

U.S. Geological Survey Open-File Report 03-040
Figure 1

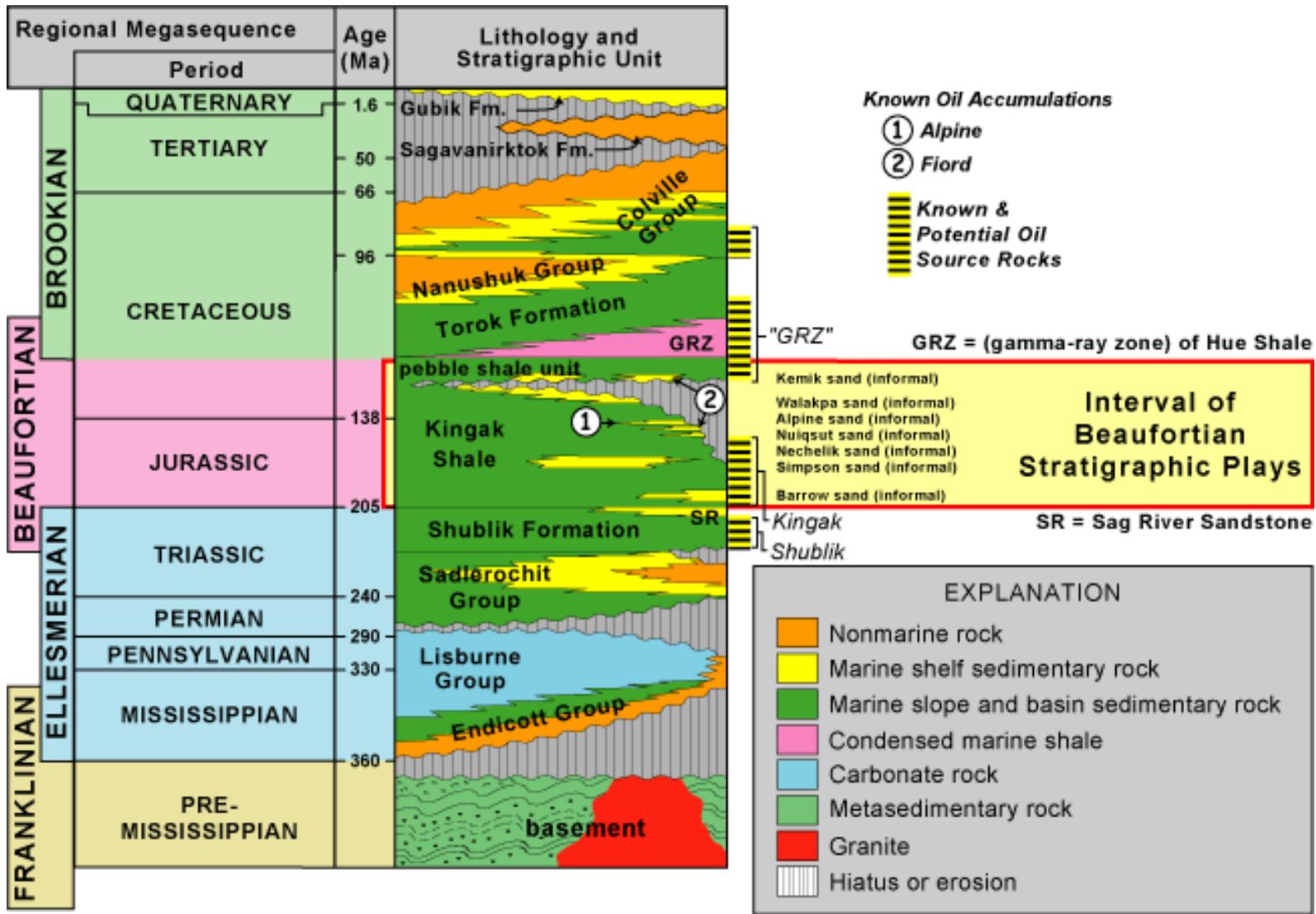


Figure 1. Generalized stratigraphy in the National Petroleum Reserve in Alaska (NPR) showing stratigraphic positions of study interval, known oil source rocks, and Alpine and Fiord oil pools.

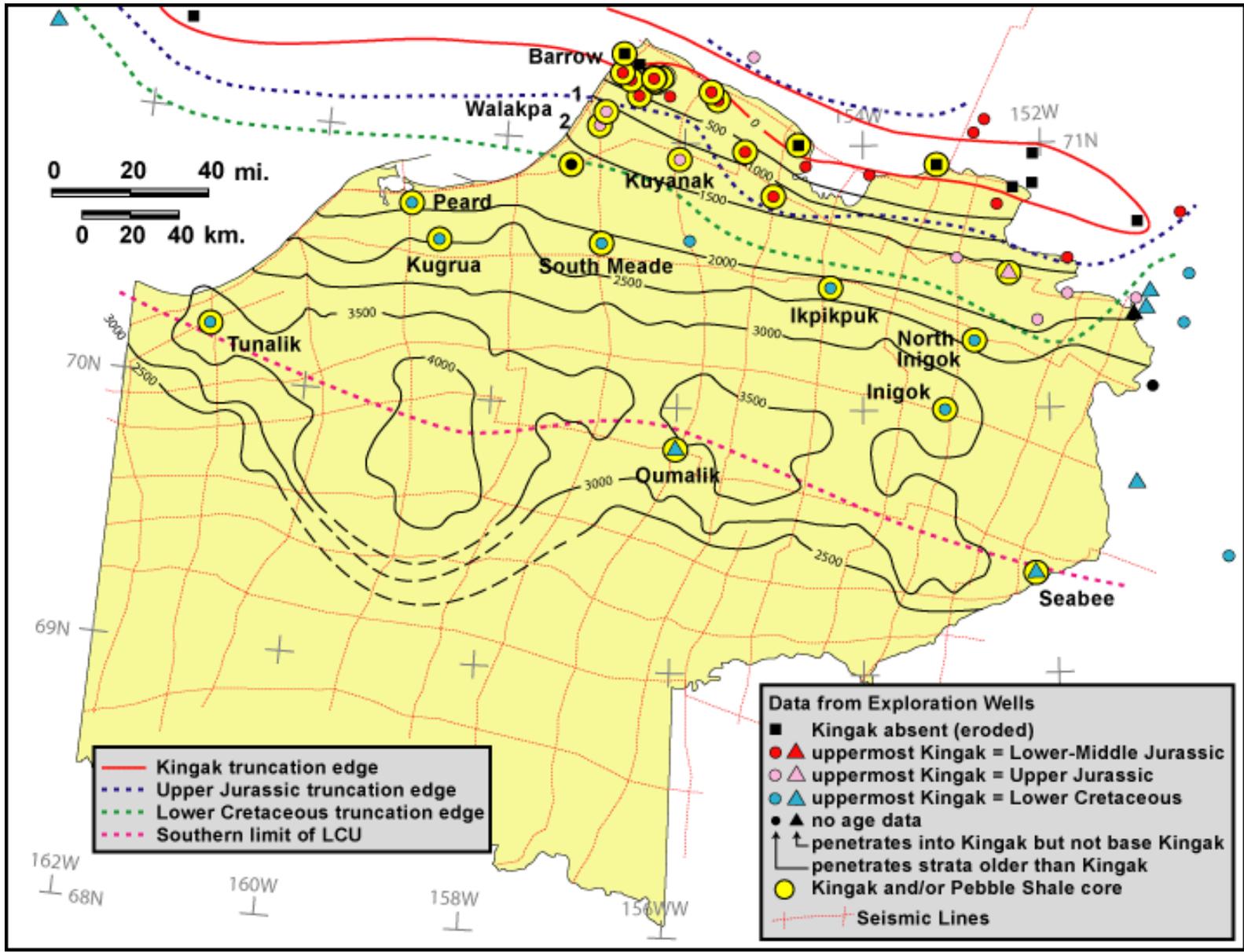


Figure 2. Map of the NPRA showing generalized total thickness of Kingak Shale (derived from depth-converted seismic data), wells that penetrate Kingak Shale with symbols indicating age of uppermost strata and core control, names of selected wells, and approximate truncation edges of chronostratigraphic intervals. Grid of 2-D seismic data interpreted as a basis for assessing the undiscovered petroleum potential of Beaufortian strata also is shown. Note that only selected wells are shown outside NPRA.

Figure 3

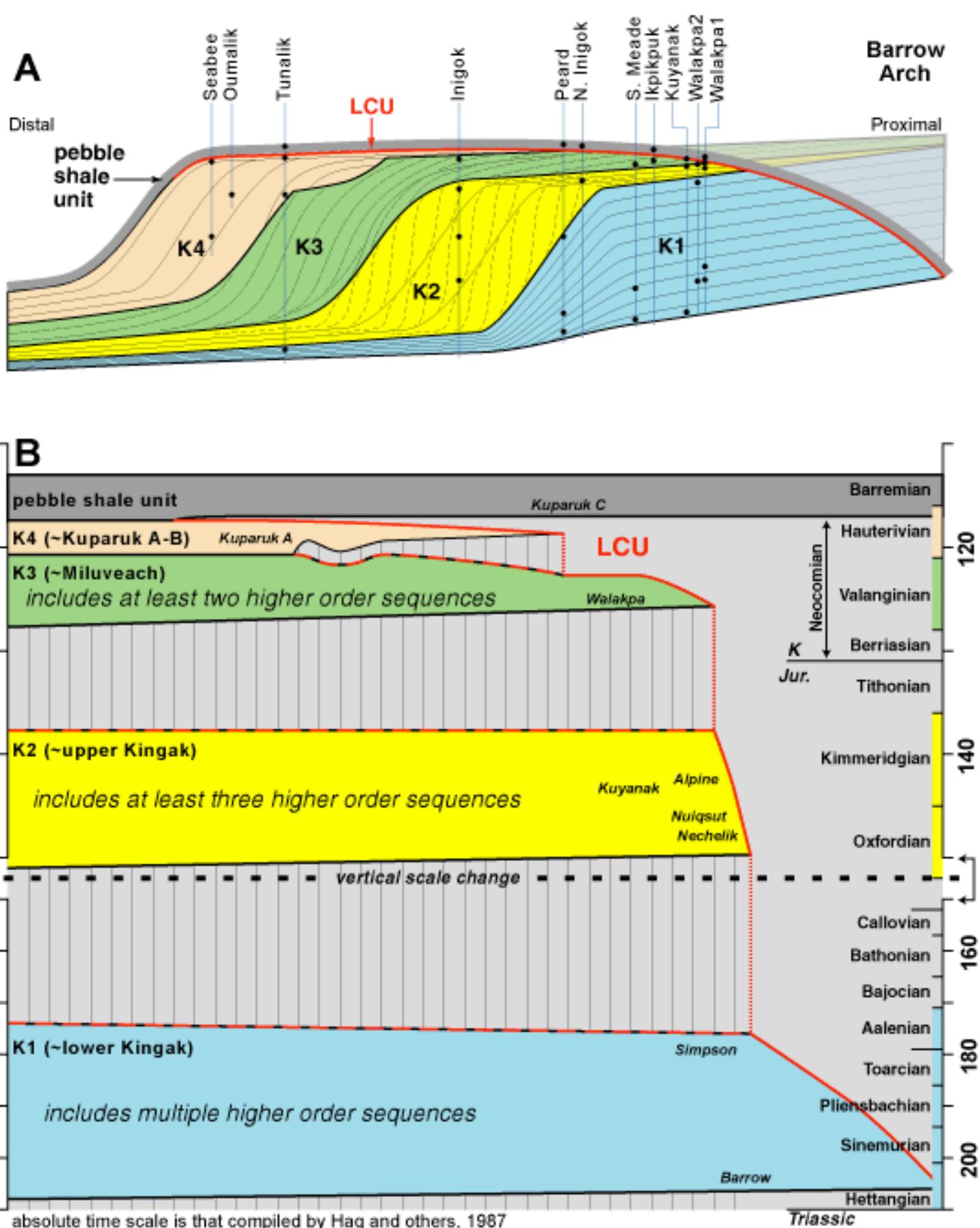


Figure 3. Schematic summary of inferred depositional sequence sets in Beaufortian strata of NPRA. *A.* Proximal (~north) to distal (~south) cross section schematically illustrating stratigraphic relationships among four Beaufortian depositional sequence sets, showing general aspects of internal stratal geometry. Note that LCU bevels Beaufortian strata northward to a zero edge on the Barrow Arch. Selected wells are shown in positions relative to locations where they penetrate Beaufortian sequence sets, and dots on wells represent approximate stratigraphic positions of cores used in this study.

B. Chronostratigraphic depiction of Beaufortian sequence sets. Shown in parentheses are stratigraphic names widely applied to strata that are approximate age-equivalents of the four Beaufortian sequence sets. Names in italics show approximate positions of sandstones known to be reservoirs in some cases. Vertical lines denote time gaps between Beaufortian sequence sets. Note scale change near center of diagram. Time scale is that compiled by Haq and others (1988).

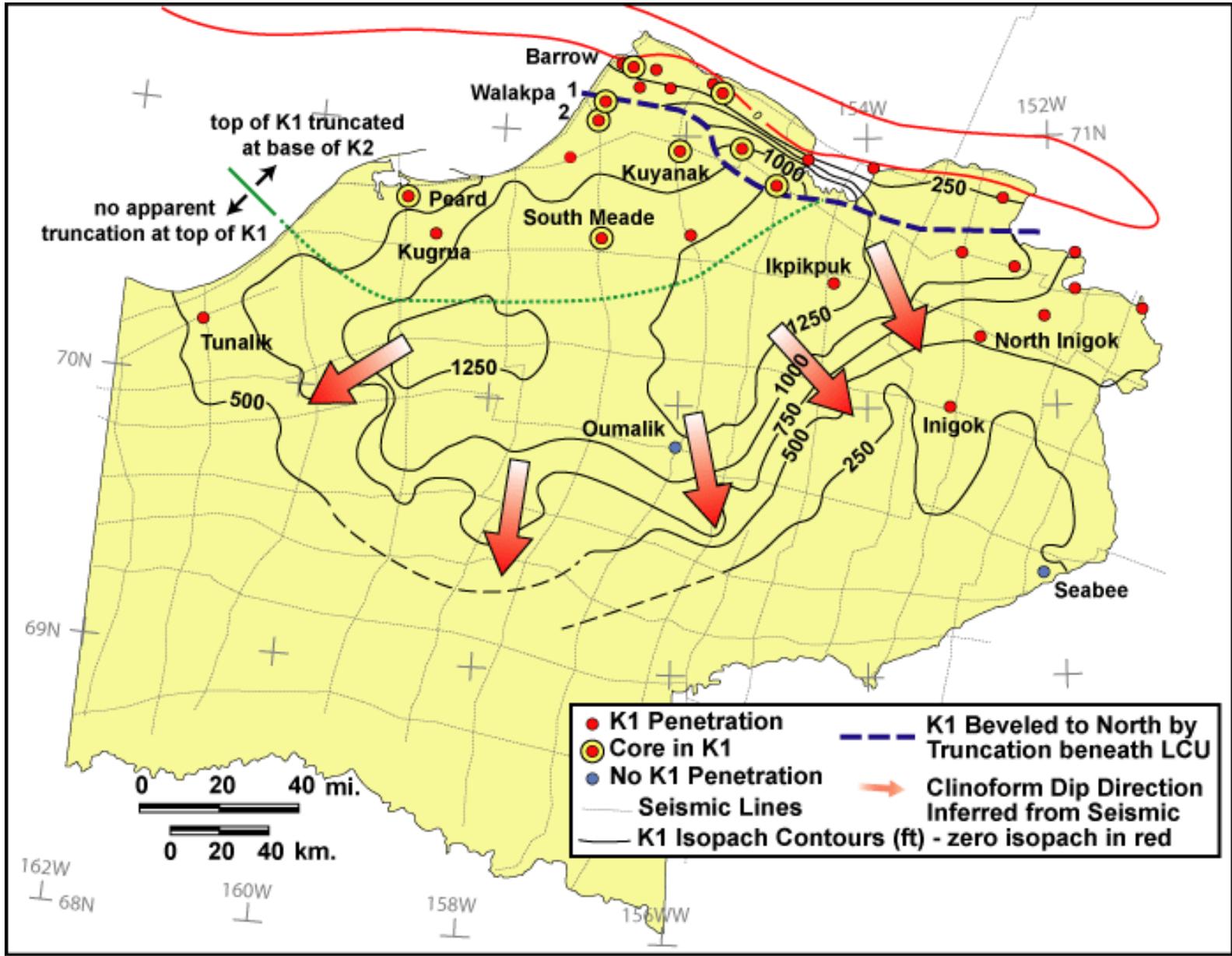


Figure 4A. Map of the NPRA showing generalized thickness (in feet) of Beaufortian sequence set K1, public domain seismic grid used to map sequence sets, well penetrations of K1, and wells with public domain cores in K1. Arrows indicate dip directions of K1 clinoforms, with base and tip of each arrow showing approximate updip (proximal) and downdip (distal) extent of clinoforms.

