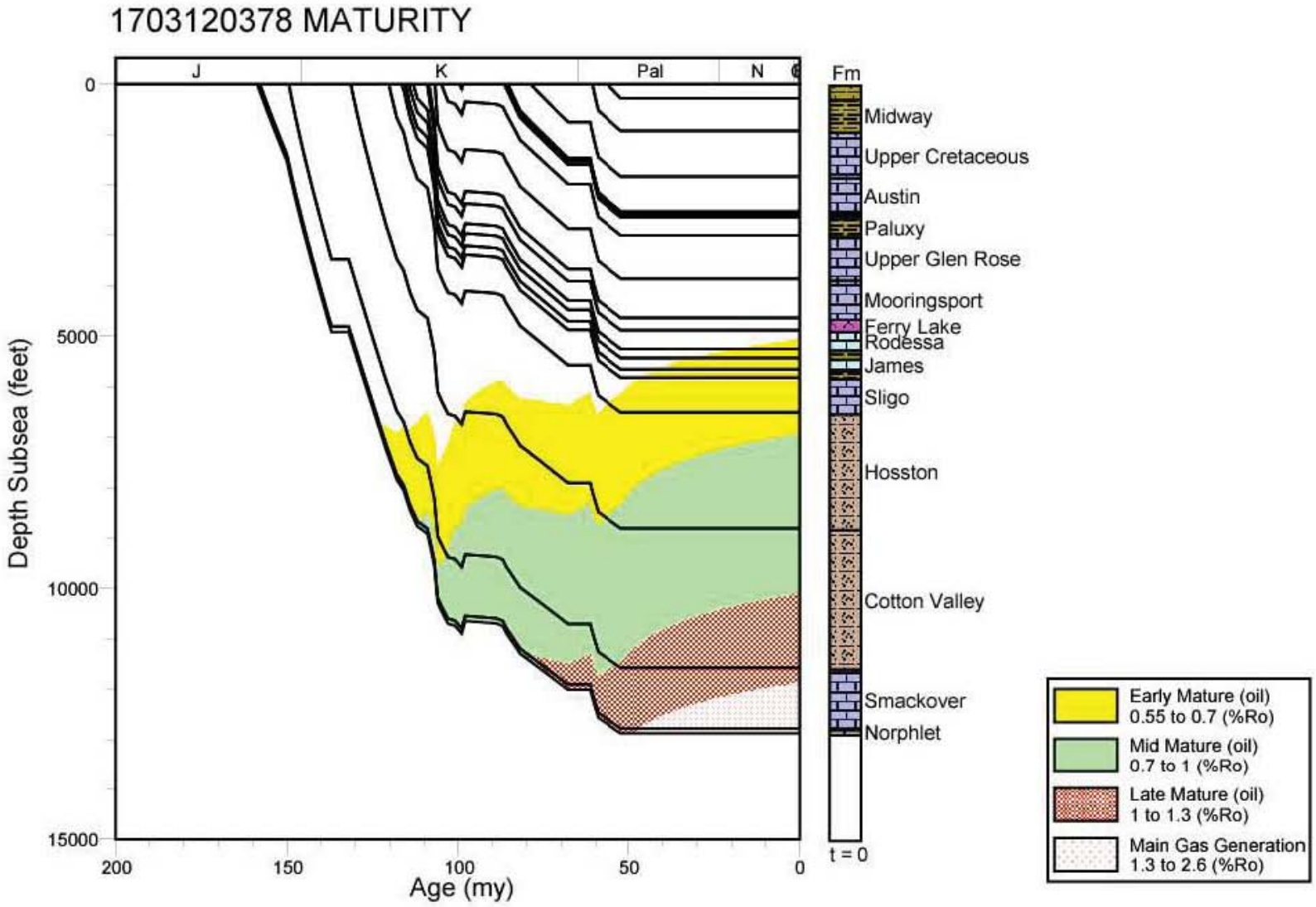


Figure 93. Thermal maturation profile for well 1703120378, North Louisiana Salt Basin.

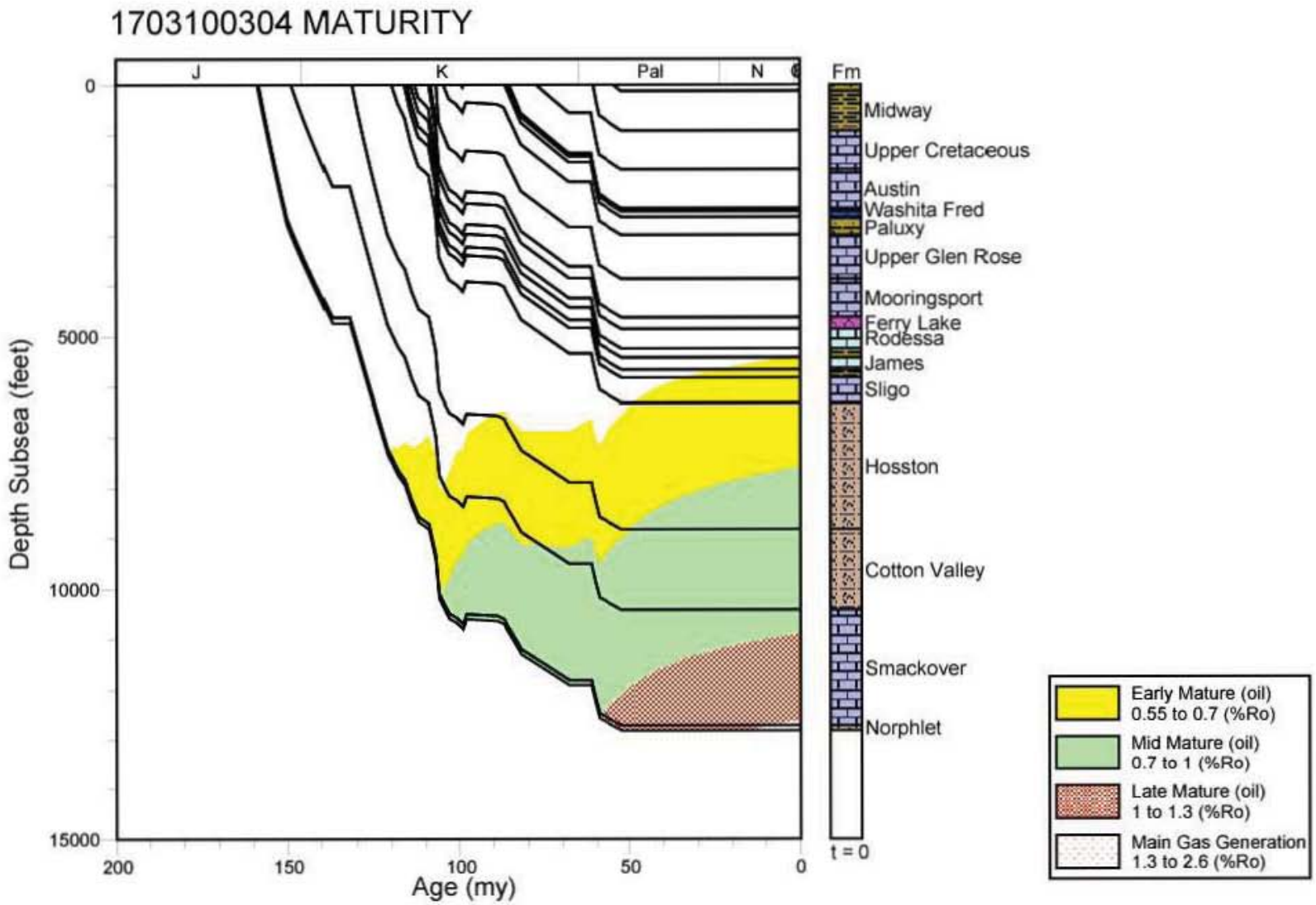


Figure 94. Thermal maturation profile for well 1703100304, North Louisiana Salt Basin.

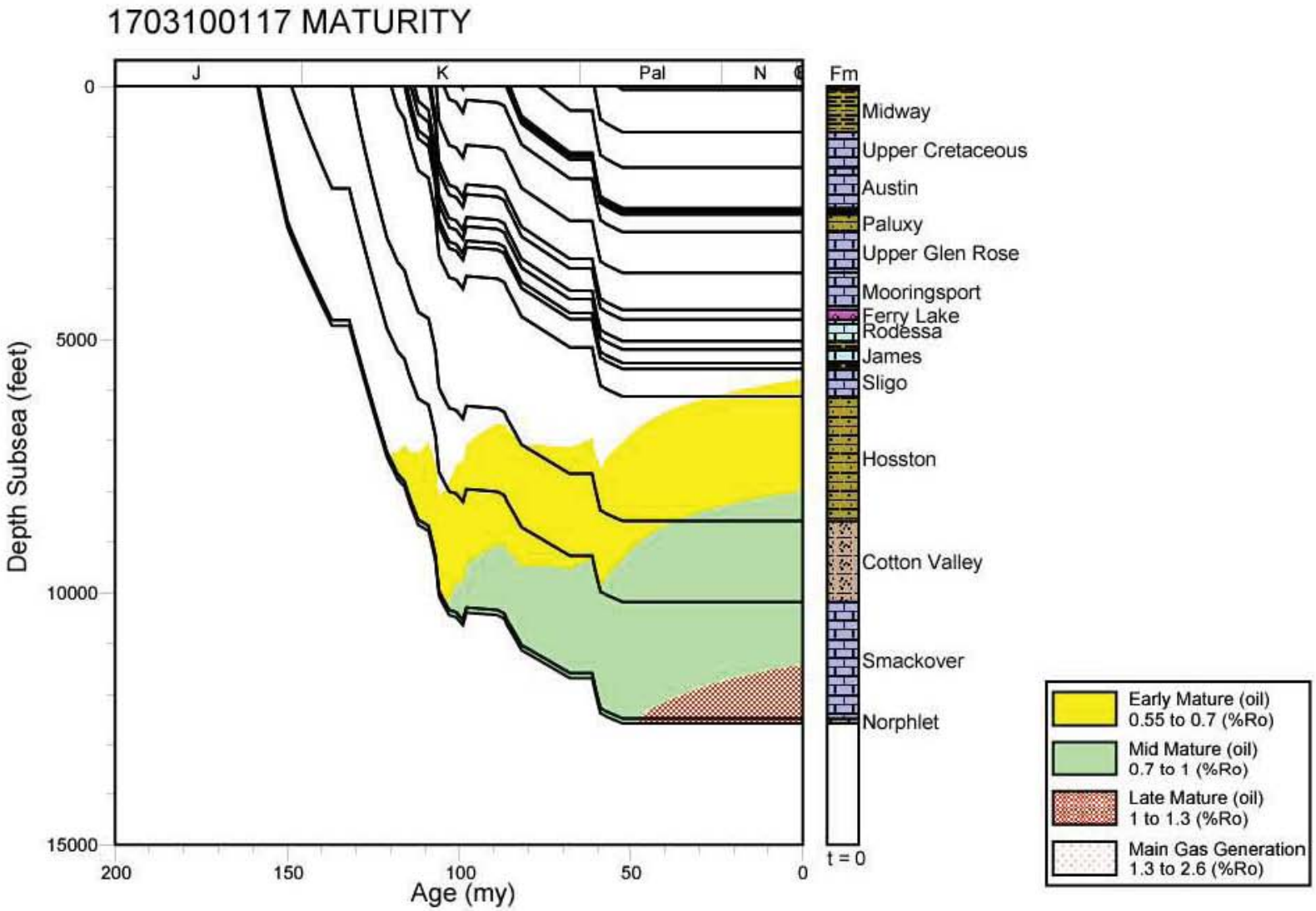


Figure 95. Thermal maturation profile for well 1703100117, North Louisiana Salt Basin.

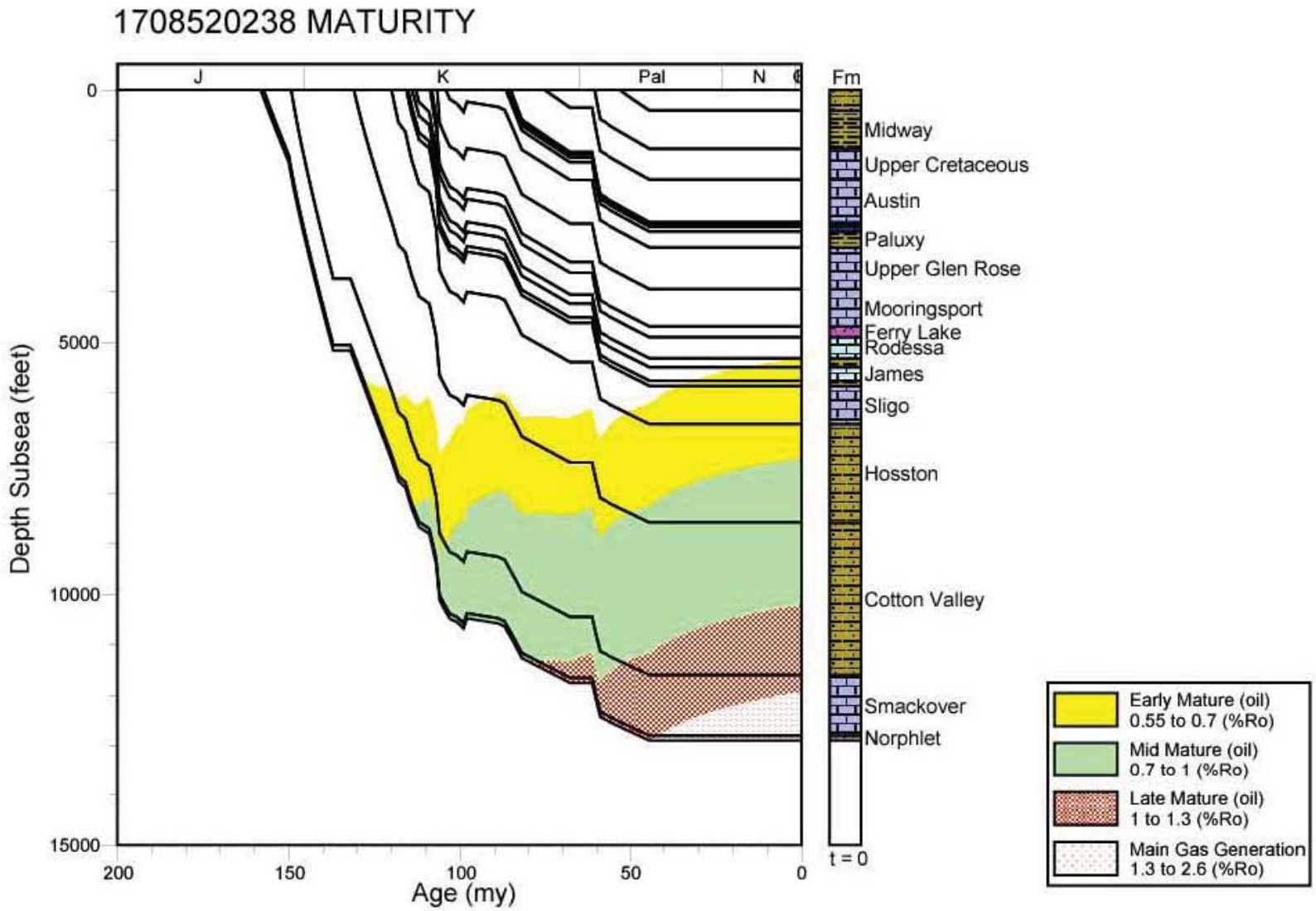


Figure 96. Thermal maturation profile for well 1708520238, North Louisiana Salt Basin.

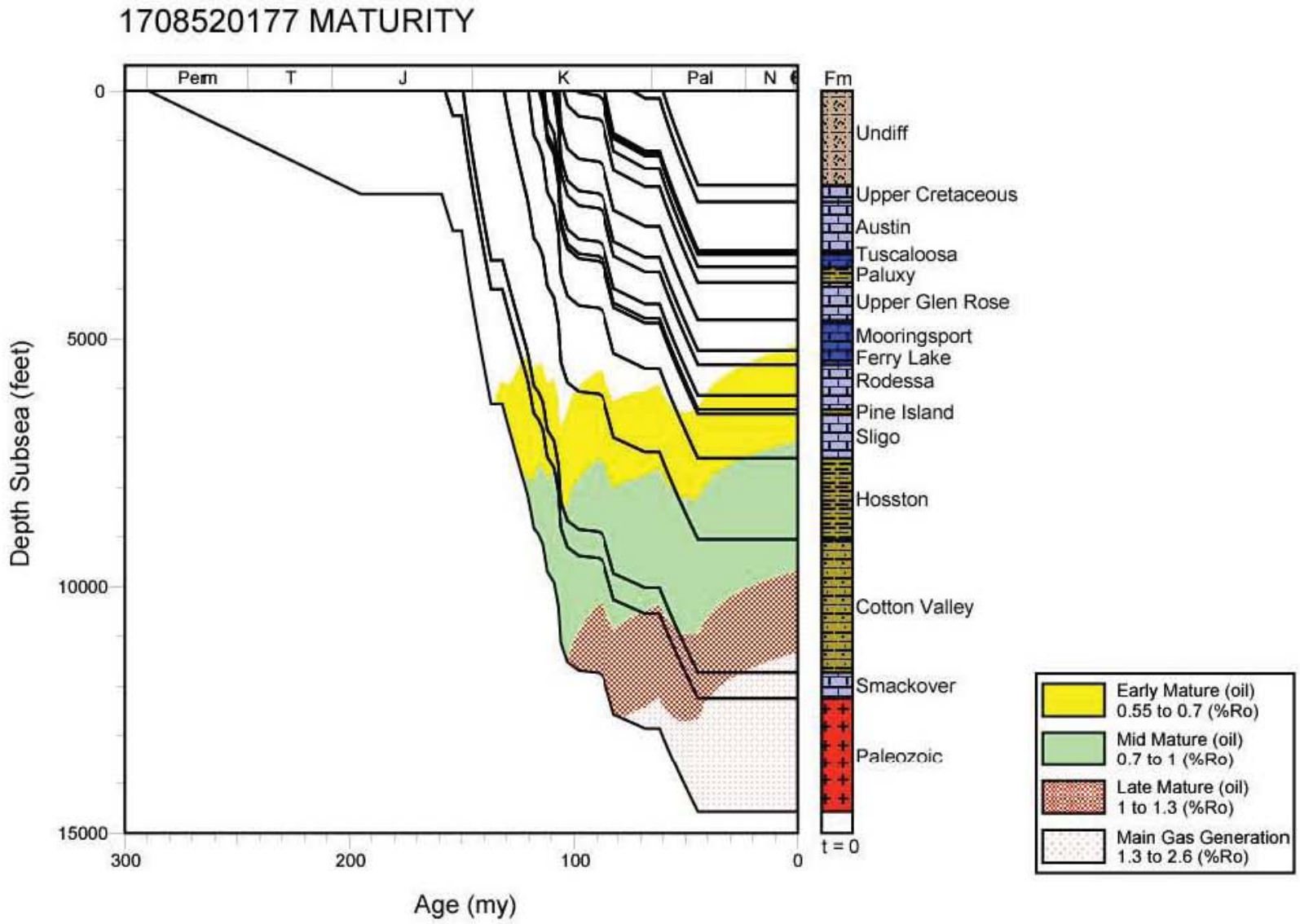


Figure 97. Thermal maturation profile for well 1708520177, North Louisiana Salt Basin.

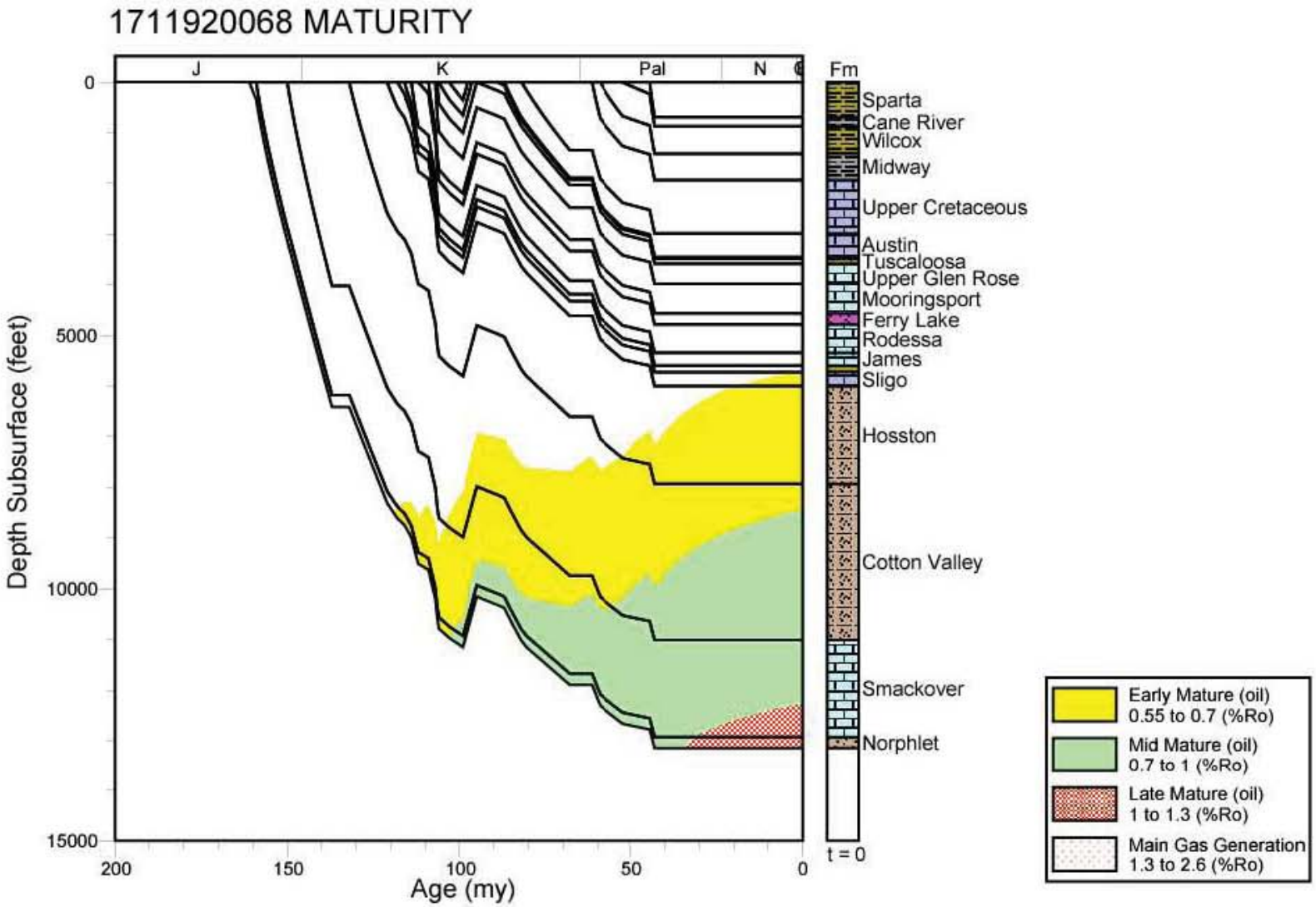


Figure 98. Thermal maturation profile for well 1711920068, North Louisiana Salt Basin.

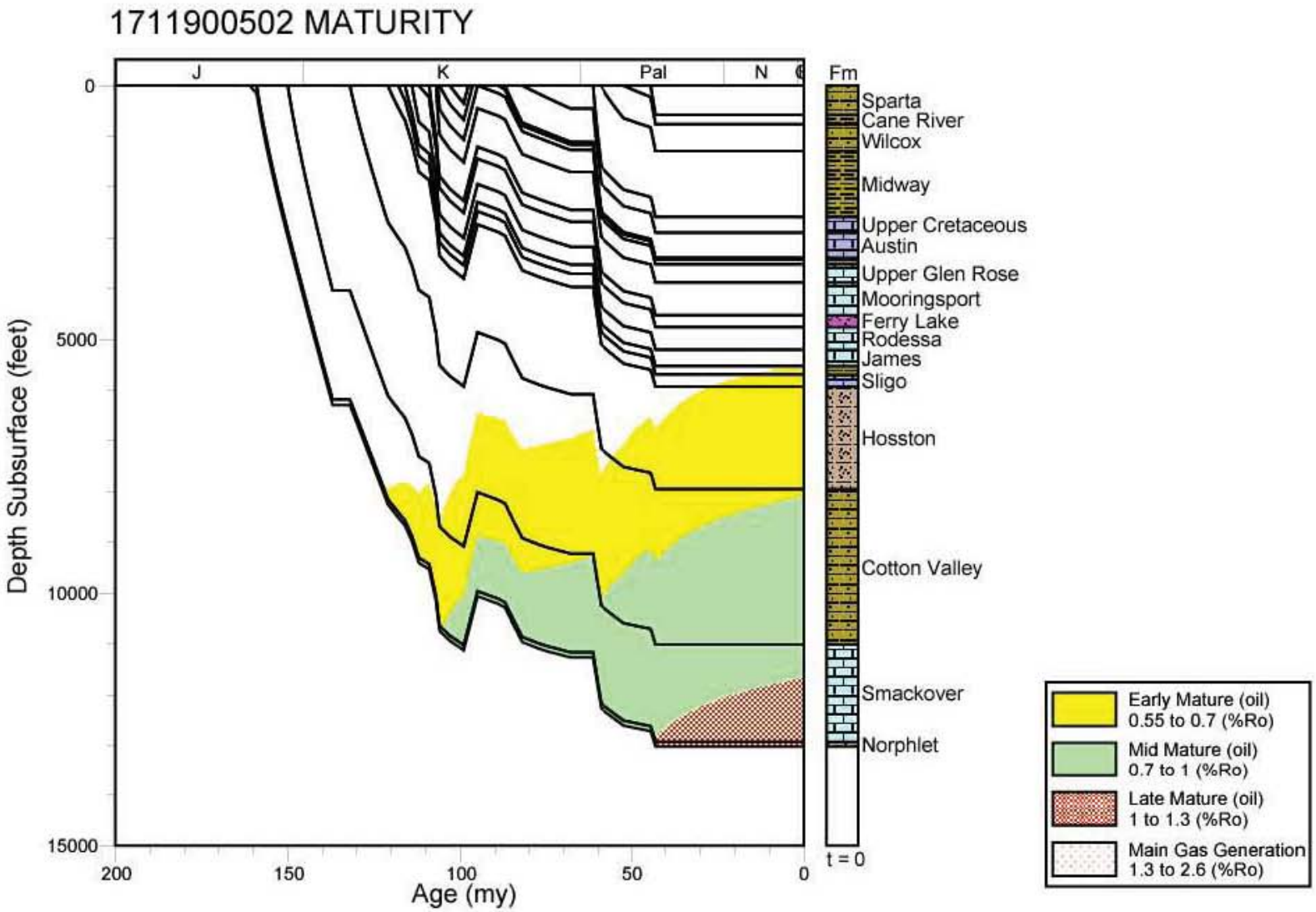


Figure 99. Thermal maturation profile for well 1711900502, North Louisiana Salt Basin.

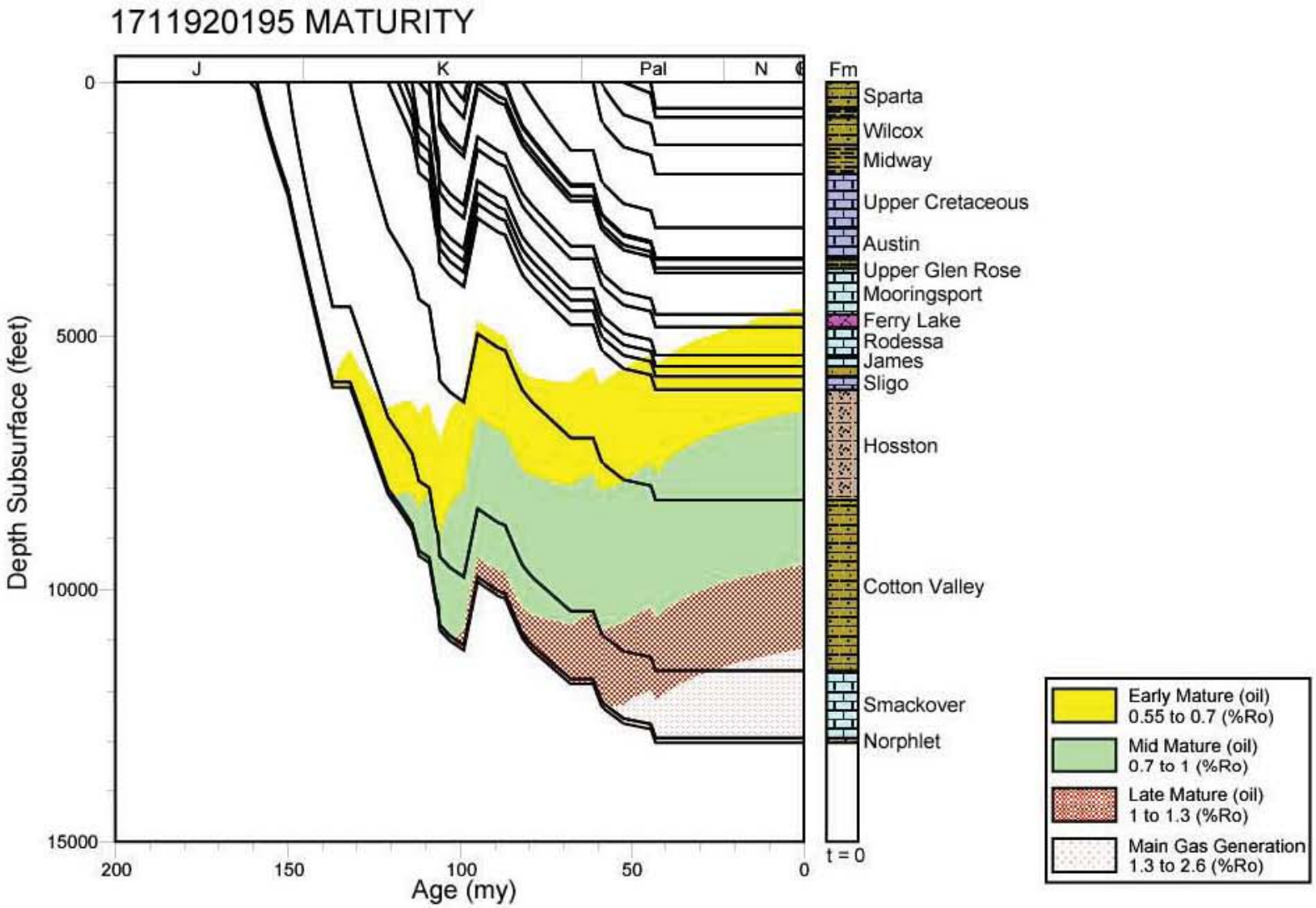


Figure 100. Thermal maturation profile for well 1711920195, North Louisiana Salt Basin.

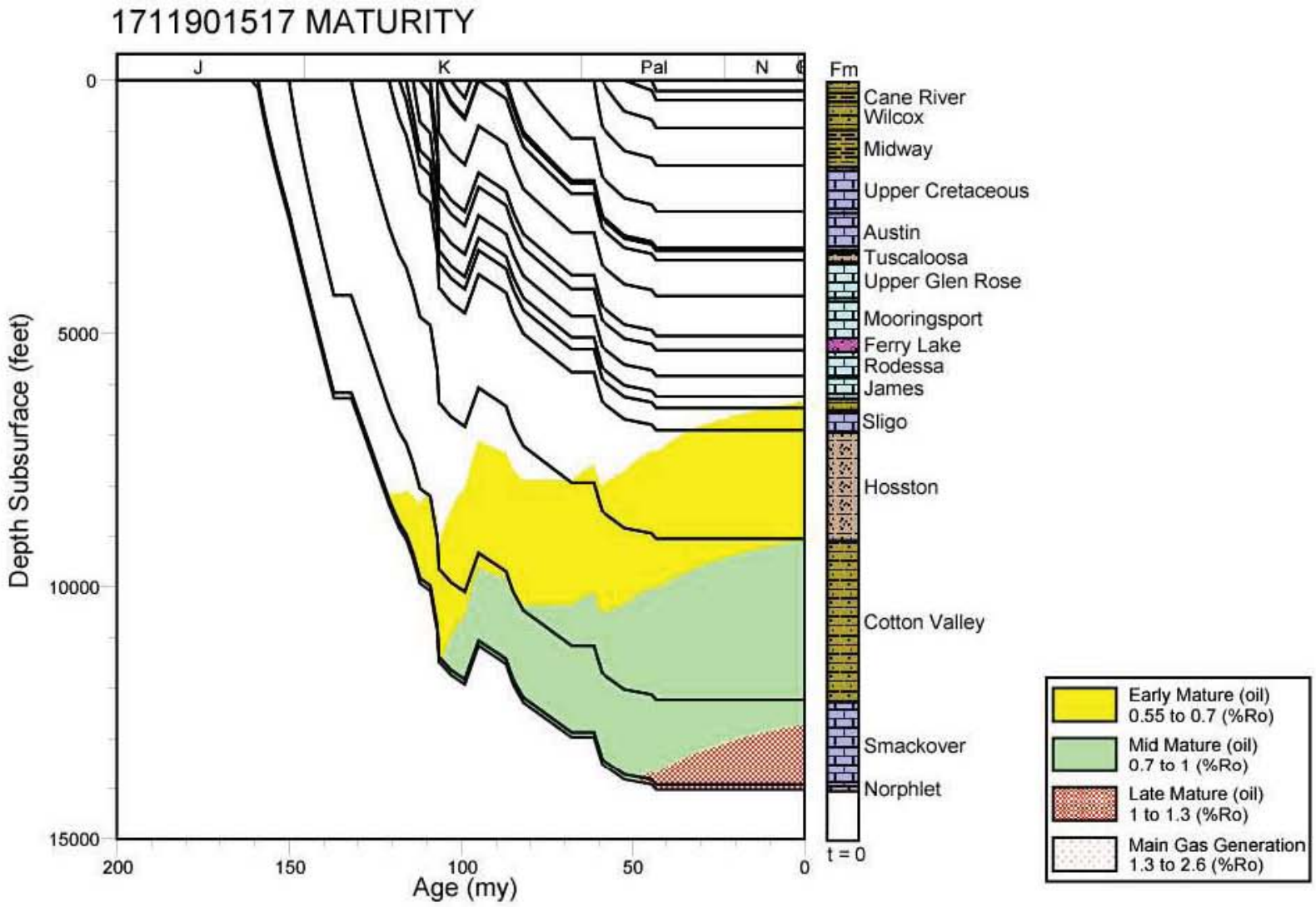


Figure 101. Thermal maturation profile for well 1711901517, North Louisiana Salt Basin.

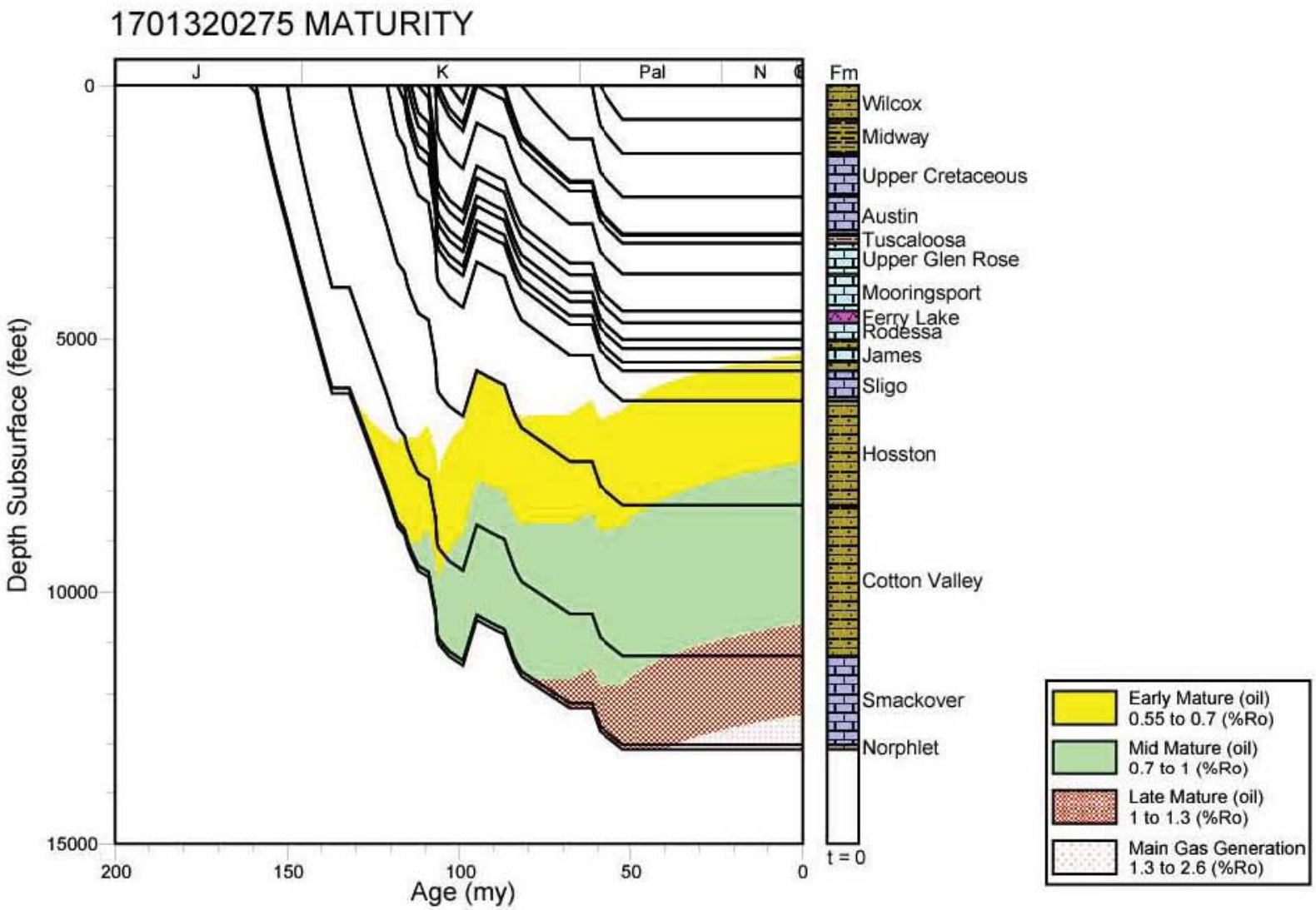


Figure 102. Thermal maturation profile for well 1701320275, North Louisiana Salt Basin.

