Hydrocarbon Potential of Arkosic Sands in the Weiser-Payette Basin, Southwest Idaho: A Discussion on Basin Fill, Subsurface Structure, and Syndepositional Maturation and Migration History*

Renee L. Breedlovestrout[1]

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[1]Idaho Geological Survey, Moscow, ID, USA (reneeb@uidaho.edu)

Abstract

Miocene-Pliocene arkosic sandstone and mudstone deposits in the Payette Basin of southwest Idaho are derived dominantly from the Idaho Batholith and provide several unconsolidated to slightly consolidated fine to coarse sand stacked reservoir intervals for the natural gas and liquid condensate play. Other unique interbedded lithologies within the lacustrine and fluvial depositional system are tuffaceous and bentonitic intervals, rhyolitic and basaltic dikes and flows, and large deposits of evaporitic rocks. Recent analyses of well cuttings place the subsurface deposits in the Glenns Ferry, Chalk Hills, and Poison Creek formations of the Idaho Group. The middle Miocene Payette and Succor (Sucker) Creek formations may be present beneath the basal volcanic interval where the majority of the wells TD but is usually not penetrated because it lies in the poorly imaged and understood ‘Miocene acoustic basement’. Possible localized hydrocarbon source beds are exposed near Horseshoe Bend and a previous total organic carbon analysis report (Geochem Laboratories Report, 1981) indicates adequate organic content is present surficially but are undermature and are in the pre-peak oil generation window. These organic-rich surficial units project southward into the Payette Basin and may contribute to the hydrocarbons produced from conventional wells. Under higher geothermal regimes, more liquid condensate and an addition of liquid hydrocarbons is possible. In this study x-ray diffraction, clay, and petrophysical analyses help delineate significant sedimentary packages and highlight the interplay between clastic deposition and coeval volcanic rocks. Simplified depth-structure maps and isochores derived from well tops show a relative deepening and thickening of basin sediments in the northwest part of the basin. A detailed examination of the kerogen and palynomorph samples collected from surficial sediments north of the producing fields also show thermally immature indicators relative to hydrocarbon generation which is congruent and comparable to the geochemical report from Horseshoe

Bend (Staplin, 1969; 1977) and Palynomorph Darkness Index (Goodhue and Clayton, 2010). Down-to-basin normal faults appear to provide structural controls for hydrocarbon-bearing sandstones. More exploration is needed to assess adequate hydrocarbon source, and the maturation and migration history in the basin. Other older organic-rich sedimentary rocks also occur in southern Idaho and may contribute to the hydrocarbons of the Payette Basin.

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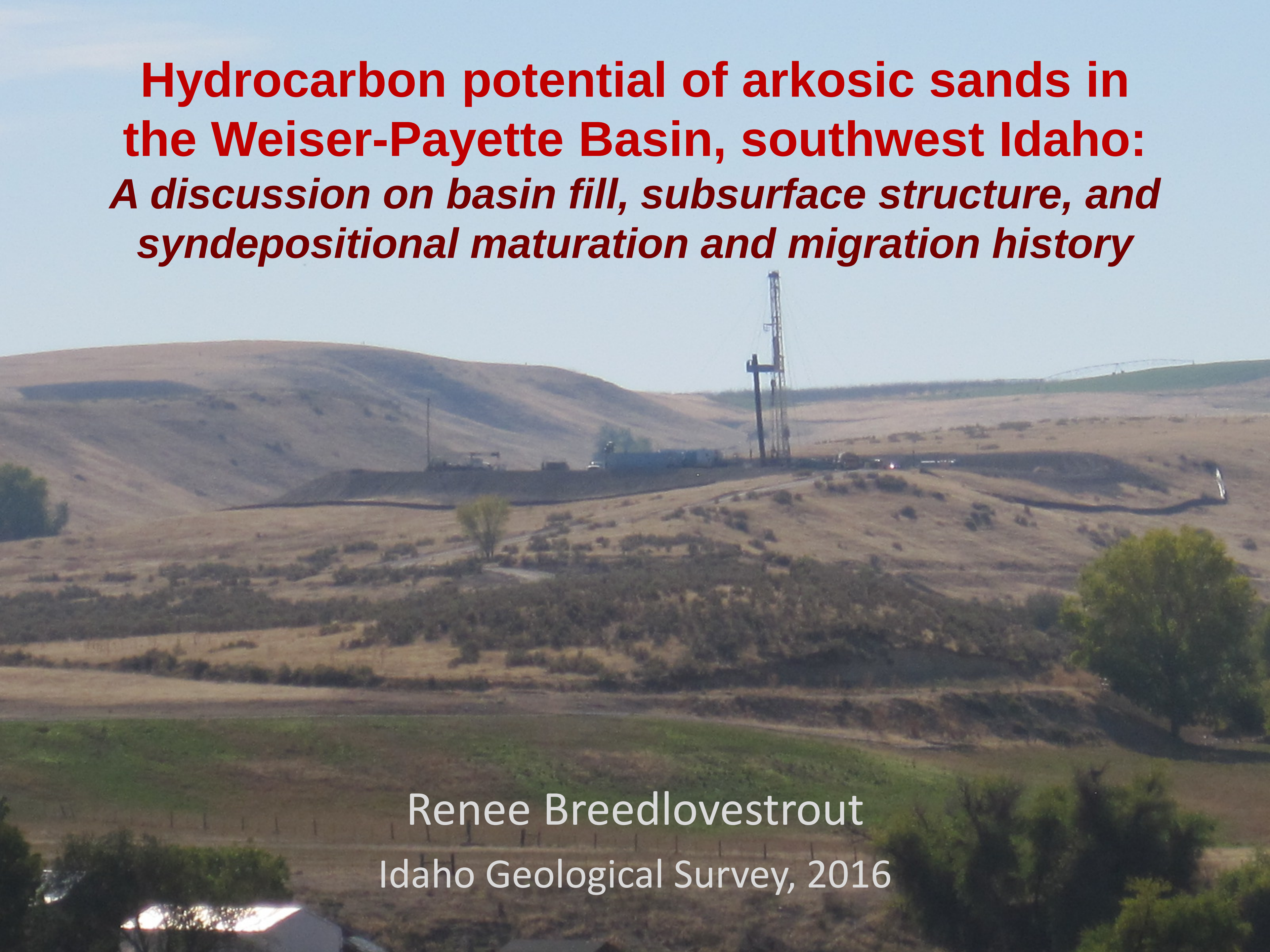
Hydrocarbon potential of arkosic sands in the Weiser-Payette Basin, southwest Idaho:

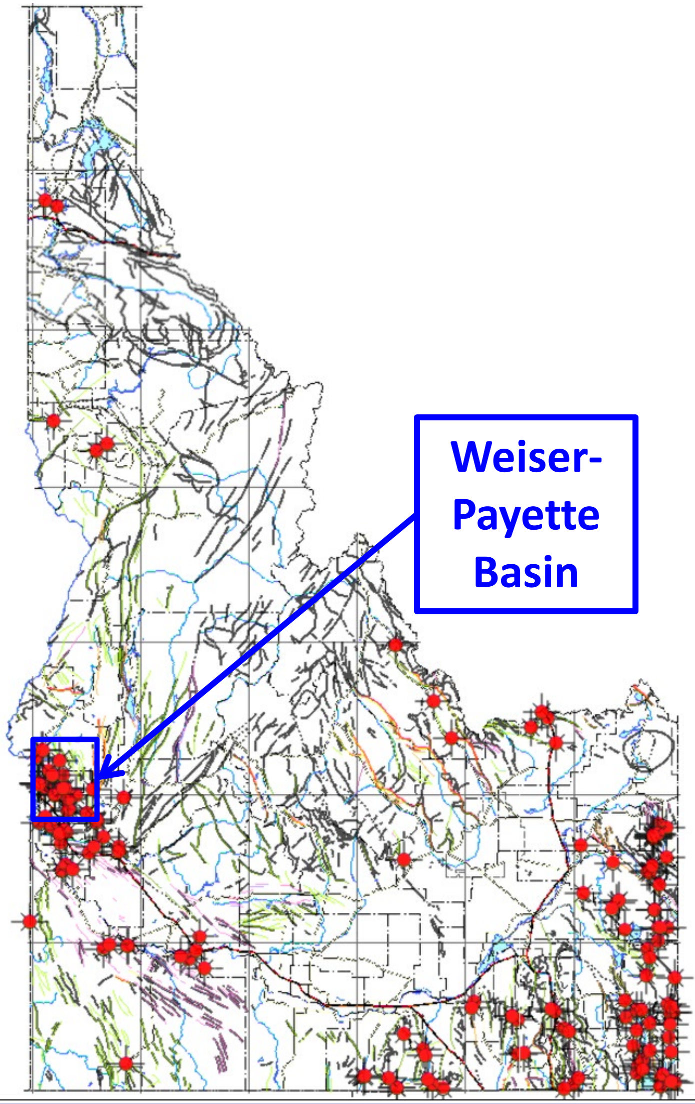
A discussion on basin fill, subsurface structure, and syndepositional maturation and migration history

Renee Breedlovestrout

Idaho Geological Survey, 2016

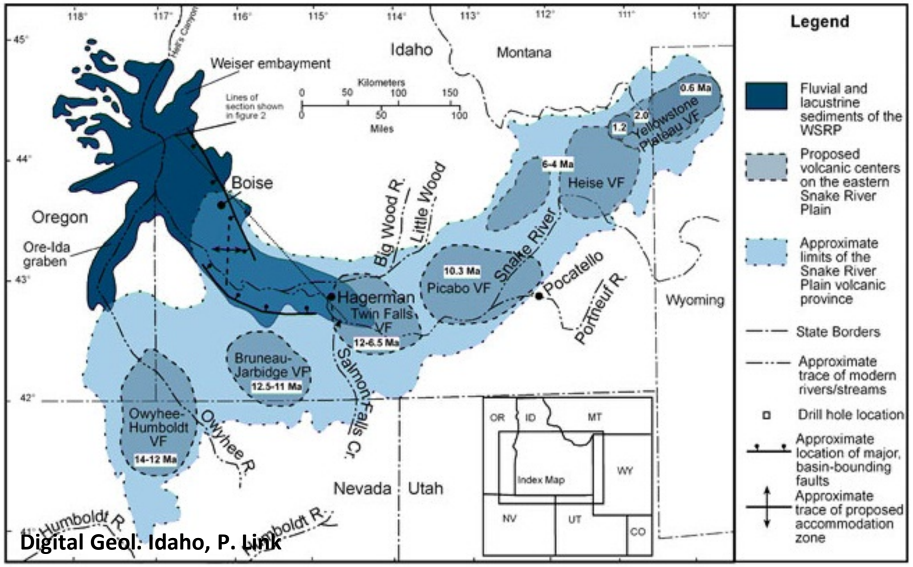


Historic Oil and Gas Wells in Idaho

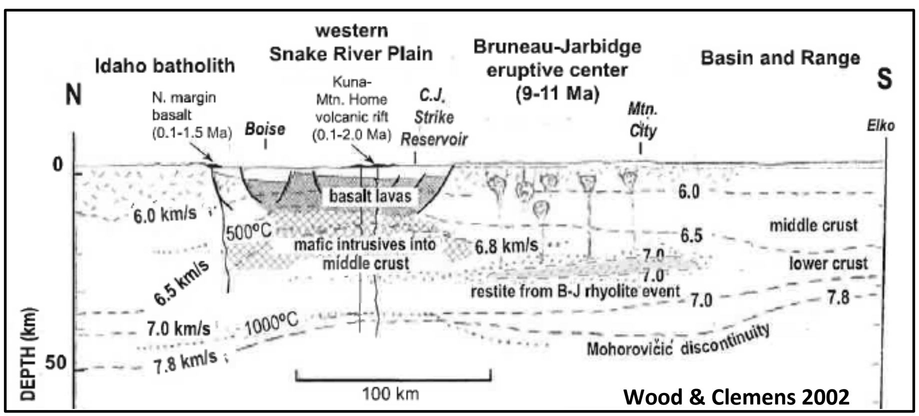


- Over 150 wells have been drilled in Idaho since 1903
- Majority were short-lived and uneconomic. Major challenges include:
  - Subsurface imaging
  - Presence, maturation timing, and trapping mechanisms
  - Sustainable reserves
- The Weiser-Payette Basin may be the first successful production field in Idaho containing natural gas, liquid condensate, and some oil
- Exploration of basin began in 2008 by Bridge and Paramax Resources ; production of wells began in 2014 by Alta Mesa and Snake River Oil and Gas (Weiser-Brown)
- Lacustrine and fluvial deposition interspersed with subordinate amounts of rhyolitic and basaltic flows and sills create a unique hydrocarbon play