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 Figure 4B

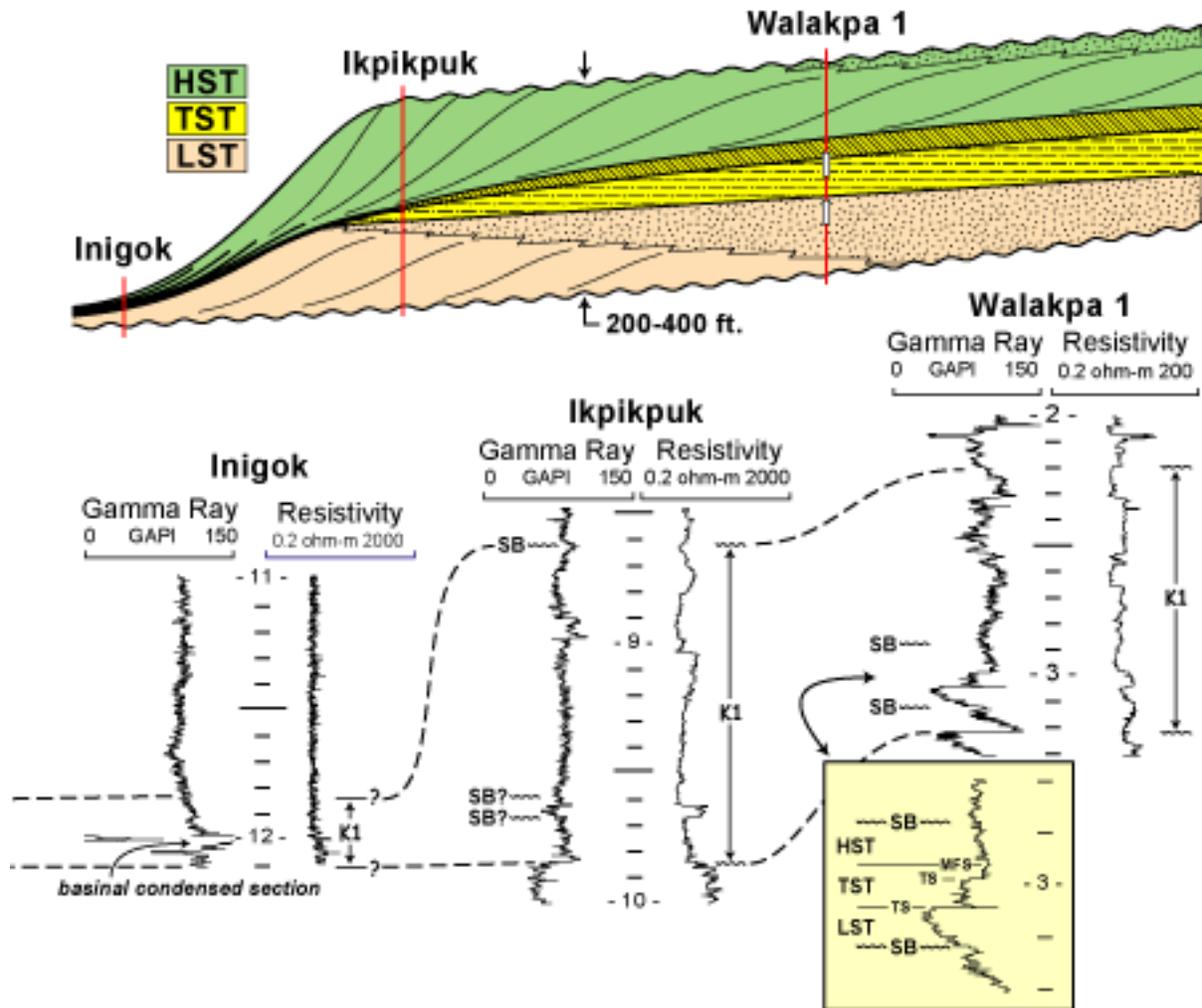


Figure 4B. Schematic illustration of an idealized depositional sequence within K1 and wireline logs from wells inferred to penetrate various locations within K1 sequence set. Wireline log depth ticks are at 100 ft. intervals and numbers are 1000's ft. Note log response of basinal condensed section in Inigok well log. HST, highstand systems tract; TST, transgressive systems tract; LST, lowstand systems tract, SB, sequence boundary; SB?, candidate sequence boundary; MFS, maximum flooding surface; TS, transgressive surface.

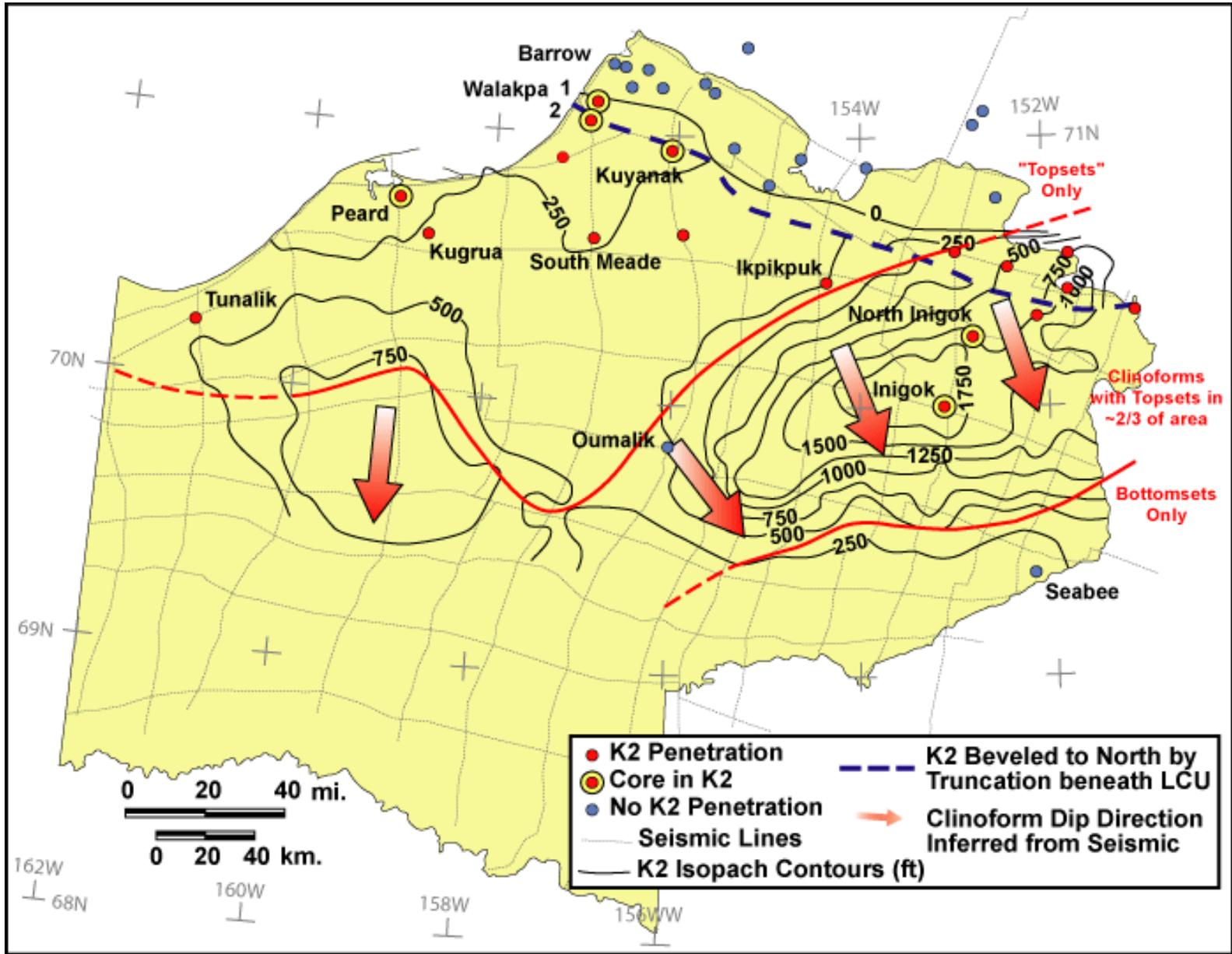


Figure 5A. Map of the NPRA showing generalized thickness (in feet) of Beaufortian sequence set K2, public domain seismic grid used to map sequence sets, well penetrations of K2, and wells with public domain cores in K2. Arrows indicate dip directions of K2 clinoforms, with base and tip of each arrow showing approximate updip (proximal) and downdip (distal) extent of clinoforms. Red lines delineate a northern area where K2 sequence set comprises exclusively topset seismic facies (north), a central area where K2 sequence set comprises clinoforms with topsets in the northern 2/3 of area, and a southern area where K2 sequence set comprises exclusively bottomset seismic facies.

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 Figure 5B

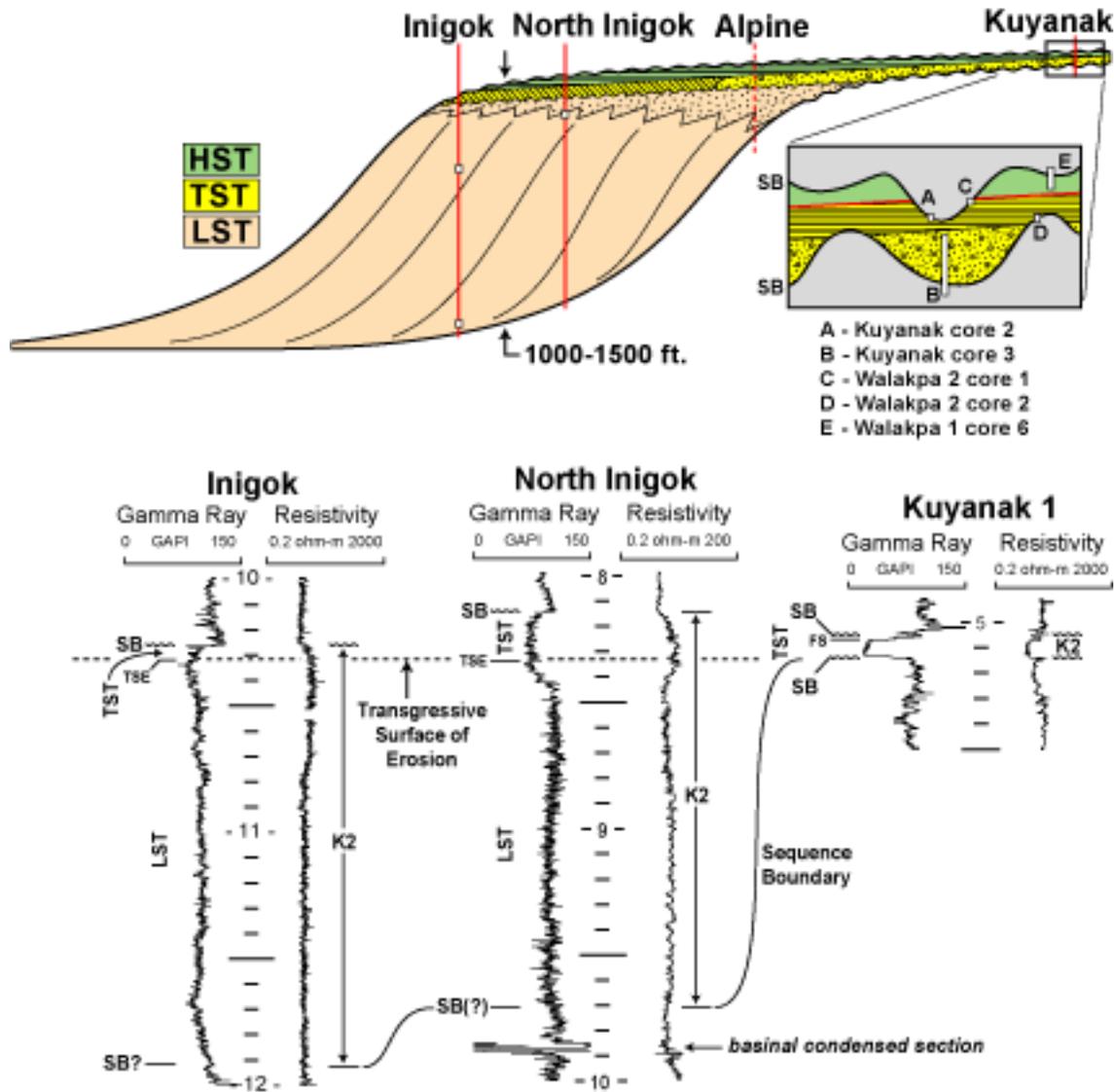


Figure 5B. Schematic illustration of an idealized depositional sequence within K2 and wireline logs from wells inferred to penetrate various locations within K2 sequence set. Dashed line labeled Alpine shows inferred position of “Alpine interval” within idealized depositional sequence in Alpine oil field (see Fig. 13). Wireline log depth ticks are at 100 ft. intervals and numbers are 1000’s ft. Note log response of basinal condensed section in sequence set K1 in Inigok well log. Abbreviations are the same as in Fig. 4b, plus TSE, transgressive surface of erosion (ravinement); FS, flooding surface.

Figure 6A

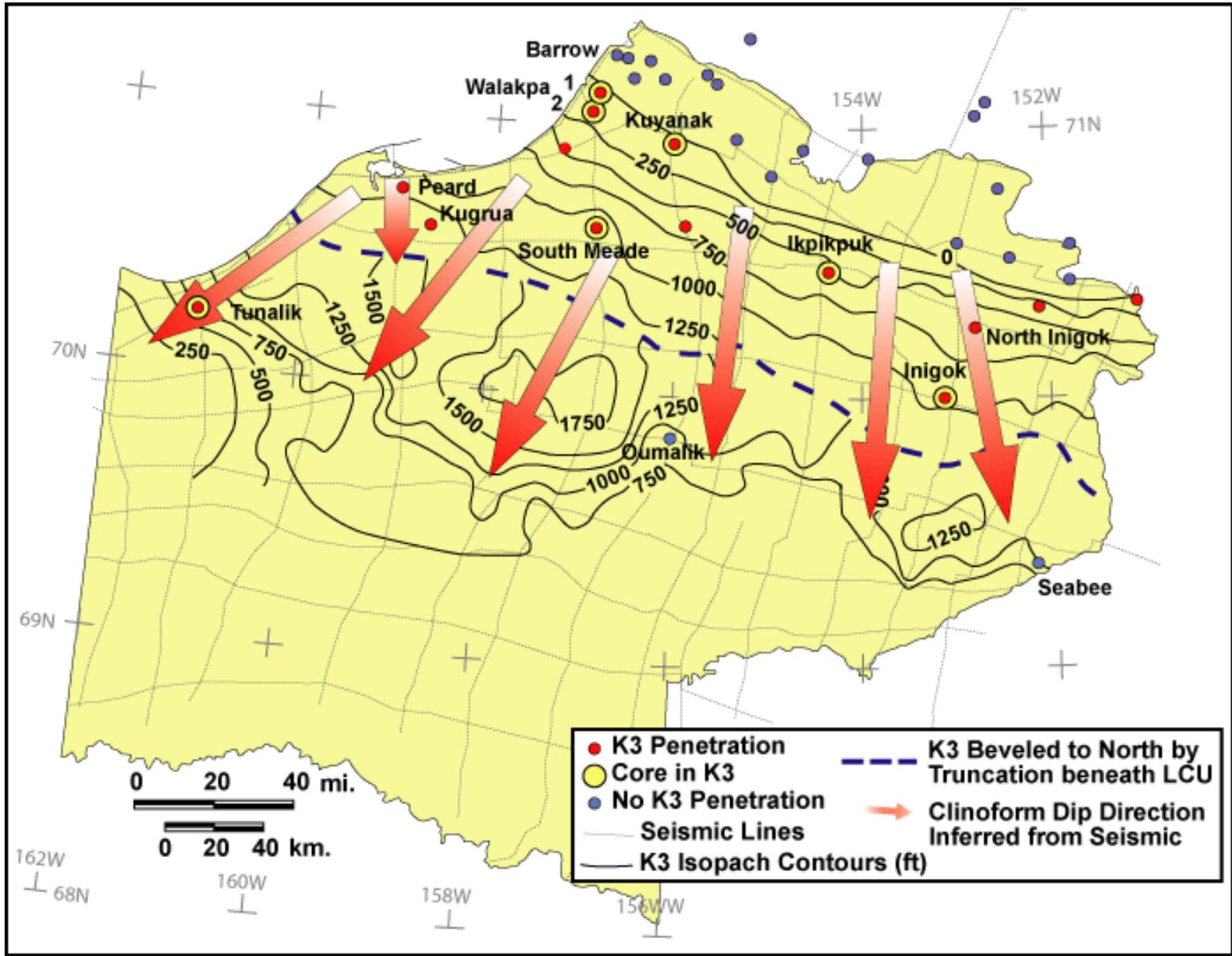


Figure 6A. Map of the NPRA showing generalized thickness (in feet) of Beaufortian sequence set K3, public domain seismic grid used to map sequence sets, well penetrations of K3, and wells with public domain cores in K3. Arrows indicate dip directions of K3 clinoforms, with base and tip of each arrow showing approximate updip (proximal) and downdip (distal) extent of clinoforms.

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 Figure 6B

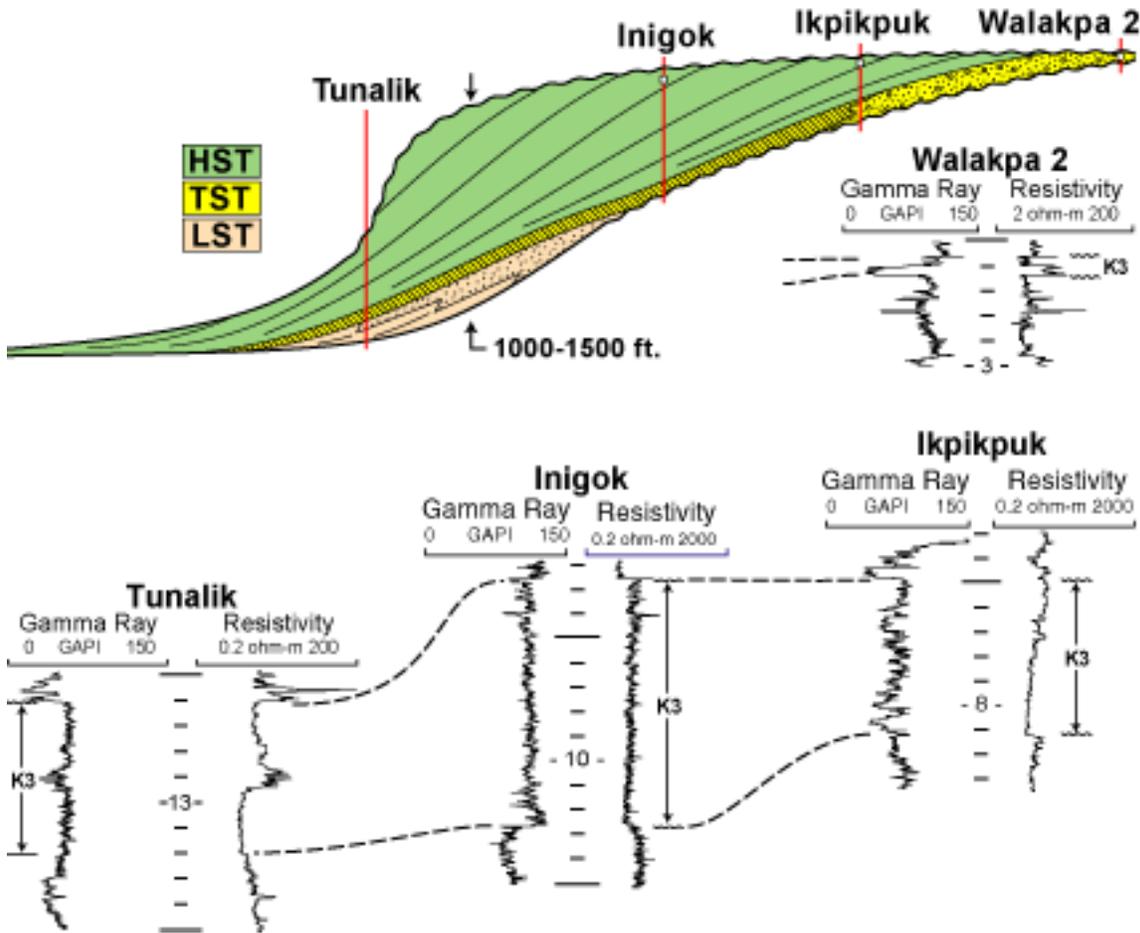


Figure 6B. Schematic illustration of an idealized depositional sequence within K3 and wireline logs from wells inferred to penetrate various locations within K3 sequence set. Wireline log depth ticks are at 100 ft. intervals and numbers are 1000's ft.