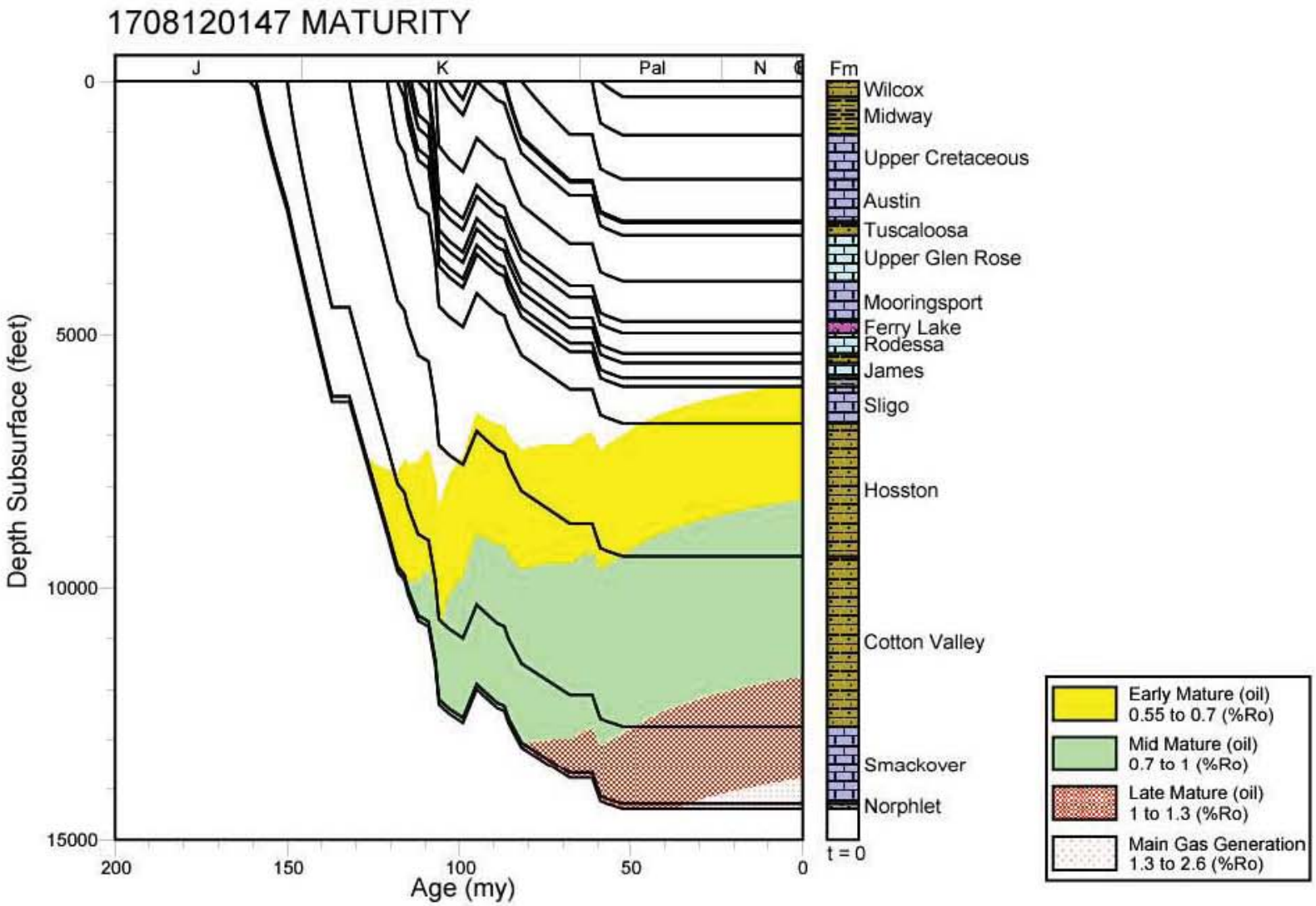


Figure 103. Thermal maturation profile for well 1708120147, North Louisiana Salt Basin.

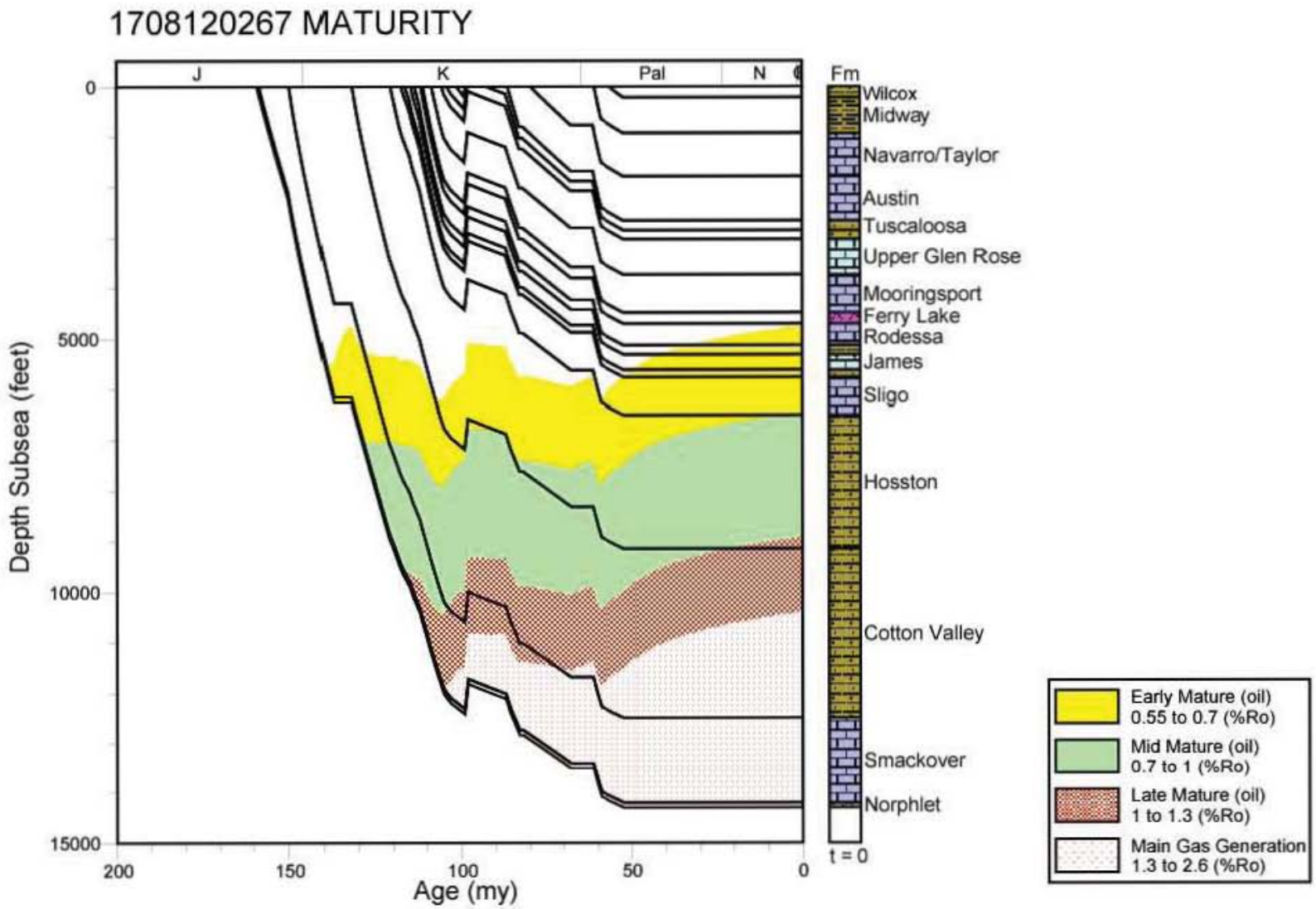


Figure 104. Thermal maturation profile for well 1708120267, North Louisiana Salt Basin.

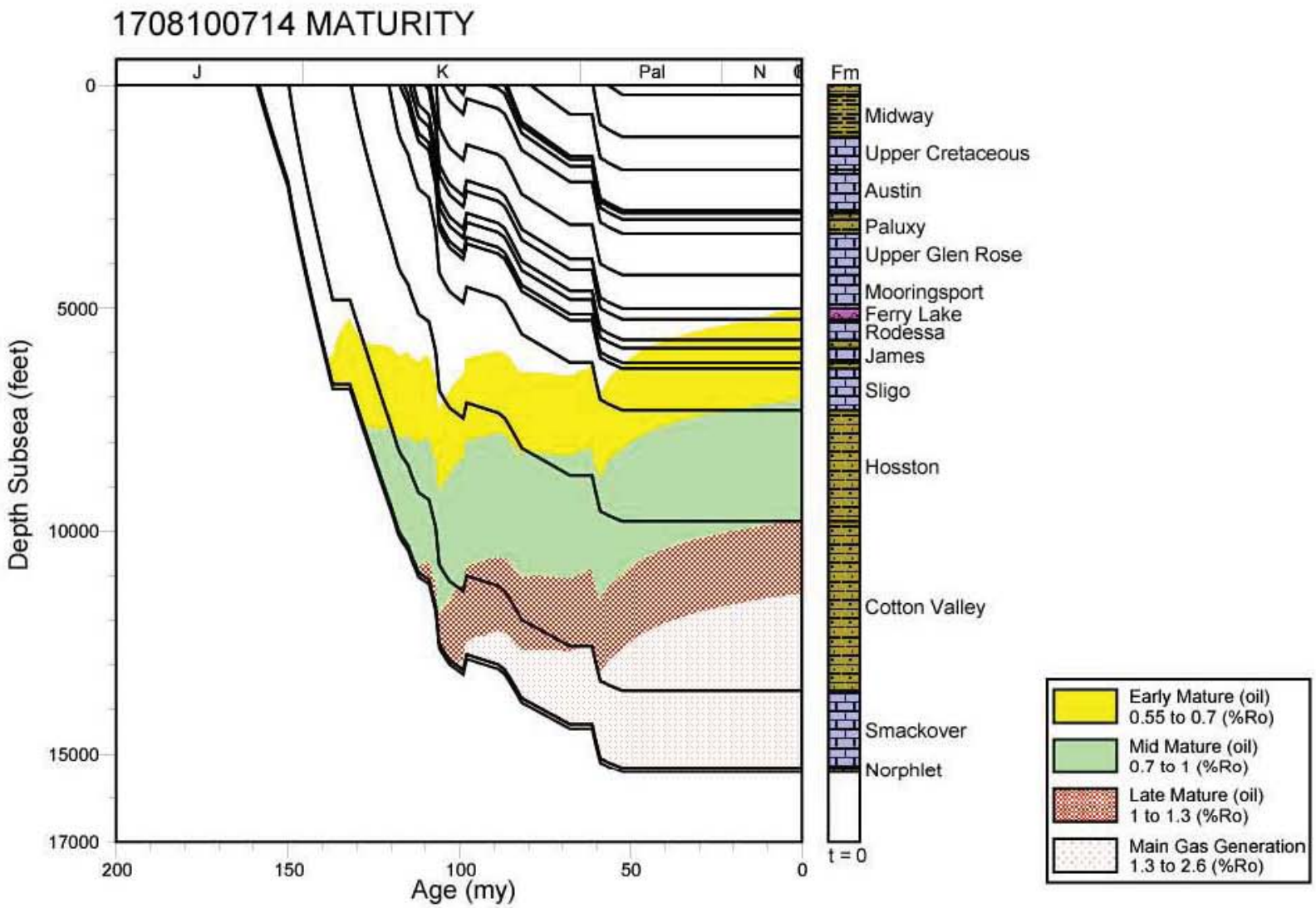


Figure 105. Thermal maturation profile for well 1708100714, North Louisiana Salt Basin.

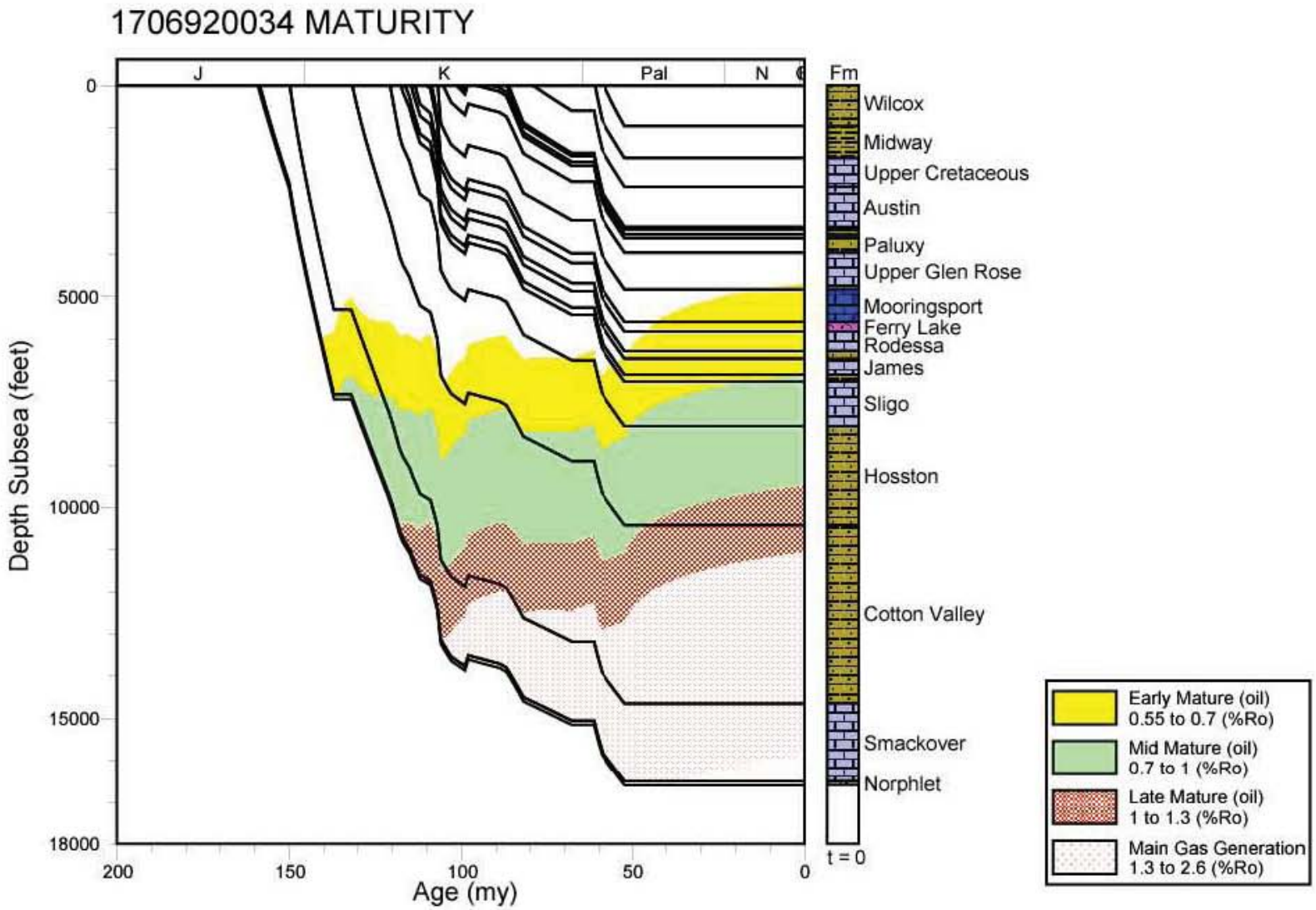


Figure 106. Thermal maturation profile for well 1706920034, North Louisiana Salt Basin.

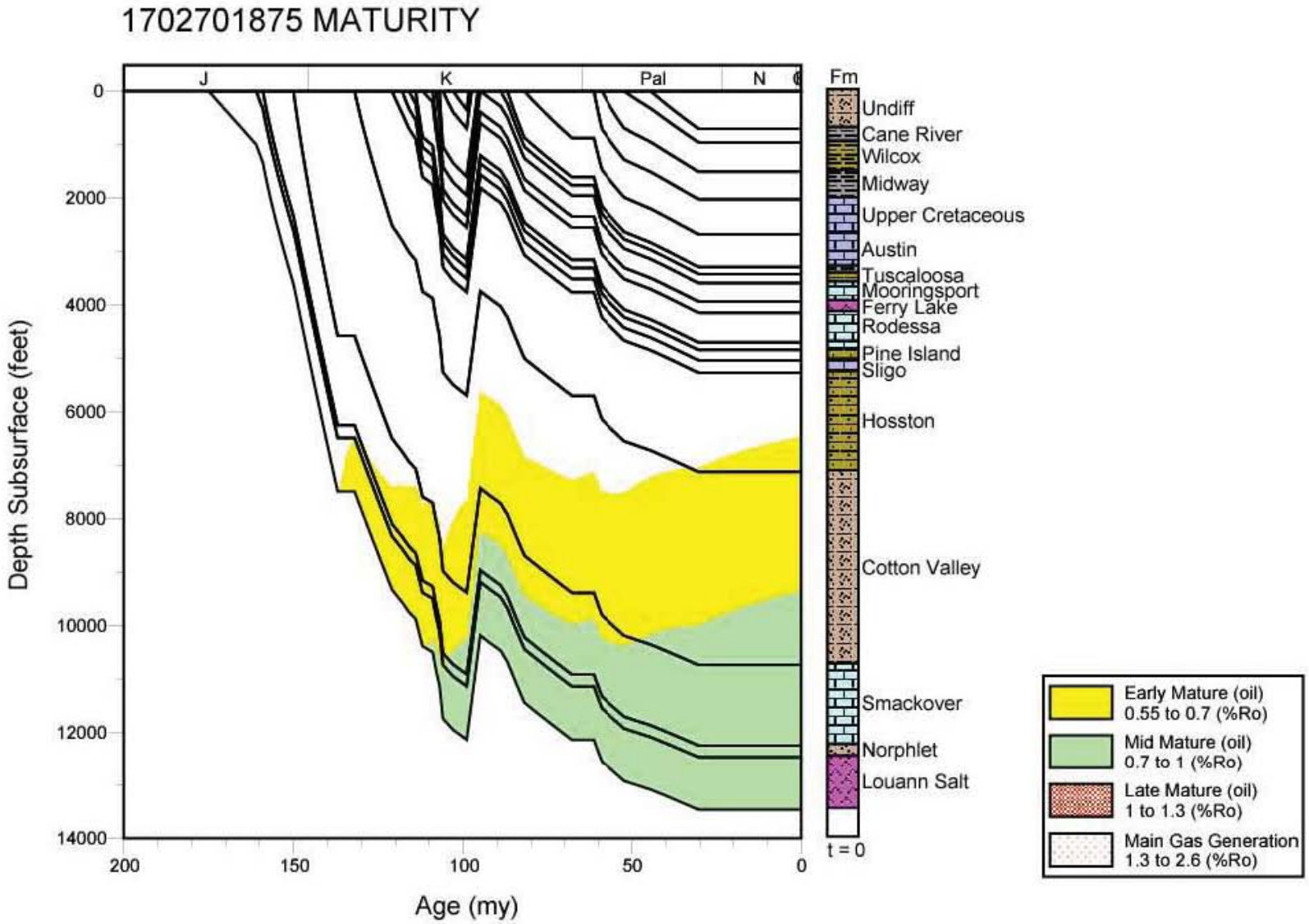


Figure 107. Thermal maturation profile for well 1702701875, North Louisiana Salt Basin.

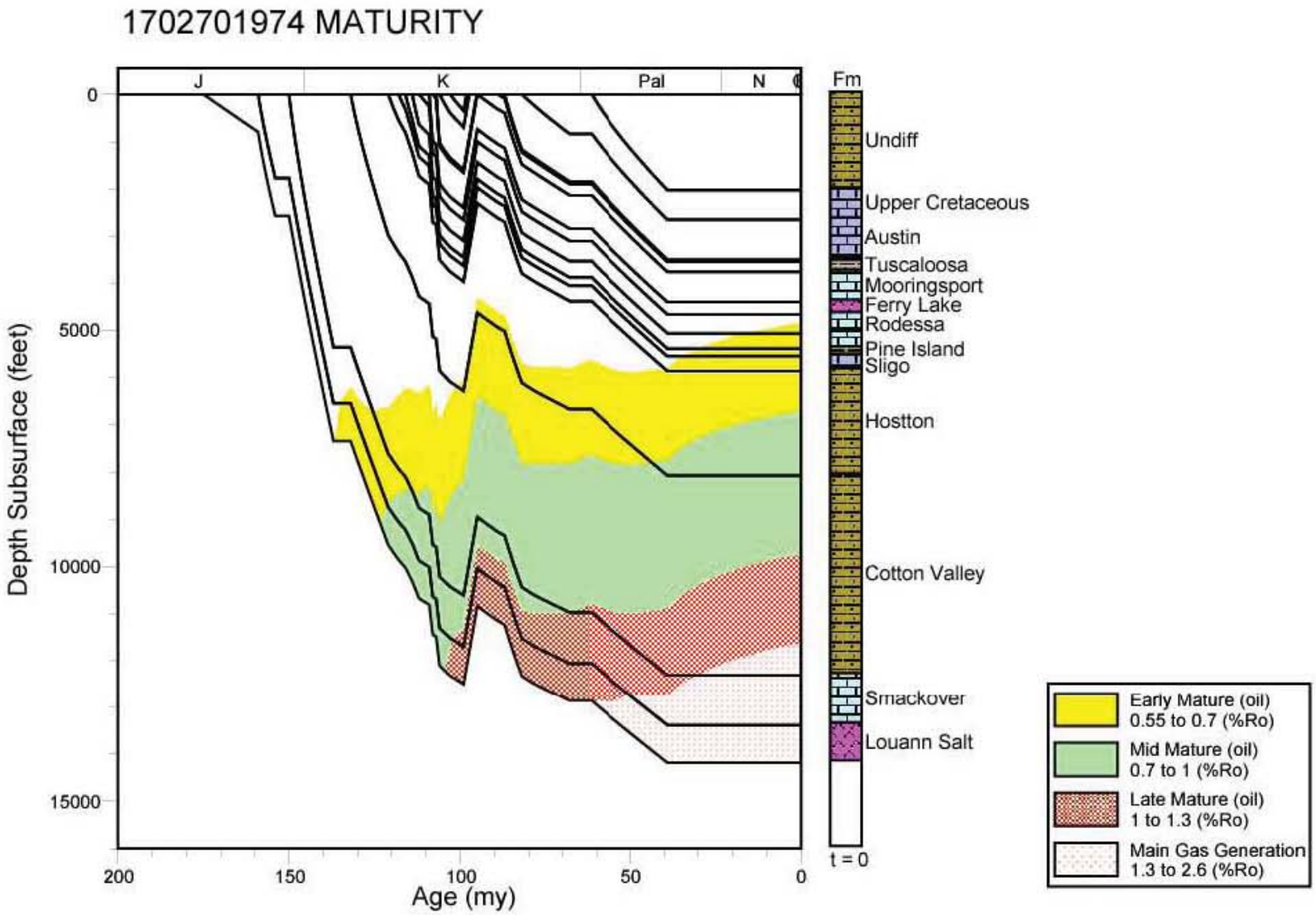


Figure 108. Thermal maturation profile for well 1702701974, North Louisiana Salt Basin.

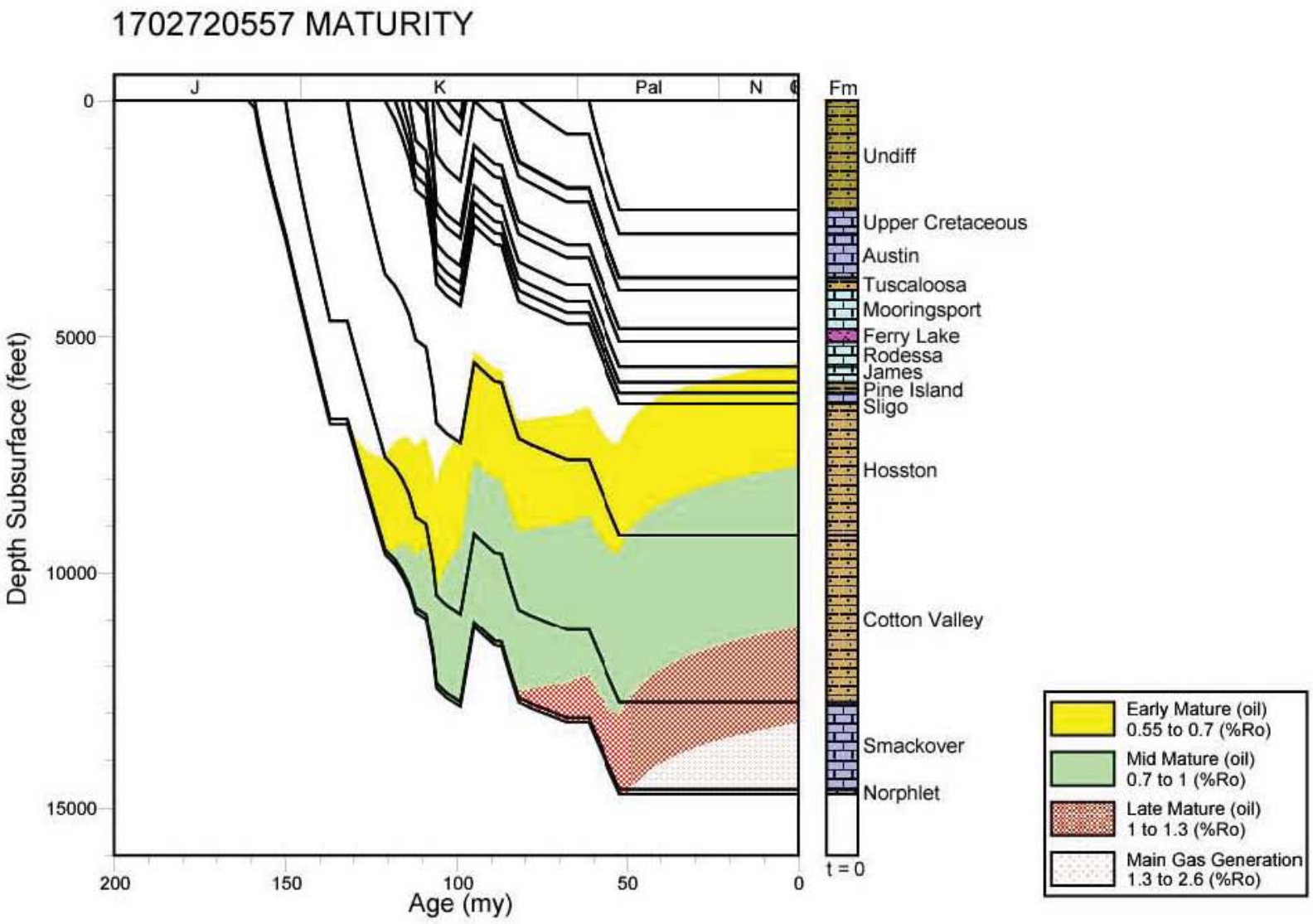


Figure 109. Thermal maturation profile for well 1702720557, North Louisiana Salt Basin.

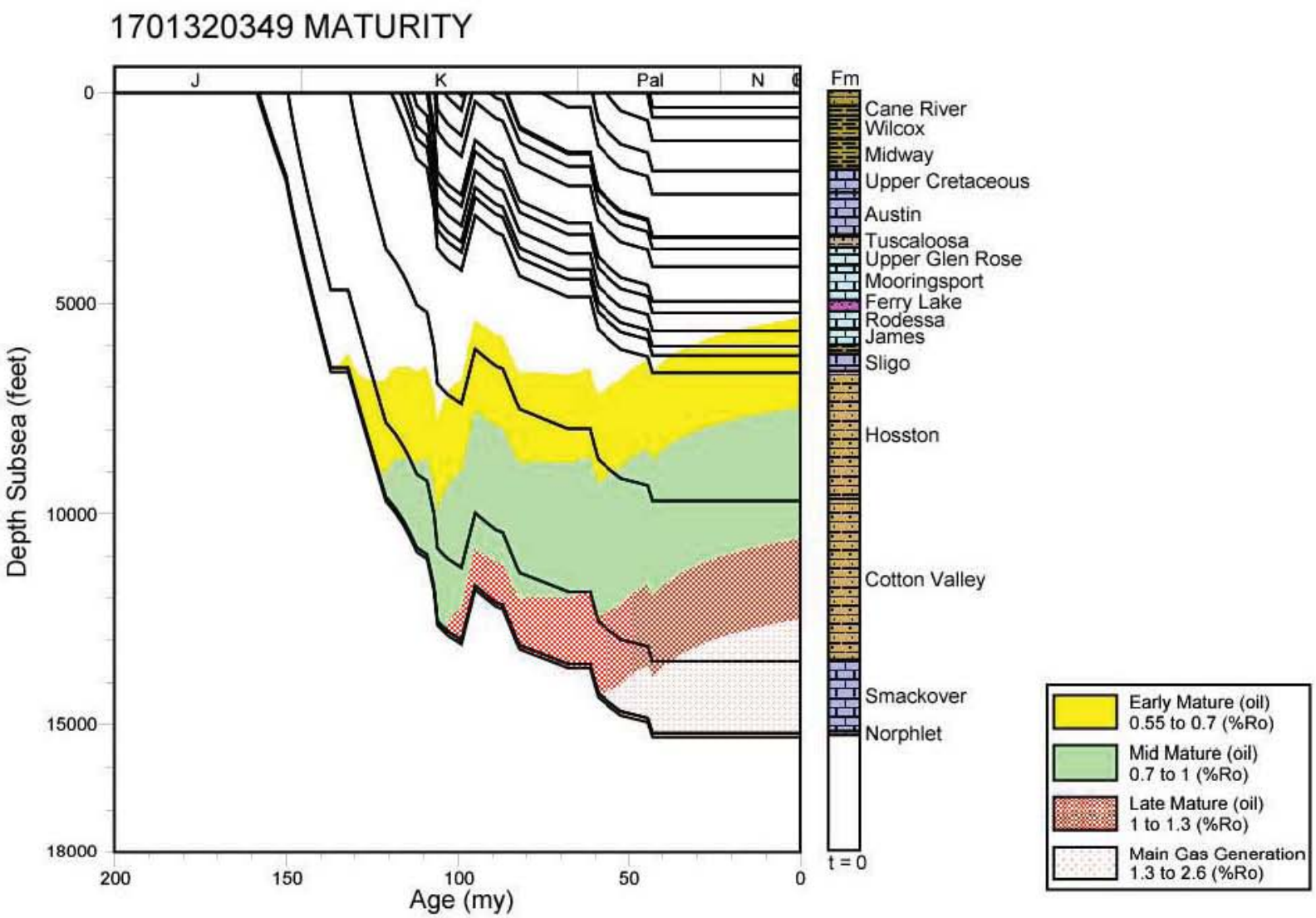


Figure 110. Thermal maturation profile for well 1701320349, North Louisiana Salt Basin.

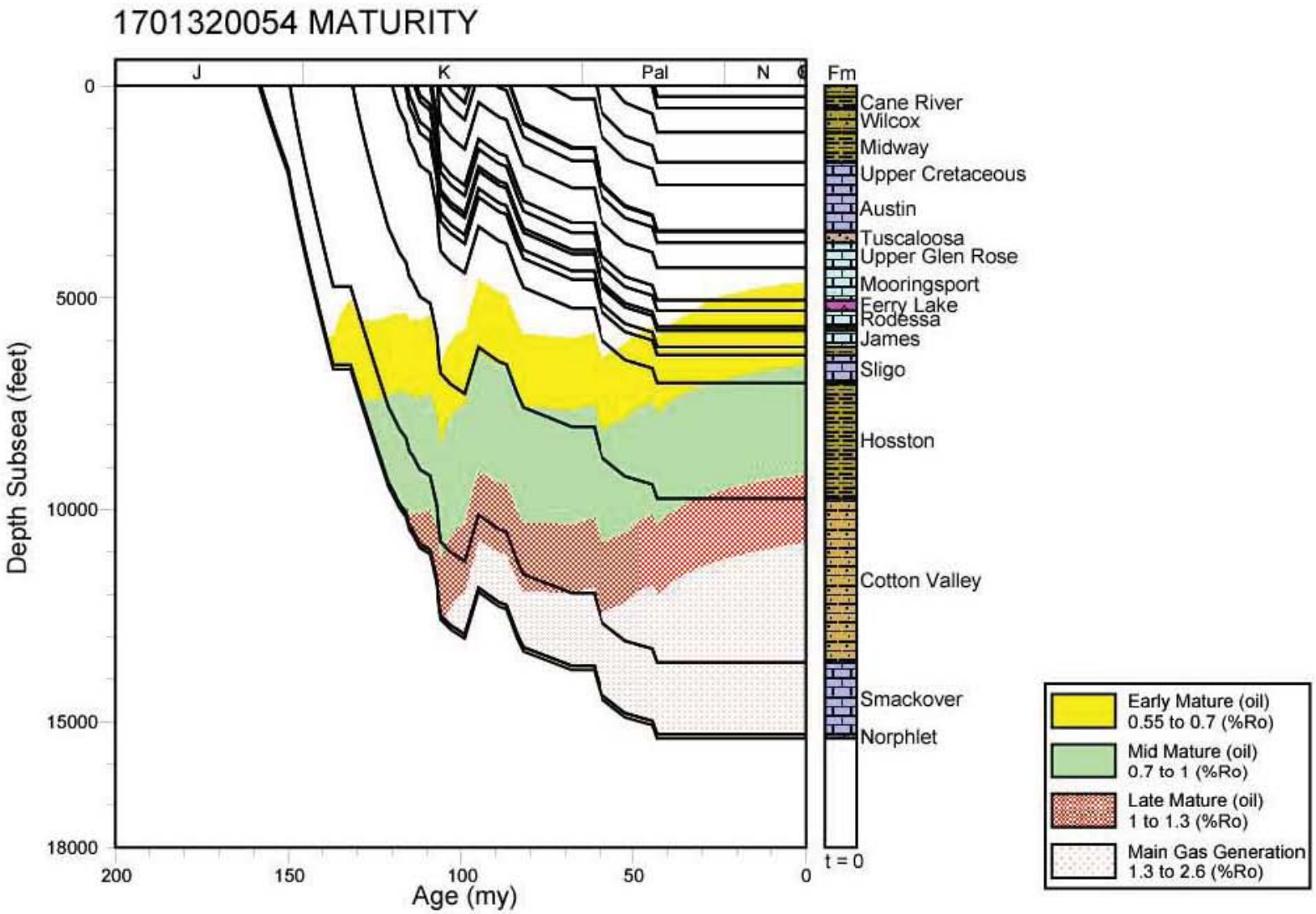


Figure 111. Thermal maturation profile for well 1701320054, North Louisiana Salt Basin.

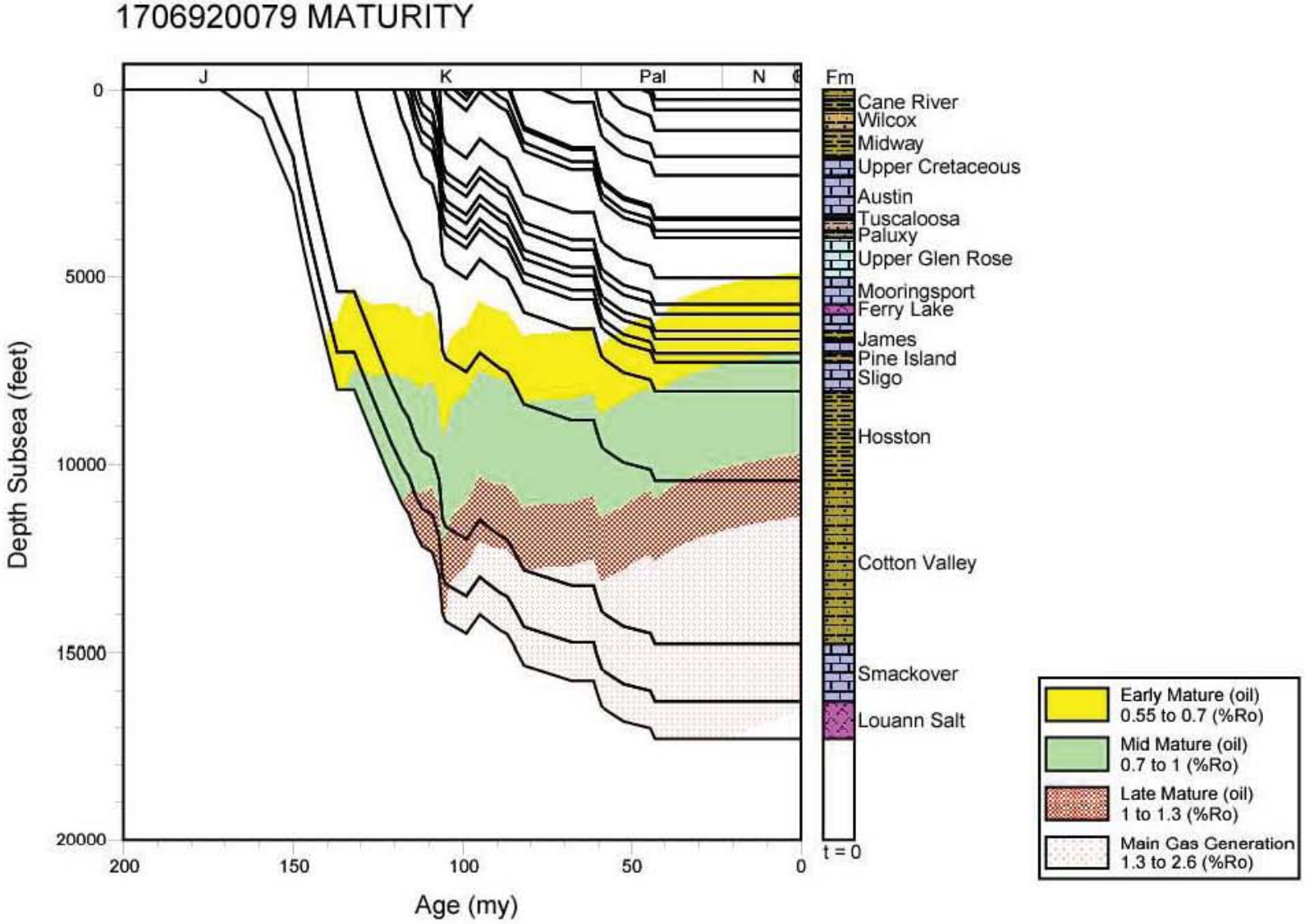


Figure 112. Thermal maturation profile for well 1706920079, North Louisiana Salt Basin.

