Pantheon Great Bear Theta West 1 well: Characterization of a World Class Petroleum System Using AHS's Cuttings' Volatiles Stratigraphy.

Michael P. Smith, PhD, President Advanced Hydrocarbon Stratigraphy, Tulsa OK USA
19 August 2022

Executive Summary*:* This report summarizes the main conclusions listed below from AHS's analyses of Sealed-at-Well and Lab-Loaded cuttings' volatiles from the Great Bear Pantheon Theta West 1 well, North Slope, Alaska.

Great Bear Pantheon's Theta West 1 drilled a world-class petroleum system comprised of:

1) A 1360' thick continuous column of oil-bearing cuttings. The actual length of the oil column is unquestionably greater than 1360', as the base of the analyzed cuttings' oil column is the TD of the well, and the oil in the cuttings shows no sign of tapering off.
2) High quality oil of 37-39 degrees API gravity.
3) Abundant good quality reservoirs.
4) An ultimate non-permeable oil seal that occurs at 7070'. Oil bearing cuttings are not observed above 7070', and oil is analyzed in every cuttings sample, both Sealed-at-Well and Lab-Loaded, below 7070' to TD.
5) A seal within the oil-rich zone occurs at 7480' separating a shallower from a deeper compartment based of different oil compositions found above and below 7480'.
6) Elevated Helium is observed, in part confirming Theta West's excellent seals.
7) These results are in complete accord and supportive of AHS's previous analyses of cuttings from Great Bear Pantheon Talitha A well, as well as AHS's study of Shelf Margin Deltaic cuttings' samples from the Talitha A, Pipeline, Alkaid, Merak, and Alcor wells.

__Data Overview:__ Drill cuttings volatiles, as analyzed by AHS on Theta West 1, are unique in their ability to characterize the importance of a petroleum system as the cuttings are direct and unique samples of the reservoirs, source rocks, seals, and migration conduits that comprise the drilled petroleum system.

AHS's cuttings volatiles analyses of both sealed-at-well and lab-loaded cuttings samples from Theta West 1 indicate a world class petroleum system in which every cuttings sample below 7070' contains oil (see Figures 1 through 4).

The transition from abundant cuttings oil in all samples from both sample types below 7070' to absent cuttings oil in every sample above 7070', indicates that 7070' is the top of the ultimate petroleum seal at the Theta West 1 location (Figure 1 through 4).

