What Now? Developing Conventional Reservoirs Unconventionally (or Otherwise)*

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Abstract

Activity in the oil patch over the last decade has focused more on the unconventional shale gas, shale oil, and other "resource"-type plays, to varying success, than on conventional, lower cost exploration and development. Improved fracture technology, large shale resources, and higher oil prices had driven the push to develop these resources, and it paid off in providing our country with more energy independence. The economics of many of these plays, however, even during the period of high oil prices, were, in places, marginal to uneconomic, with notable exceptions. Part of the problem with developing economic resource plays is a lack of understanding of the geology and long-term decline characteristics of those reservoirs, as many of them had not been producing long enough to get a good sense of their projected performance. Many of the plays are statistically, rather than scientifically driven. The "follow the leader" mentality in the industry often created a void in the search for more proven, conventional reservoirs, drove up leasing costs wherever it was perceived there was even proximity to a shale play, and severely impaired the ability of smaller players to be involved with conventional reservoirs in or out active resource play areas.

Development of conventional reservoirs in the United States had taken a back seat to the unconventional and resource plays, even though many opportunities have always existed for new field, infill, and step-out development in old fields. As we are, at least temporarily, entrenched in another cycle of depressed oil prices, the need to hunker down with real science to develop lower-(finding)cost reserves is of paramount concern to many companies that are heavily invested in higher-cost shale and resource plays, and to smaller players who may now be able to have the breathing room they need to acquire acreage where they were previously pre-empted because of artificially inflated leasing costs brought on by shale plays. Now, more than ever, if vendor prices come down commensurate with oil prices, modern drilling and completion technologies can be applied to the conventional reservoirs, as a means of accelerating production from old fields and in step-out development. A number of conventional reservoirs in the Permian, Denver, and Williston Basins (and elsewhere) are amenable to step-out development and horizontal drilling, and would benefit by the extraction of bypassed reserves, and accelerated production of lower permeability reservoirs.

An understanding of reservoir development and geometry is essential to the success of such plays, and so requires that we get back to the science of exploration, if we have the resources to work through the present downturn. Examples of such potential plays are presented for the Morrow of the Permian and Denver Basins, Cisco-Canyon of the Permian Basin, and the Madison of the Williston Basin.

WHAT NOW? DEVELOPING CONVENTIONAL RESERVOIRS UNCONVENTIONALLY (OR OTHERWISE)

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UNCONVENTIONAL VS. CONVENTIONAL PLAYS

- **RESOURCE PLAYS (e.g., "WOLFBERRY") AIMED AT STATISTICAL REPEATABILITY, NOT ALWAYS BASED ON GEOLOGIC MODELING OF THE RESERVOIRS. MULTI-STAGE COMPLETIONS SELDOM LOOK AT THE CONTRIBUTIONS OF INDIVIDUAL ZONES TO THE TOTAL PRODUCTION BUDGET, SO WE DON'T OFTEN KNOW WHERE THE OIL IS COMING FROM, AND RISK CROSS-FLOW.**

- **HORIZONTAL RESOURCE PLAYS (e.g., "CLINE", NIOBRARA) ARE HIGH RISK AND DEPENDENT UPON BRITTLENESS TO MAINTAIN OPEN FRACTURES. OFTEN COME ON STRONG, BUT VARIABLY SUSTAIN PRODUCTION AND PAYOUT. *HIGH DRILLING COSTS, ECONOMICS ARE MORE SENSITIVE TO OIL PRICE FLUCTUATIONS.***

- **CONVENTIONAL RESERVOIRS ARE BETTER UNDERSTOOD, MAPABLE, AND EASIER TO PREDICT WITH A GOOD UNDERSTANDING OF THE GEOLOGY AND ARCHITECTURE OF THE RESERVOIRS. THEY ARE PROVEN PRODUCERS IN VERTICAL WELLS, AND MANY MAY BENEFIT FROM UNCONVENTIONAL DEVELOPMENT TECHNIQUES.**

- **THERE IS A LOT OF BYPASSED AND UNDER-DEVELOPED PAY IN ESTABLISHED AND YET-TO-BE-DISCOVERED CONVENTIONAL RESERVOIRS BECAUSE OF INSUFFICIENT DRAINAGE AND MIS-UNDERSTANDING OF RESERVOIRS, AND LACK OF ATTENTION TO THESE PLAYS IN FAVOR OF UNCONVENTIONALS. EXISTING WELL CONTROL, PROVEN EXPLORATION METHODS, AND GEOLOGIC MODELS ARE AVAILABLE TO FACILITATE THEIR DEVELOPMENT.**

- **LESS STAGES OF COMPLETION MAY BE NEEDED IN MANY CONVENTIONAL RESERVOIRS= LESS DRILLING AND COMPLETION COSTS. IDEALLY SUITED FOR TODAY'S PRICE ENVIRONMENT, AS LONG AS VENDOR COSTS COME IN LINE.**

OBJECTIVES OF HORIZONTAL DRILLING IN CONVENTIONAL RESERVOIRS

- EXPOSE MORE FORMATION TO THE WELLBORE BY DRILLING ALONG PREFERRED DEPOSITIONAL DIRECTIONS, AND STEERING TO STAY IN ZONE

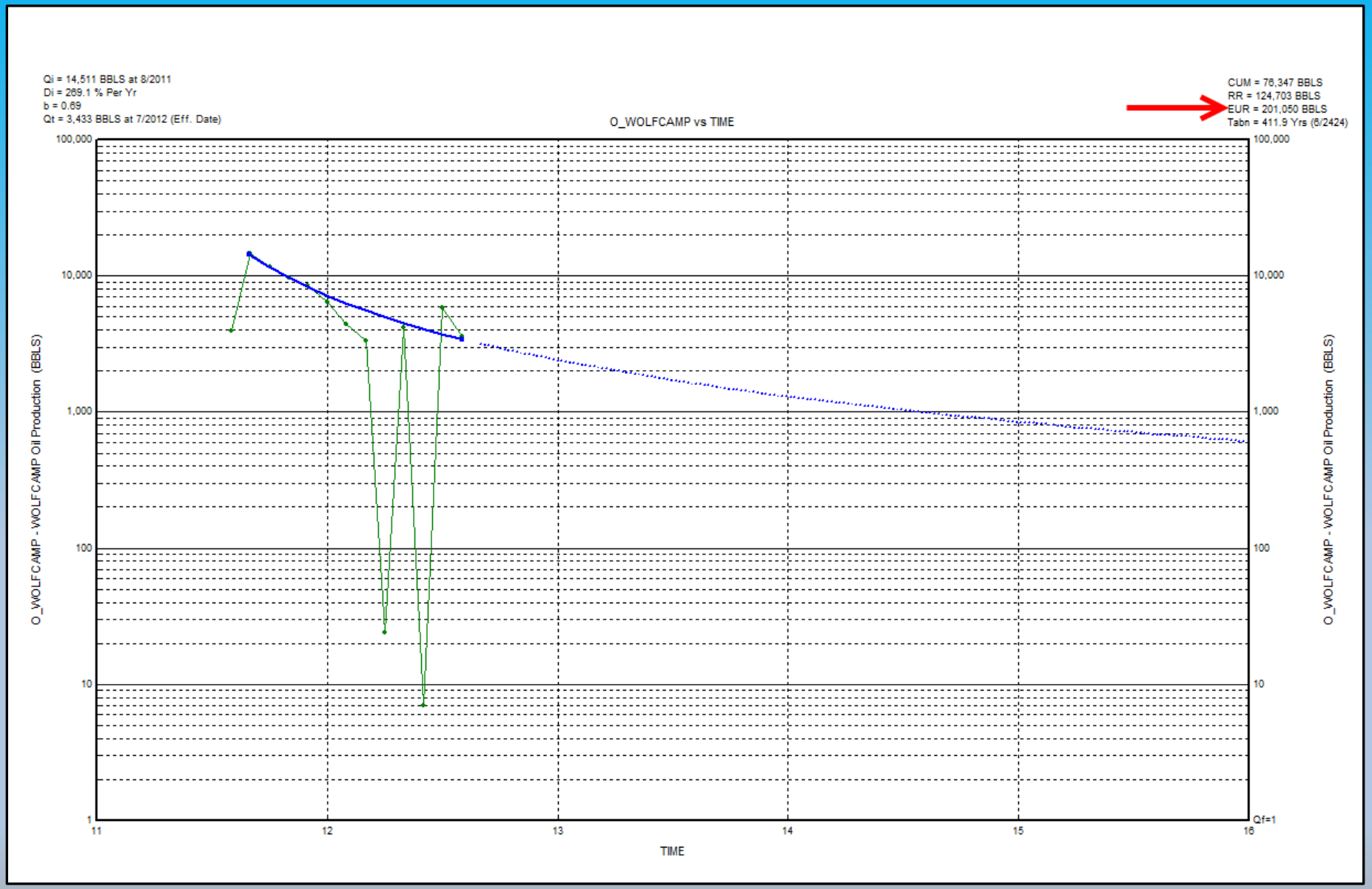
- MINIMIZE WATER CONING BY SPREADING THE PRESSURE DROP ACROSS A LONGER WELLBORE INTERVAL

- MORE EFFICIENT DRAINAGE OF THE RESERVOIR USING GEOLOGIC MODELS, AND FEWER NUMBER OF SURFACE LOCATIONS (LIMIT THE NUMBER OF “STRAWS” IN THE POOL)

- MORE COST-EFFICIENT WAY TO DEVELOP BYPASSED PAY, SOURCE ROCKS, AND "ATTIC" OIL IN APPROPRIATE CASES

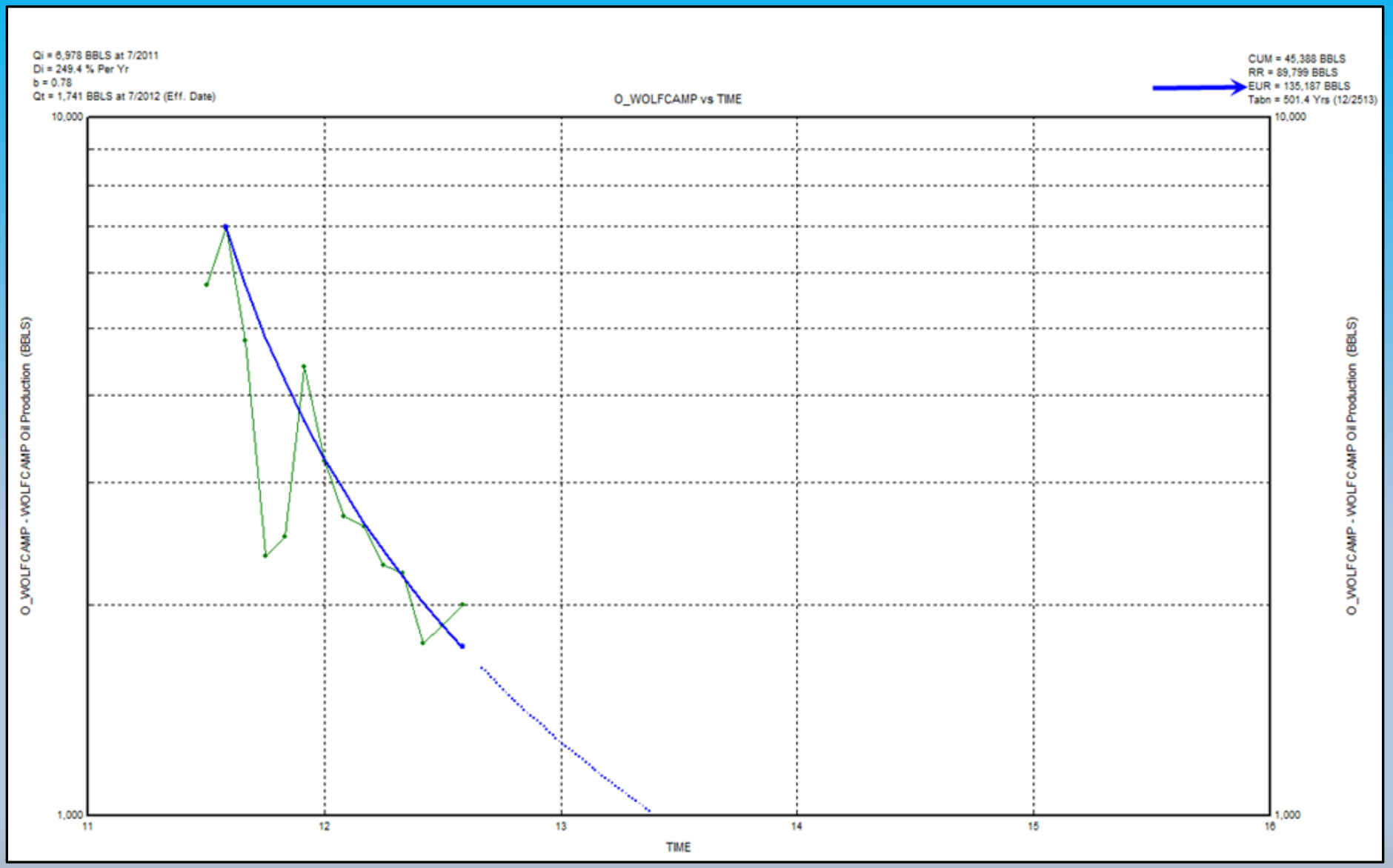
- ACCELERATE PRODUCTION AND PAYOUT, PARTICULARLY IN LOW PERMEABILITY RESERVOIRS AND LOWER OIL PRICE ENVIRONMENT

CLINE SHALE, PERMIAN BASIN: BETTER PERFORMER



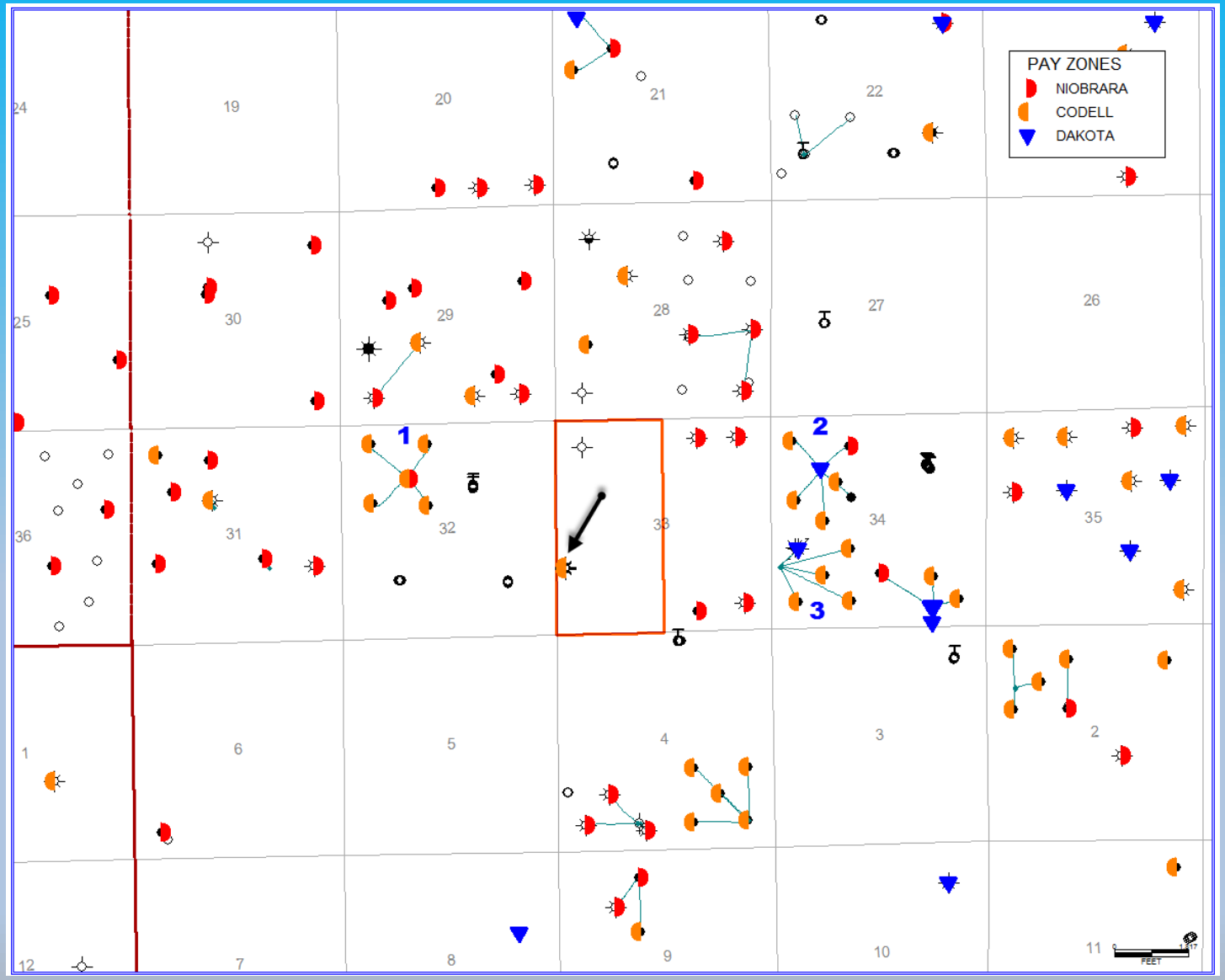
OPERATORS CLAIM UP TO 450,000 BO/WELL OR MORE