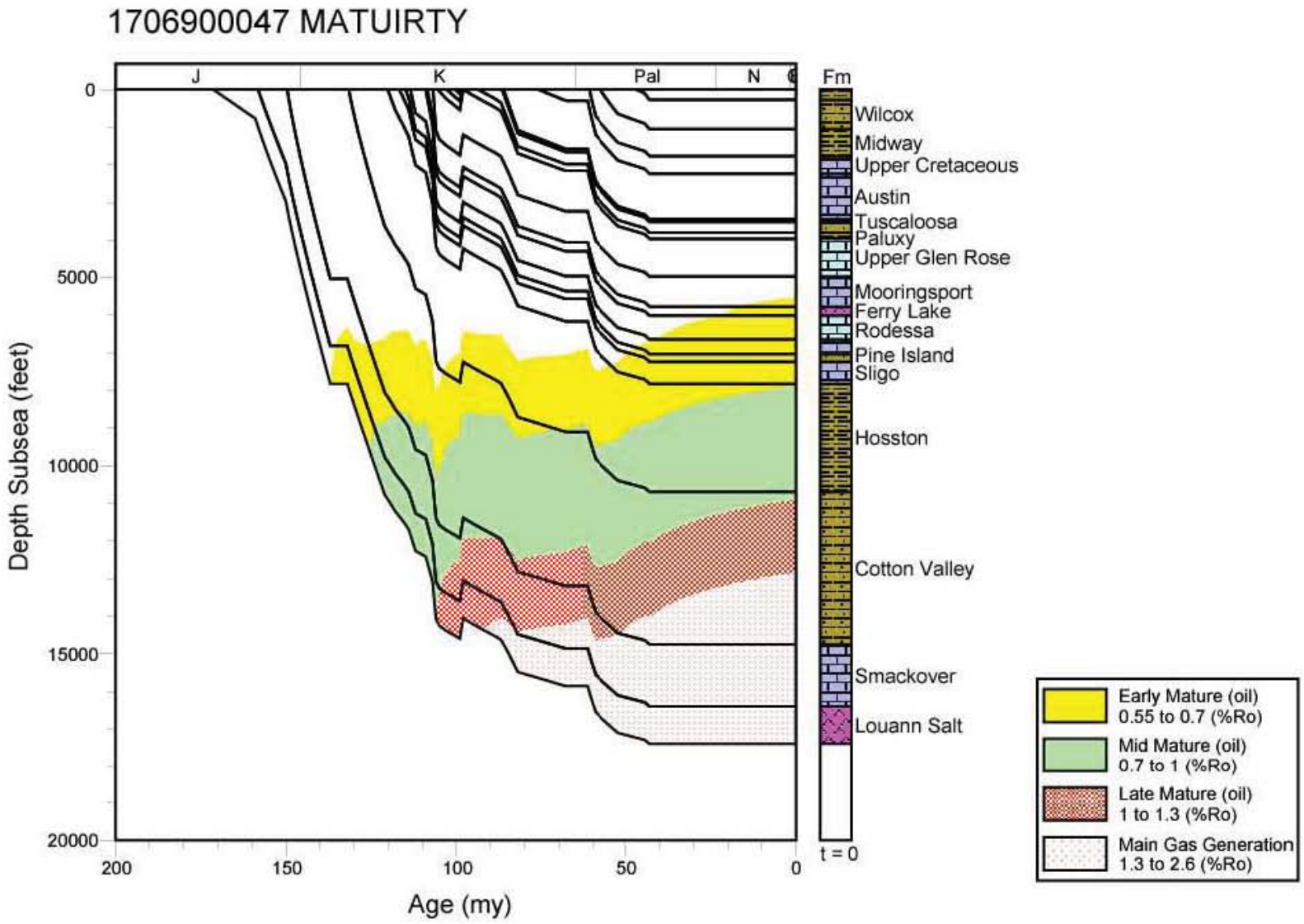


Figure 113. Thermal maturation profile for well 1706900047, North Louisiana Salt Basin.

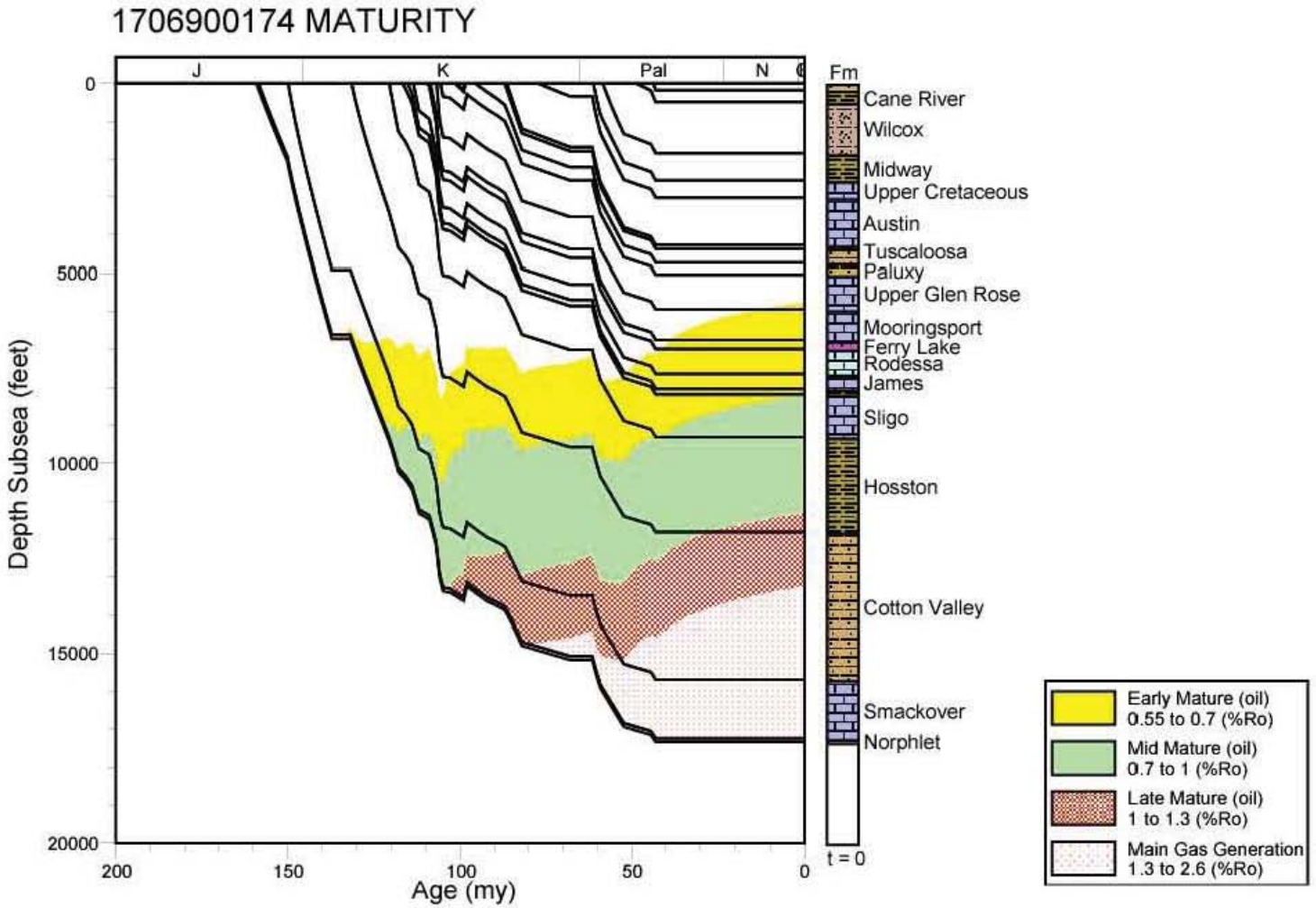


Figure 114. Thermal maturation profile for well 1706900174, North Louisiana Salt Basin.

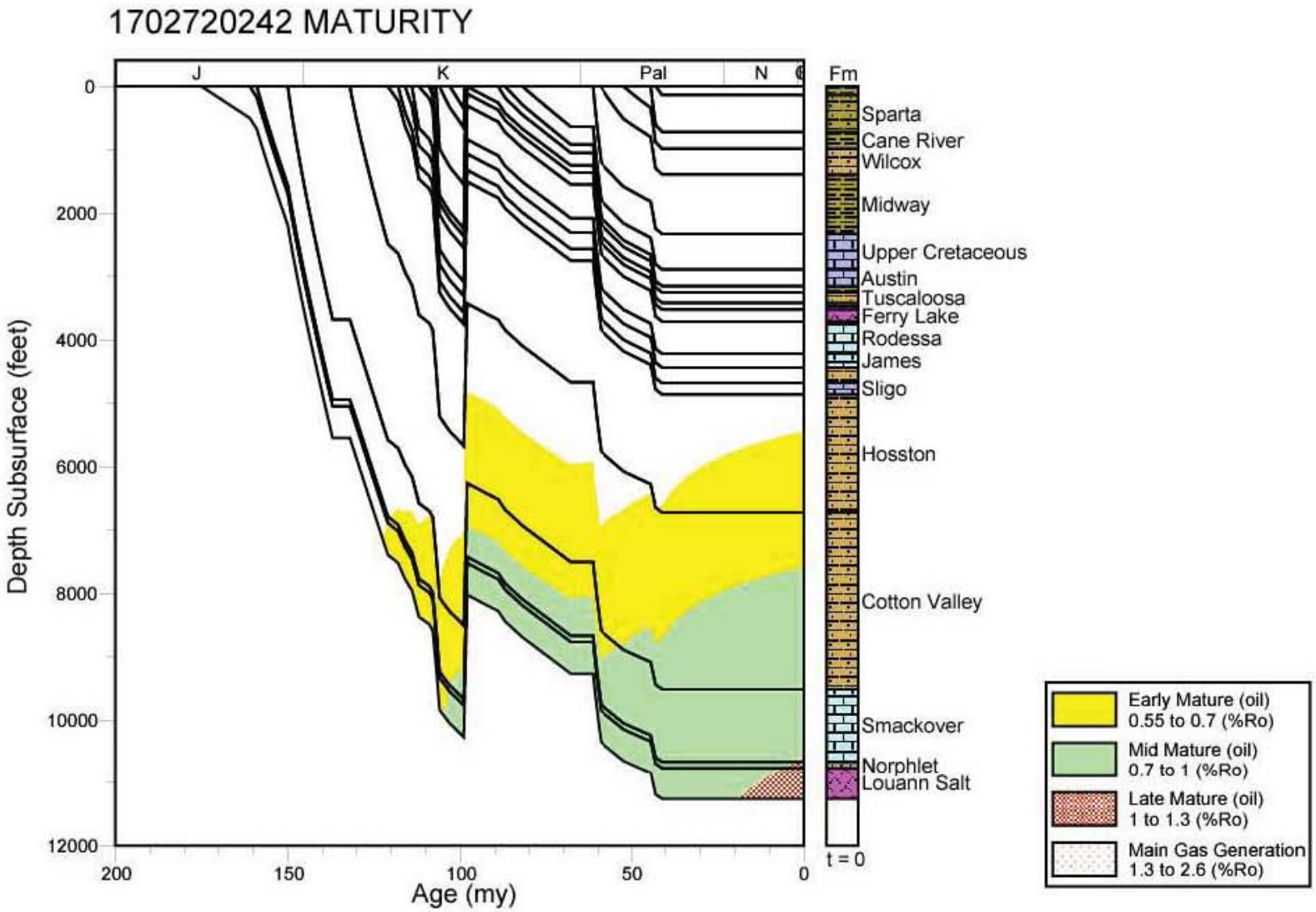


Figure 115. Thermal maturation profile for well 1702720242, North Louisiana Salt Basin.

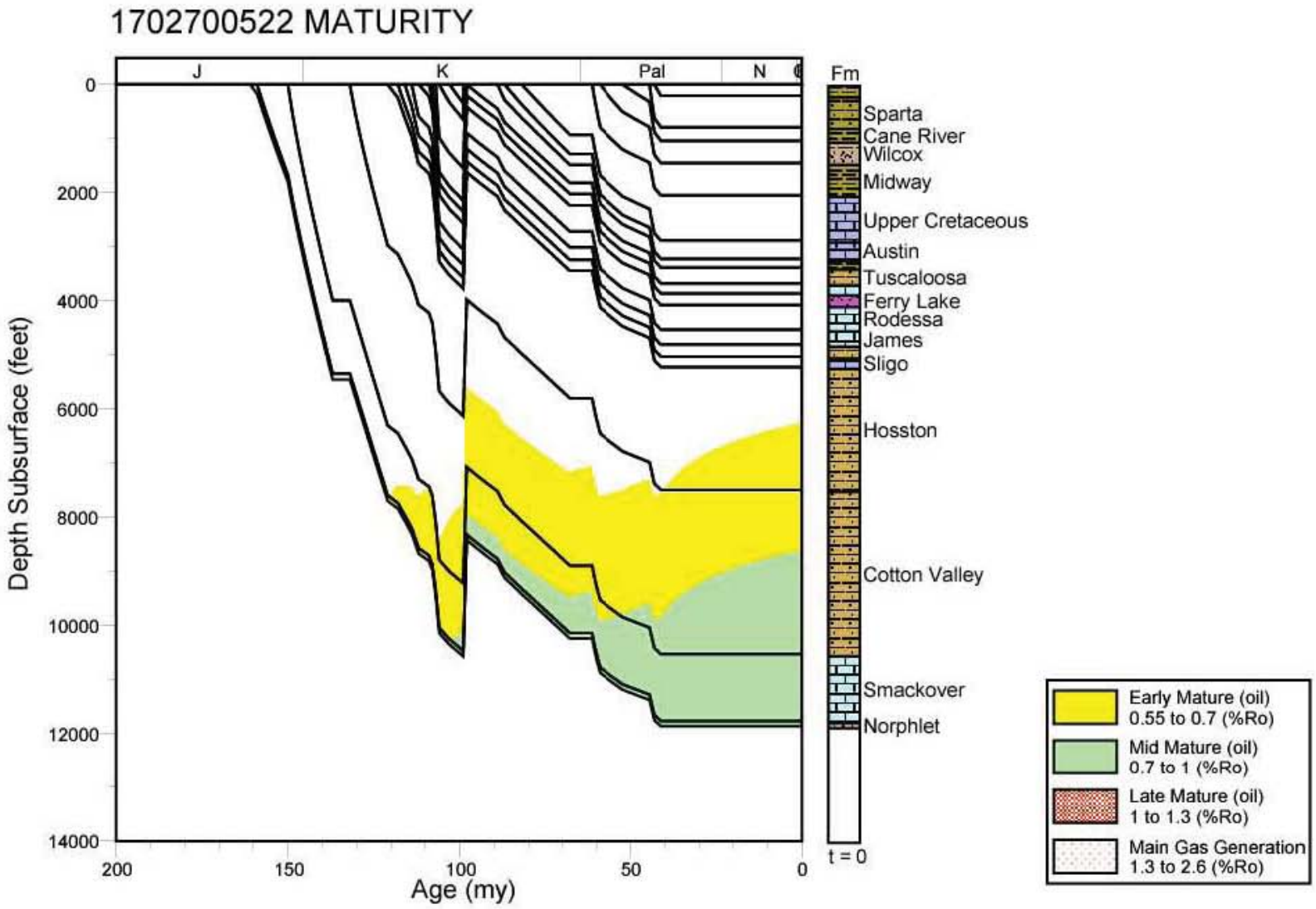


Figure 116. Thermal maturation profile for well 1702700522, North Louisiana Salt Basin.

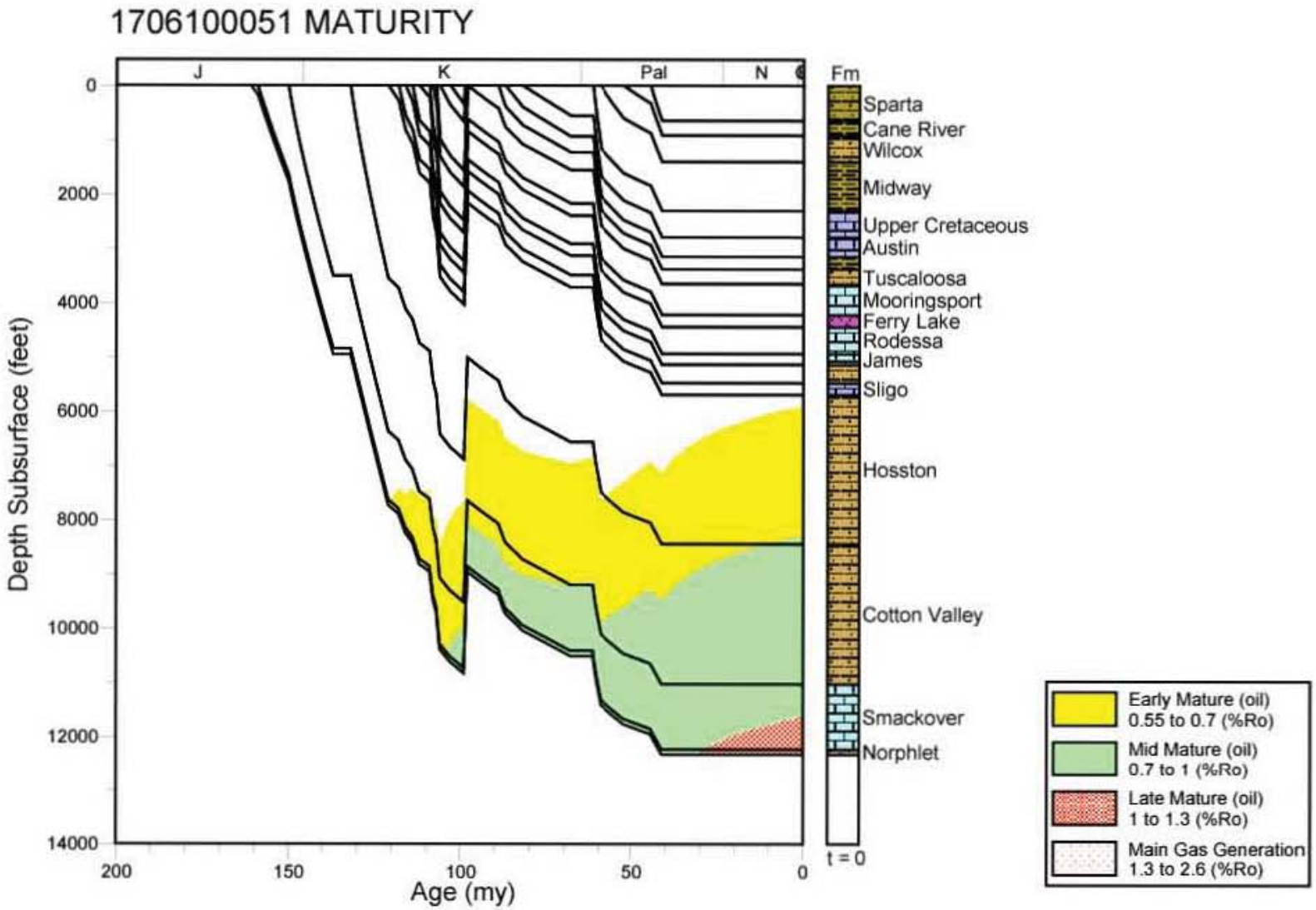


Figure 117. Thermal maturation profile for well 1706100051, North Louisiana Salt Basin.

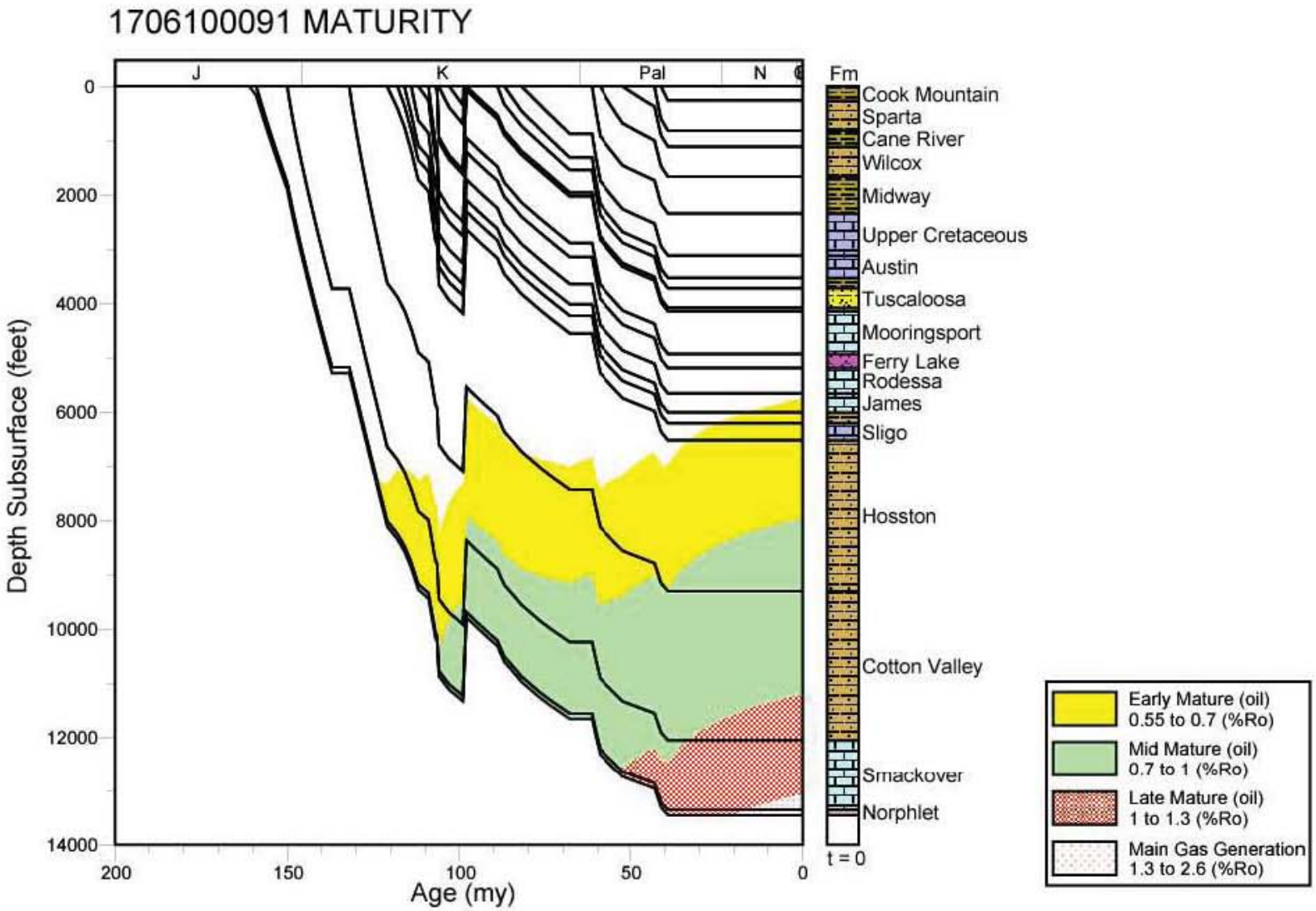


Figure 118. Thermal maturation profile for well 1706100091, North Louisiana Salt Basin.

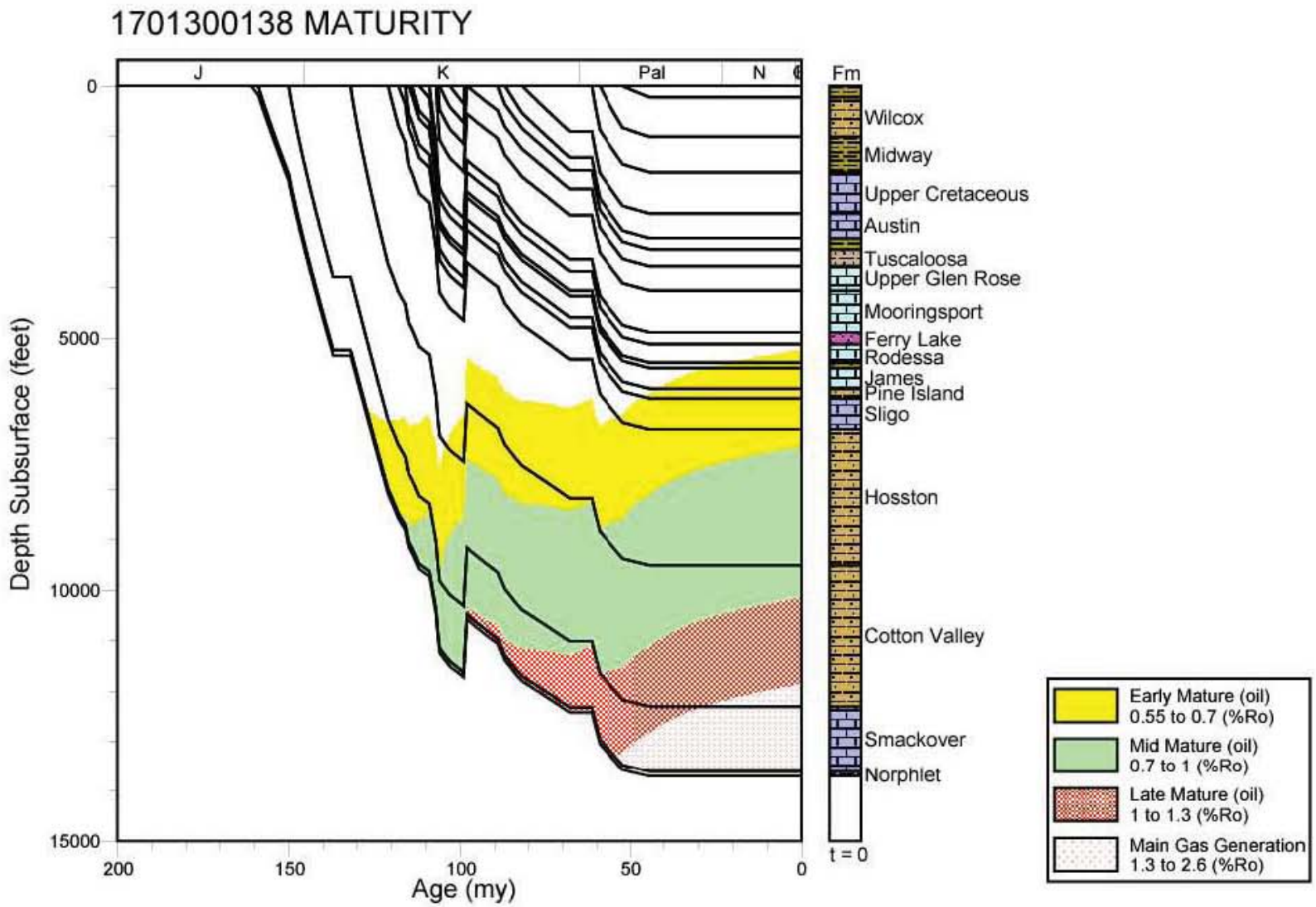


Figure 119. Thermal maturation profile for well 1701300138, North Louisiana Salt Basin.

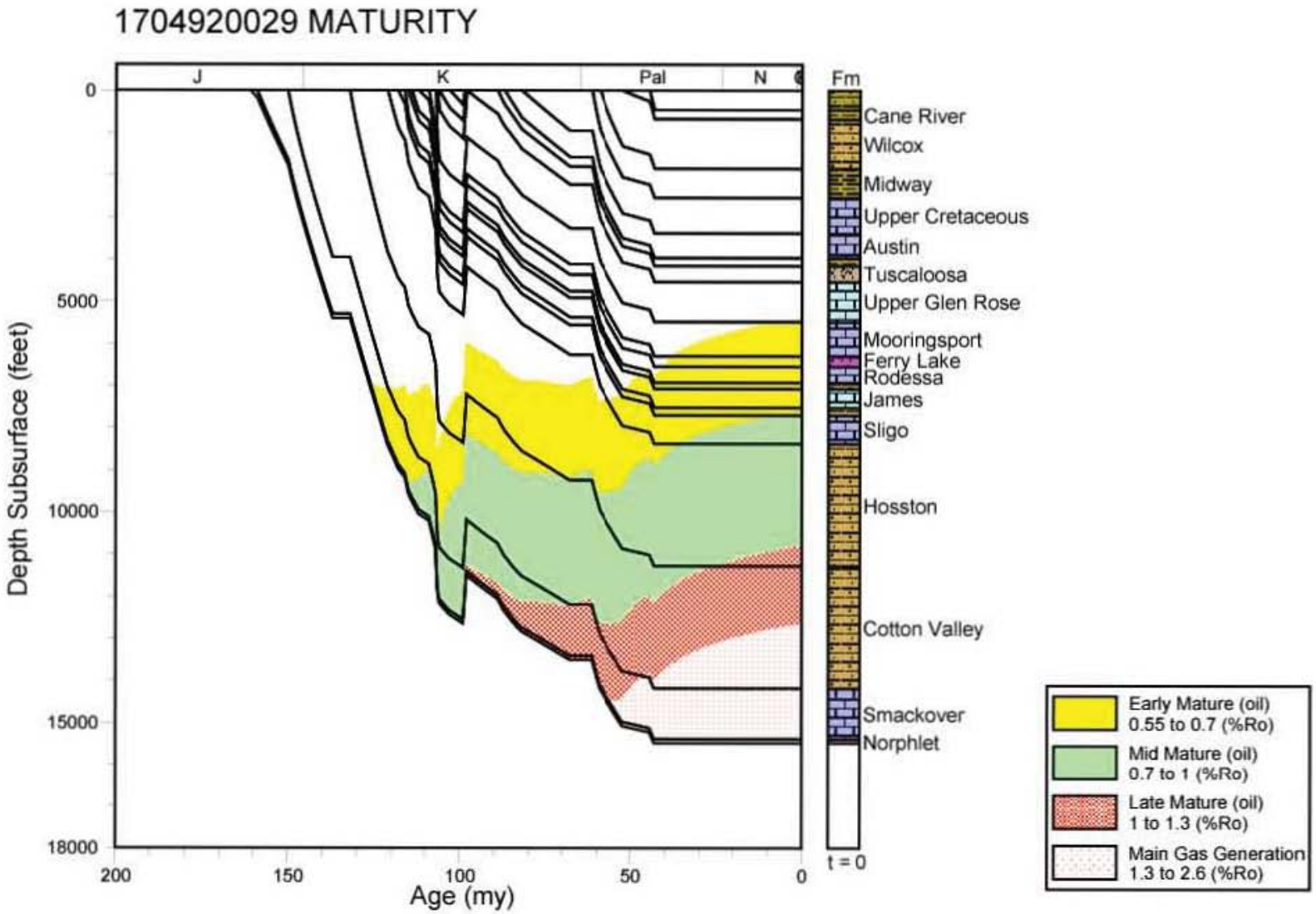


Figure 120. Thermal maturation profile for well 1704920029, North Louisiana Salt Basin.

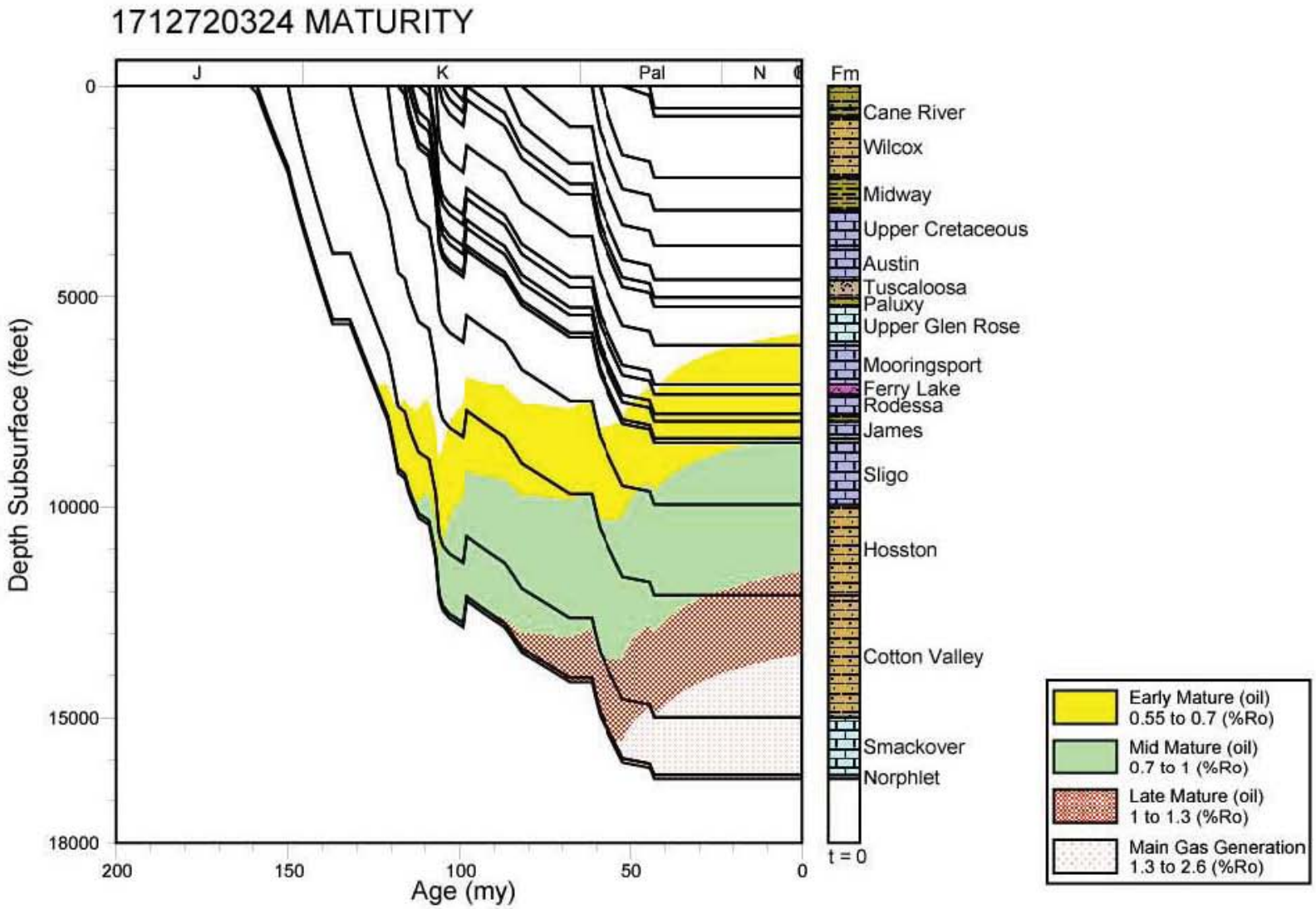


Figure 121. Thermal maturation profile for well 1712720324, North Louisiana Salt Basin.

