

Evolution of the Lower Tertiary Elko Formation, a Potential Lacustrine Petroleum Source Rock in Northeast Nevada*

Ronald C. Johnson¹ and Justin E. Birdwell¹

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¹U.S. Geological Survey, Denver, CO (jbirdwell@usgs.gov)

Abstract

The Eocene-Oligocene Elko Formation of northeastern Nevada was deposited in a structural and sedimentary basin containing a fresh to moderately saline lake (or a series of lakes) following a long period of fluvial deposition. The Elko Formation includes thick intervals of petroliferous mudrocks, some of which contain sufficient organic matter to have been mined as an oil shale resource in the early twentieth century. The organic-rich intervals are also presumed to be the source for oil deposits in northeastern Nevada.

Lithology, mineralogy and organic geochemistry of the Elko Formation were studied in outcrop and core samples. The core and outcrop samples are all thermally immature and, with the exception of a few very organic-rich intervals in two cores, show moderate to good source rock potential. Generally, these outcrop and core samples have limited value as an oil shale resource in comparison to the lacustrine basins of the nearby and similarly aged Eocene Green River Formation. The majority of samples (62%) had total organic carbon contents between 1 and 5 weight % and most (78%) had hydrogen index (HI) values of 500 mg/g or higher. Oil yields determined by Fischer assay were generally between 1 and 4 weight % (3 to 11 gallons per ton), but the yields from many samples were less than 1 weight % (about 3 GPT). The organic matter in the Elko cores consists of varying mixtures of Type I and Type III kerogen.

Results from X-ray diffraction indicate the Elko Formation contains abundant quartz and feldspar, alternating dolomite-rich and calcite-rich intervals, along with some intervals rich in opal-CT and clay minerals. The Elko Formation paleolake may have become hydrologically closed leading to increased salinity as widespread lacustrine conditions developed. This is indicated by the disappearance of freshwater mollusks just above the base of the lacustrine interval. Organic-rich laminated carbonates were deposited in offshore areas of the lake, contemporaneous with pebbly sandstones and mudstones in marginal areas. Scattered air-fall tuffs indicate volcanism in northeastern Nevada during deposition of the lower part of the organic-rich interval. Greater volcanism, indicated by thick, reworked tuffaceous intervals interspersed with organic-rich mudrocks, appears to have occurred just prior to deposition of the richest oil shale in the Elko Formation. Large volumes of volcanic material are found in the remaining Elko lacustrine beds due to a period of prolonged volcanism in northeastern Nevada during this time.

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Evolution of the Lower Tertiary Elko Lake Basin, a Potential Lacustrine Petroleum Source Rock in Northeast Nevada

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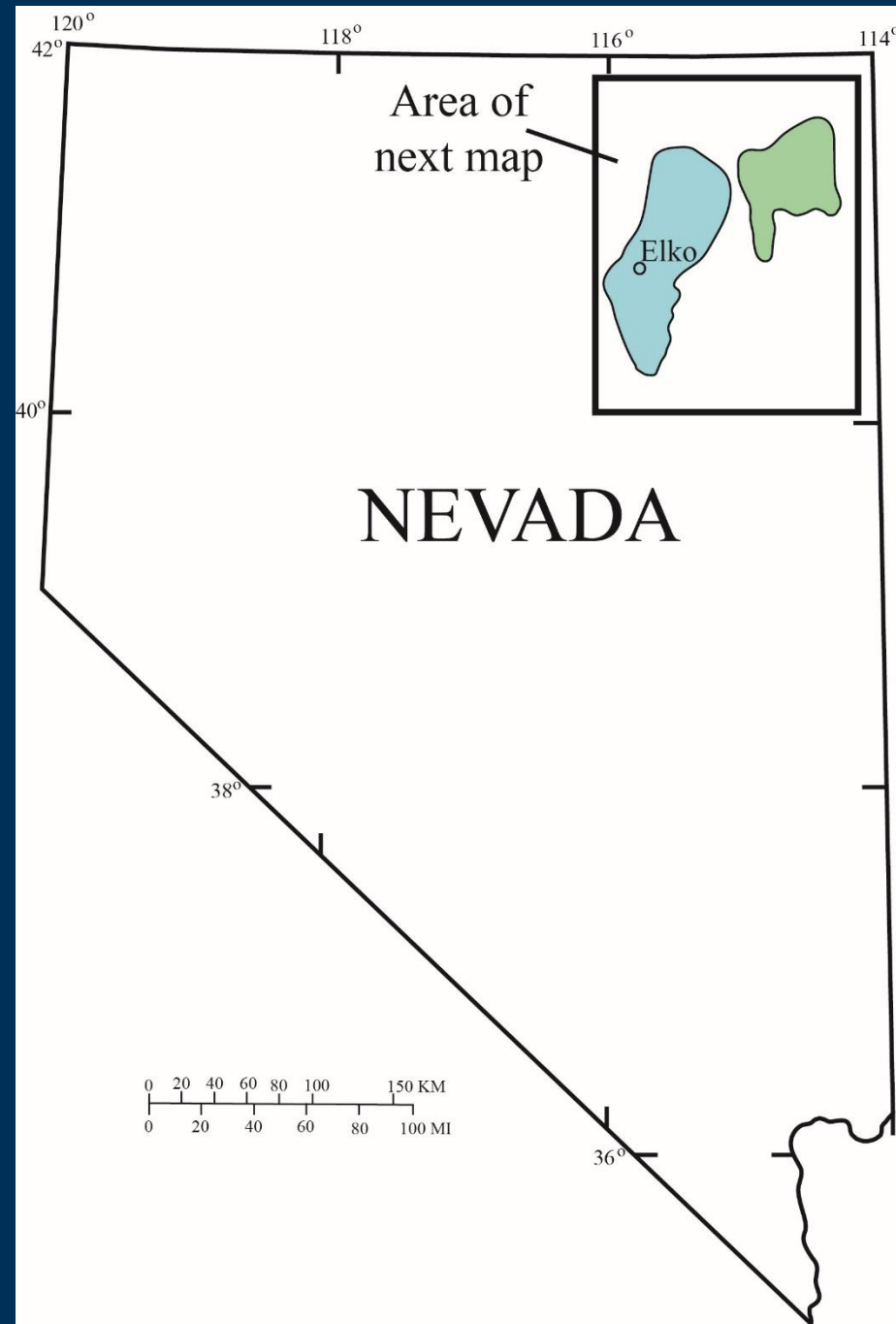
A related manuscript was published in 2016:

Johnson, R.C., and Birdwell, J.E., 2016, Evolution of the lower Tertiary Elko Lake Basin, a potential hydrocarbon source rock in northeast Nevada, chap. 9 of Dolan M.P., Higley D.H., and Lillis P.G., eds., **Hydrocarbon source rocks in unconventional plays, Rocky Mountain Region: Denver, Colo.**, Rocky Mountain Association of Geologists. [Also available at <http://www.rmag.org/hydrocarbon-source-rocks>.]

The publication includes 3 oversized plates.

Map showing present-day extent of lower Tertiary lacustrine deposits in northeast Nevada. Blue is extent of Eocene Elko Formation. Green is extent of lacustrine rocks that may be equivalent to the Elko Formation.

The Elko Formation was mined and retorted as an oil shale resource in the 1920s. Recently, oil has been discovered in the Elko Formation.



History of Elko Oil Shale Development

- “In 1924 five-thousand gallons of lubricating oil were shipped to New York. Five tunnels, 600 feet down stretched four miles. Unfortunately, while there was talk of oil, the primary product was paraffin. Oil was secondary because of its high cost of refining. Labeled ‘Hi-Power Catlin Oil,’ it sold for \$5 a gallon. The lubricant, because of its high paraffin base, worked well in the summer but in winter it congealed and gummed up engines. Durant Motor Company tested the oil in the 1924 Indianapolis 500. E.E. ‘Monte’ Mouton used the lubricant on his Elko to Reno air mail route and claimed his engine ran more than fifty revolutions per minute faster compared to standard oil.” (Howard Hickson, Great Basin College, written commun., 2003).



Photo of Catlin Oil Shale Plant ,1923. (Northeastern Nevada Museum,
<http://www.gbcnv.edu/howh/CatlinShale.htm>)

Index map showing area in northeast Nevada where the Eocene rocks including the Elko Formation crop out (beige). Location shown on previous Nevada index map.

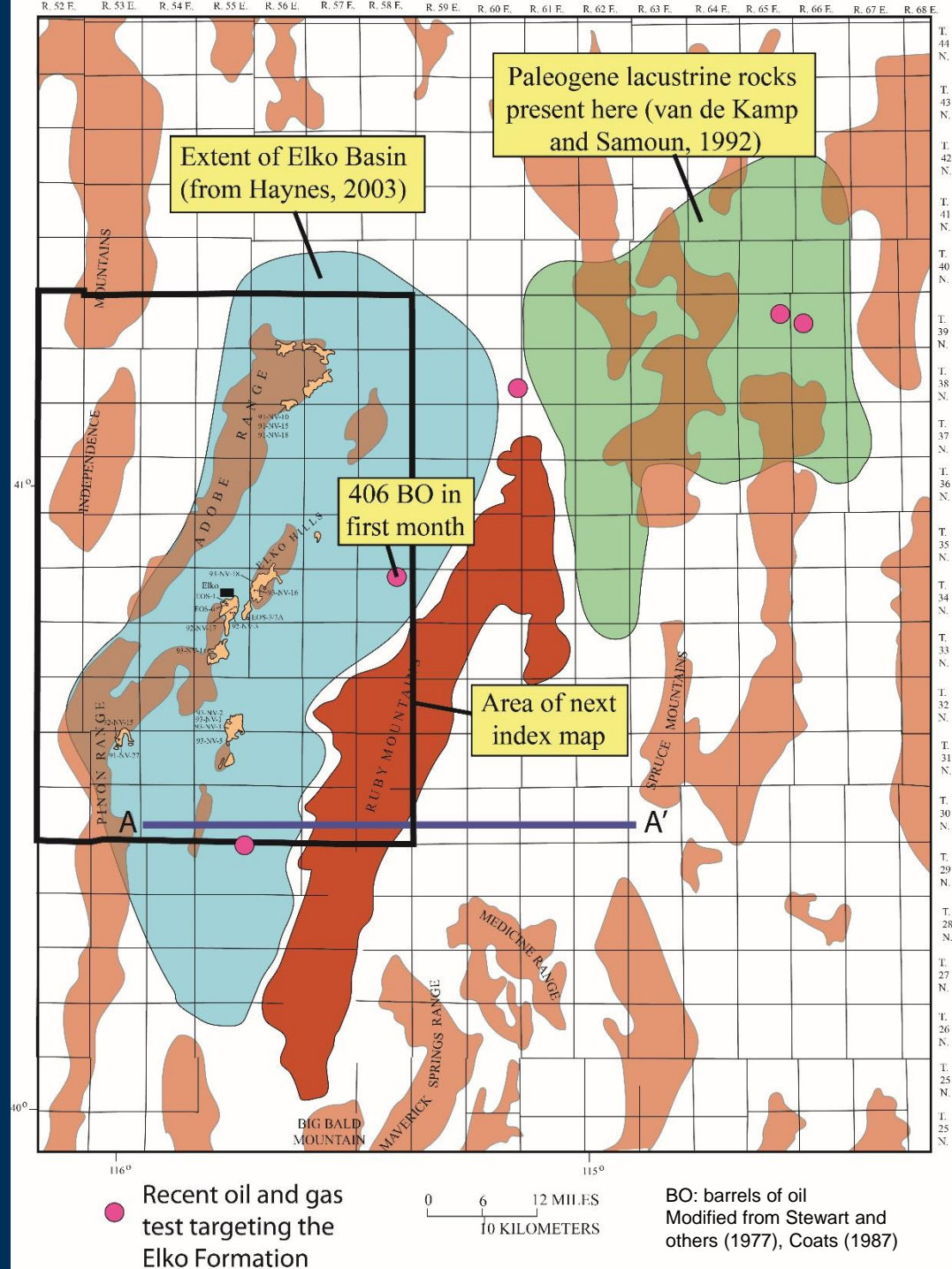
Approximate original extent of Elko lacustrine basin shown in blue.

The Ruby Mountains, a metamorphic core complex (dark red), were present during deposition of the Elko Formation.

The other ranges (salmon) rose during basin and range faulting that postdated deposition of the Elko Formation.

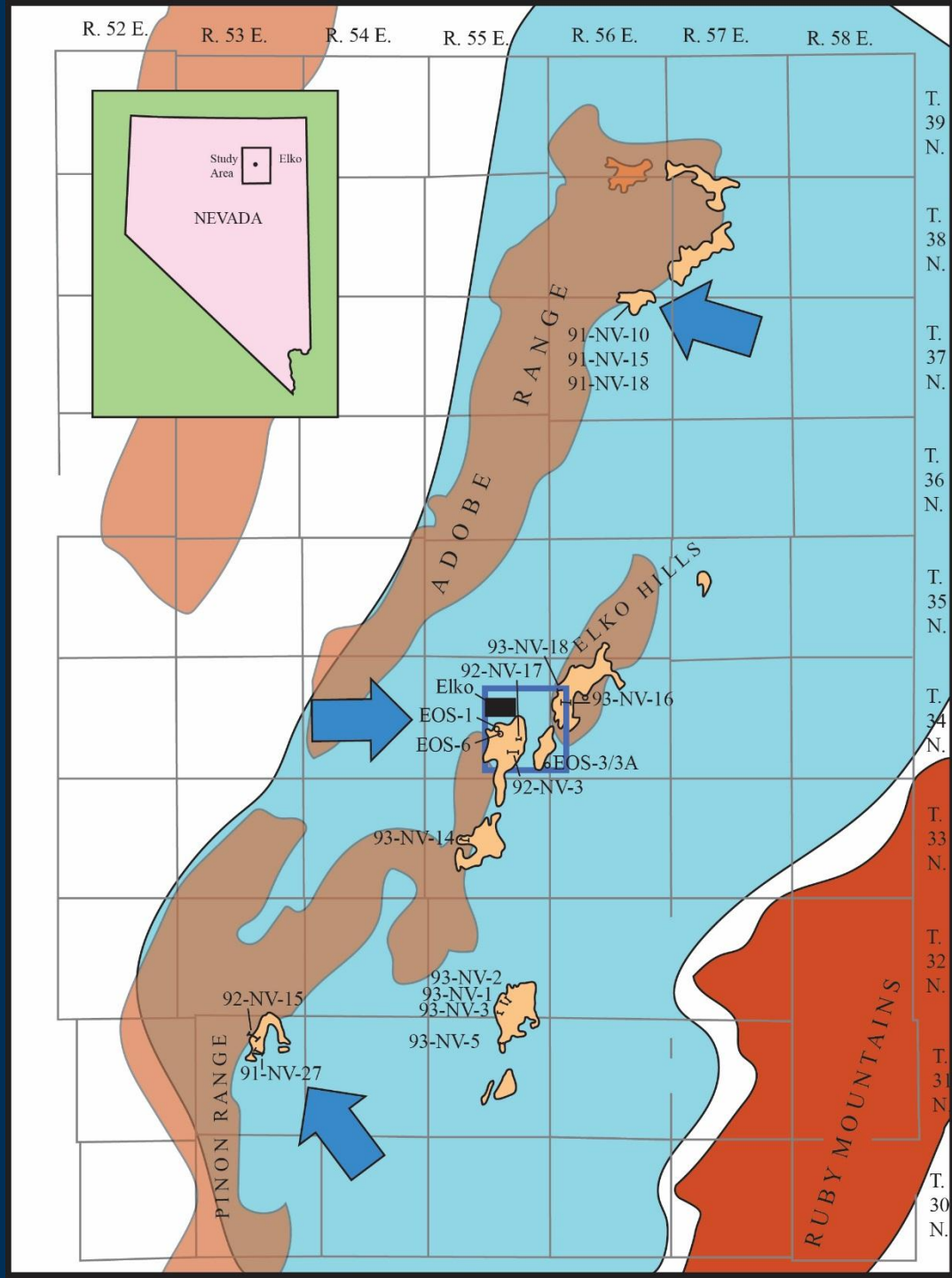
Lacustrine rocks also are present northeast of the Elko lake (green). It is not known if this lake is the same age as the Elko lake.

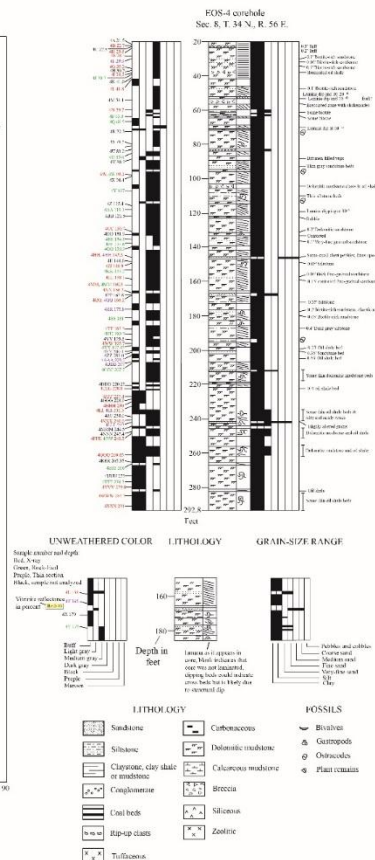
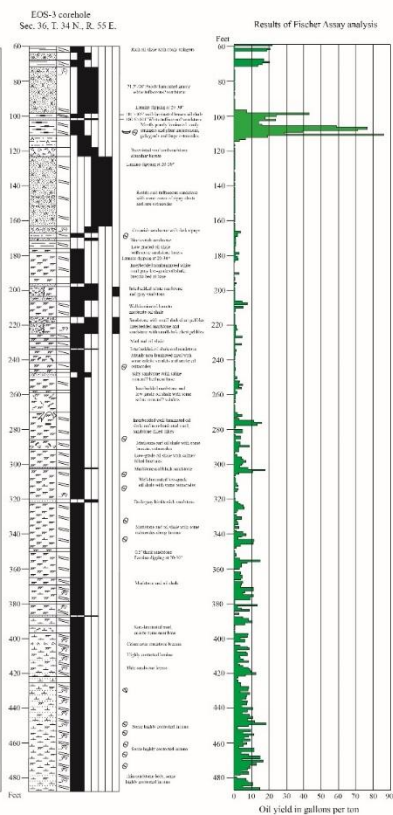
Pink dots indicate recent oil and gas tests targeting the Elko Formation.