CLINE SHALE, PERMIAN BASIN: MORE TYPICAL PERFORMER



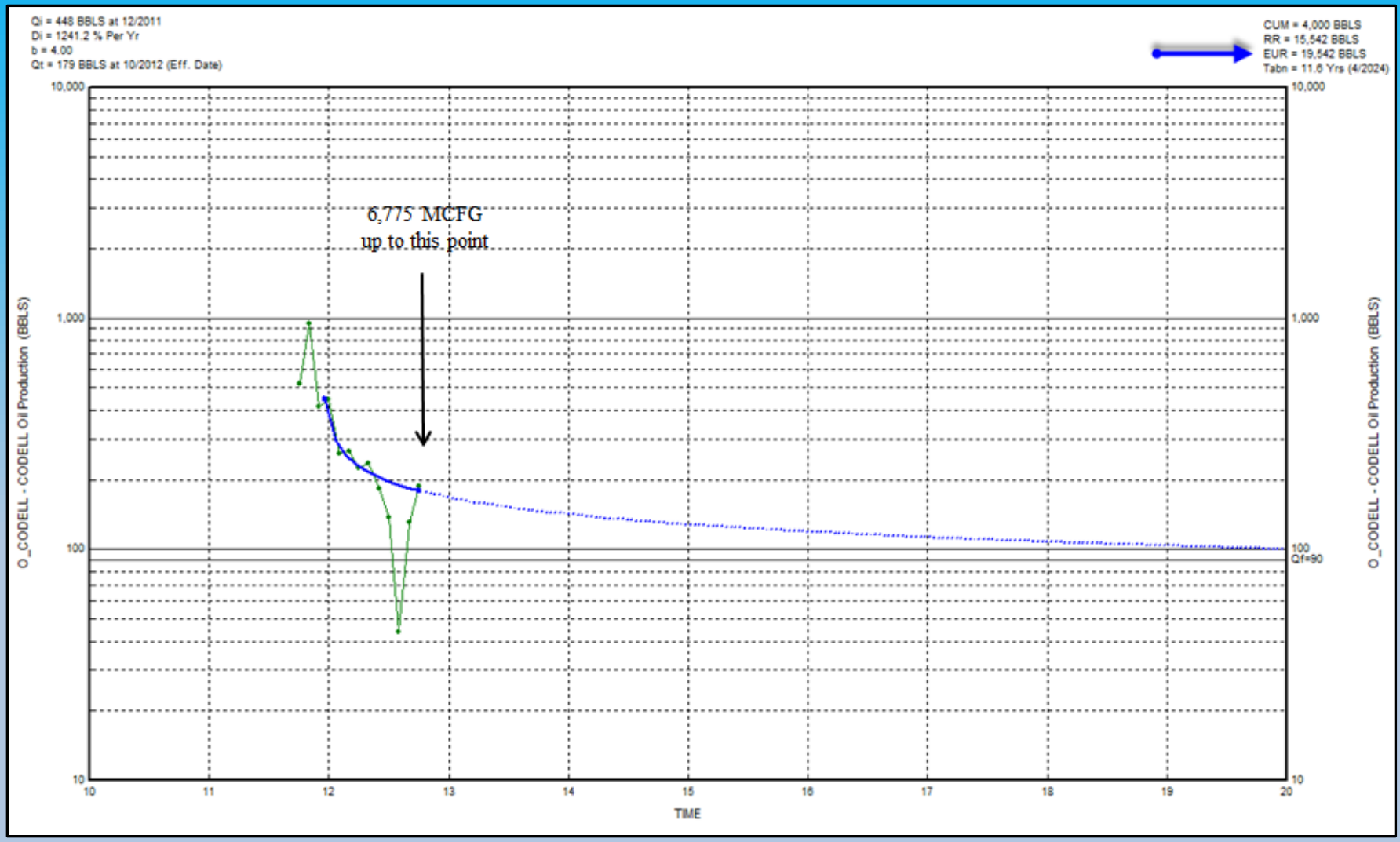
MANY WELLS WILL FAIL TO MAKE THIS NUMBER UNLESS FRACTURED MULTIPLE TIMES

NIOBRARA, D-J BASIN: SHORT LATERAL DEVIATED CASE



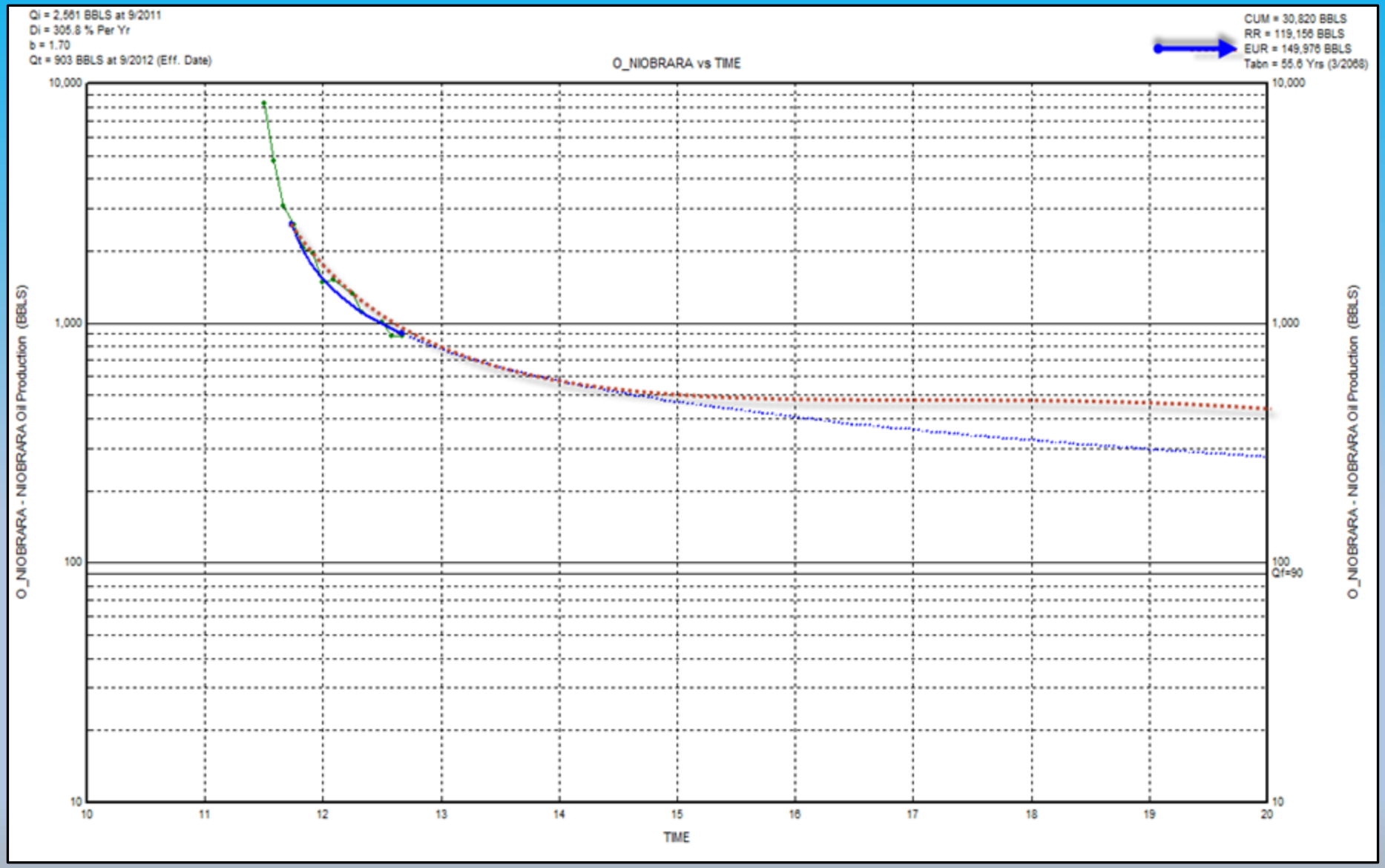
IN THIS CASE, HARD-PRESSED TO MAKE MORE THAN AN AVERAGE OF 31,000 BO

NIOBRARA, D-J BASIN: SHORT LATERAL DEVIATED CASE



IN THIS CASE, HARD-PRESSED TO MAKE MORE THAN AN AVERAGE OF 31,000 BO

NIOBRARA, D-J BASIN: TYPICAL LONG LATERAL CASE



A SHALLOWER DECLINE (RED) MIGHT YIELD MORE, BUT OVER WHAT PERIOD OF TIME?

CONVENTIONAL RESERVOIR EXAMPLES

MADISON GROUP, WILLISTON BASIN

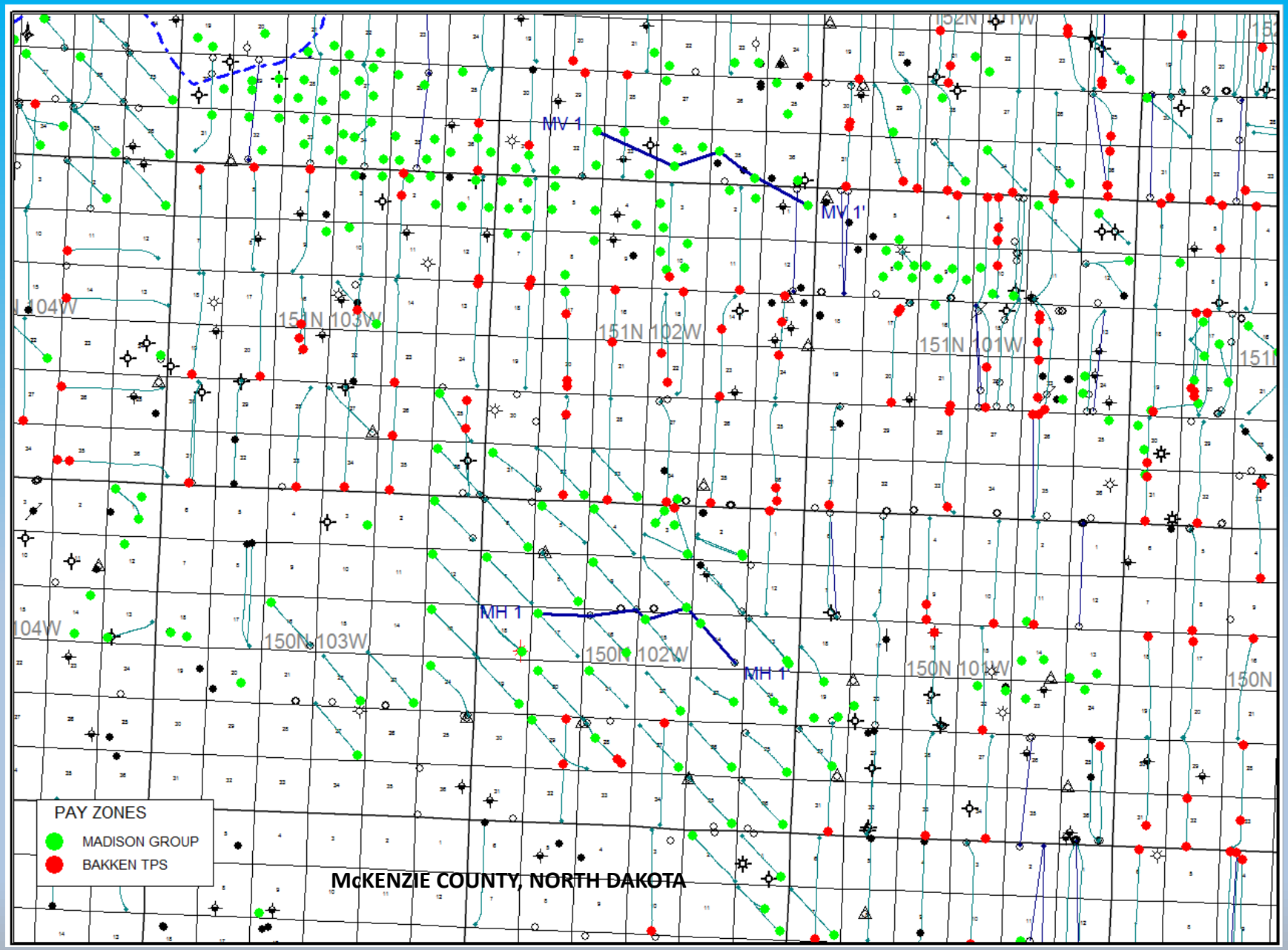
- ONE OF THE OLDEST PRODUCING HORIZONS IN THE WILLISTON BASIN, ACCOUNTS FOR 60% OF ALL OIL PRODUCED HISTORICALLY IN THE BASIN BEFORE THE BAKKEN-THREE FORKS KICKED IN

- MISSISSIPPIAN MOUNDS, LIMITED AREAL AND LATERAL EXTENT IN ANY GIVEN SEQUENCE, MULTIPLE, DISCRETE PAY HORIZONS IN SOME PLACES

- LOW PERMEABILITY RESERVOIRS, MODERATE TO LOW WATER CUTS IN SOME PLACES

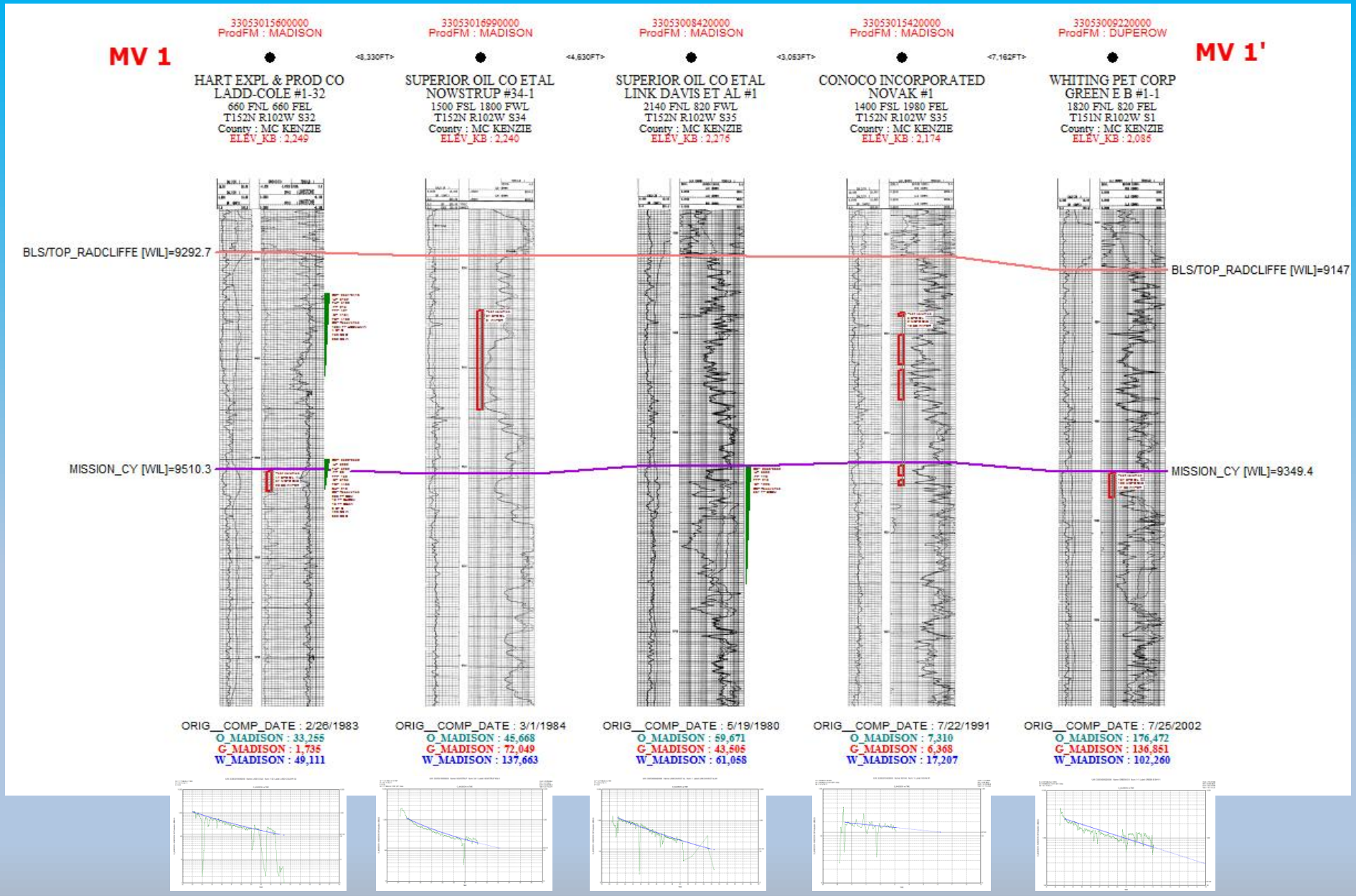
- SHALLOWER THAN THE BAKKEN, ESPECIALLY AWAY FROM THE DEEPER BASIN BAKKEN PLAY AREAS, WITH OLDER FIELDS THAT COULD BE ACQUIRED FOR INFILL AND STEP-OUT RE-DEVELOPMENT