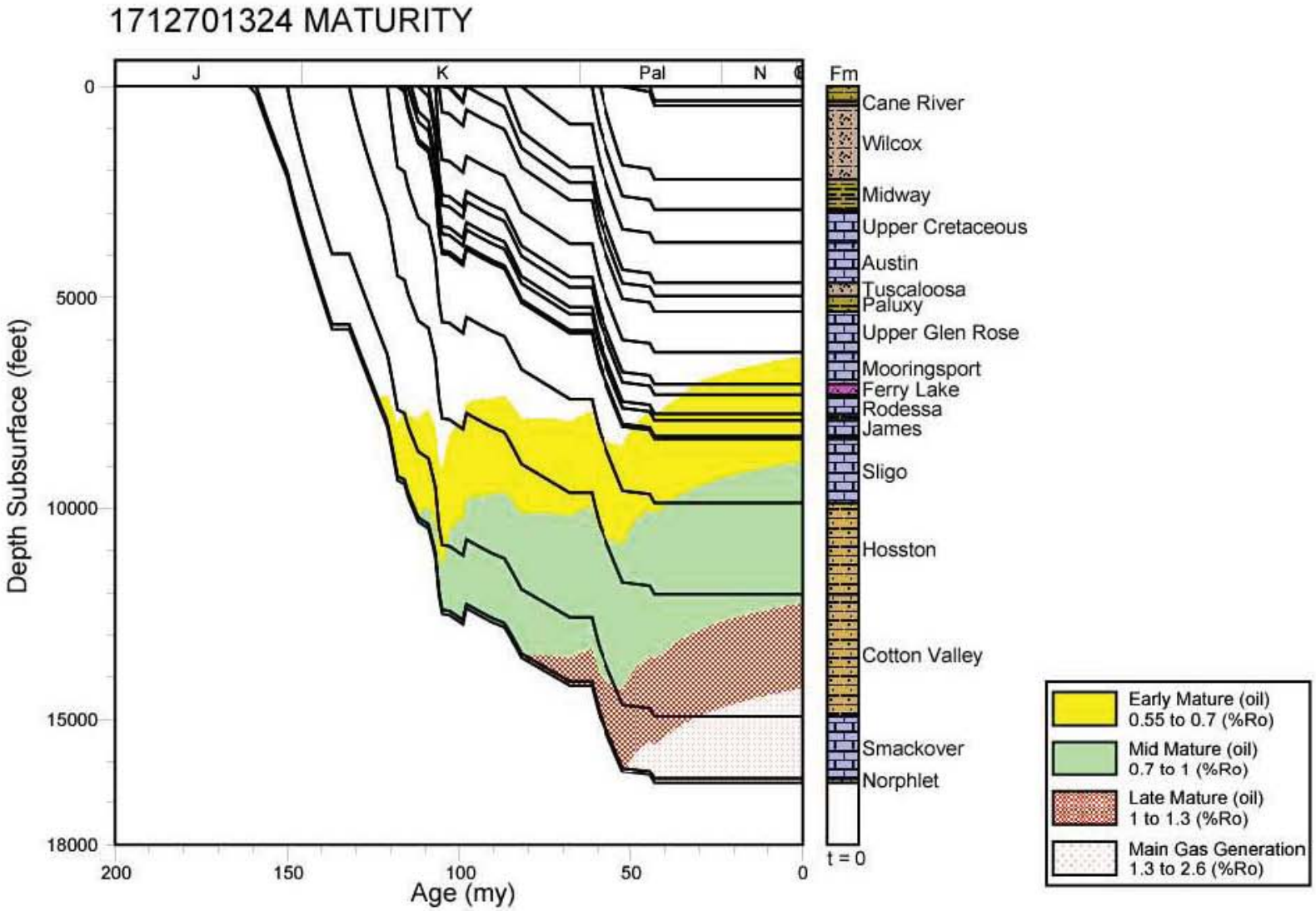


Figure 122. Thermal maturation profile for well 1712701324, North Louisiana Salt Basin.

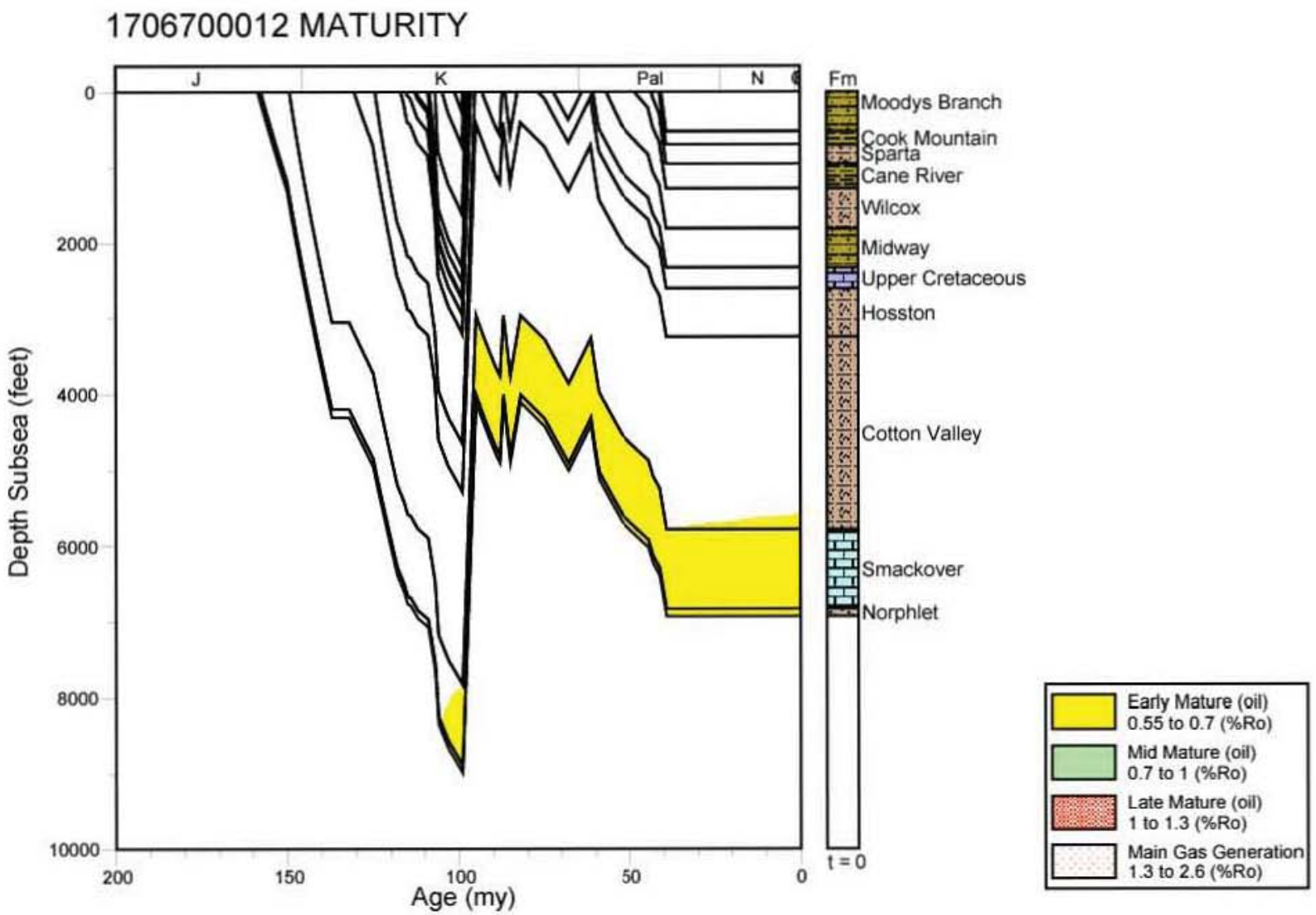


Figure 123. Thermal maturation profile for well 1706700012, North Louisiana Salt Basin.

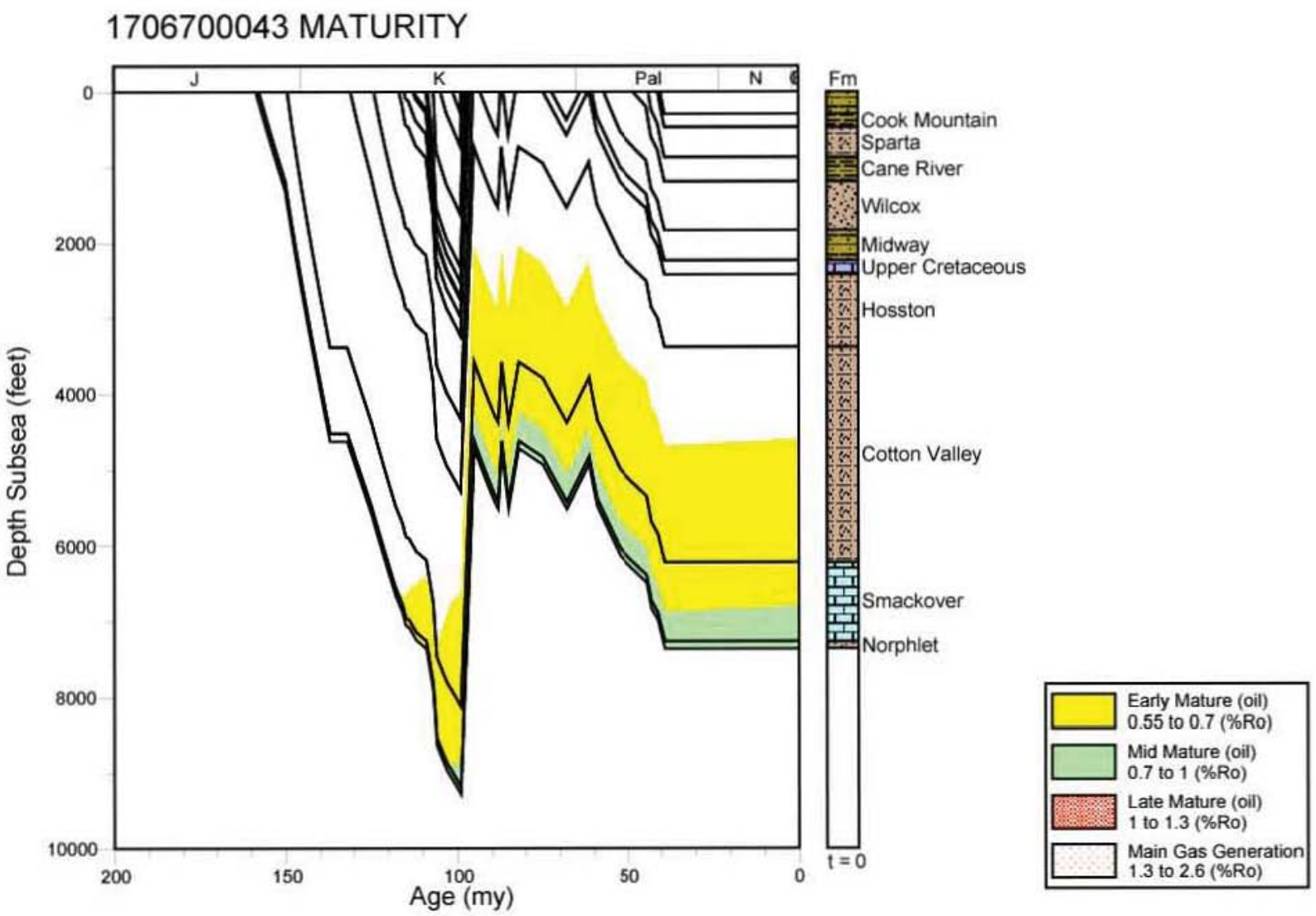


Figure 124. Thermal maturation profile for well 1706700043, North Louisiana Salt Basin.

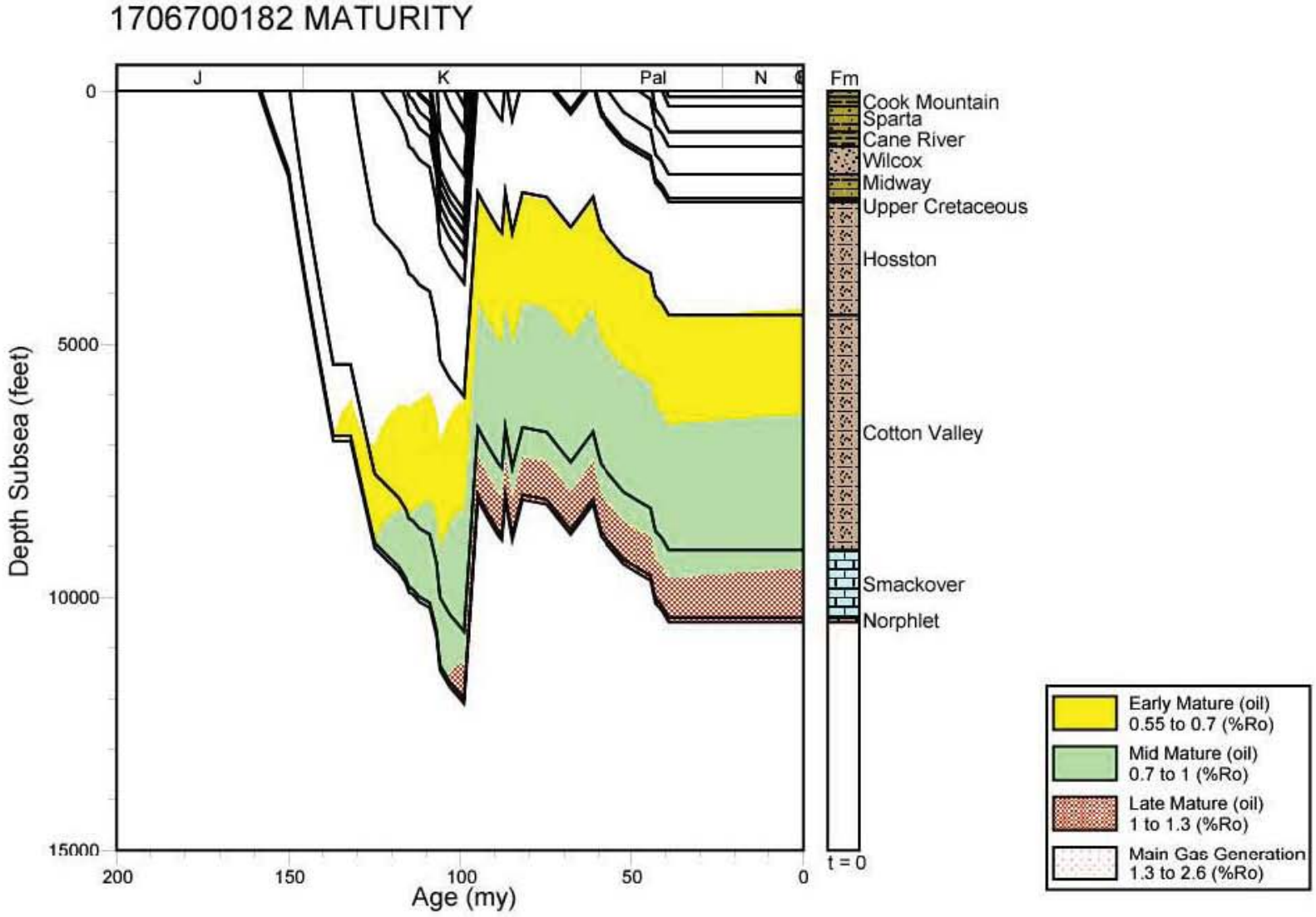


Figure 125. Thermal maturation profile for well 1706700182, North Louisiana Salt Basin.

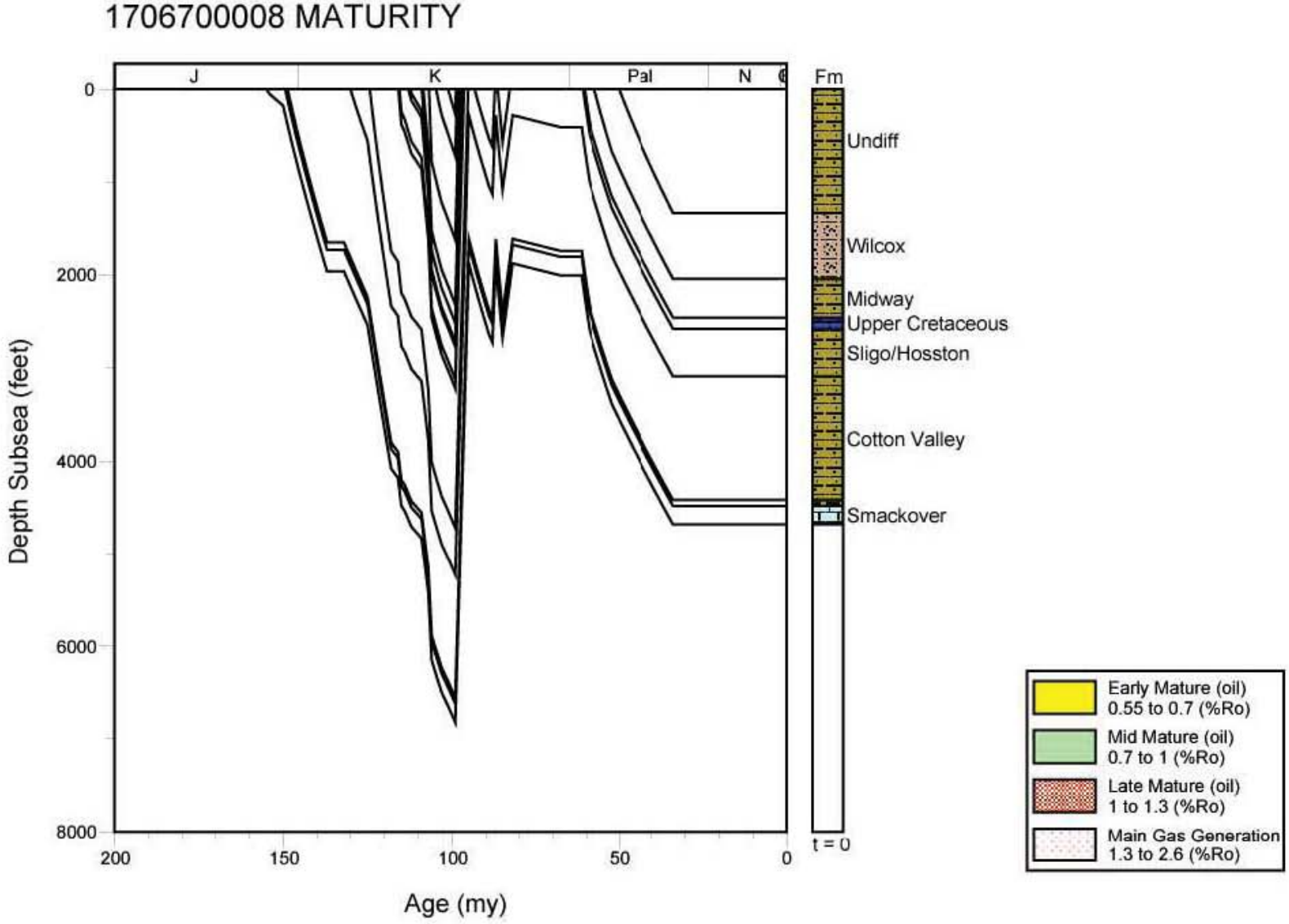


Figure 126. Thermal maturation profile for well 1706700008, North Louisiana Salt Basin.

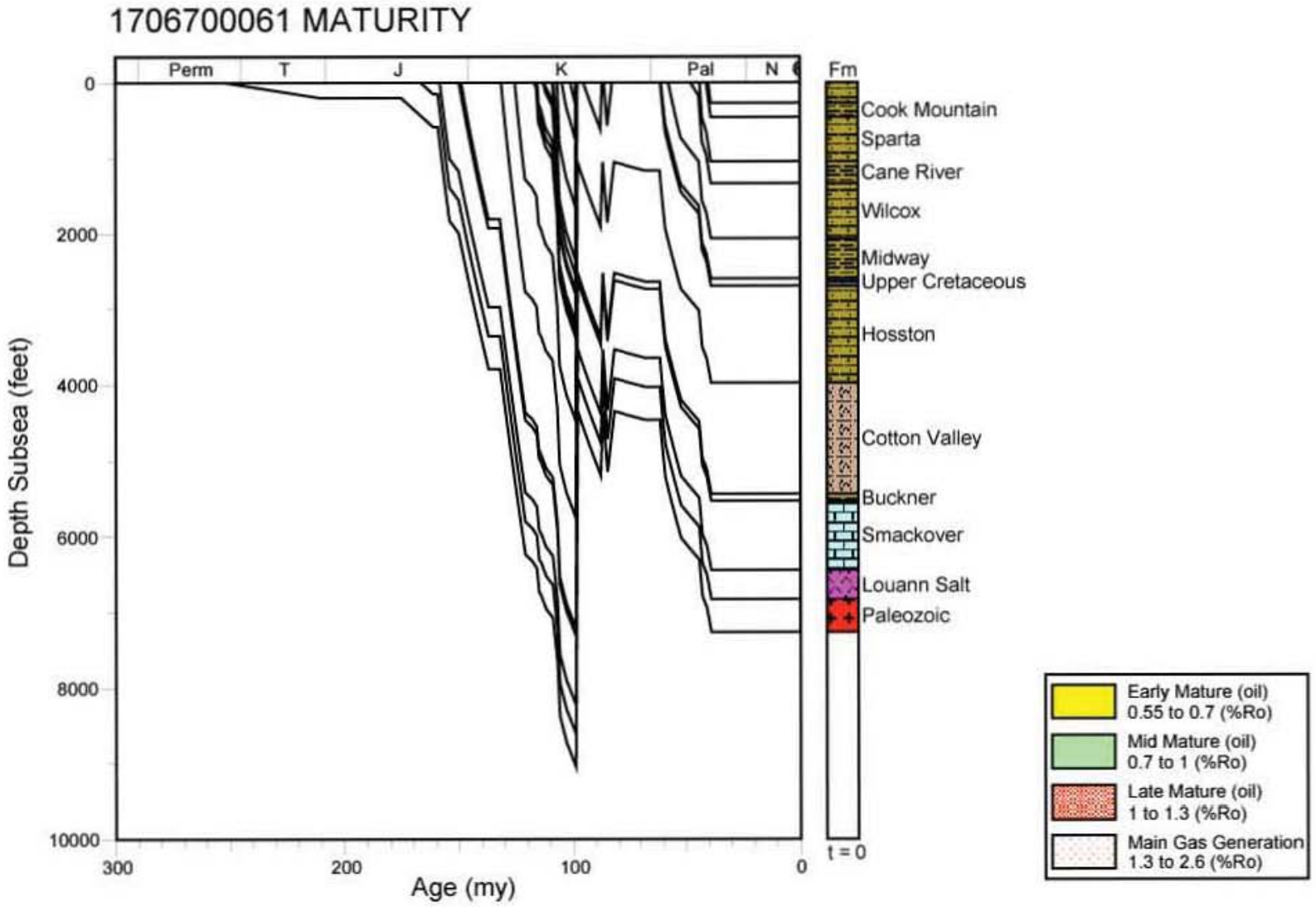


Figure 127. Thermal maturation profile for well 1706700061, North Louisiana Salt Basin.

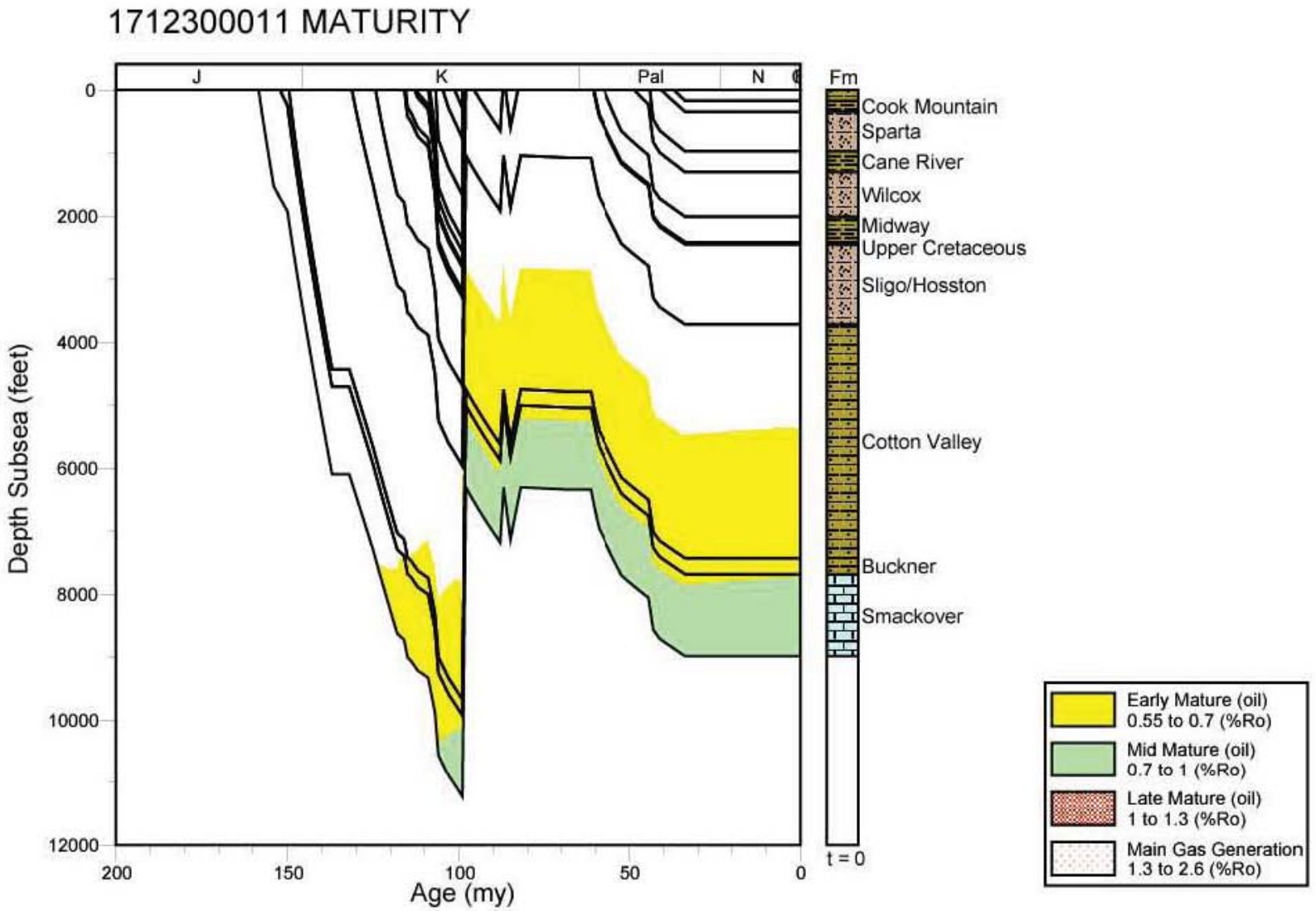


Figure 128. Thermal maturation profile for well 1712300011, North Louisiana Salt Basin.

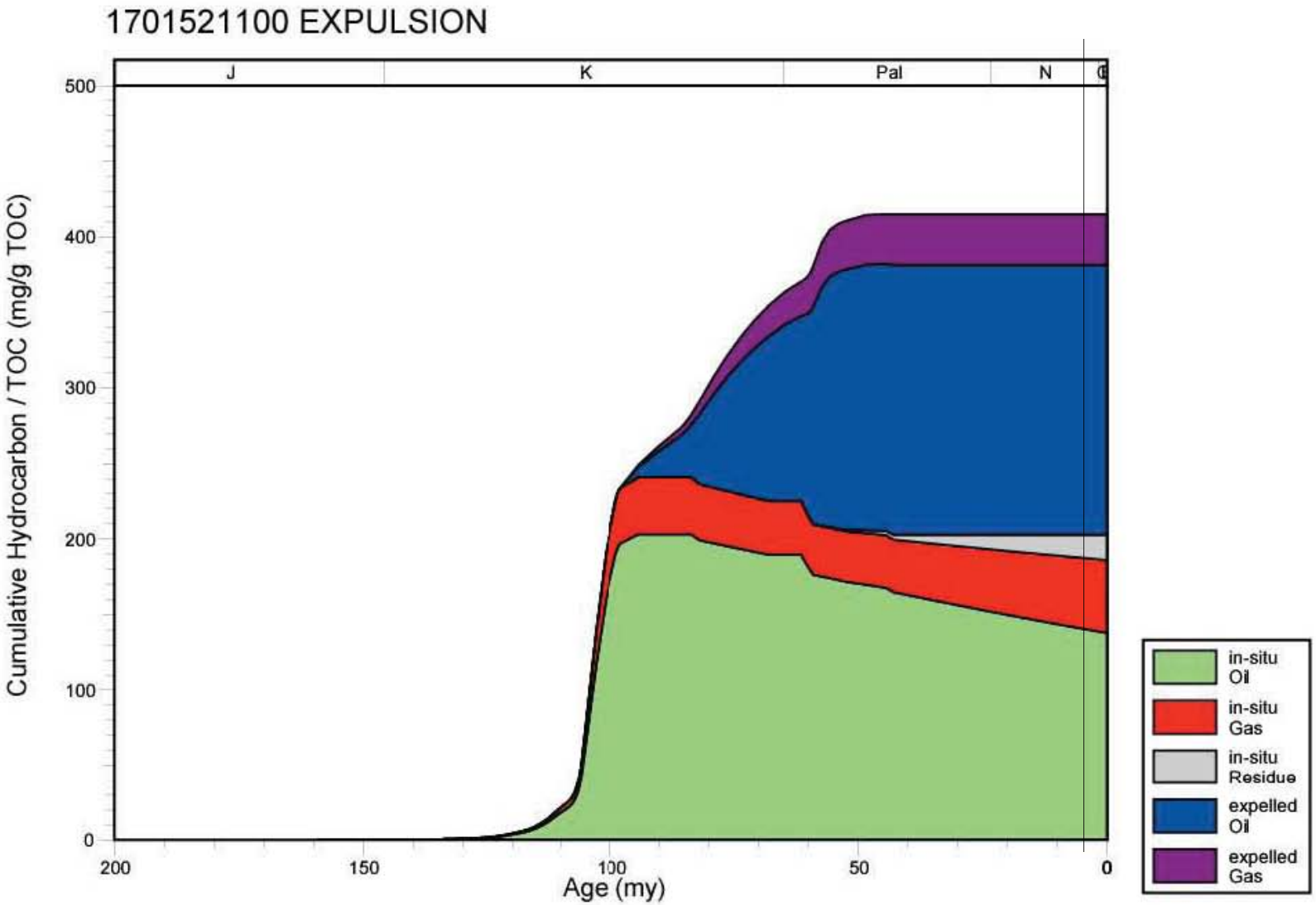


Figure 129. Hydrocarbon expulsion plot for well 1701521100, North Louisiana Salt Basin.

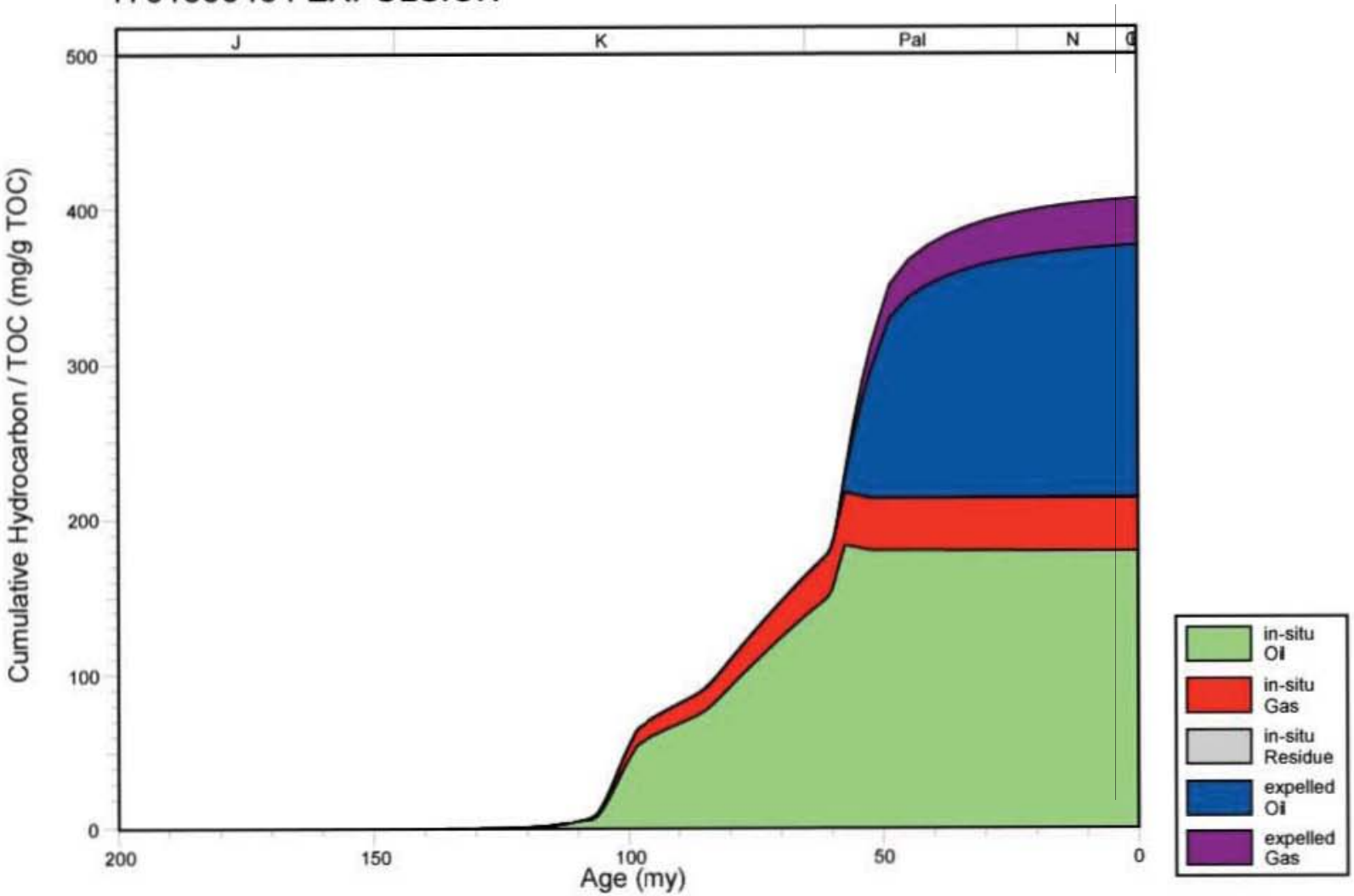


Figure 130. Hydrocarbon expulsion plot for well 1701500464, North Louisiana Salt Basin.

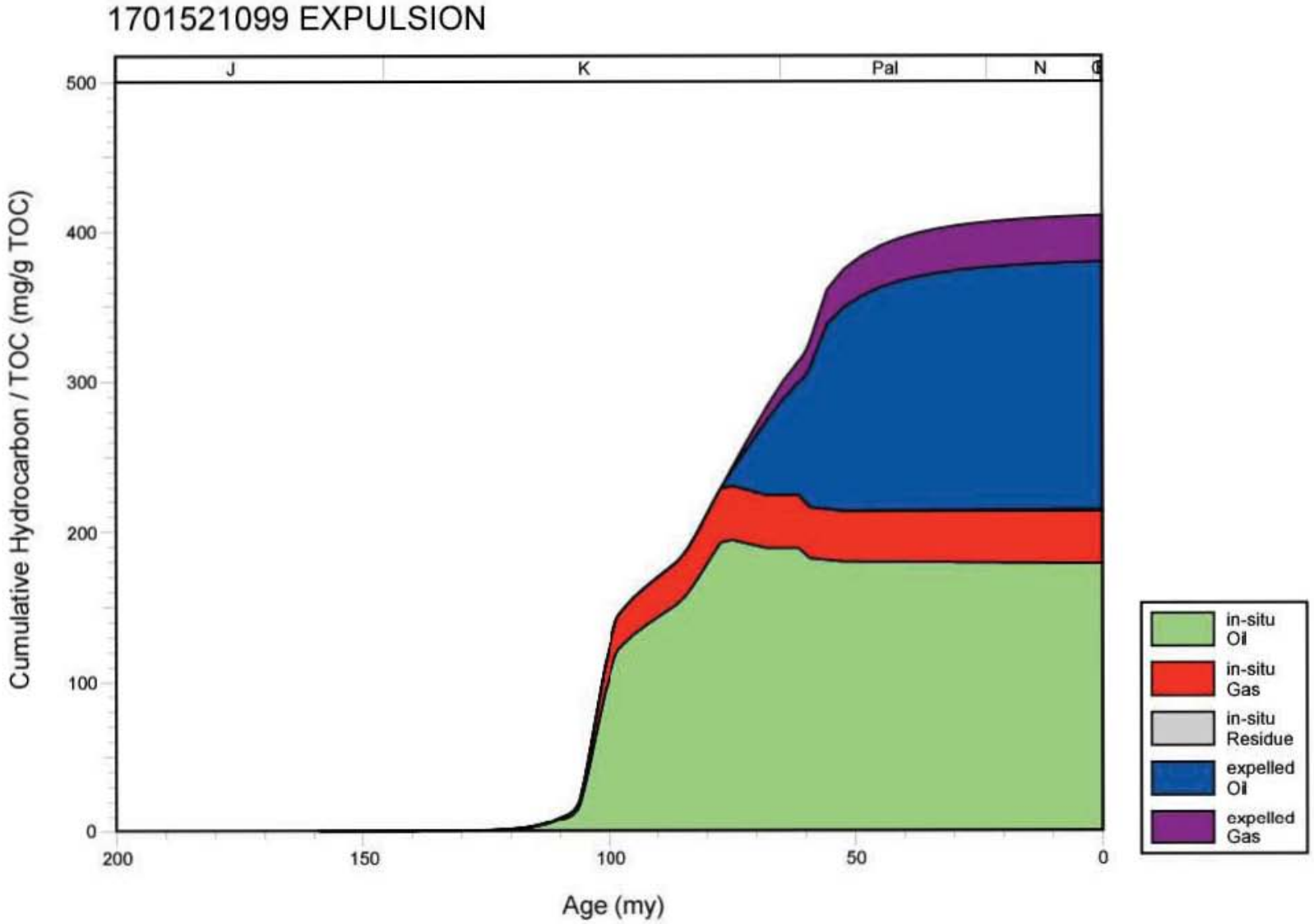


Figure 131. Hydrocarbon expulsion plot for well 1701521099, North Louisiana Salt Basin.