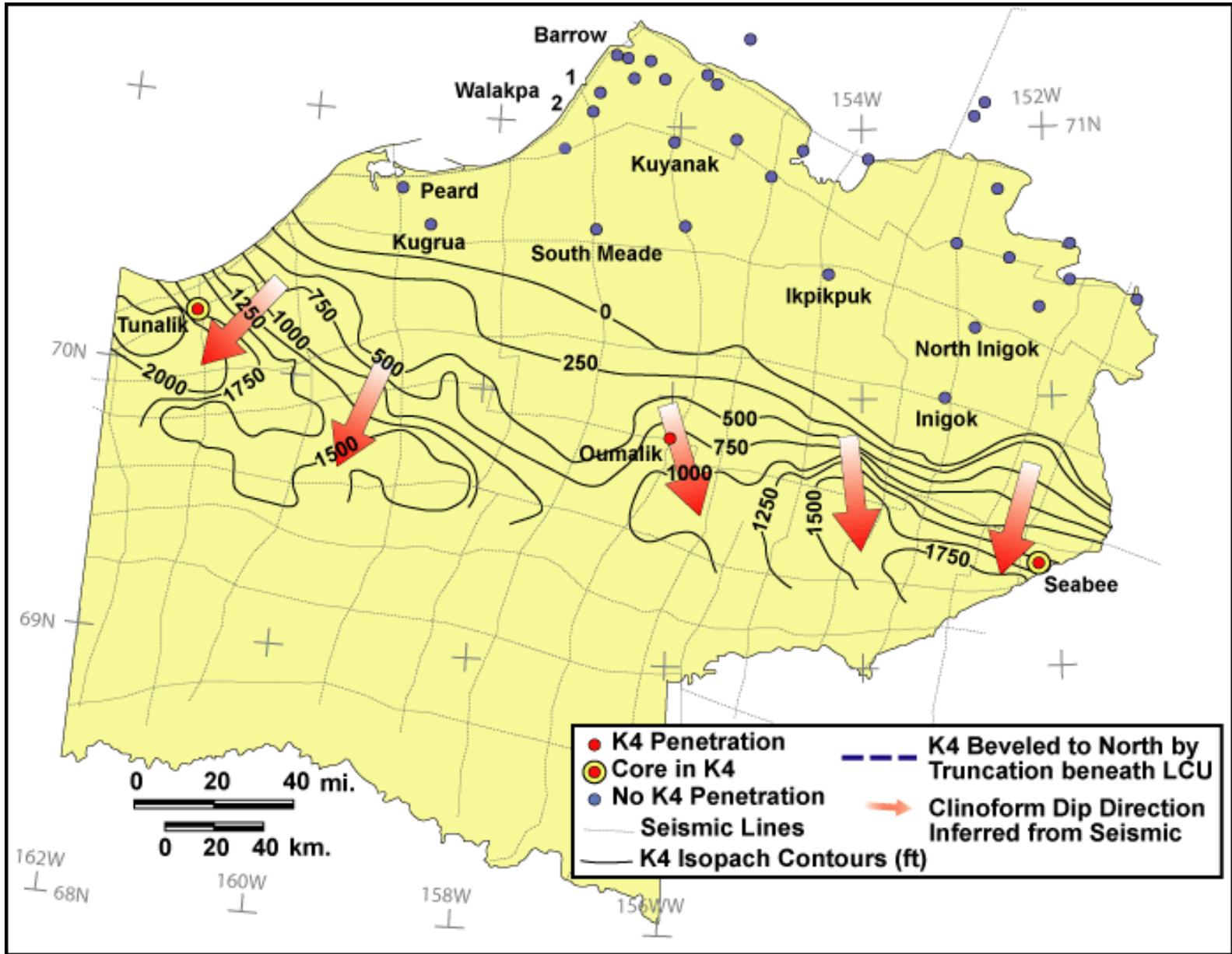


Figure 7A. Map of the NPRA showing generalized thickness (in feet) of Beaufortian sequence set K4, public domain seismic grid used to map sequence sets, well penetrations of K4, and wells with public domain cores in K4. Arrows indicate dip directions of K4 clinoforms, with base and tip of each arrow showing approximate updip (proximal) and downdip (distal) extent of clinoforms.

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 Figure 7B

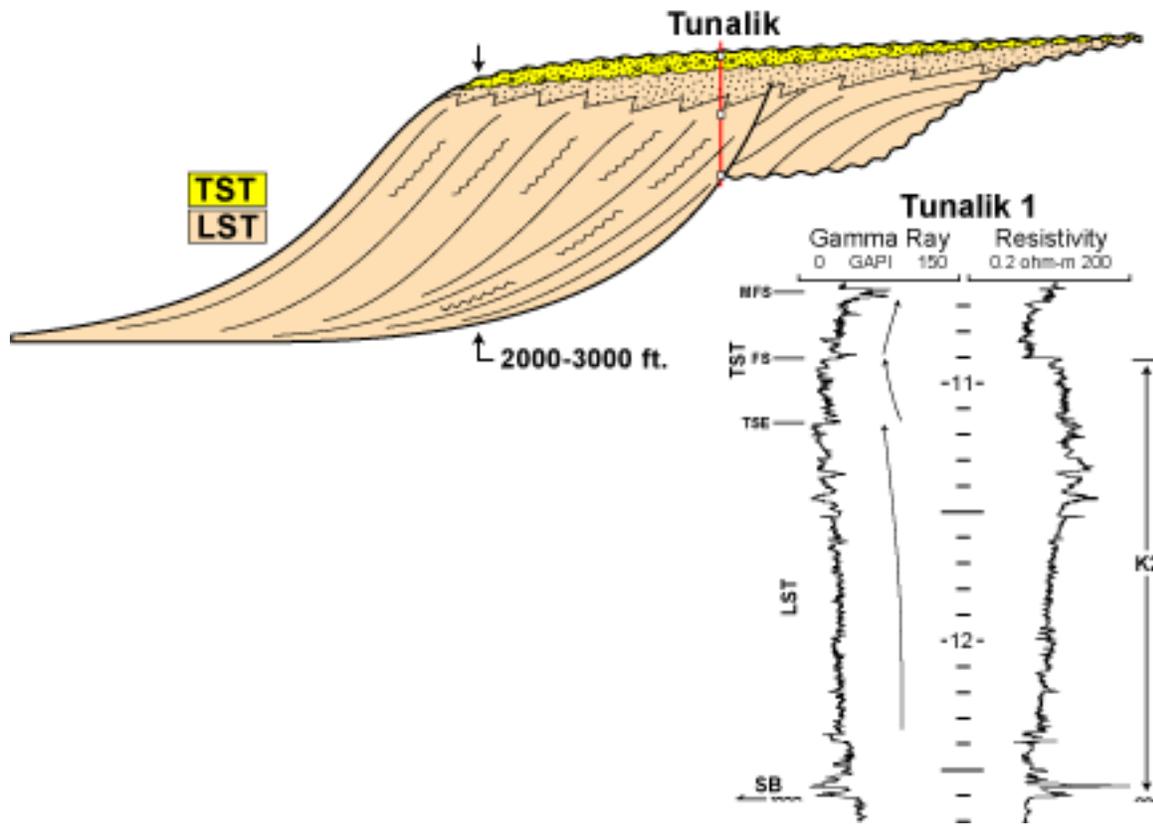


Figure 7B. Schematic illustration of an idealized depositional sequence within K4 and wireline log from Tunalik well. Wireline log depth ticks are at 100 ft. intervals and numbers are 1000's ft. Abbreviations are the same as in Figs. 4b and 5b.

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 Figure 8

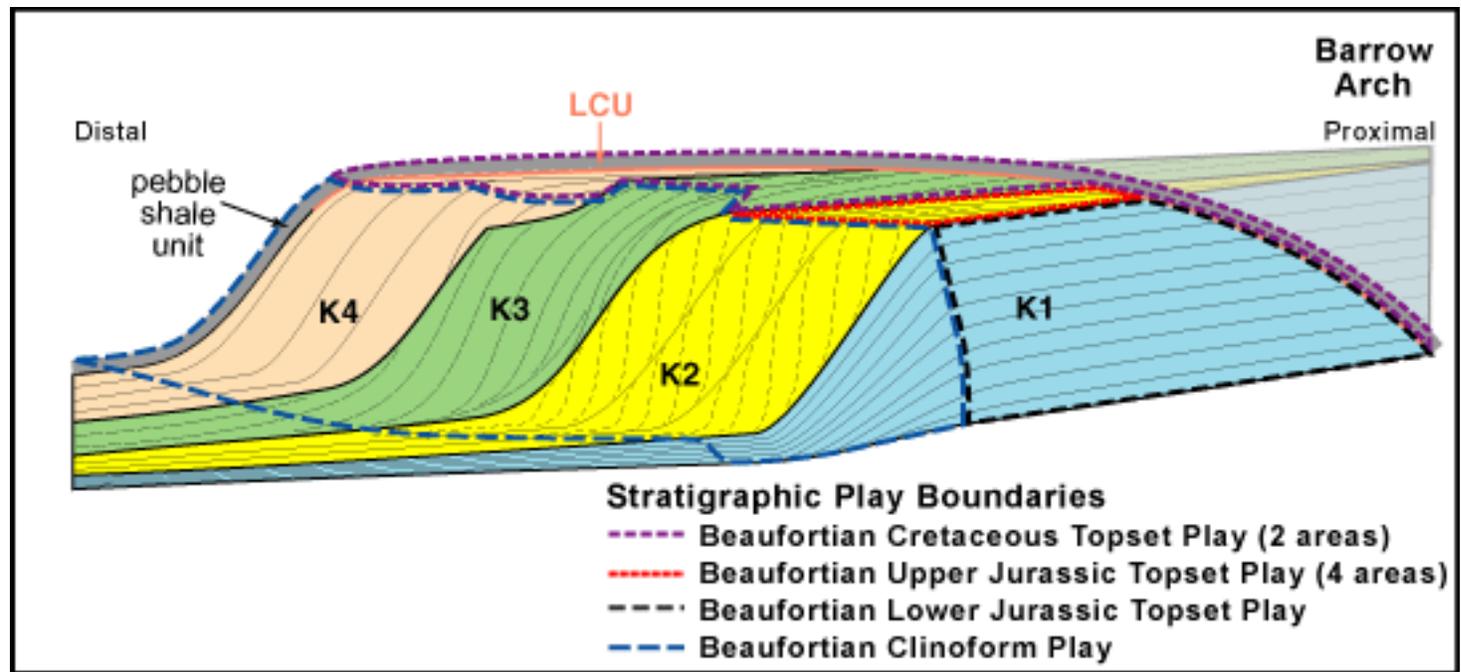


Figure 8. Proximal (~north) to distal (~south) cross section schematically illustrating stratigraphic relationships among four Beaufortian depositional sequence sets, showing general stratigraphic definition of Beaufortian plays. Refer to Fig. 3 for additional context.

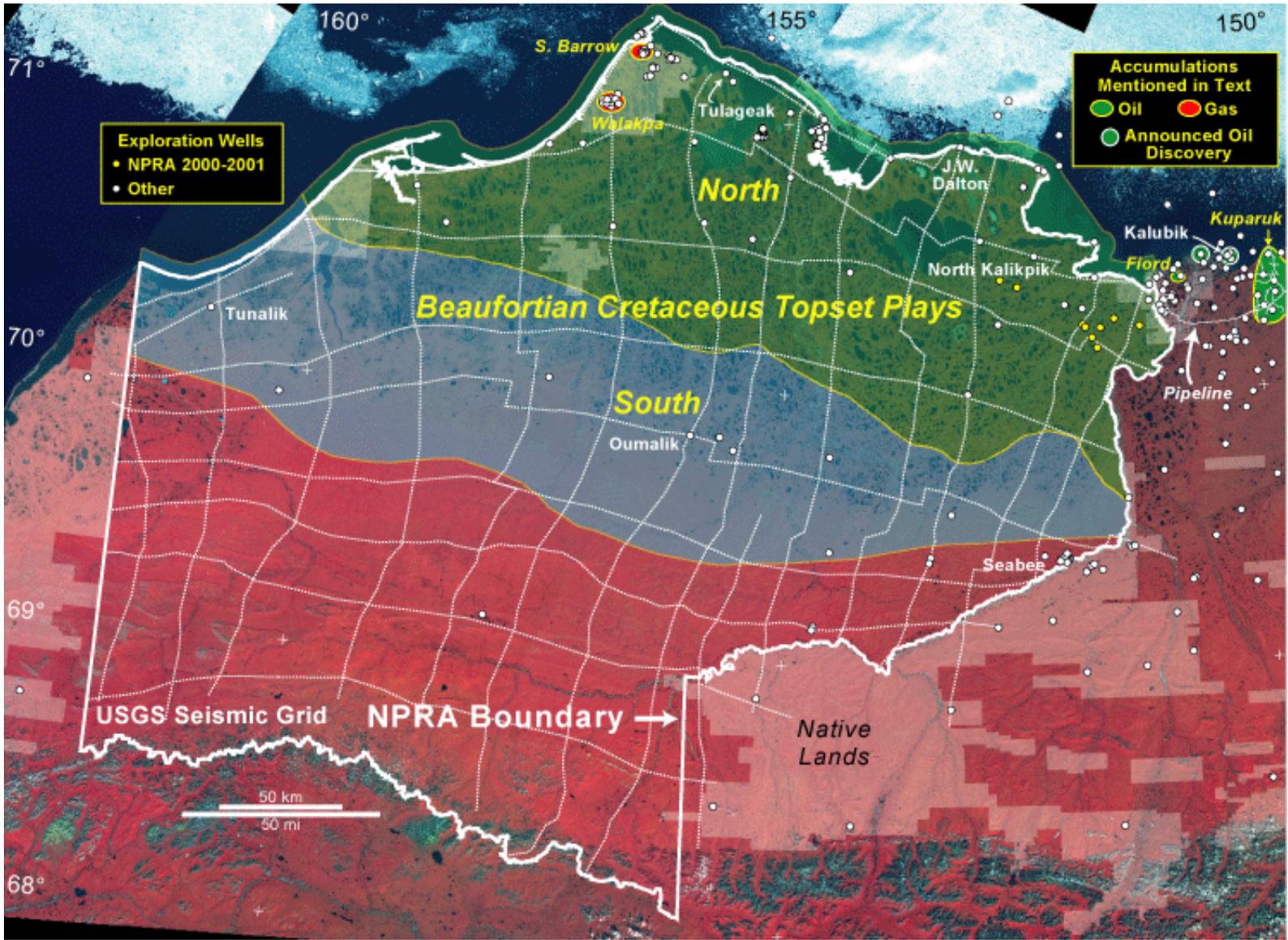


Figure 9. Map of Beaufortian Cretaceous Topset North Play and Beaufortian Cretaceous Topset South Play. Known accumulations in these plays or in extensions of these plays outside NPR 2000-2001 are shown with pertinent names in yellow. Names of selected wells mentioned in text are shown in white.

Figure 10

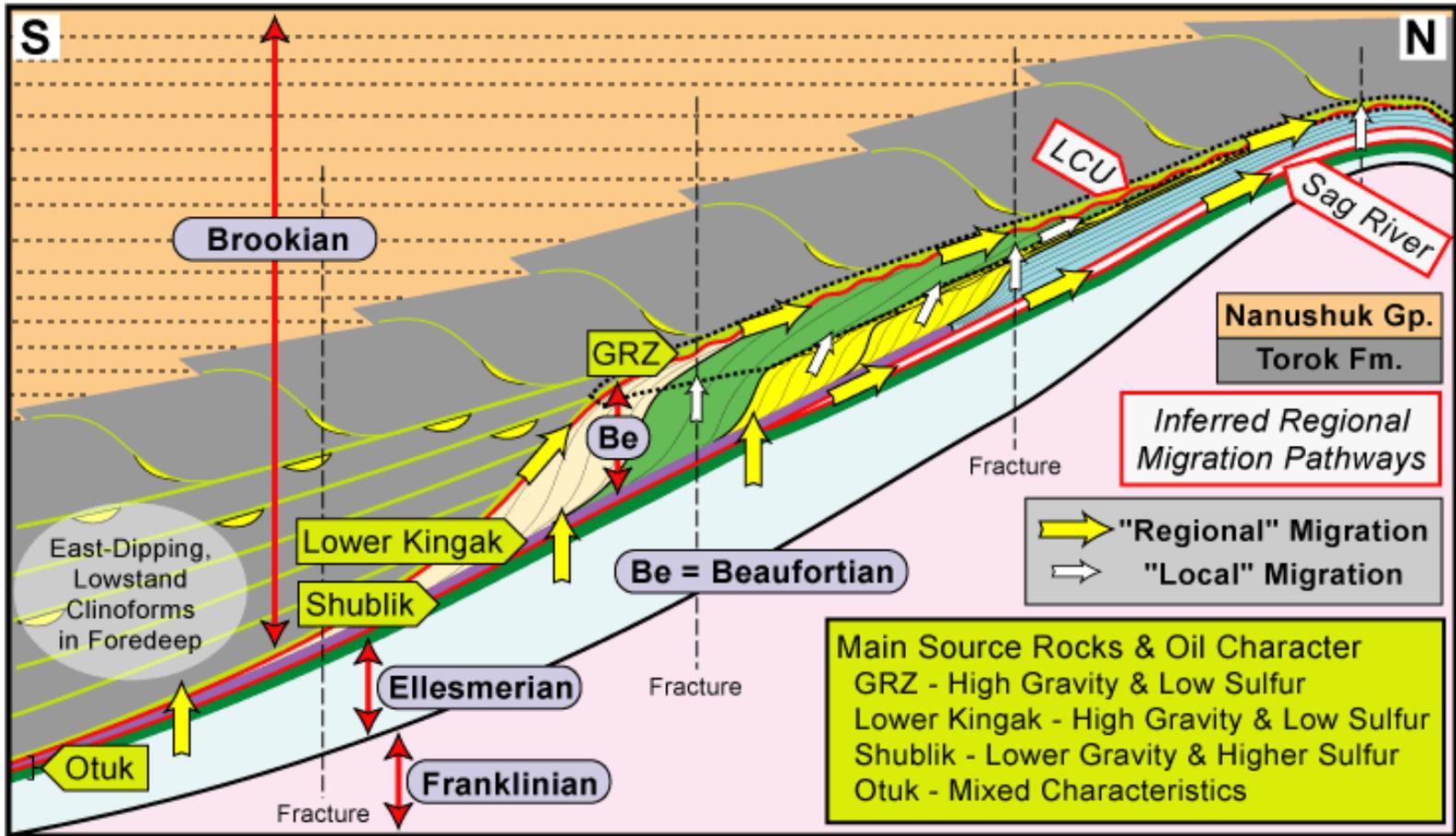


Figure 10. Schematic south-north cross section in eastern NPRA showing stratigraphic positions of major source rocks, generalized geometry of Brookian and Beaufortian strata, and inferred scenarios for migration of hydrocarbons from source rocks to stratigraphic traps in the Beaufortian Cretaceous Topset plays. Colors of Beaufortian strata are same as sequence sets defined in Fig. 3 (blue, K1; yellow, K2; green, K3; tan; K4). Strata involved in the Beaufortian Cretaceous Topset North and South Plays are outlined by black dotted line. “Regional” migration is inferred to have occurred along regionally extensive migration pathways, such as the Lower Cretaceous Unconformity (LCU) and the Sag River Sandstone. “Local” migration is inferred to have occurred along sub-regional or local migration pathways, such as clinofolds within Beaufortian strata and fractures.