- SHALLOWER AREAS IN THE BASIN WITH RELATIVELY LITTLE DEVELOPMENT ARE IDEAL FOR EXPLORATION

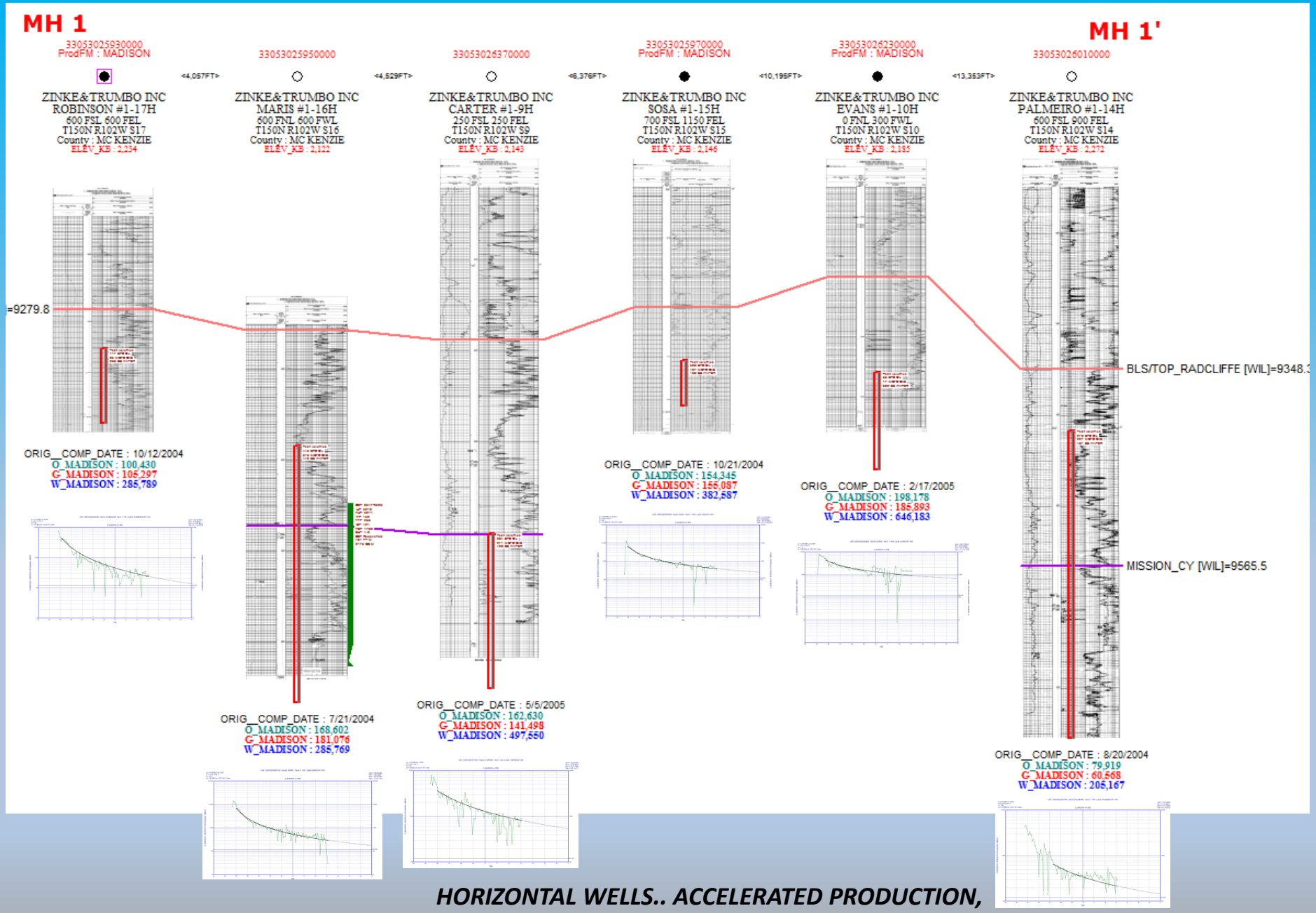


MADISON: 1980s VERTICAL WELLS

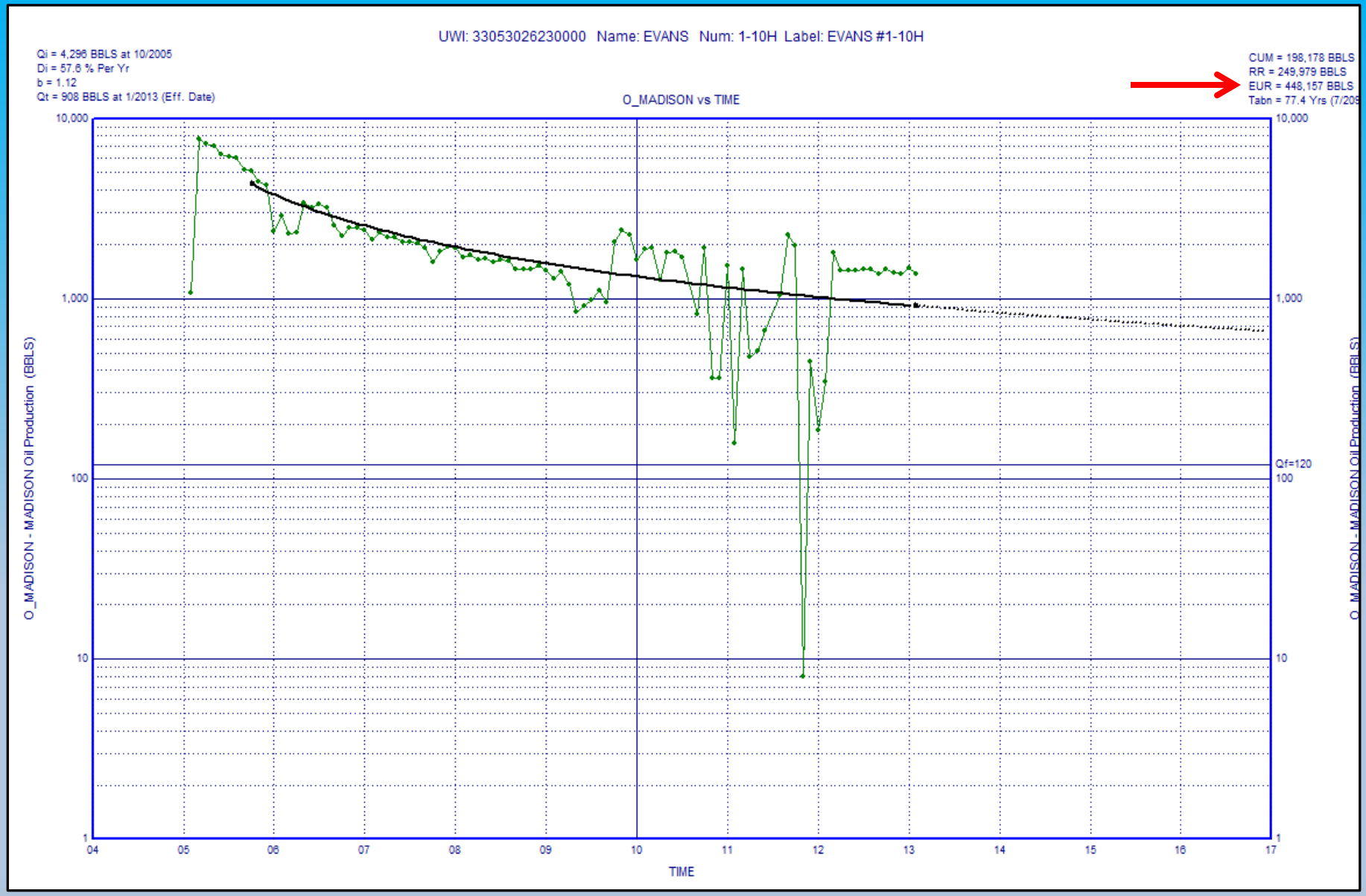
EARLY TO LATE 2000Ss HORIZONTALS, NONE DRILLED SINCE BAKKEN TOOK OVER



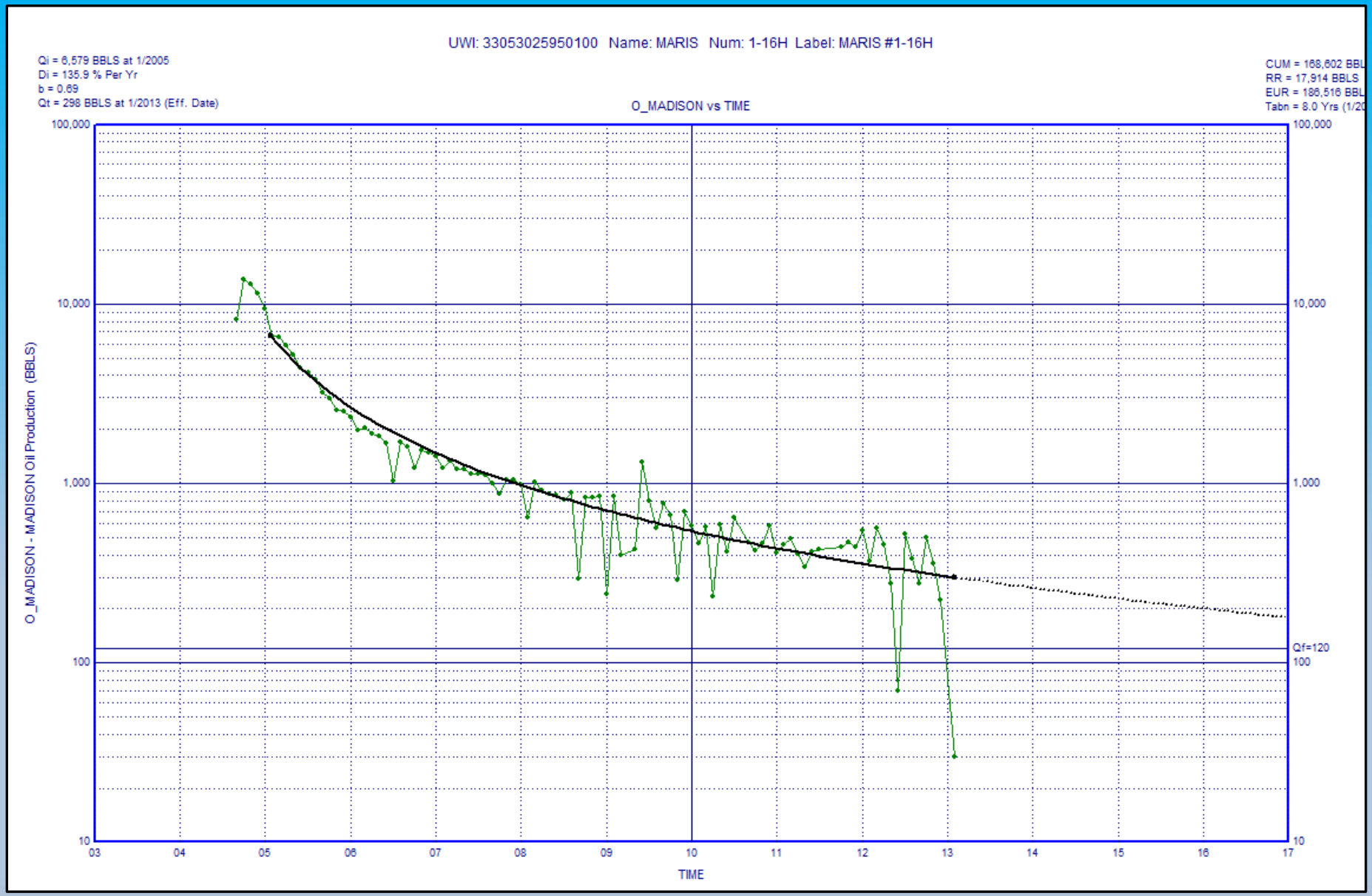
OLDER, VERTICAL WELLS; GENERALLY LONG-LIVED (30+ YEARS), LINEAR DECLINE



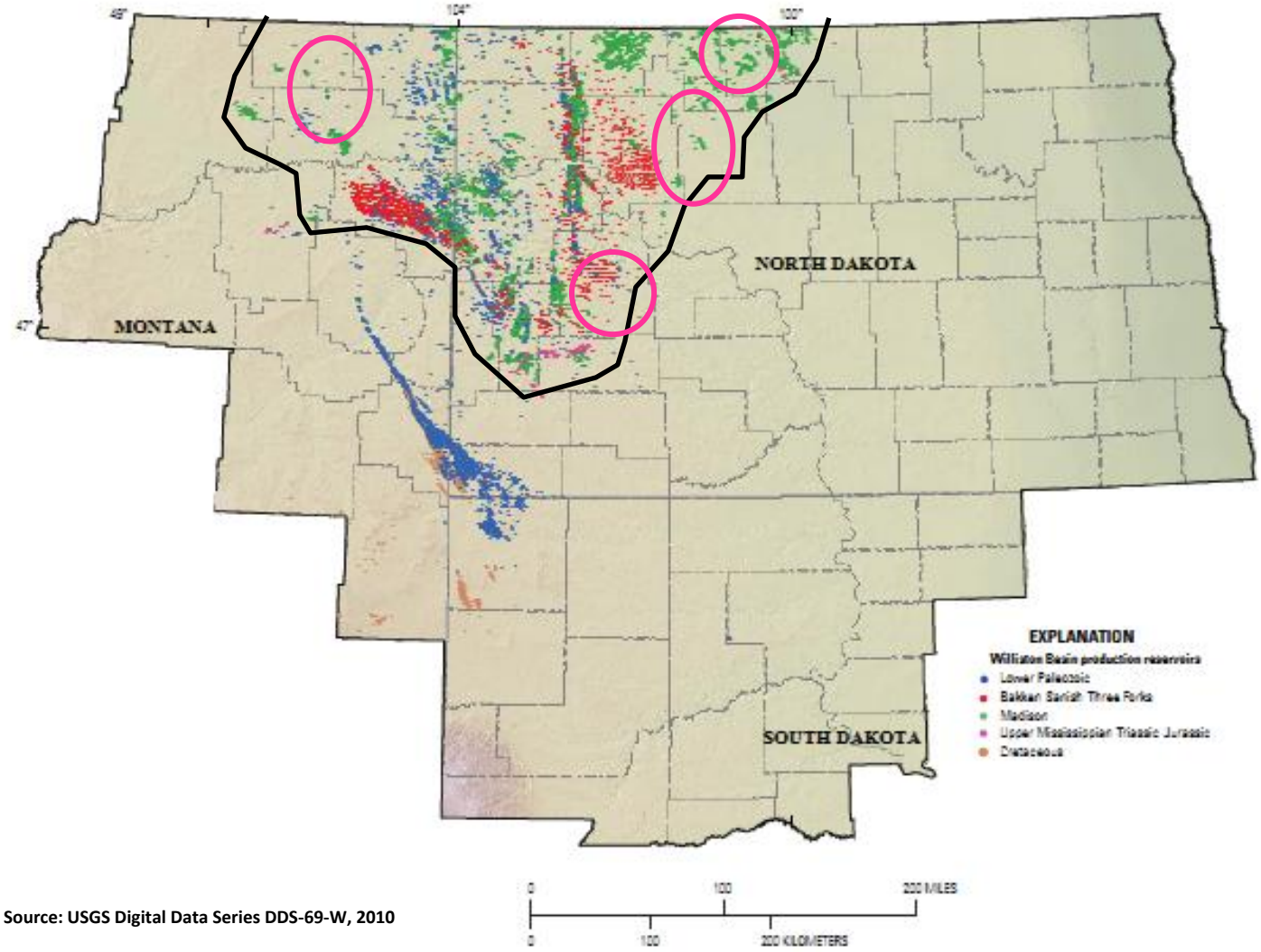
HORIZONTAL WELLS.. ACCELERATED PRODUCTION, HYPERBOLIC DECLINE, GENERALLY 2-4X PRODUCTION INCREASE OVER A SHORTER PERIOD