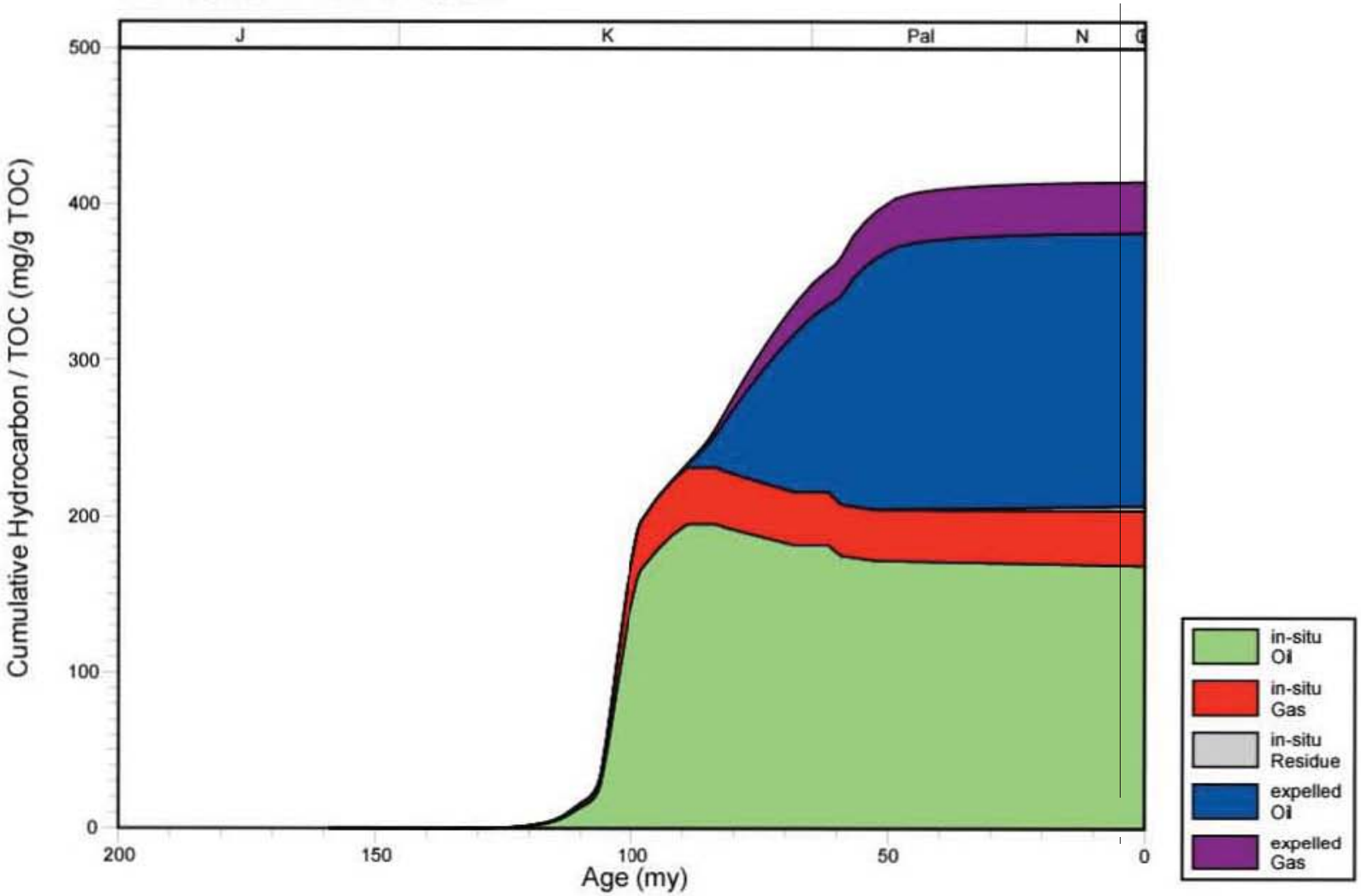


Figure 132. Hydrocarbon expulsion plot for well 1701500977, North Louisiana Salt Basin.

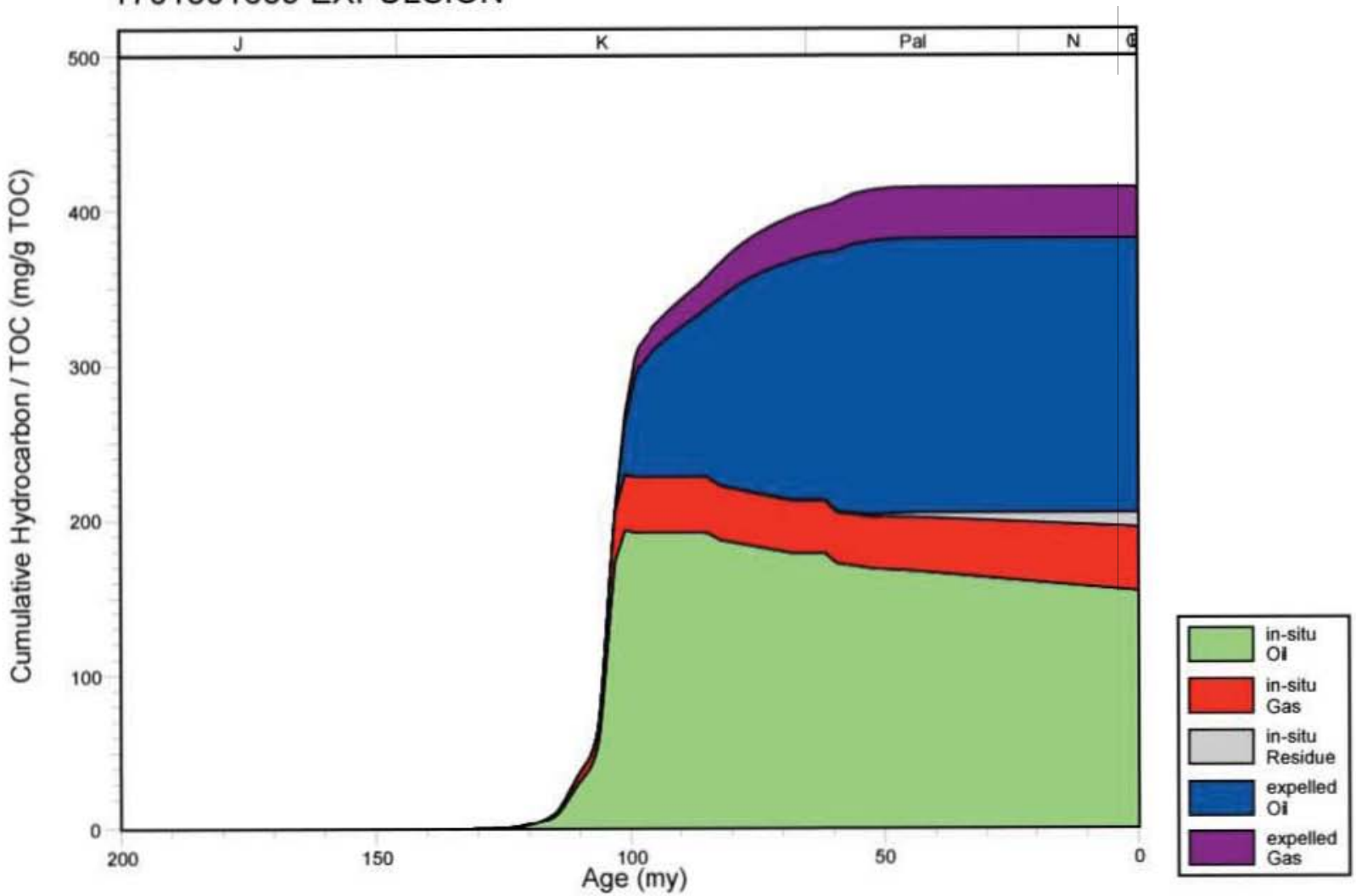


Figure 133. Hydrocarbon expulsion plot for well 1701501689, North Louisiana Salt Basin.

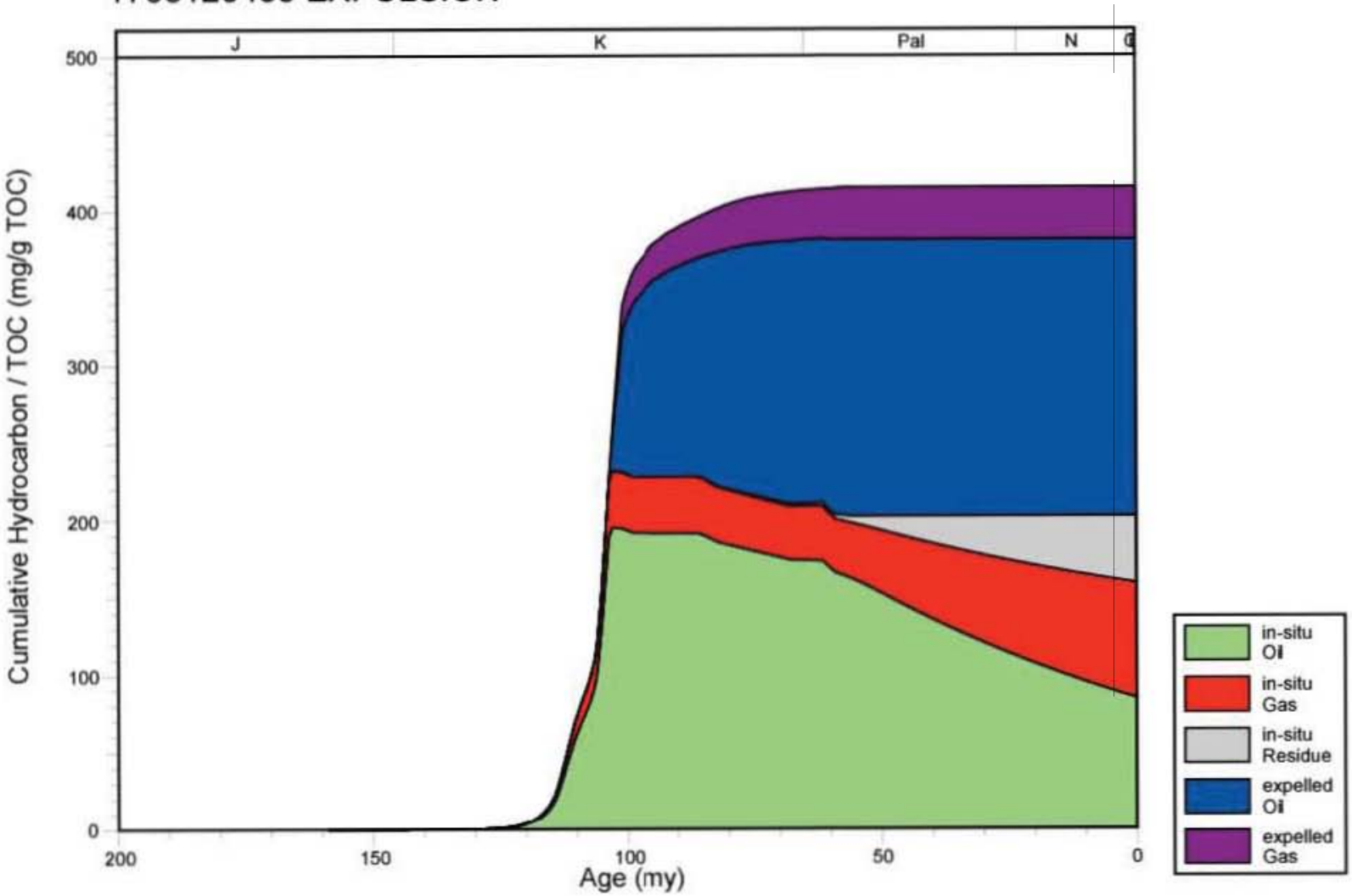


Figure 134. Hydrocarbon expulsion plot for well 1703120488, North Louisiana Salt Basin.

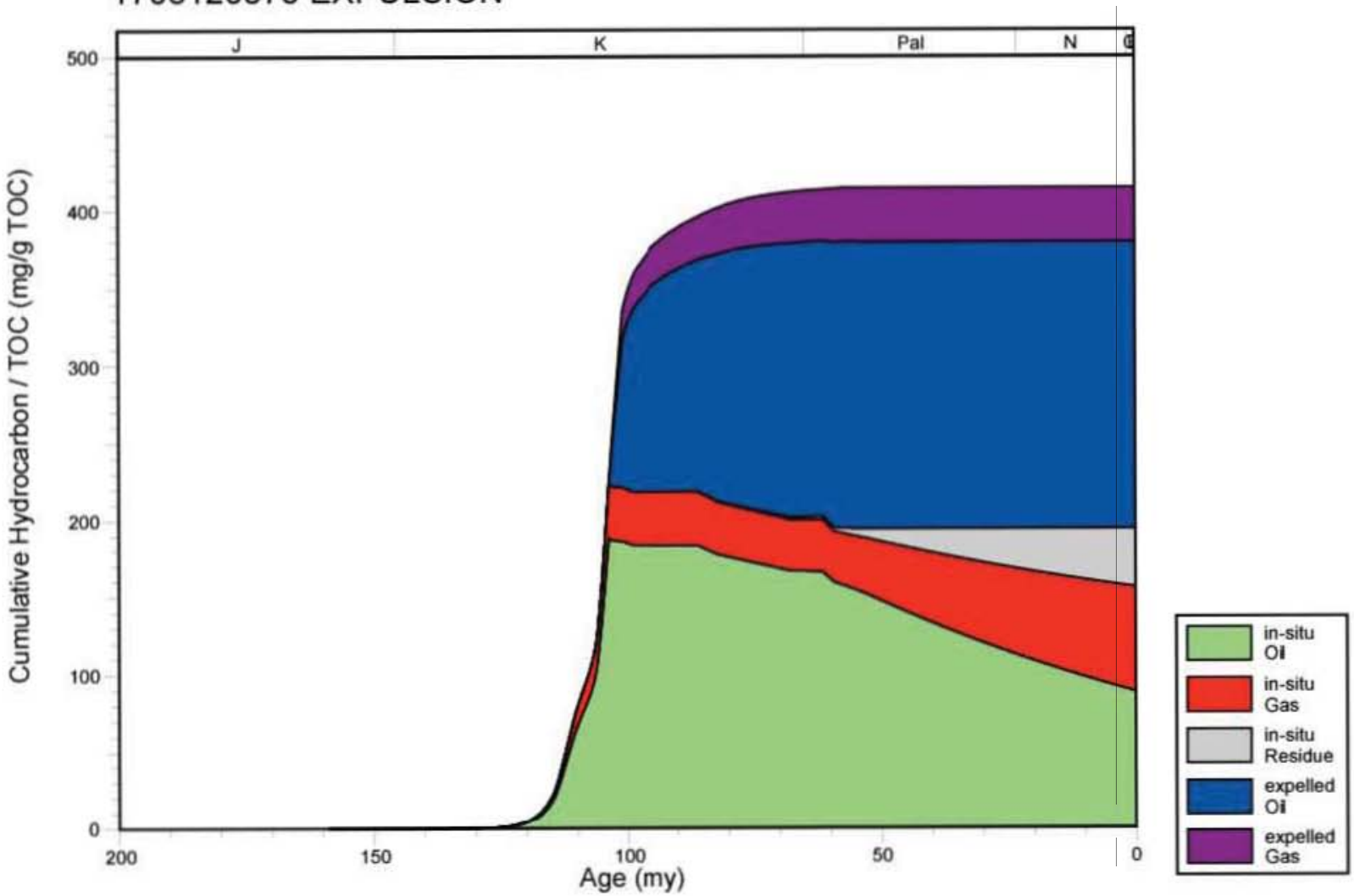


Figure 135. Hydrocarbon expulsion plot for well 1703120378, North Louisiana Salt Basin.

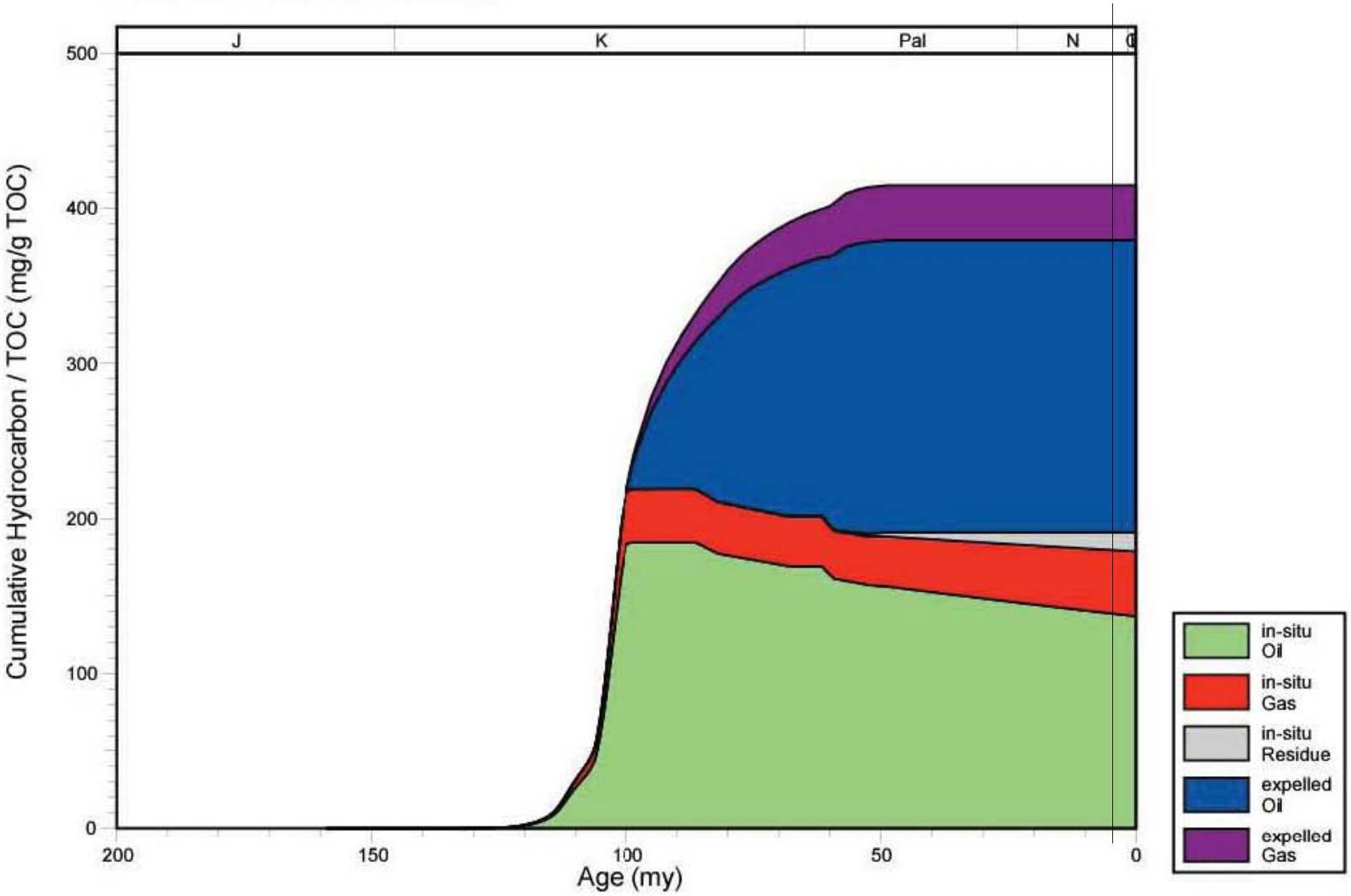


Figure 136. Hydrocarbon expulsion plot for well 1703100304, North Louisiana Salt Basin.

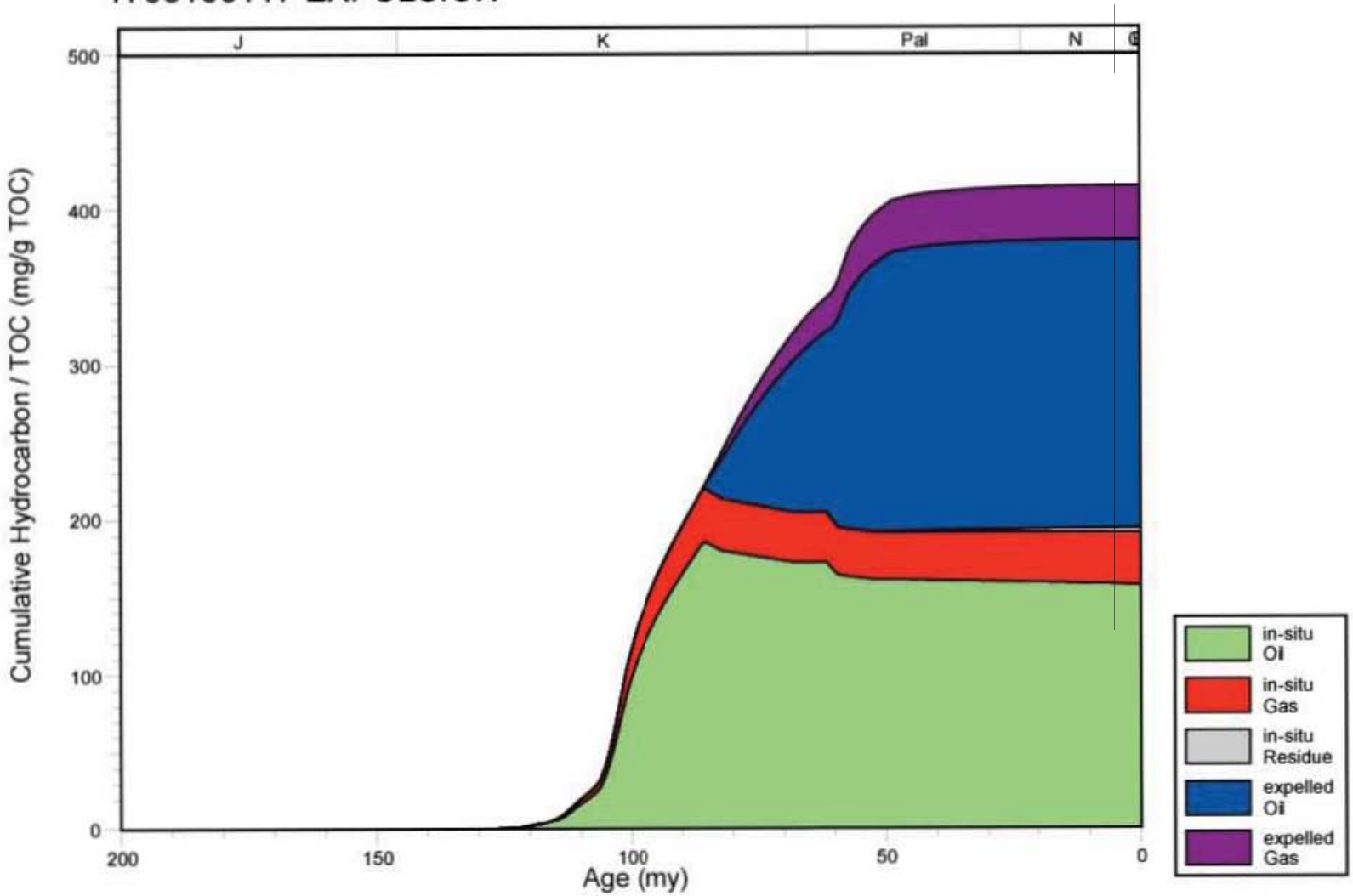


Figure 137. Hydrocarbon expulsion plot for well 1703100117, North Louisiana Salt Basin.

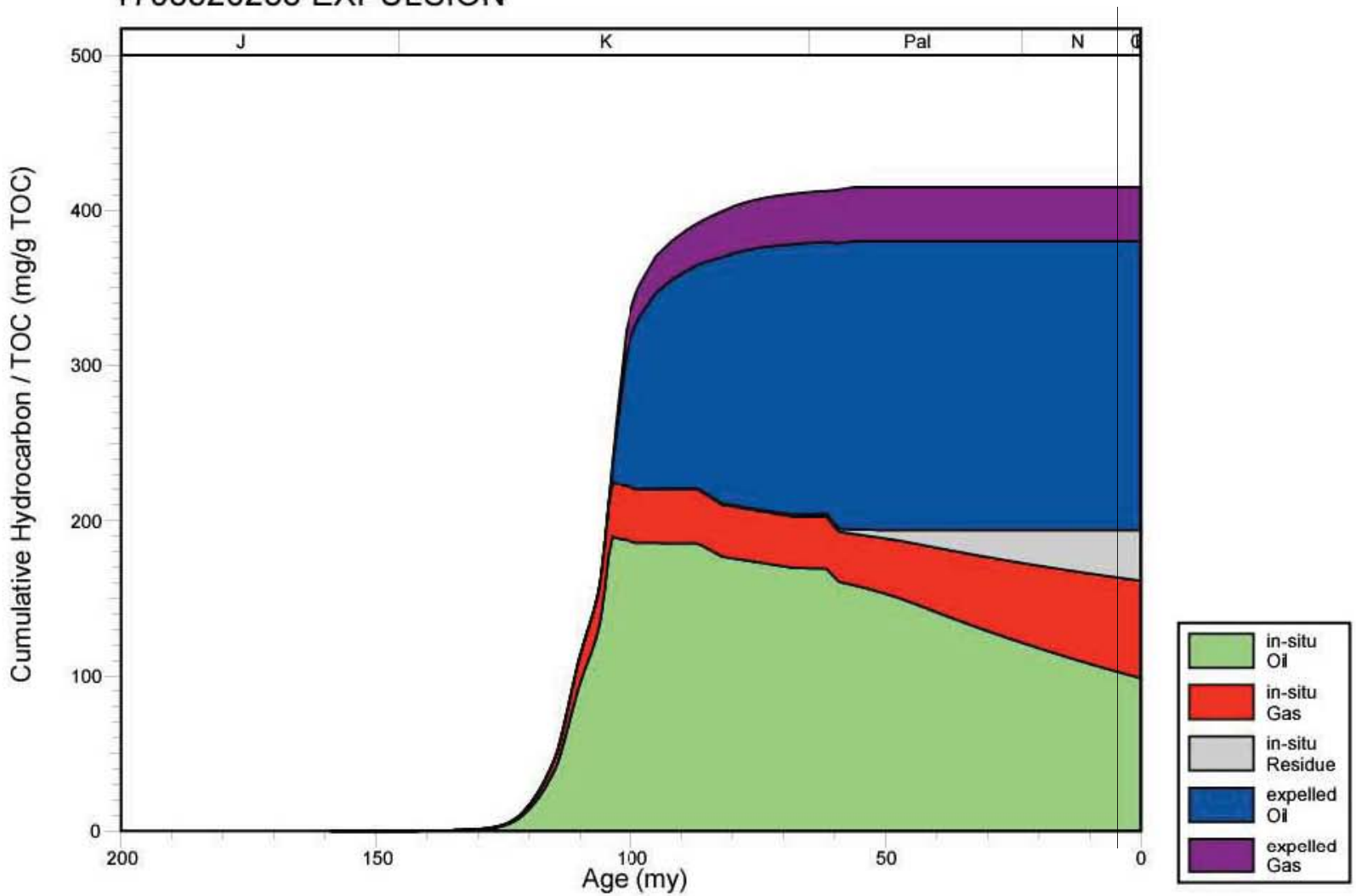


Figure 138. Hydrocarbon expulsion plot for well 1708520238, North Louisiana Salt Basin.

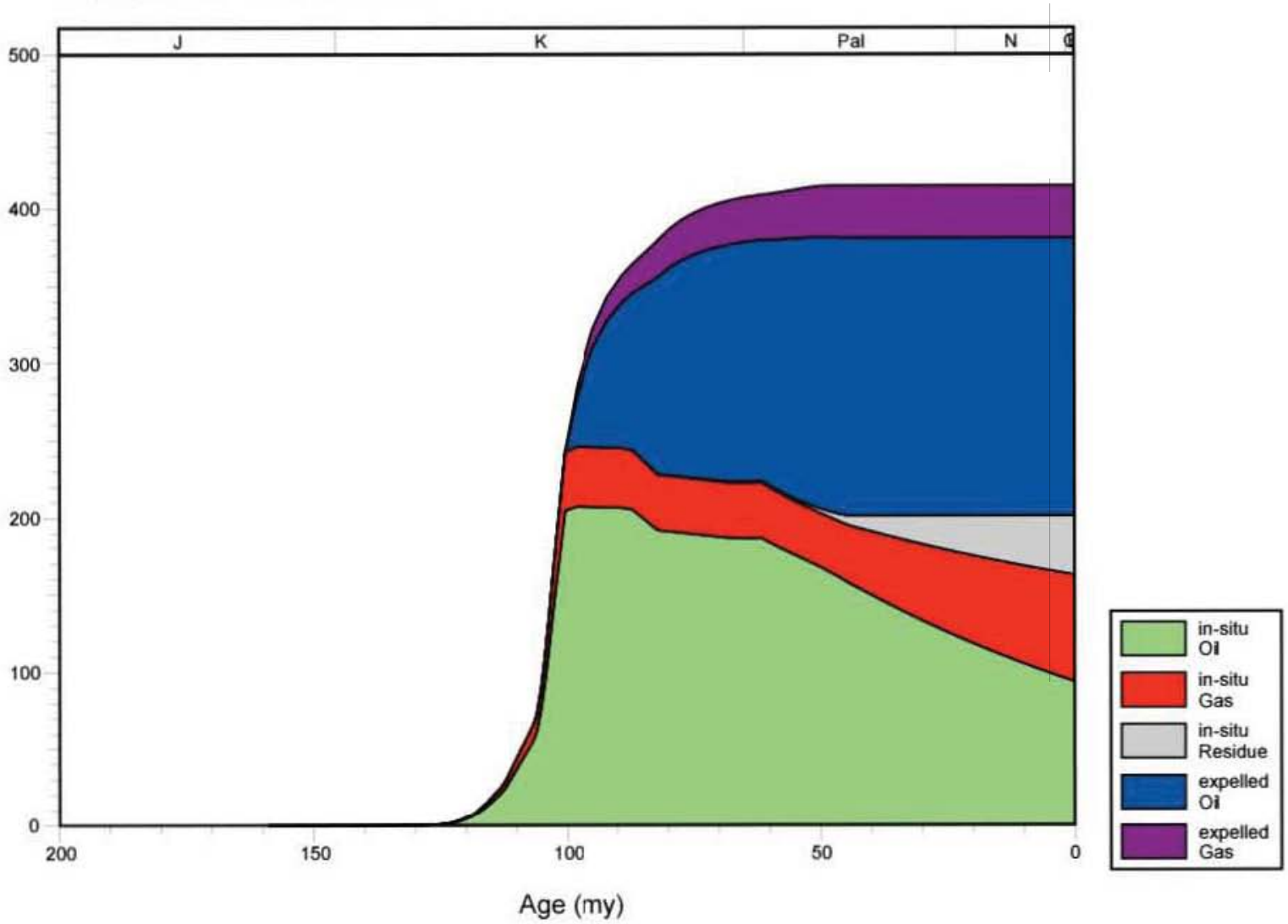


Figure 139. Hydrocarbon expulsion plot for well 1708520177, North Louisiana Salt Basin.

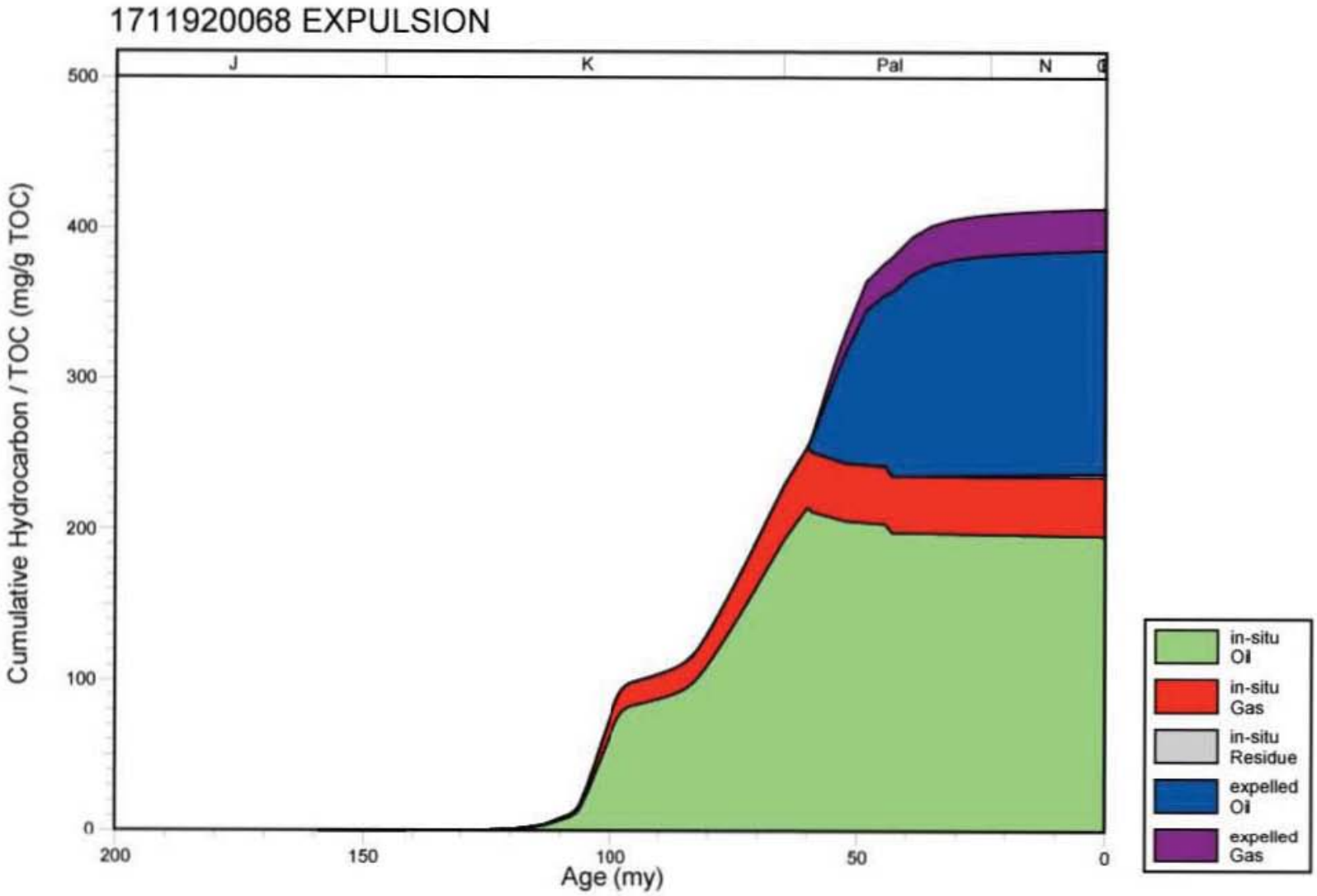


Figure 140. Hydrocarbon expulsion plot for well 1711920068, North Louisiana Salt Basin.

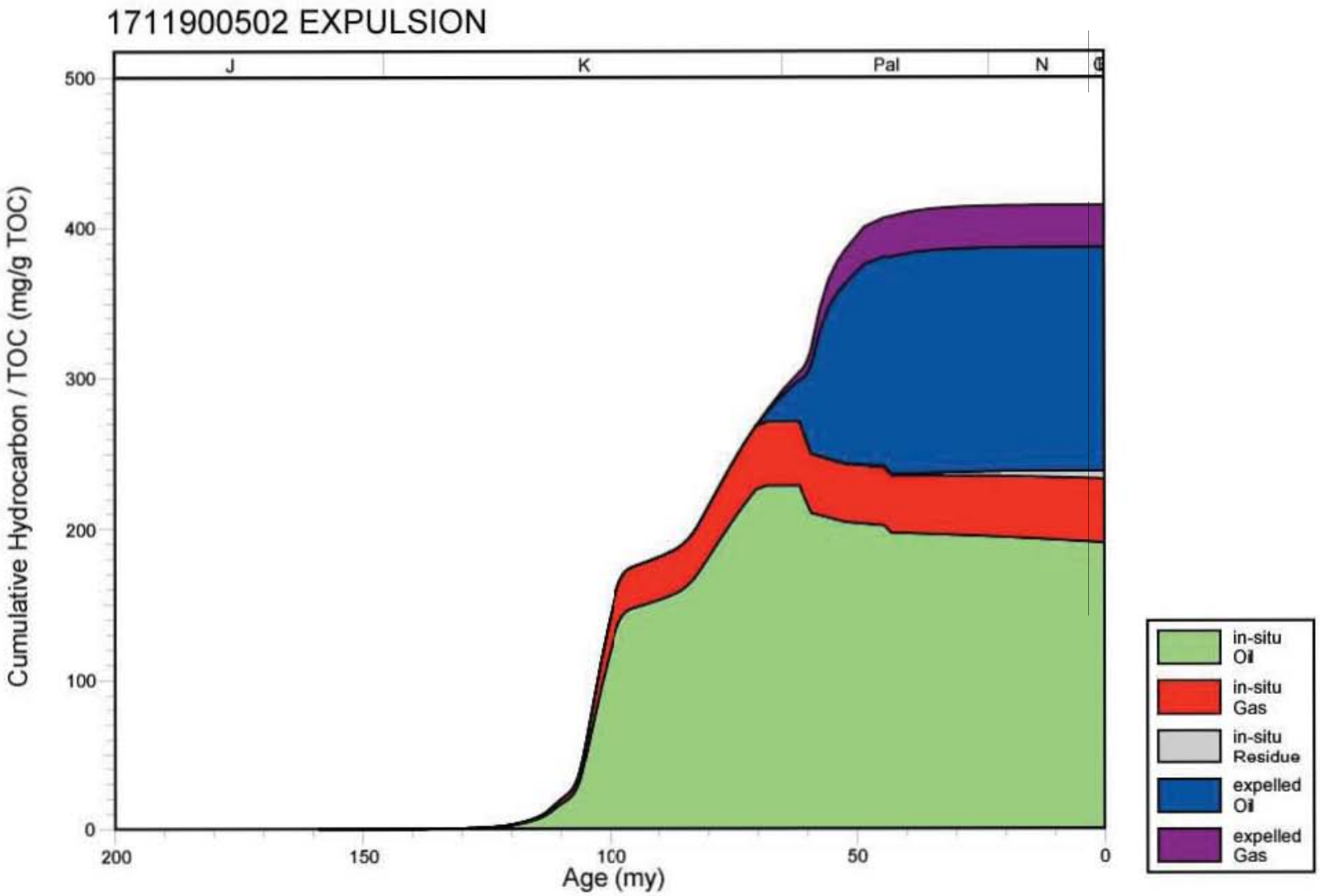


Figure 141. Hydrocarbon expulsion plot for well 1711900502, North Louisiana Salt Basin.