Depositional setting and resulting deposition

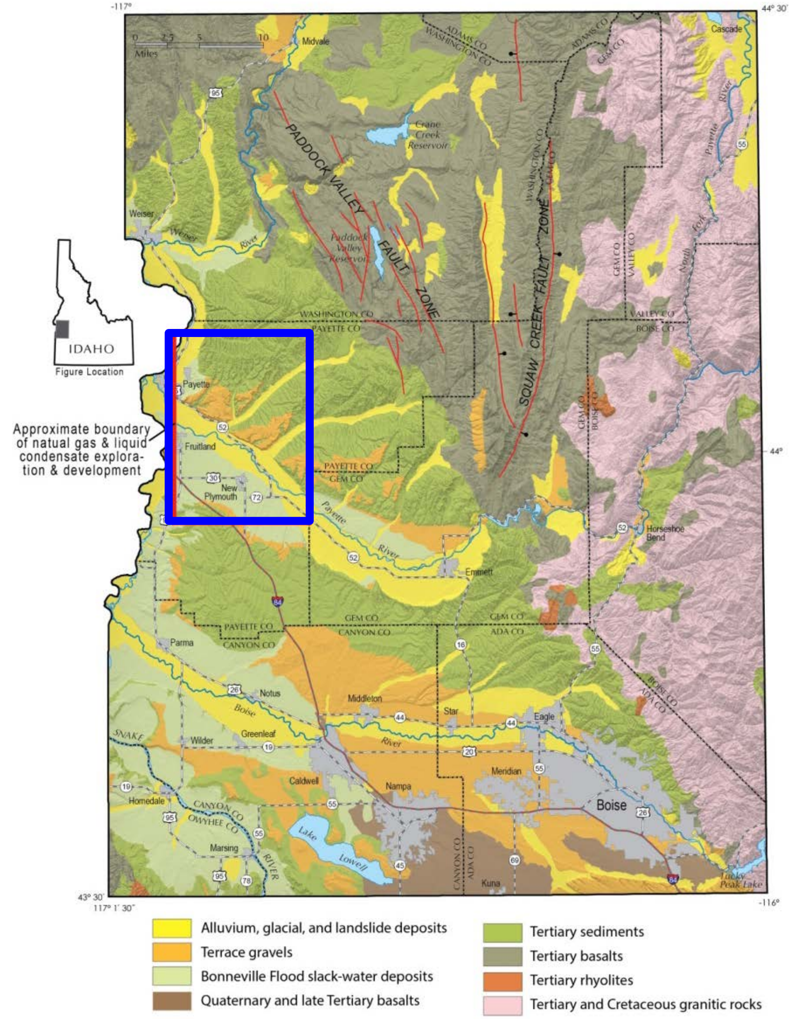


Digital Geol. Idaho, P. Link



Wood & Clemens 2002

NW-SE intracratonic extensional basin formation between 5-15 Ma



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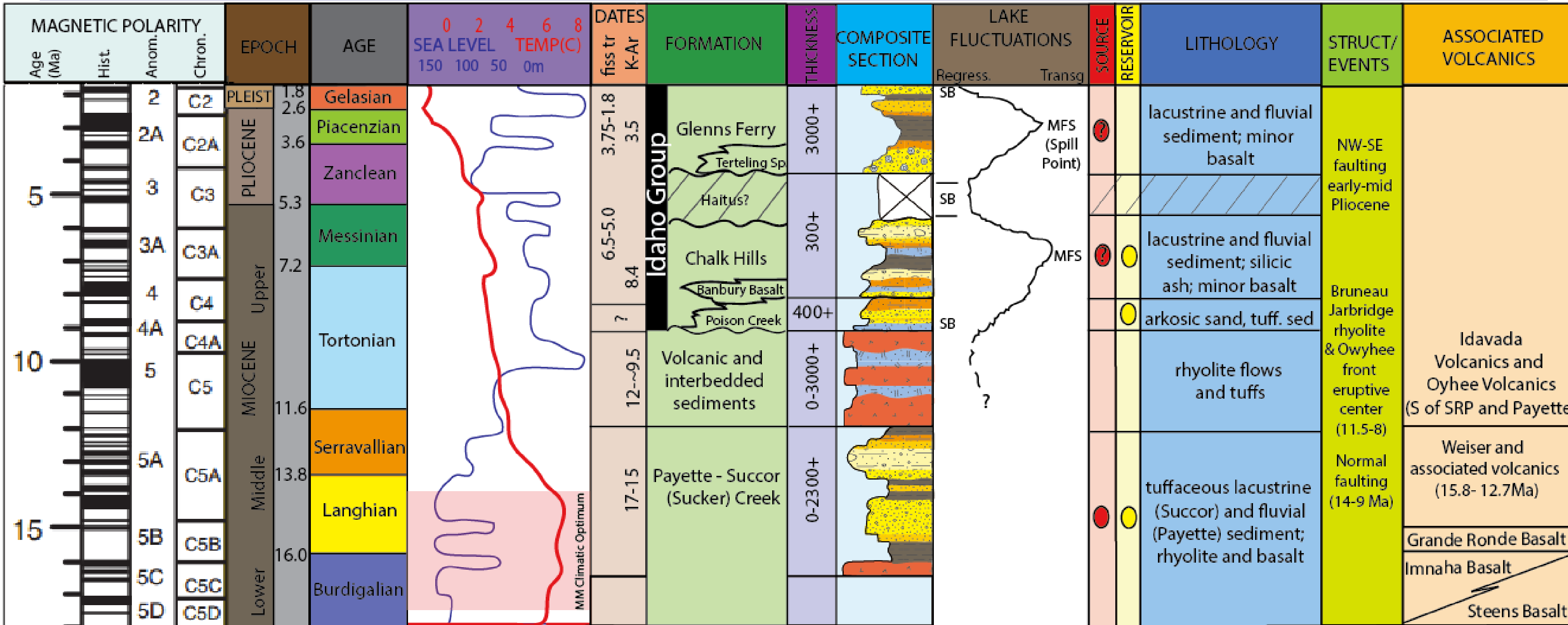
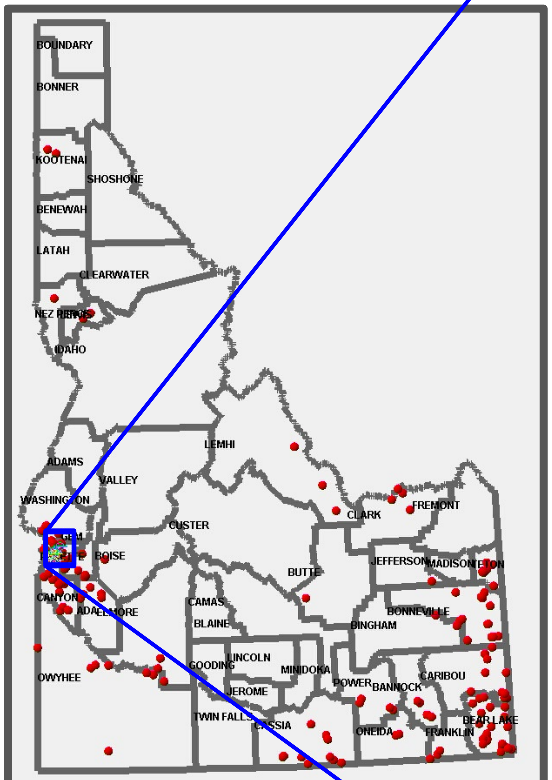


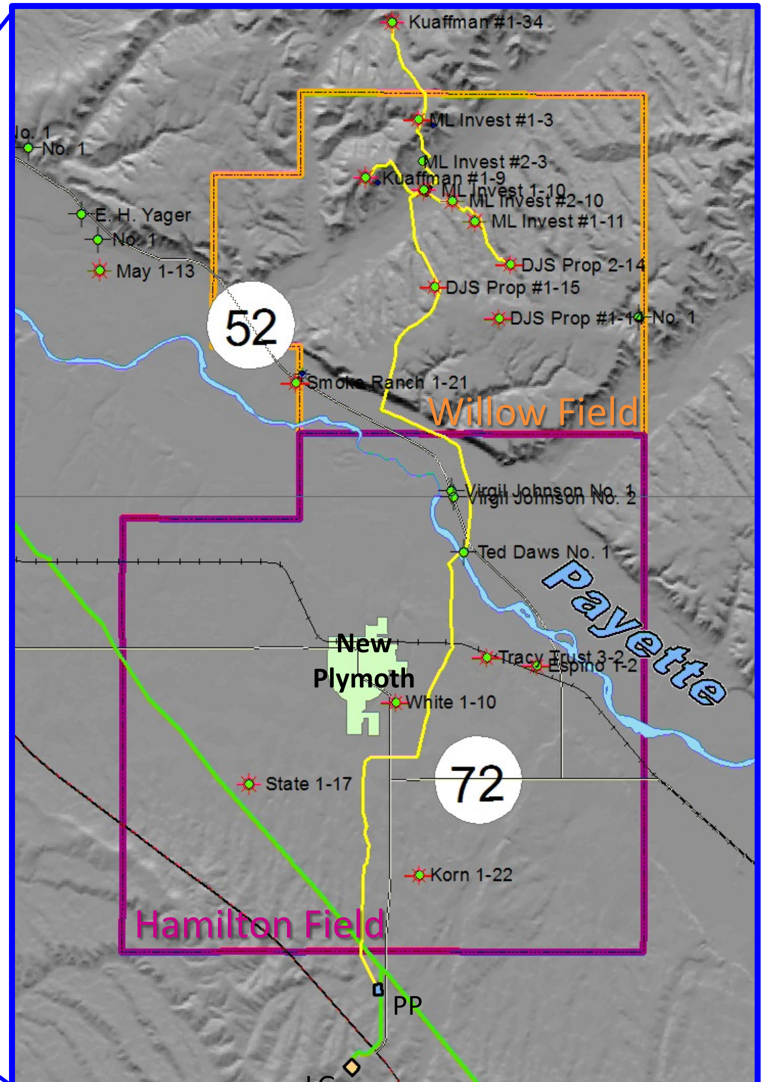
Redrafted from Wood, 1994; Wood and Clemens, 2002; Zachos et al., 2001; Haq et al., 1987; Reidel et al., 2003

Play elements:

- **Source:** Payette or unknown older formation?
- **Maturation:** Type 3 (herbaceous-woody)?; gas to minor oil prone
- **Migration pathways:** unknown
- **Reservoir:** Payette, Chalk Hills, and Glenns Ferry formations?
- **Trap/Seal:** 3-way fault and stratigraphic?
- **Timing:** unknown

Willow and Hamilton fields in Production





Alta Mesa's Hwy 30 Processing Plant (PP)

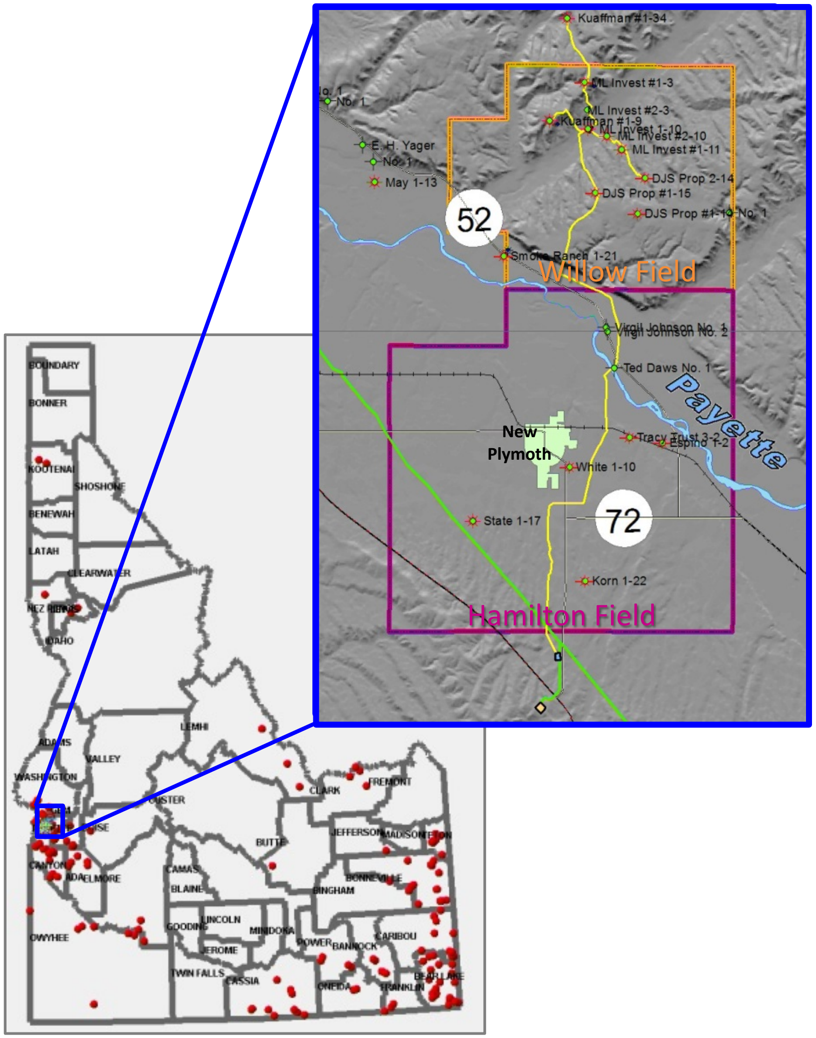
Langley Gulch 330 Mw Gas-Fired Power Plant (LG)

Goals of larger study; preliminary work completed

Goal: To characterize the reservoir, source (local/distal), migration history and timing, maturation timing, seal and trapping mechanisms, reservoir continuity/channel fairways, surface to subsurface correlation within the Weiser-Payette Basin

Data: Seventeen active natural gas and liquid condensate wells, eight of which are in production; surficial deposits

Preliminary Analysis: Eleven wells analyzed petrographically. Of those, three wells examined with use of well cuttings and XRD analysis, XRD study ongoing. Kerogen TAI analysis initiated.



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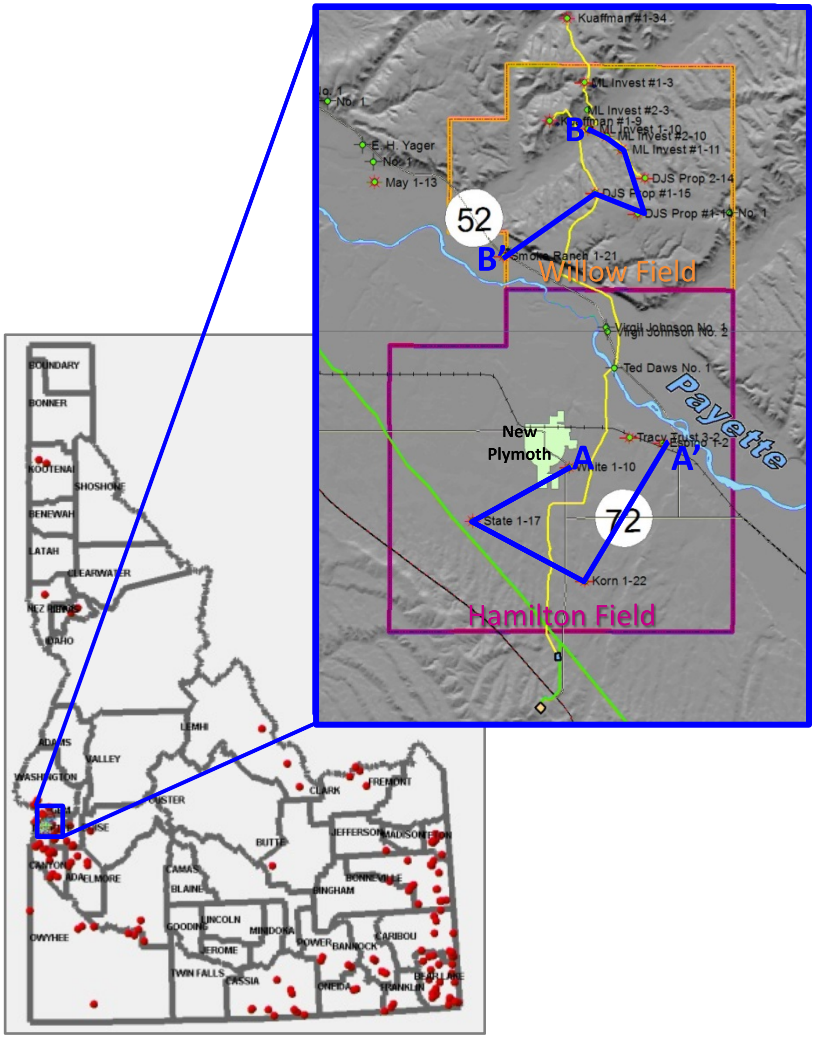
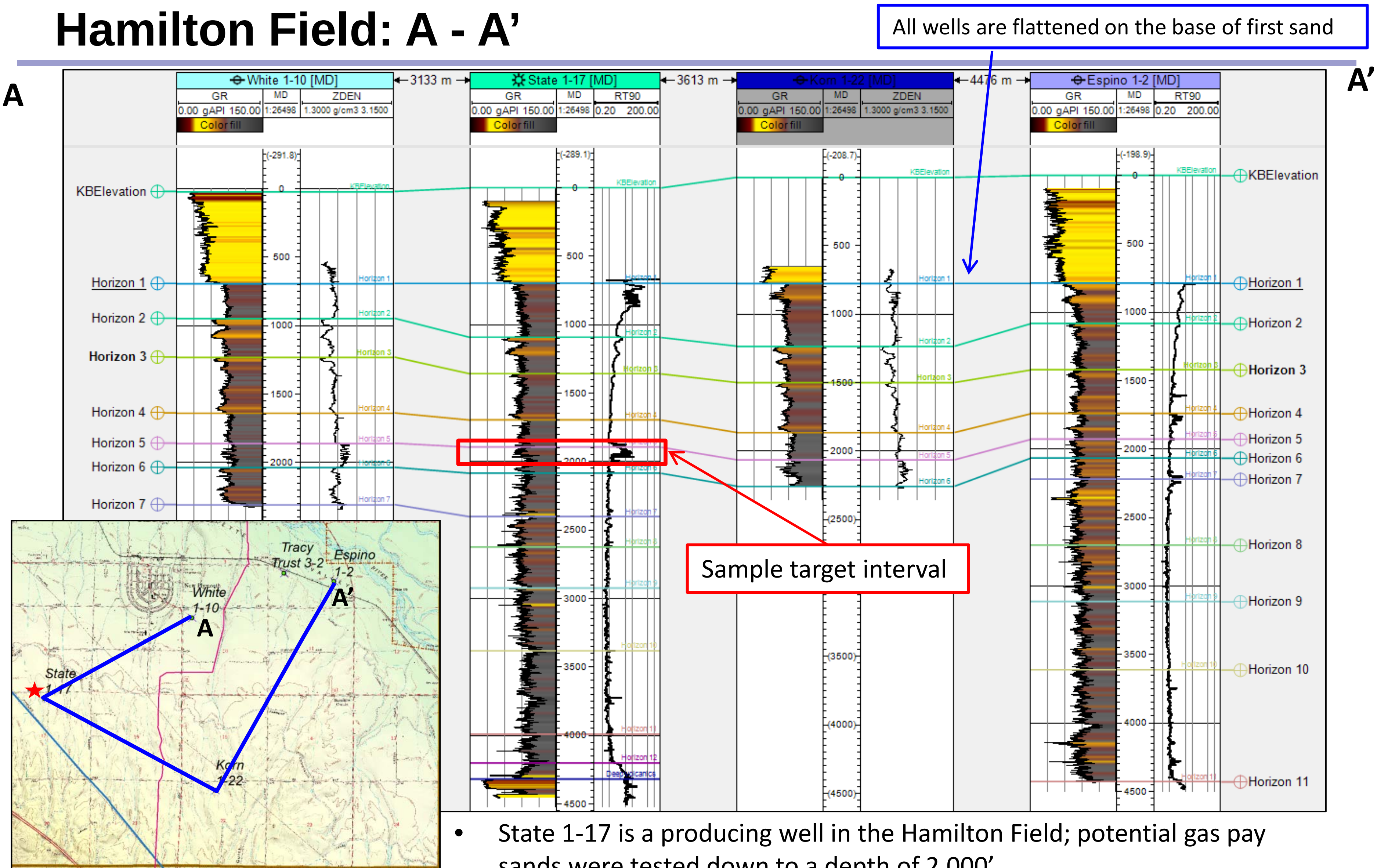