Detailed studies of the Elko Formation were conducted where it crops out in the northern Adobe Range, Elko Hills, and Pinon Range.

In addition, cores of the Elko Formation (EOS-1, EOS-6, and EOS-3/3A), which are stored at the Nevada Bureau of Mines core facility, were described and extensively sampled for programmed pyrolysis (Rock-Eval), X-ray, and thin-section analysis. All of the cores are from the immediate Elko area, where oil shale was mined in the past.





Results of Fischer Assay analysis

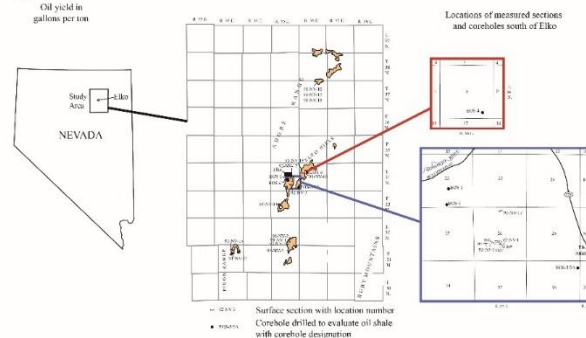
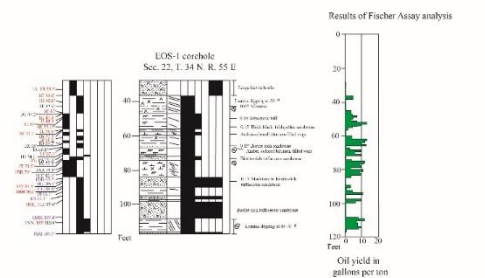
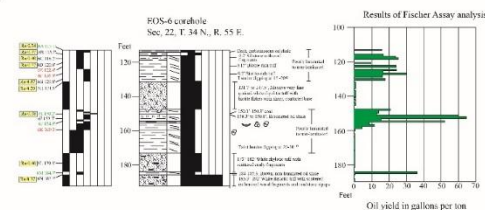
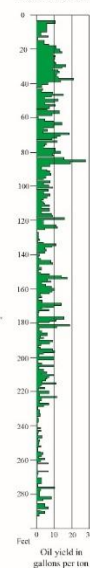


Plate 1 of Johnson and Birdwell (2016) showing detailed descriptions of core holes EOS-1, EOS-2, EOS-4, and EOS-6. Oil-yield histograms are from Moore and others (1983).

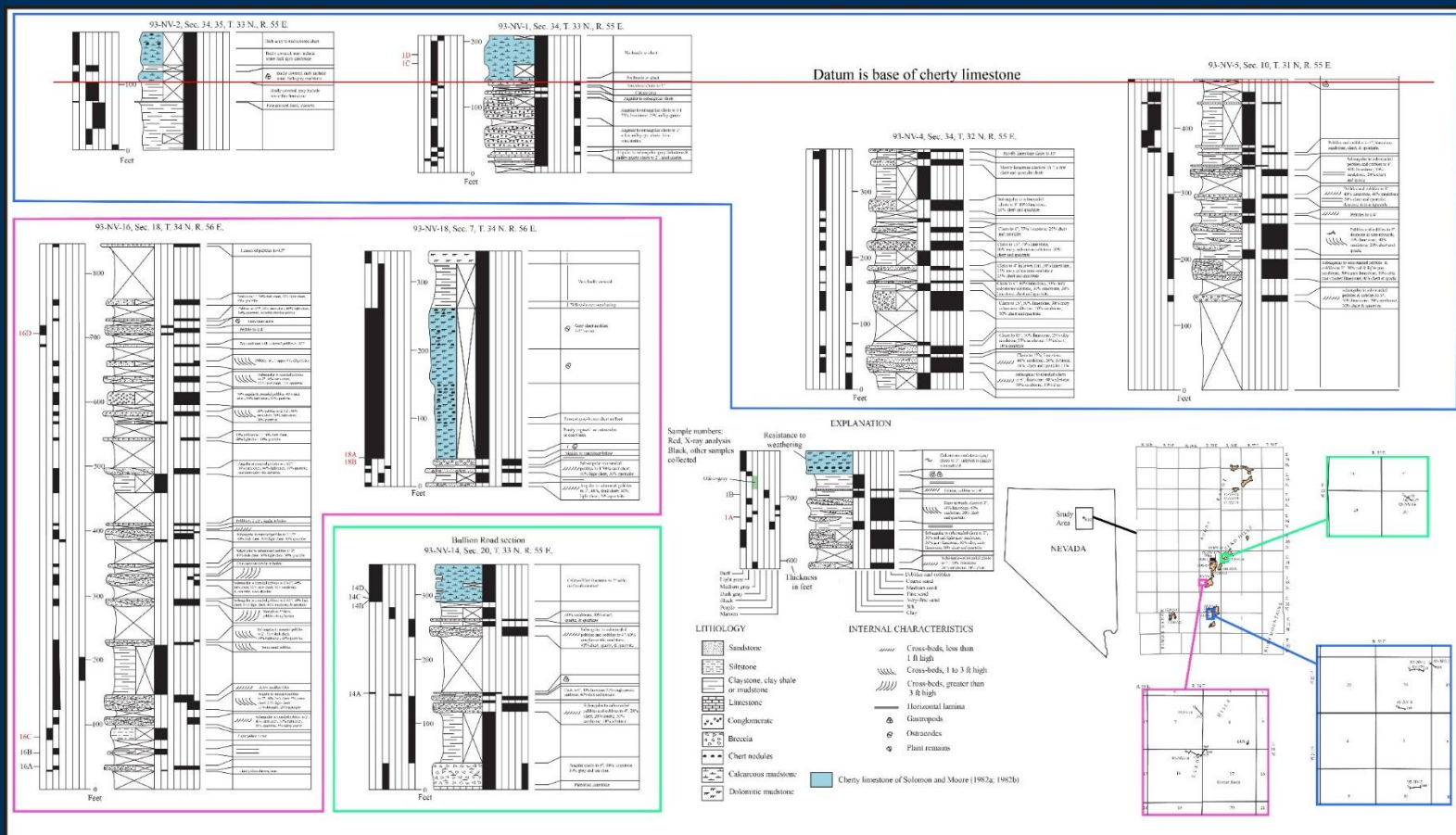
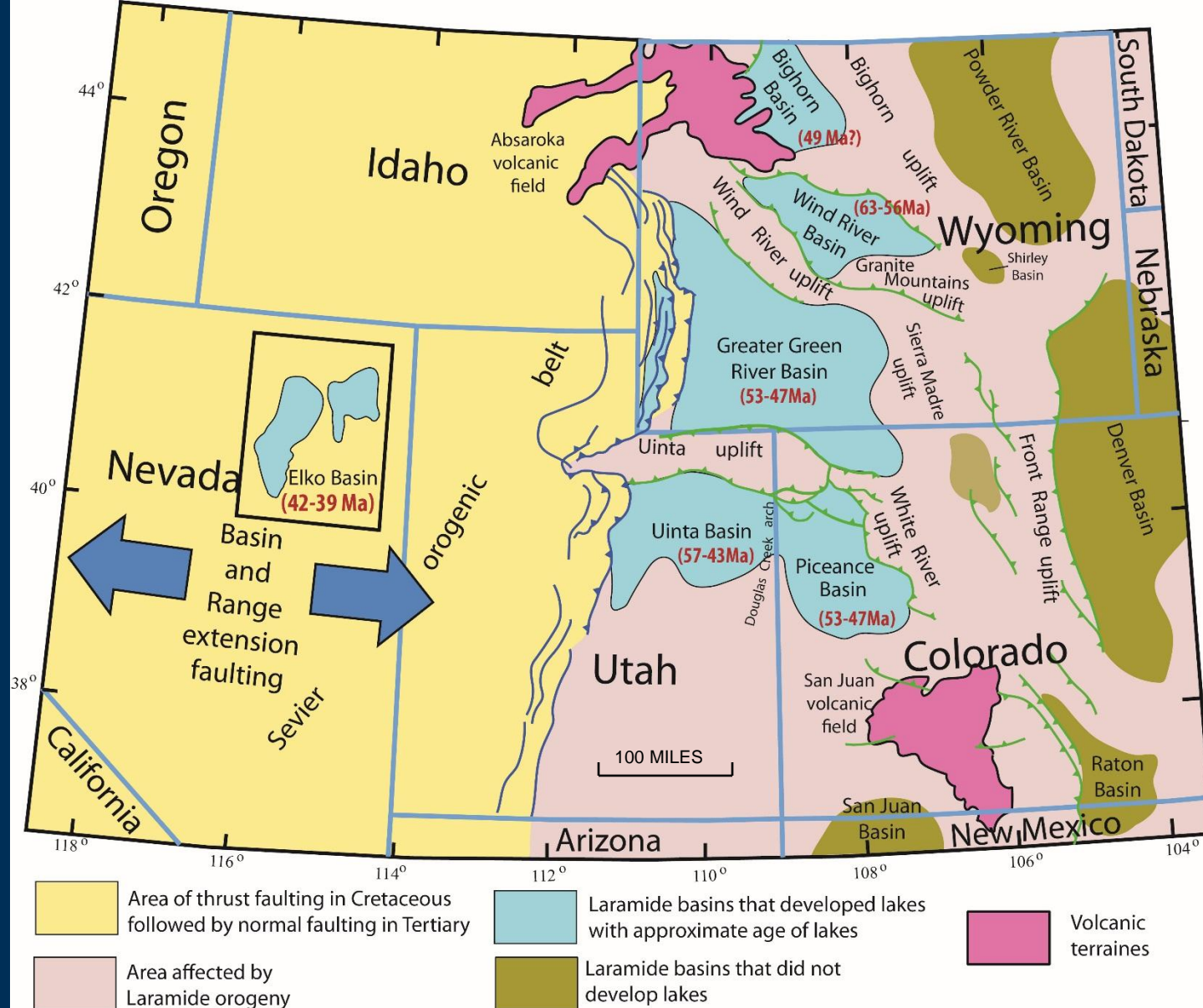


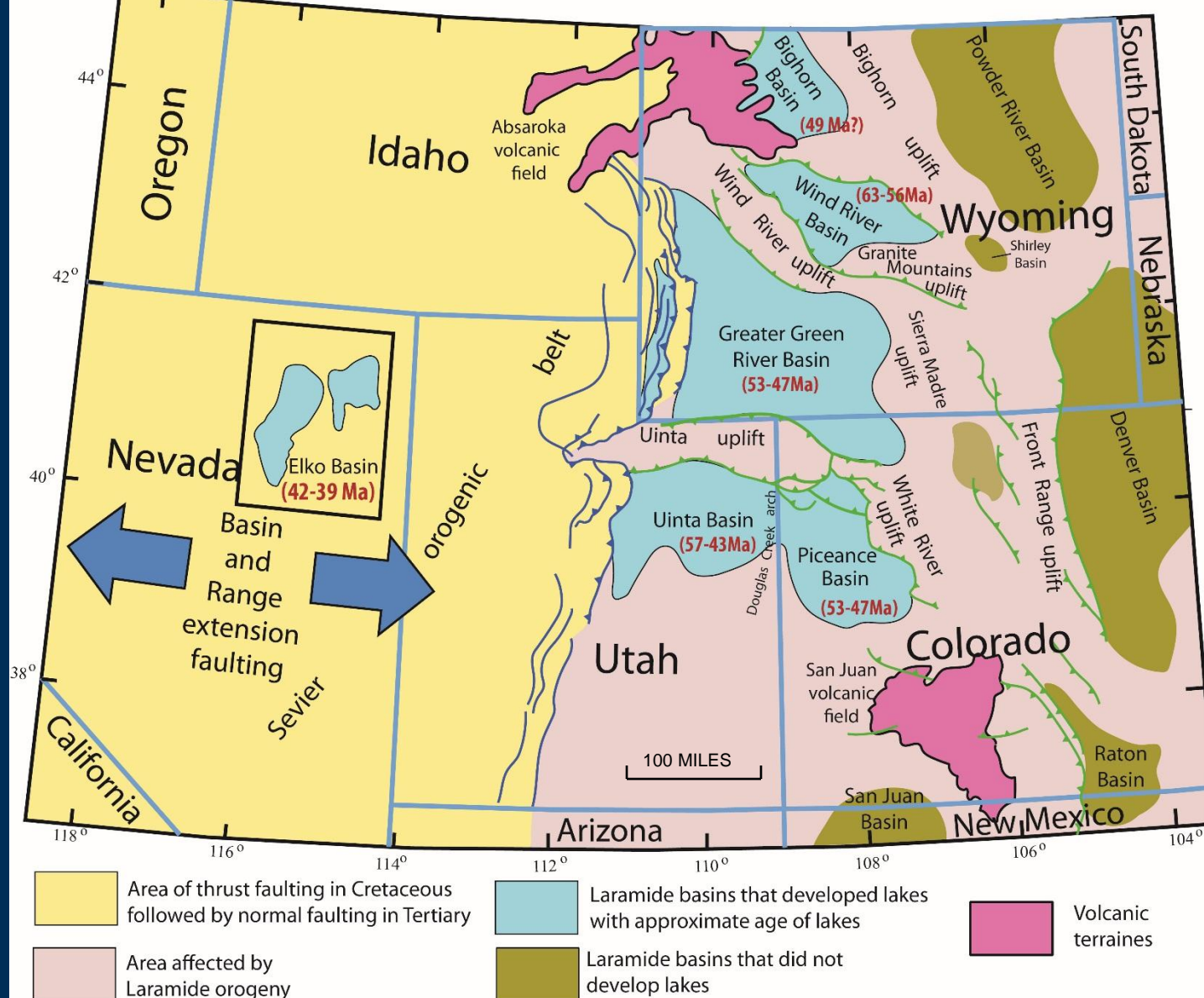
Plate 3 of Johnson and Birdwell (2016) showing detailed measured sections of the lower Tertiary rocks west of Twin Bridges about 15 miles south of Elko (blue), in the Elko Hills just east of Elko (pink), and near the Bullion Road about 6 miles south of Elko (green).

				92-NV-1, 92-NV-3, Elko Formation section south of Elko							(Plate 2)						
Sample ID	Feet	Description	Quartz	Feldspar	K-feldspar	Plagioclase	Total clay	Biotite	Muscovite	Opal-CT	Pyrite	Calcite	Dolomite	Clinoptilolite	Analcite	Gypsum	
92-NV-1Y	1231	Concretion	5						4			100					
92-NV-1X	1217	Medium-gray mudstone	100		8		2						3				
92-NV-1W	1185	Dolomitic concretion	5							7			100				
92-NV-1V	1170	White mudstone	100		9					17			3				
92-NV-1U	1138.5	Olive-gray mudstone	100		41		22			72							
92-NV-1S	1115	Laminated olive-gray mudstone	100		13		13			27							
92-NV-1R	1092	Low-density brown mudstone	96		94		24			100				48	43		
92-NV-1Q	1077	White mudstone	100		5								2			5	
92-NV-1N	1055	Low-density brown mudstone	21							100							
92-NV-1L	1032	White mudstone	100		23	25	9			89							
92-NV-1K	1023	Medium-brown mudstone	40		37		54			100			11				
92-NV-1J	1006	White mudstone	100		20	22							7		20		
92-NV-1H	997	Olive-gray mudstone	65			27	43			78				100			
92-NV-1G	995	Olive-gray mudstone	81			34	60	34		100				74			
92-NV-1F	975	White tuff	37					37		32				100			
92-NV-1E	945	White tuff	32			23	19	11		43				100			
92-NV-1C	925	White tuff	14			100	7			17				60			
92-NV-1B	905	White tuff	35			31	31			47				100			
92-NV-1A	895	14 ft thick white tuff	20			25		7		30				100			
92-NV-3Z	790	Medium-gray mudstone	100		5		5						82				
92-NV-3Y	725	White silty mudstone	100		4												
92-NV-3R	522	Medium-gray mudstone	100		4		6					28					
92-NV-3J	455	Dark-gray mudstone	100				8					26					
92-NV-3B	345	Cherty limestone	100										24				

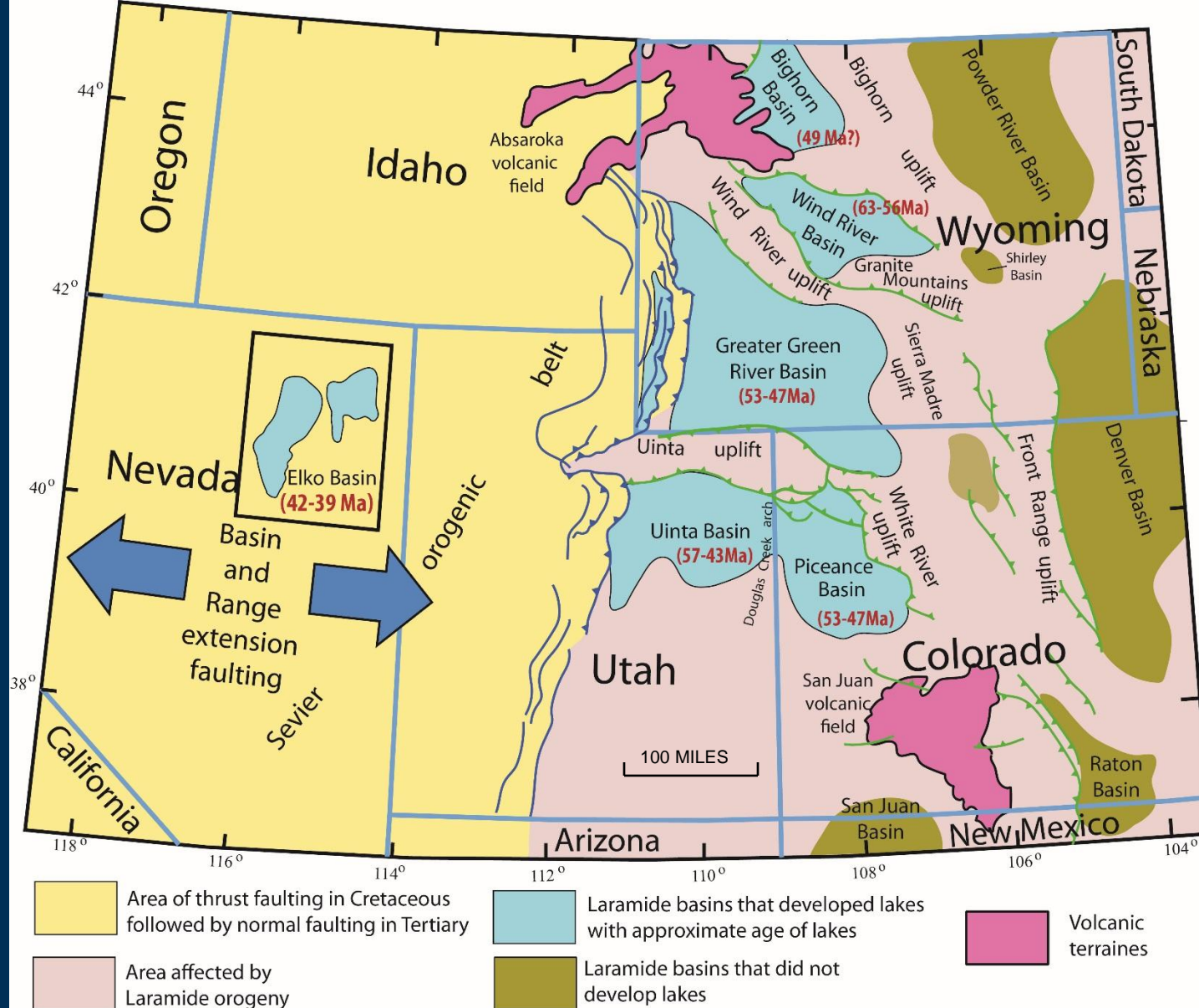
Example of x-ray diffraction data included in Johnson and Birdwell (2016). Numbers are peak heights normalized to the highest peak. Green denotes rocks from the early nonvolcanic period and pink denotes the later volcanic period in the Elko Basin. **These two periods will be discussed in detail later.** Note that clinoptilolite and opal-CT are confined to the volcanic-rich interval.