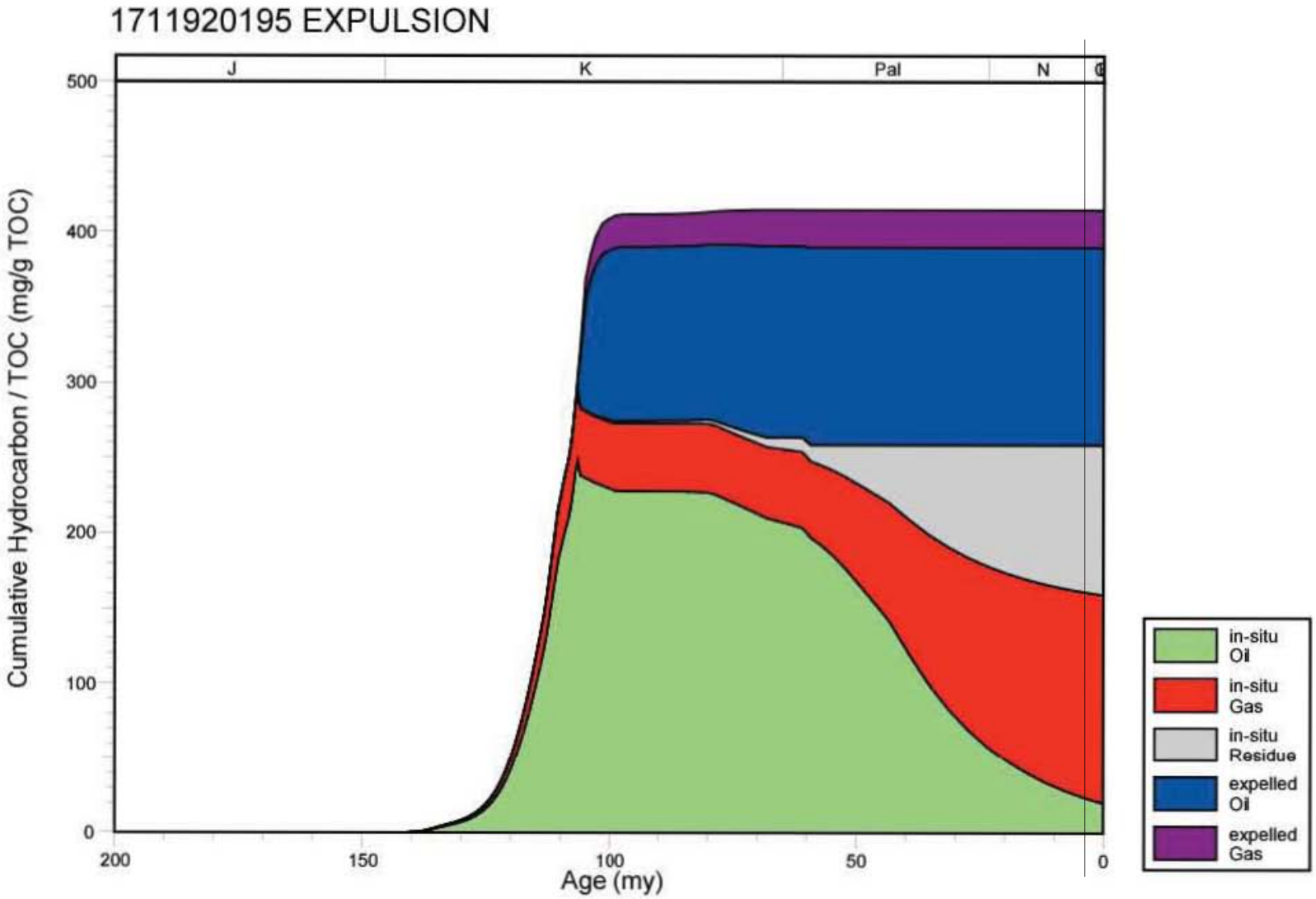


Figure 142. Hydrocarbon expulsion plot for well 1711920195, North Louisiana Salt Basin.

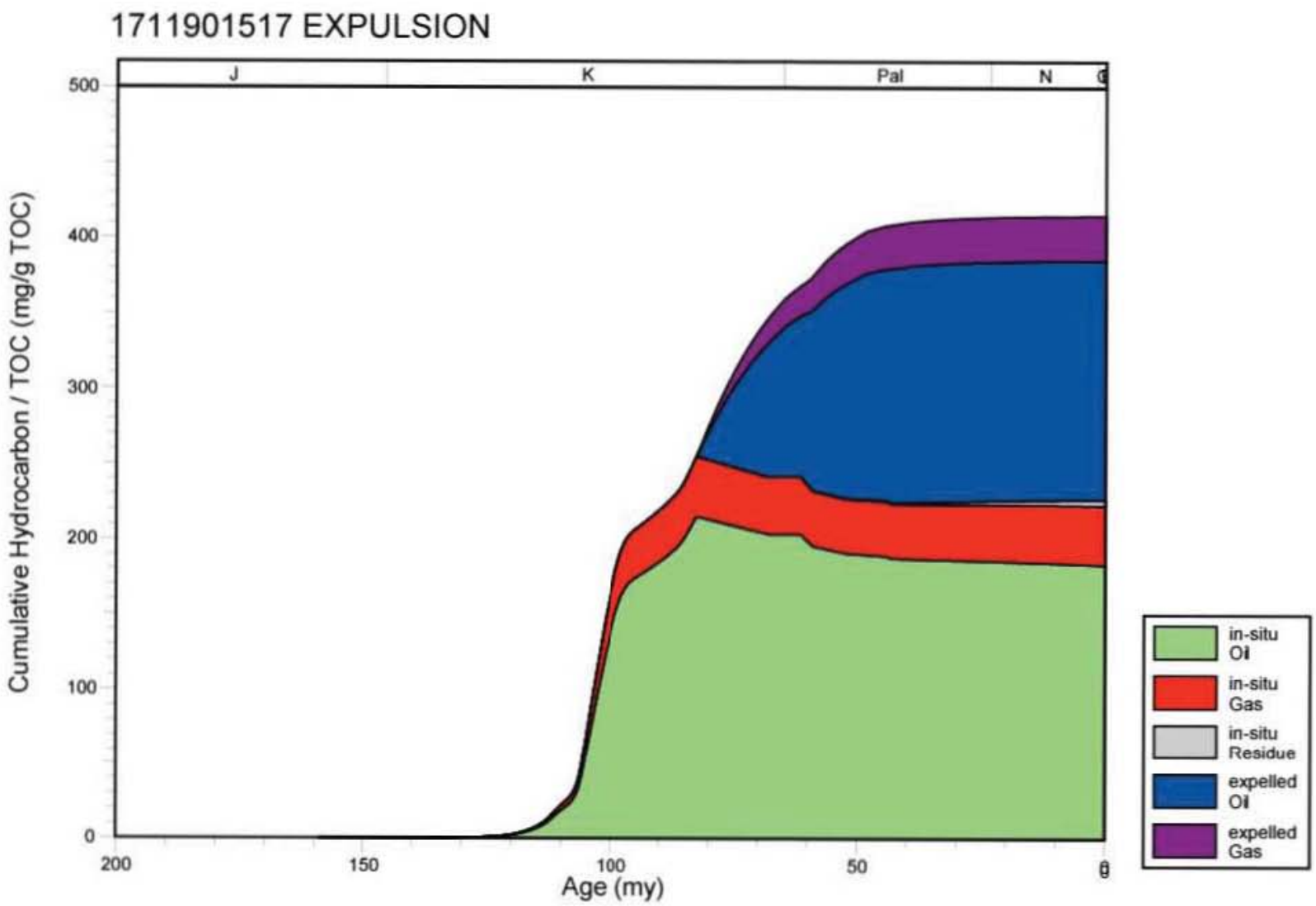


Figure 143. Hydrocarbon expulsion plot for well 1711901517, North Louisiana Salt Basin.

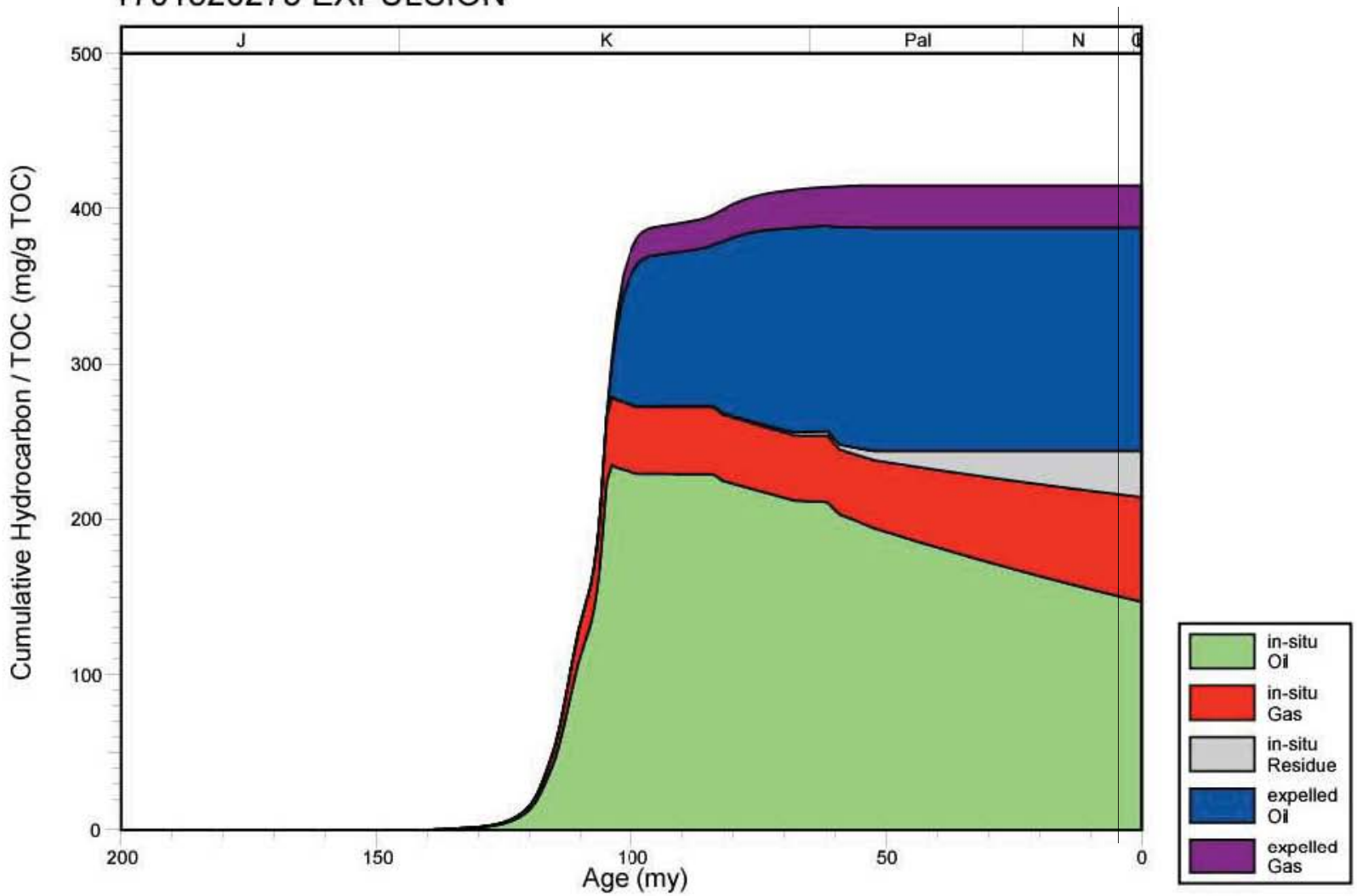


Figure 144. Hydrocarbon expulsion plot for well 1701320275, North Louisiana Salt Basin.

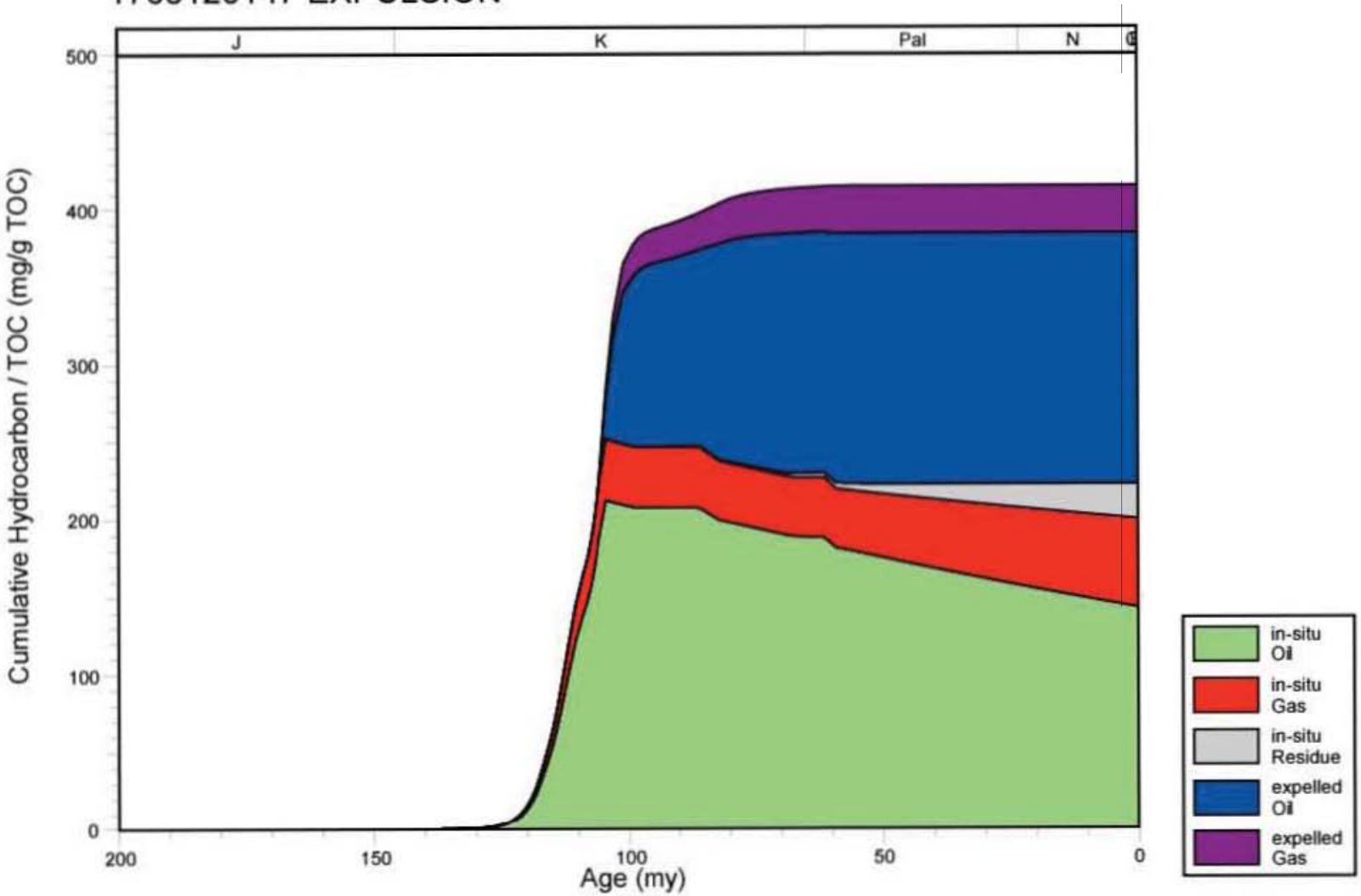


Figure 145. Hydrocarbon expulsion plot for well 1708120147, North Louisiana Salt Basin.

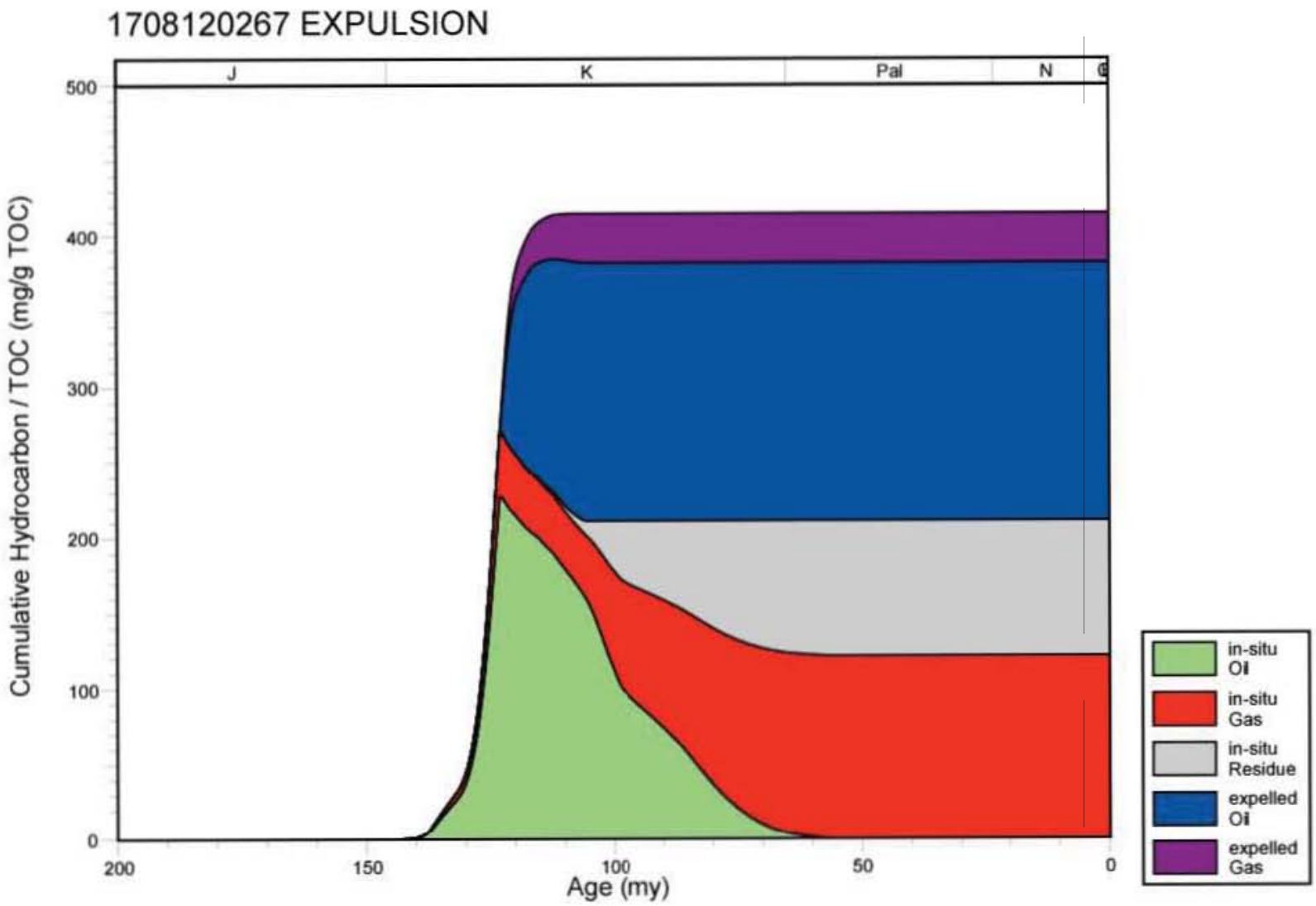


Figure 146. Hydrocarbon expulsion plot for well 1708120267, North Louisiana Salt Basin.

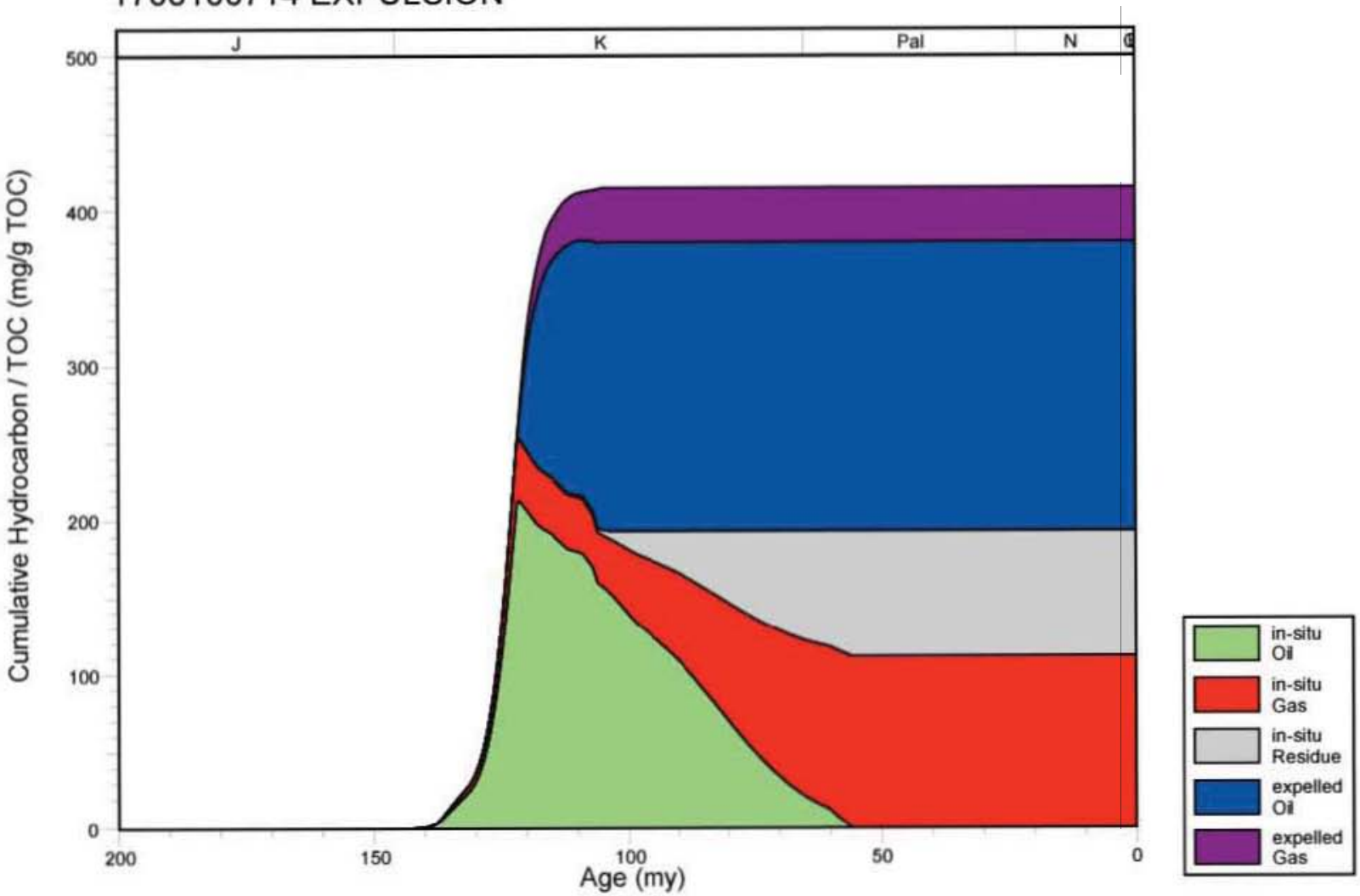


Figure 147. Hydrocarbon expulsion plot for well 1708100714, North Louisiana Salt Basin.

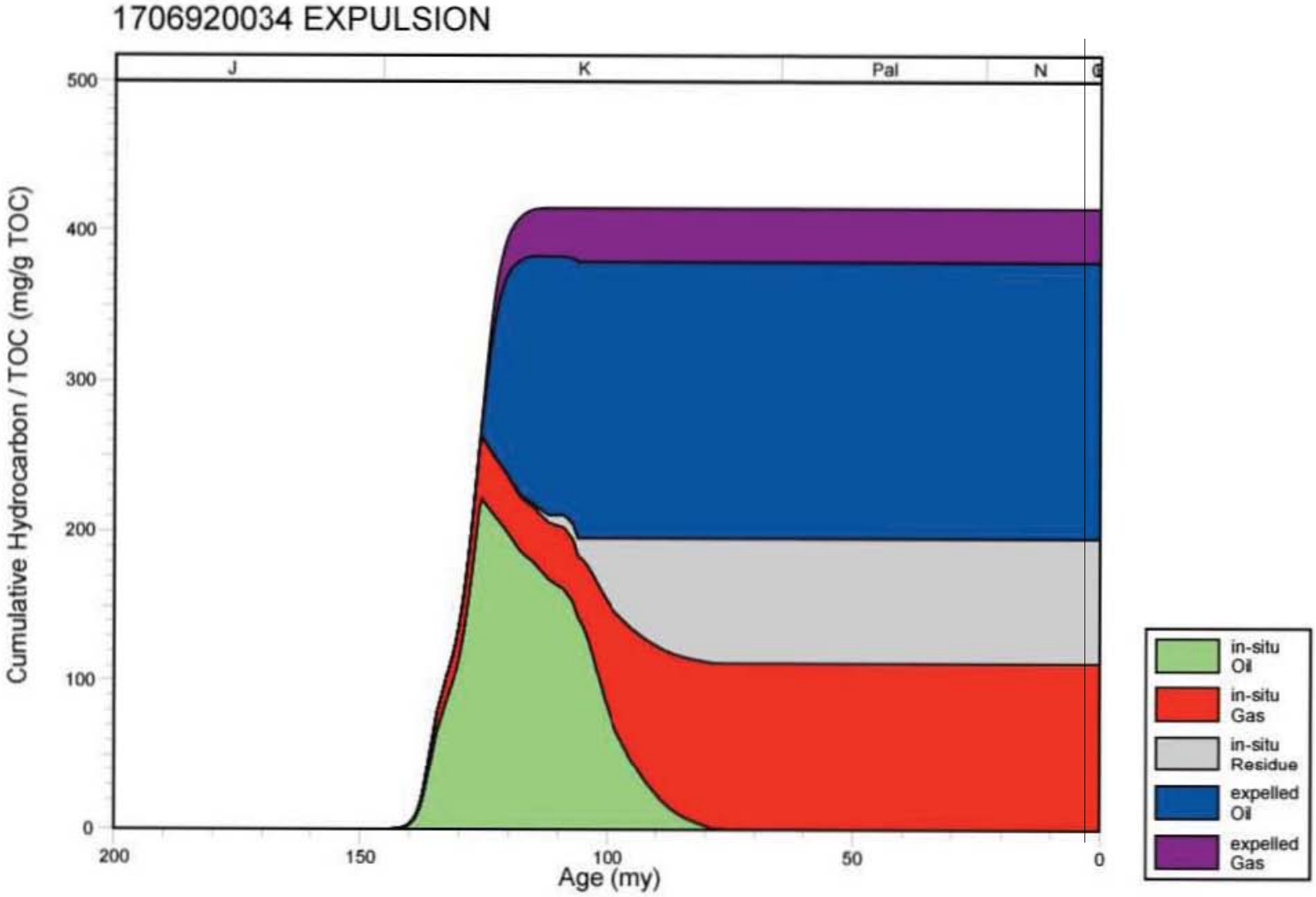


Figure 148. Hydrocarbon expulsion plot for well 1706920034, North Louisiana Salt Basin.

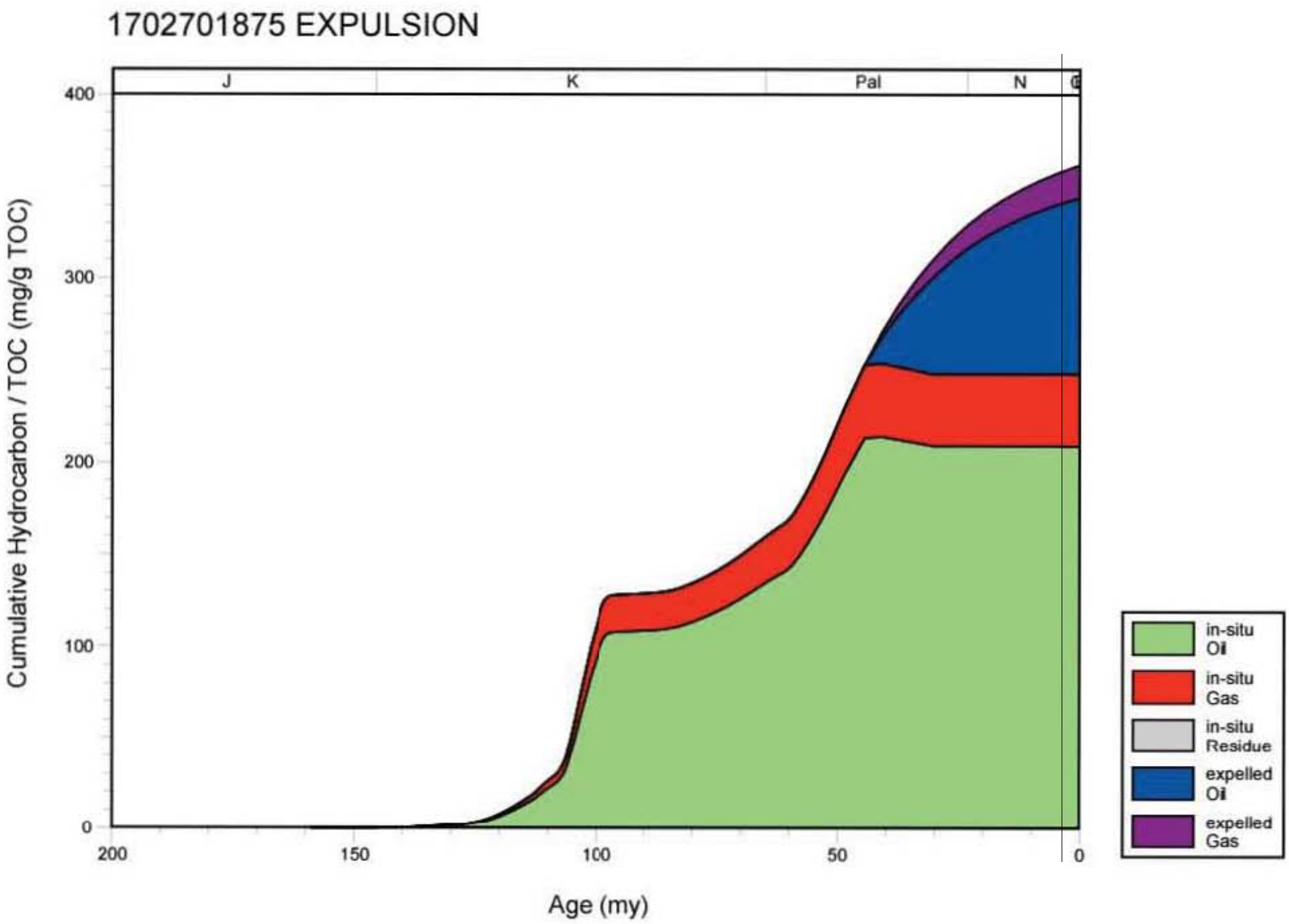


Figure 149. Hydrocarbon expulsion plot for well 1702701875, North Louisiana Salt Basin.

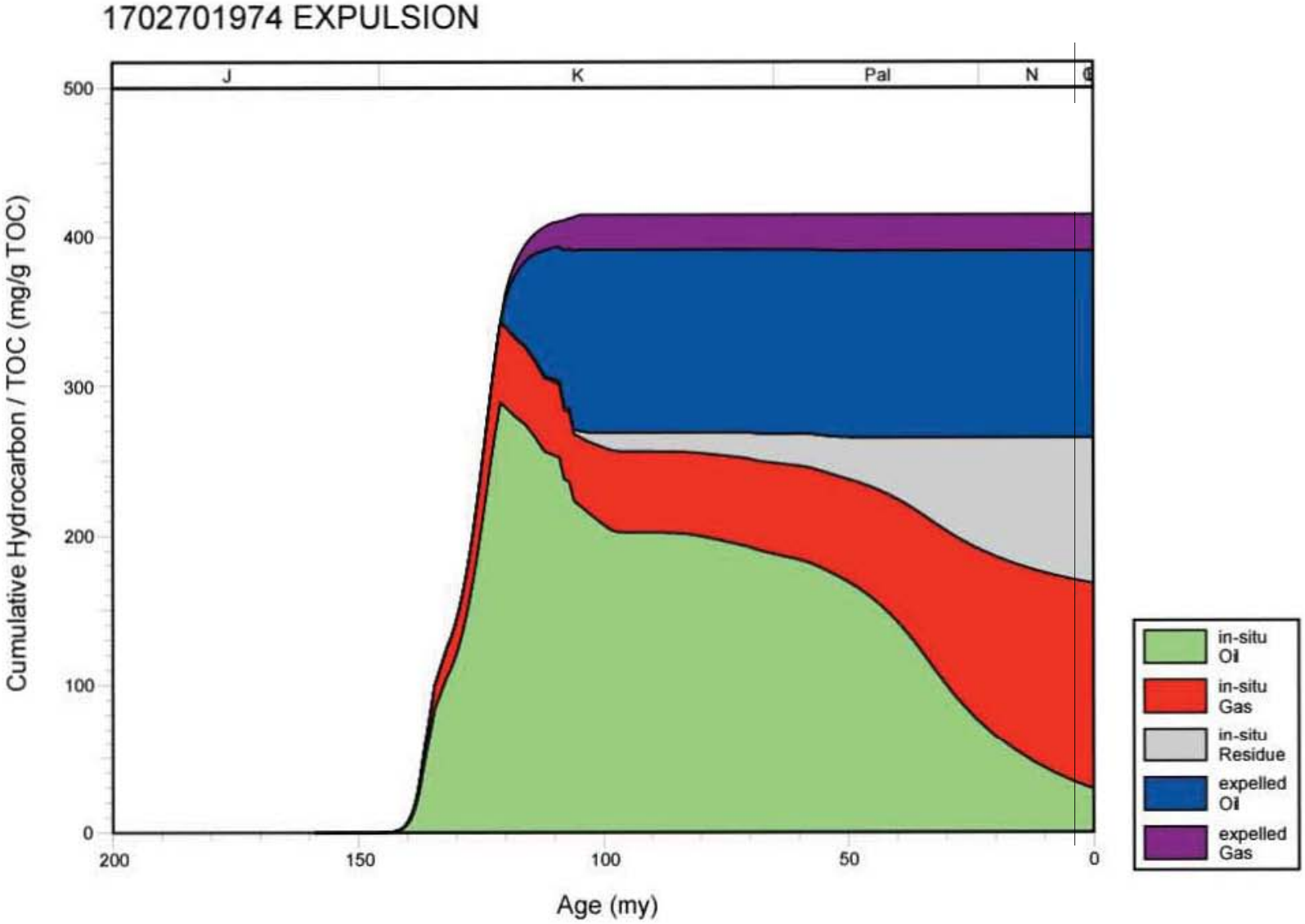


Figure 150. Hydrocarbon expulsion plot for well 1702701974, North Louisiana Salt Basin.

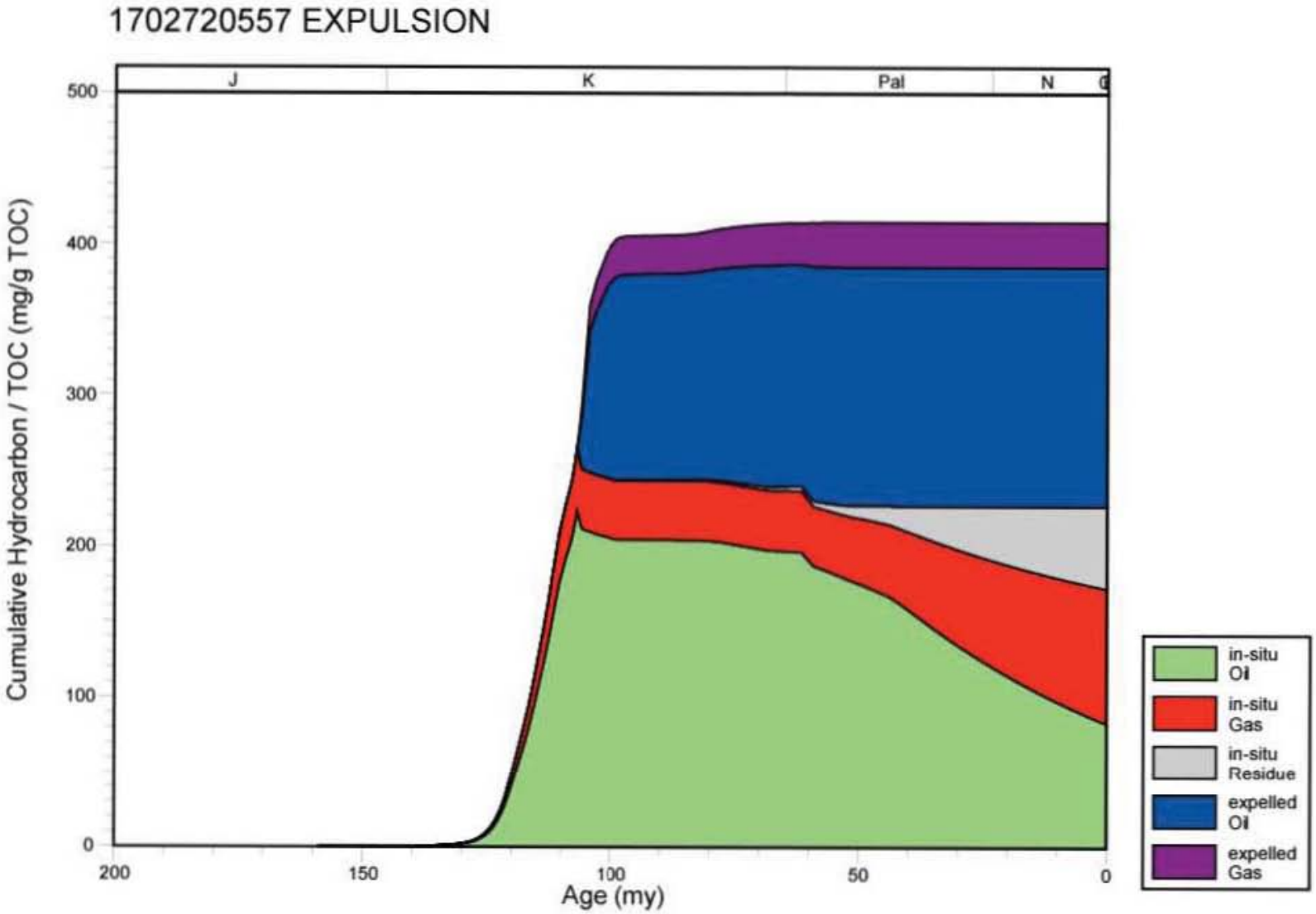


Figure 151. Hydrocarbon expulsion plot for well 1702720557, North Louisiana Salt Basin.