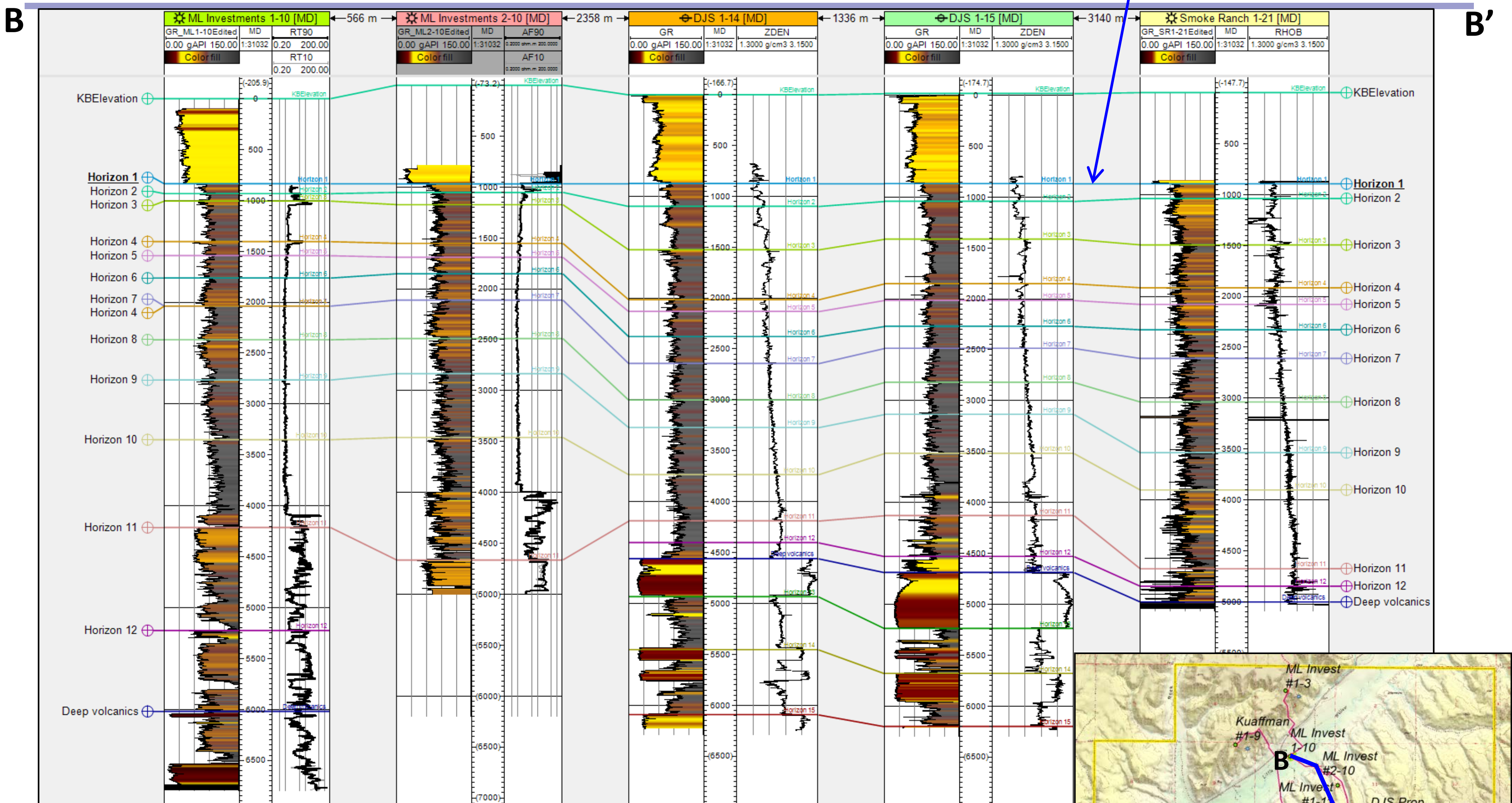
Hamilton Field: A - A’

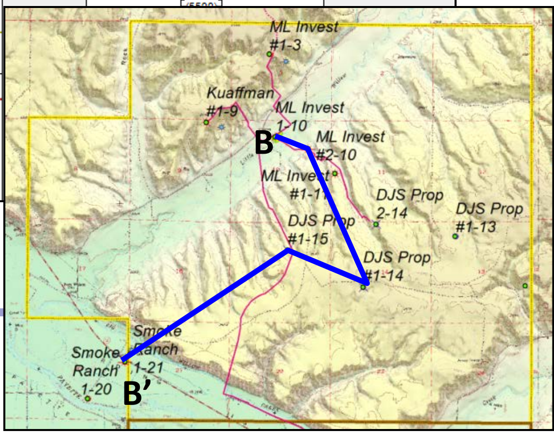


- State 1-17 is a producing well in the Hamilton Field; potential gas pay sands were tested down to a depth of 2,000’
- Sample target interval shown; sandy interval with high resistivity response

Willow Field: B - B'

All wells are flattened on the base of first sand





- Correlation horizons across wells mark genetically related sedimentary packages; most lie on max shale baseline (flooding surfaces)

Willow Field: B - B'

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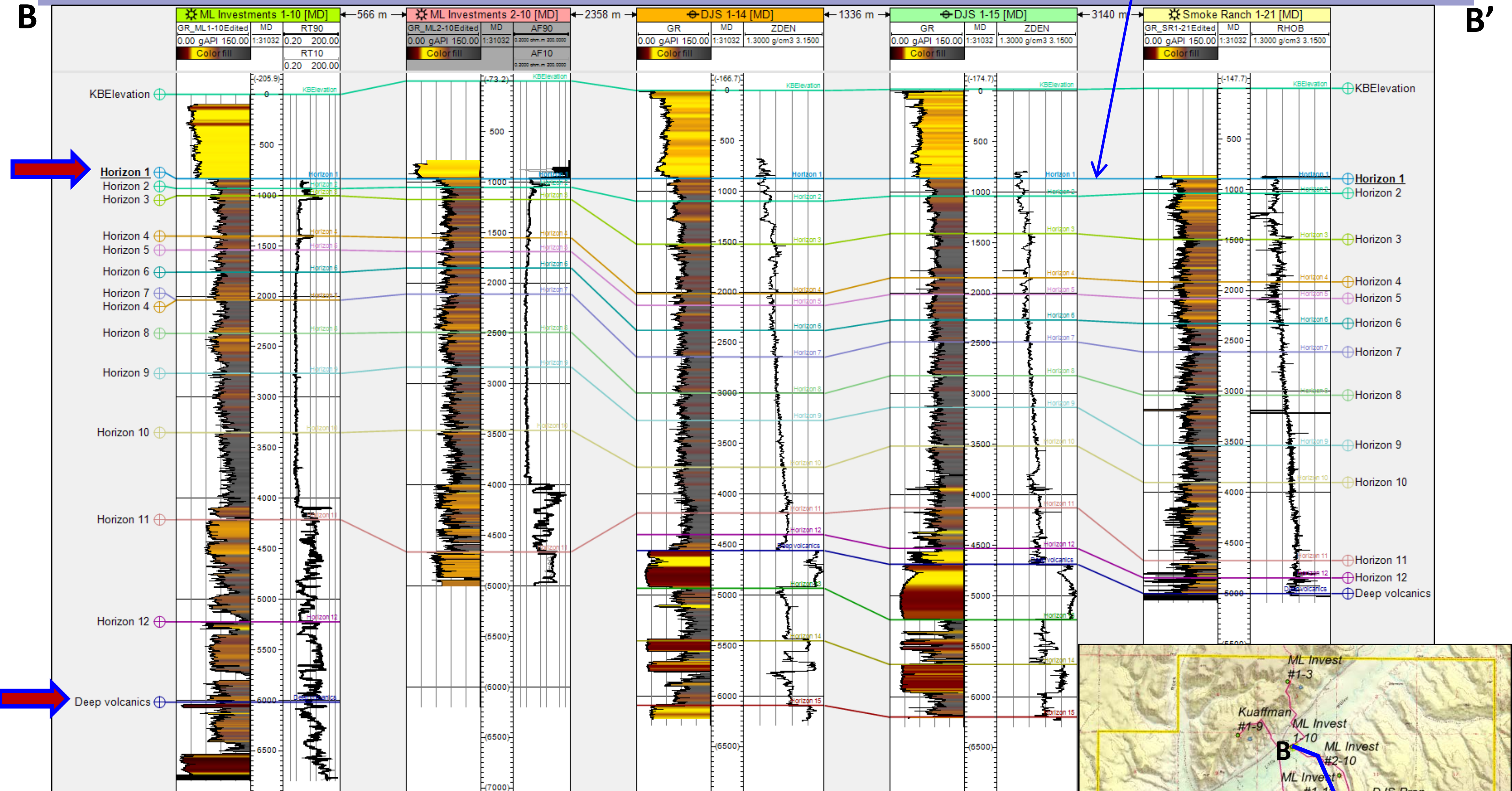

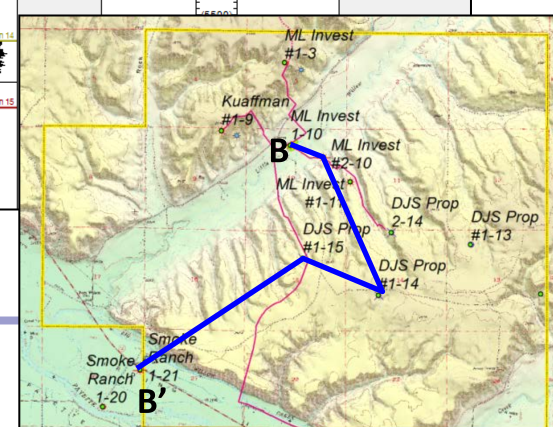

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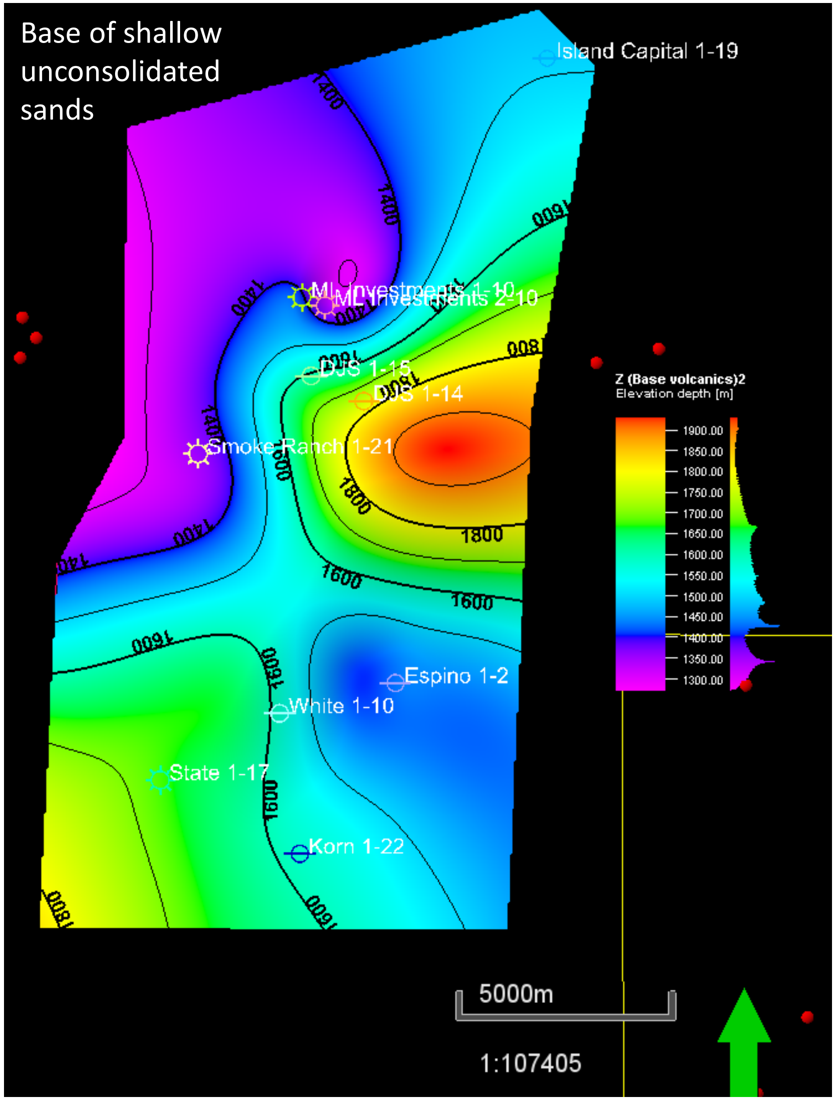
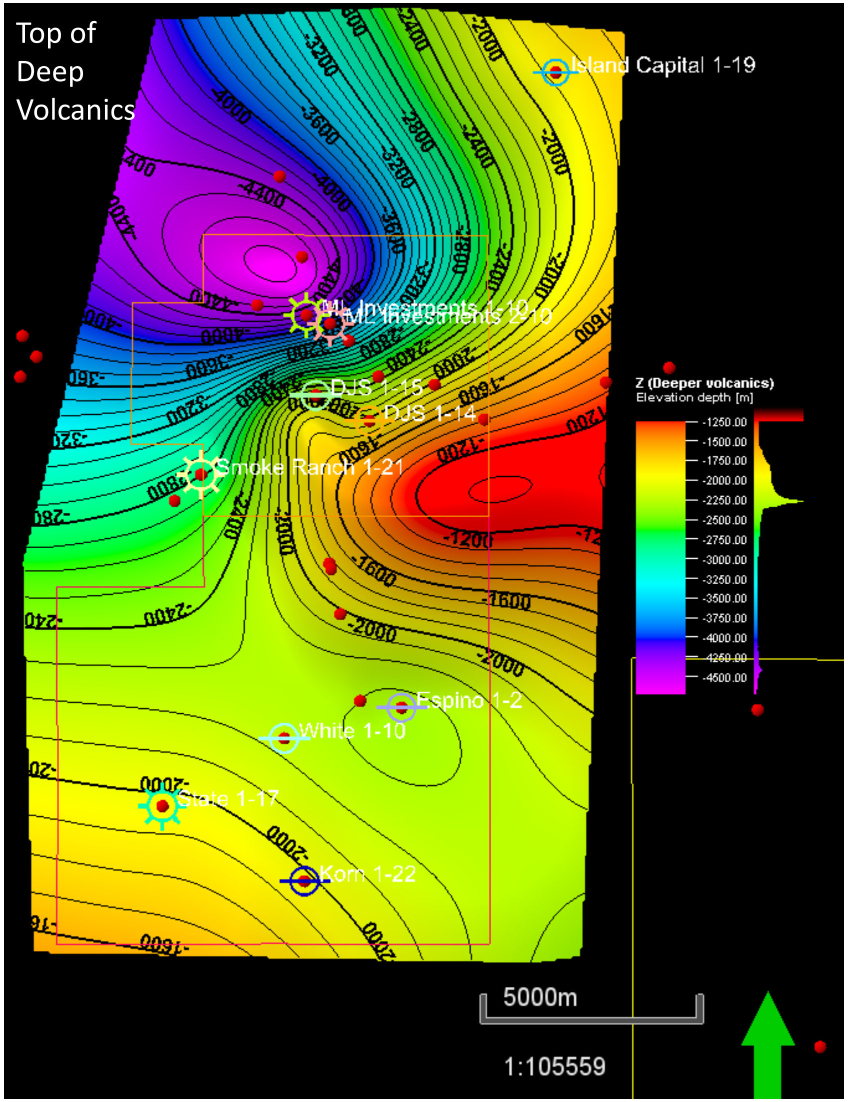
Depth-structure maps – Shallow sands and deep volcanics