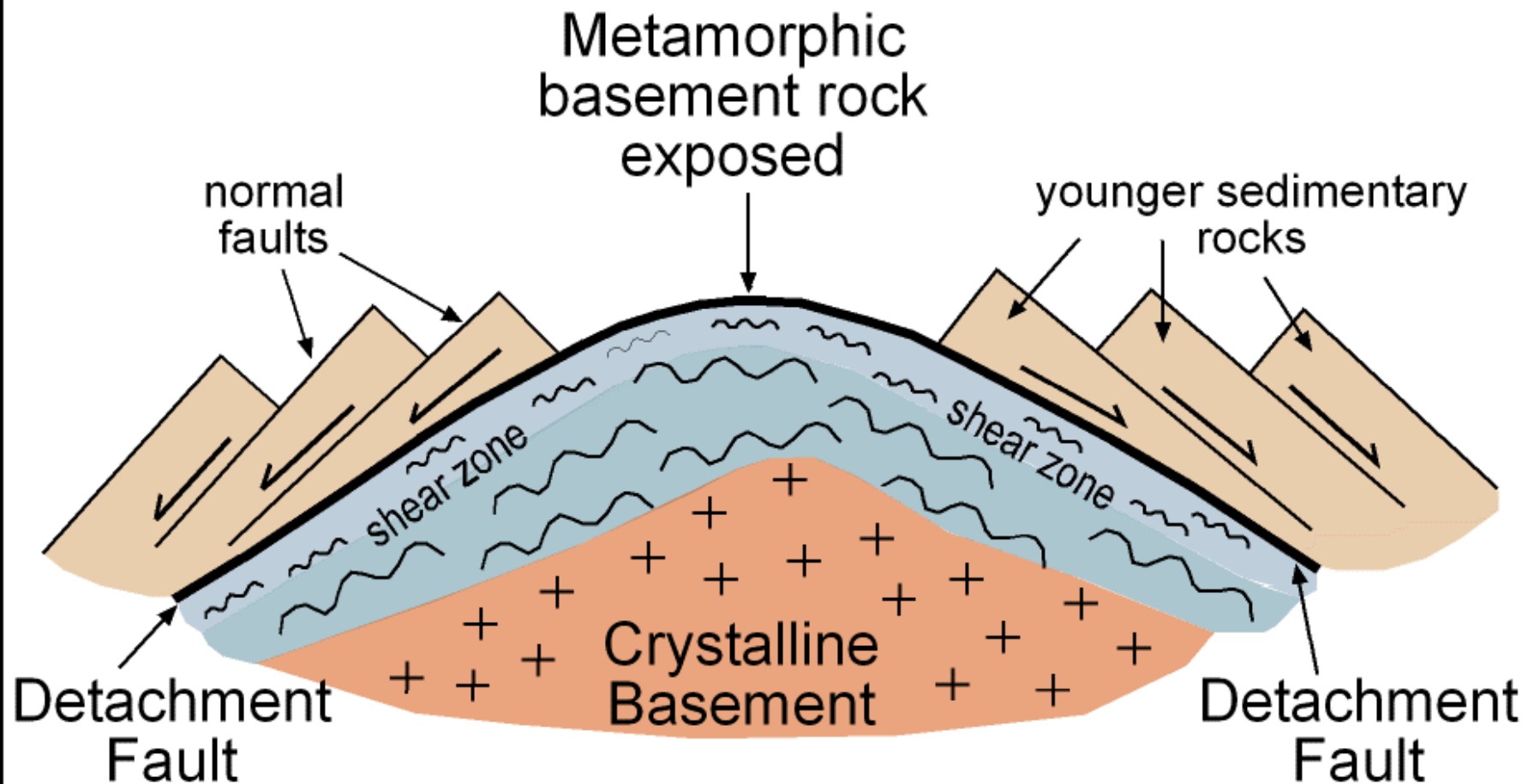
The Laramide orogeny in the Rocky Mountain region (Upper Cretaceous through Eocene) was a period of basement-involved thrusting that affected a large area east of the Sevier orogenic belt (light pink) creating a number of basins and uplifts. Modified from King (1969).



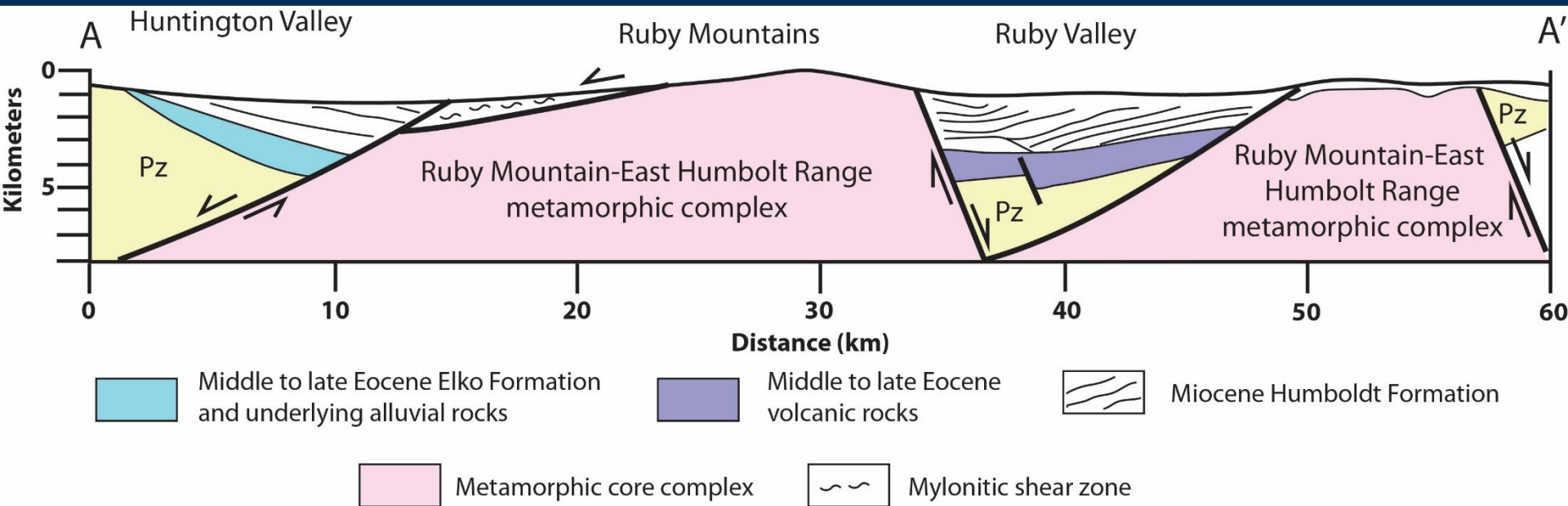
Lakes formed in many Laramide basins including Lake Uinta in the Uinta and Piceance Basins, Lake Gosiute in the Greater Green River Basin, Lake Waltman in the Wind River Basin, and Lake Tatman in the Bighorn Basin. Age of these lakes is shown in red. Modified from King (1969).



The Elko Basin began to form about 42 millions of years ago (Ma) during the initial stages of basin and range extension. Basin subsidence ended about 39 Ma. The lake that occupied the Elko Basin does not appear to overlap in time with lakes in Laramide basins to the east. Modified from King (1969).

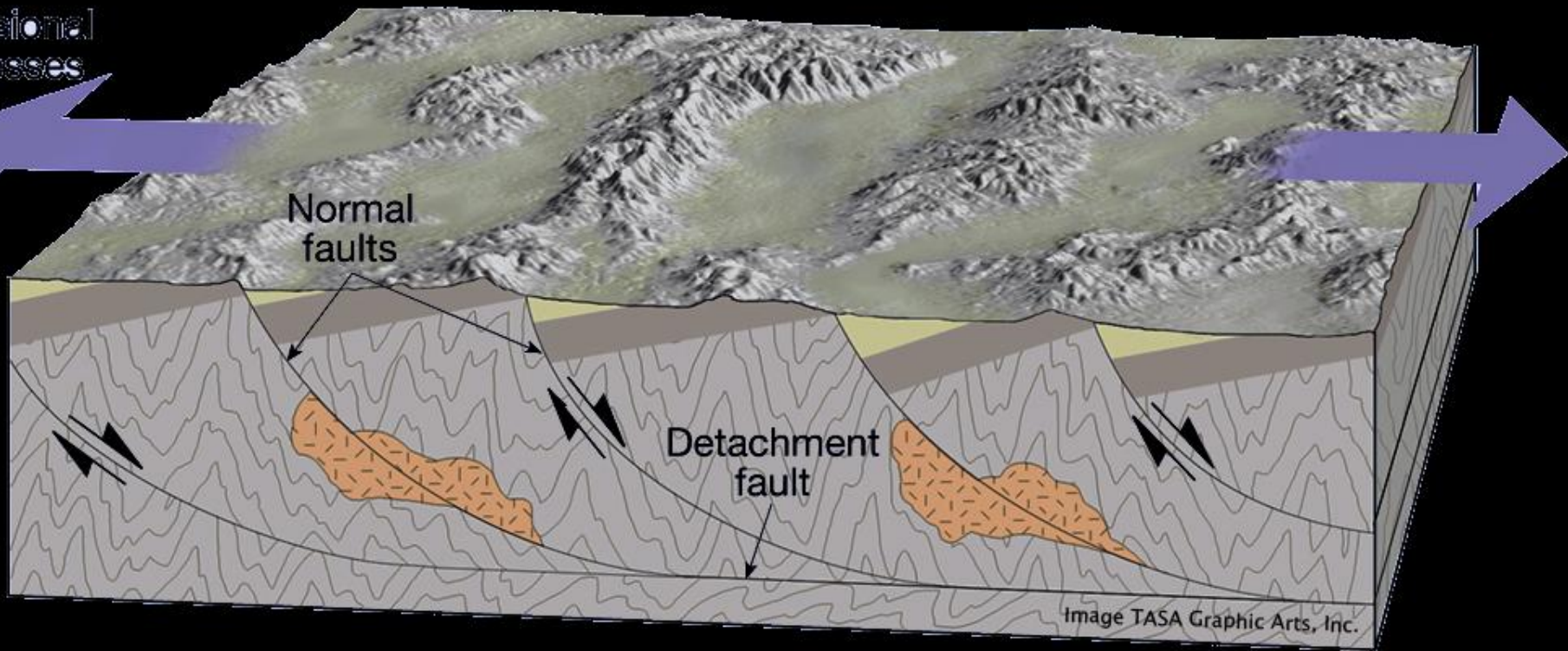


The early stages of regional extension created metamorphic core complexes in which lower crustal rocks were brought to the surface. Sedimentary basins, such as the Elko Basin, formed on the flanks of these complexes. From DeGrey and Link (2017).



West-east cross section of the Huntington Valley, where the Elko Formation was deposited, the Ruby Mountain metamorphic complex, and the Ruby Valley to the east. Note the mylonitic shear zone. (Modified from a seismic line by Satarugsa and Johnson, 2000). Location shown on slide 7.

Tensional
stresses

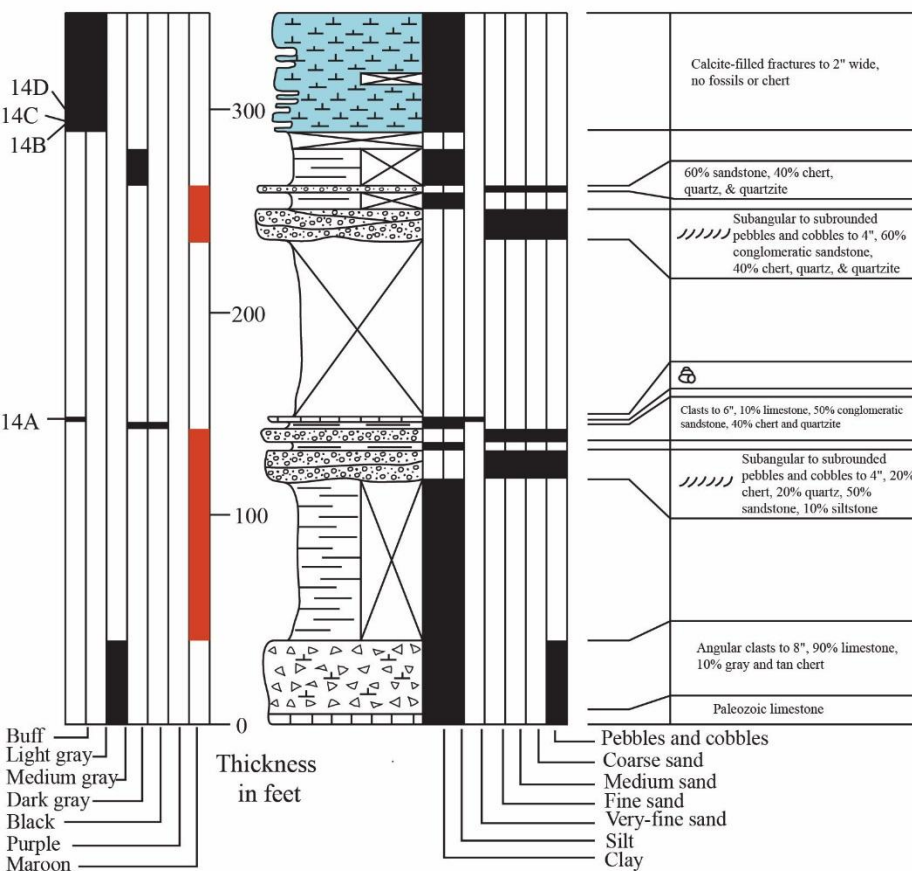


Lacustrine rocks of the Elko Formation were brought to the surface during a later stage of extension that began about 17 Ma producing the half graben “basin and range” topography that characterizes the province today.

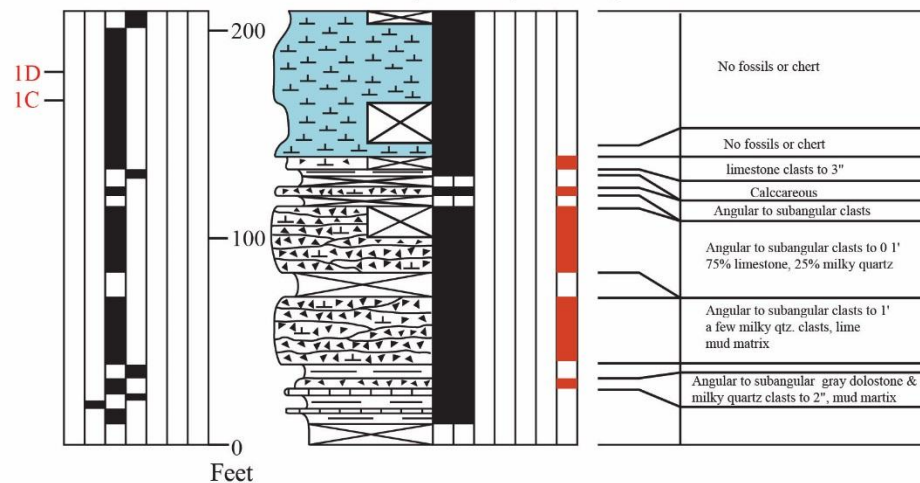
Block diagram of basin and range faulting

Fluvial and Alluvial Period

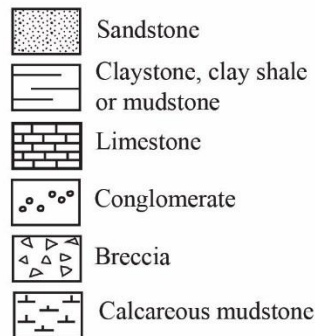
Bullion Road section
93-NV-14, Sec. 20, T. 33 N. R. 55 E.



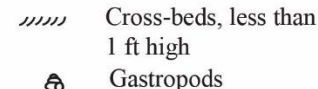
93-NV-1, Sec. 34, T. 33 N., R. 55 E.