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 Figure 11

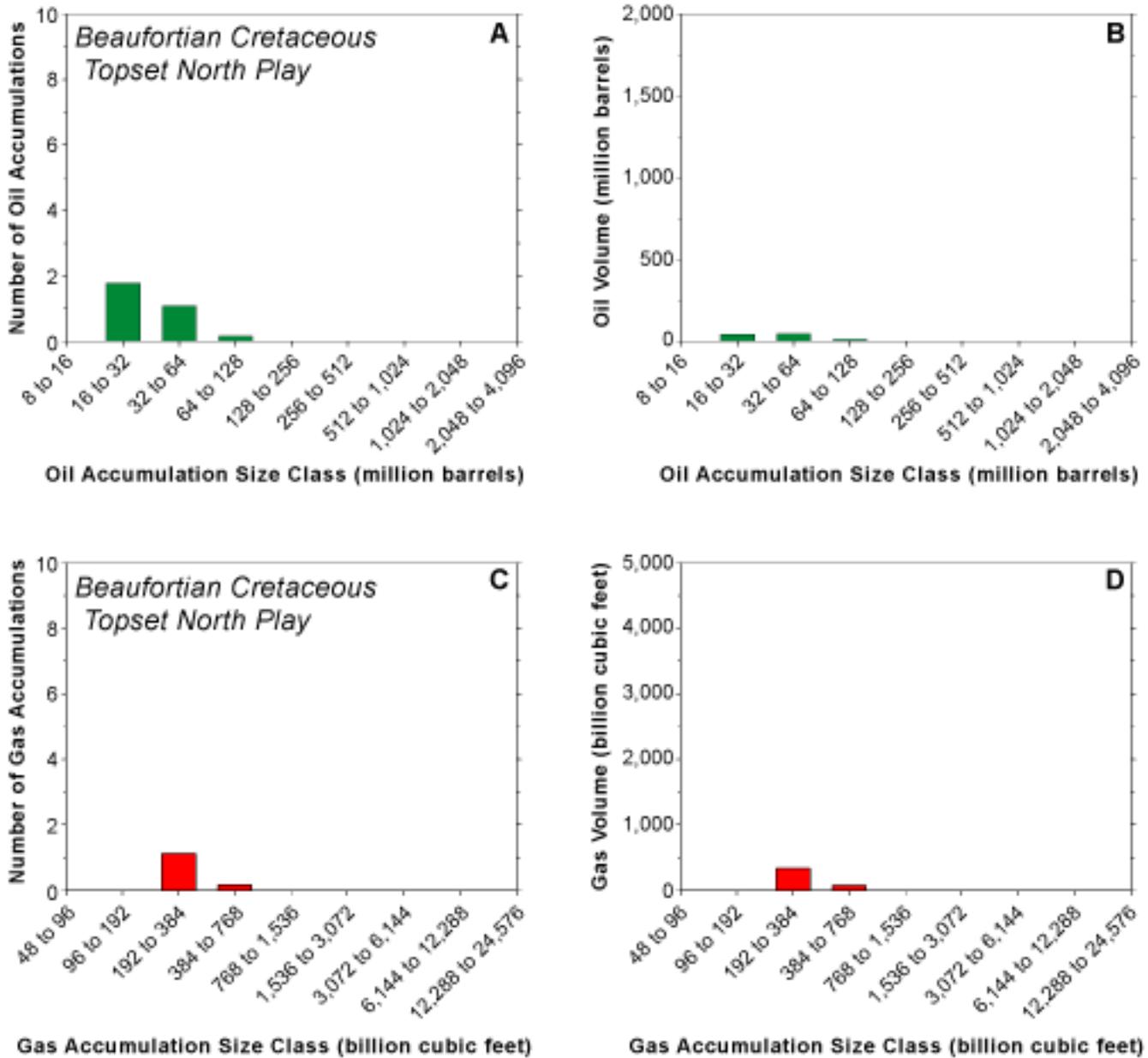


Figure 11. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Cretaceous Topset North Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

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 Figure 12

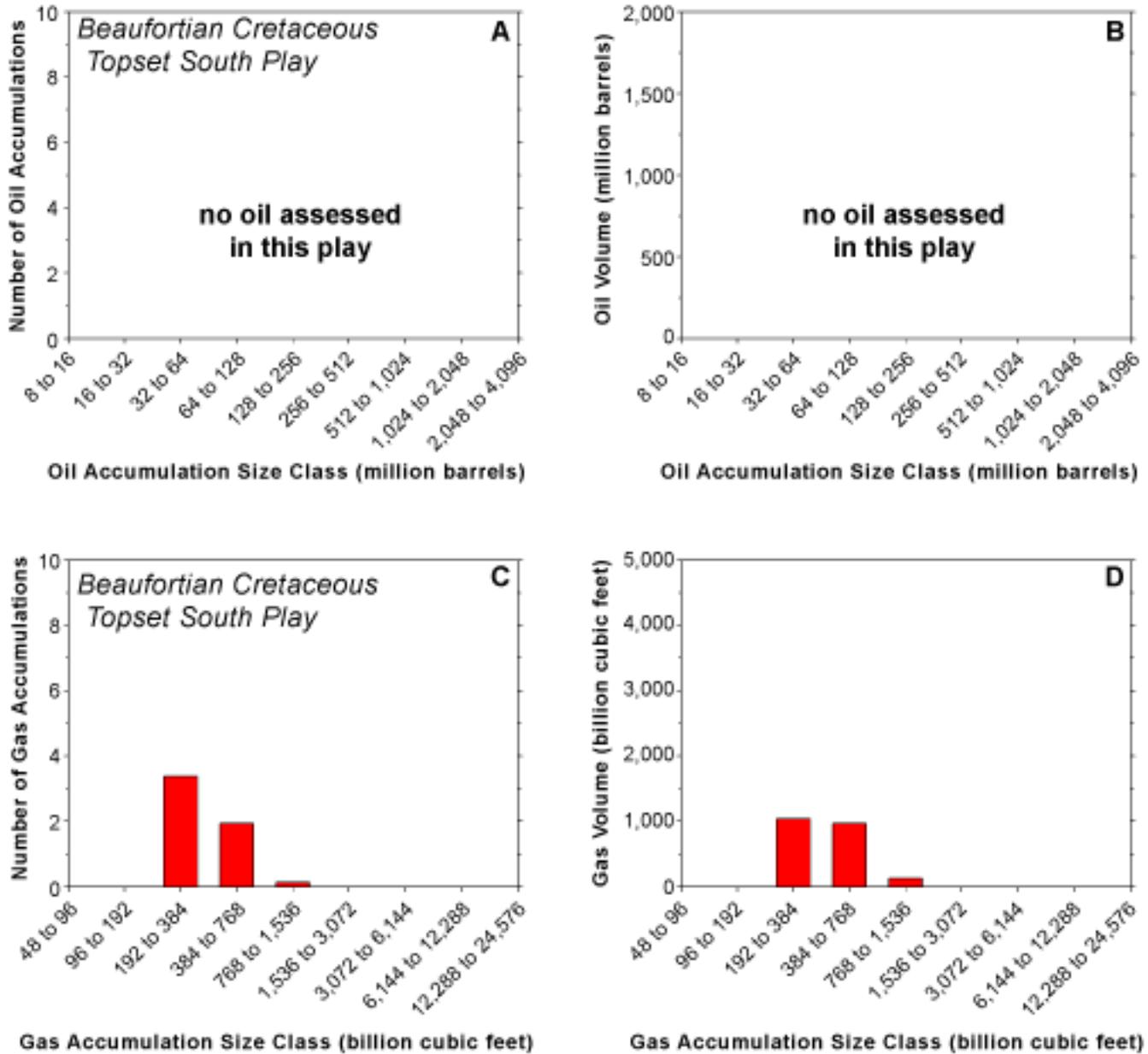


Figure 12. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Cretaceous Topset South Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

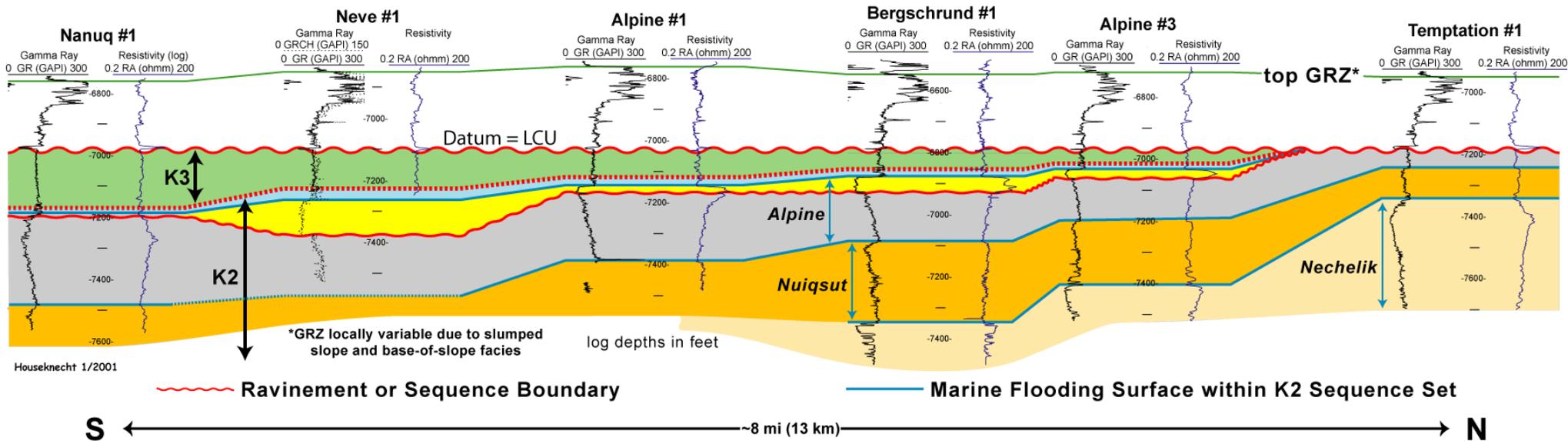


Figure 13. Wireline log cross section through Alpine oil field. Stratigraphic interval shown includes much of sequence set K2 and all of sequence set K3, which is thin in this area owing to erosion beneath the Lower Cretaceous Unconformity (LCU). Successions labeled Alpine, Nuiqsut, and Nechelik (all informal terms) are interpreted as individual depositional sequences bounded by marine flooding surfaces within sequence set K2. Within the Alpine sequence, coarsening-upward succession colored gray is interpreted as lowstand systems tract (LST) and blocky sandstone (yellow) capped by mudstone (light blue) is interpreted as transgressive systems tract (TST). The primary reservoir in Alpine field is the yellow, blocky shoreface sandstone at base of TST.

Figure 14

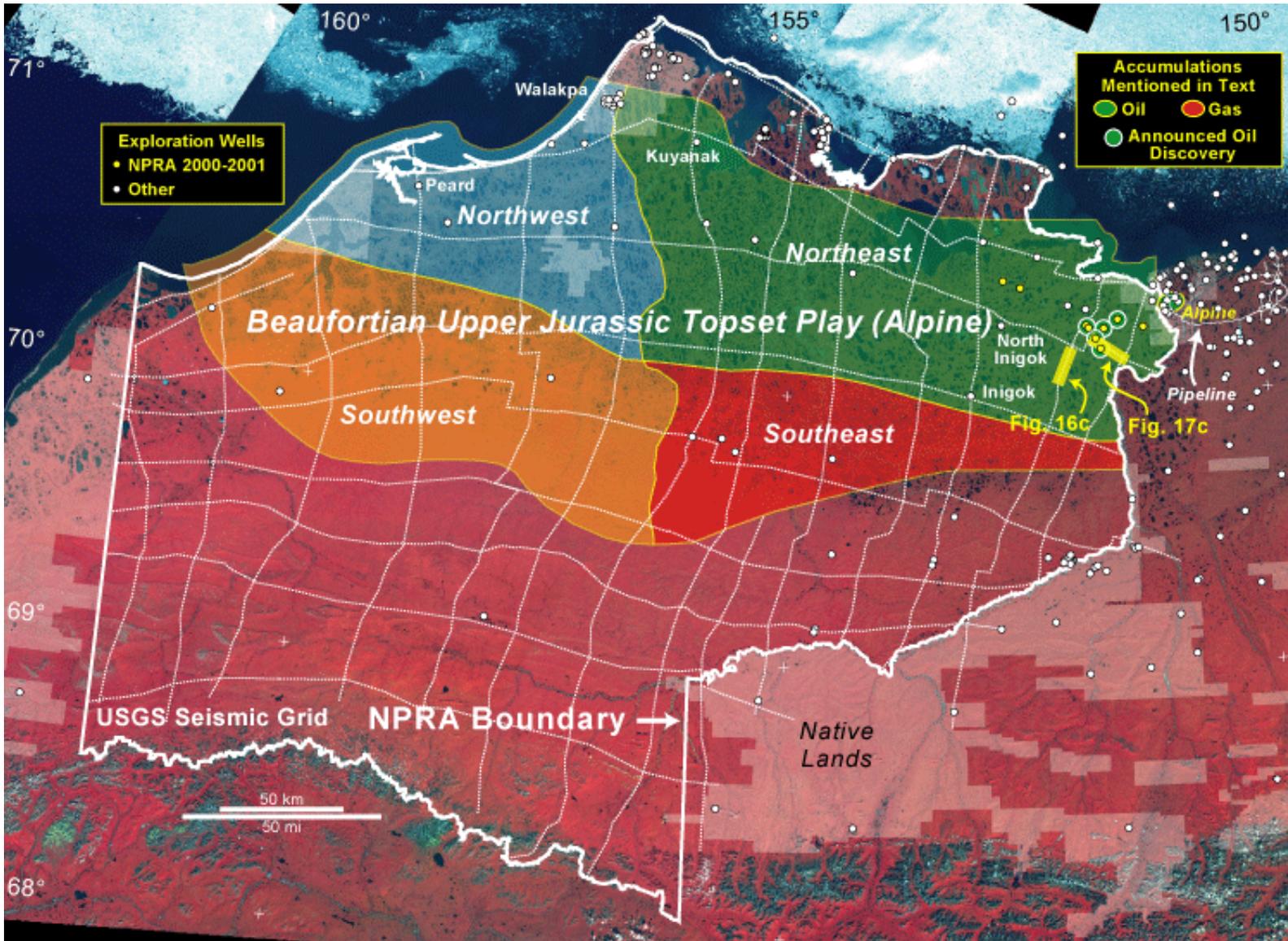


Figure 14. Map of Beaufortian Upper Jurassic Topset Northeast Play, Beaufortian Upper Jurassic Topset Southeast Play, Beaufortian Upper Jurassic Topset Northwest Play, and Beaufortian Upper Jurassic Topset Southwest Play. Known accumulations in these plays or in extensions of these plays outside NPRA are shown with pertinent names in yellow. Names of selected wells mentioned in text are shown in white. Locations of seismic sections shown in Figs. 16c and 17c also are shown.