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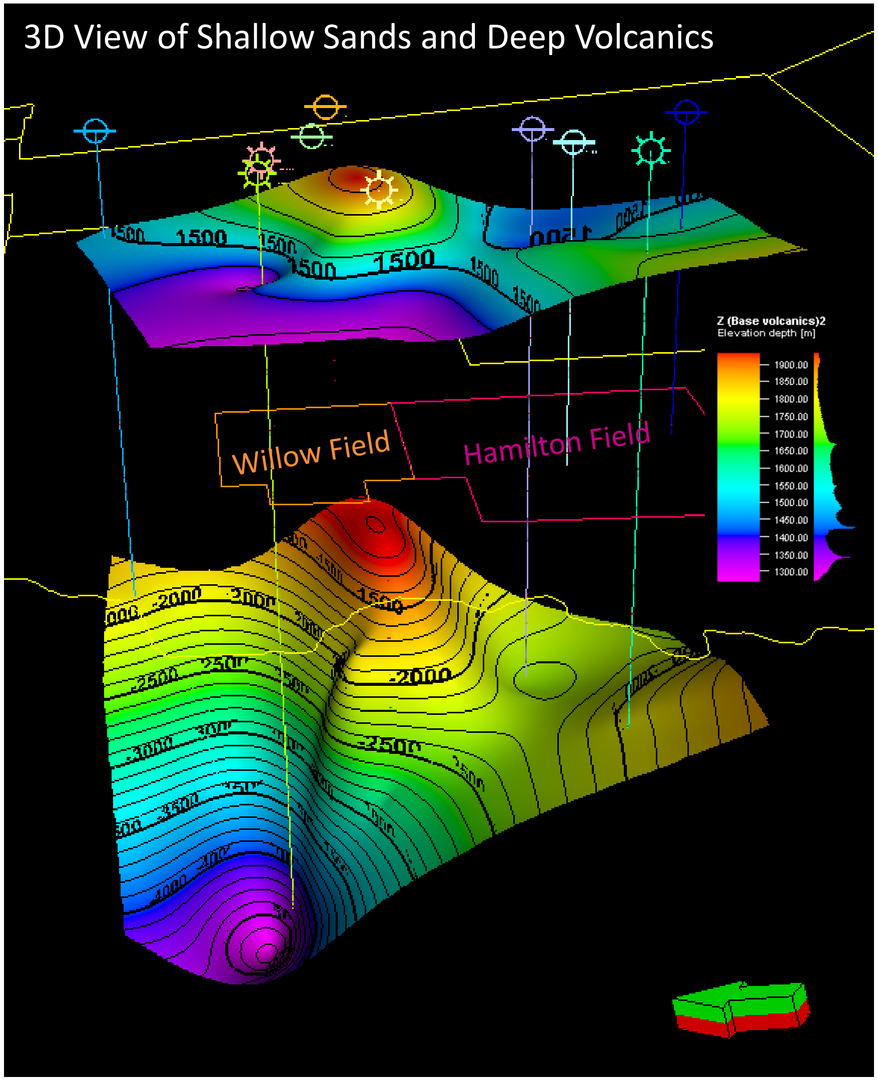
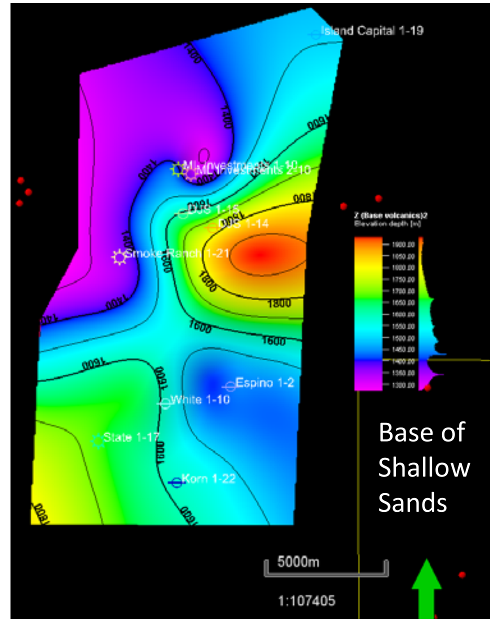
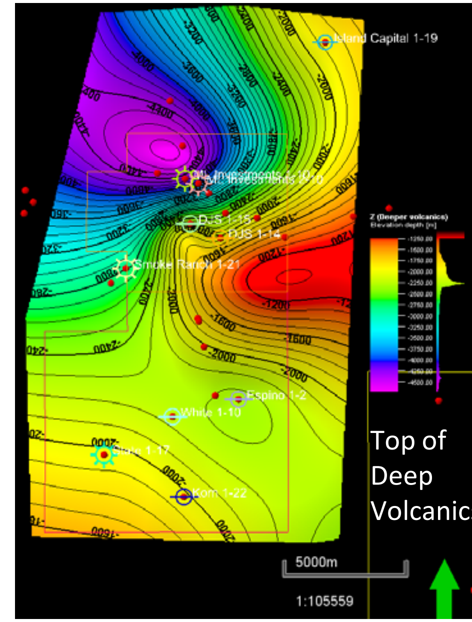


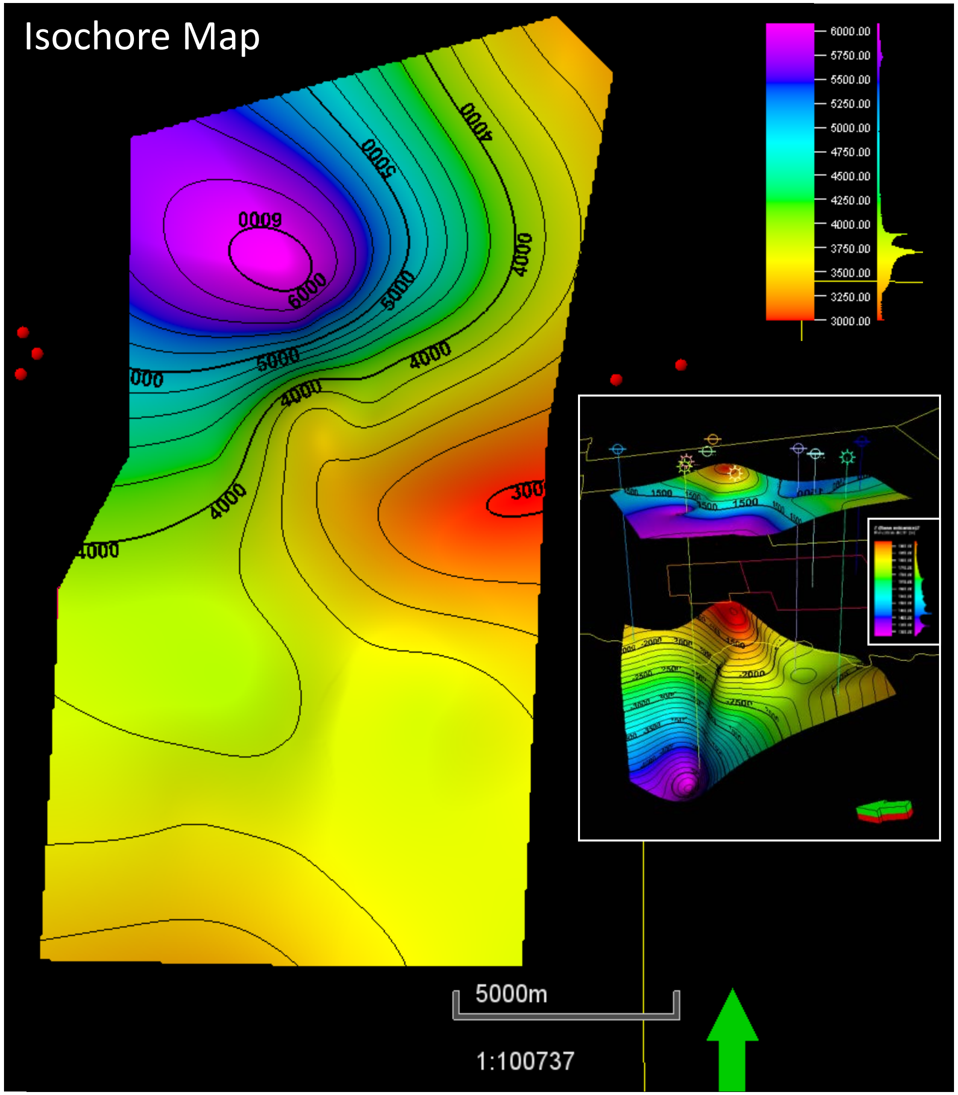


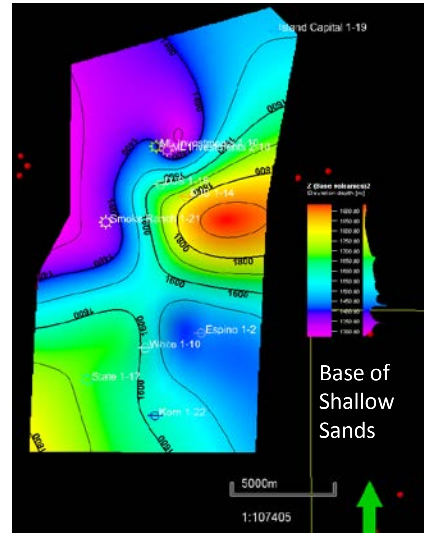


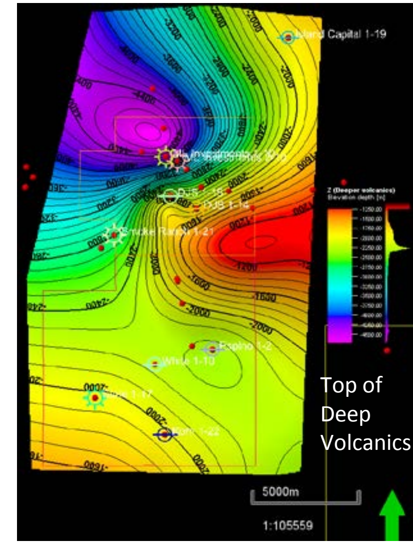
- Reds = highs
- Purple/Blue = lows

- Initial imaging of the subsurface shows that the Weiser-Payette Basin deepens to the west and shallows to the east
- Initial model is simplified; an understanding of the fault network is needed

Map showing thickness between two surfaces





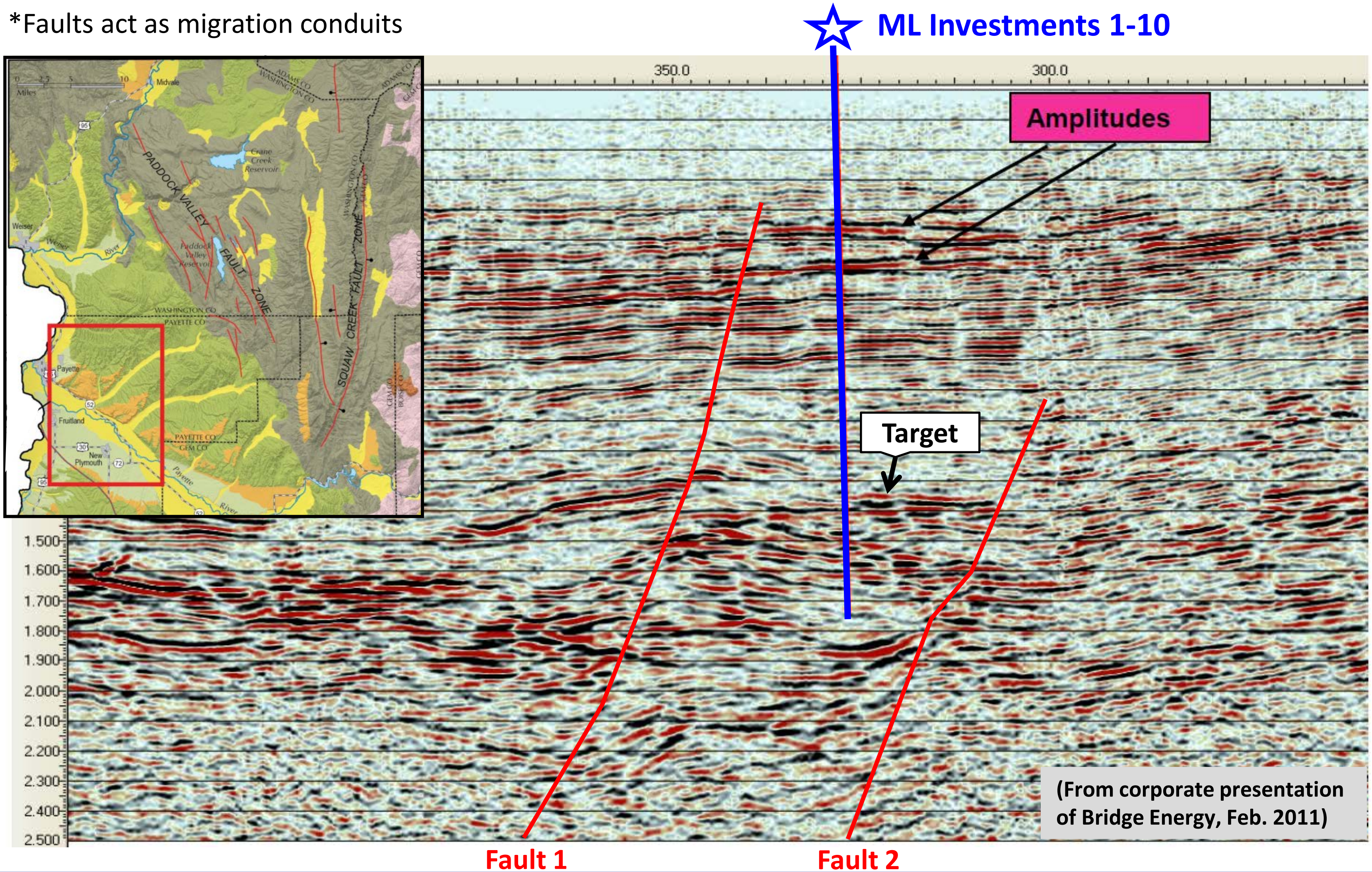


- Reds = thinnest section
- Purple/Blue = thickest section

- Thickest part of the immediate vicinity of the Willow/Hamilton fields is to the northwest
- More to come after historic wells are digitized and incorporated
- Trap/seal still not known without fault network

Migration pathways

*Faults act as migration conduits

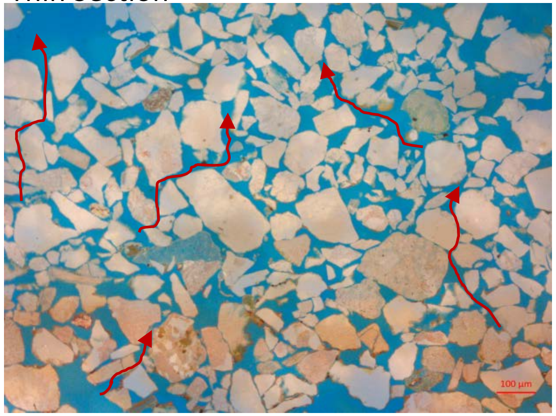


Reservoir porosity estimates

- Range in porosities: 17-40%
- Average porosity: 28%
- Sufficient permeability present