LITHOLOGY



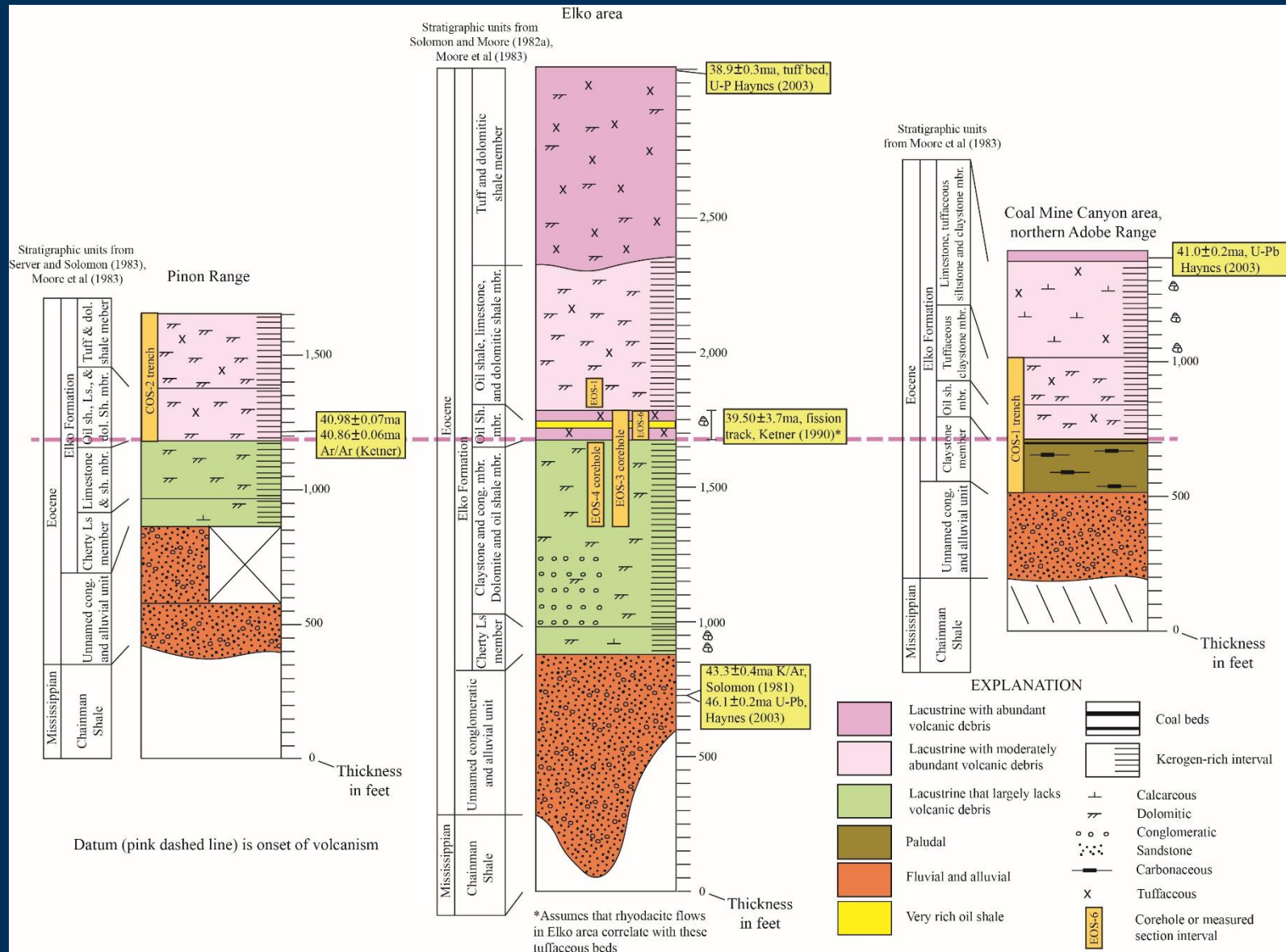
INTERNAL CHARACTERISTICS



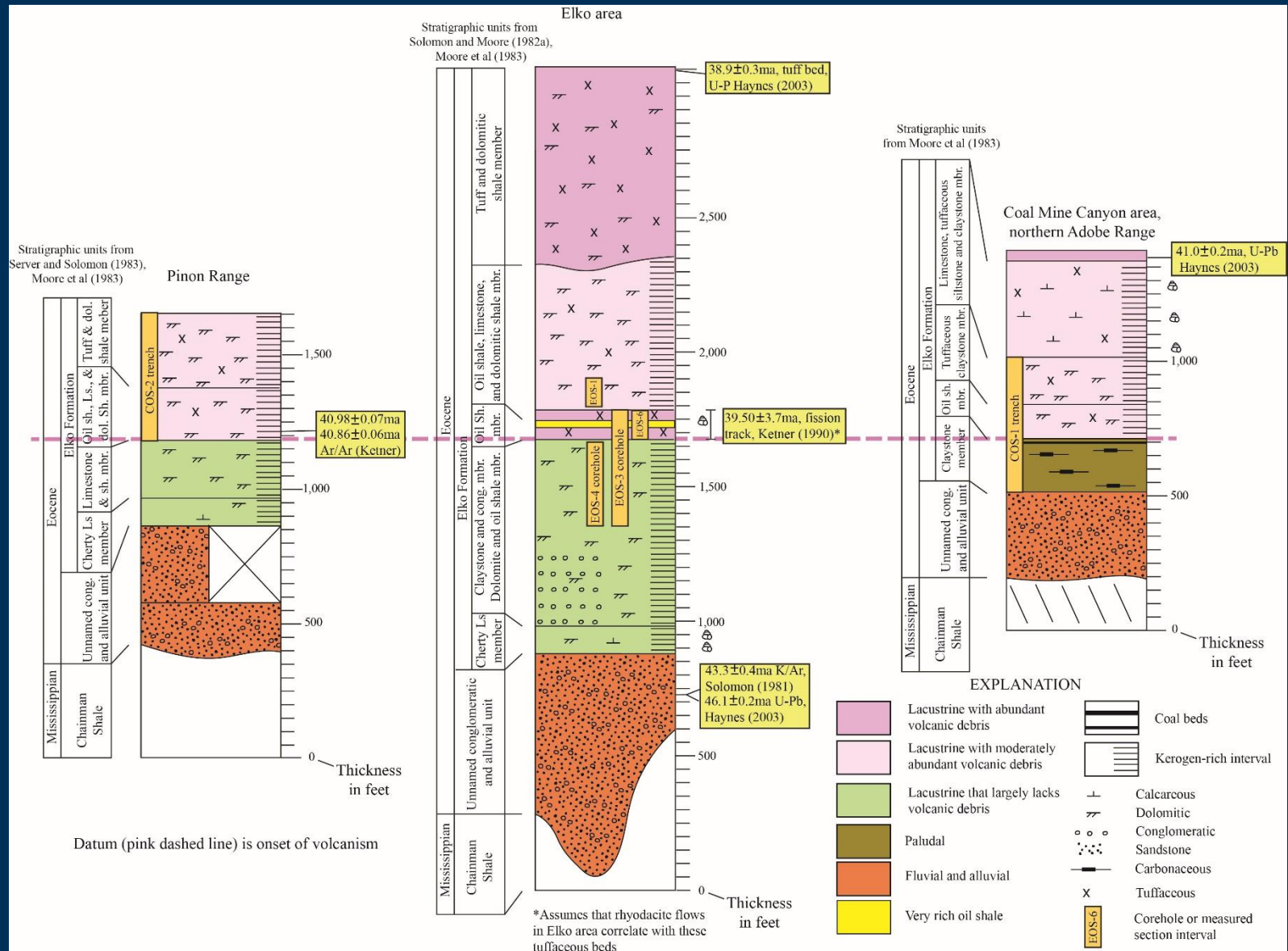
Cherty limestone of Solomon and Moore (1982a; 1982b)

Measured thicknesses of fluvial and alluvial rocks beneath the lacustrine interval varies from about 284 ft to more than 845 ft and consists largely of variegated maroon and gray mudstone and conglomeratic channel sandstones with clasts from nearby uplands. Mass-movement deposits, with clasts to small boulder-sized fragments were also observed. Collapsed karsts developed locally on the underlying Paleozoic limestones. A cherty limestone is the oldest lacustrine unit in most areas.

Nonvolcanic Paludal and Lacustrine Period

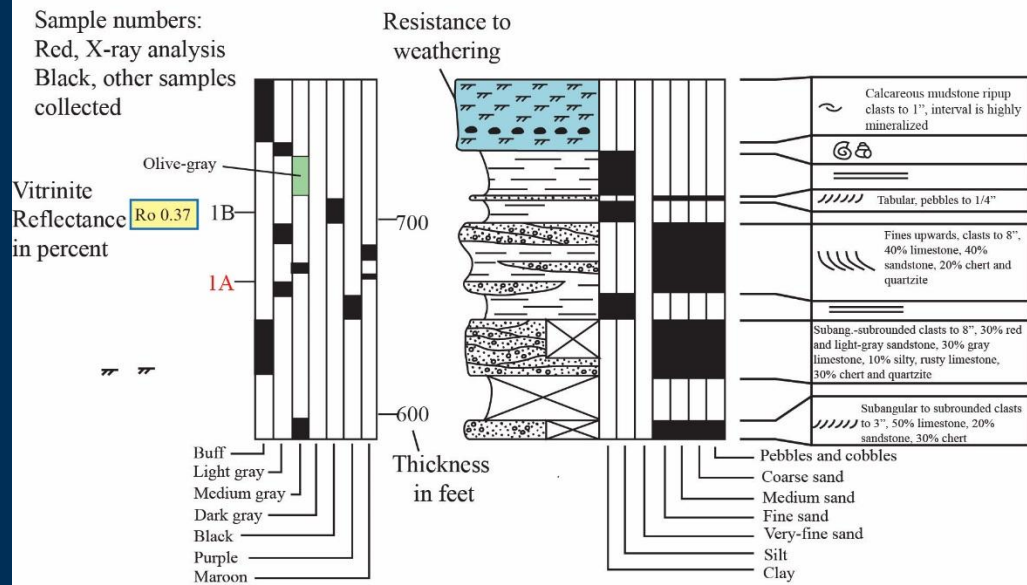


The overlying nonvolcanic lacustrine interval consists of dolomitic low-grade oil shale in offshore areas. It can be conglomeratic in marginal lacustrine areas and appears to grade into a paludal interval with coal beds up to 6-ft thick in the northern Adobe Range.





If you want to work on the Elko Formation bring a shovel. Outcrops are typically poor.



LITHOLOGY

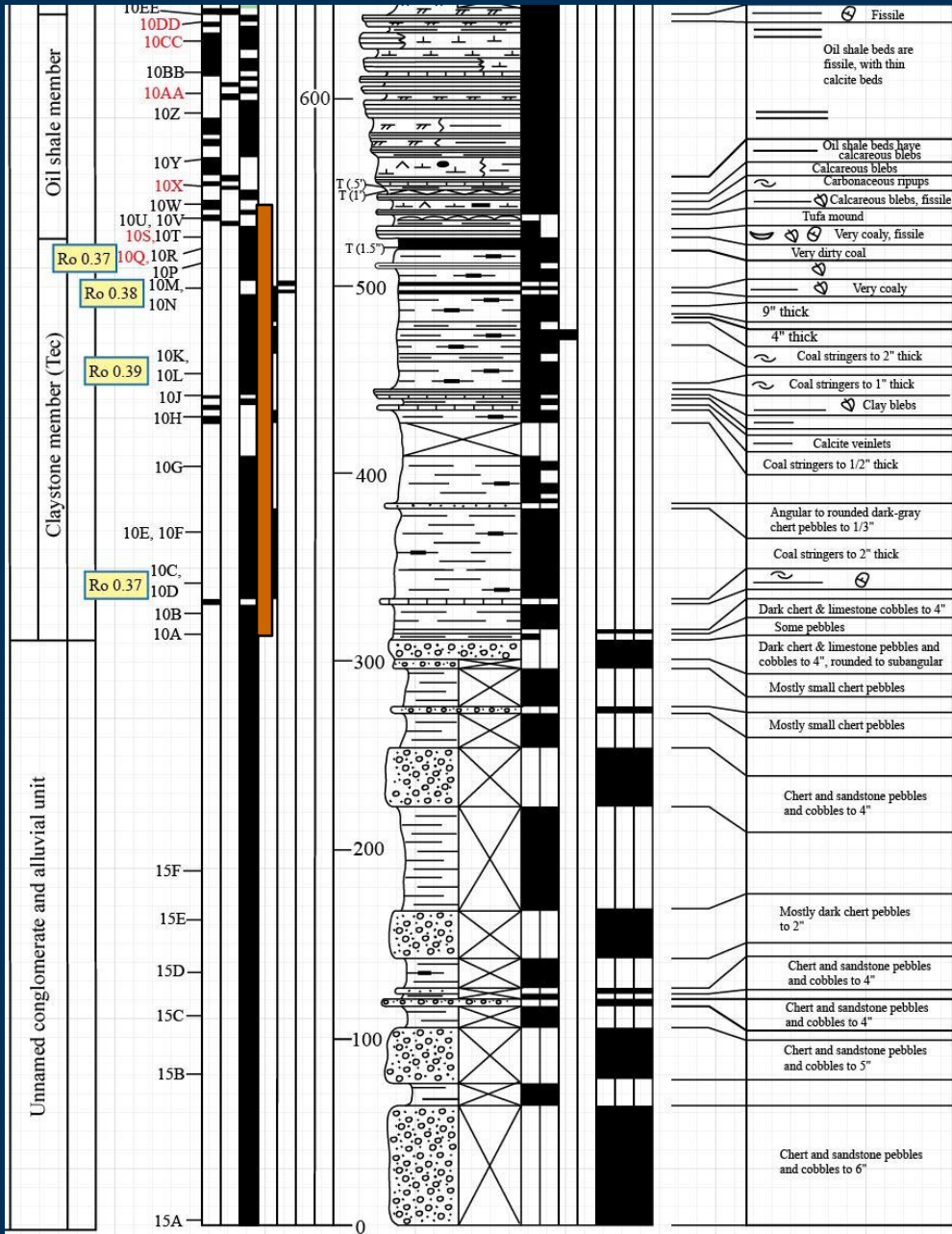
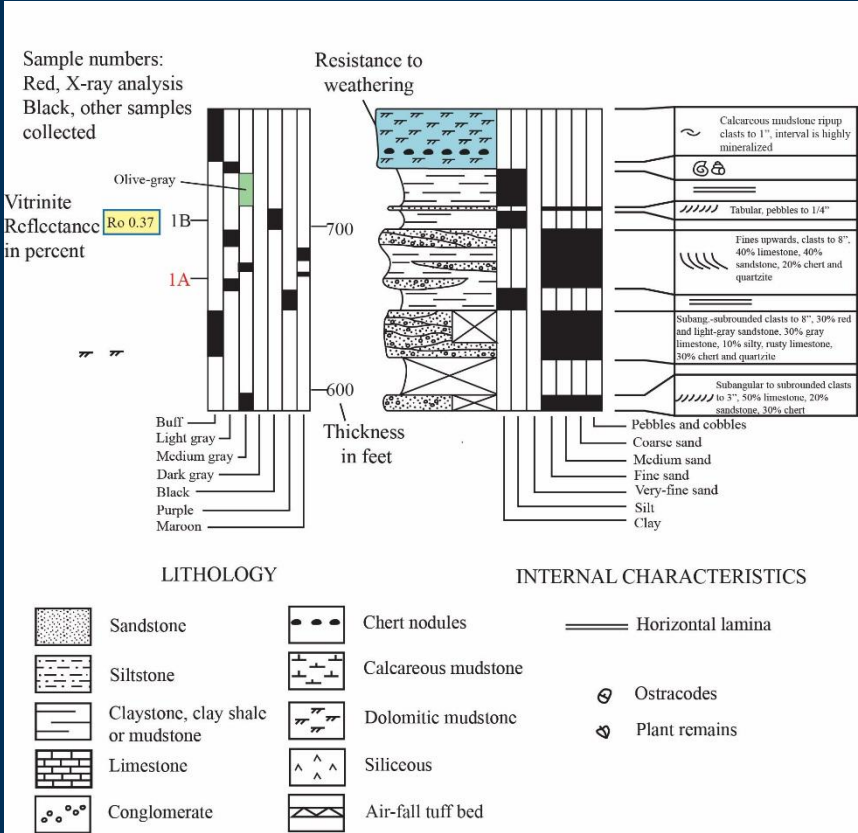
	Sandstone
	Siltstone
	Claystone, clay shale or mudstone
	Limestone
	Conglomerate
	Breccia
	Chert nodules
	Calcareous mudstone
	Dolomitic mudstone
	Siliceous
	Rip up clasts
	Tuffaceous
	Air-fall tuff bed

INTERNAL CHARACTERISTICS

	Cross-beds, less than 1 ft high
	Cross-beds, 1 to 3 ft high
	Cross-beds, greater than 3 ft high
	Horizontal lamina
	Gastropods
	Ostracodes
	Plant remains
	Cherty limestone of Solomon and Moore (1982a; 1982b)