Figure 15

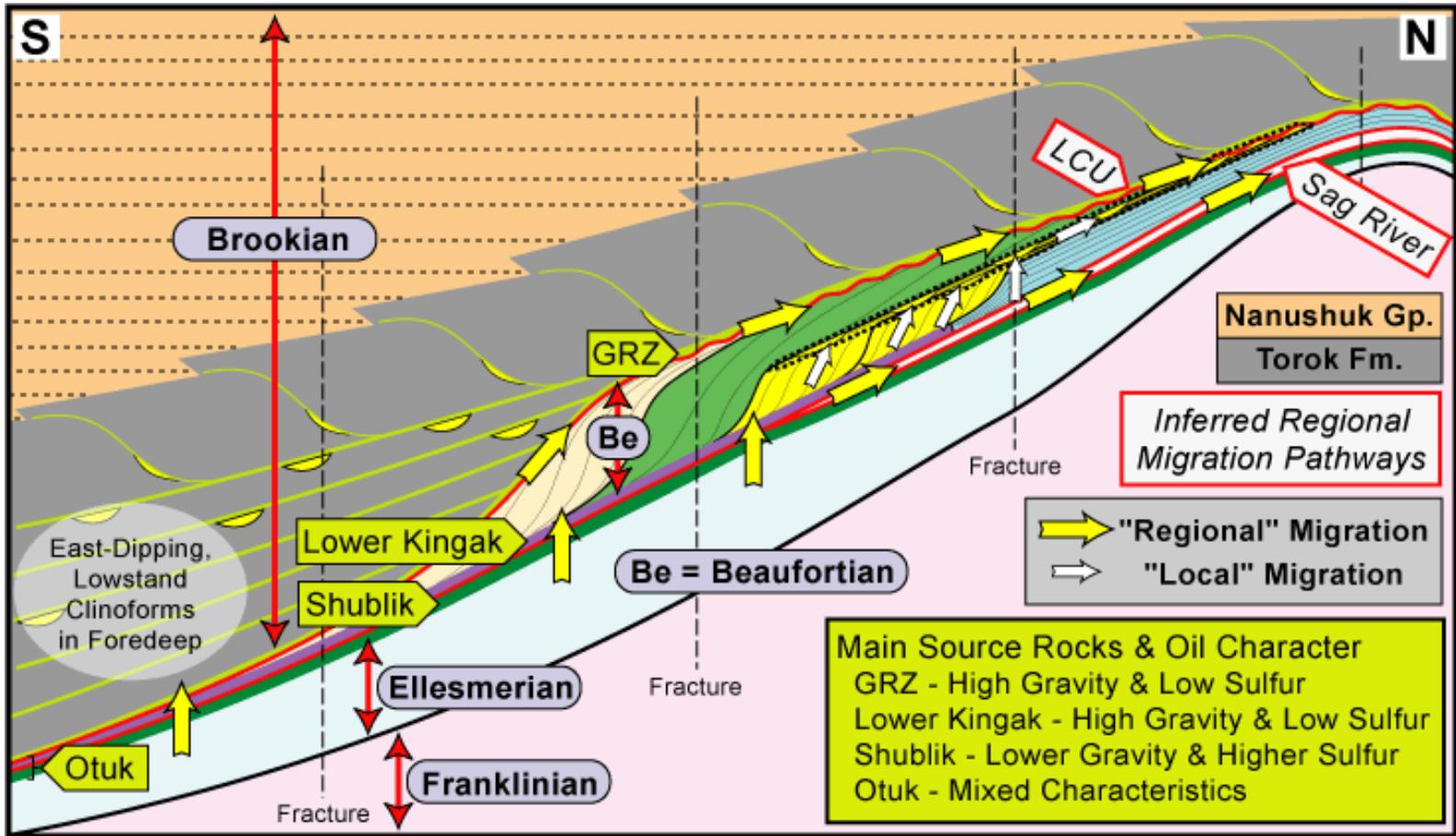


Figure 15. Schematic south-north cross section in eastern NPRA showing stratigraphic positions of major source rocks, generalized geometry of Brookian and Beaufortian strata, and inferred scenarios for migration of hydrocarbons from source rocks to stratigraphic traps in the Beaufortian Upper Jurassic Topset plays. Colors of Beaufortian strata are same as sequence sets defined in Fig. 3 (blue, K1; yellow, K2; green, K3; tan; K4). Strata involved in the Beaufortian Upper Jurassic Topset Northeast, Southeast, Northwest, and Southwest Plays are outlined by black dotted line. “Regional” migration is inferred to have occurred along regionally extensive migration pathways, such as the Lower Cretaceous Unconformity (LCU) and the Sag River Sandstone. “Local” migration is inferred to have occurred along sub-regional or local migration pathways, such as clinofolds within Beaufortian strata and fractures.

Figure 16A

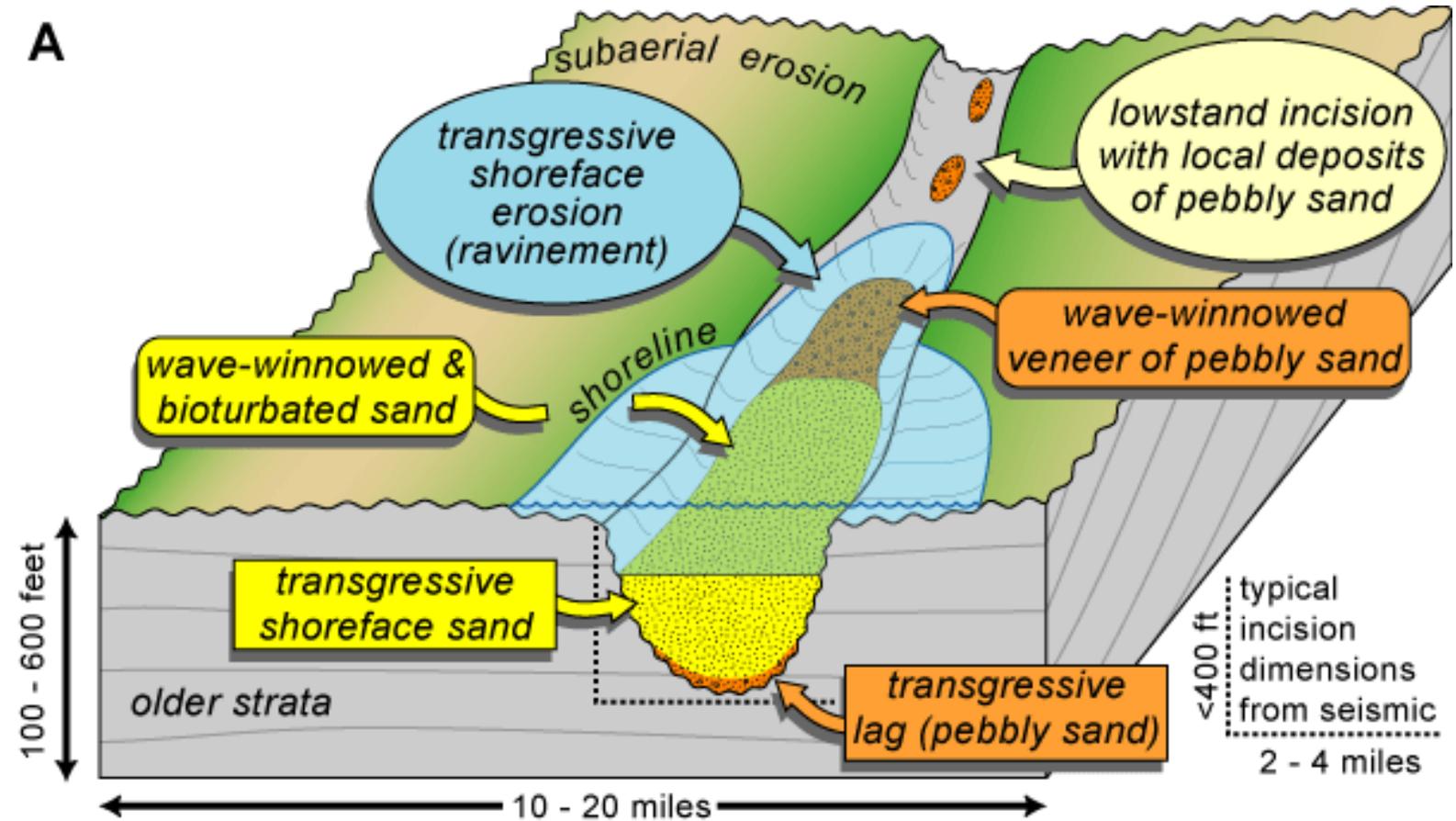


Figure 16. Incision model for deposition of shoreface sand within transgressive systems tract in sequence set K2. A. Deposition of transgressive shoreface sand within incision cut during lowstand. Transgressive shoreface sandstones deposited in settings similar to this are potential reservoirs in Beaufortian Upper Jurassic Topset plays.

Figure 16B

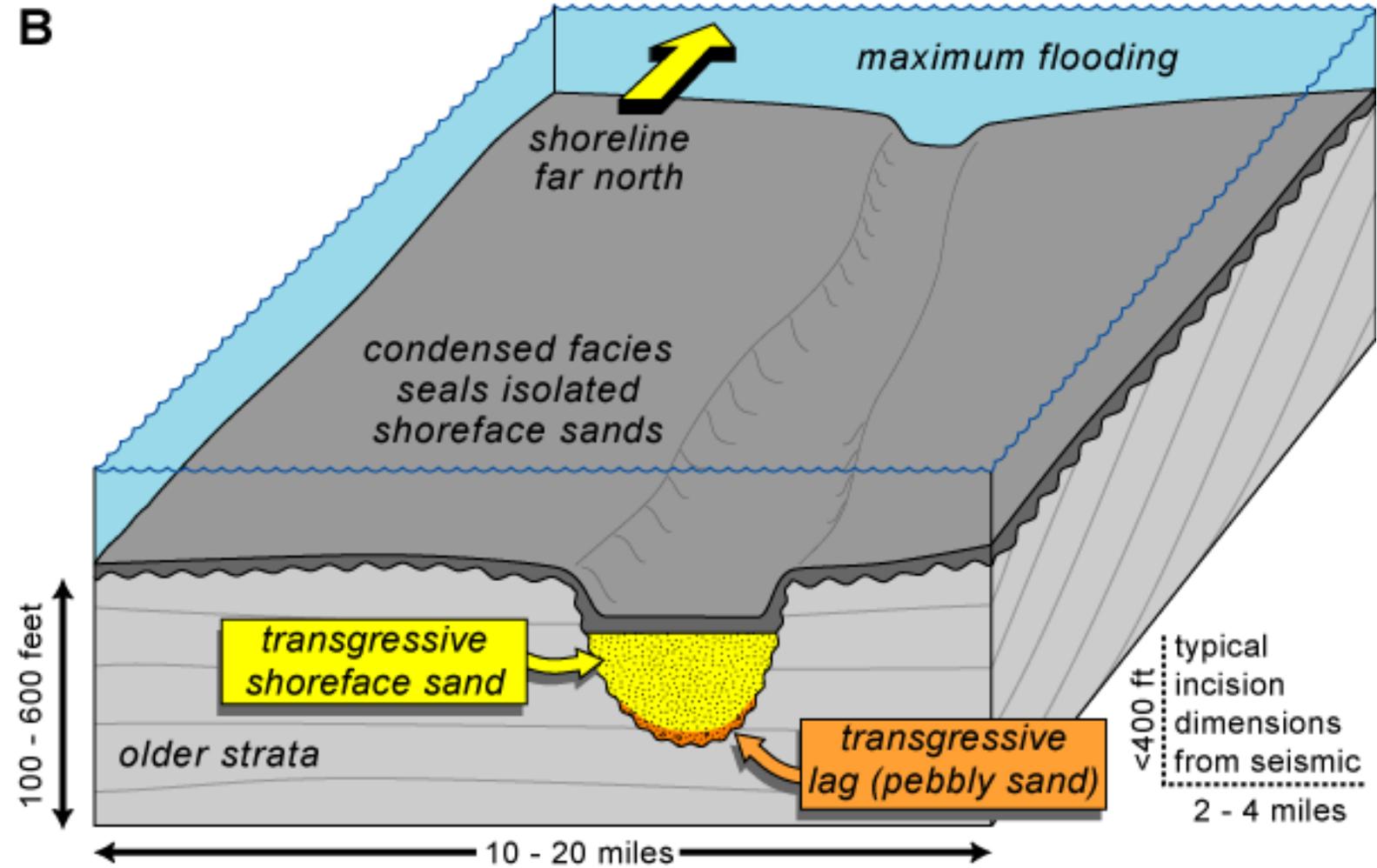


Figure 16B. Incision model for deposition of shoreface sand within transgressive systems tract in sequence set K2. *B.* Deposition of condensed mudstone above transgressive shoreface sand during maximum flooding. Condensed mudstone deposited in settings similar to this forms a potential seal for stratigraphic traps in Beaufortian Upper Jurassic Topset plays.

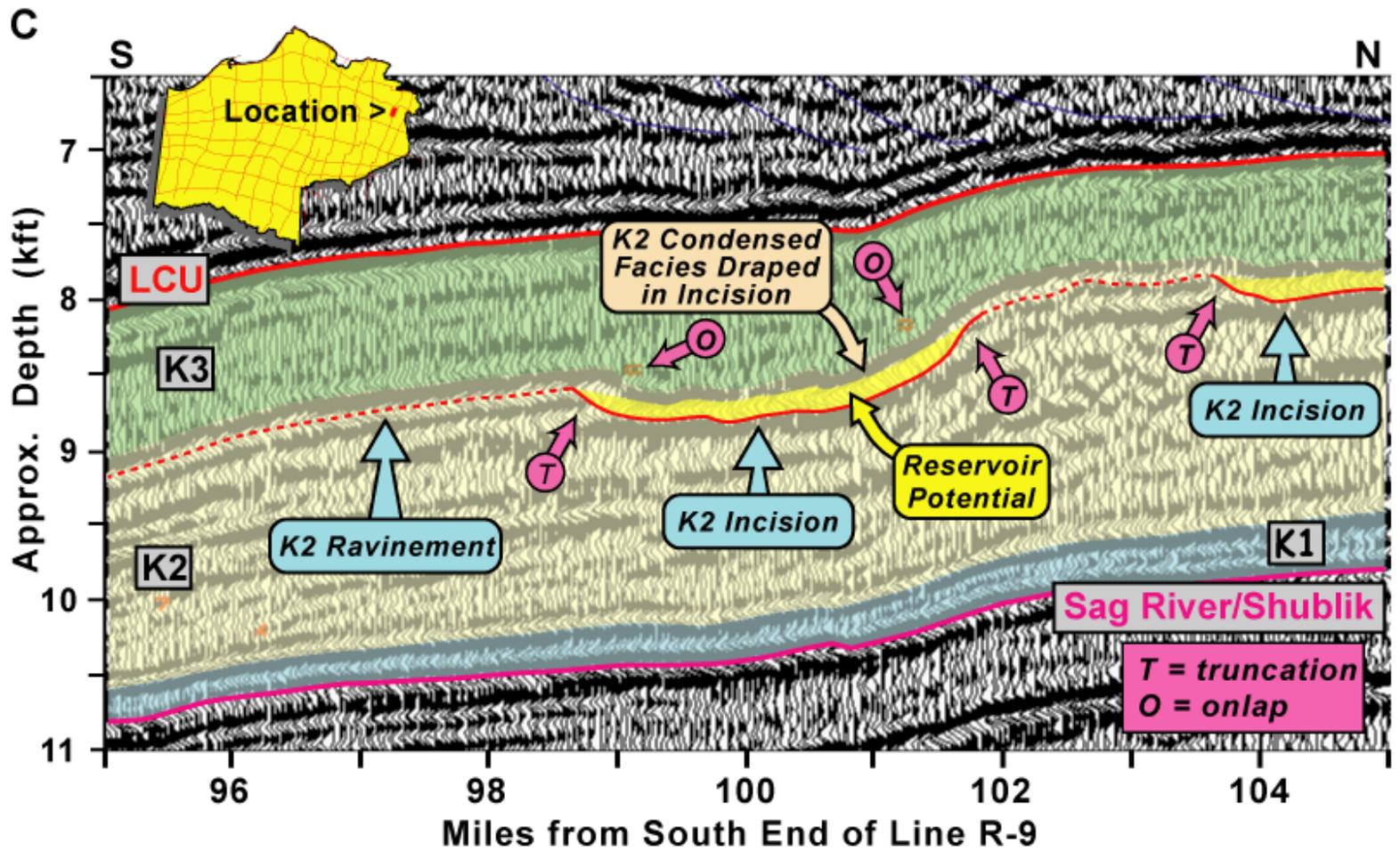


Figure 16C. Incision model for deposition of shoreface sand within transgressive systems tract in sequence set K2. C. Segment of USGS seismic line R-9 illustrating feature interpreted to be incision in upper part of sequence set K2 in eastern NPRA. Features such as this may be petroleum prospects if reservoir-quality sandstone is present within the incision and if the sandstone is adequately sealed by condensed mudstones. An additional example of a possible incision in this play is illustrated in Fig. 25. Model modified from Houseknecht (2002).

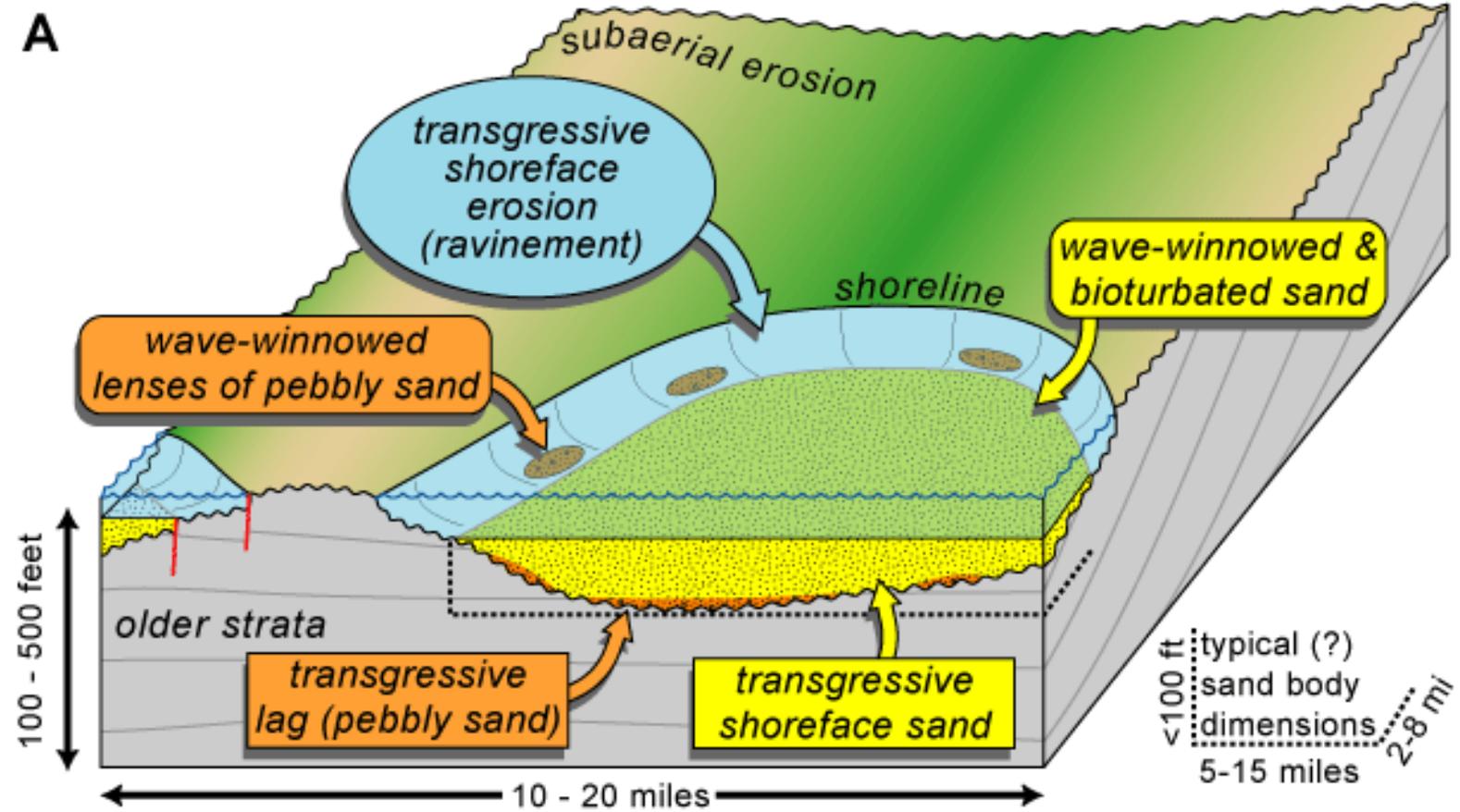


Figure 17A. Embayment model for deposition of shoreface sand within transgressive systems tract in sequence set K2. A. Deposition of transgressive shoreface sand within embayment eroded during lowstand and modified during transgression. Transgressive shoreface sandstones deposited in settings similar to this are potential reservoirs in Beaufortian Upper Jurassic Topset plays.