16RLB038: Hand Sample

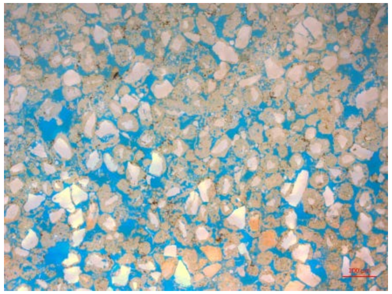
Thin Section



16RLB022: 28%

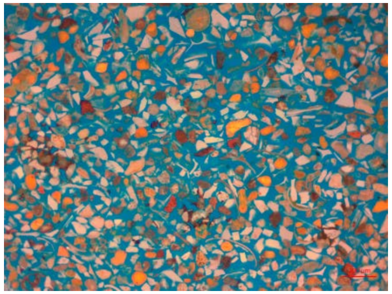
16RLB038: 26%

16RLB057: 24%

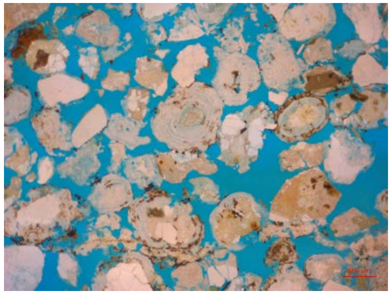


16RLB085: 17%

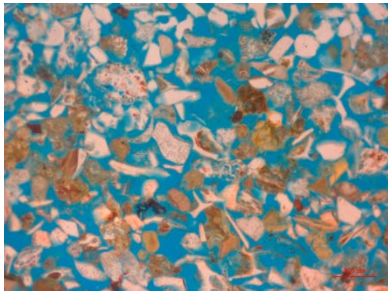
16RLB037: 40%



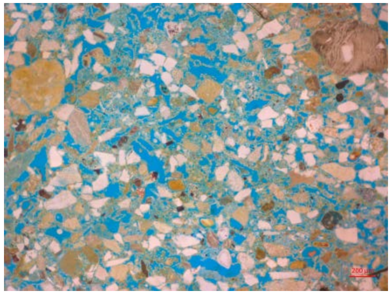
16RLB055: 30%



16RLB061: 36%

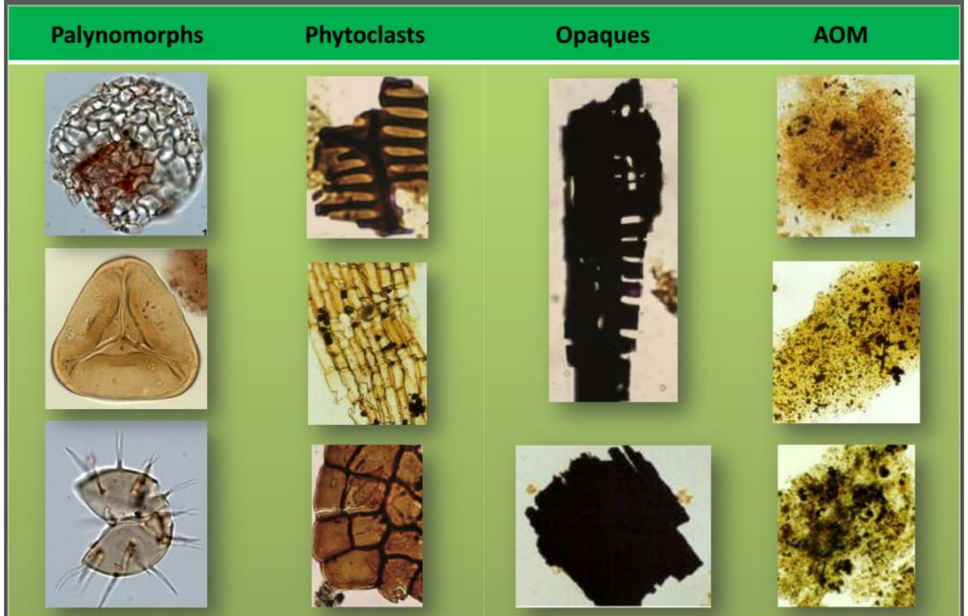


16RLB086: 20%



Source and Maturation : Kerogen analysis

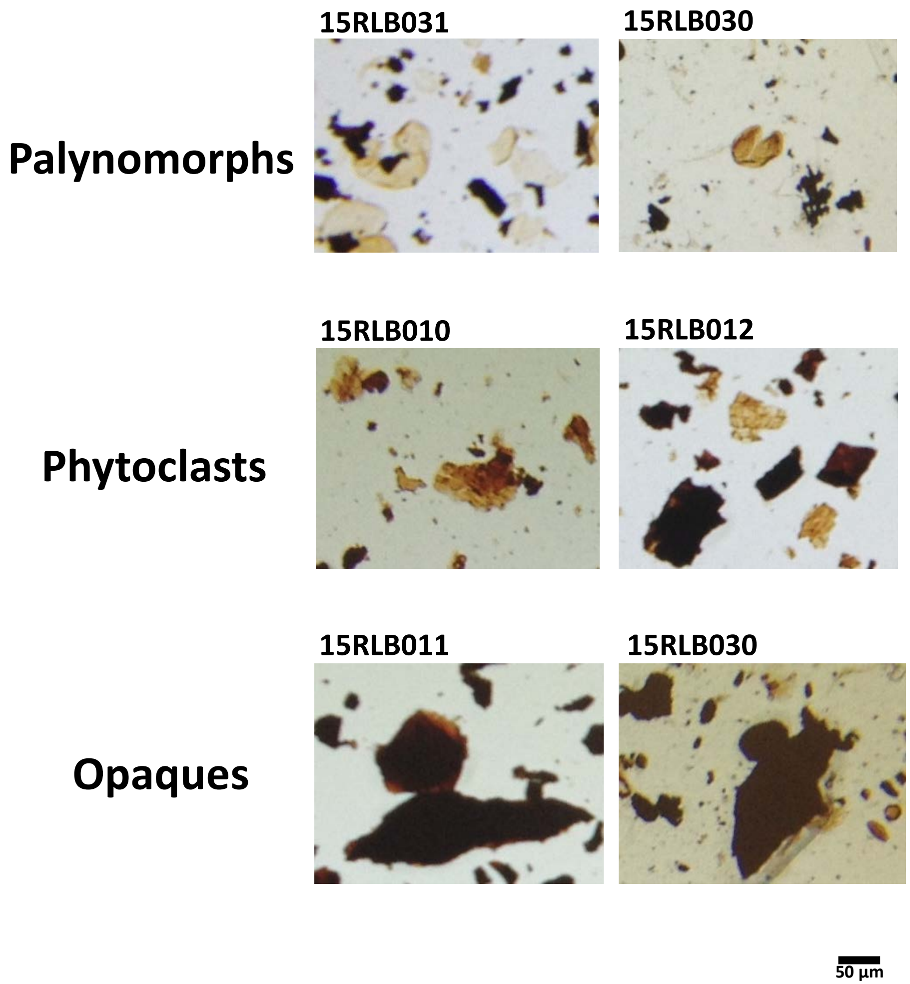
Image Examples of Kerogen Particles



Kerogen Types and Source Rock Determination

Kerogen Type	Characteristics	Source Rock Indication
I	Almost entirely AOM	Highly oil-prone
II	Mainly AOM; minor other kerogen particles present	Oil-prone
III	Mainly phytoclasts; minor other kerogen particles present	Gas-prone
IV	Mainly opaques; minor other kerogen particles present	Inert material

Surficial Samples



*AOM=Amorphous Organic Matter

Source and Maturation : Kerogen analysis

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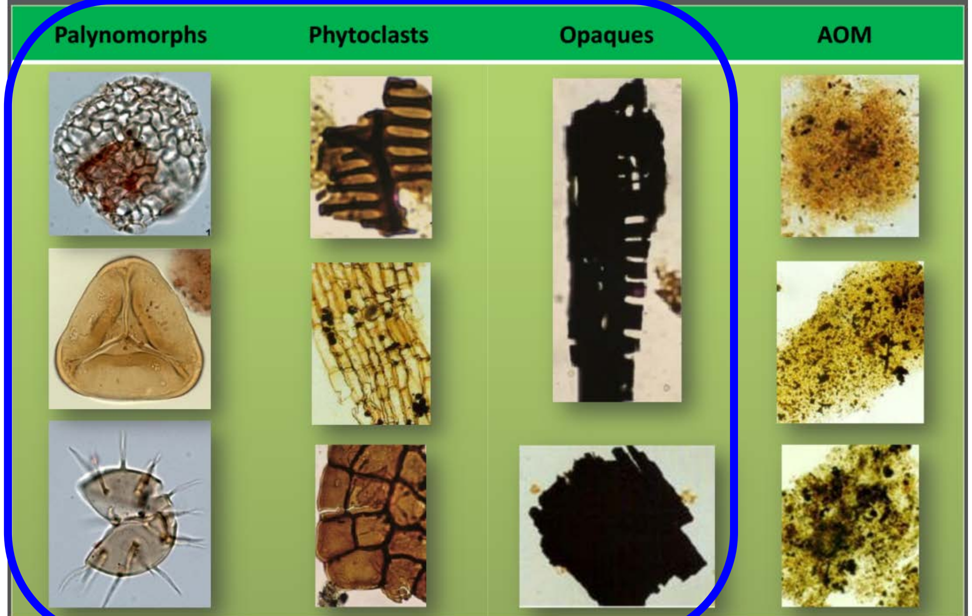

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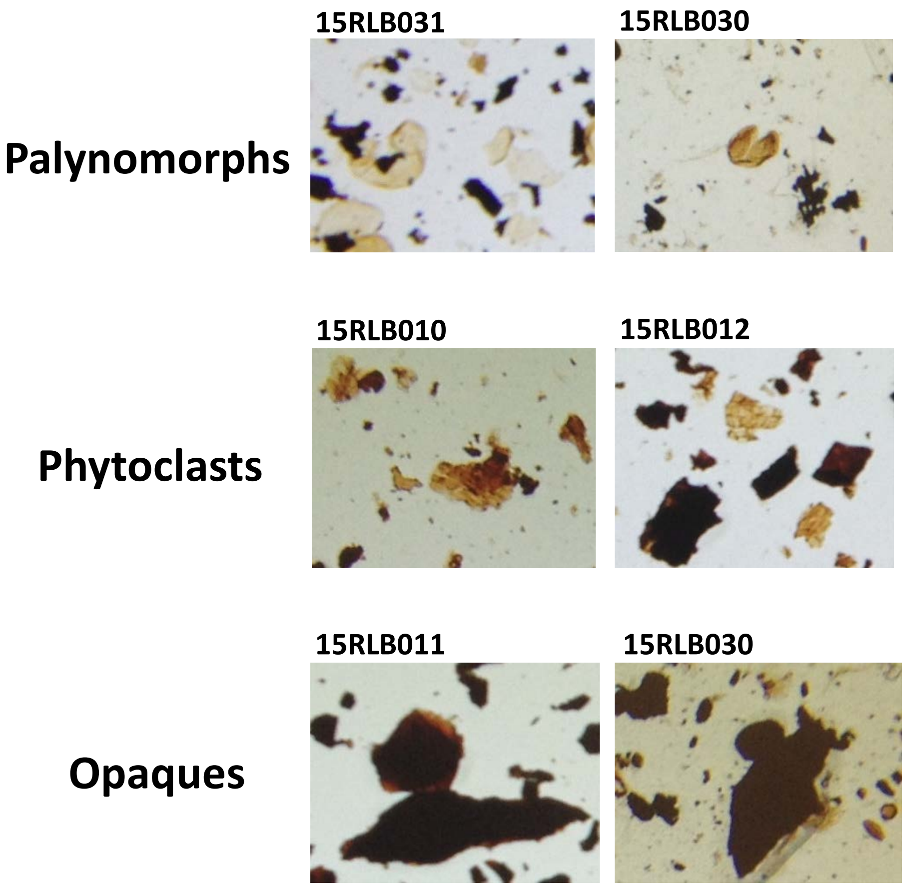


Type III: Gas-prone

50 µm

*AOM=Amorphous Organic Matter

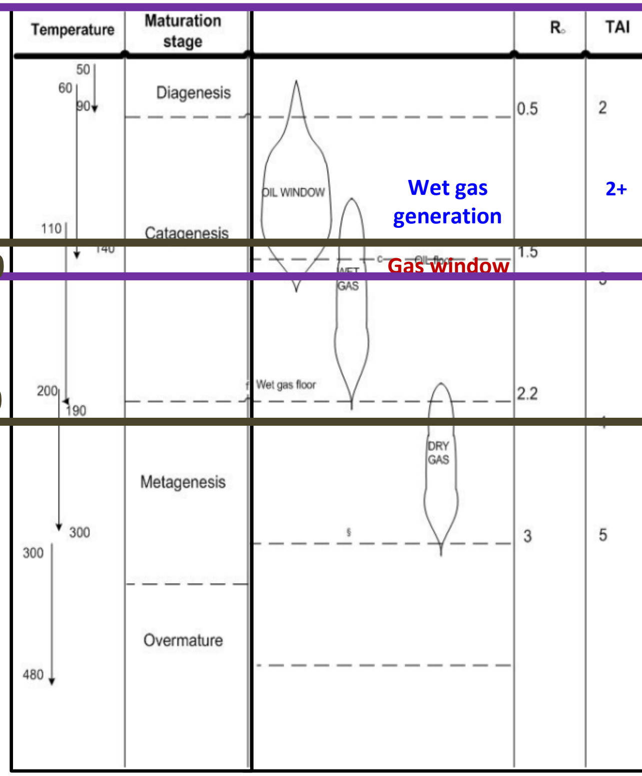
Palynomorph Thermal Alteration Index (TAI) analysis

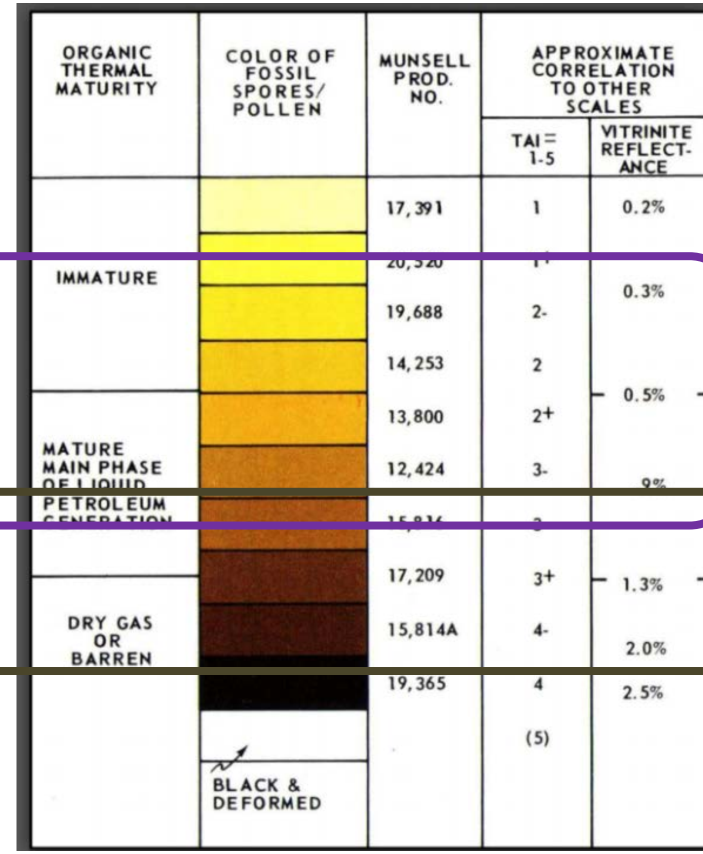
Surficial — **Subsurface**

15RLB027

15RLB031
15RLB010, 22, 23
15RLB011, 30

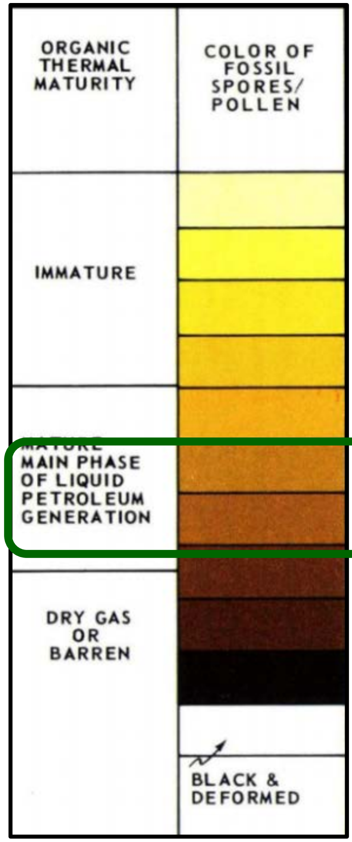
Espino 1-2, ML Invest 1-10
Espino 1-2
ML Invest 1-10





Pearson 1984; Traverse 1988; Marshall 1990; Utting and Hamblin 1991; Almashramah 2011