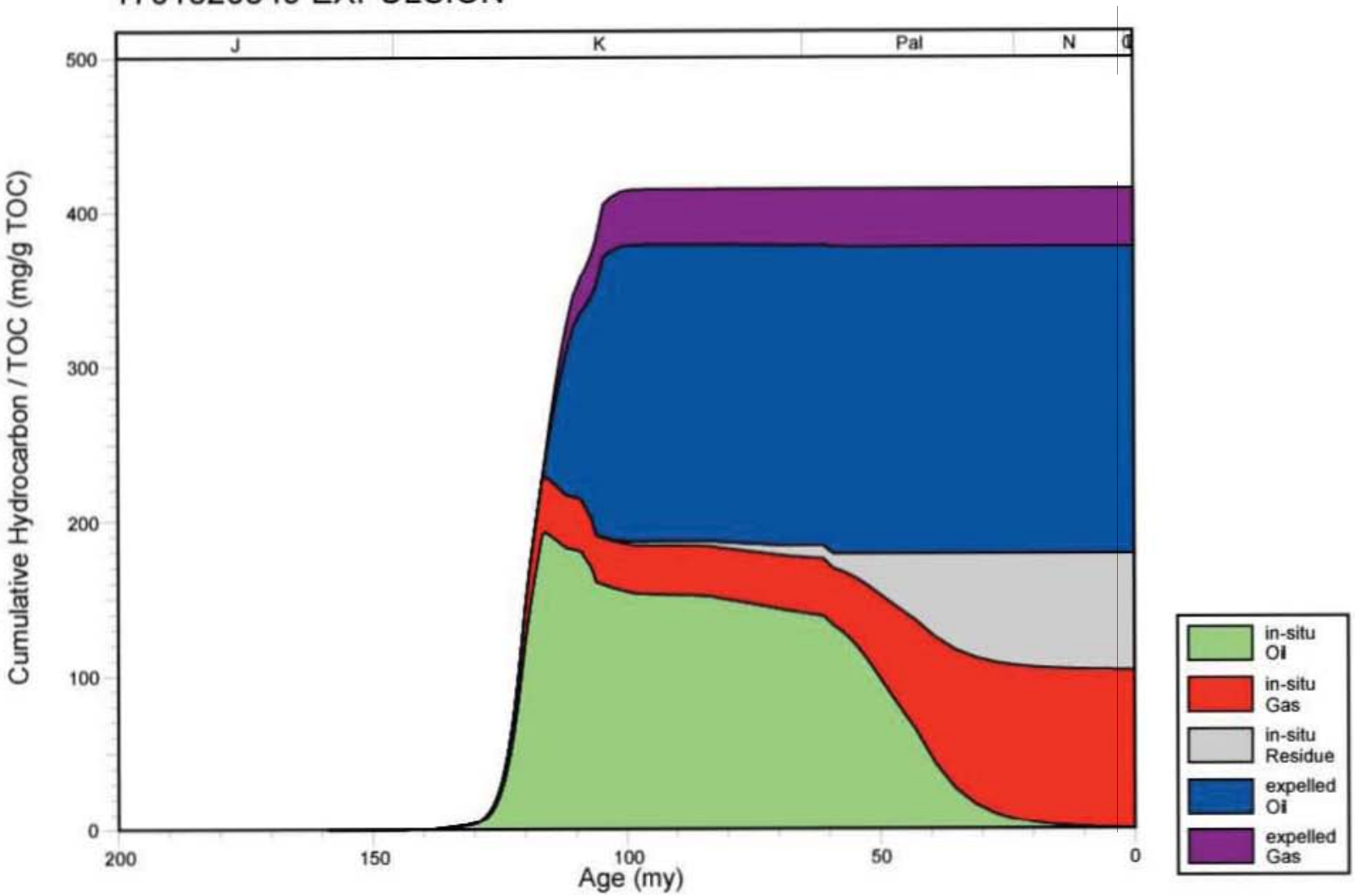


Figure 152. Hydrocarbon expulsion plot for well 1701320349, North Louisiana Salt Basin.

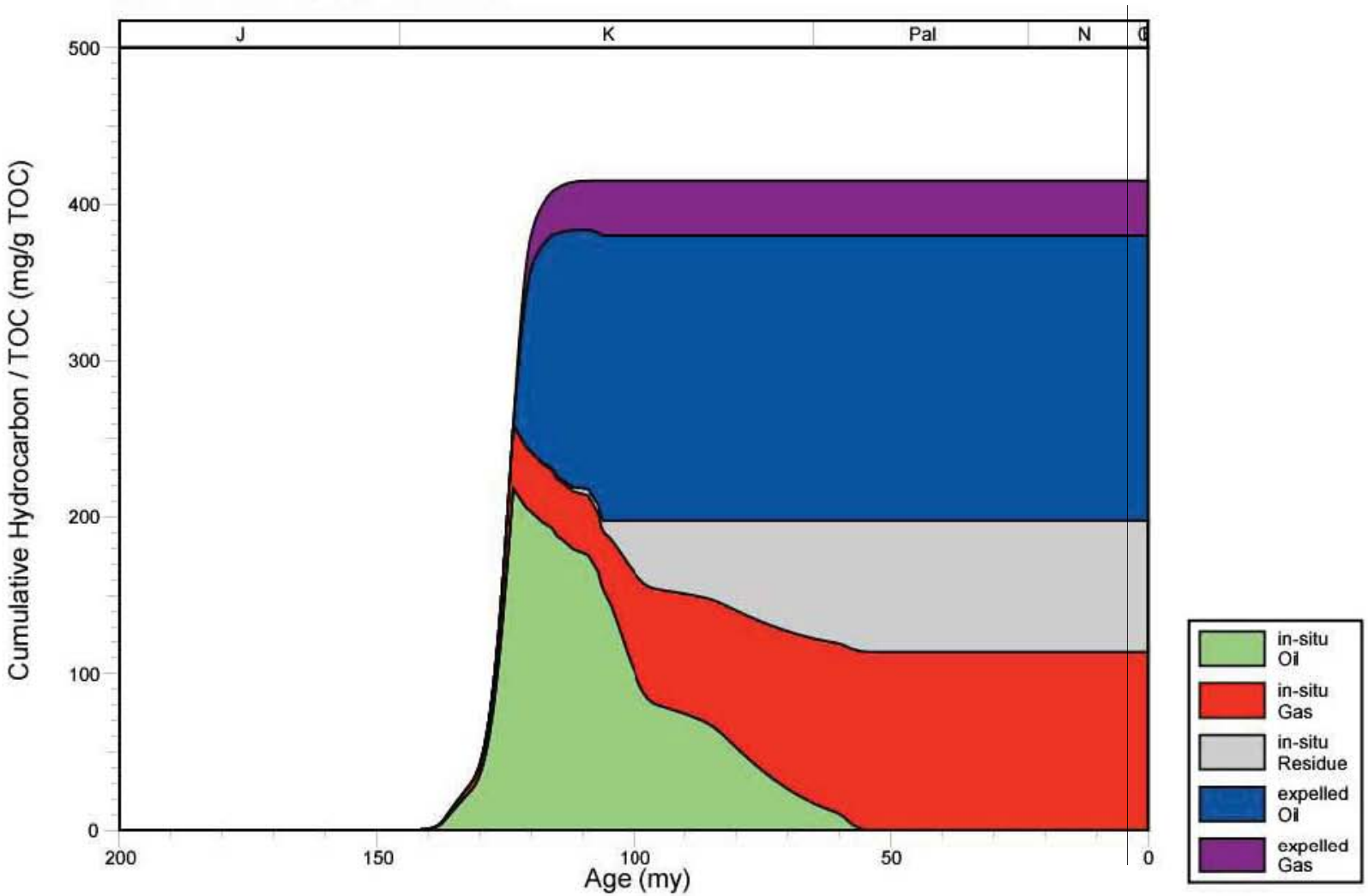


Figure 153. Hydrocarbon expulsion plot for well 1701320054, North Louisiana Salt Basin.

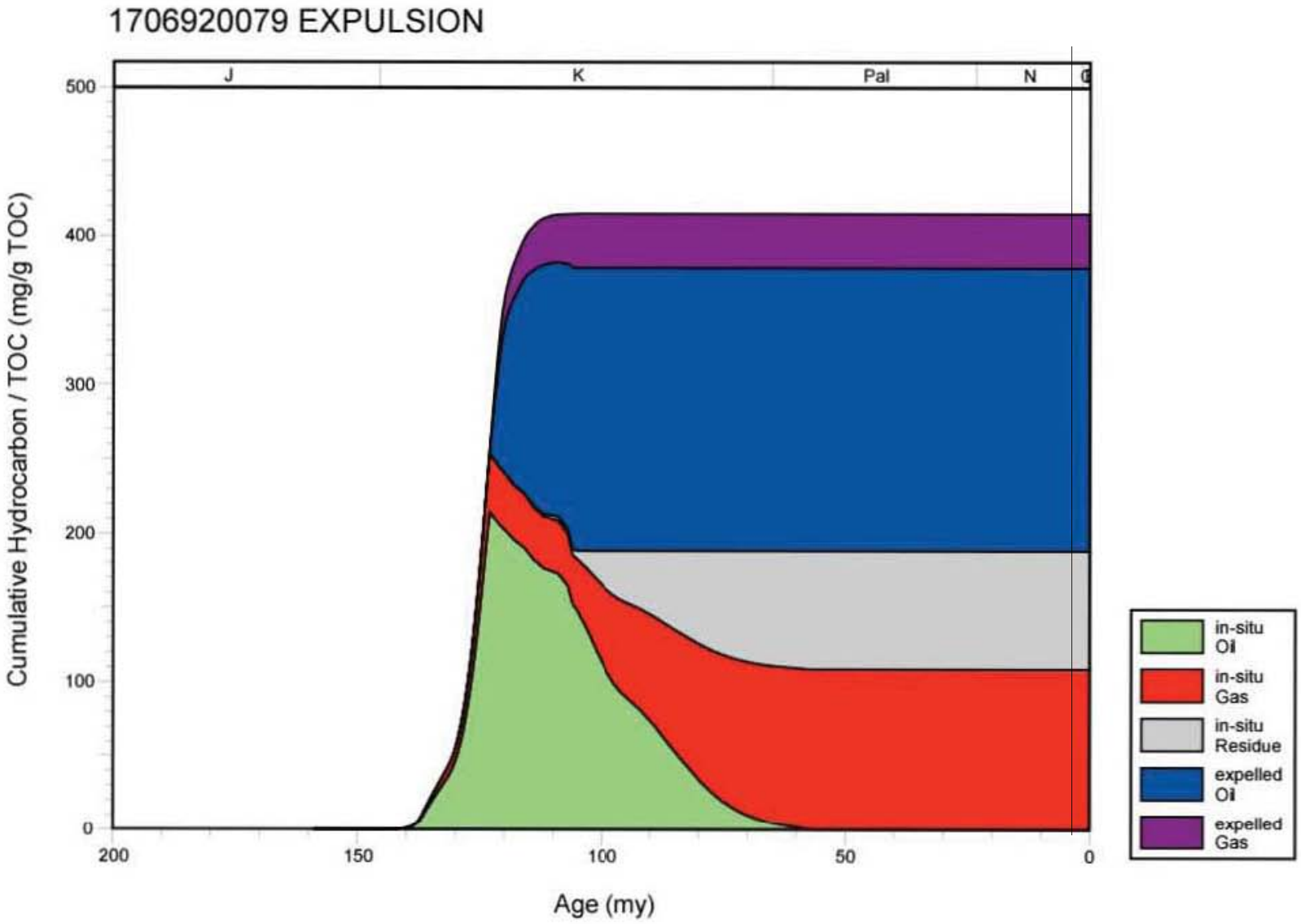


Figure 154. Hydrocarbon expulsion plot for well 1706920079, North Louisiana Salt Basin.

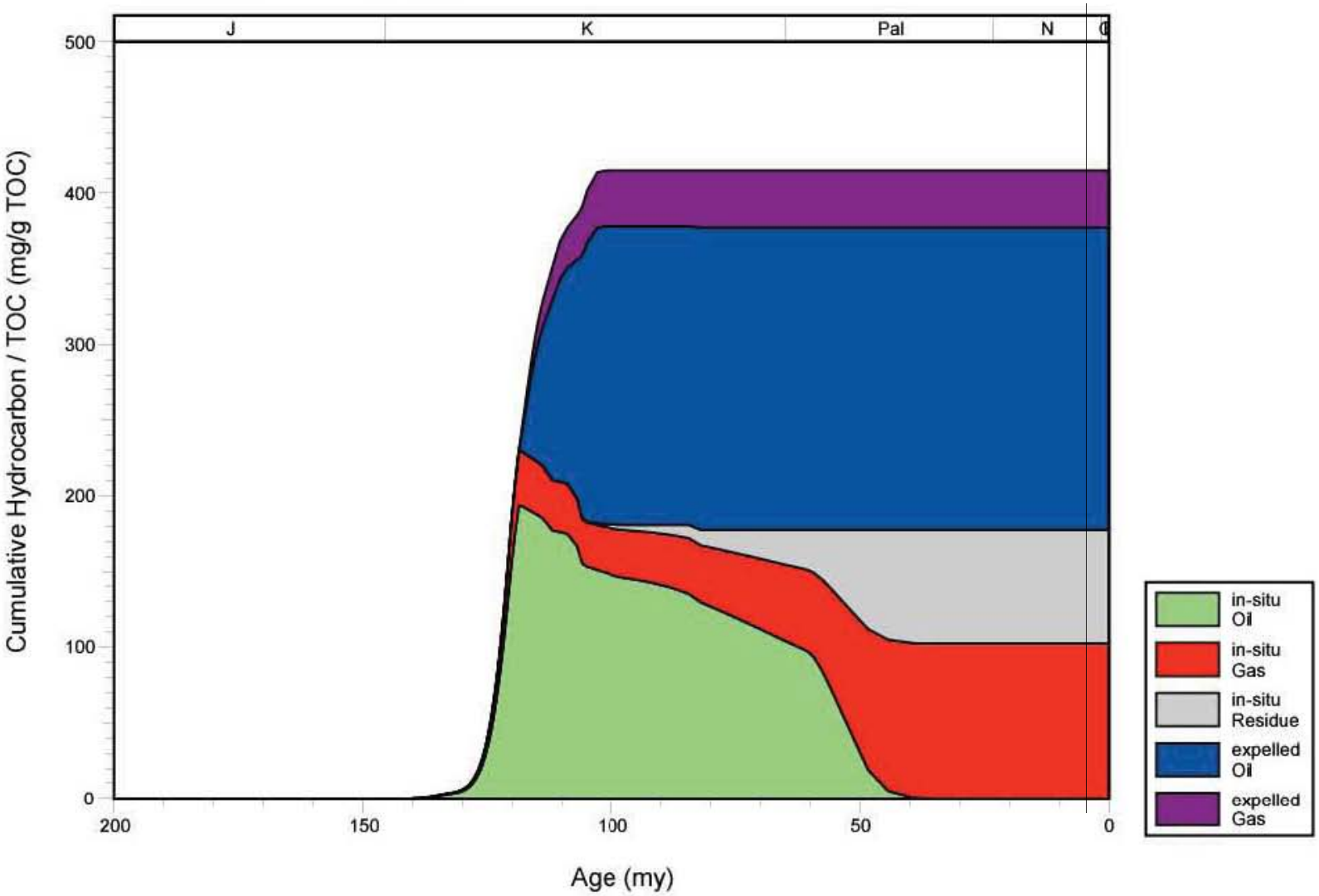


Figure 155. Hydrocarbon expulsion plot for well 1706900047, North Louisiana Salt Basin.

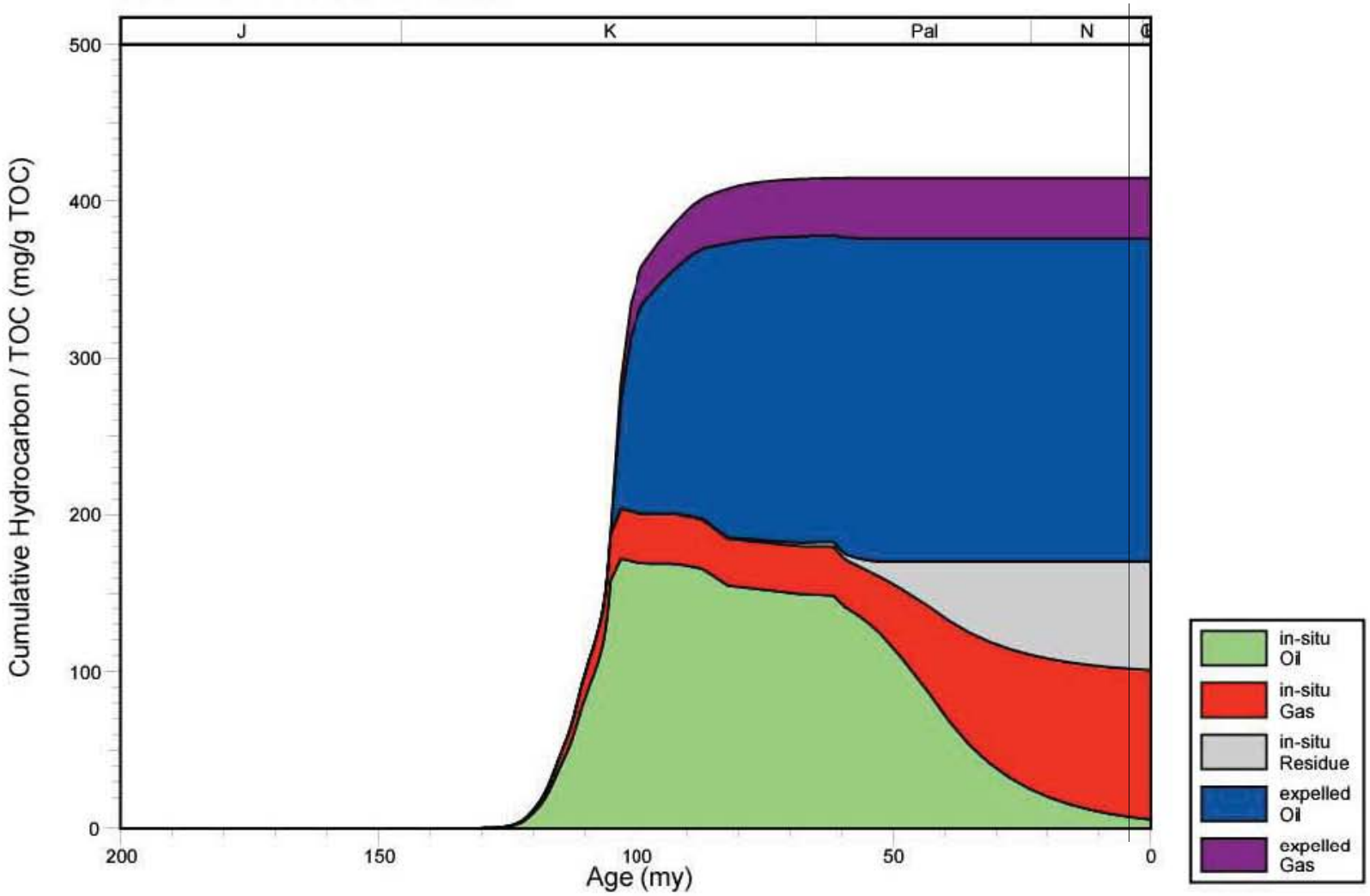


Figure 156. Hydrocarbon expulsion plot for well 1706900174, North Louisiana Salt Basin.

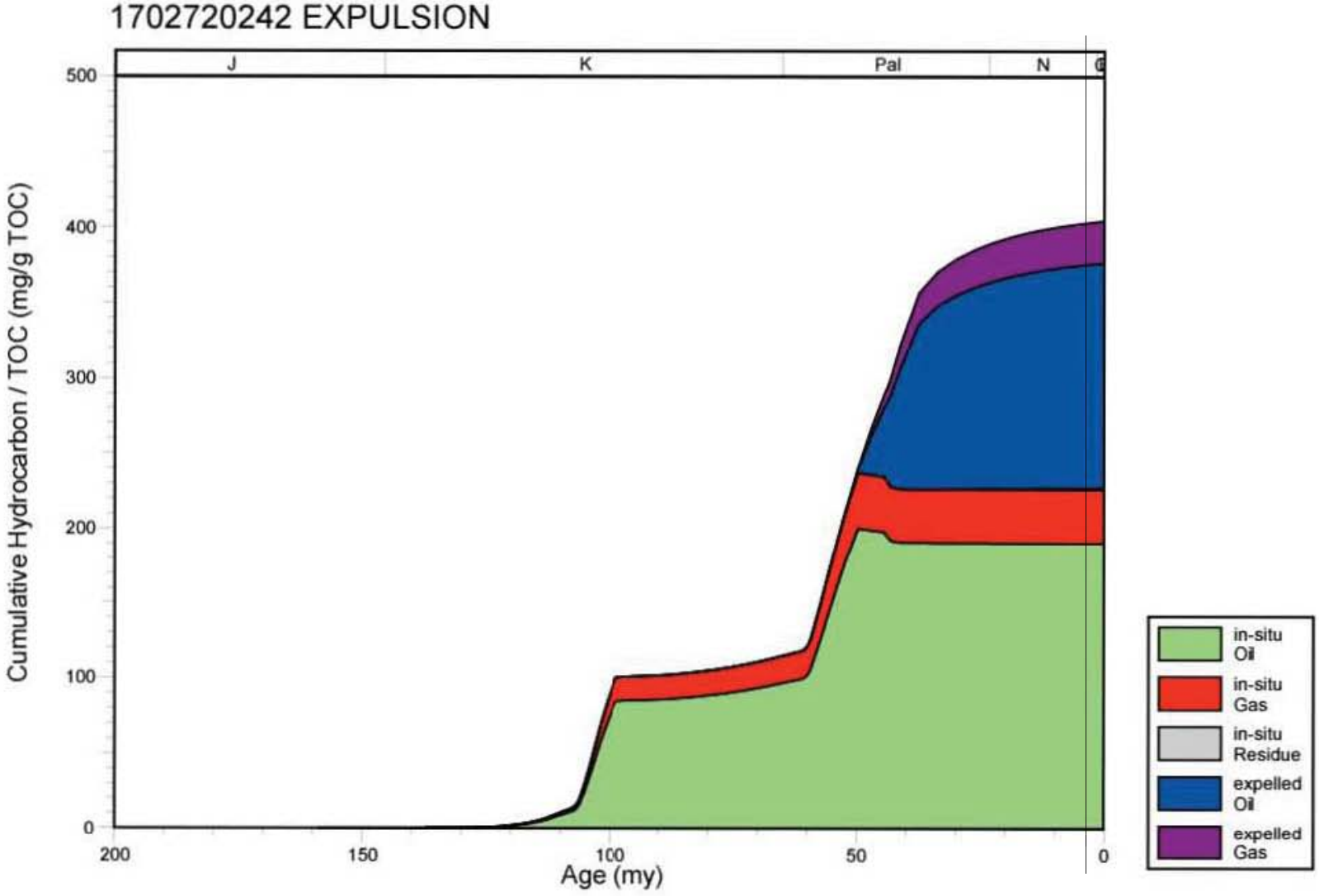


Figure 157. Hydrocarbon expulsion plot for well 1702720242, North Louisiana Salt Basin.

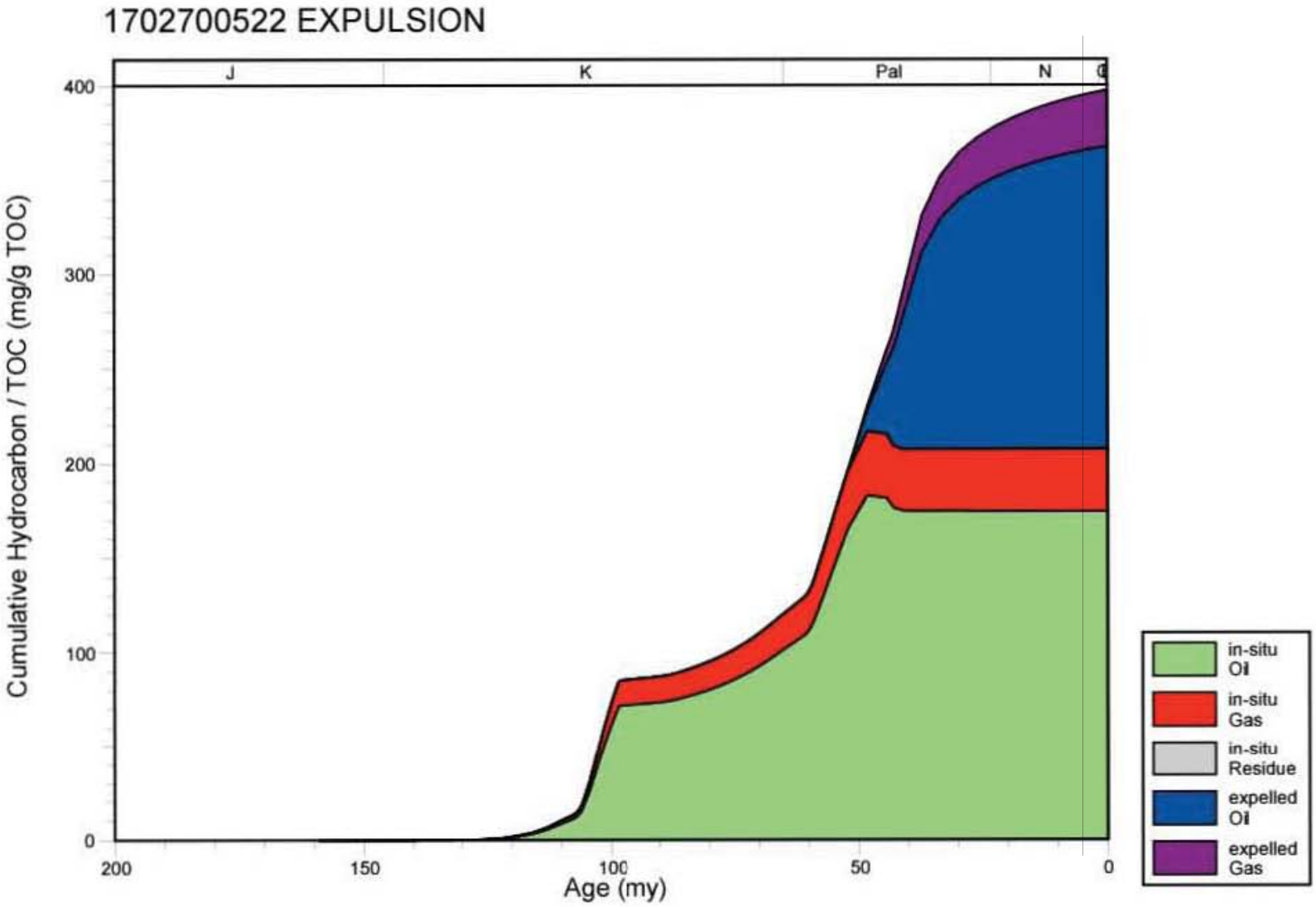


Figure 158. Hydrocarbon expulsion plot for well 1702700522, North Louisiana Salt Basin.

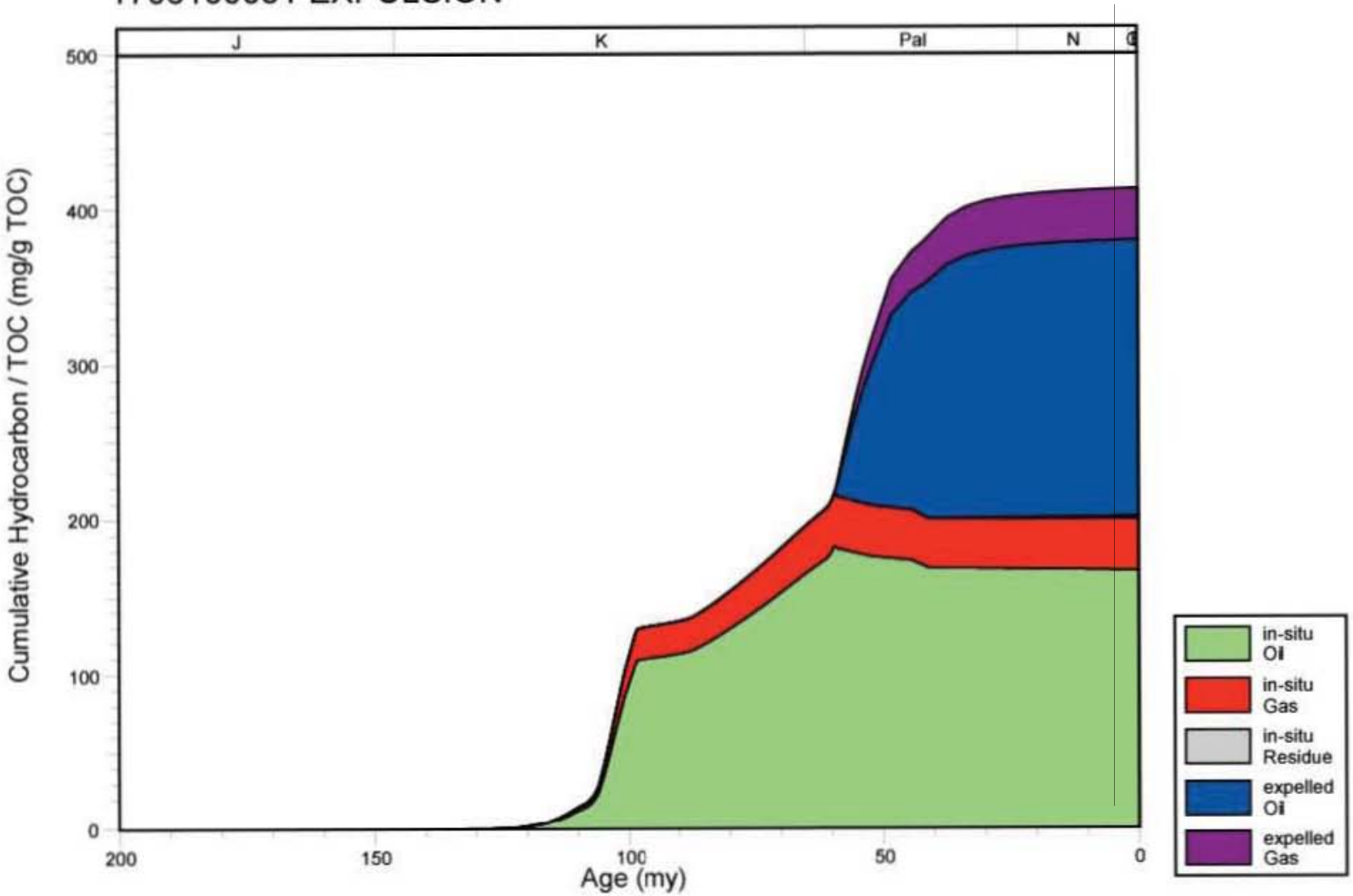


Figure 159. Hydrocarbon expulsion plot for well 1706100051, North Louisiana Salt Basin.

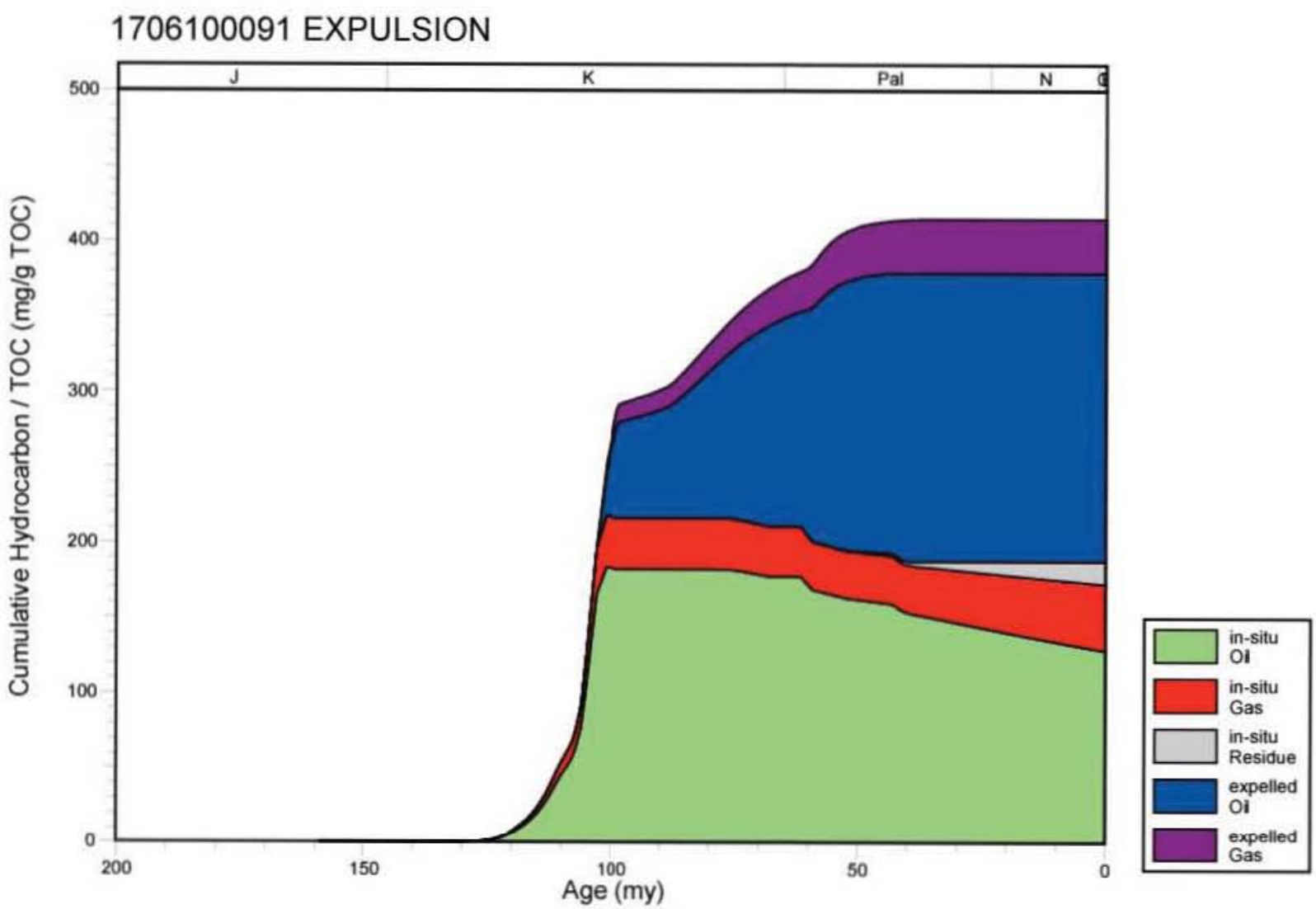


Figure 160. Hydrocarbon expulsion plot for well 1706100091, North Louisiana Salt Basin.