ONE OF THE BETTER-PERFORMING HORIZONTAL WELLS PROJECTS TO AN EUR OF NEARLY 450,000 BO, WITH A RELATIVELY FLAT HYPERBOLIC DECLINE. <u>UP TO A 9X INCREASE OVER THE AVERAGE VERTICAL WELL SHOWN PREVIOUSLY.</u>



AN AVERAGE WELL IN THIS CLUSTER



Source: USGS Digital Data Series DDS-69-W, 2010

THE MADISON GROUP (GREEN) HAS THE MOST WIDESPREAD PRODUCTION THROUGHOUT THE BASIN, WITH MANY OPPORTUNITIES FOR FIELD RE-DEVELOPMENT AND NEW DRILLING AWAY FROM, AND SHALLOWER THAN, THE BAKKEN-THREE FORKS

MORROW SANDSTONES
PERMIAN BASIN, MID-CONTINENT

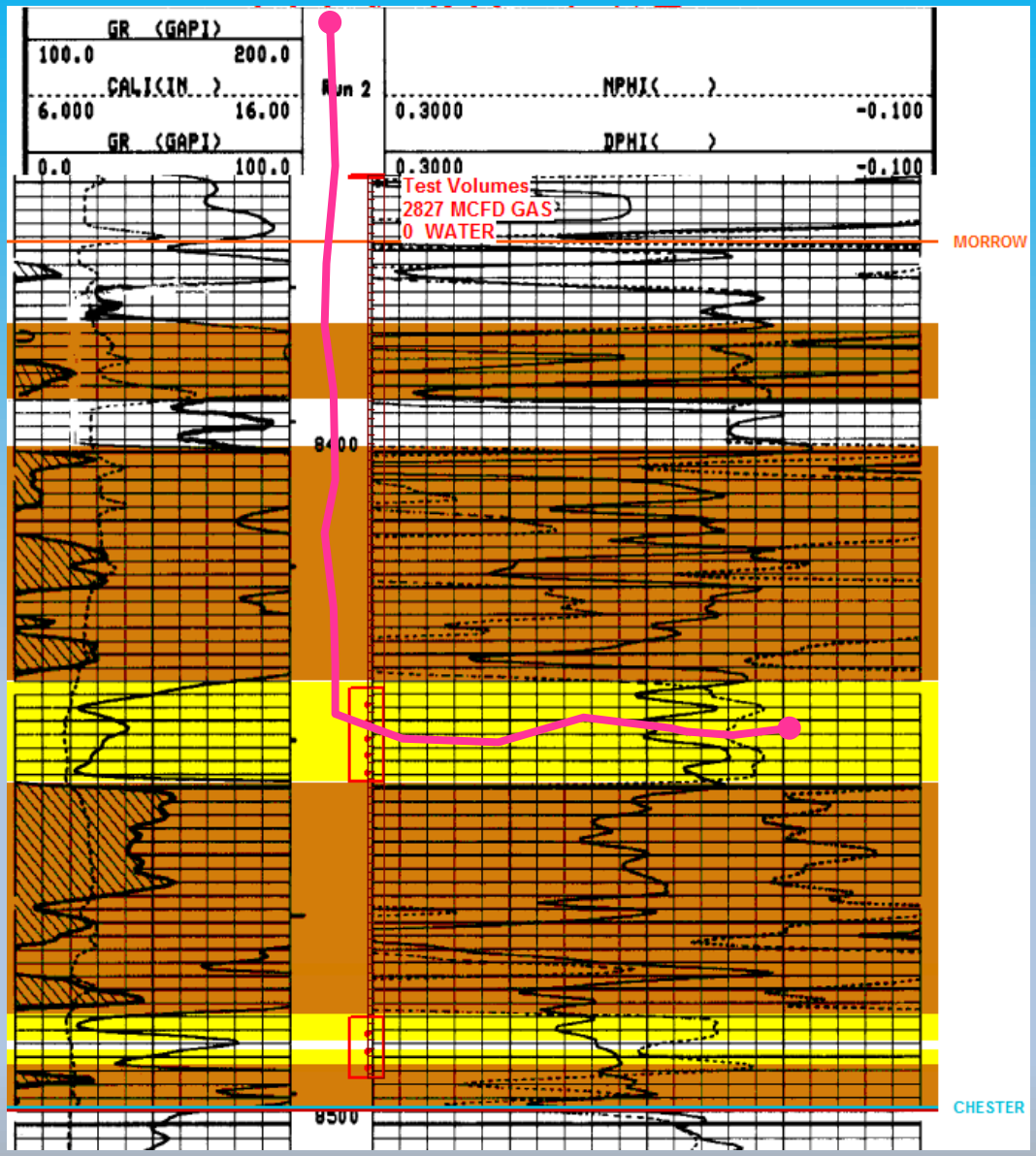
- OFTEN LOW–PERMEABILITY SANDS, RELATIVELY LOW TO NO WATER CUTS

- COMMONLY DRILLED ON SPACING UNITS RATHER THAN ON GEOLOGIC TRENDS, OR ON TRENDS NOT APPROPRIATE TO THE ACTUAL RESERVOIR ARCHITECTURE

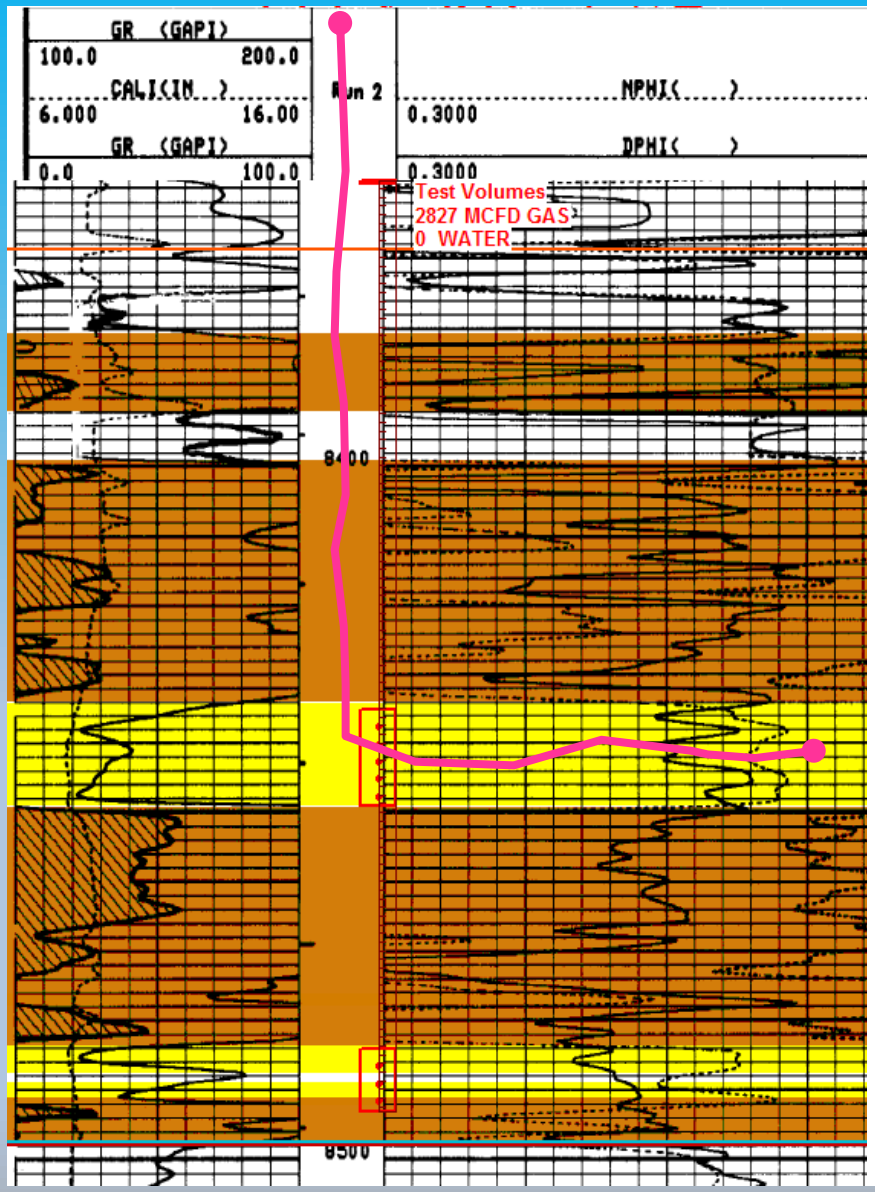
- POTENTIAL FOR HIGH PERCENTAGE OF BYPASSED RESERVES IN THE RESERVOIR, AND POSSIBLE SOURCE LIQUIDS IN THE SHALES

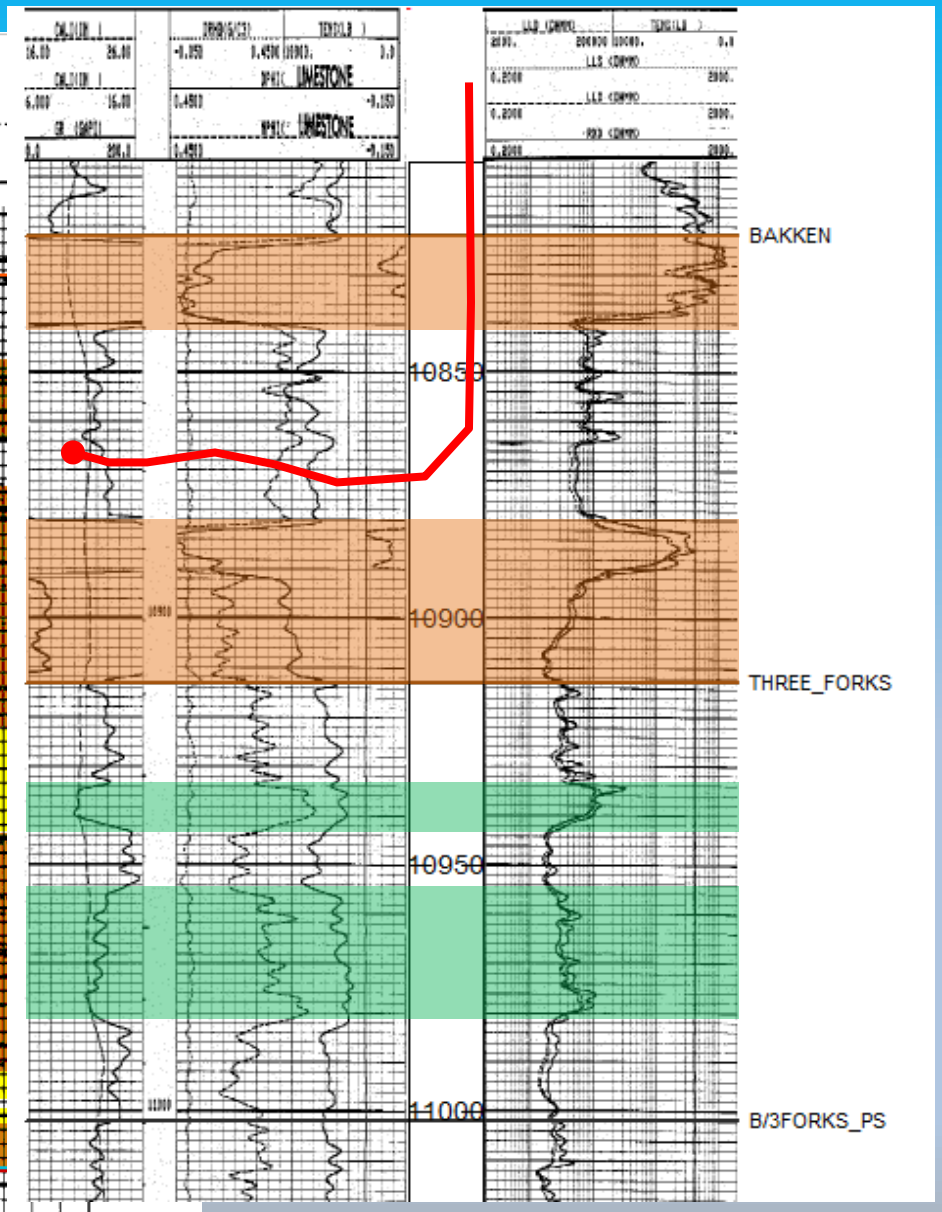
- EXAMPLES FROM GAS SANDS OF SE NEW MEXICO APPLY AS WELL TO OIL SANDS OF THE MID-CONTINENT

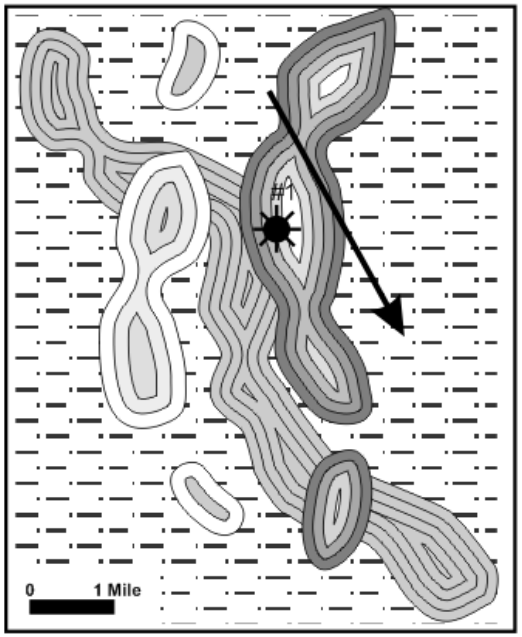
THE MORROW "SANDWICH"



VS. THE BAKKEN "SANDWICH"