Espino 1-2: Kerogen analysis



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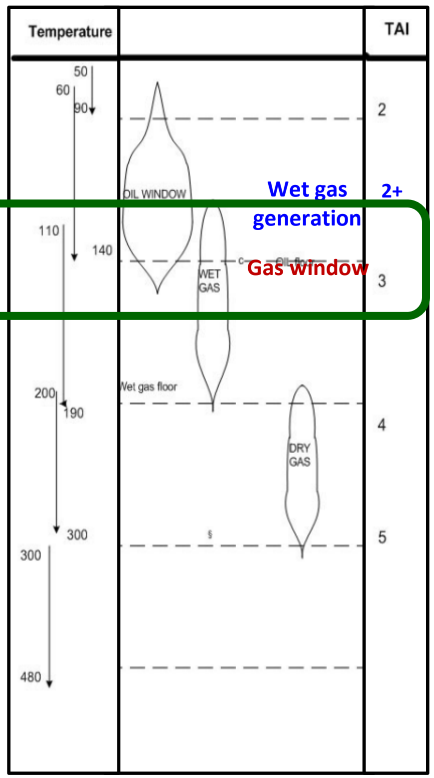
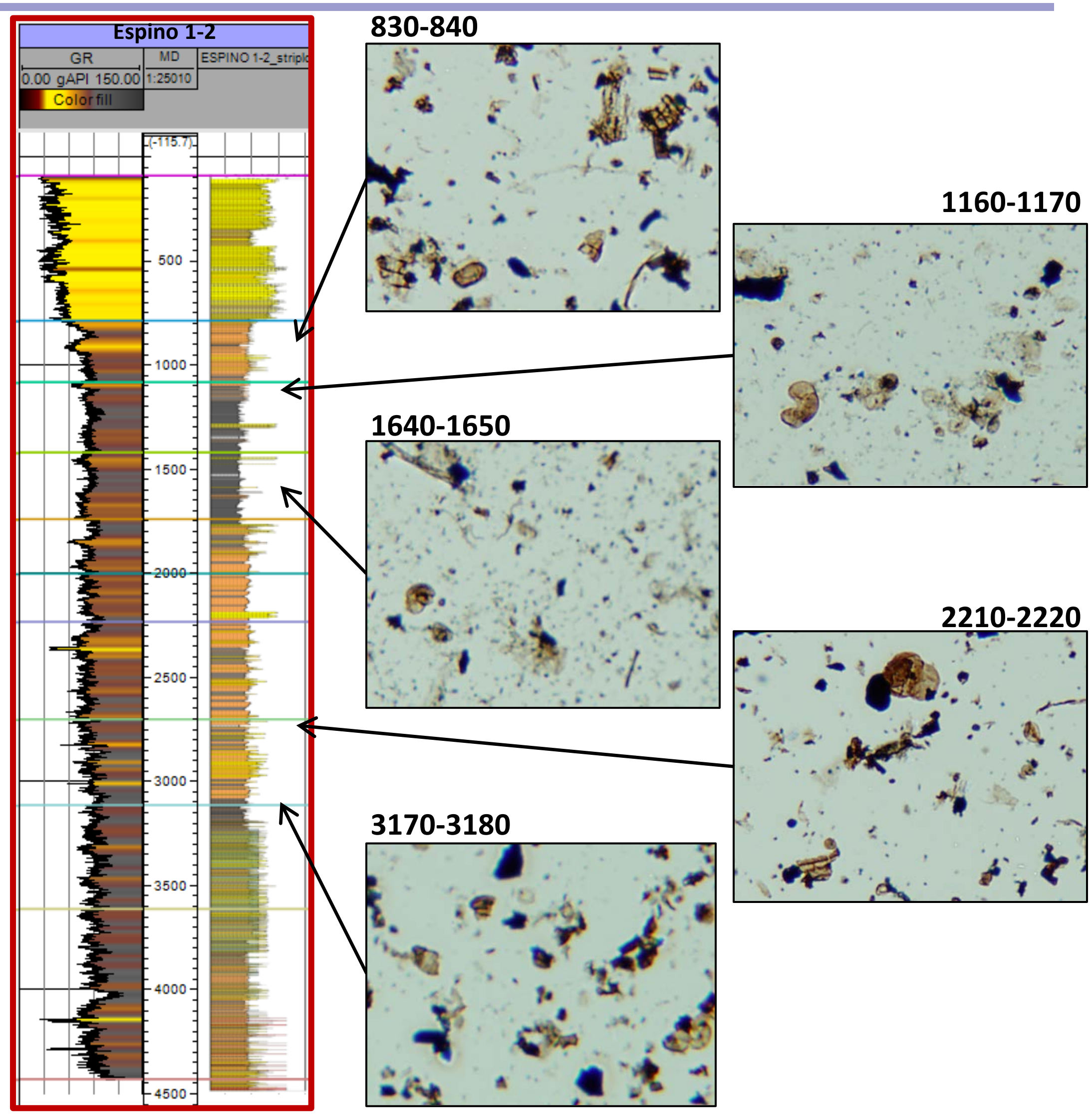
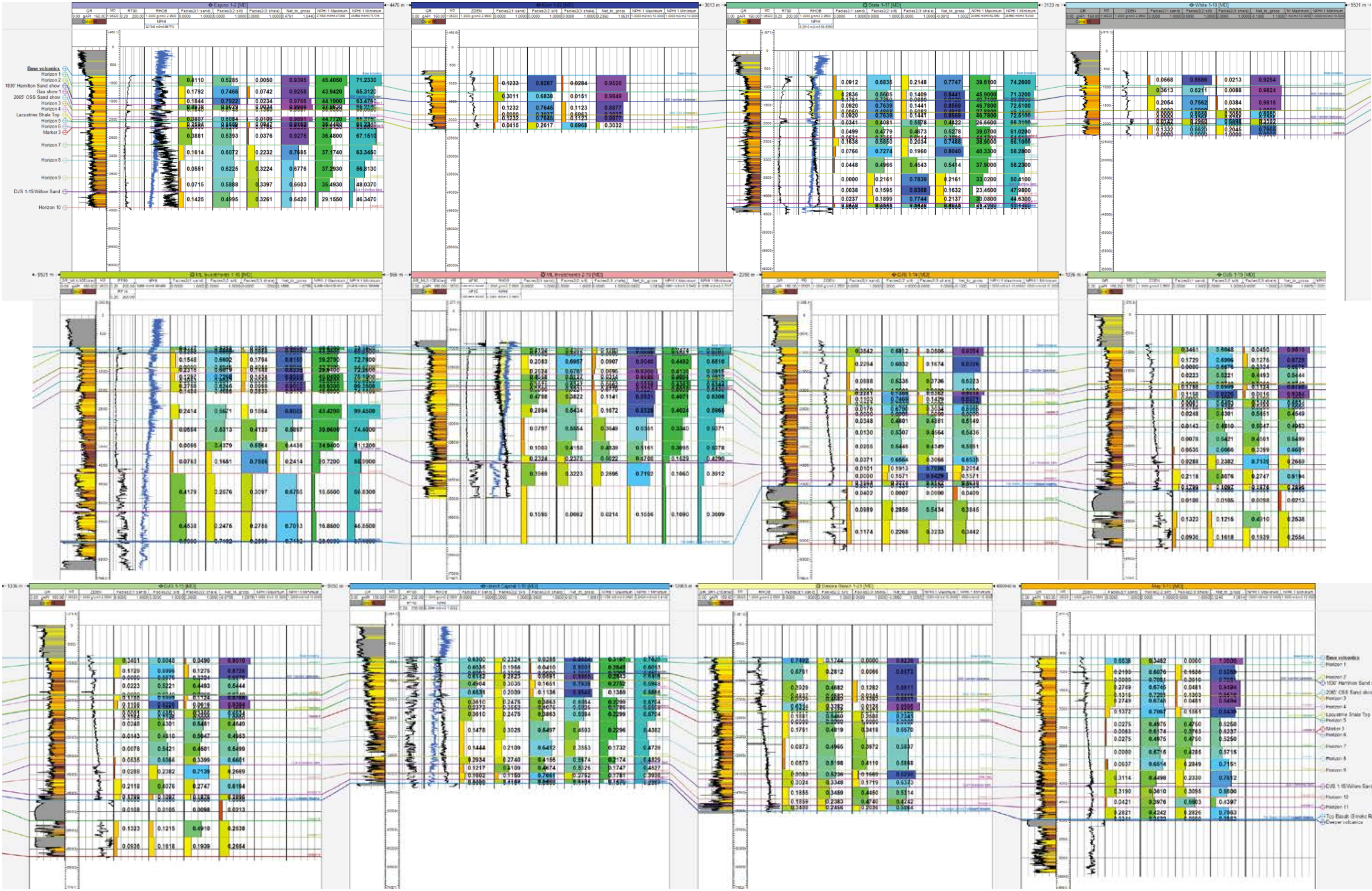


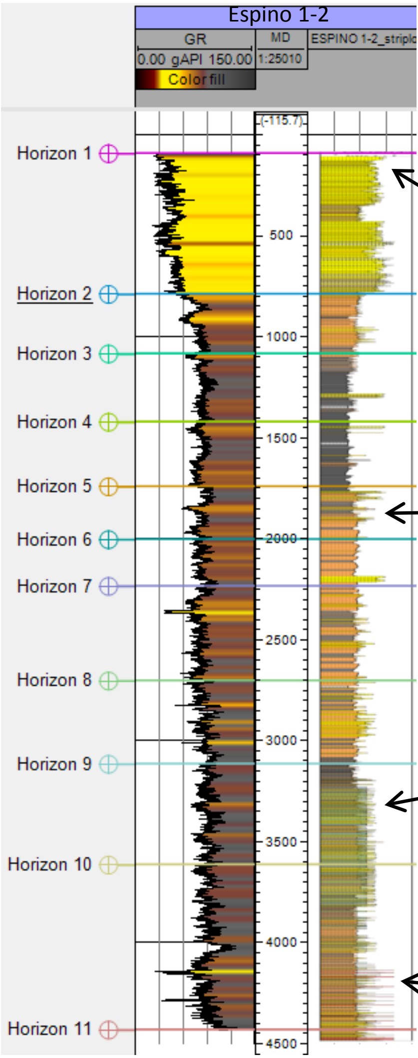


Subsurface interpretation – Reservoir vs. non-reservoir



Subsurface interpretation – Reservoir vs. non-reservoir

Examination of the well cuttings reveal that hot (radioactive) sands skew the net to gross numbers



Arkosic medium-coarse grained sandstone

65% evaporitic sandstone; 35% mud & sand

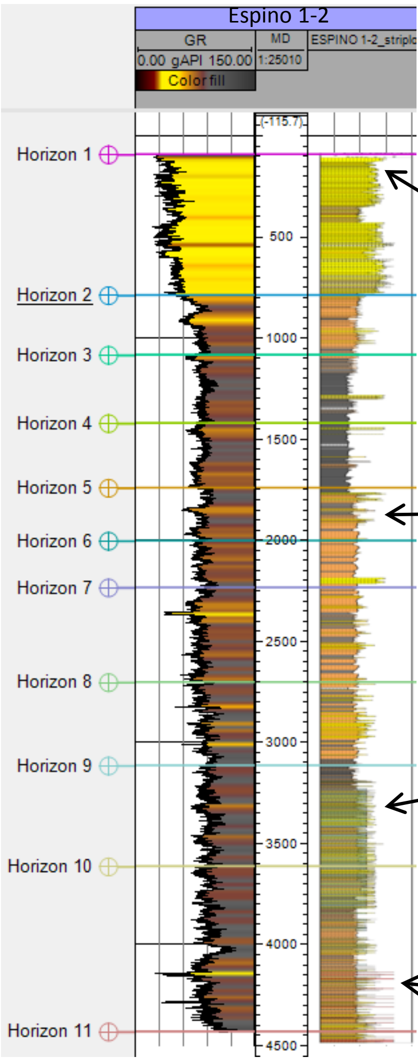
* Most likely there is more reservoir to non-reservoir than originally calculated due to the arkosic composition of the rocks

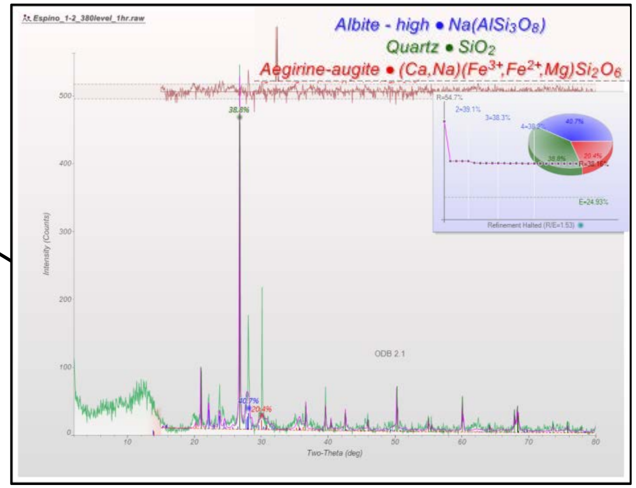
Mudstone-siltstone with 20% arkosic sand

40% evaporites, 20% arkosic sand, 40% mudstone

Drafted up stratigraphic column from well cuttings

Ongoing XRD analysis





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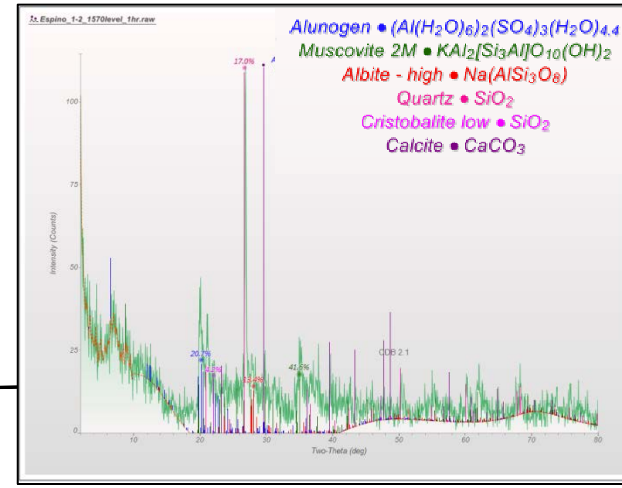

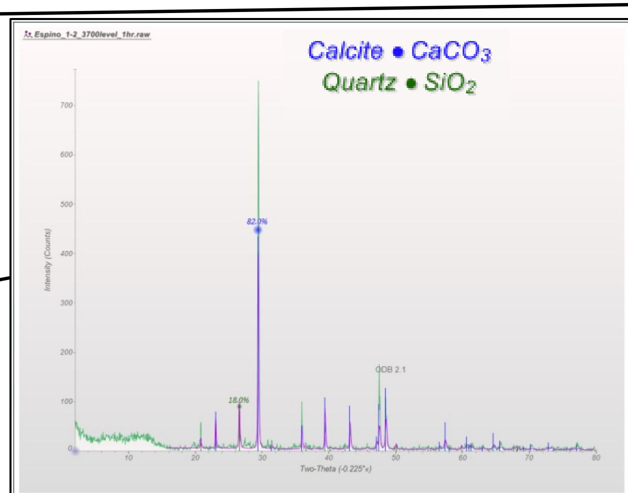

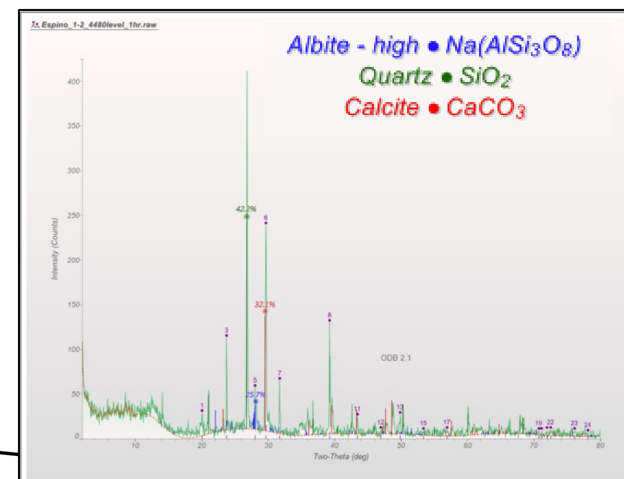

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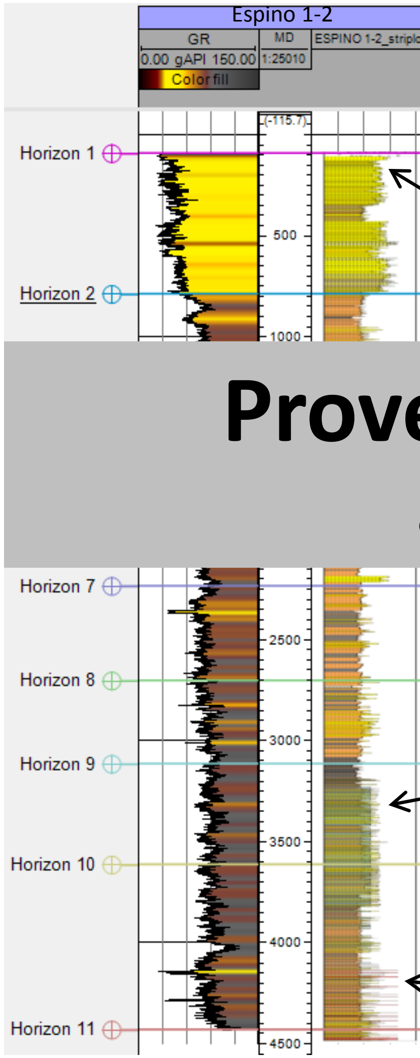
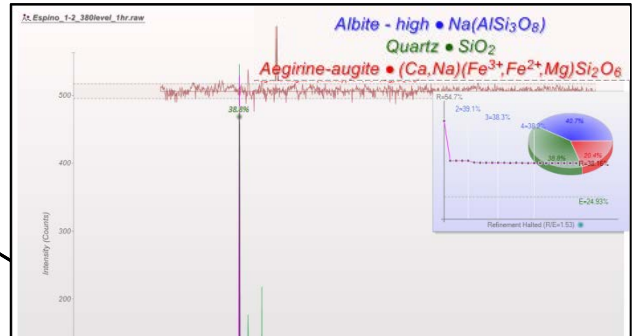
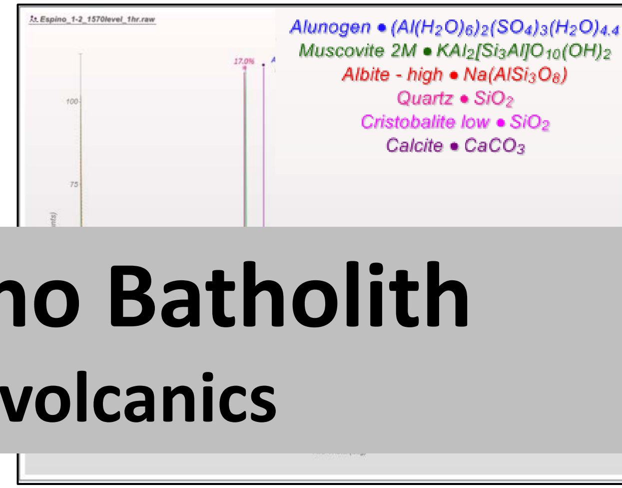


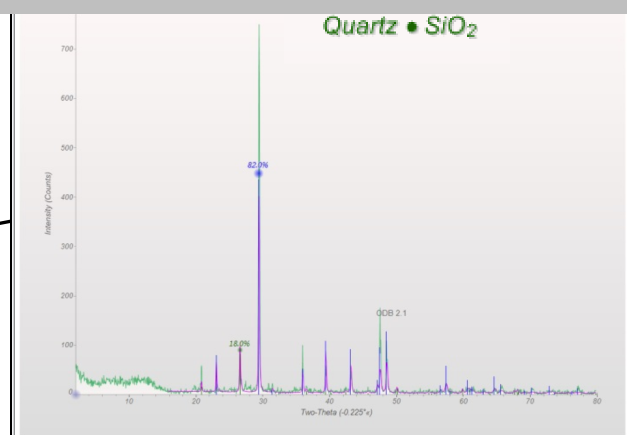


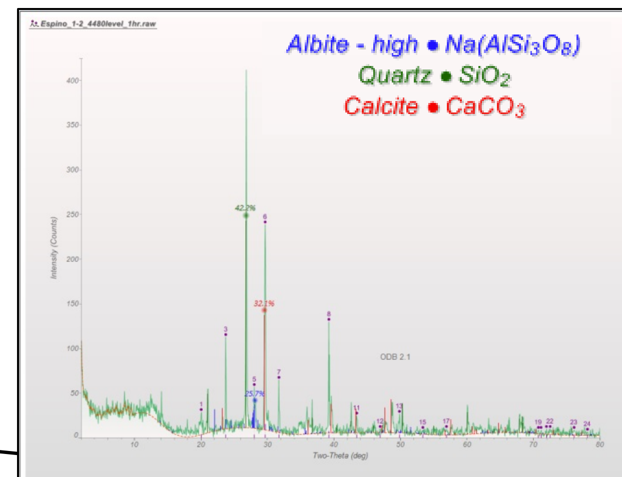
* Most likely there is more reservoir to non-reservoir than originally calculated due to the arkosic composition of the rocks