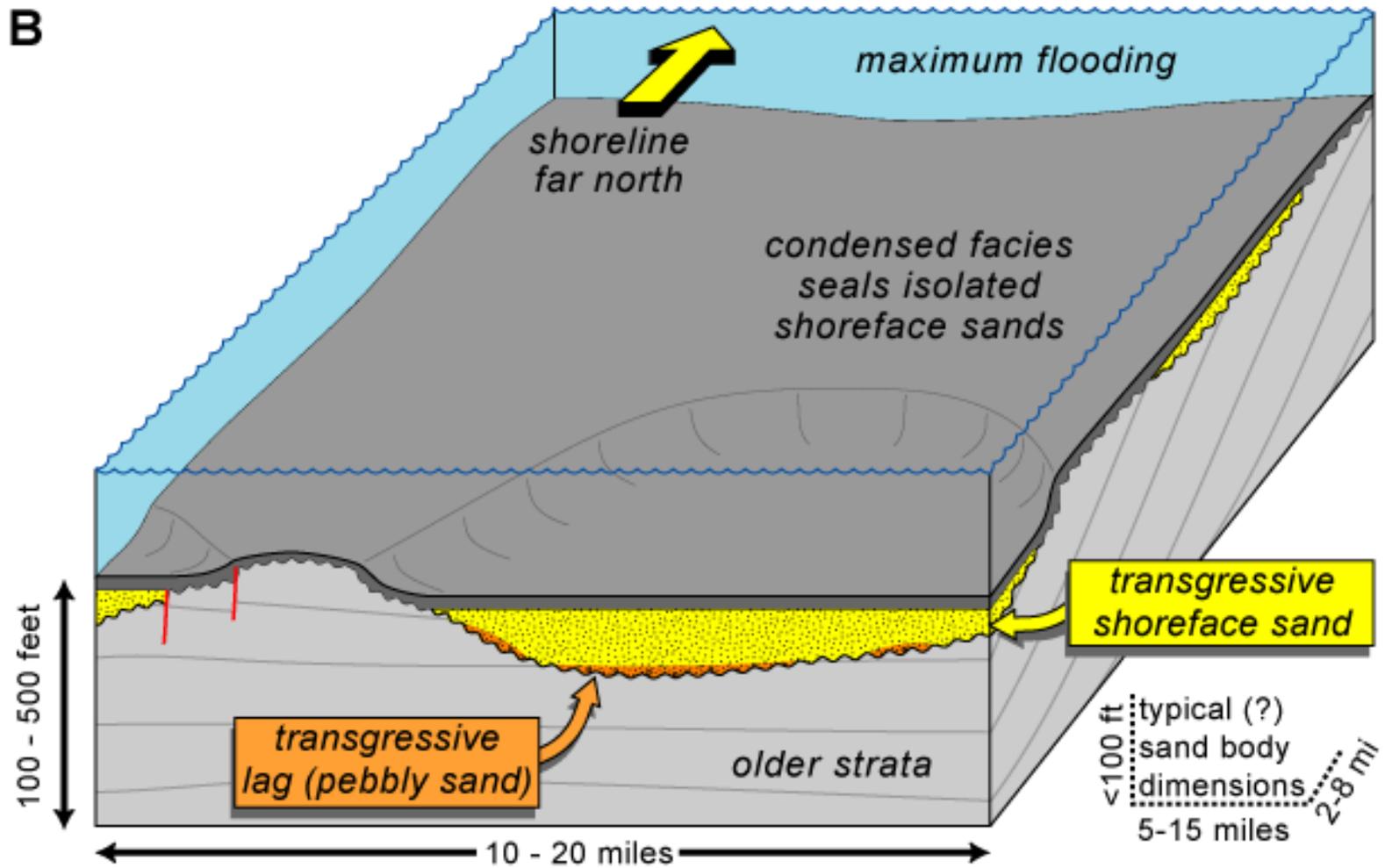


Figure 17B. Embayment model for deposition of shoreface sand within transgressive systems tract in sequence set K2. *B.* Deposition of condensed mudstone above transgressive shoreface sand during maximum flooding. Condensed mudstone deposited in settings similar to this forms a potential seal for stratigraphic traps in Beaufortian Upper Jurassic Topset plays.

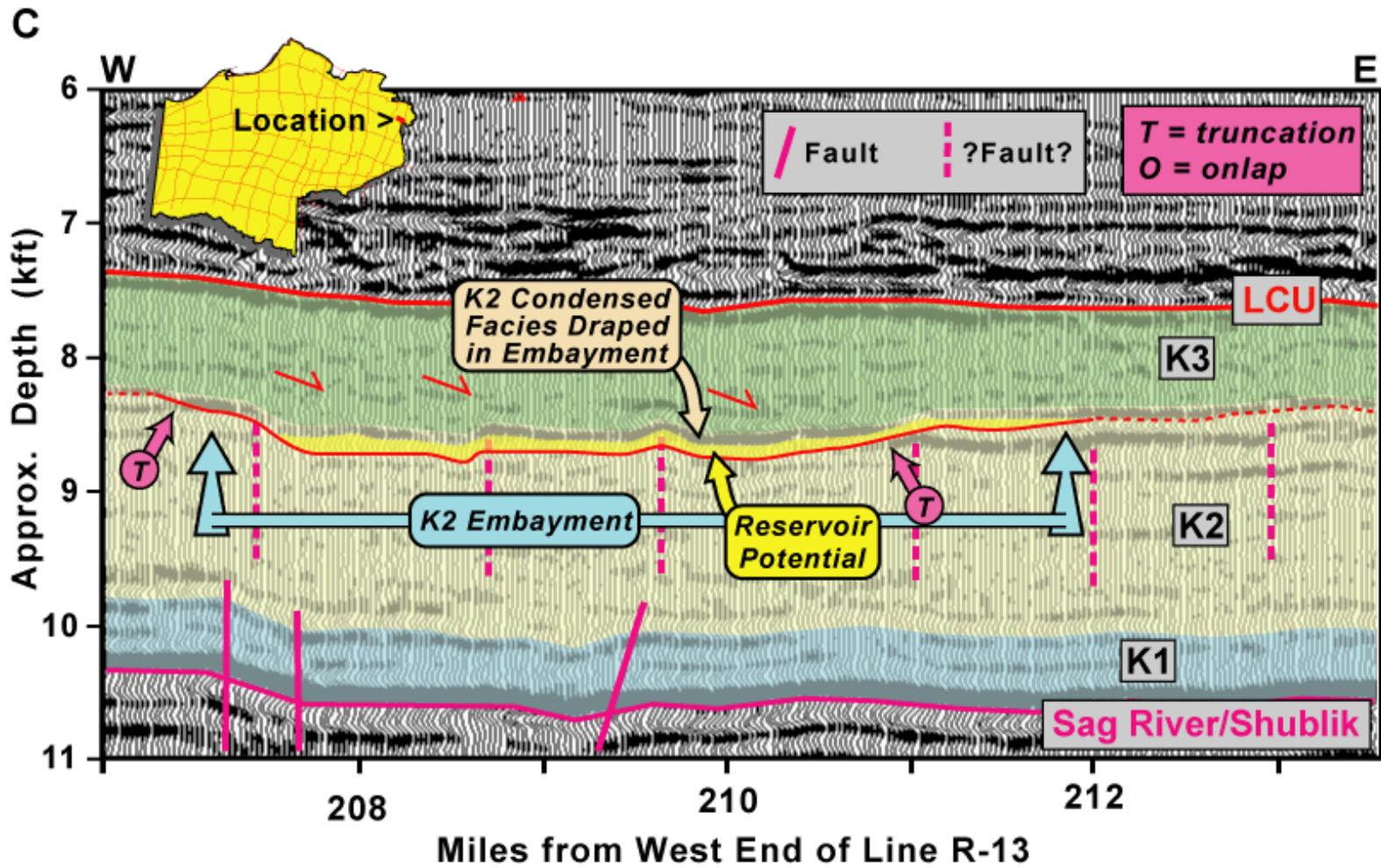


Figure 17C. Embayment model for deposition of shoreface sand within transgressive systems tract in sequence set K2. C. Segment of USGS seismic line R-13 illustrating feature interpreted to be embayment in upper part of sequence set K2 in eastern NPRA. Features such as this may be petroleum prospects if reservoir-quality sandstone is present within the embayment and if the sandstone is adequately sealed by condensed mudstones. Model modified from Houseknecht (2002).

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 Figure 18

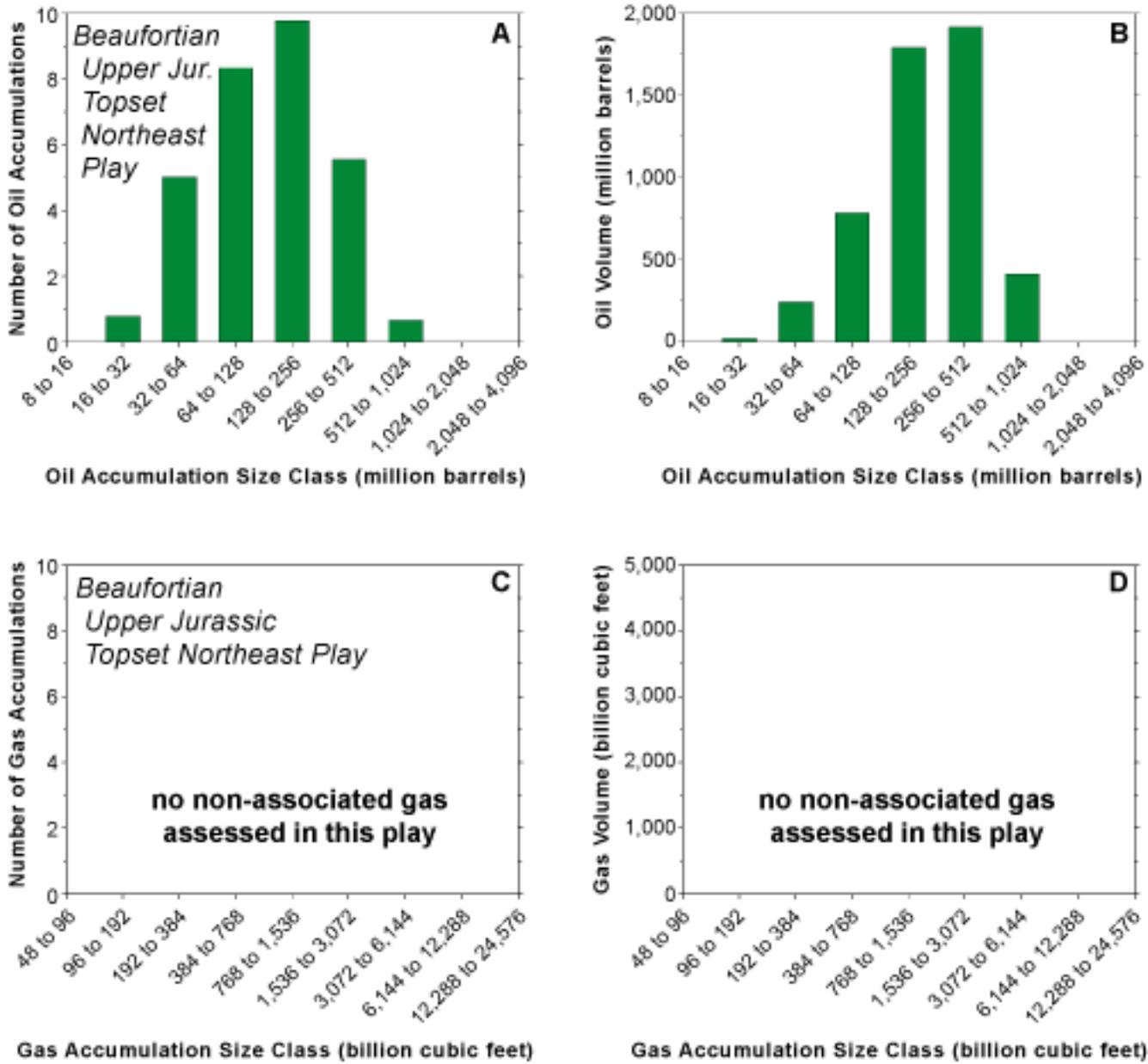


Figure 18. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Upper Jurassic Topset Northeast Play. *A*. Number of oil accumulations in various oil accumulation size classes. *B*. Volume of oil in various oil accumulation size classes. *C*. Number of nonassociated gas accumulations in various gas accumulation size classes. *D*. Volume of nonassociated gas in various gas accumulation size classes.

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 Figure 19

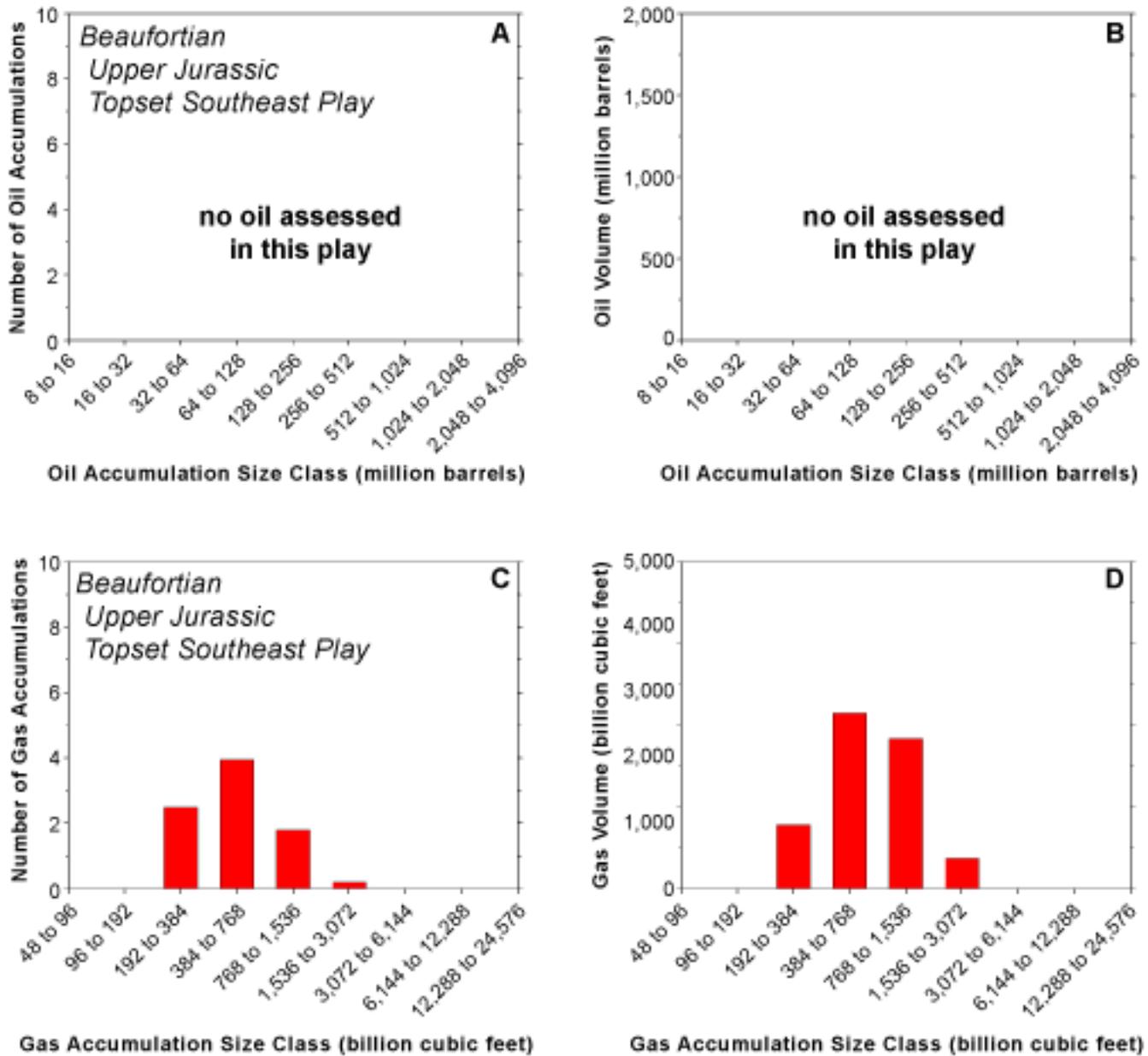


Figure 19. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Upper Jurassic Topset Southeast Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