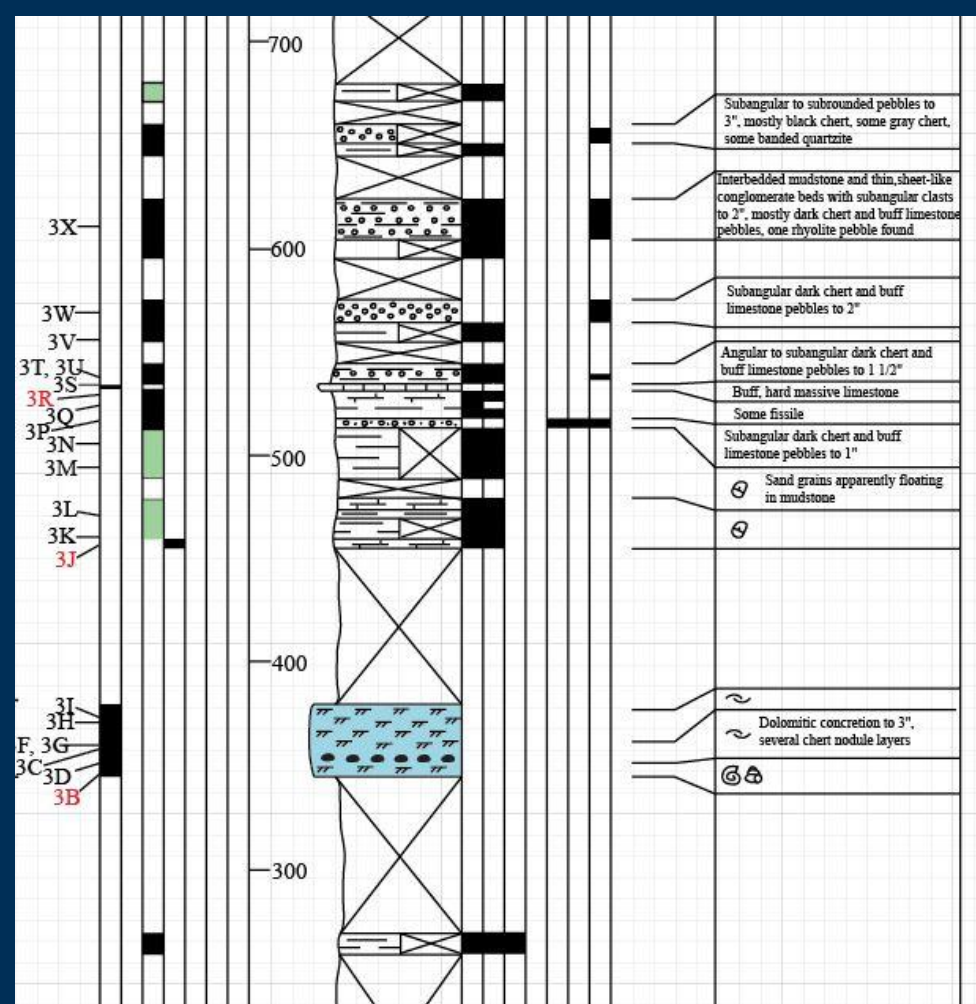
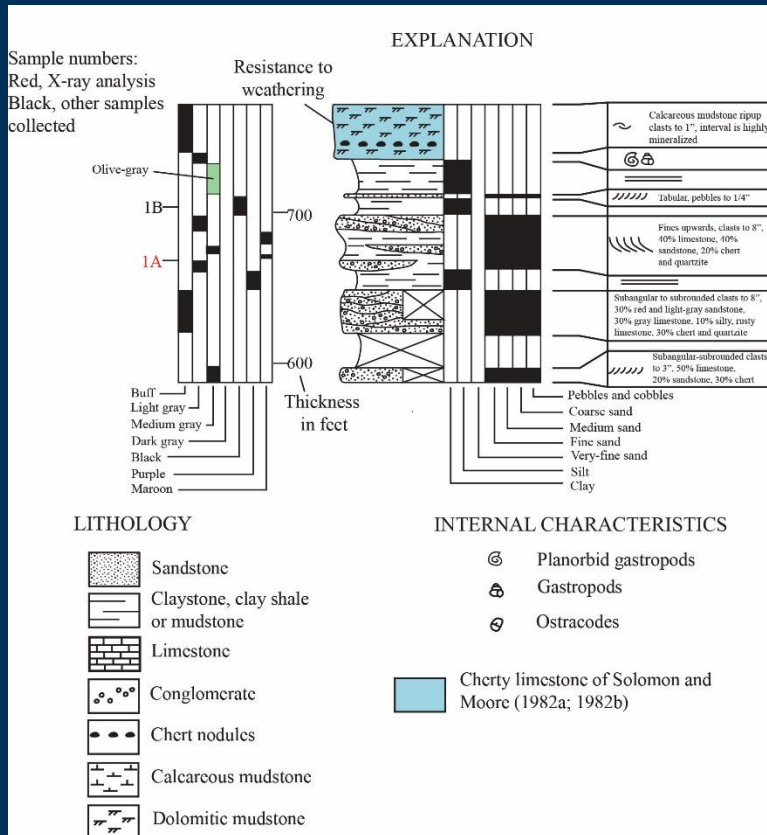
In the northern Adobe Range, paludal rocks (orange interval), with coal beds to 6 ft thick in their upper parts, occur between the alluvial and overlying volcanic-rich lacustrine rocks. Thickness of the paludal interval (brown) is about 210 ft.

The paludal interval overlies a 300-ft thick conglomeratic fluvial interval.

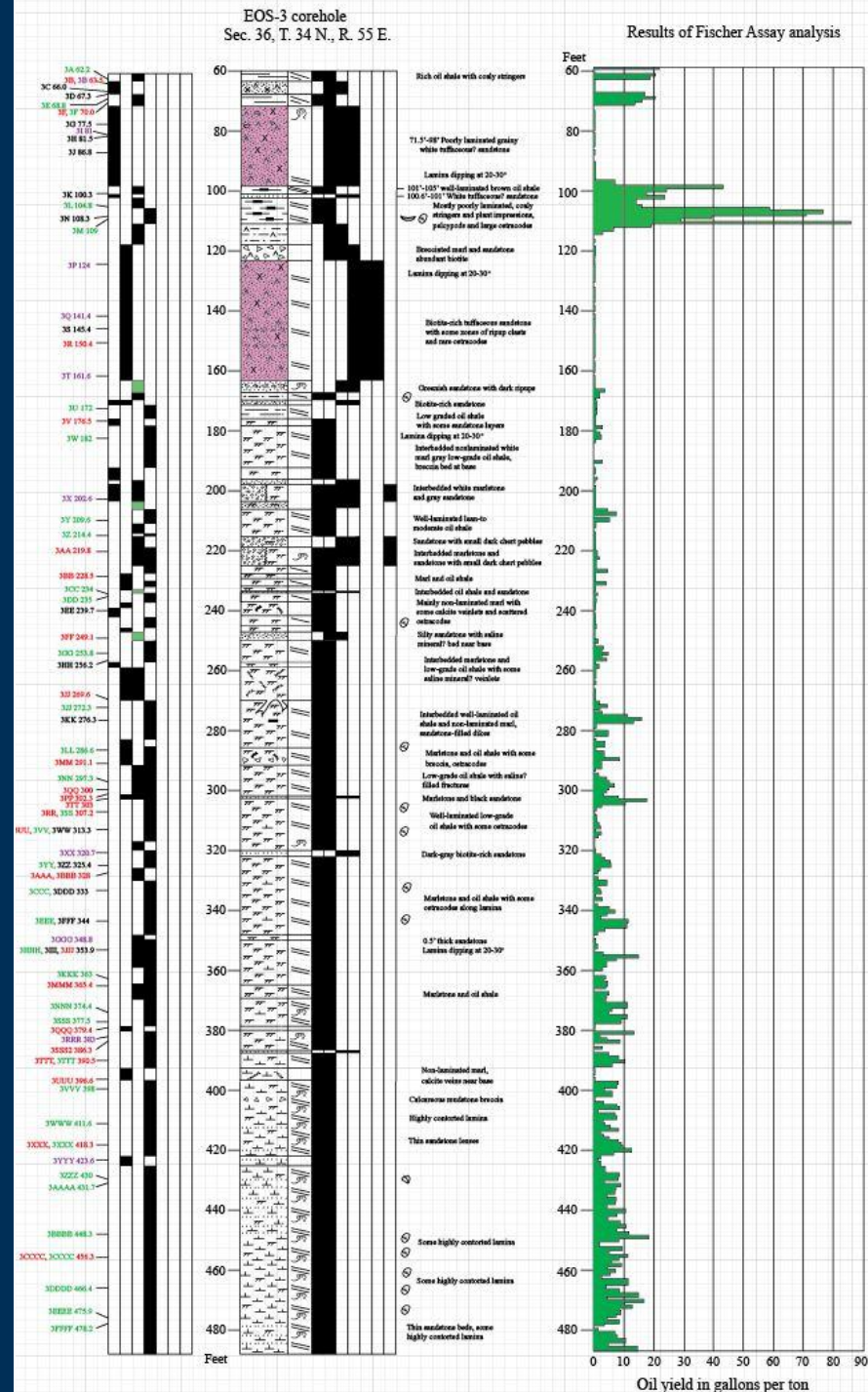
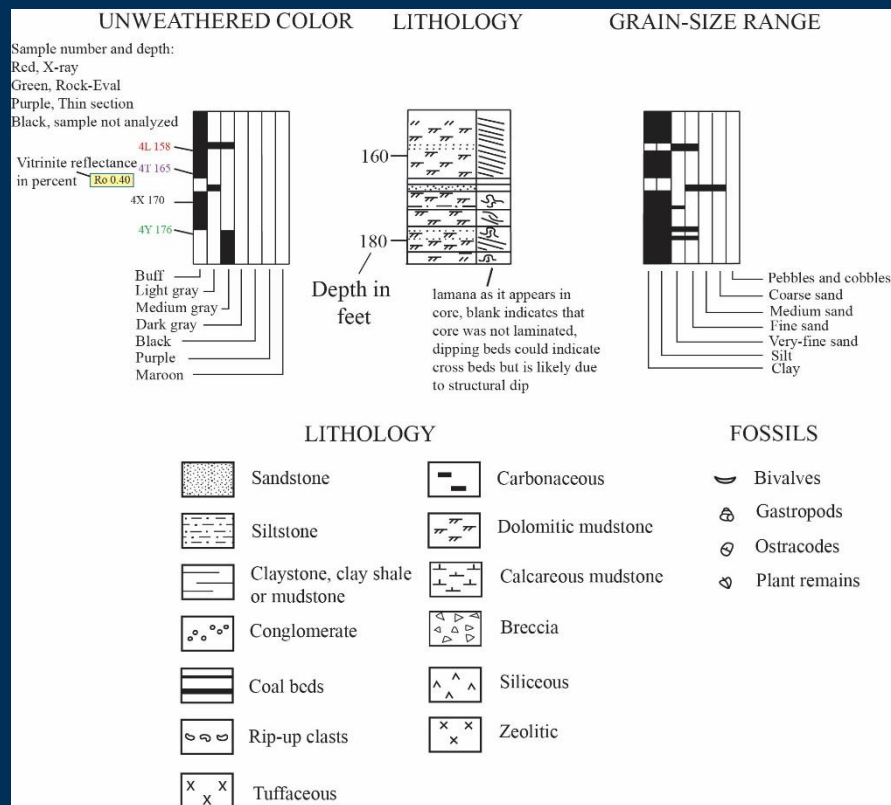


In the measured section near the city of Elko, the prevolcanic lacustrine interval is marginal lacustrine with chert pebble conglomerates. One rhyolite pebble was found.

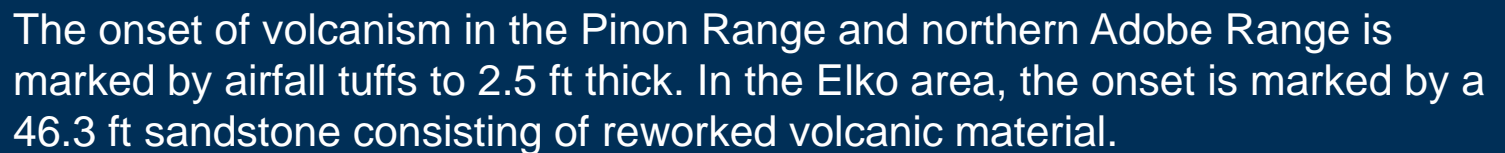
This conglomeratic marginal lacustrine interval grades into mostly well-laminated, low-grade dolomitic oil shale in the EOS-3 corehole 3 miles to the southeast. Note the basal lacustrine cherty limestone unit (blue).



The nonvolcanic lacustrine interval in the EOS-3 core (between white arrows) consists of dolomitic and calcareous mudstone and low-grade oil shale. Oil shale is typically well laminated. X-ray analysis indicates that both lithologies consist of varying amounts of quartz, calcite, dolomite, and smectite..

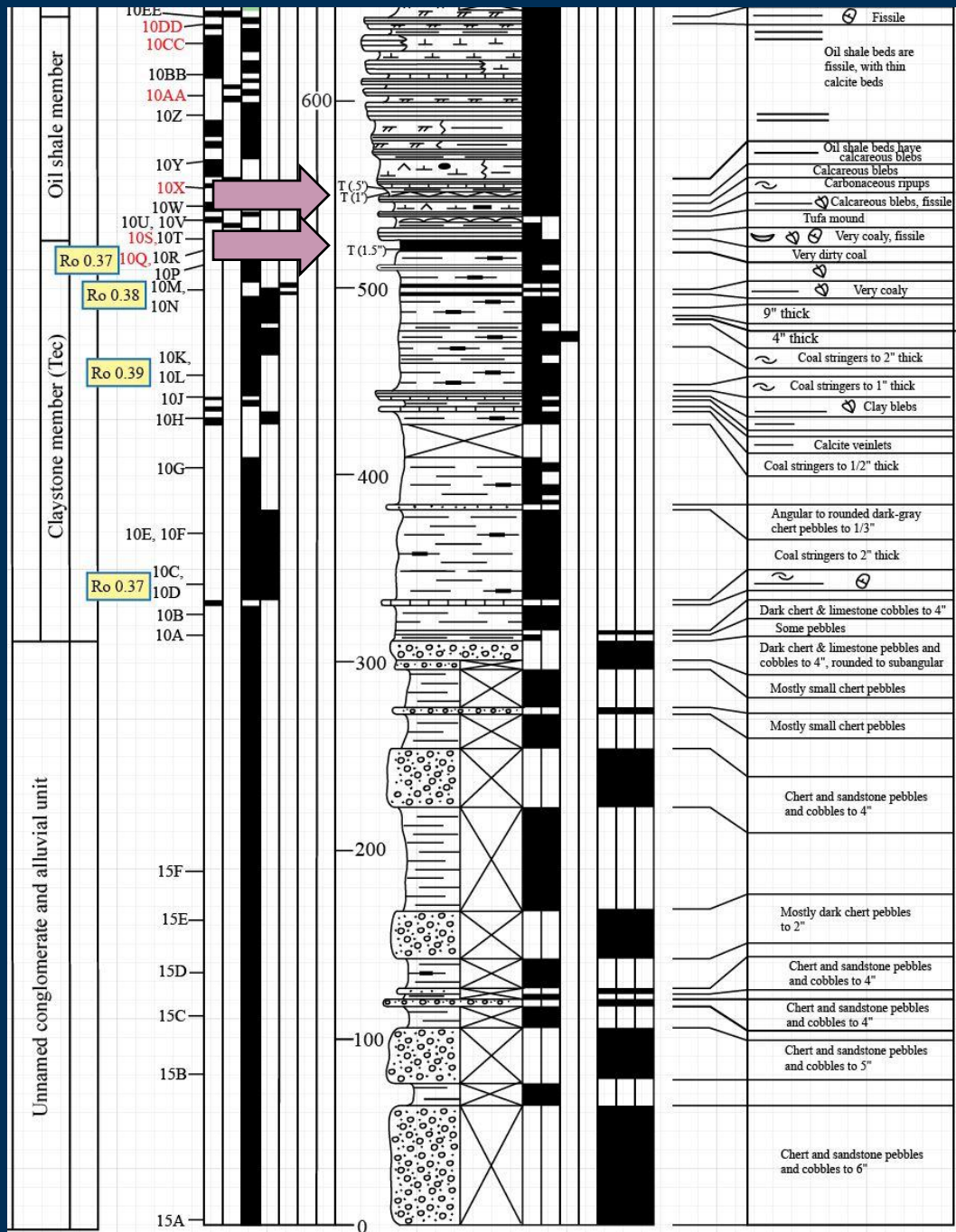
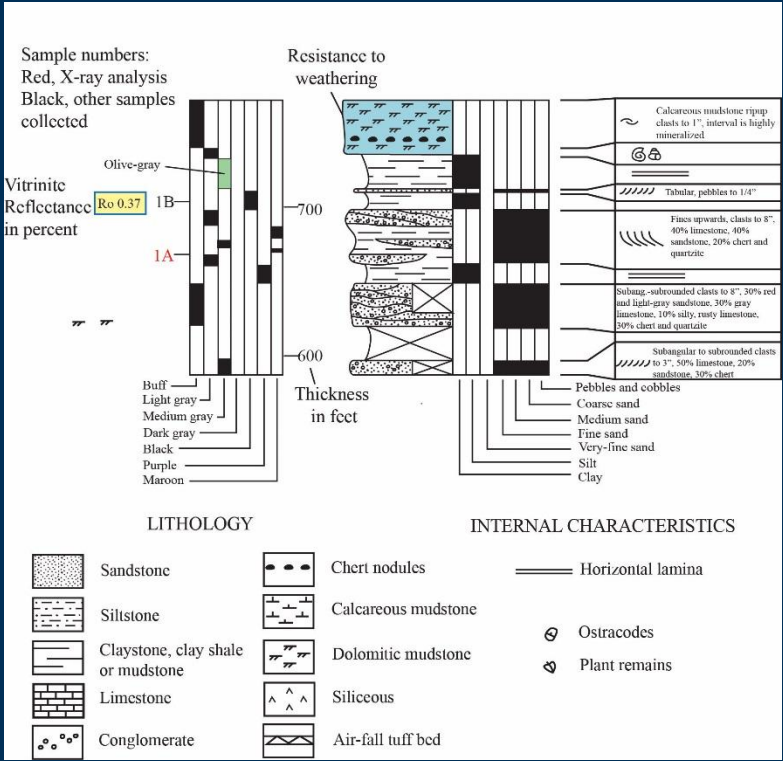


Volcanic Lacustrine Period



Tuffs in the Adobe Range section are marked by pink arrows. The lowest tuff is 1.5 inches thick and is in the uppermost coal bed.

The onset of volcanism appears to correspond to the expansion of the Elko Basin Lake into this area.