Provenance: nearby Idaho Batholith

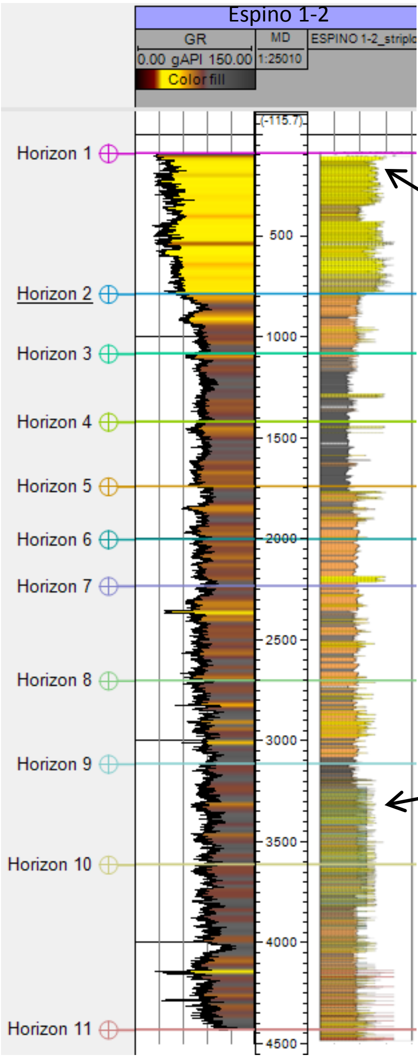
and unidentified nearby volcanics

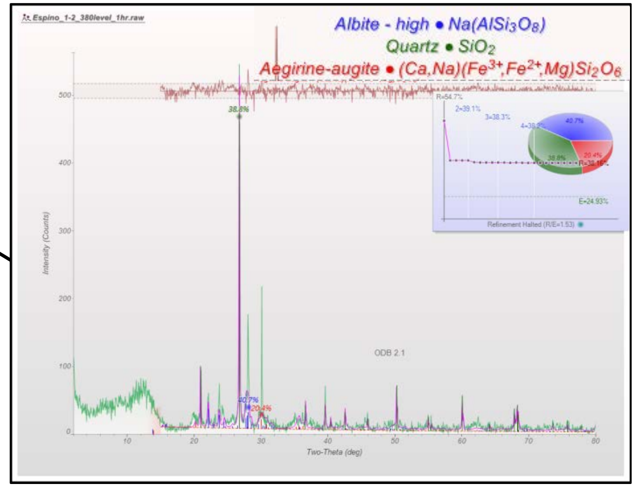


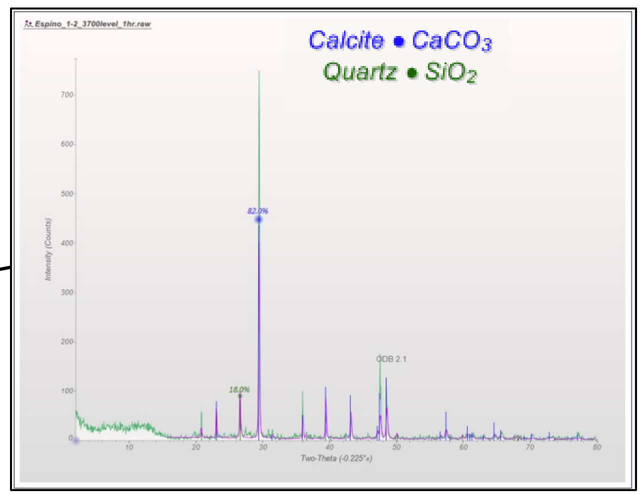


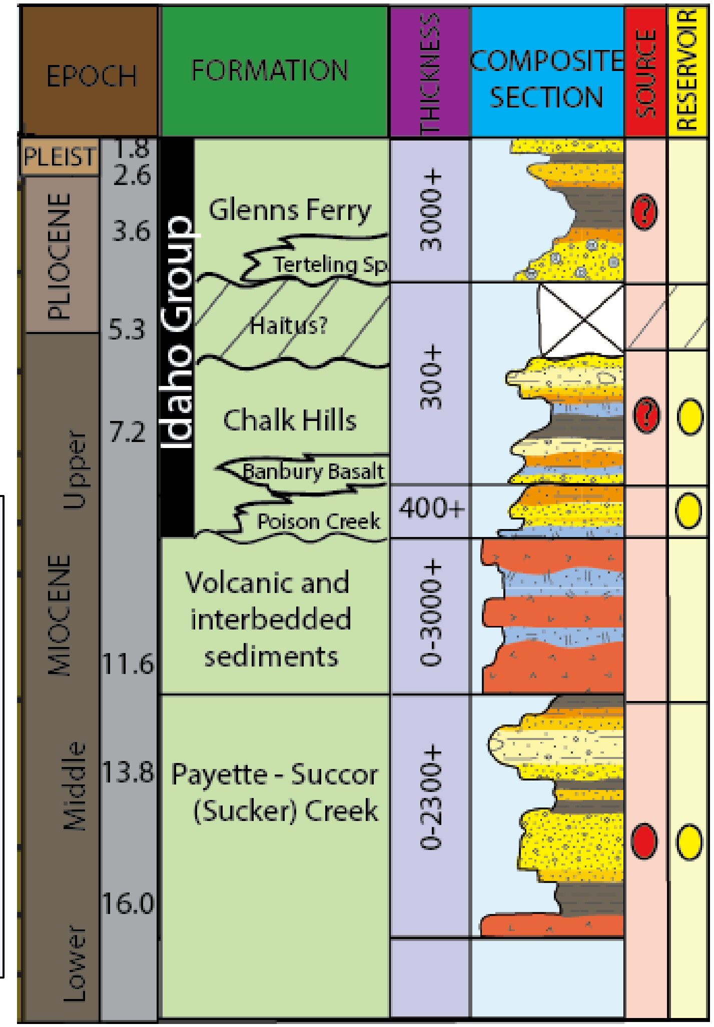
Drafted up stratigraphic column from well cuttings

Ongoing XRD analysis – which formations are represented?









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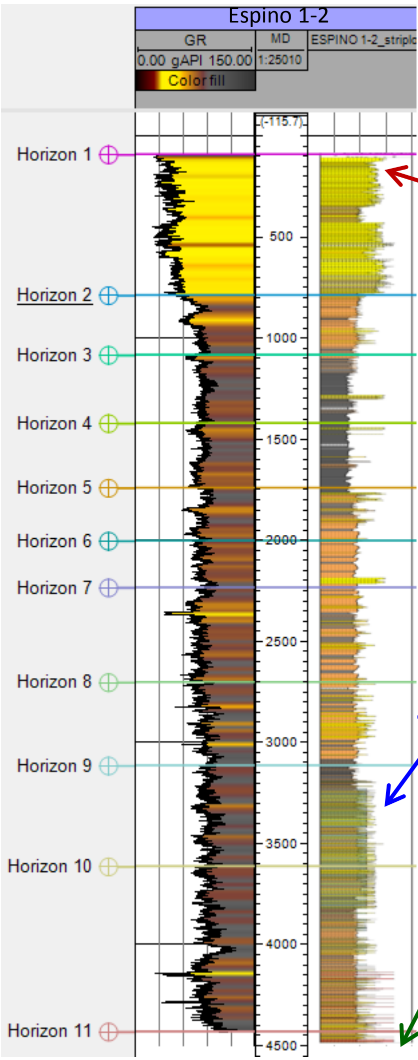
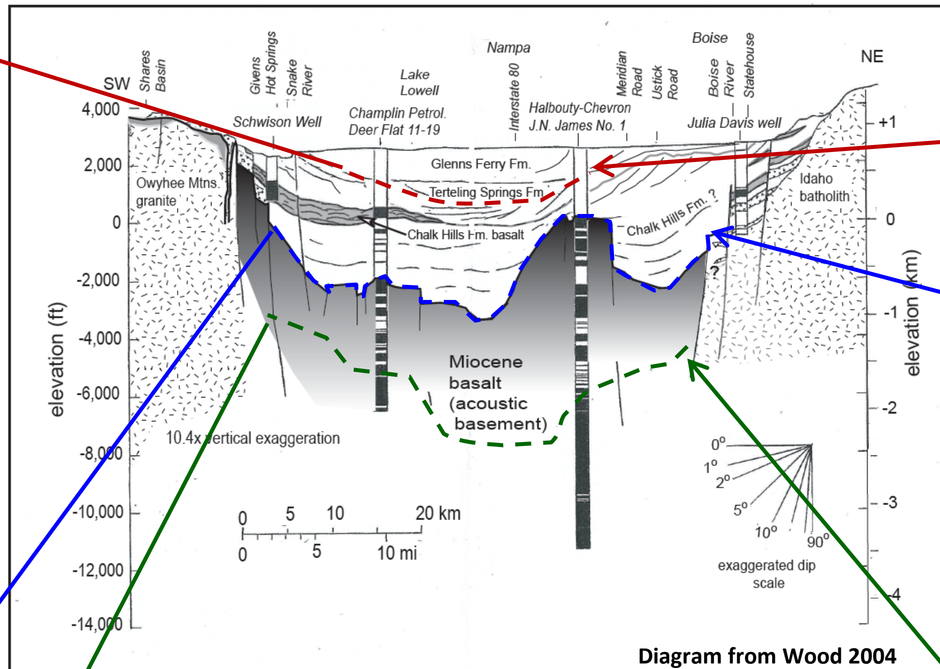
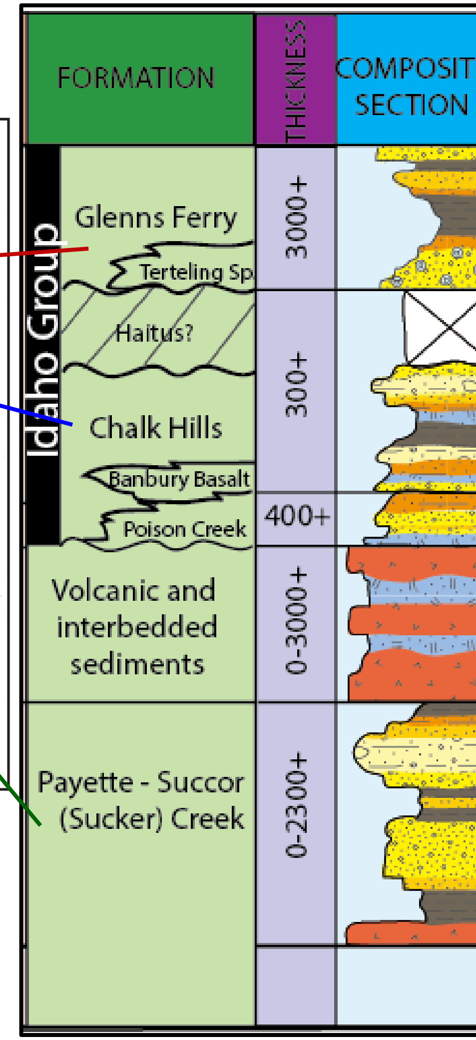
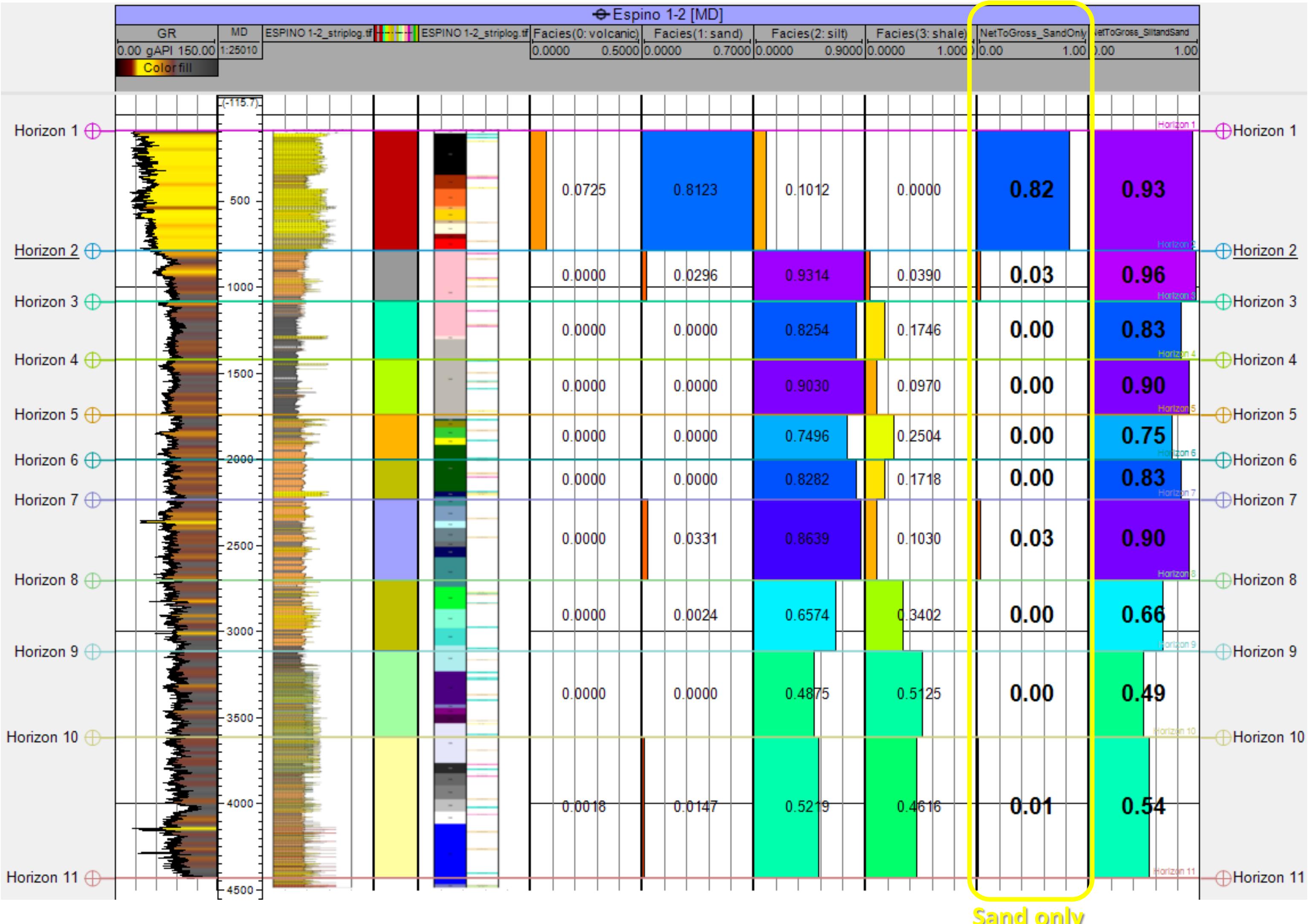






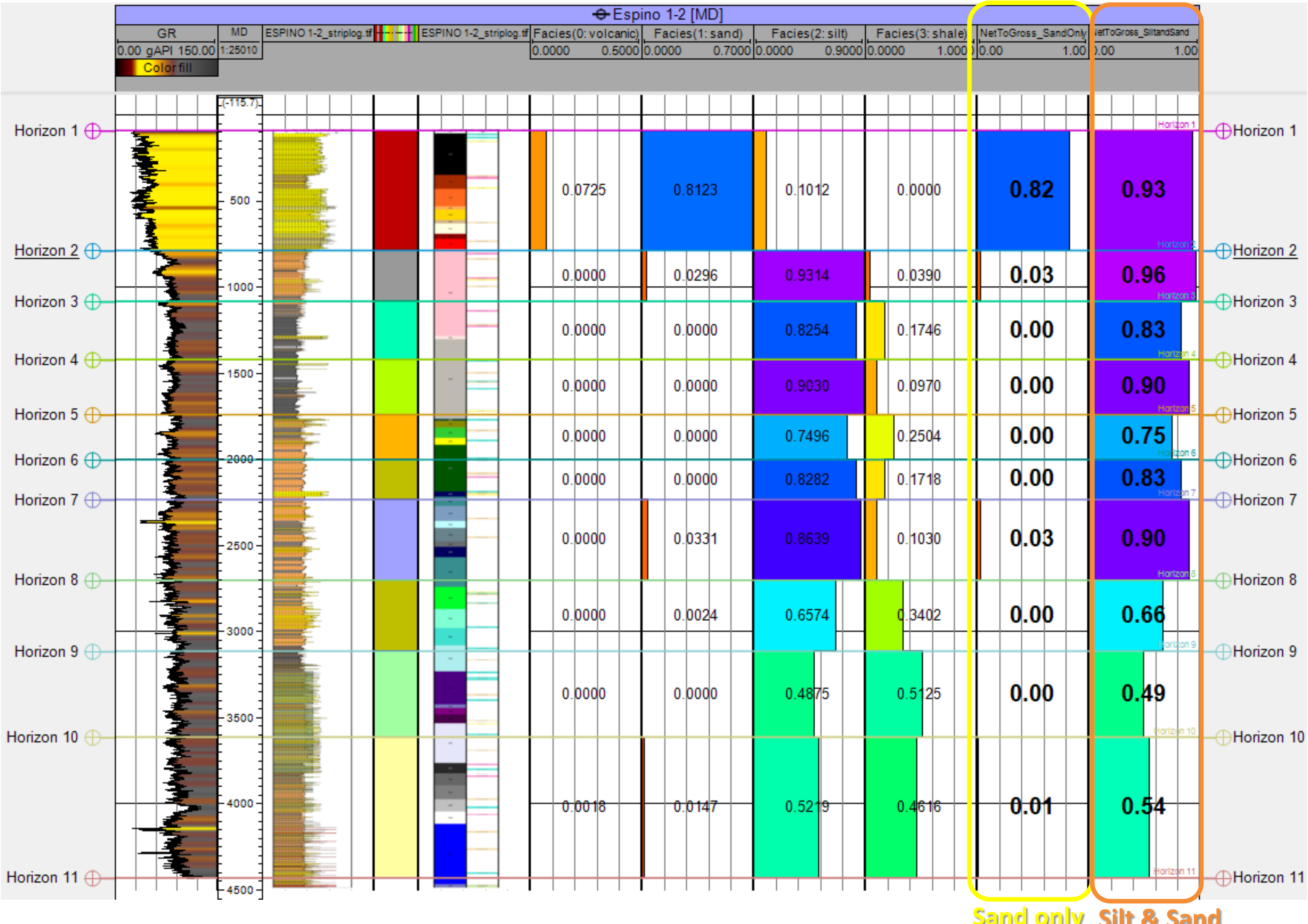
How much is the Payette Formation represented in the wells?