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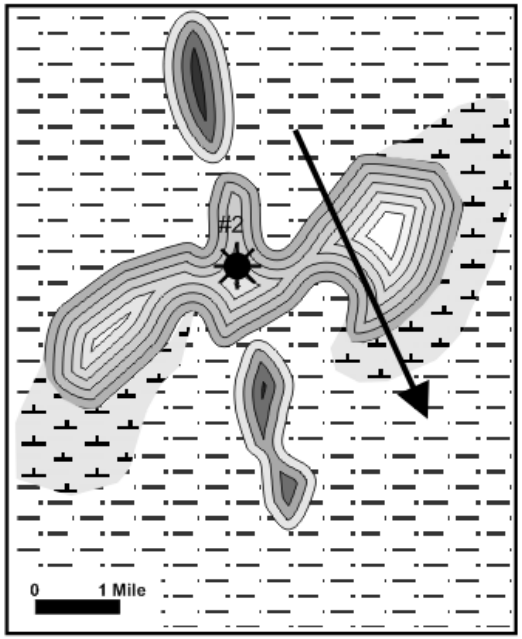
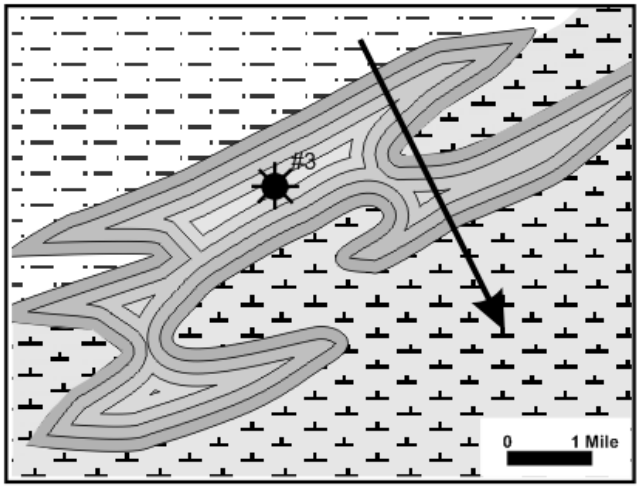


B

SANDSTONE GEOMETRY TYPES

Alluvial to transitional marine shales and silts

Marine shales and carbonates



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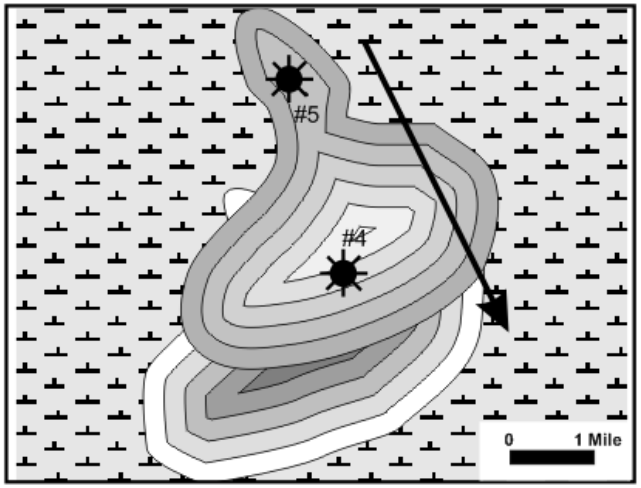
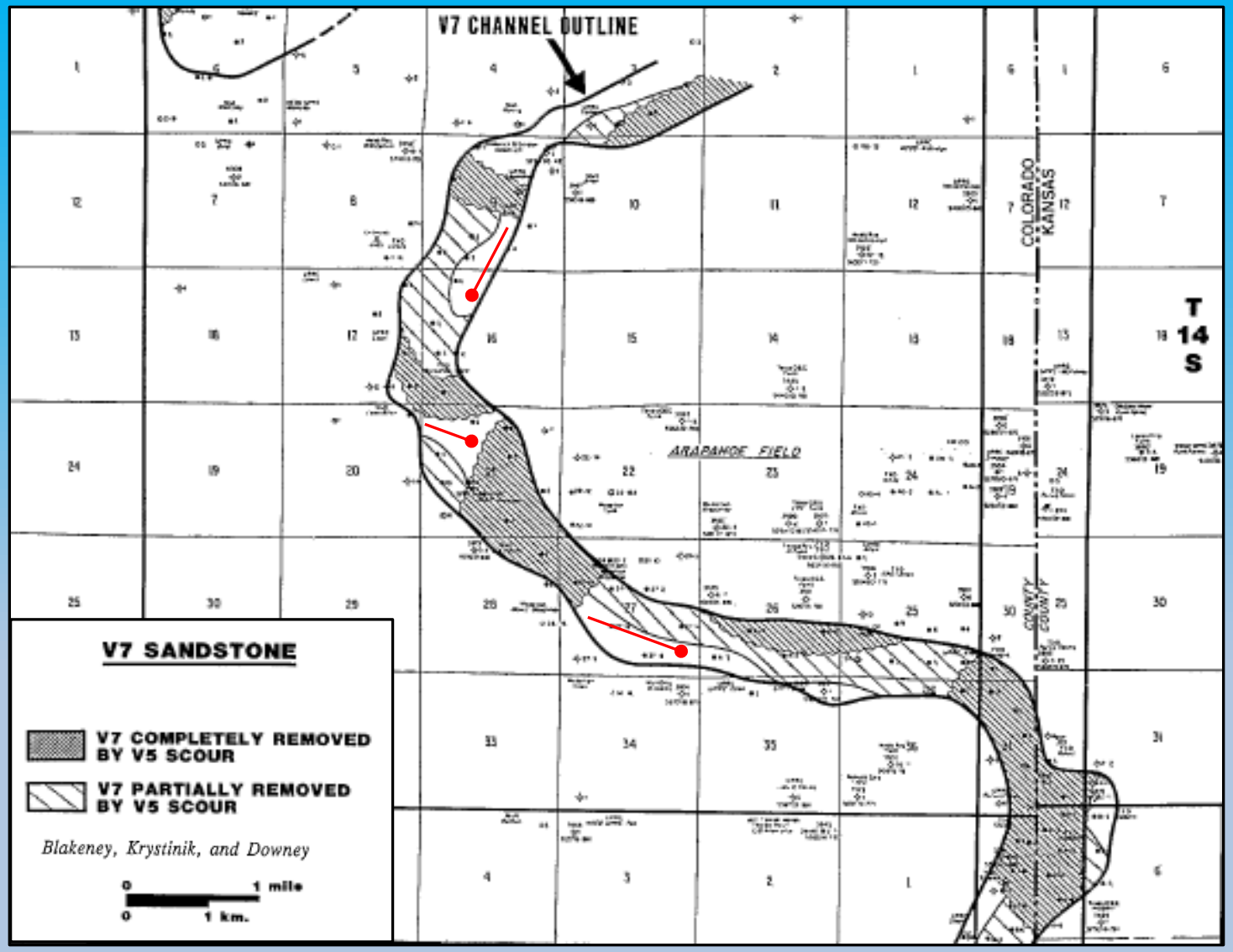
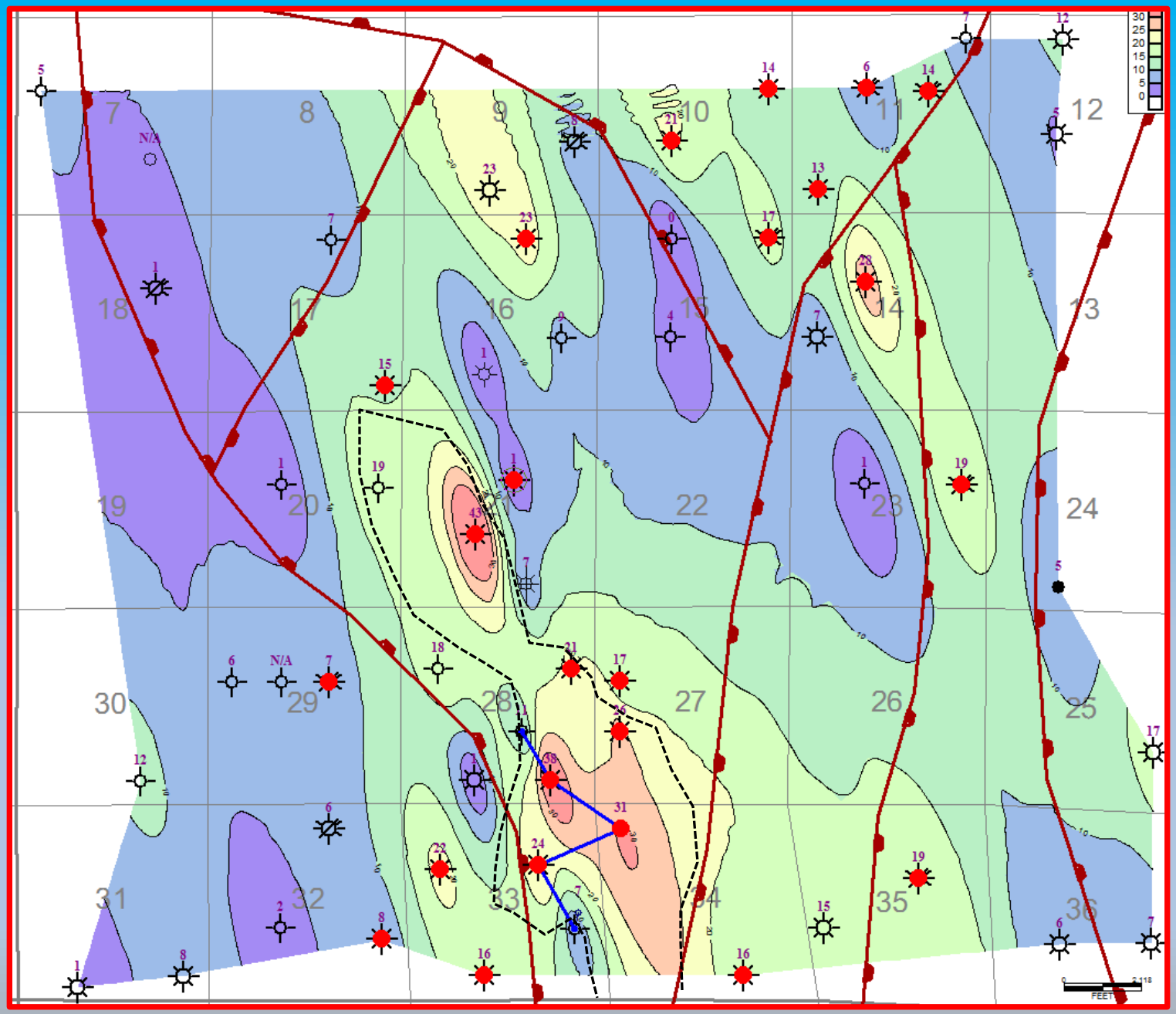


D

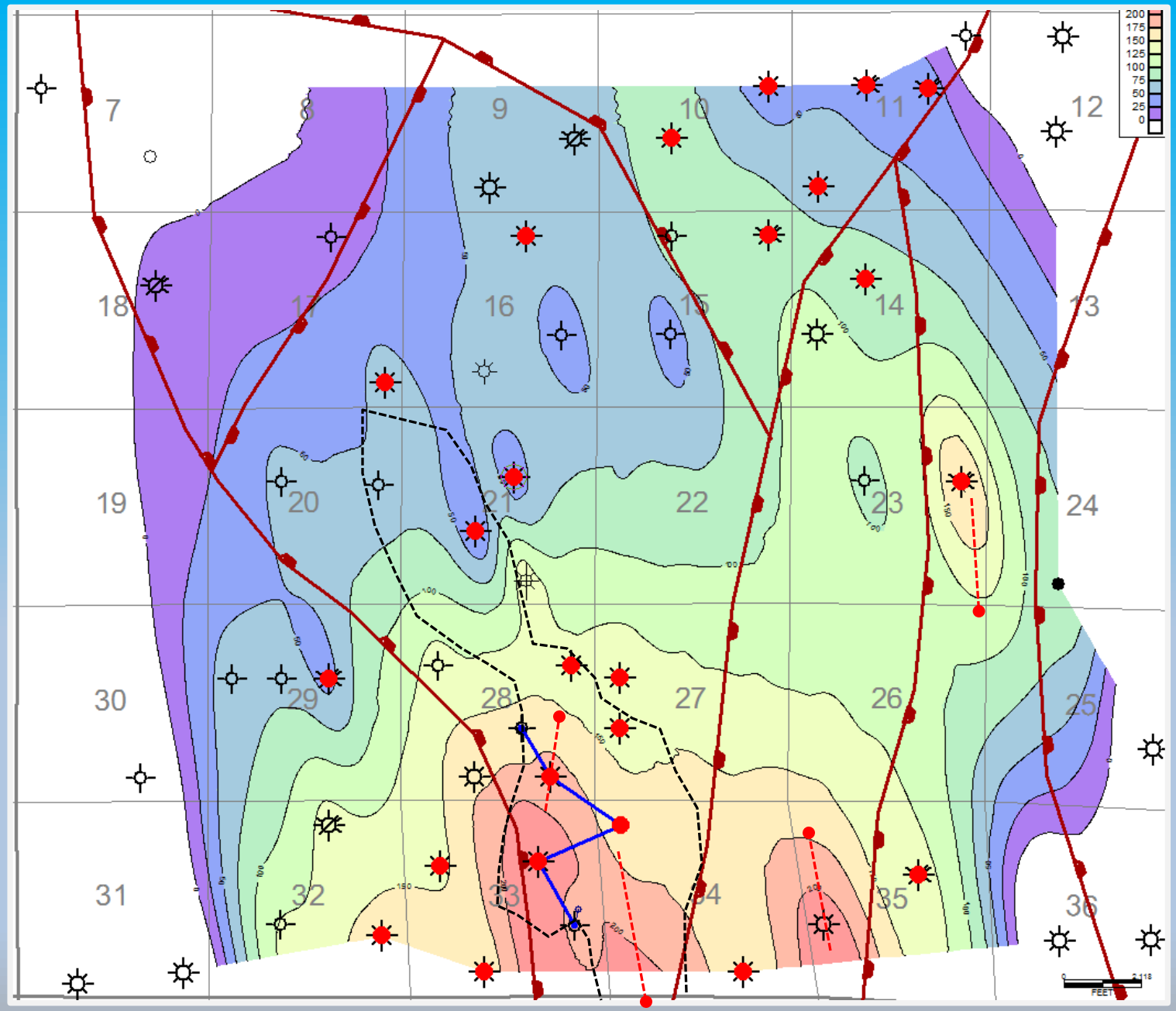
MORROW SANDS COME IN ALL KINDS OF FLAVORS. RESERVOIR ARCHITECTURE MUST BE PRECISELY MAPPED FOR HORIZONTAL DEVELOPMENT TO BE EFFECTIVE



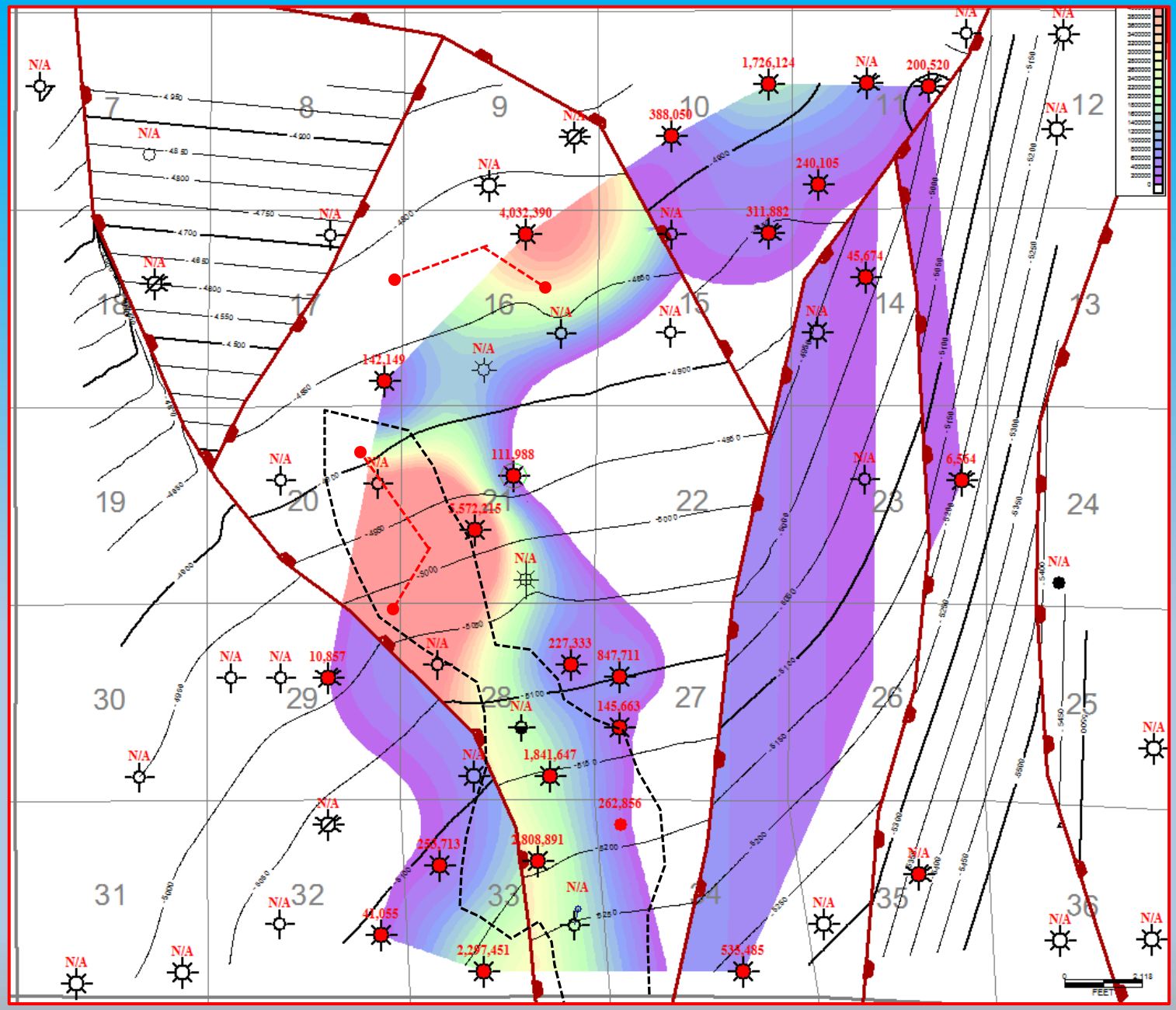
AN EXAMPLE OF COMPLEX INTERNAL RESERVOIR HETEROGENEITY, COMPARTMENTALIZATION, SE COLORADO. ONCE THESE FACTORS ARE UNDERSTOOD, DEVELOPMENT CAN BE MORE PREDICTABLE.