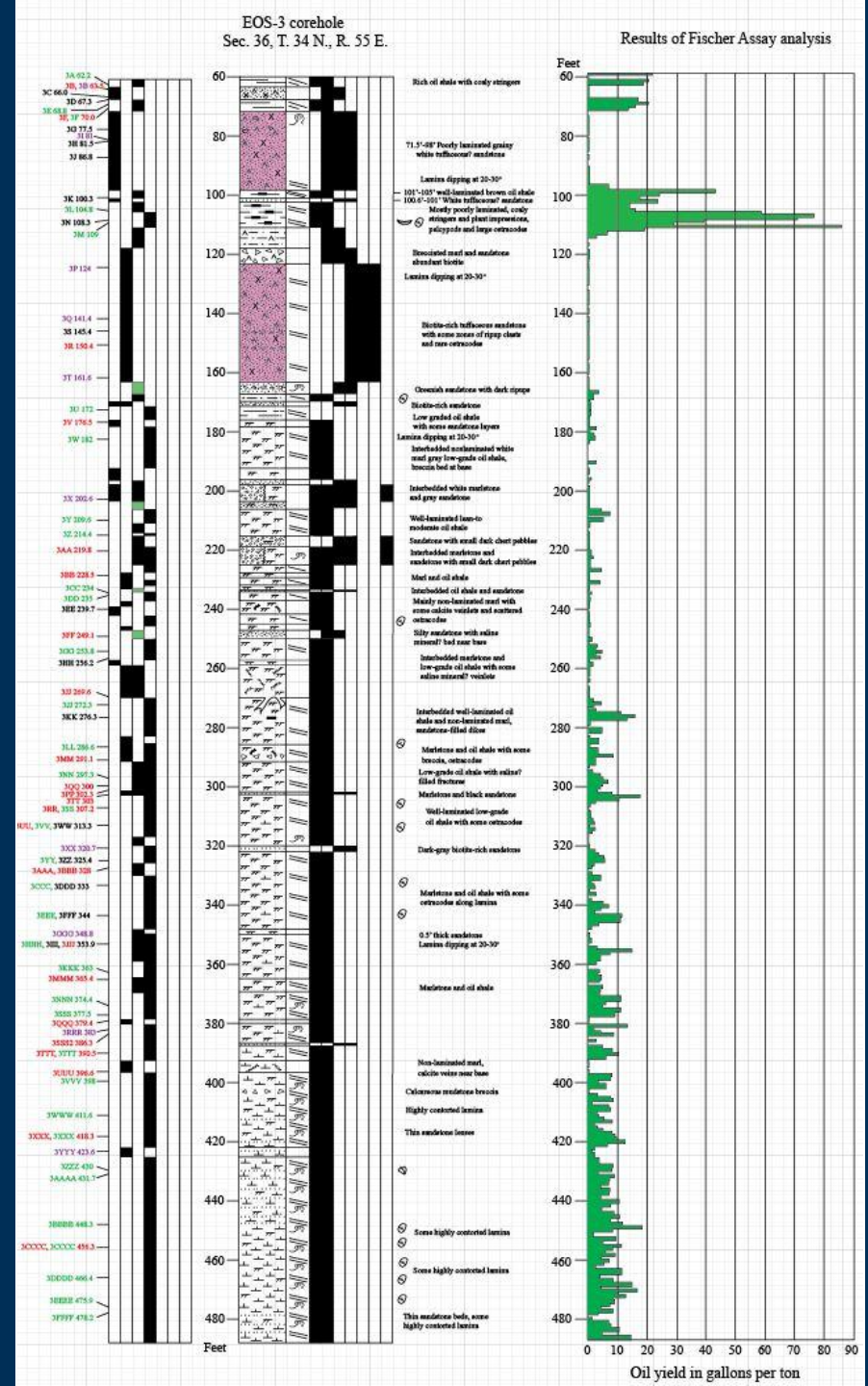
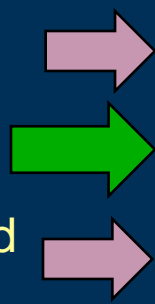
Sandstone, white, highly altered, rhyolitic?

Very rich, non-dolomitic oil shale

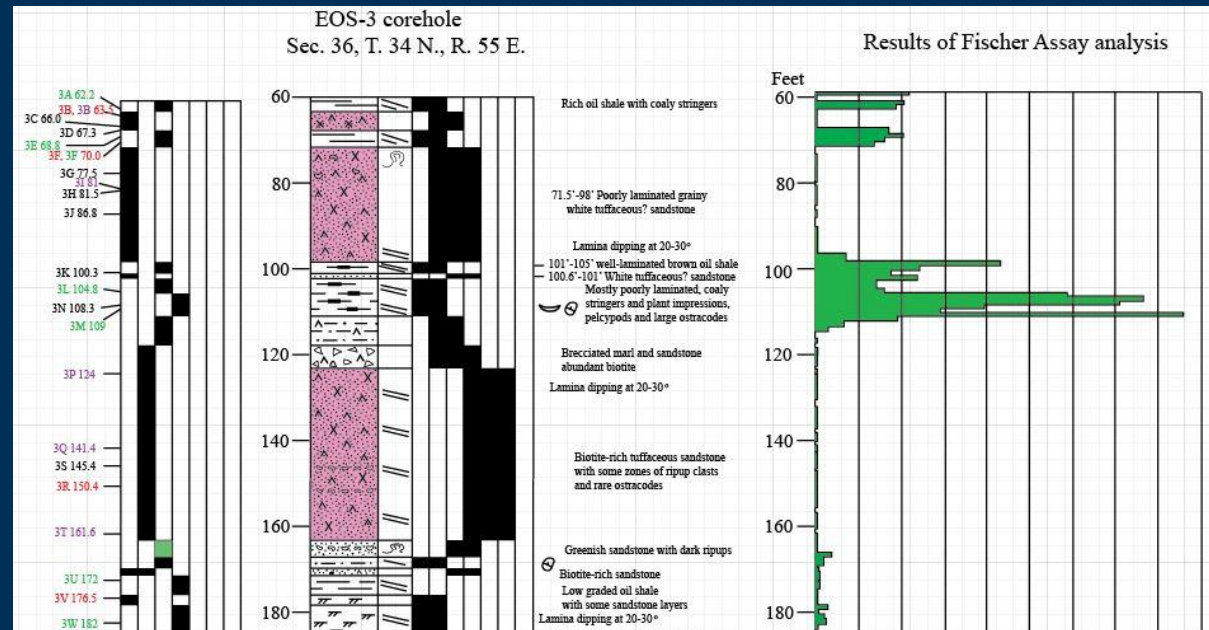
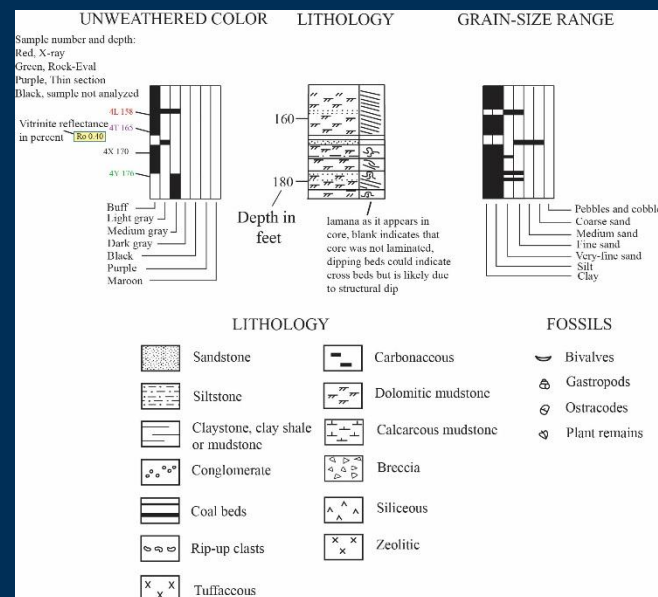
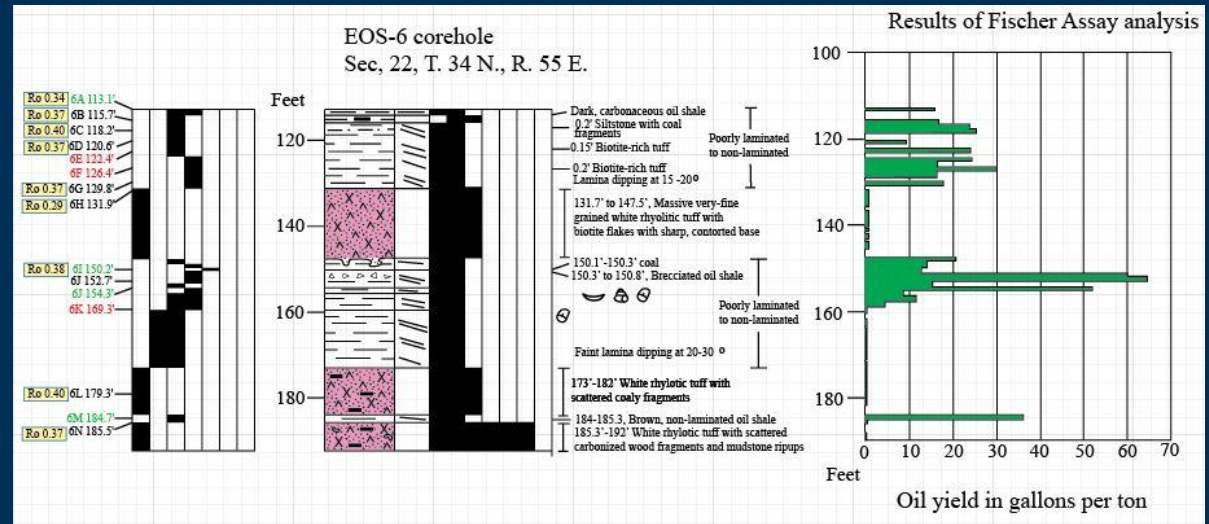
46.3-feet thick white, highly altered rhyolitic Ss

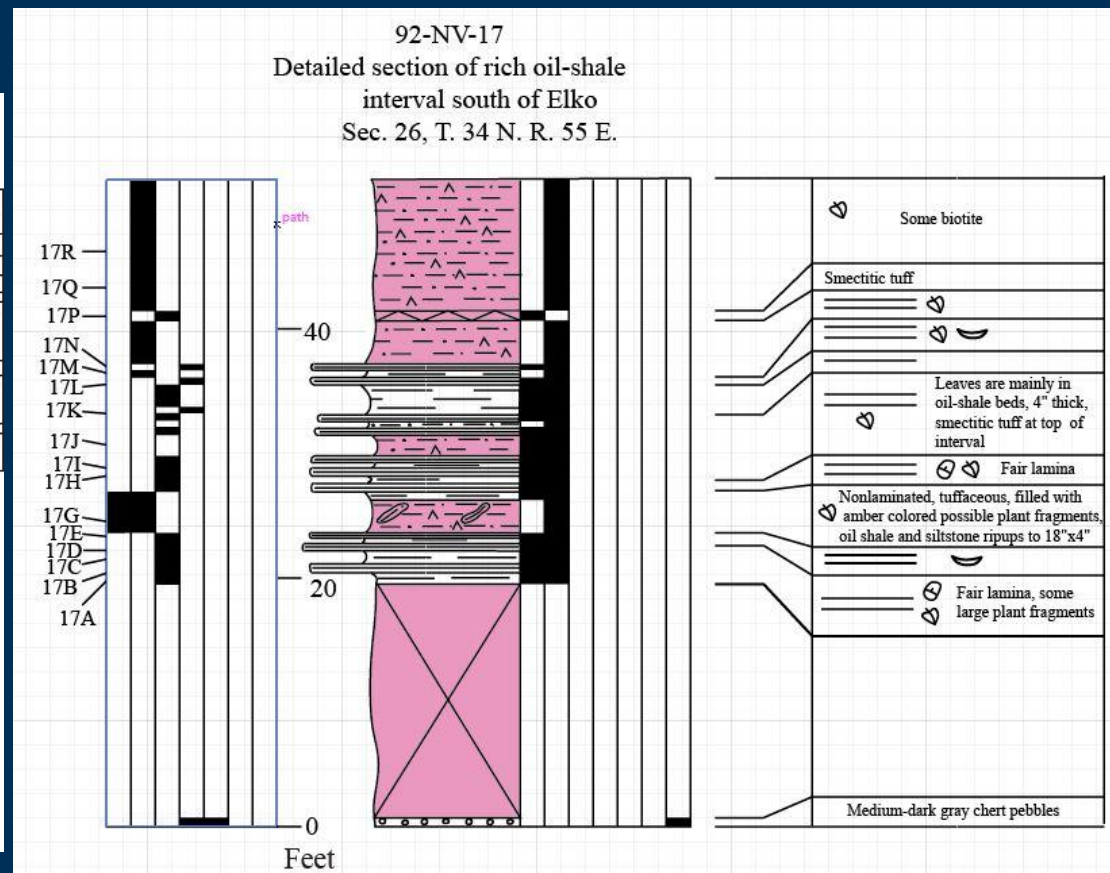
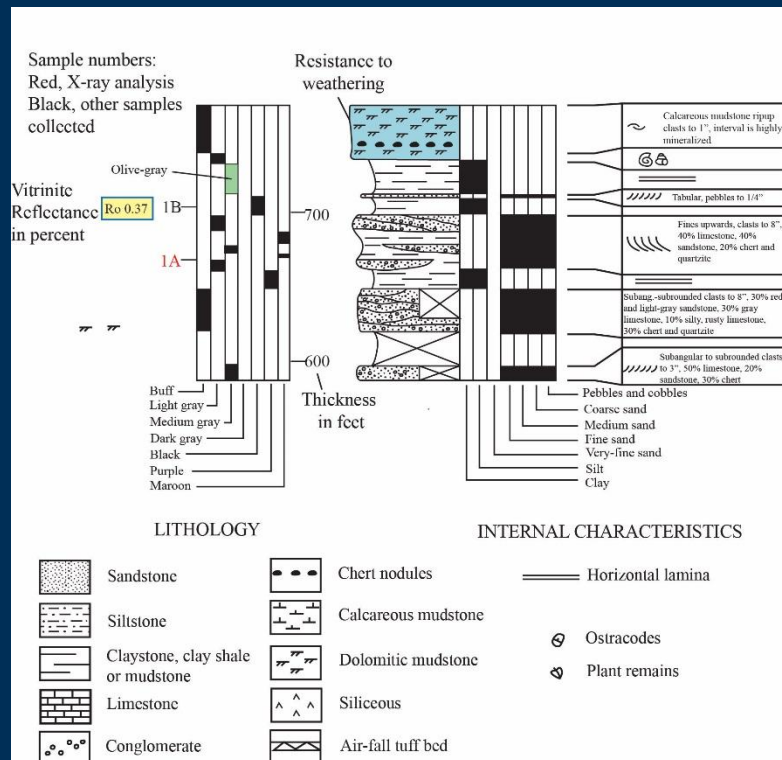
A shift from low-grade dolomitic oil shale to very rich clayey oil shale occurred after deposition of reworked volcanic sandstone.

Programmed pyrolysis (Rock-Eval) and Fischer assay data indicate that the kerogen is thermally immature in all coreholes and at all surface localities.



Tuffaceous sandstones consist mainly of plagioclase, orthoclase, clinoptilolite, opal-CT, and biotite.





The rich oil shale was exposed near the two previous coreholes and described in detail. The rich oil shale beds are fairly well-laminated and contain abundant plant debris and some clam shells. Tuffaceous beds contain large oil shale and siltstone ripups.

Conclusions on Geology of Elko Formation

- The Elko Formation is entirely younger than the Green River Formation.
- The Elko oil-shale basin formed during a period of regional extension (basin and range faulting), whereas the Green River oil-shale basins formed during an earlier period of regional compression (Laramide orogeny).
- The rich oil-shale interval in the Elko was deposited immediately after the onset of volcanism in the area, suggesting that the input of volcanic material to the lake may have initiated a period of high organic productivity.

Geochemistry of Elko Oil Shale

Palmer (1984) performed a study of the hydrocarbon potential and thermal maturity of Elko Formation oil shales outcropping in the Adobe Range. Two organic-rich facies, immature oil shale and siltstones, were identified.

Analyses included XRD, organic petrography, kerogen isolation and elemental analysis, programmed pyrolysis (Rock-Eval), TOC, and biomarker analysis of extractable organic matter.

Hydrous pyrolysis experiments were also conducted to assess potential crude oil quality in the Elko.

HYDROCARBON SOURCE POTENTIAL OF ORGANIC FACIES OF THE LACUSTRINE ELKO FORMATION (EOCENE/OLIGOCENE), NORTHEAST NEVADA

SUSAN E. PALMER¹

ABSTRACT

The hydrocarbon potential and thermal maturity of the Elko Formation, an Eocene-Oligocene lacustrine deposit cropping out in northeastern Nevada, was assessed. Two distinctly different organic-rich facies can be recognized — a lignitic siltstone and an oil shale. The lignitic siltstone contains higher plant remains in the form of vitrinite, which is gas prone, while the oil shale is composed of oil-prone, amorphous kerogen of algal origin. A third facies (organic-lean) is represented by mudstones which contain small amounts of fine-grained reworked kerogen. The deposit is immature with respect to oil generation.

The most useful indicators of the two major organic facies of the Elko Formation are the distribution of steranes and diterpanes, the presence or absence of a specific triterpenoid biomarker (gammacerane), kerogen form, and Rock-Eval pyrolysis parameters, S_2/S_3 and $(S_1 + S_2)/TOC$. In general, the immature siltstones are characterized by: (1) gas-prone vitrinitic kerogen, (2) pristane/phytane ratios slightly greater than 1.0, (3) relatively less negative $\delta^{13}C$ values for kerogen and $C_{15}+$ hydrocarbons, (4) a predominance of C_{29} steranes, e.i., 5 α (H) and 5 β (H)-stigmastane (20R) and small amounts of rearranged C_{27} , C_{28} , and C_{29} steranes, (5) primarily C_{19} and C_{20} triaromatic diterpanes, and (6) a predominance of 17 β (H)-22, 29, 30-trisnorhopane with respect to 17 α (H) hopanes and 17 β (H) moretanes. The immature oil shales are characterized by: (1) oil-prone algal kerogen, (2) pristane/phytane ratios less than 0.5, (3) relatively more negative $\delta^{13}C$ values for kerogen and $C_{15}+$ hydrocarbons, (4) a mixture of C_{27} , C_{28} , and C_{29} steranes, i.e., 5 α (H) and 5 β (H) 20R cholestane, ergostane, and stigmastane, and C_{28} , C_{29} , and C_{30} 4-methyl steranes, (5) a mixture of C_{19} to C_{26} diterpanes, and (6) a predominance of hopane and moretane and the presence of gammacerane. Hydrous pyrolysis of solvent-extracted oil shale produced a waxy oil-like bitumen whose more "mature" biomarkers and stable carbon isotopic composition resembled that of the unreacted (immature) oil shale.

INTRODUCTION

In a recent review of oil shale resources, Knutson and Dana (1983) outline the economics of mining the stratigraphically and structurally complex Elko oil shale. The Elko was mined briefly in the early 1900's; the Southern Pacific Company and the U.S. Bureau of Mines constructed an oil shale plant in 1918 and the Catlin Shale Products Company operated an experimental rector from 1916 to 1924 at Elko, Nevada (Solomon and others, 1979; and Knutson and Dana, 1983). Although a poor candidate for mining and shale oil production, the organic-rich Elko Formation is considered by many to have good potential as a petroleum source rock. However, stratigraphic and structural complexities also make it difficult to estimate the volume and quality of source rock in the subsurface. For example, it is possible that the outcrops of the Elko Formation contain only nearshore deposits (i.e., lignitic siltstones and oil shales, etc.) while offshore rocks of unknown source rock quality may occur only in the subsurface (Solomon and others, 1979).