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 Figure 20

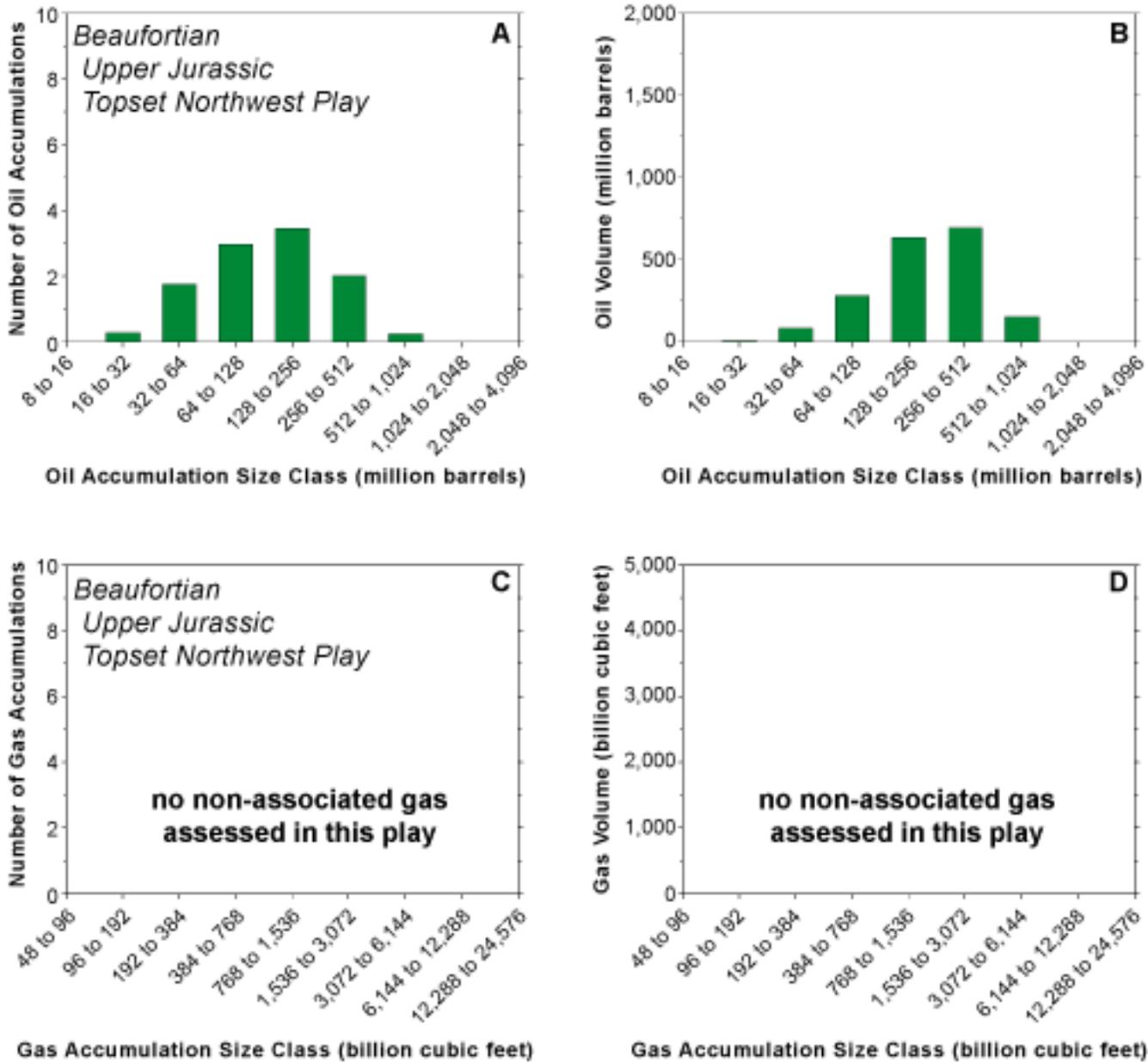


Figure 20. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Upper Jurassic Topset Northwest Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

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 Figure 21

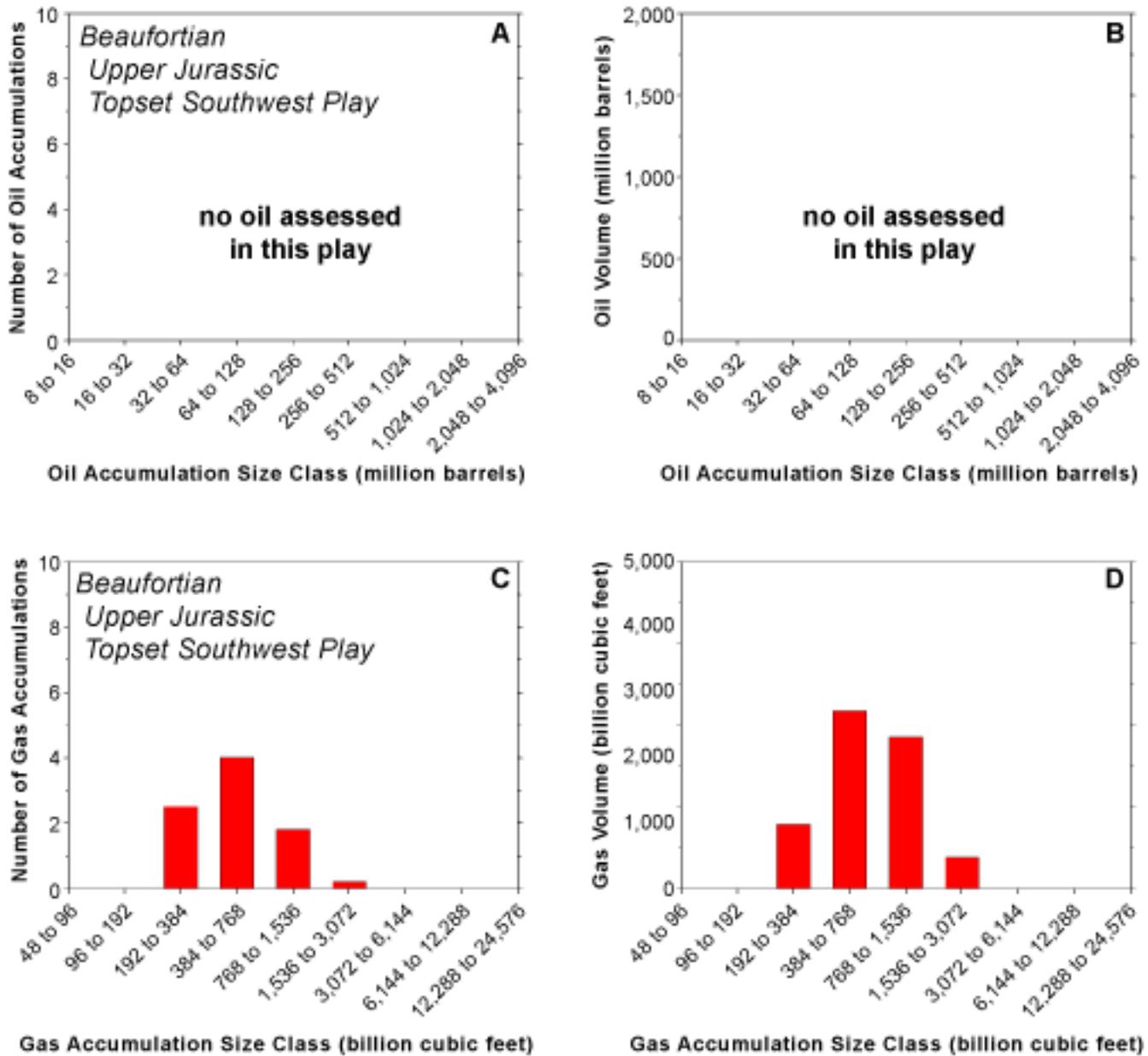


Figure 21. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Upper Jurassic Topset Southwest Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

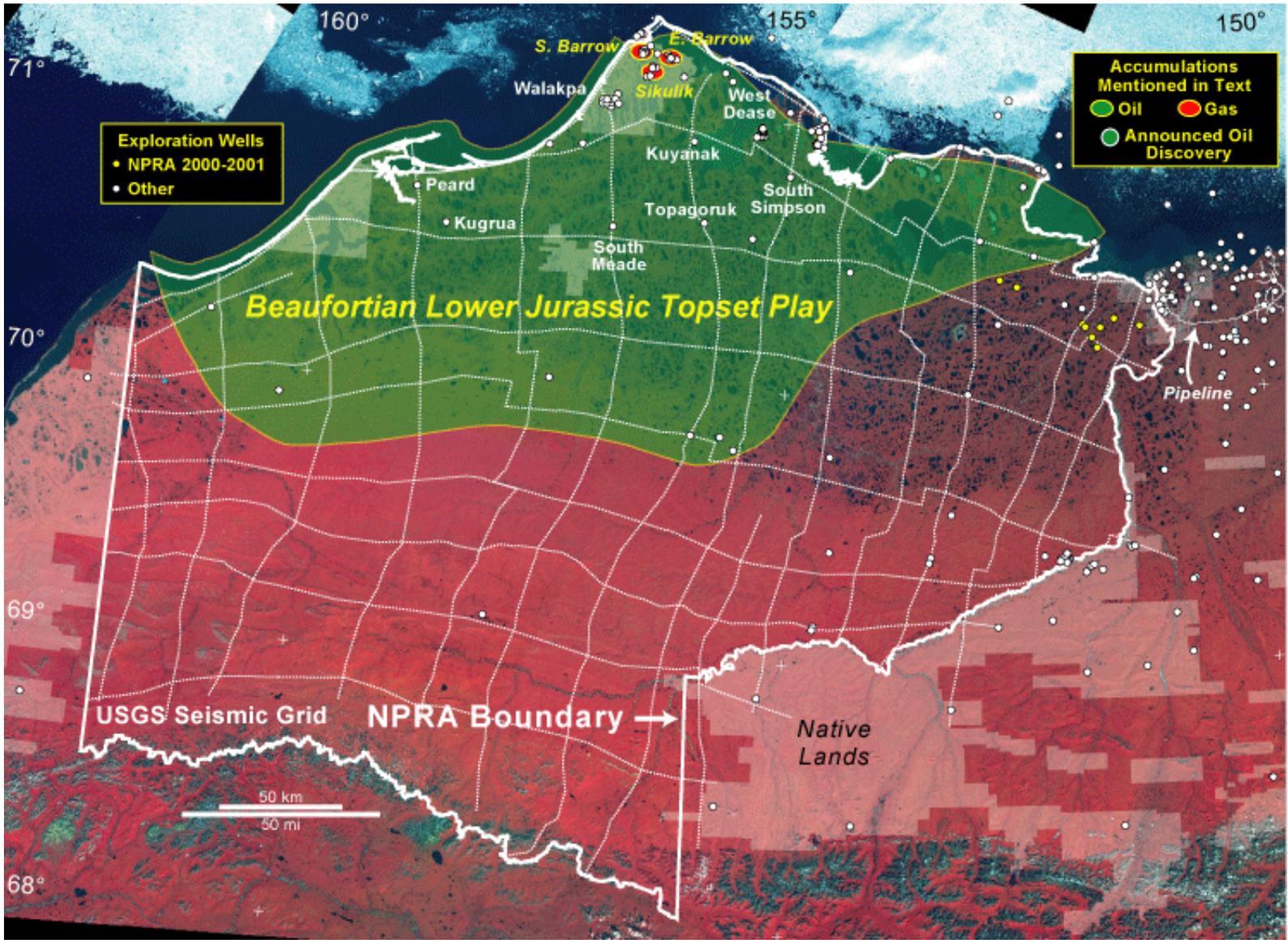


Figure 22.

Map of Beaufortian Lower Jurassic Topset Play. Known accumulations pertinent to this play and mentioned in text are shown with names in yellow. Names of selected wells mentioned in text are shown in white.

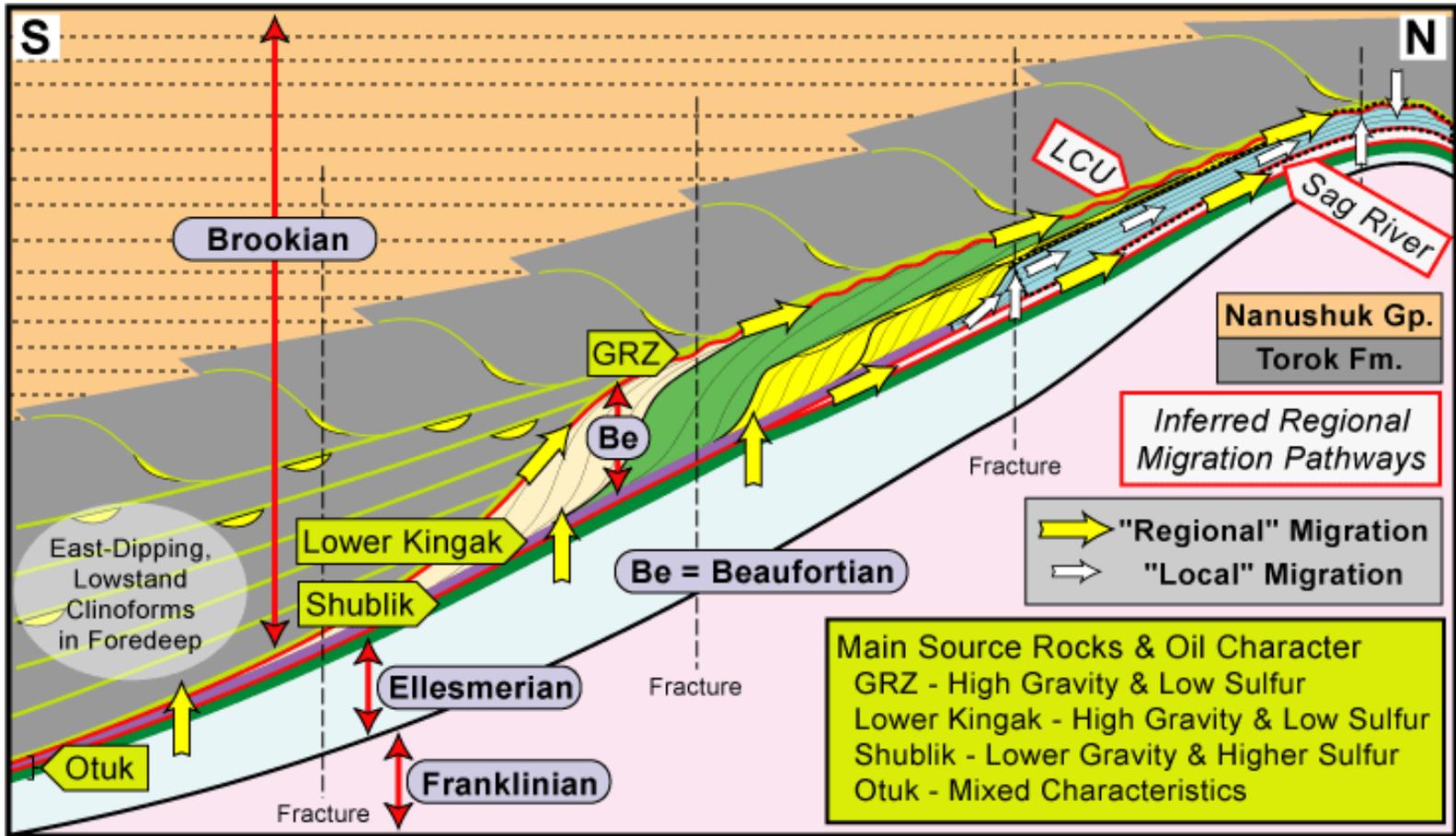


Figure 23. Schematic south-north cross section in eastern NPRA showing stratigraphic positions of major source rocks, generalized geometry of Brookian and Beaufortian strata, and inferred scenarios for migration of hydrocarbons from source rocks to stratigraphic traps in the Beaufortian Lower Jurassic Topset Play. Colors of Beaufortian strata are same as sequence sets defined in Fig. 3 (blue, K1; yellow, K2; green, K3; tan; K4). Strata involved in the Beaufortian Lower Jurassic Topset Play are outlined by black dotted line. "Regional" migration is inferred to have occurred along regionally extensive migration pathways, such as the Lower Cretaceous Unconformity (LCU) and the Sag River Sandstone. "Local" migration is inferred to have occurred along sub-regional or local migration pathways, such as clinoforms within Beaufortian strata and fractures.

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 Figure 24

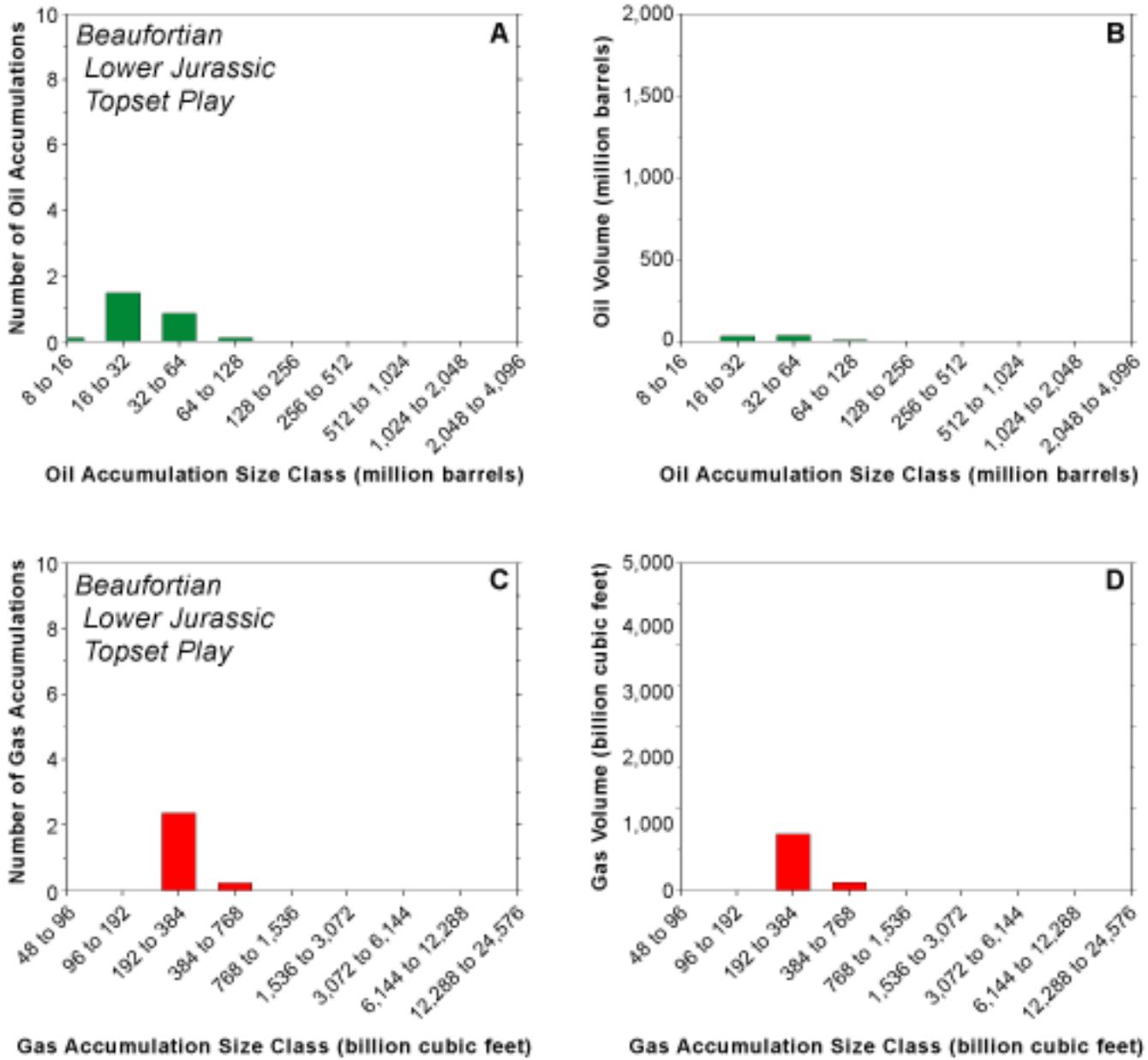


Figure 24. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Lower Jurassic Topset Play. *A.* Number of oil accumulations in various oil accumulation size classes. *B.* Volume of oil in various oil accumulation size classes. *C.* Number of nonassociated gas accumulations in various gas accumulation size classes. *D.* Volume of nonassociated gas in various gas accumulation size classes.