FLUVIALLY-DOMINATED RESERVOIR, SE NEW MEXICO. NET SAND MAP COULD BE ONE WAY TO ESTABLISH DRILLING DIRECTIONS.

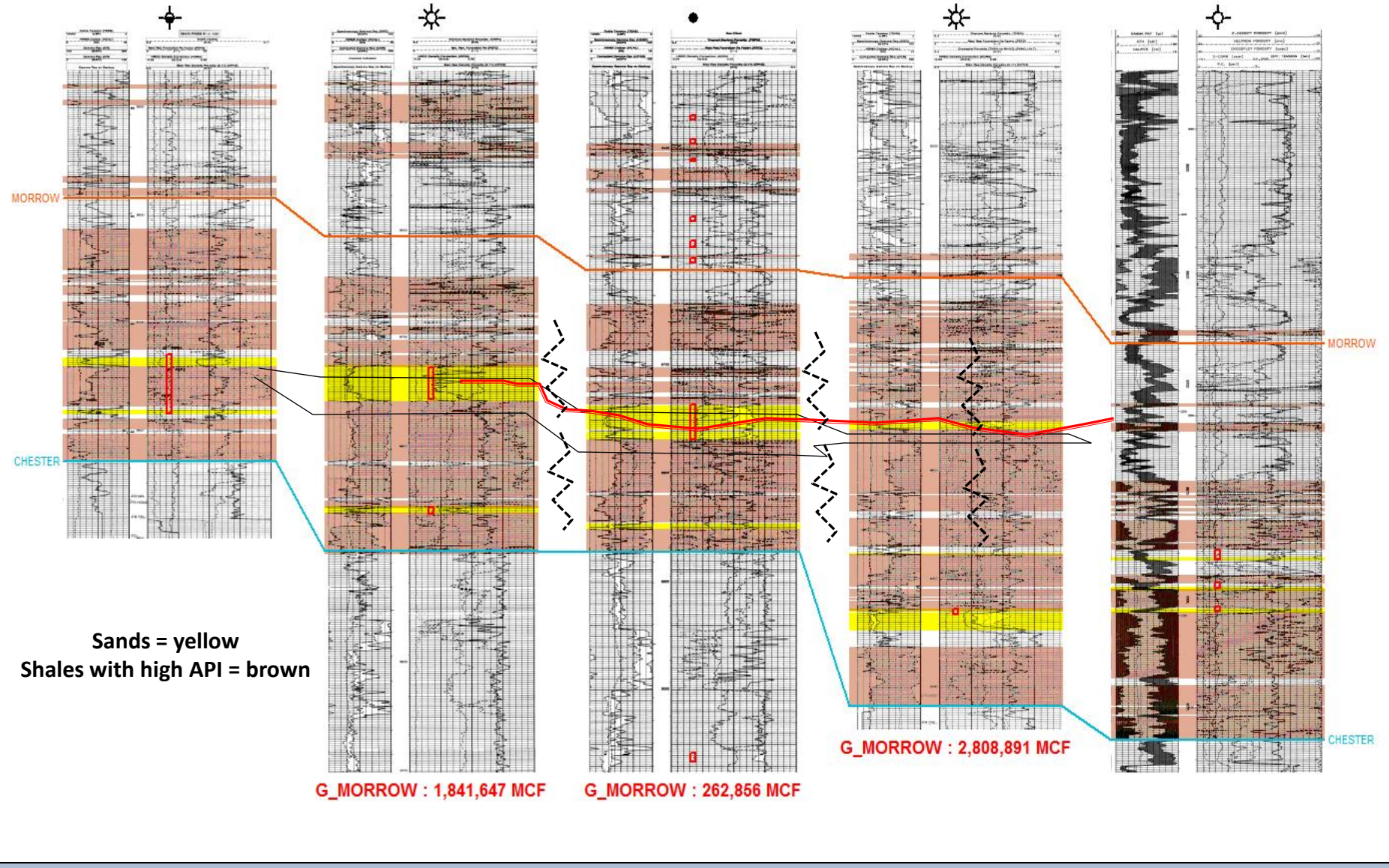


SOURCE ROCK SHALE ISOPACH MAY ALSO GUIDE LOCATION SELECTION



POSSIBLE HORIZONTAL RE-DEVELOPMENT BASED ON UNDRAINED RESERVES

N S



LATERALS IN MORE COMPETENT SANDS. FRACTURE INTO SHALE SOURCE BEDS, RECOVER ATTIC GAS AND POSSIBLE SOURCE LIQUIDS.

PERMO-PENN MOUND SEQUENCES
PERMIAN BASIN

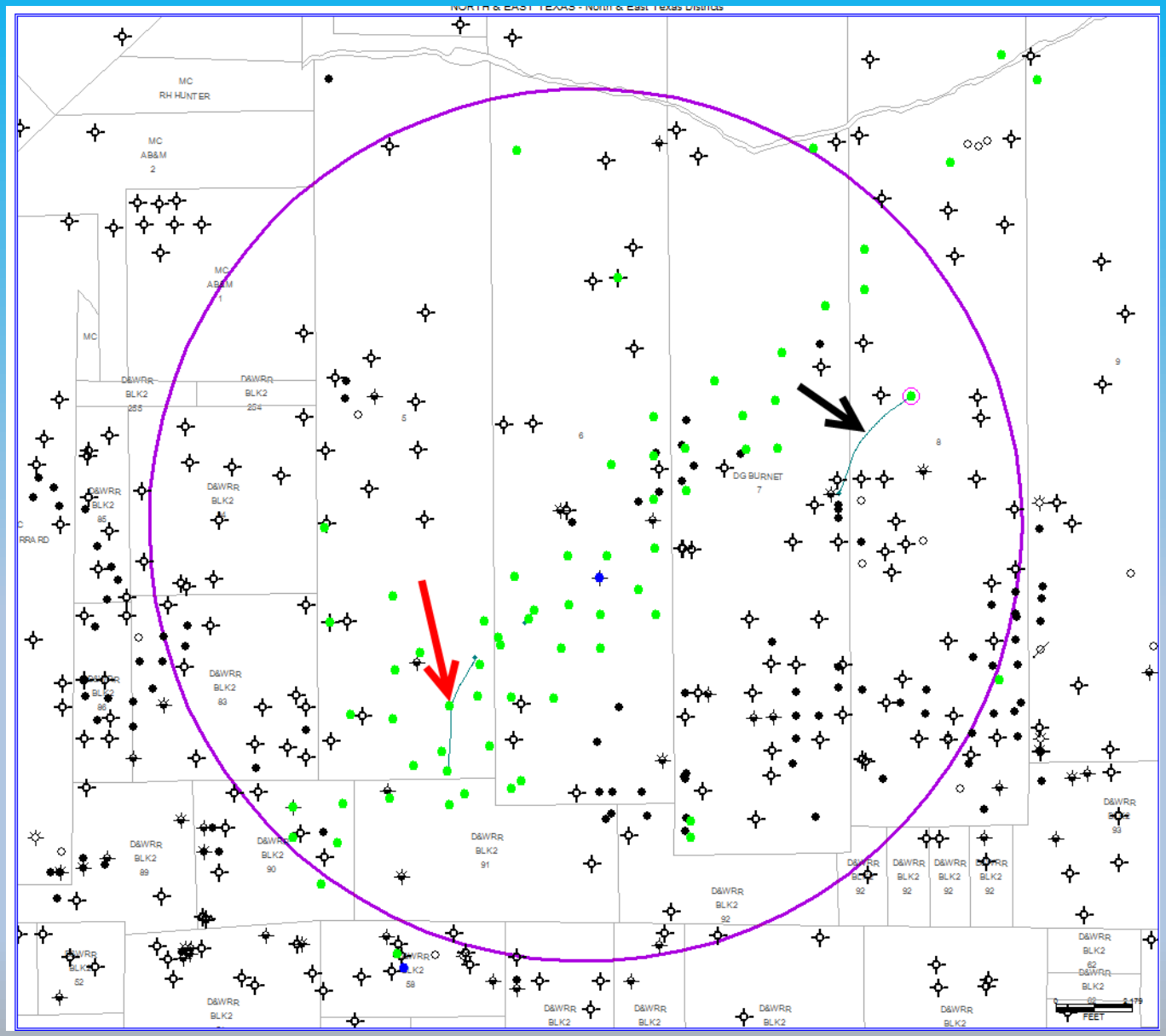
- HAVE HISTORICAL PRECEDENT FOR RESERVE ACCELERATION WITH HORIZONTAL DRILLING IN OLDER HORIZONTAL WELLS, PRIMARILY ON EASTERN SHELF OF THE PERMIAN BASIN

- HORIZONTAL DEVELOPMENT PRIMARILY CONFINED AT THE PRESENT TIME TO THE EASTERN SHELF

- DISCRETE AND COMPOSITE MOUND MORPHOLOGY, AND HIGH BOTTOM DRIVE WATER IN SOME RESERVOIRS, MAKE MOUND COMPLEXES A GOOD CANDIDATE

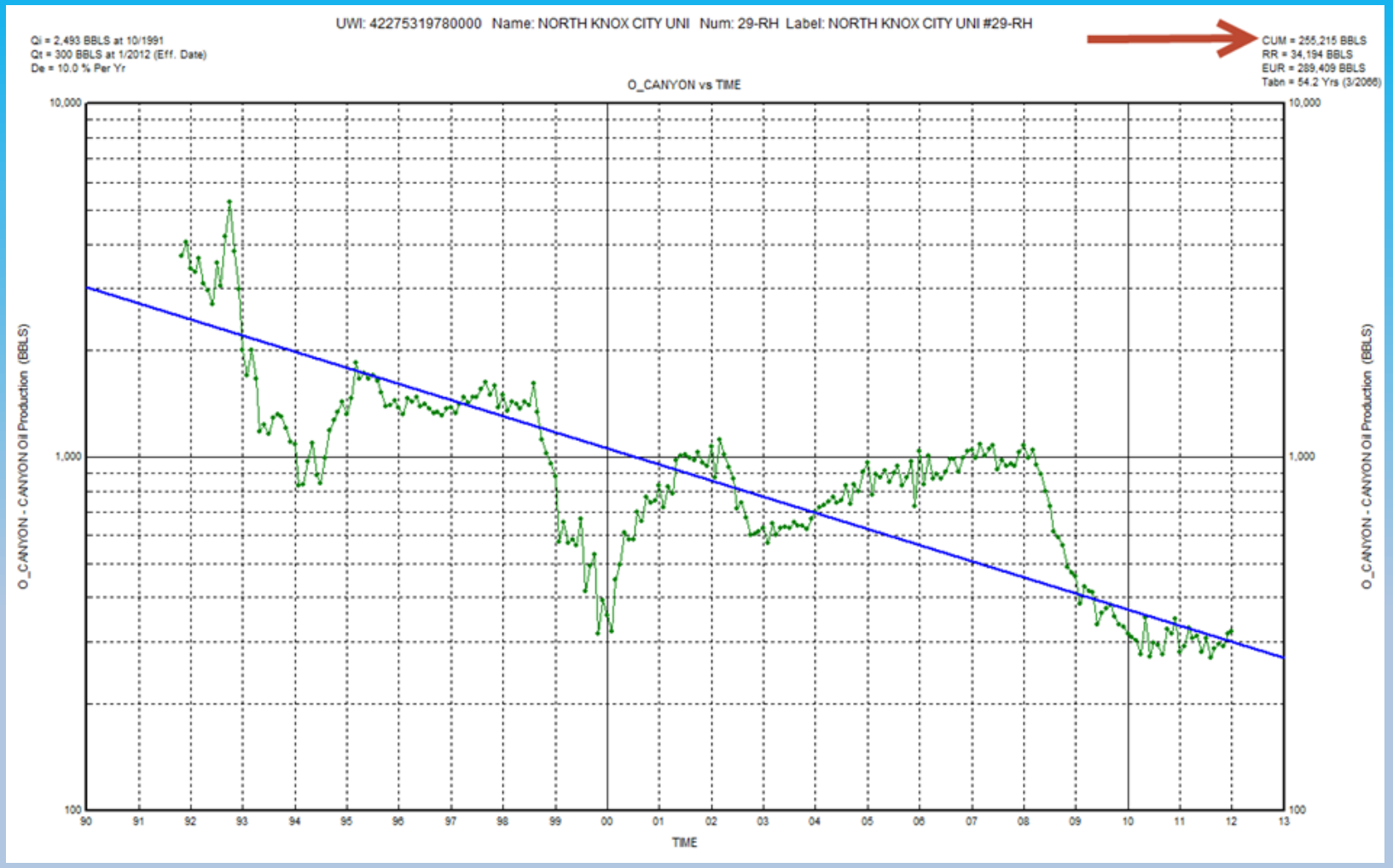
- PAST NON-ORDERLY DEVELOPMENT OF THESE RESERVOIRS RESULTED, IN MANY CASES, IN MISSED PAY AND TOO MANY “STRAWS”

PALO PINTO (LOWER CANYON) MOUNDS, KNOX COUNTY, TEXAS



HORIZONTAL WELLS DATE BACK TO 1990s. PRESENT TECHNOLOGY MAY IMPROVE RESERVE ACCELERATION.