Examination of the well cuttings reveal that hot (radioactive) sands skew the net to gross numbers



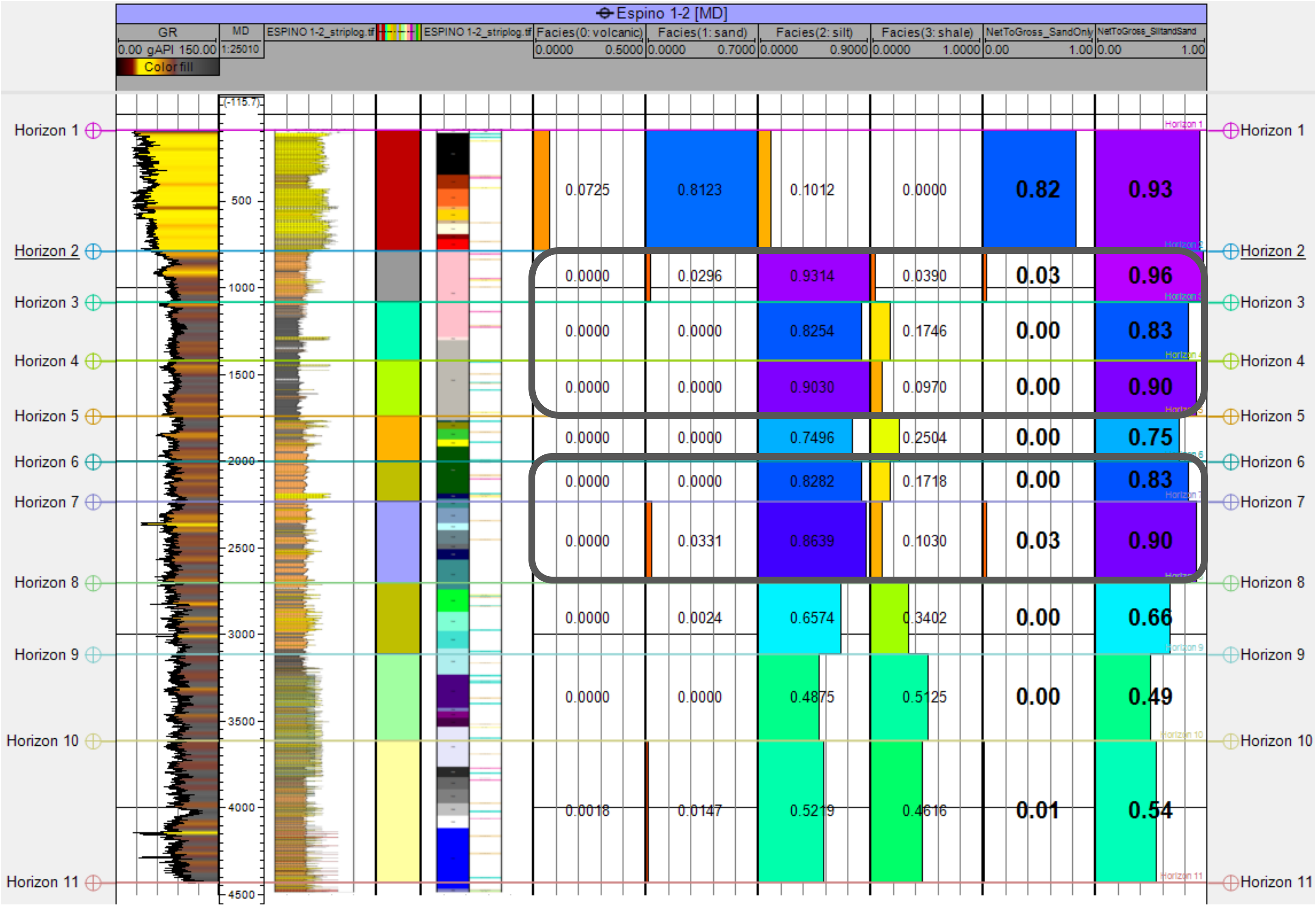
- There's more reservoir present than originally calculated, especially in the evaporitic zones

Examination of the well cuttings reveal that hot (radioactive) sands skew the net to gross numbers



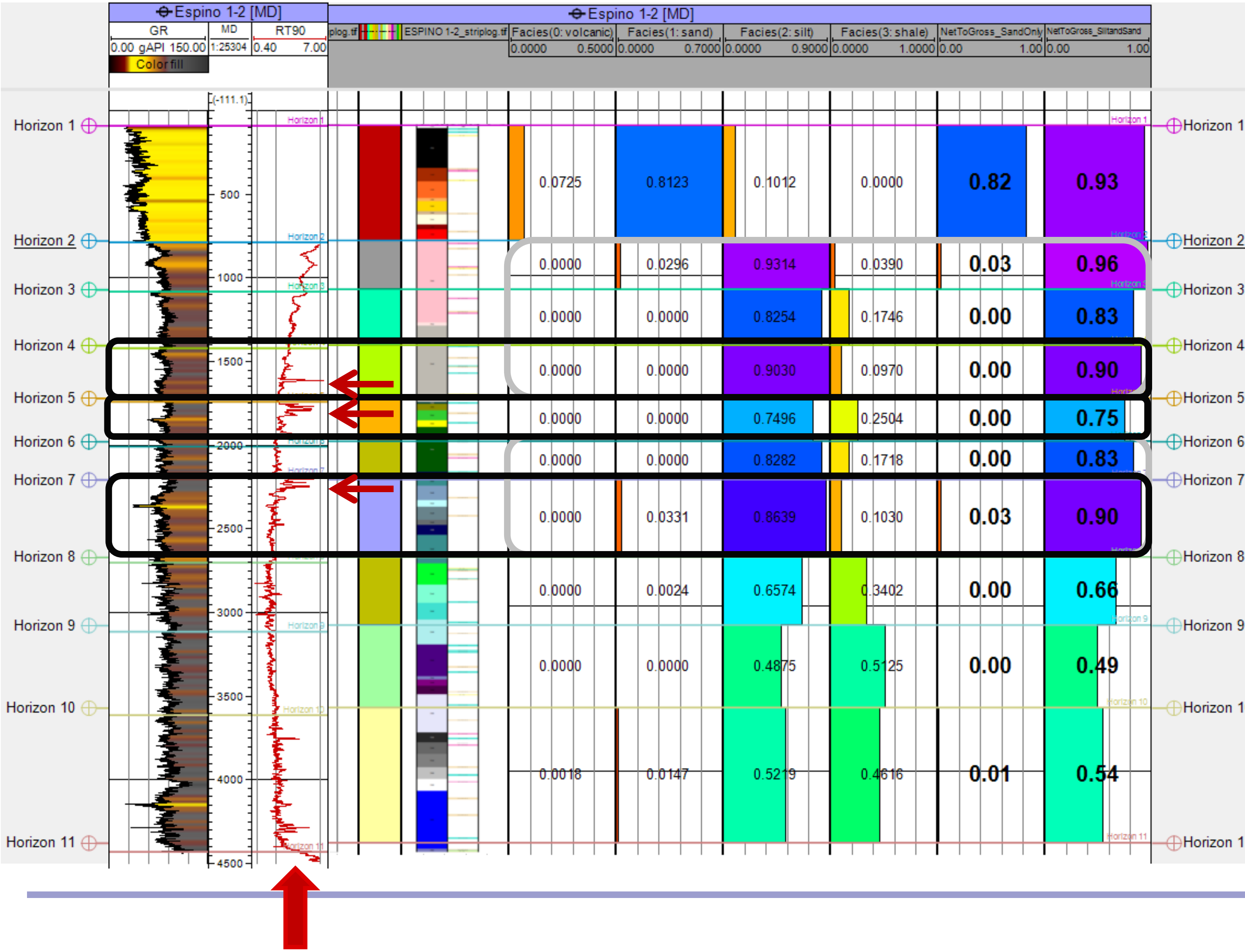
- There's more reservoir present than originally calculated, especially in the evaporitic zones
- Including the silt fraction helps but another method needed to estimate reservoir

Resistivity logs are more reliable in determining targets



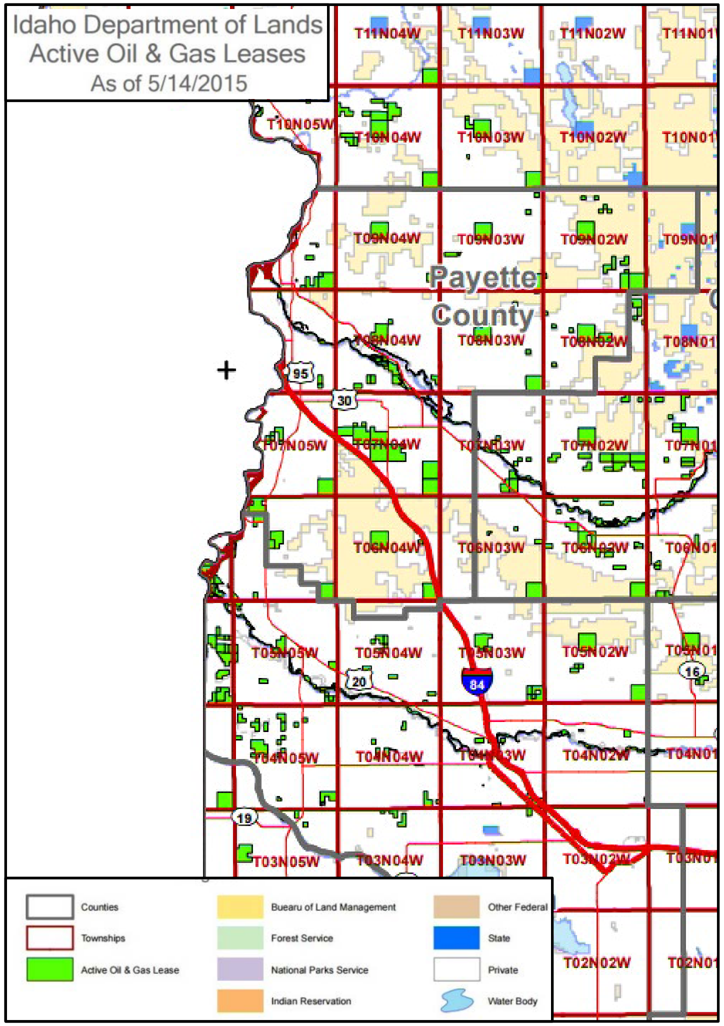
- Grey polygons show potential target intervals based on N:G from GR log

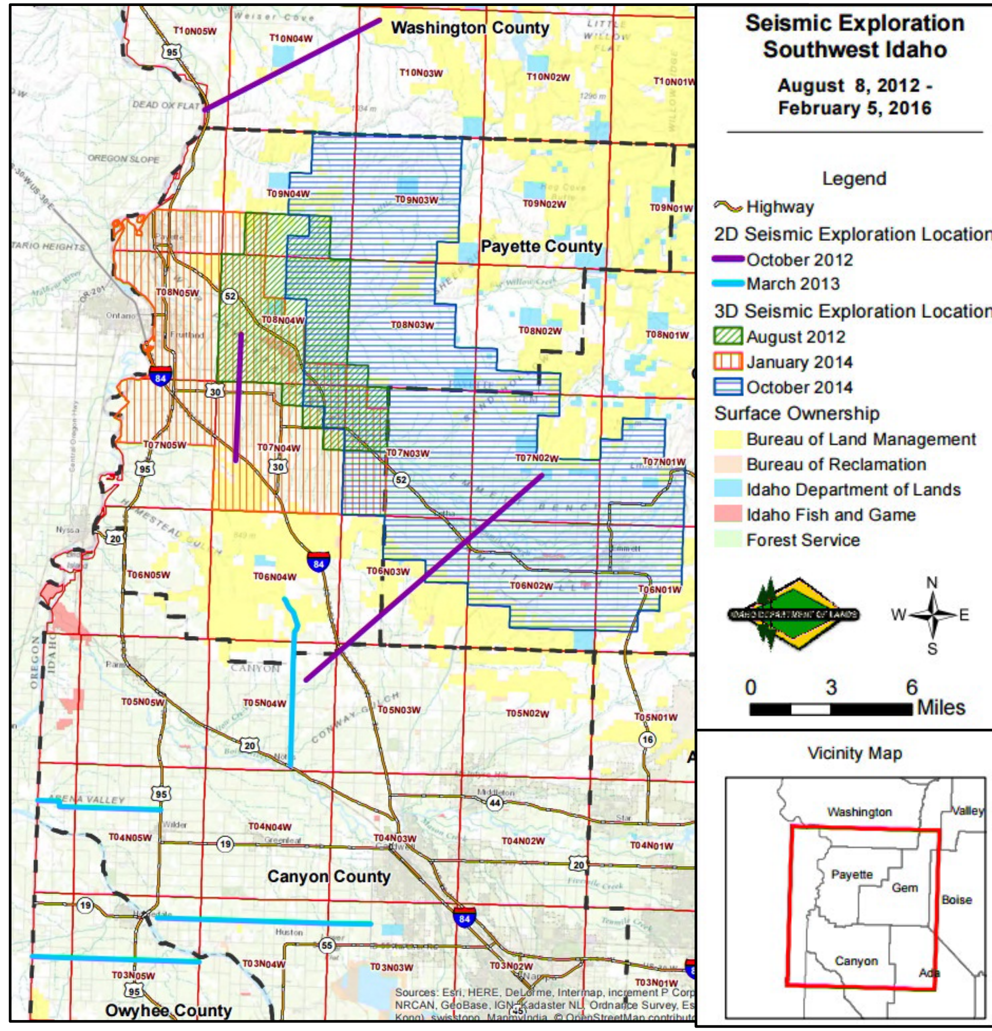
Resistivity logs are more reliable in determining targets



- Grey polygons show potential target intervals based on N:G from GR log
- Resistivity logs are more reliable for determining reservoir and target intervals
- Zones 4, 5 and 7 potential targets; GR log misleading because of the hot sands

Exploration in the Payette Basin





Future work and ongoing studies

- XRD and analyses of well cuttings help delineate provenance, reservoir versus non-reservoir, and sealing clays. The dominant provenance source is from the nearby Idaho Batholith…more to come on clay analysis
- Ongoing studies with petrophysical logs will help identify other target intervals to apply to net to gross. Feldspathic sands skew original net to gross estimates
- Depth-structure and isochore maps show a simplified version of the thickness and local highs in the basin's subsurface
- Identification of the evaporites help us determine how the rocks in the subsurface correlate to surface exposures; the Glenns Ferry and Chalk Hills most likely dominate the subsurface in the Weiser-Payette Basin
- We are in the preliminary stages of this research…stay tuned...

Glenns Ferry formation, a few miles south of Bruneau [Credit: Bill Bonnichsen]

Chalk Hills formation, south of Oreana [Credit: Bill Bonnichsen]

IDAHO GEOLOGICAL SURVEY