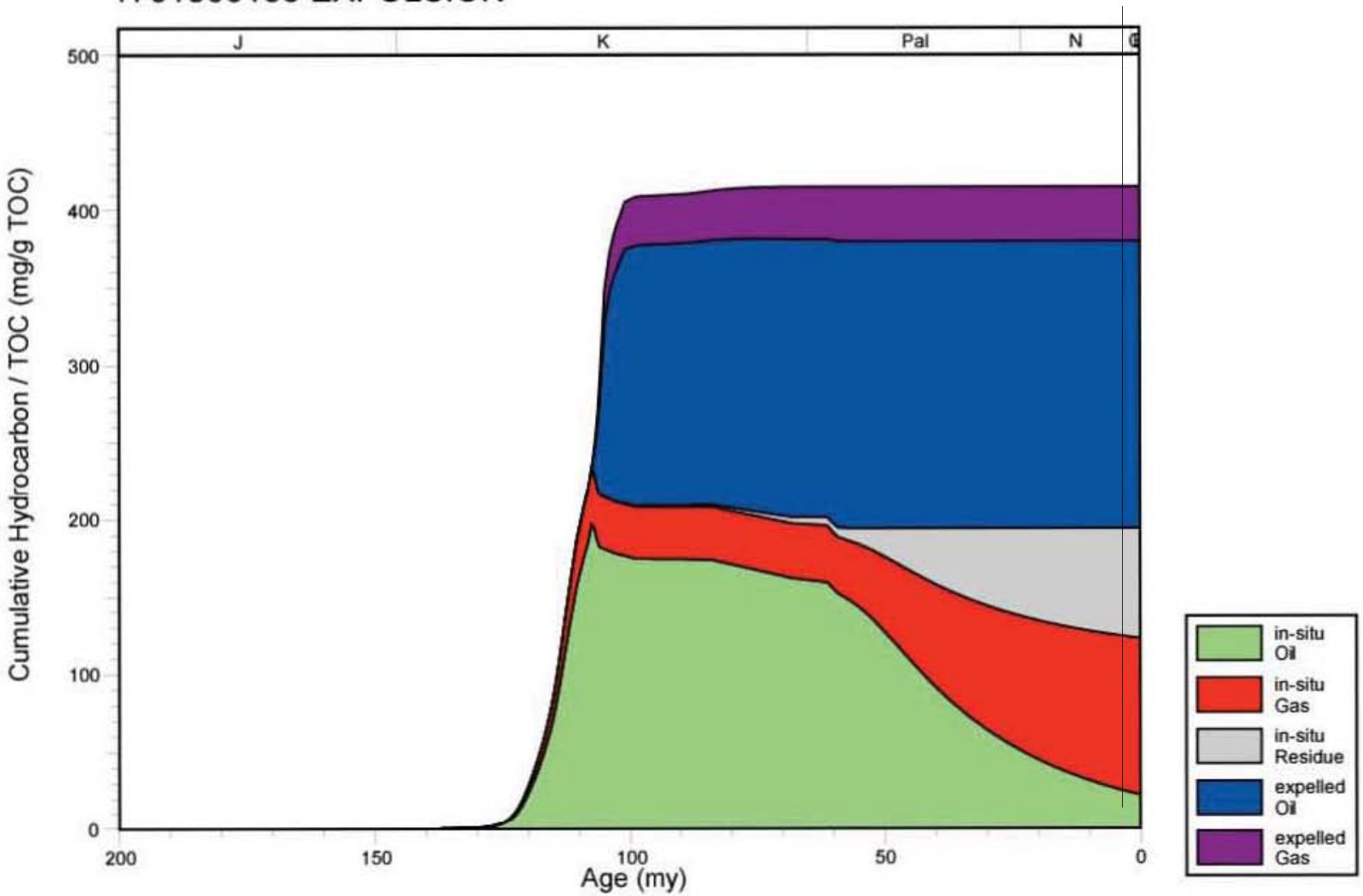


Figure 161. Hydrocarbon expulsion plot for well 1701300138, North Louisiana Salt Basin.

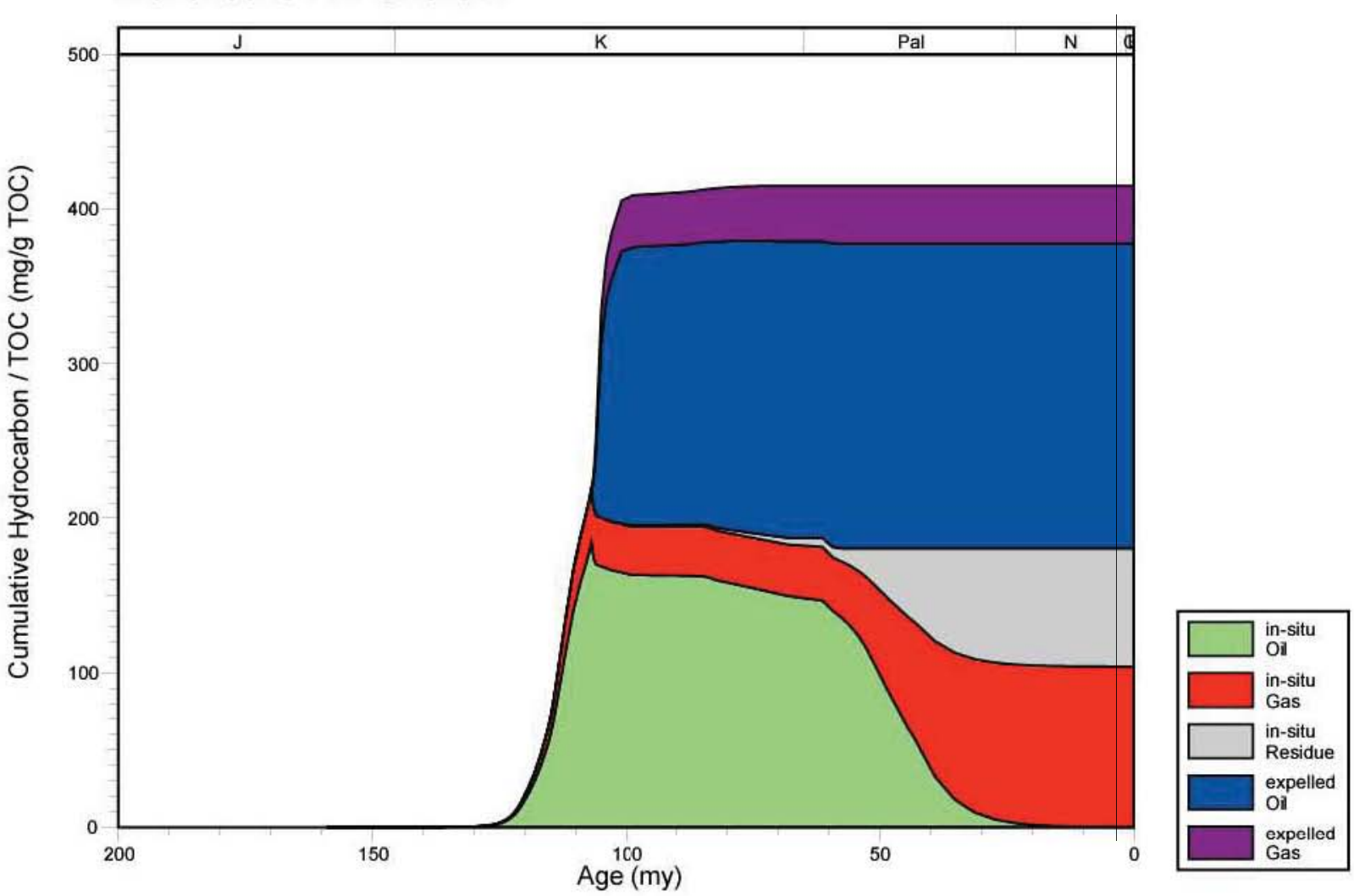


Figure 162. Hydrocarbon expulsion plot for well 1704920029, North Louisiana Salt Basin.

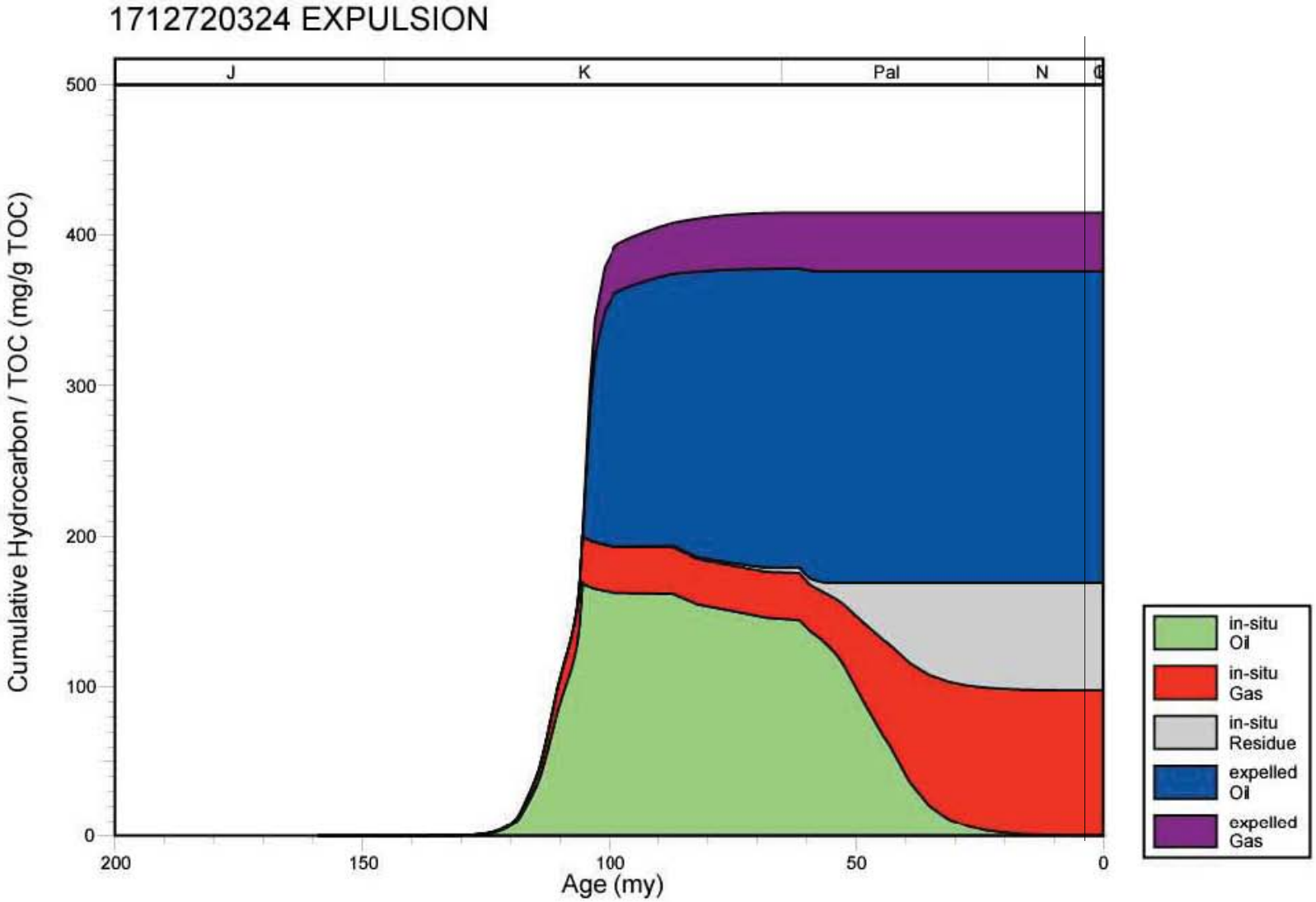


Figure 163. Hydrocarbon expulsion plot for well 1712720324, North Louisiana Salt Basin.

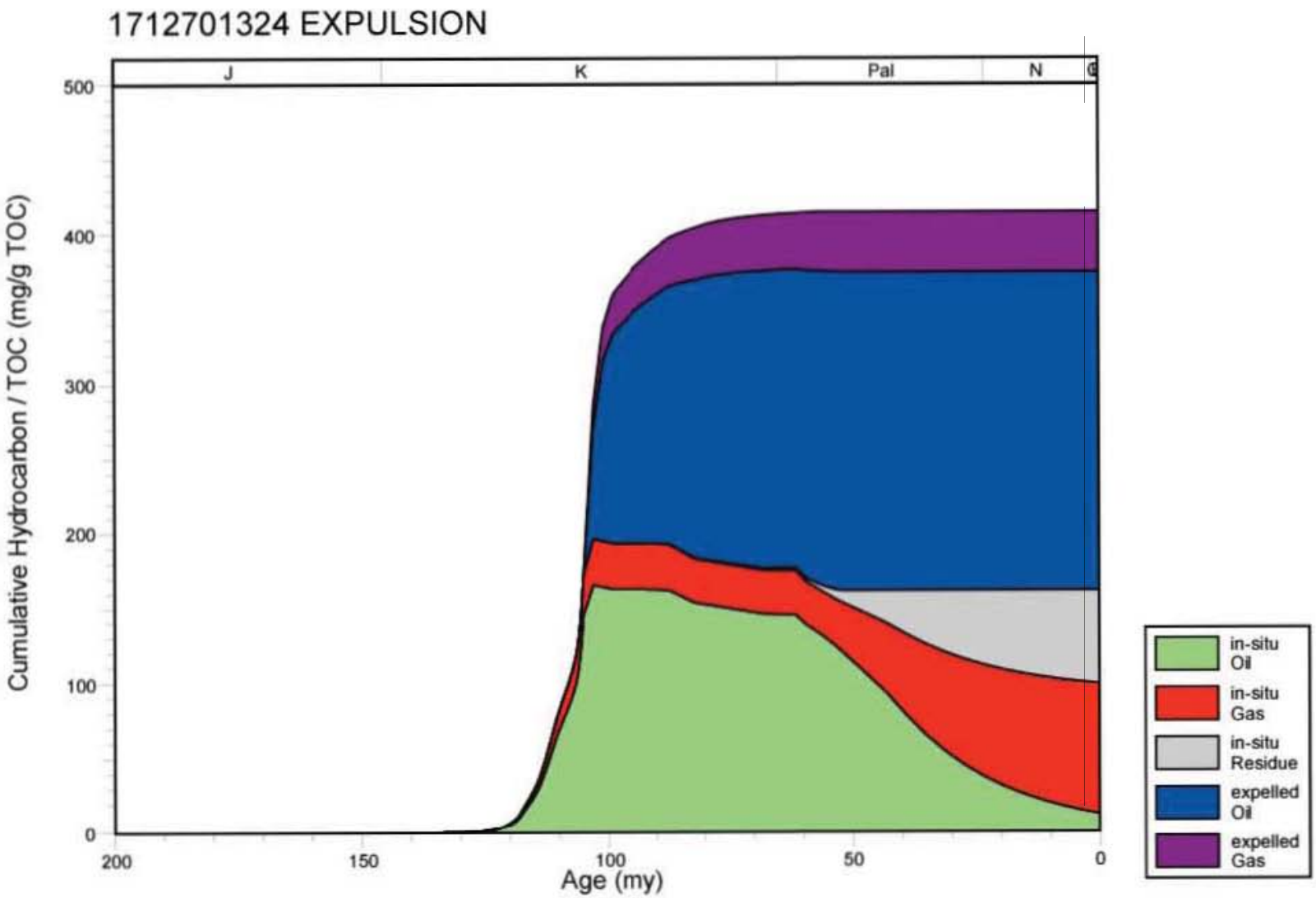


Figure 164. Hydrocarbon expulsion plot for well 1712701324. North Louisiana Salt Basin.

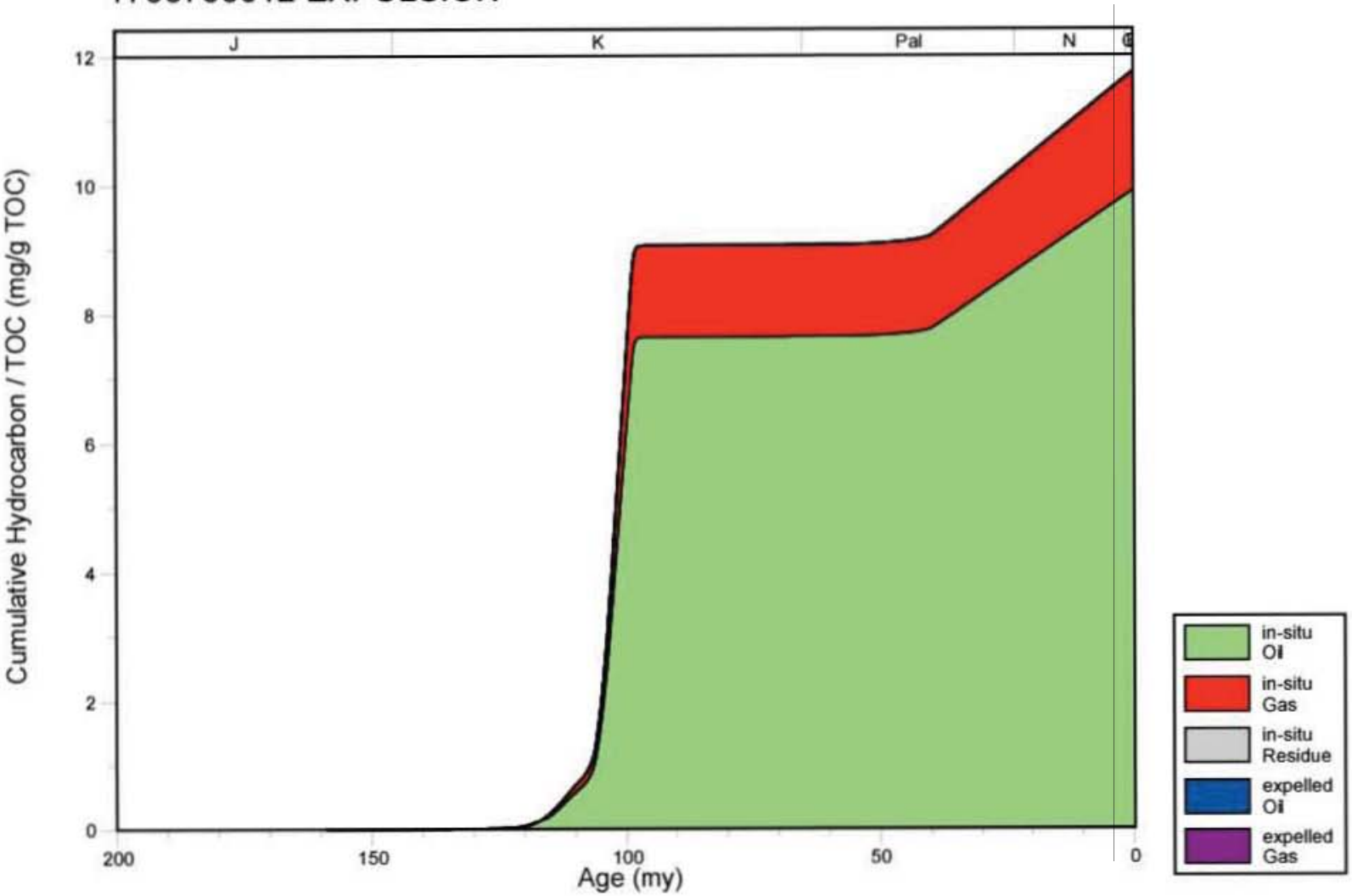


Figure 165. Hydrocarbon expulsion plot for well 1706700012, North Louisiana Salt Basin.

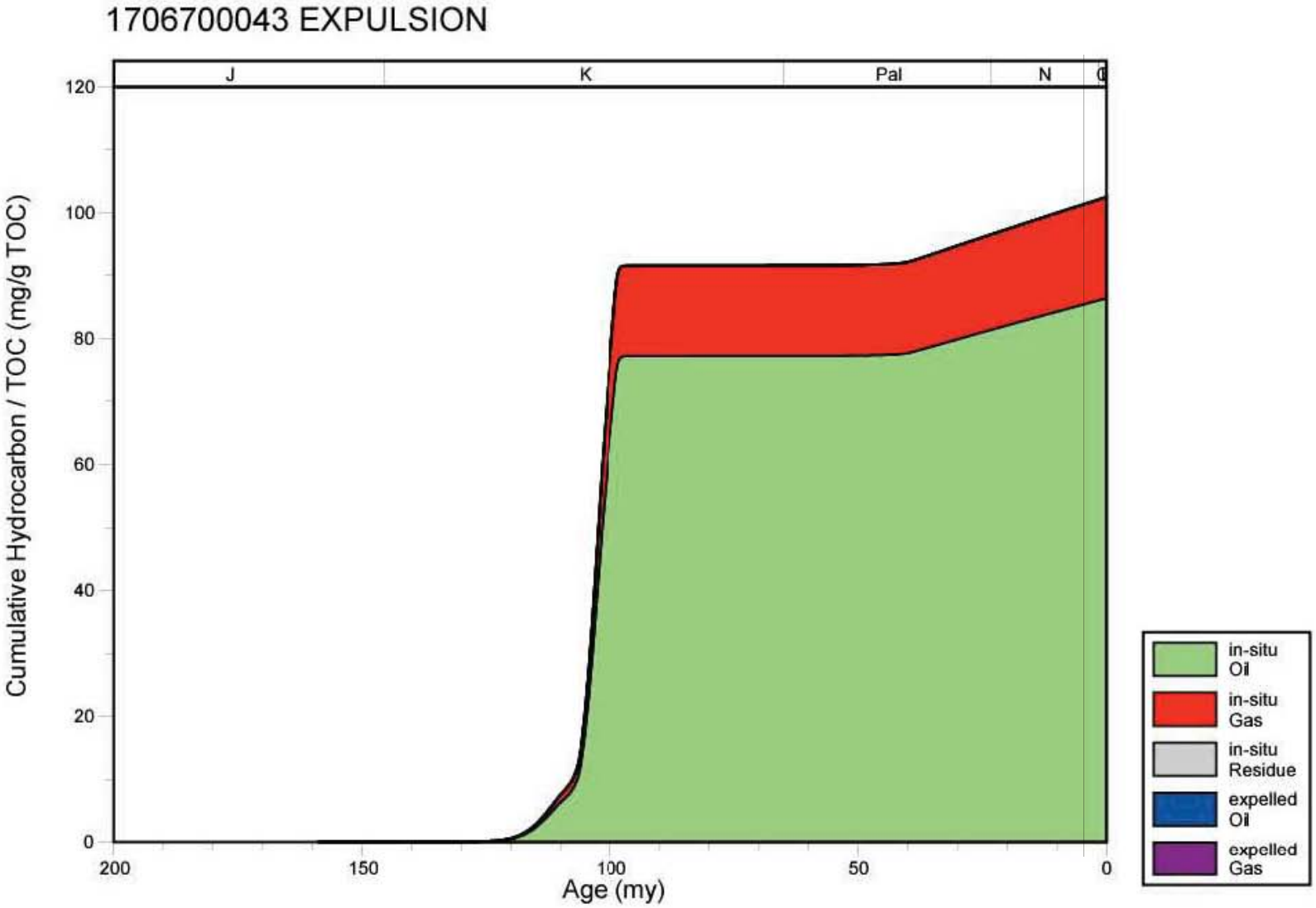


Figure 166. Hydrocarbon expulsion plot for well 1706700043, North Louisiana Salt Basin.

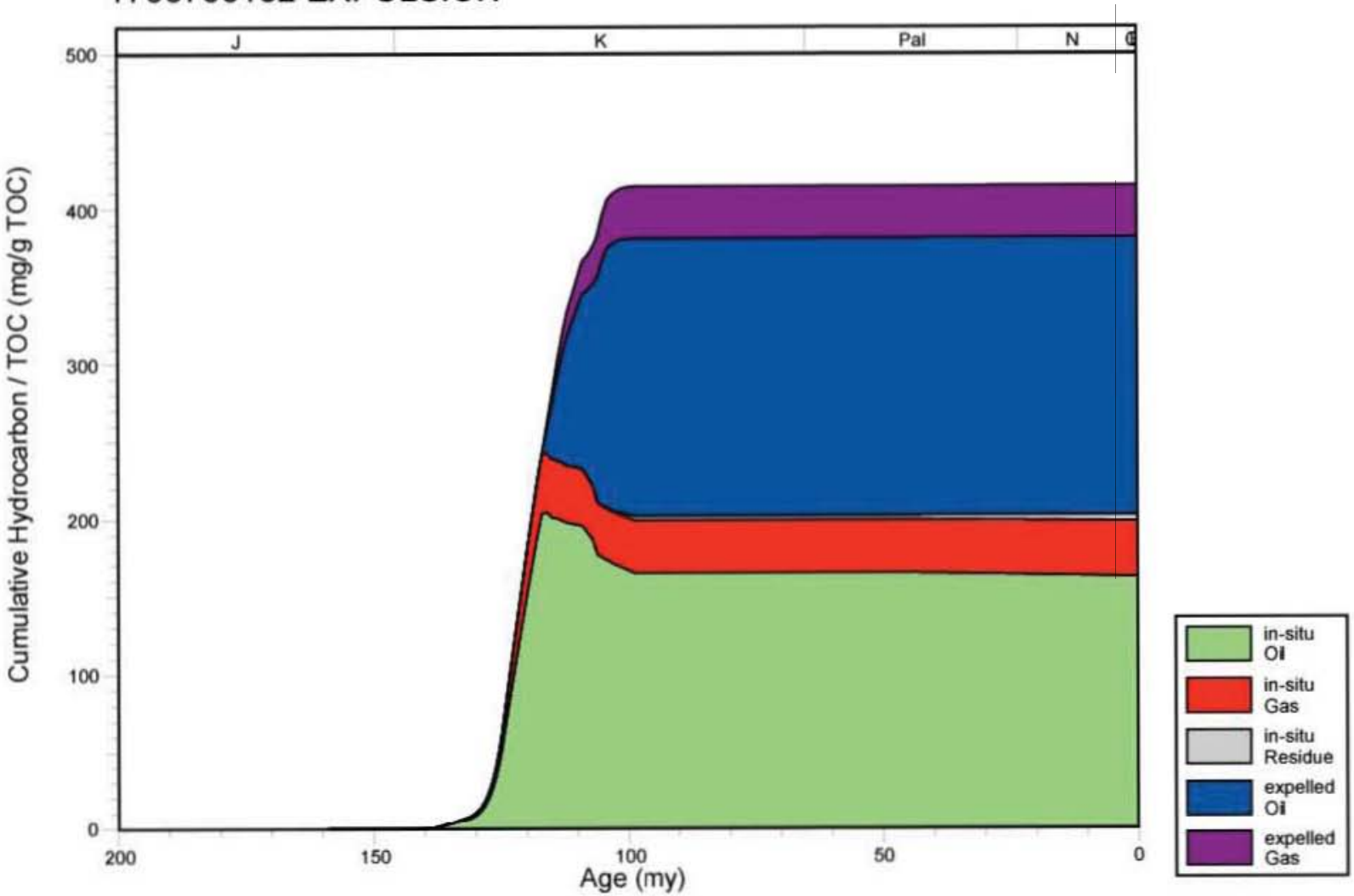


Figure 167. Hydrocarbon expulsion plot for well 1706700182, North Louisiana Salt Basin.

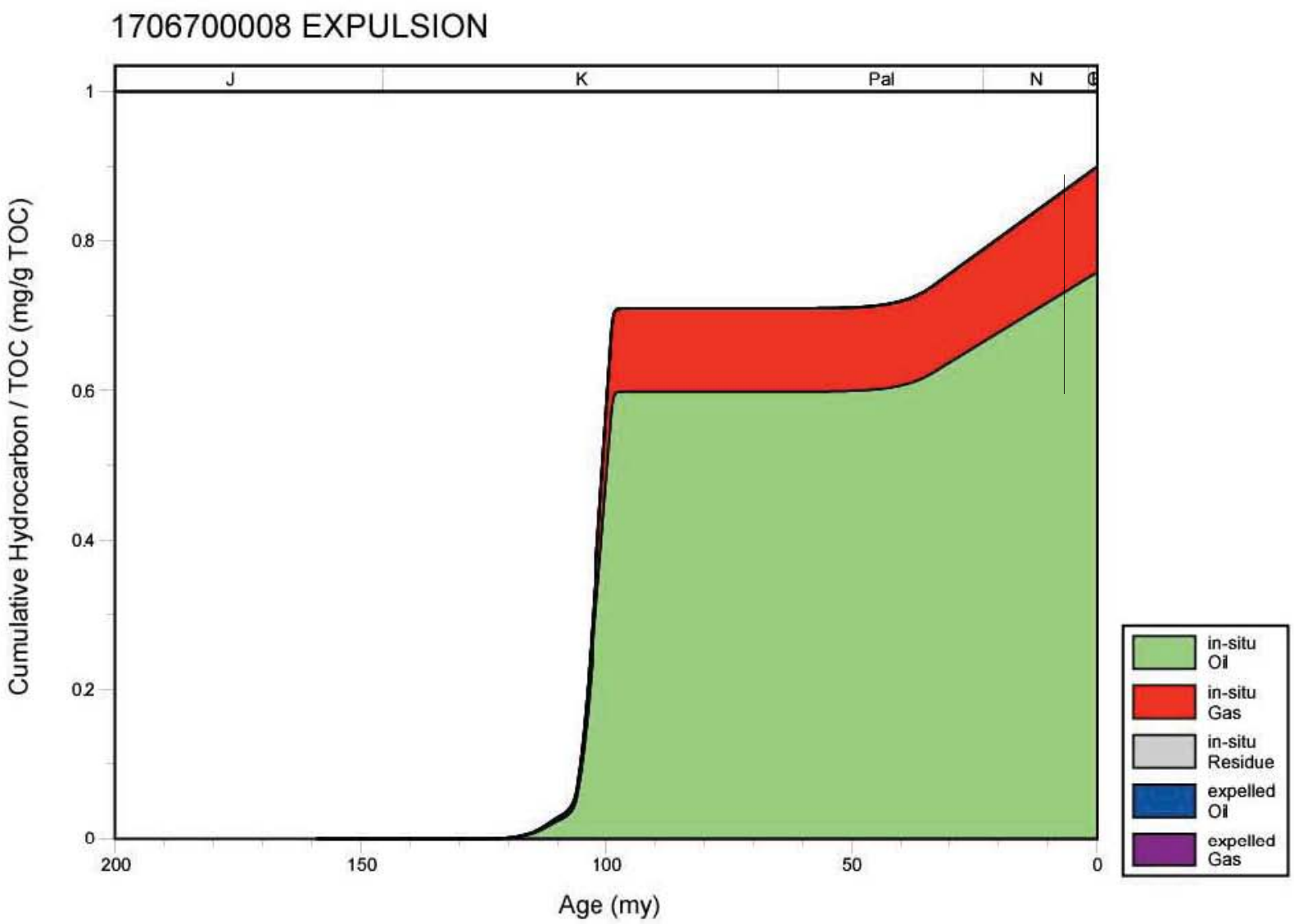


Figure 168. Hydrocarbon expulsion plot for well 1706700008, North Louisiana Salt Basin.

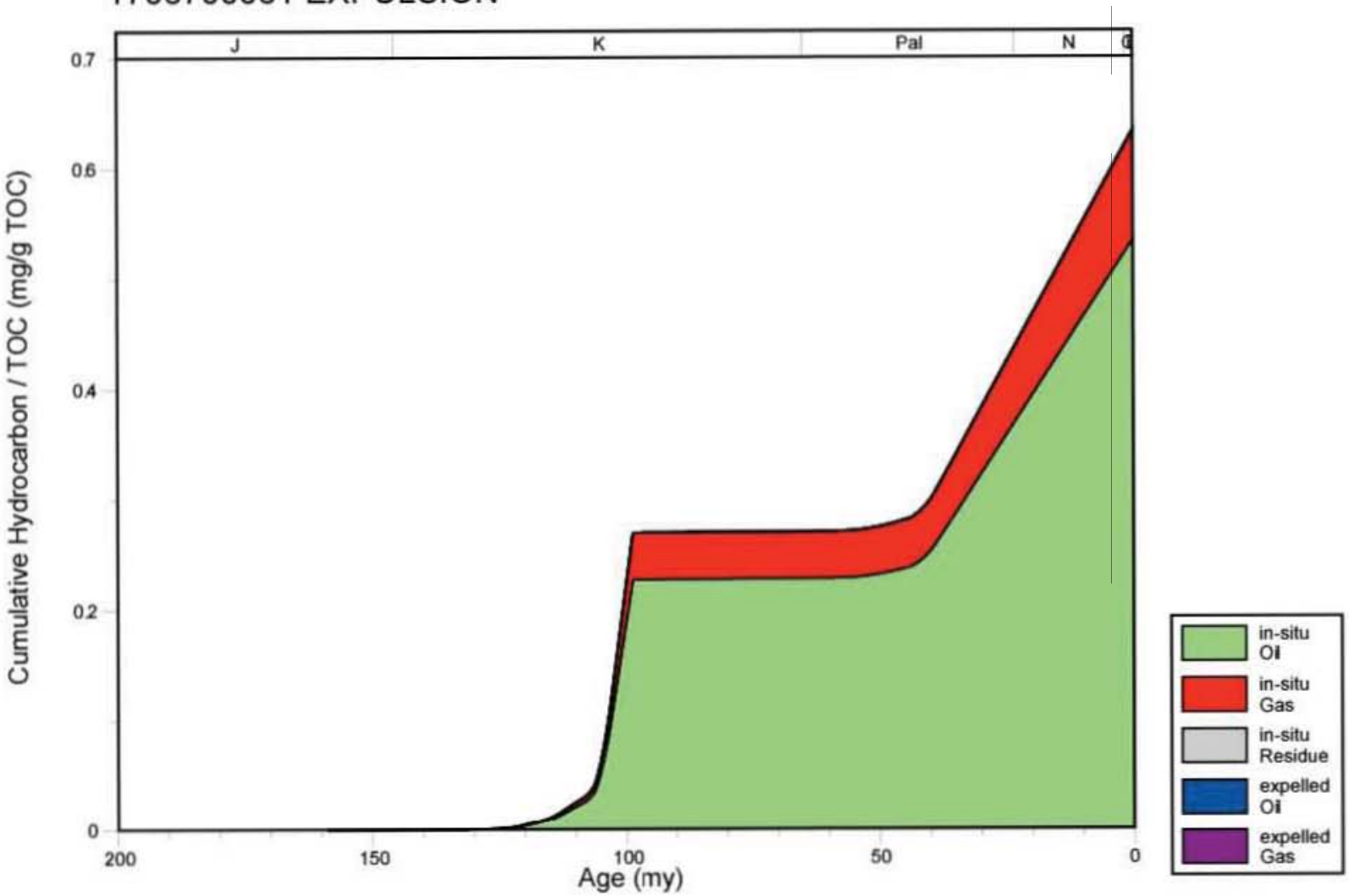


Figure 169. Hydrocarbon expulsion plot for well 1706700061, North Louisiana Salt Basin.

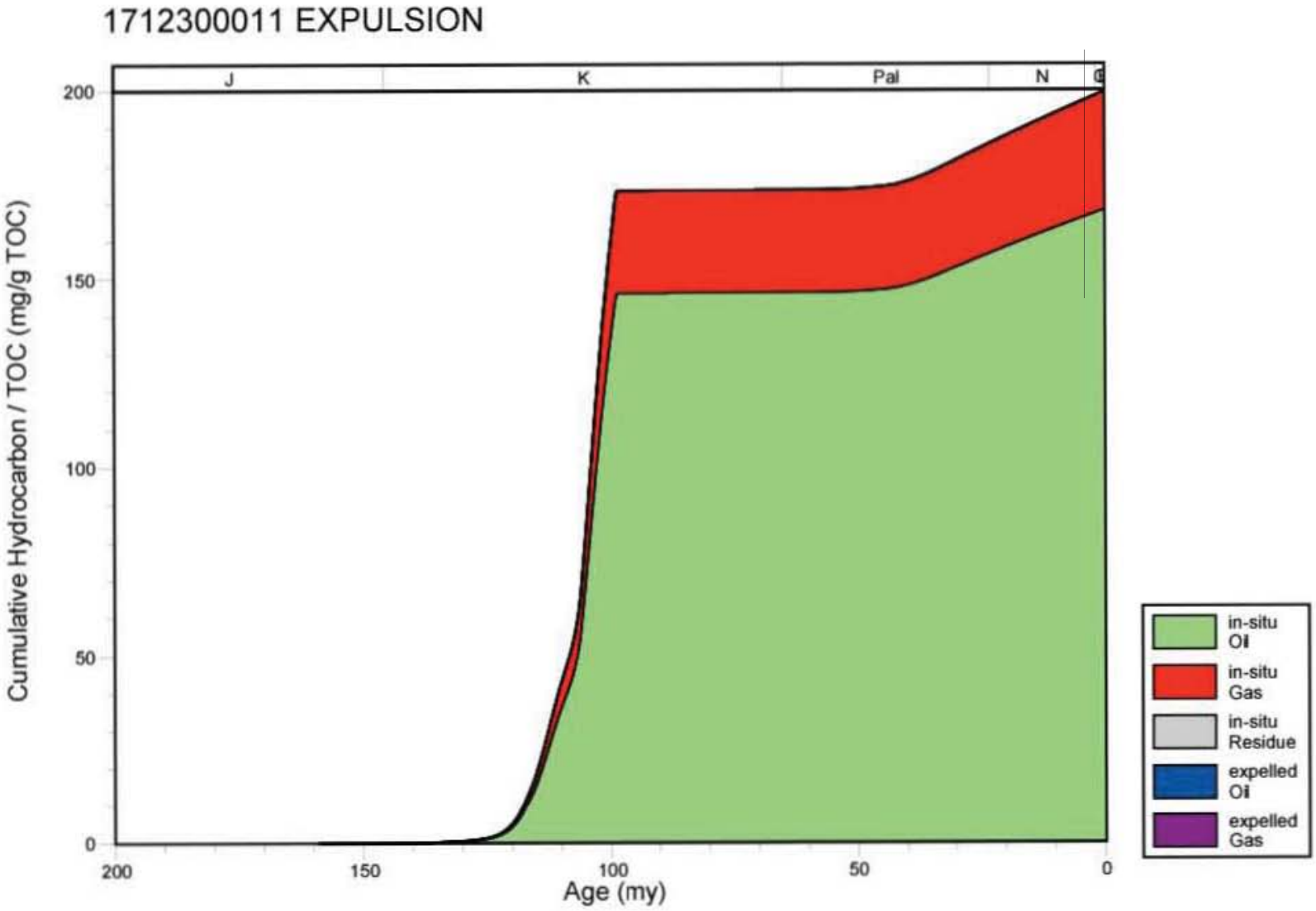


Figure 170. Hydrocarbon expulsion plot for well 1712300011, North Louisiana Salt Basin.

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