In spite of these geologic complexities, the occurrence of the Elko Formation in outcrop provides an opportunity to geochemically delineate two very distinct organic facies which, according to Solomon and others (1979), were deposited in a shallow, alkaline, freshwater lake. The geochemical signature of the two specific organic facies would aid in recognizing oils

sourced from the Elko Formation. The study of the assemblage of organic matter present in the Elko Formation includes the insoluble fraction (kerogen) and extractable $C_{15}+$ hydrocarbons. In this study emphasis is placed on the use of sterane and terpane biomarkers as indicators of lacustrine depositional environments and also on the use of hydrous pyrolysis in the study of low maturity possible source rocks and for simulating oil generation.

SAMPLE COLLECTION AND EXPERIMENTAL METHODS

Twenty-four samples of three lithologically distinct units (i.e., lignitic siltstone, oil shale, and mudstone) were collected from depths of at least one foot into the trenched outcrop. The multiple sampling of these three units allowed monitoring of the amount of variation in mineralogical and organic geochemical parameters as well as selection of representative samples for detailed geochemical study.

Total organic carbon was determined using a LECO WR12 carbon analyzer. Kerogen was isolated by HCl , HF treatment followed by $ZnBr$ flotation. Kerogen quality and thermal maturity (i.e., spore coloration and vitrinite reflectance) were determined by transmitted and reflected light microscopy using a Zeiss Photomicroscope III and Zeiss Universal Microscope, respectively. Kerogen fluorescence studies were made using a Zeiss Photomicroscope III equipped with a vertical illuminator III RS and UV filter package. Rock-Eval pyrolysis was performed on crushed rock samples using a New Version Rock-Eval, and elemental analysis of solvent-extracted kerogen samples was performed by the Williams Brothers Laboratories (Tulsa) using a Carlo Erba Model 1106 elemental analyzer.

Hydrous pyrolysis experiments were conducted using a 75 milliliter volume capacity stainless steel Parr bomb equipped

¹Cities Service Oil and Gas Corporation, Exploration & Production Research Group, Box 3908, Tulsa OK 74102.

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Fischer assay

ASTM method D3904-90

(American Society for Testing
and Materials, 1980)

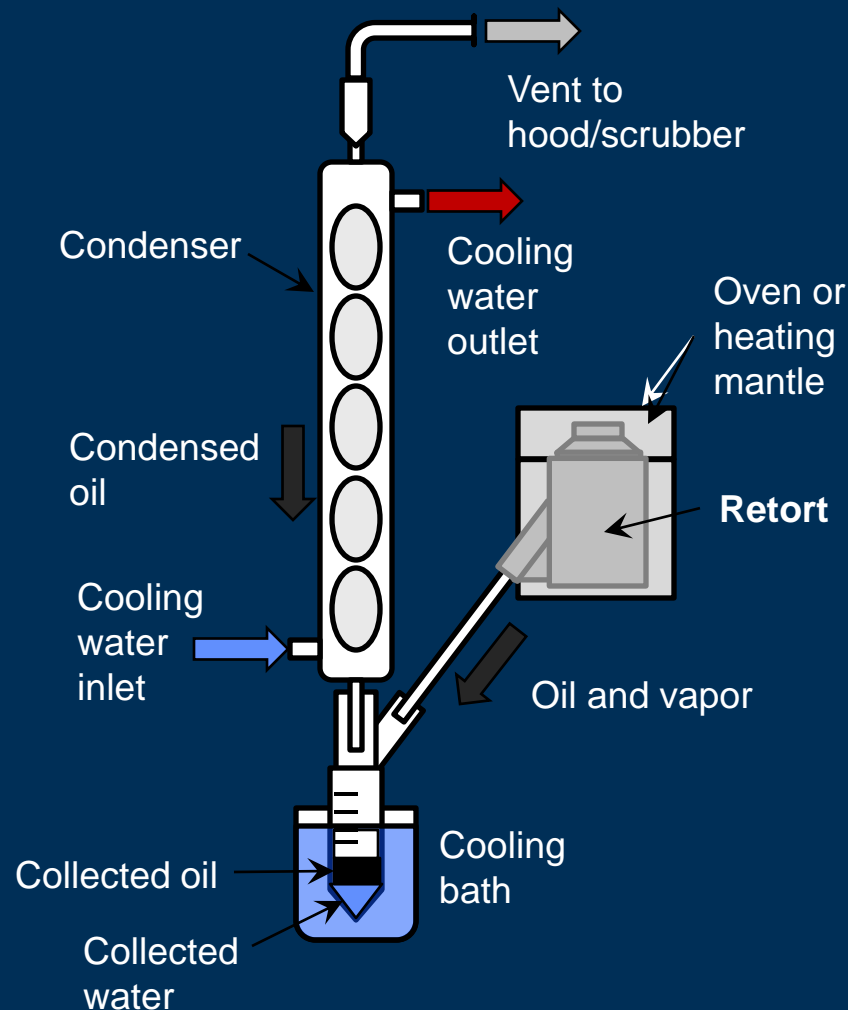
Products collected

Condensed oil
Condensed water
Spent rock

Reported values

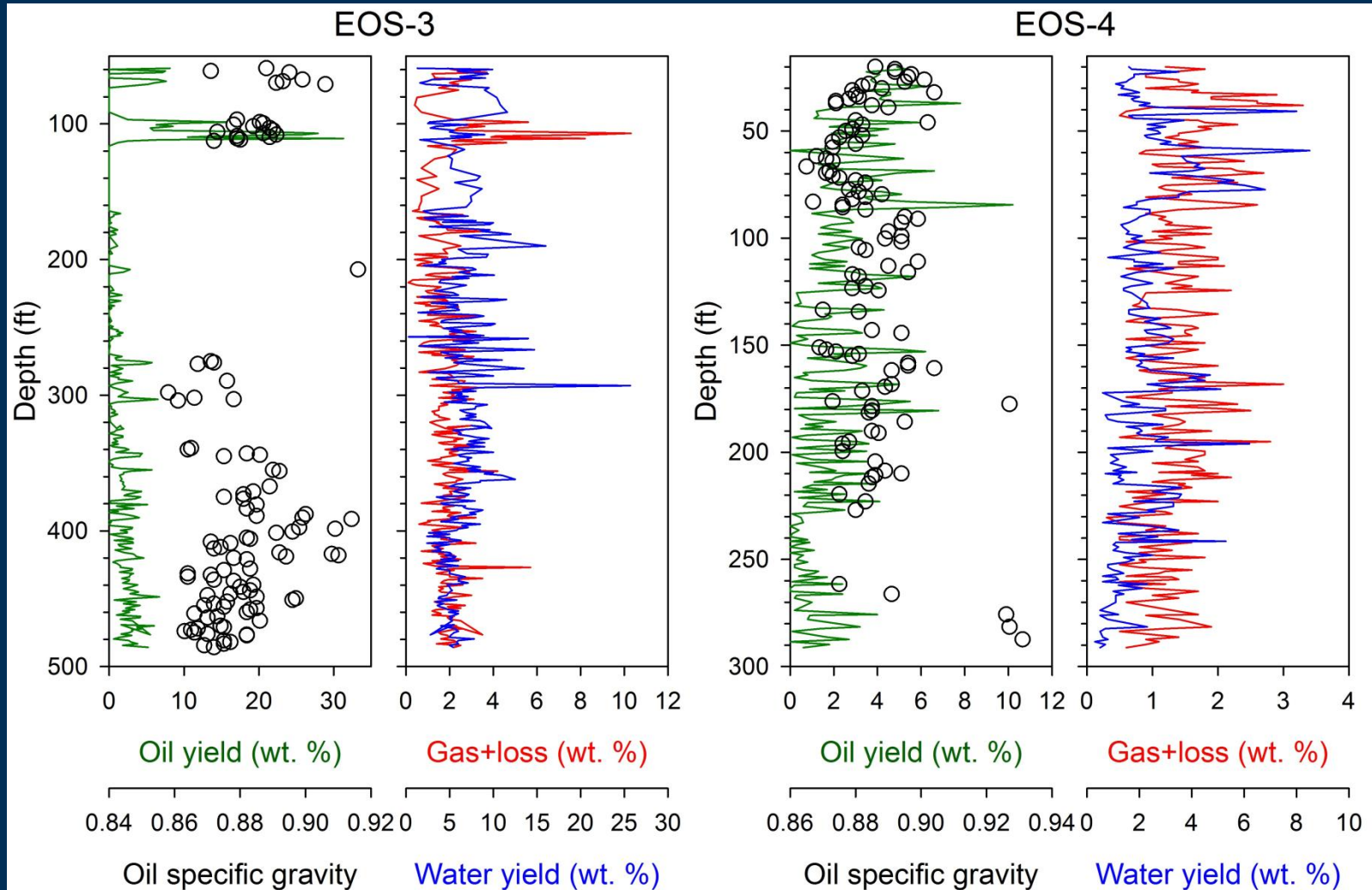
Oil percentage by weight (wt%)
Water wt%
Loss (gases) wt%
Oil density
Coking tendency

The Fischer assay method does not distinguish between oil that is present in the sample and oil that is generated by kerogen during the retort process and does not analyze the composition of the uncondensed gas.



100 g -8 mesh (<2.36 mm) rock is heated from 25 to 500 °C in 40 minutes and held at 500 °C for an additional 40 minutes.

Summary of Fischer assay raw data

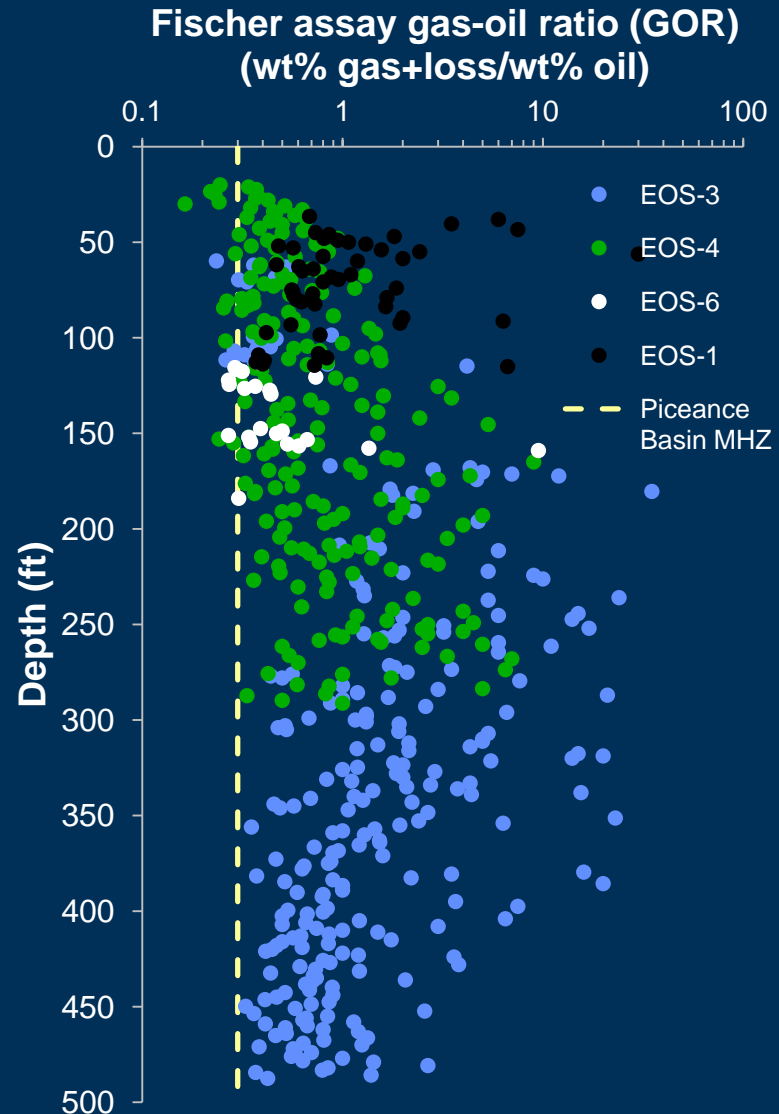


The Fischer assay results show that most of the EOS-core samples yielded less than 10 wt% oil (~27 gallons per ton) and ~2 wt% gas. EOS-6 had a few oil shales with high yields (10–20 wt%) at depths of 120–180 ft.

Fischer assay oil and gas yields

Elko oil shale **Fischer assay** product distribution (GOR) compared to average values for Green River Mahogany zone oil shale (Piceance Basin).

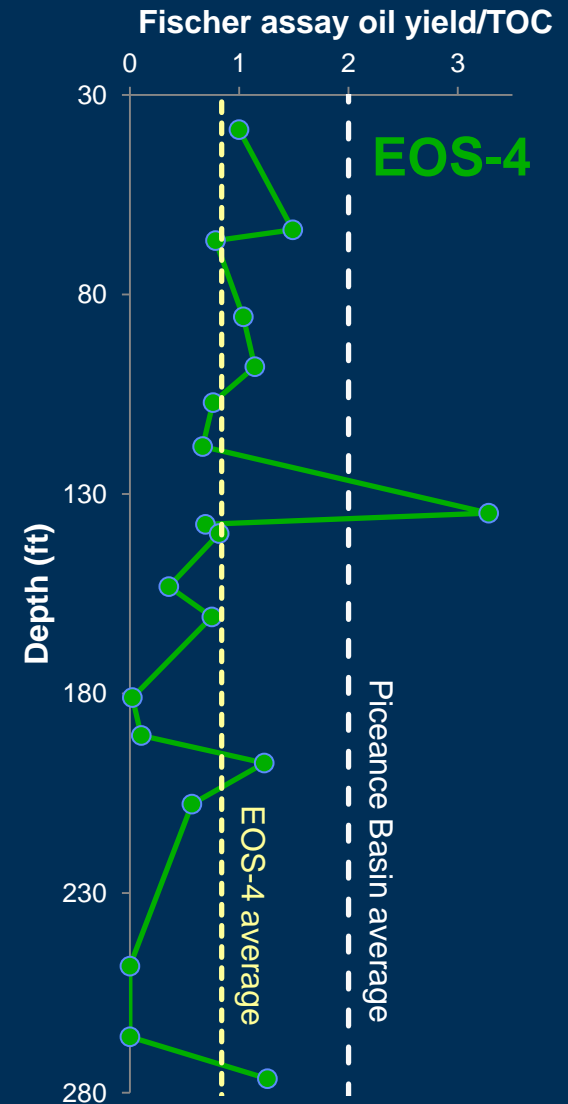
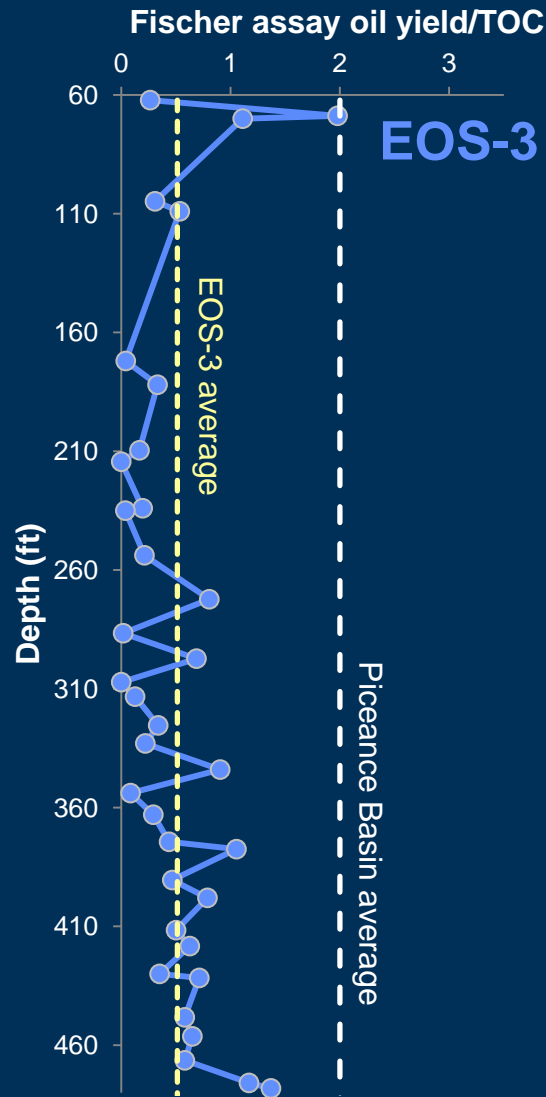
Range of Elko GOR values exceed those of all non-nahcolitic oil shale from Piceance Basin, not just Mahogany zone.