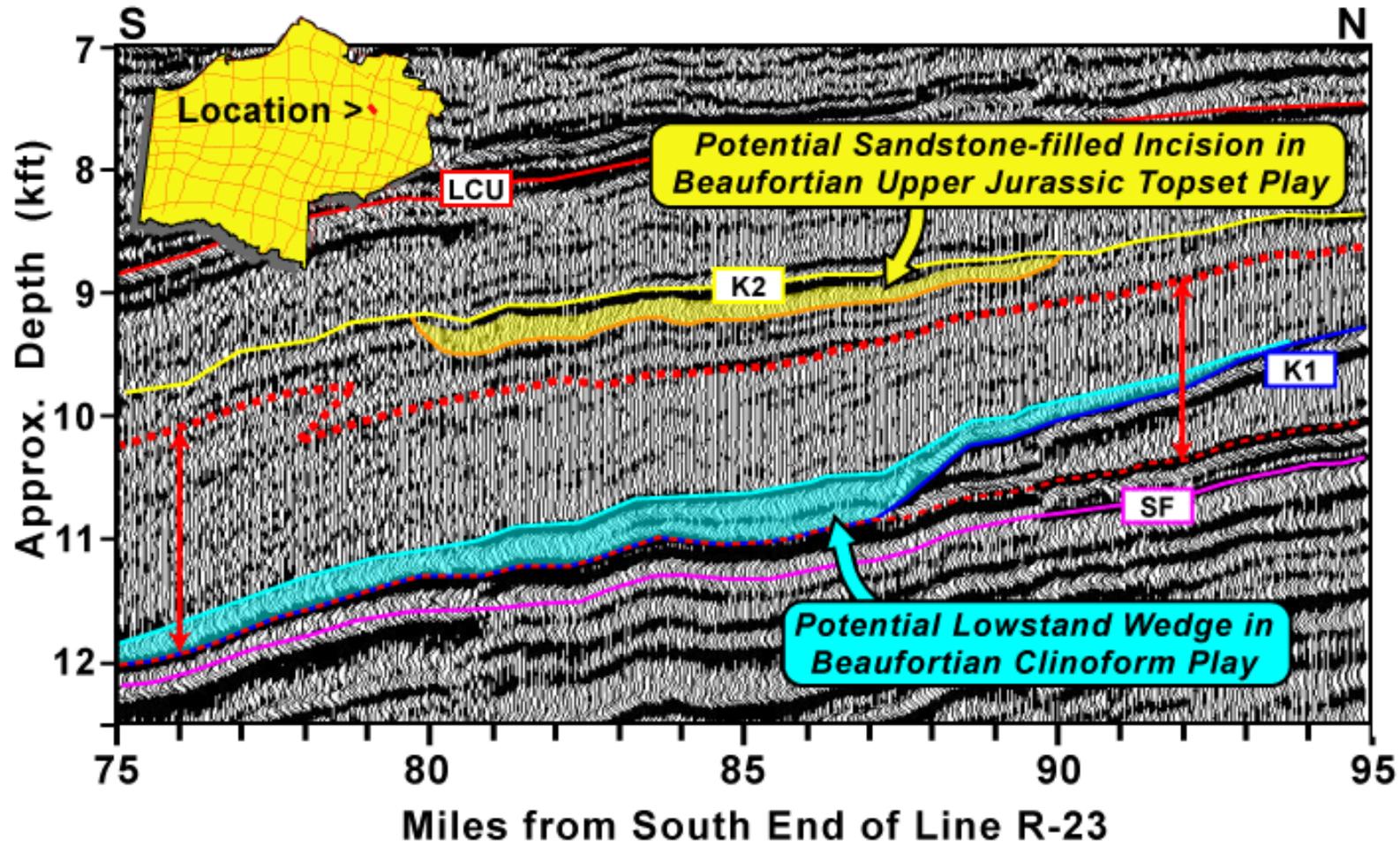


Figure 25. Seismic expression of Beaufortian clinoform lowstand wedge (highlighted in blue), which pinches out via updip onlap to north and thins gradually downdip to south. Note internal reflection that appears to onlap basal sequence boundary at mile 87 and that pinches out at mile 83. Beaufortian clinoform play interval is indicated by red dashed lines and arrows. This seismic line segment also has a feature (highlighted in yellow) near the top of sequence set K2 that is interpreted as an incision similar to that shown in Fig. 16C. Labeled stratigraphic horizons: SF = top Shublik Formation; K1 = top Kingak K1 sequence set; K2 = top Kingak K2 sequence set; LCU = Lower Cretaceous unconformity.

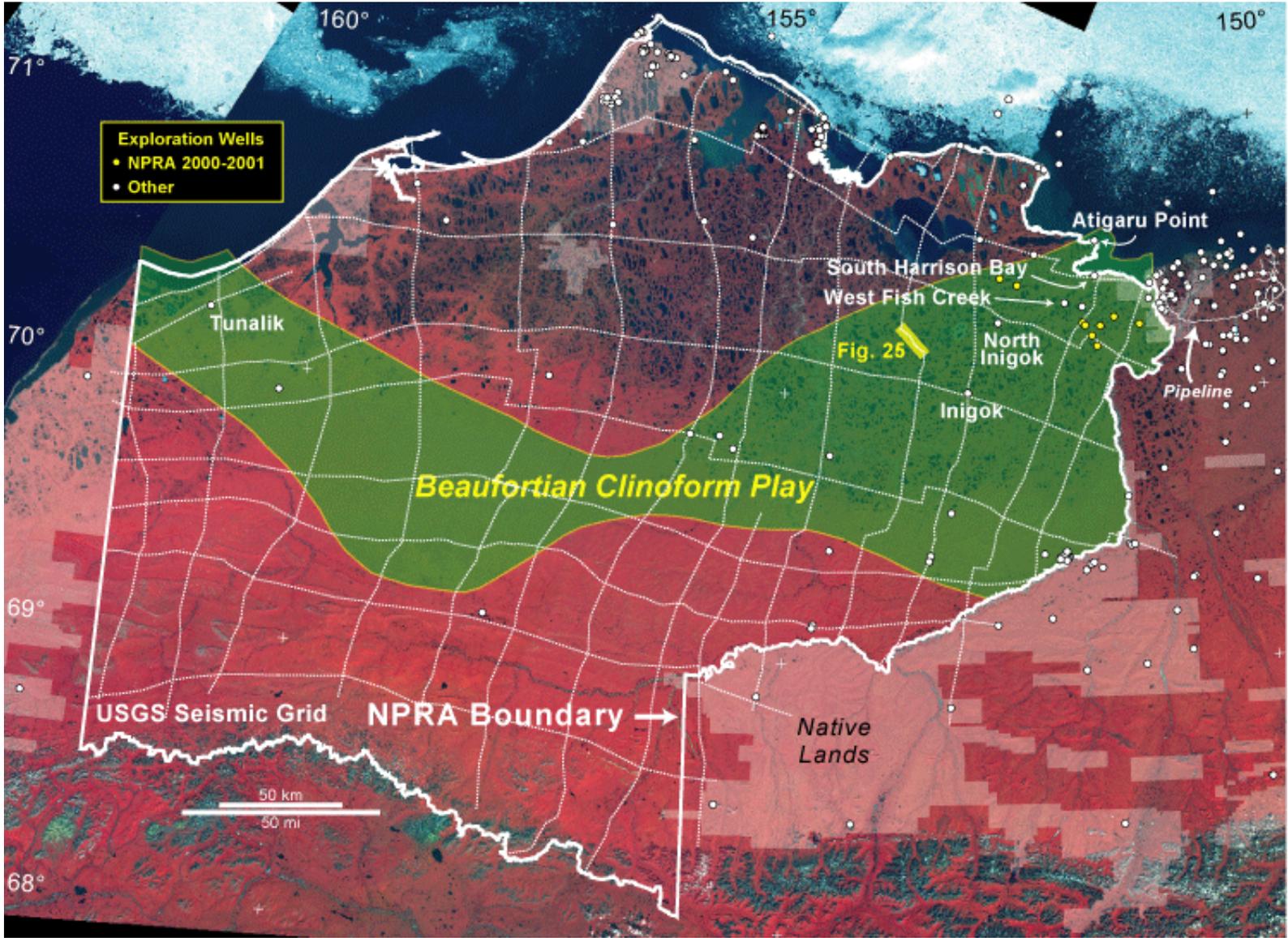


Figure 26. Map of Beaufortian Clinoform Play. Names of selected wells mentioned in text are shown in white. Location of seismic section shown in Fig. 25 also is shown.

Figure 27

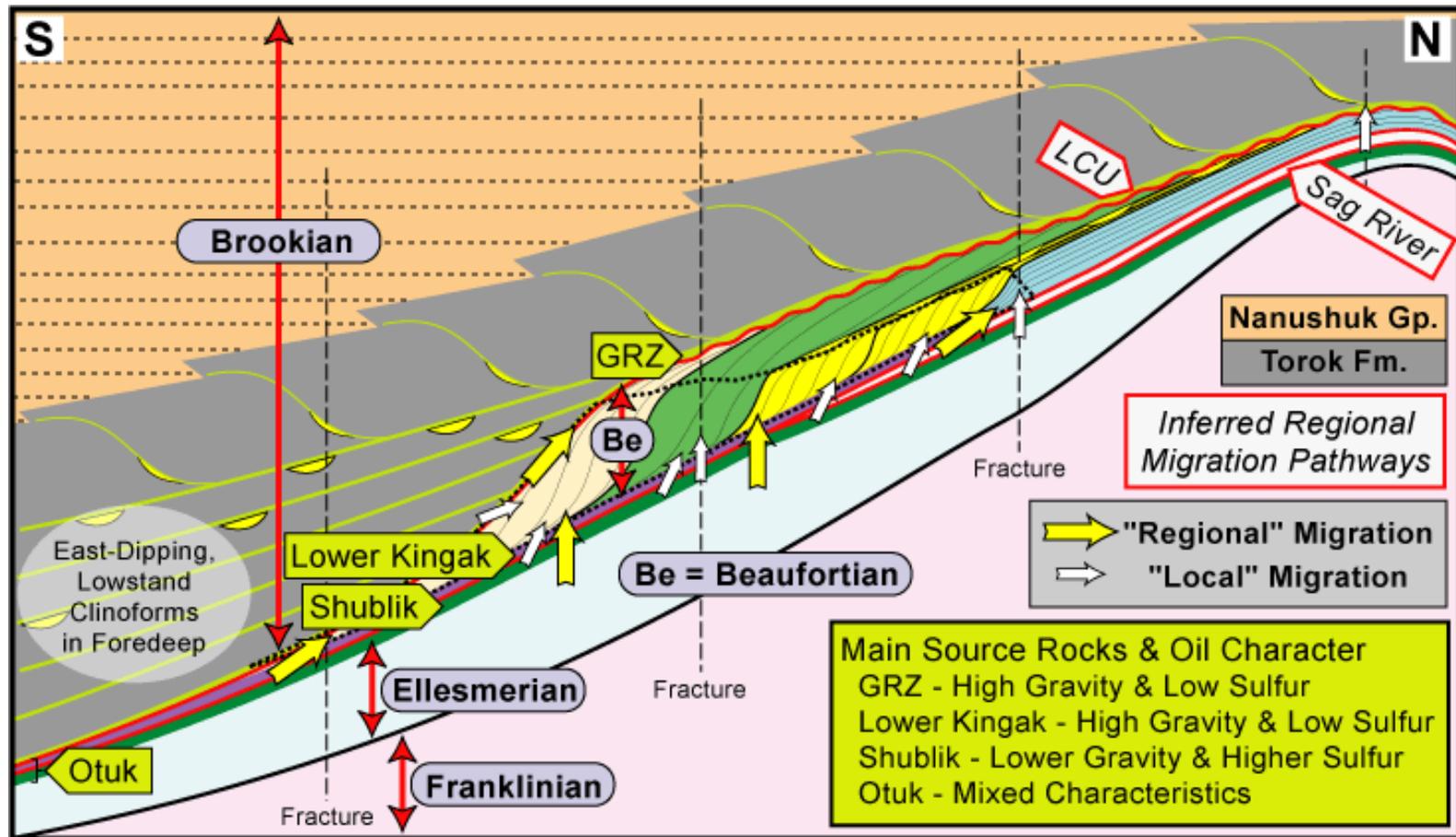


Figure 27. Schematic south-north cross section in eastern NPRA showing stratigraphic positions of major source rocks, generalized geometry of Brookian and Beaufortian strata, and inferred scenarios for migration of hydrocarbons from source rocks to stratigraphic traps in the Beaufortian Clinoform Play. Colors of Beaufortian strata are same as sequence sets defined in Fig. 3 (blue, K1; yellow, K2; green, K3; tan; K4). Strata involved in the Beaufortian Clinoform Play are outlined by black dotted line. “Regional” migration is inferred to have occurred along regionally extensive migration pathways, such as the Lower Cretaceous Unconformity (LCU) and the Sag River Sandstone. “Local” migration is inferred to have occurred along sub-regional or local migration pathways, such as clinofolds within Beaufortian strata and fractures.

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 Figure 28

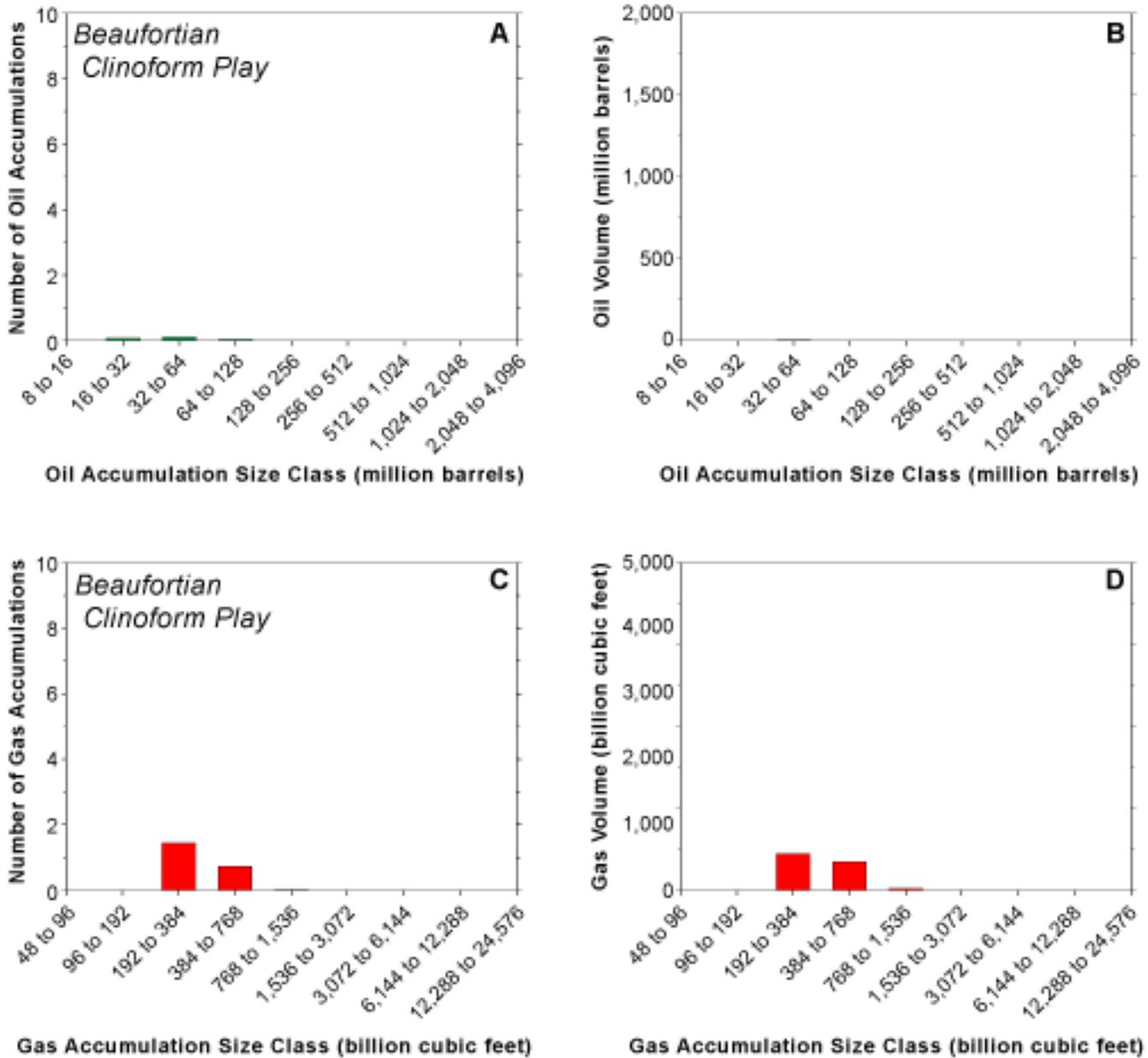


Figure 28. Histograms of oil and nonassociated natural gas estimated to occur in accumulations of various sizes in the Beaufortian Cliniform Play. *A*. Number of oil accumulations in various oil accumulation size classes. *B*. Volume of oil in various oil accumulation size classes. *C*. Number of nonassociated gas accumulations in various gas accumulation size classes. *D*. Volume of nonassociated gas in various gas accumulation size classes.