PALO PINTO (LOWER CANYON) MOUNDS, KNOX COUNTY, TEXAS



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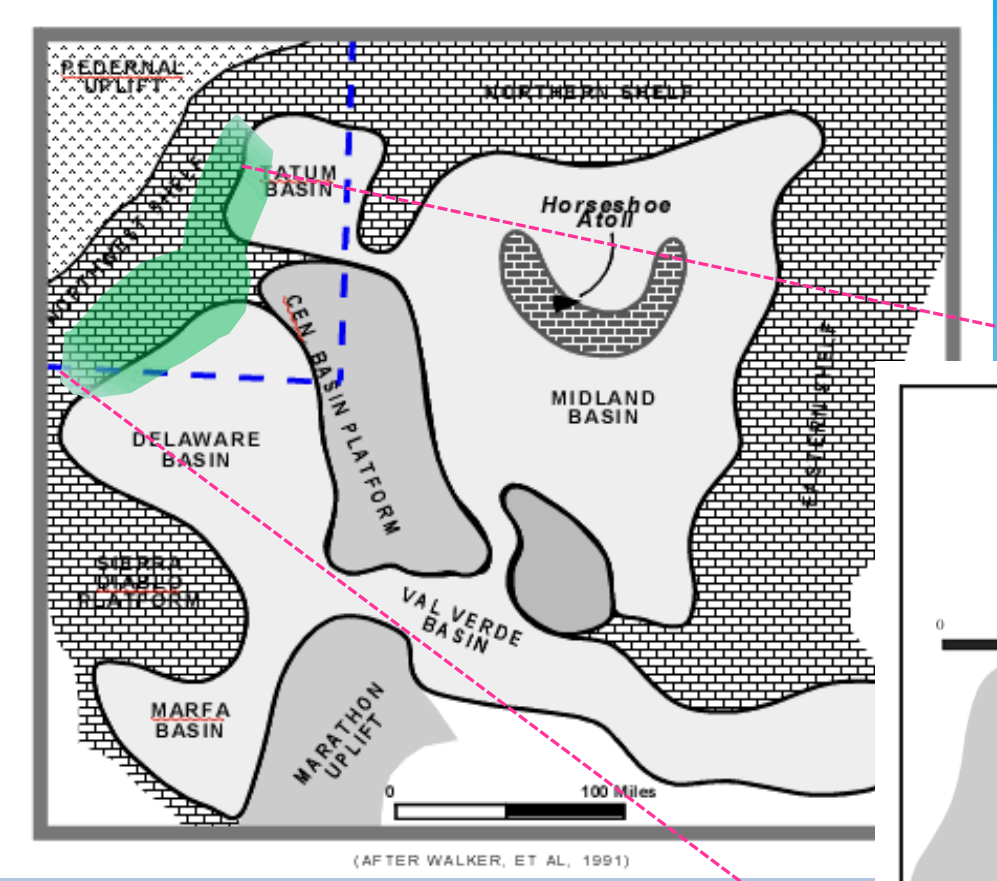
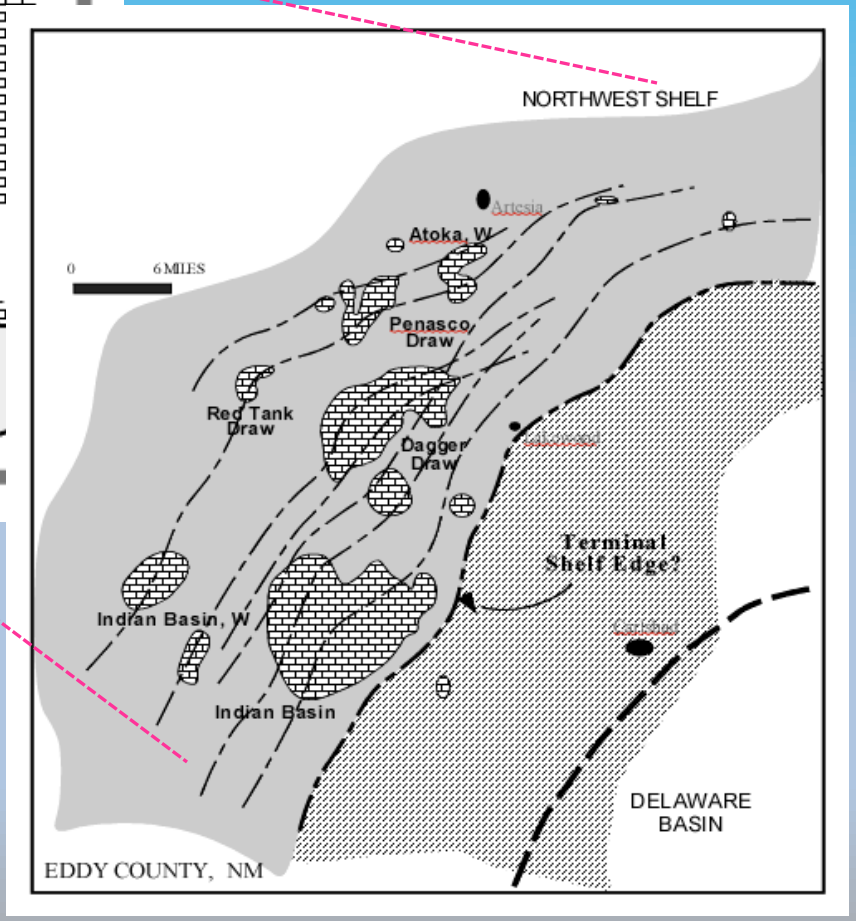
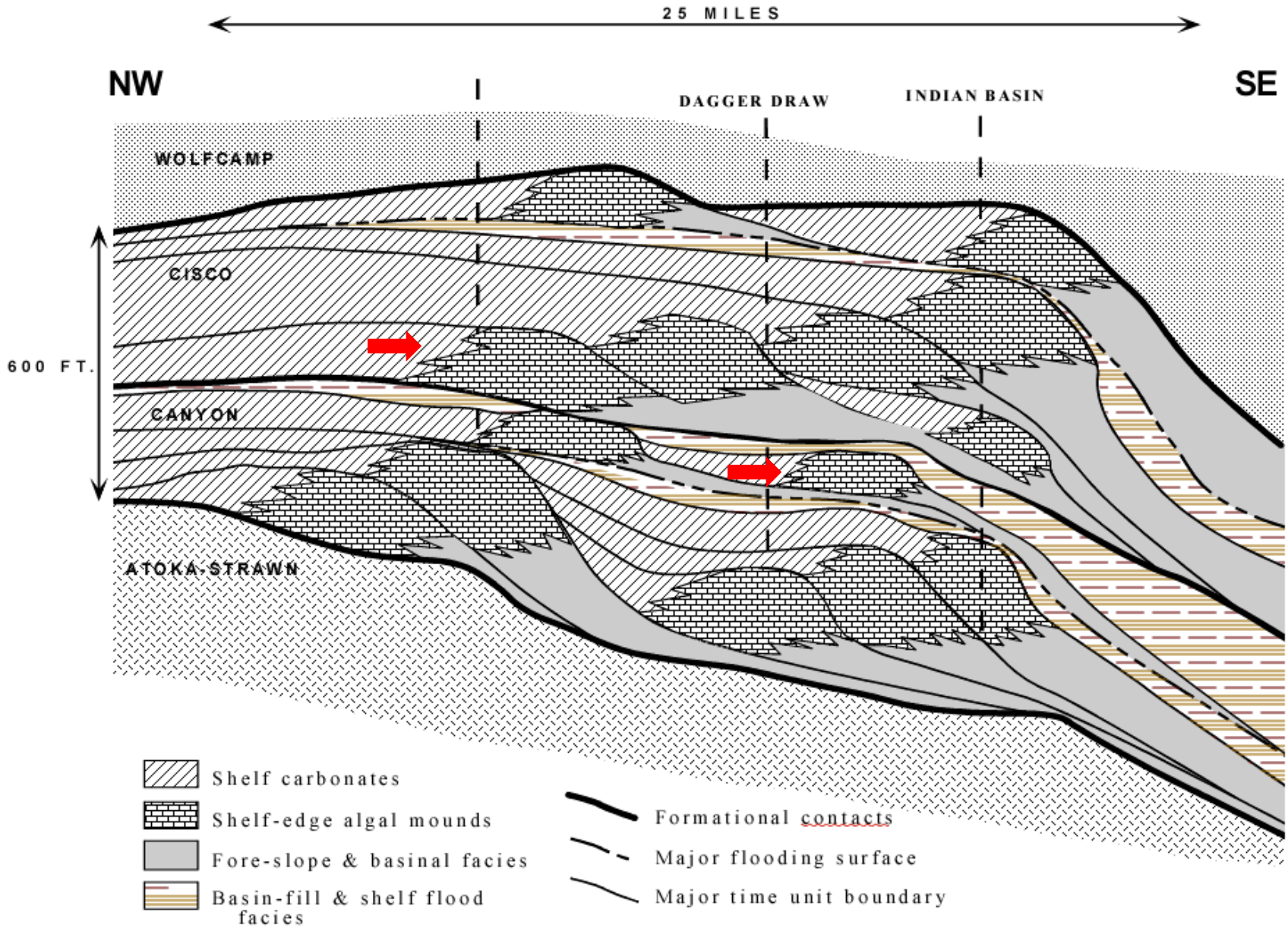
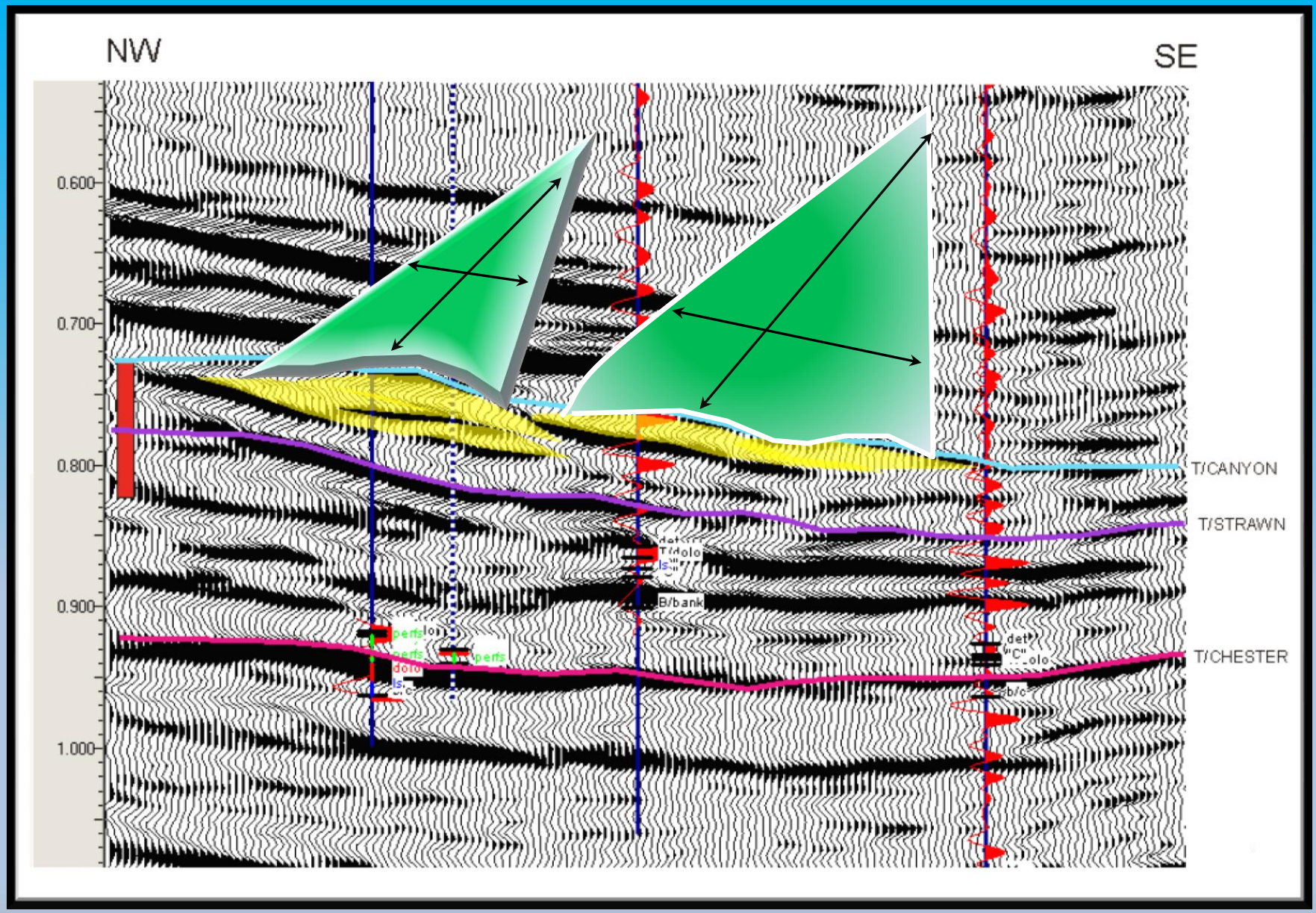




NORTHWEST SHELF OF THE PERMIAN BASIN: DISCRETE AND COMPOSITE UPPER PENN AND STRAWN MOUNDS

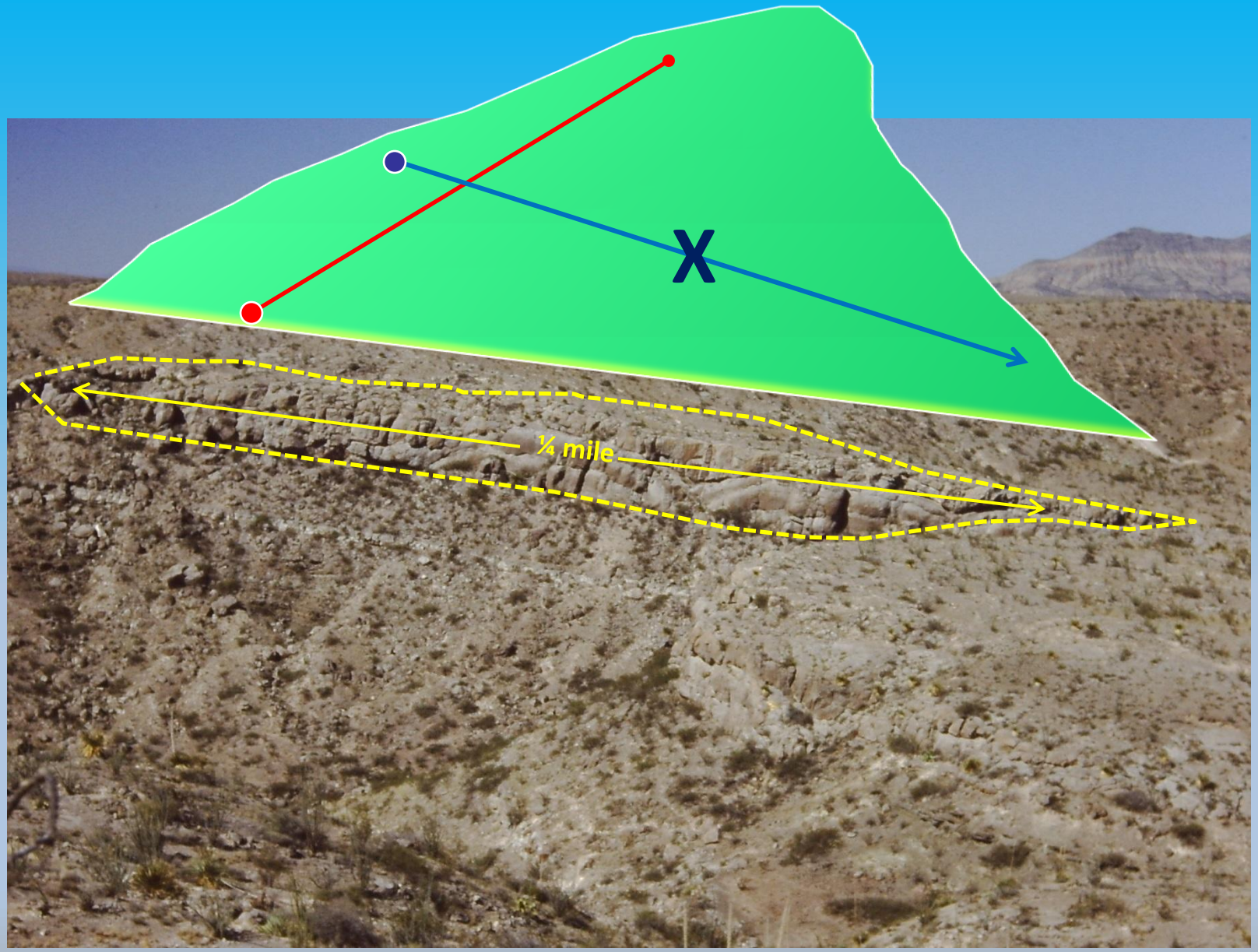


ISOLATED MOUND SEQUENCES MIGHT BE BETTER EXPLOITED HORIZONTALLY (AS ON EASTERN SHELF)



MOUND SEQUENCES HERE TEND TO BE SHINGLED, DISCRETE UNITS, LATERALLY AND VERTICALLY SEPARATED BY TIGHTER FACIES, MORE EXTENT LATERALLY THAN ALONG DEPOSITIONAL DIP.

(Courtesy of Nearburg Producing Co.)