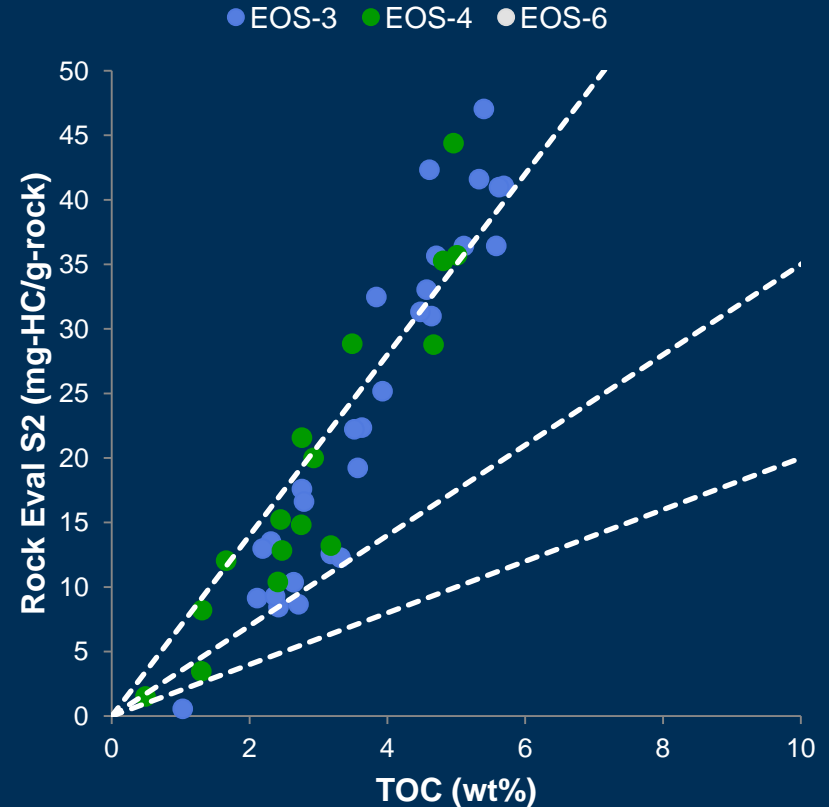
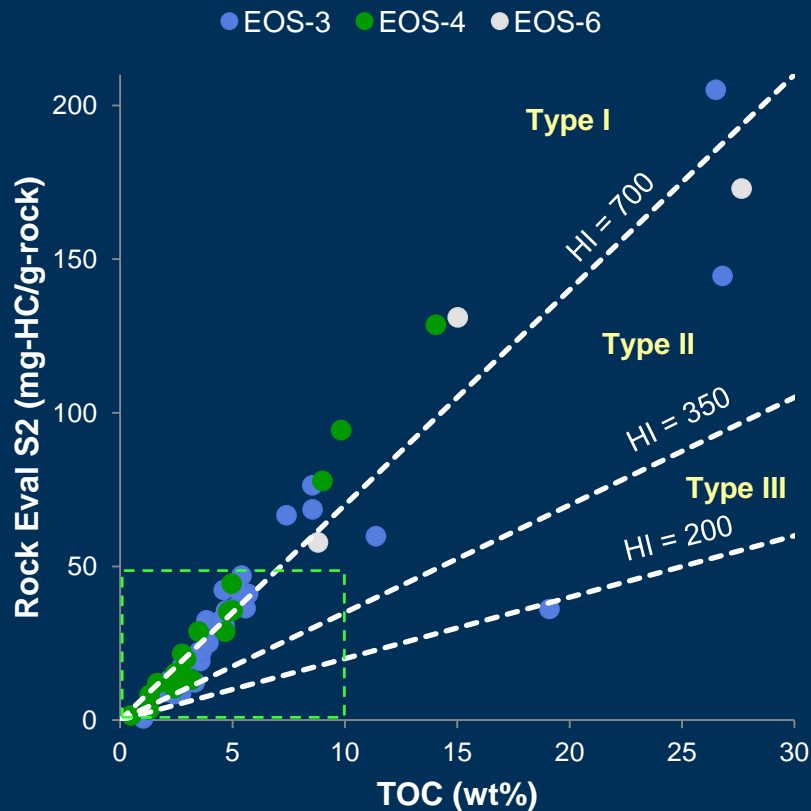
TOC-normalized Fischer assay oil yield

Elko oil shale oil-generating potential (normalized to TOC) compared to average values for Green River Mahogany zone oil shale (Piceance Basin).

Although both are Eocene lacustrine oil shales with (mostly) hydrogen-rich kerogen, Elko oil shales generate significantly more gas and less oil than those from the Green River Formation.



Rock-Eval and TOC results

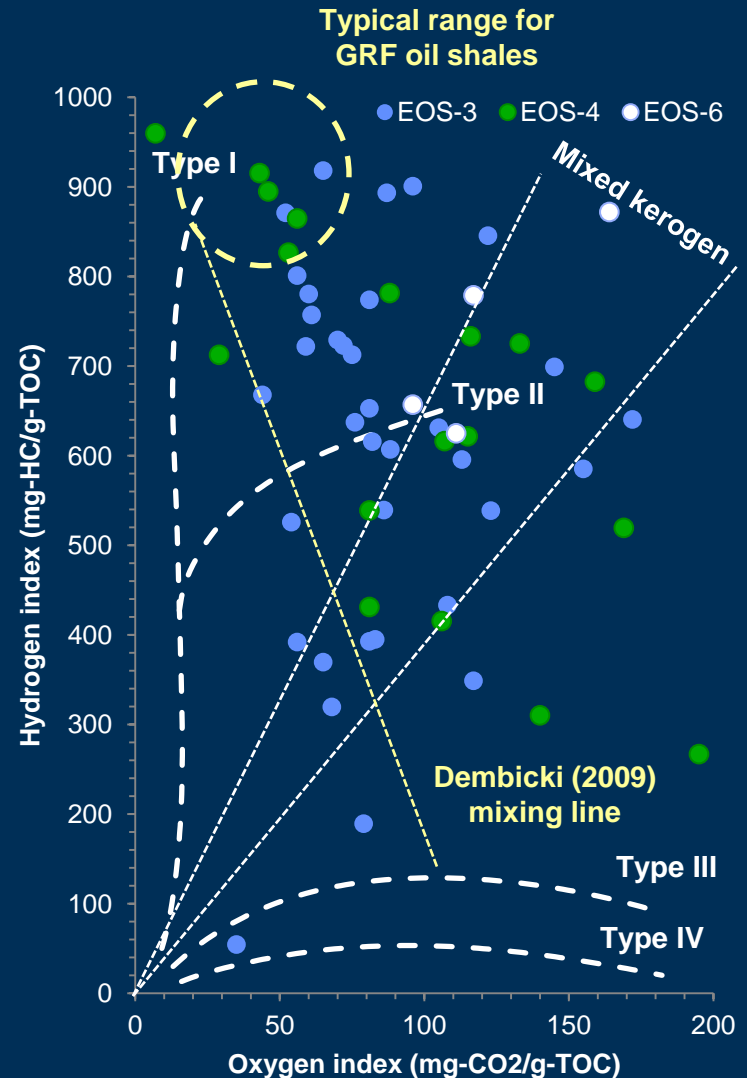


The organic matter in the Elko samples range in composition with what appears to be varying Type I and Type III kerogen content, primarily Type I. Samples with type III kerogen or type I–III mixtures were also common, consistent with Palmer (1984) geochemical and petrographic results. Plots based on method described in Langford and Blanc-Valleron (1990).

Rock-Eval and TOC results

The U.S. Geological Survey examined a set of Elko samples (58) from four cores by programmed pyrolysis (Rock-Eval)/total organic carbon (TOC) as part of an examination of the Elko oil-shale resource to supplement the larger Fischer assay dataset (640) generated by the U.S. DOE.

The Rock-Eval and TOC results showed a wide range of organic carbon and hydrogen contents, similar to what Palmer (1984) noted for samples from the Adobe Range.

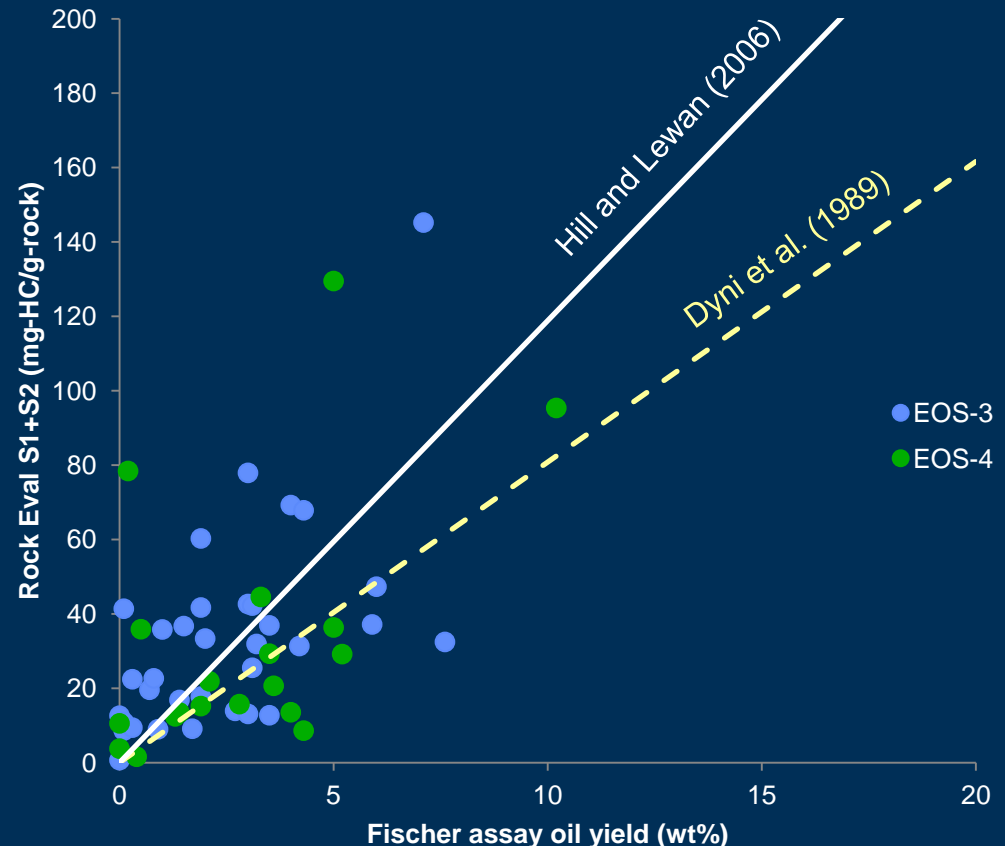


Modified from Espitalié and others (1977) and Hunt (1996).

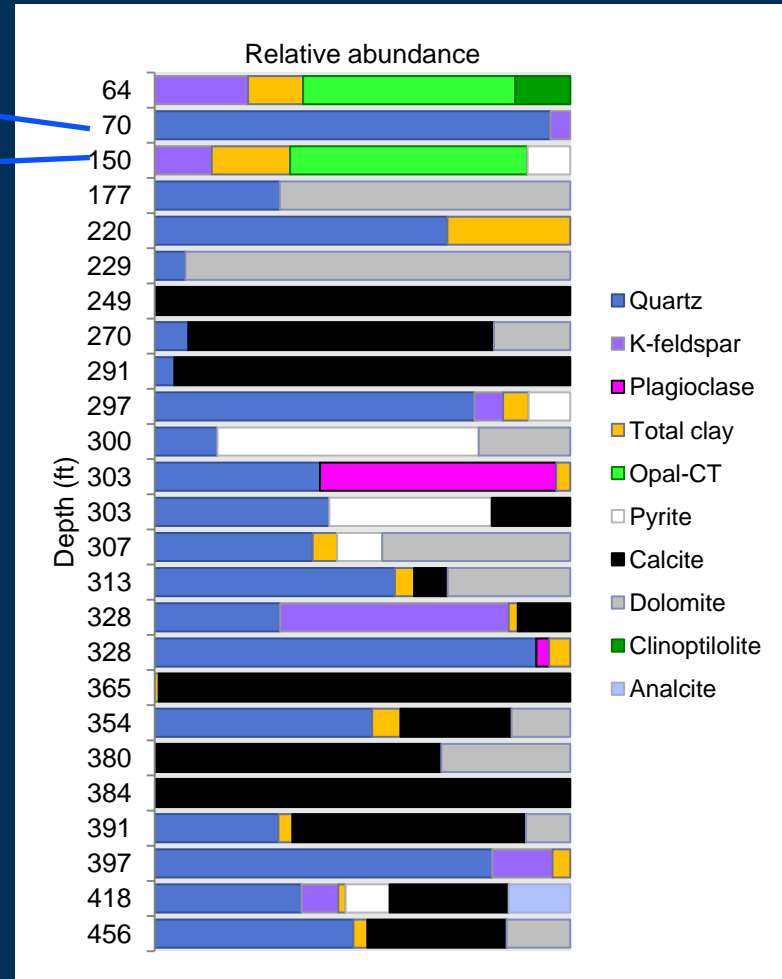
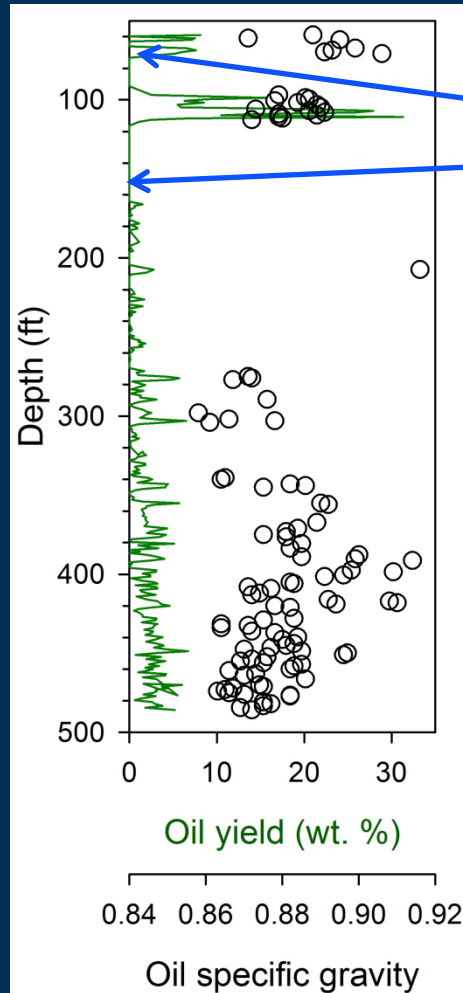
Fischer assay and Rock-Eval comparison

Elko oil shale **Fischer assay** oil yield compared to programmed pyrolysis (Rock-Eval) S1+S2 values show much more scatter than is usually observed in these kinds of correlations.

The correlations shown are mostly for oil shales with very hydrogen-rich, oil-prone kerogen. The Green River oil shales show a strong correlation between these parameters. This further illustrates the differences in these lacustrine rocks.



Relative-abundance mineralogy data in the EOS-3 (below) show the Elko Formation contains carbonate (calcite and dolomite) and quartz-rich intervals. The EOS-4 core is similar but contains more dolomite, and EOS-1 is richer in quartz and clays.

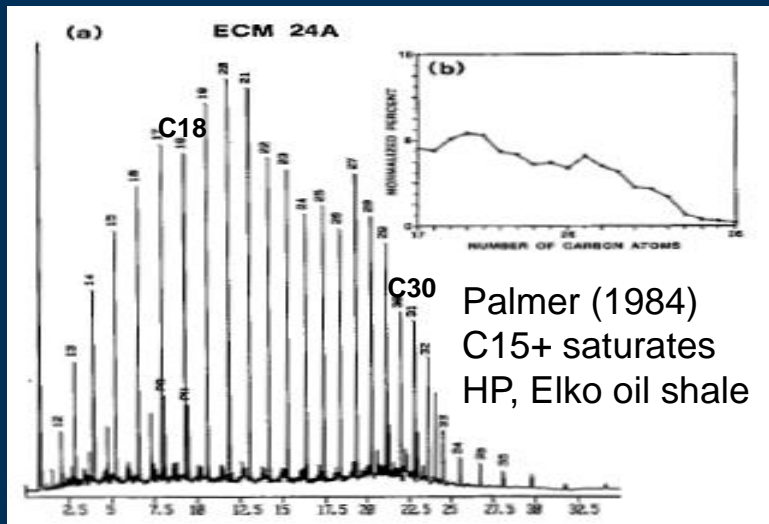


The upper section, where the richest oil shale is found (depth approximately 100 feet), is bracketed by rocks high in K-spar, clay, and opal-CT.

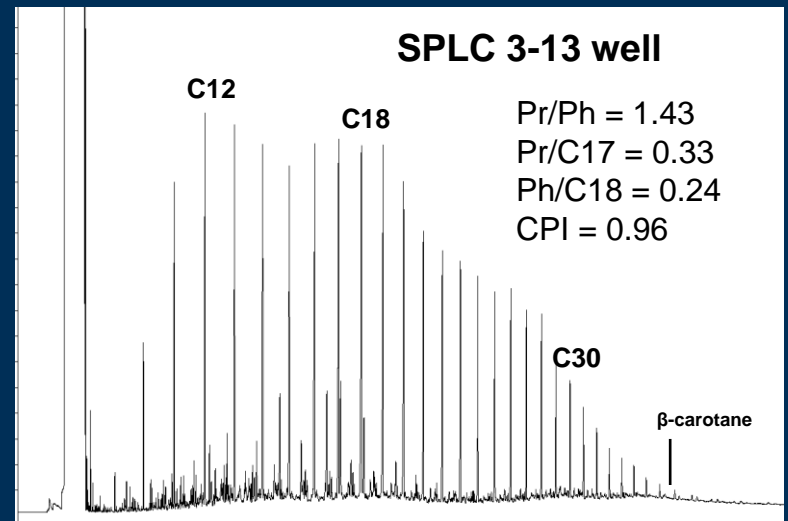
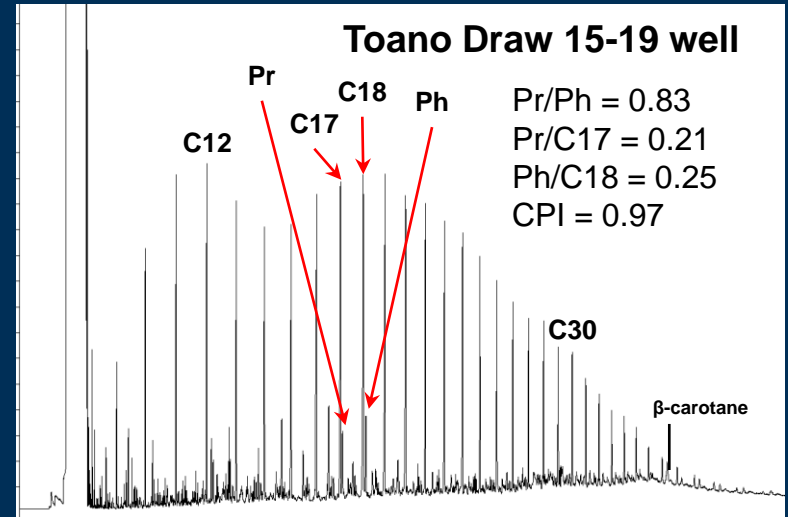
Recently, Noble Energy drilled test wells in the Elko Formation to assess its potential as a tight-oil play. The oils being produced resemble the hydrous pyrolysis oils generated by Palmer (1984).

Pristane/phytane (Pr/Ph) ratios are generally consistent with mildly reducing and dysoxic conditions. The low Pr/nC-17 and Ph/nC-18 ratio values and carbon preference indices (CPI) near 1 indicate that the oils are thermally mature.

Beta carotane was present but not abundant and could indicate that Lake Elko was a brackish to saline lake.



GC-FID chromatograms for saturate fraction of Elko crude oils



See Peters and others (2005) for details on CPI, Pr, and Ph parameters. Oil samples provided by Jerry Hansen, Great Basins Exploration.

Conclusions on Geochemistry of Elko Formation

- The Elko Formation, with its variable hydrogen content, high oxygen content, and high gas-generating potential appears to be a mixture of lacustrine-algal and terrestrially derived organic matter.
- The organic matter in the Elko Formation is distinctive from that of the Green River oil shale in that it is less dominated by Type I kerogen in much of the oil shale and therefore, it produces more gas and less oil per unit of organic carbon.
- To date, substantial gas resources have not been found.