LATERALS ALONG DEPOSITIONAL STRIKE IN UPDIP LOCATION MAKE MORE SENSE

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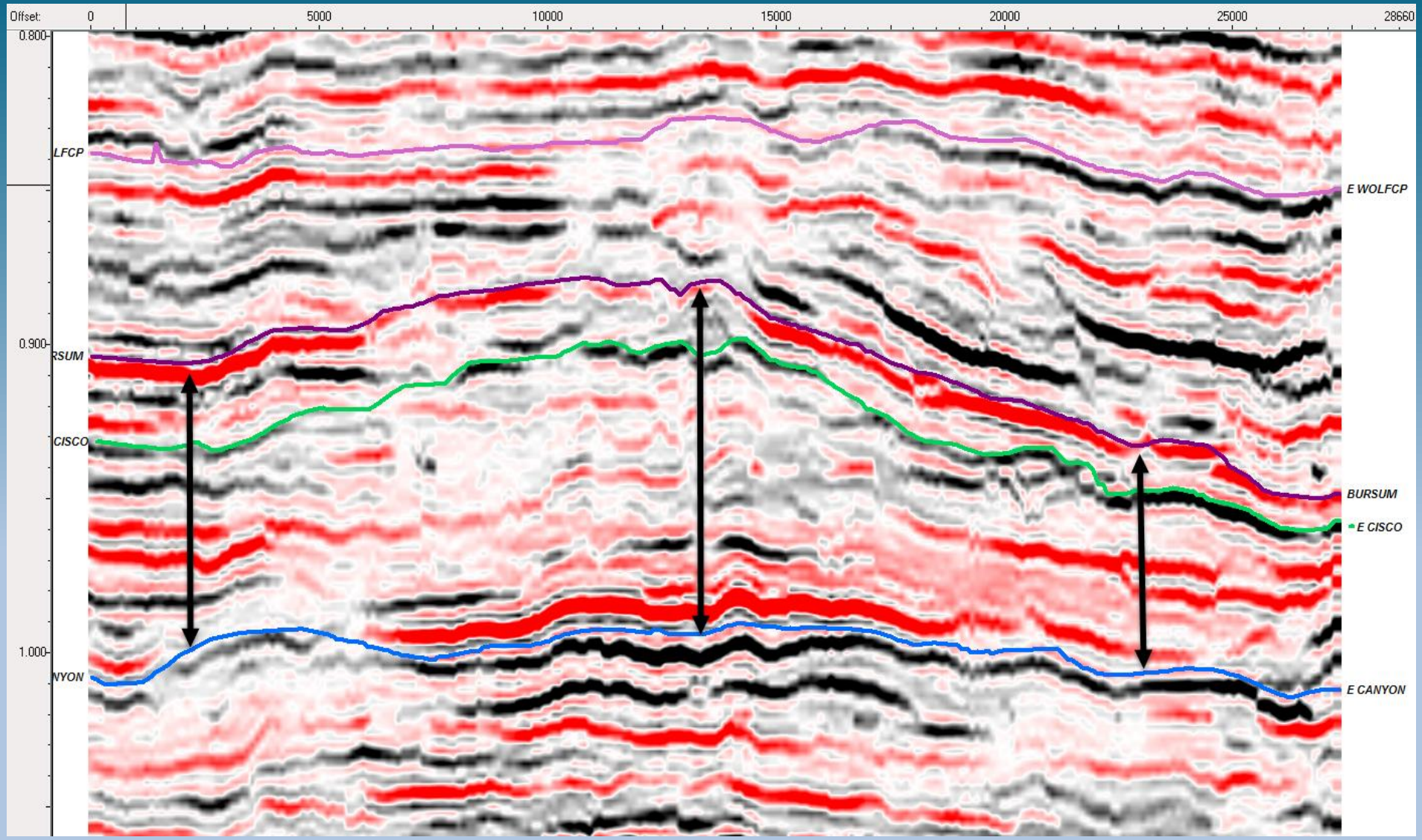
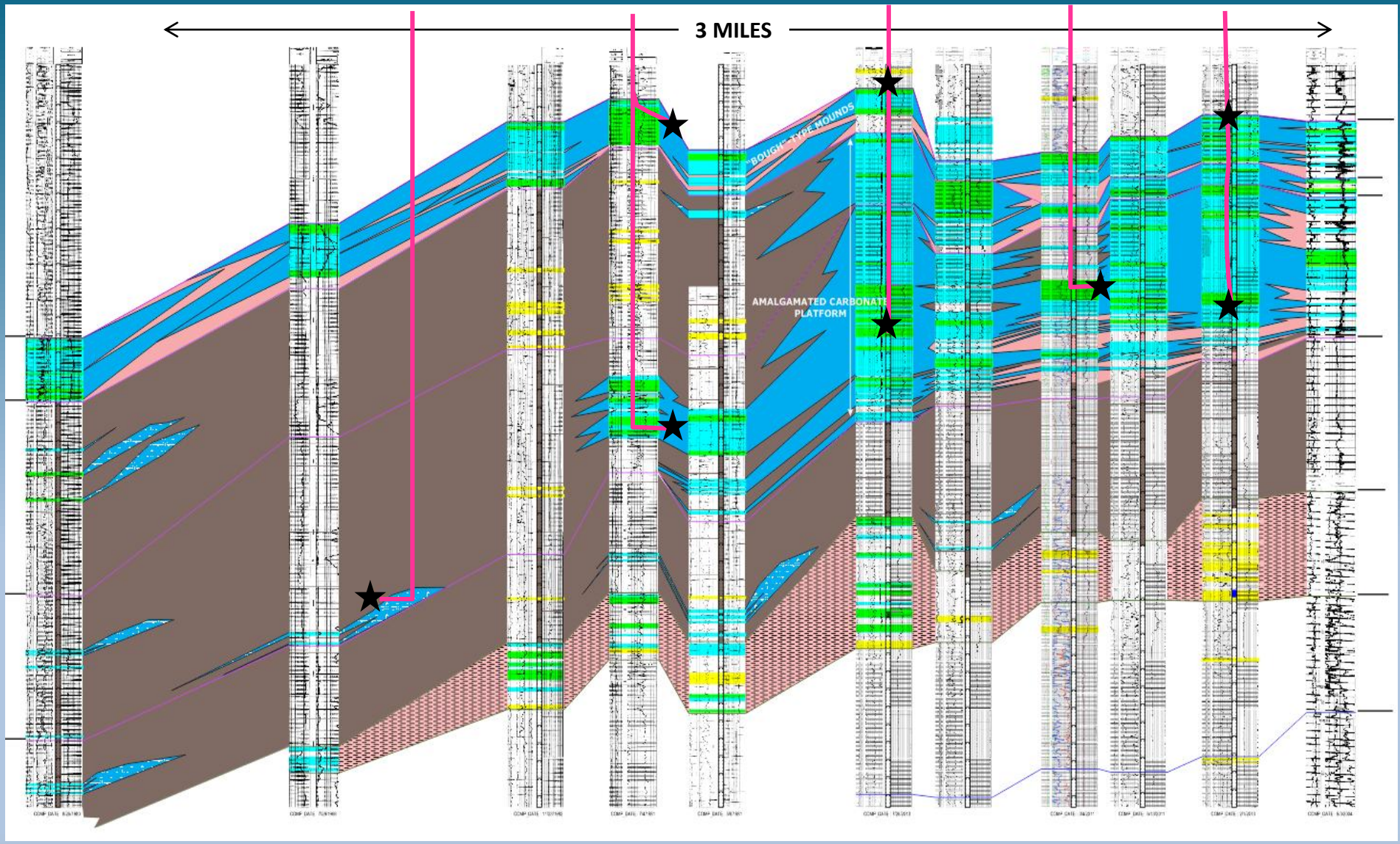


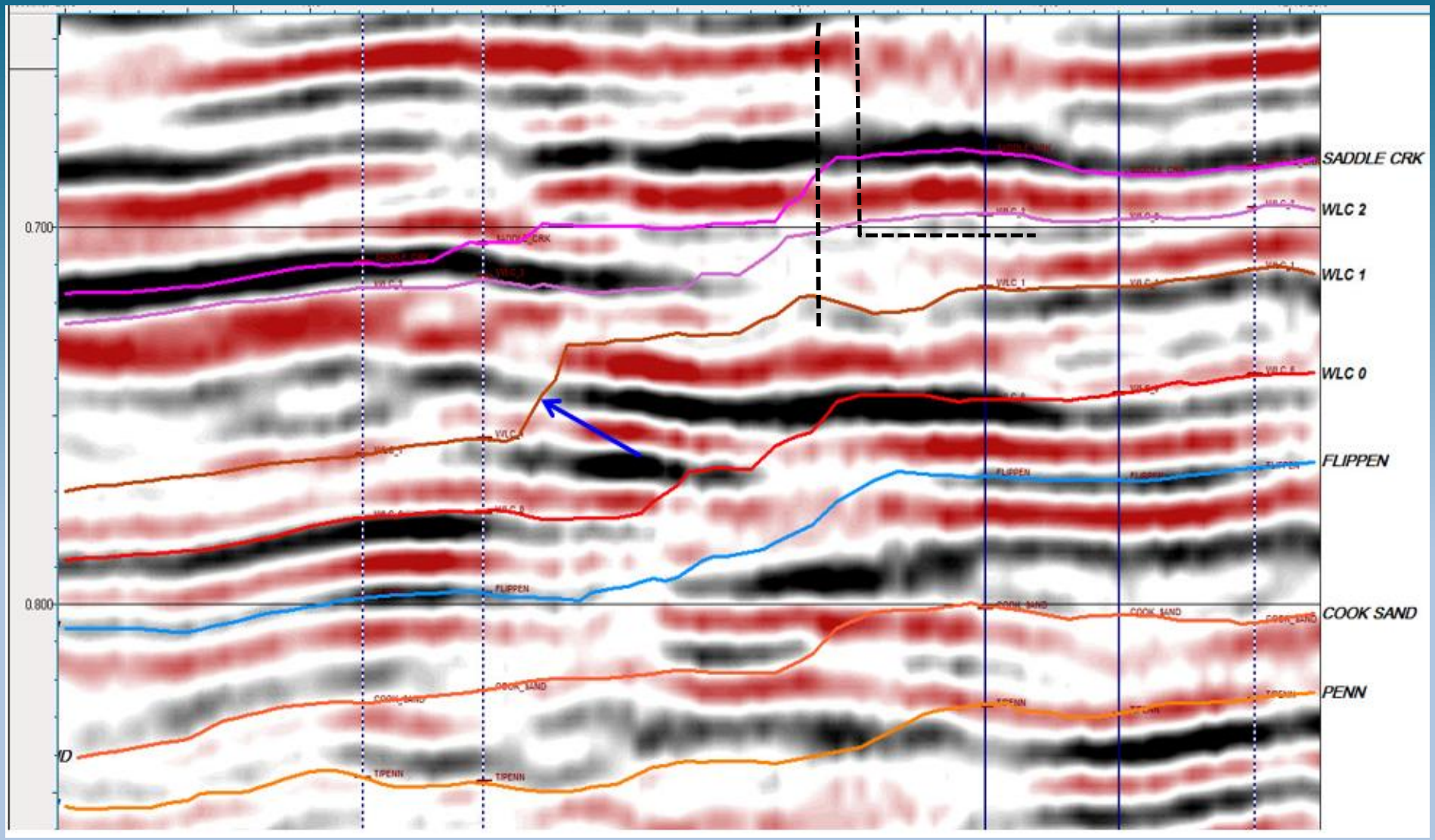
PERMO-PENN, NORTHWEST SHELF

W E



EASTERN SHELF- LOWER WOLFCAMP AMALGAMATED CARBONATE PLATFORM MOUNDS

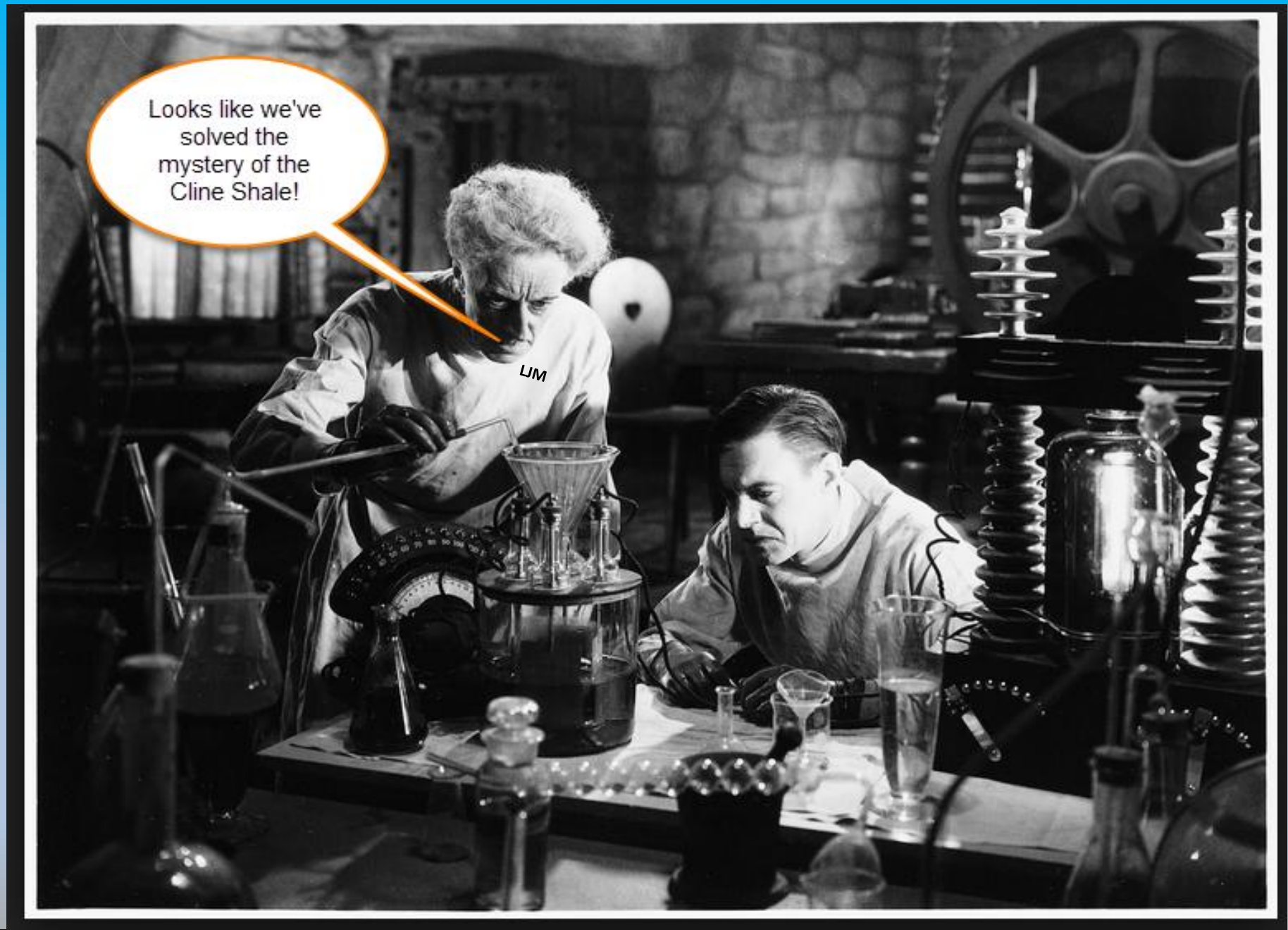
W E



MOUND SEQUENCES AMENABLE TO VERTICAL OR HORIZONTAL DEVELOPMENT

OTHER POTENTIAL APPLICATIONS

- **STRAWN SANDS, EASTERN SHELF: (e.g., HERMLEIGH FIELD, SCURRY COUNTY)**
- **GIN AND JO MILL SAND RE-DEVELOPMENT, MIDLAND BASIN (in lieu of waterfloods)**
- **DAKOTA SANDS, ROCKY MOUNTAIN BASINS**
- **RED RIVER, GUNTON, DEVONIAN CARBONATES- WILLISTON BASIN**
- **WHEREVER THE OBJECTIVES CAN BE MET!**


Looks like we've solved the mystery of the Cline Shale!
UM