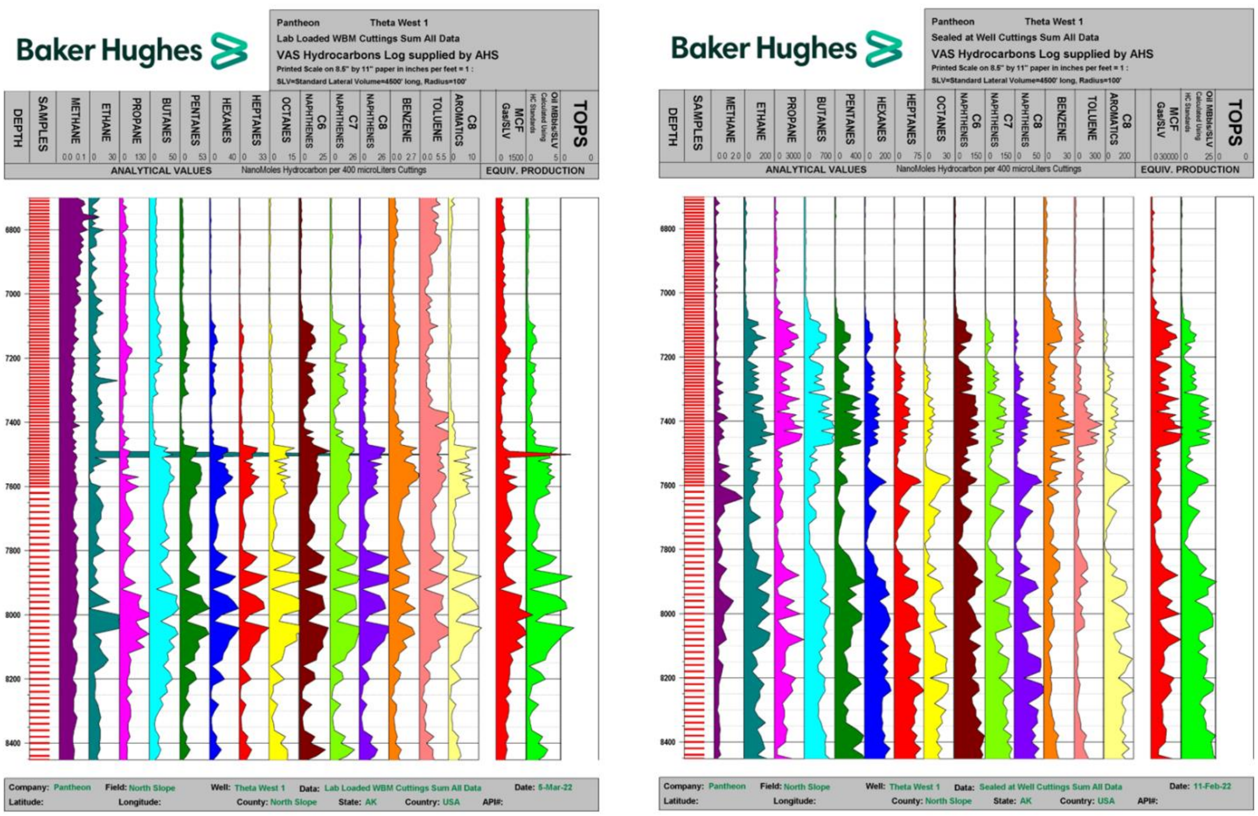

Figure 1. Pantheon Theta West 1 well's Lab-Loaded (left panel) and Sealed-at-Well (right panel) cuttings volatiles hydrocarbons logs. Oil occurs continuously for 1360' in all samples deeper than 7070' to TD in both the lab-loaded and sealed-at-well analysis, demonstrating Theta West 1 drilled a world class petroleum system. In the Sealed-at-Well samples the only liquid hydrocarbon showing noticeable concentrations above 7070' is benzene, the most water-soluble liquid hydrocarbon. In the Lab-Loaded samples both Benzene and Toluene show appreciable concentrations above 7070'. Benzene and Toluene are both aromatic compounds and Toluene is the second most water soluble liquid hydrocarbon with about one-tenth the water solubility of benzene. Water-soluble compounds migrate through water by diffusion. The occurrence of benzene and toluene in cuttings above 7070' shows that water maintains a continuous film through the oil seal and is evidence of high oil saturations below 7070'.

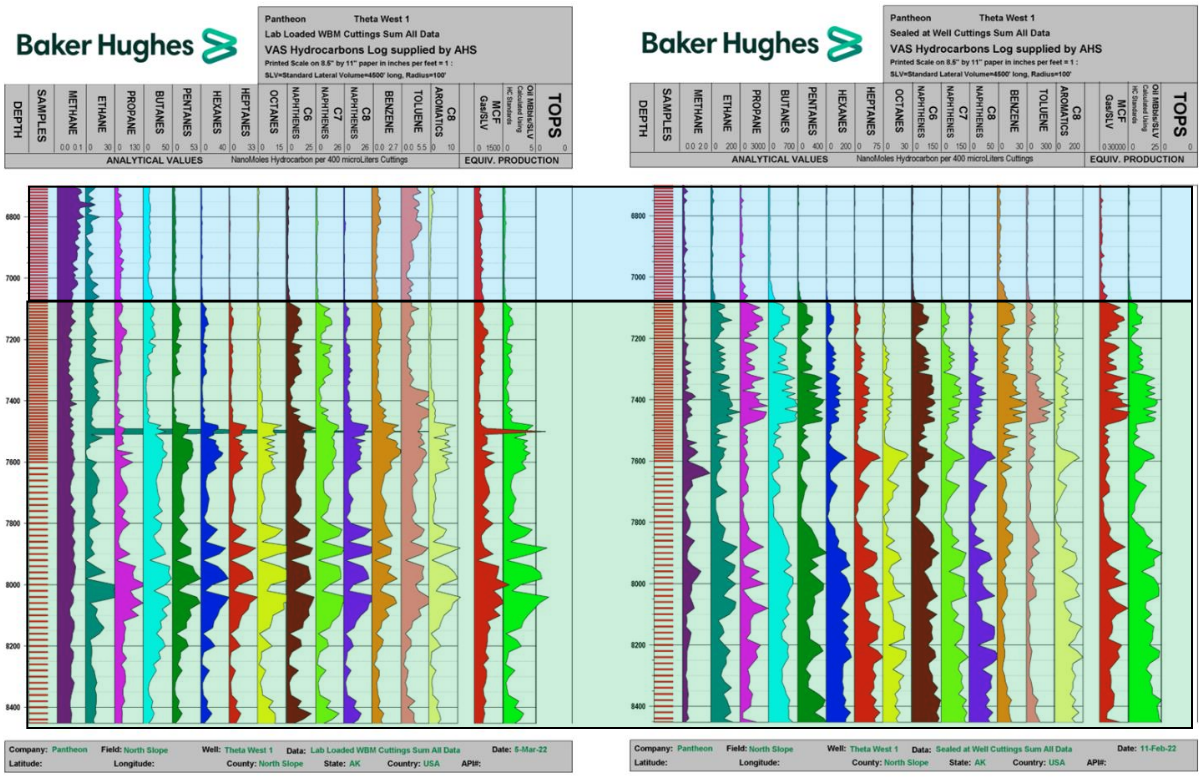

Figure 2. Pantheon Theta West 1 well's Lab-Loaded (left panel) and Sealed-at-Well (right panel) cuttings volatiles hydrocarbons logs. In the green shaded area, oil occurs continuously for 1360' in all samples deeper than 7070' to TD in both the lab-loaded and sealed-at-well analysis, demonstrating Theta West 1 drilled a world class petroleum system. The blue shaded area above 7070' shows no oil migration, indicating an ultimate seal at 7070', but does show elevated concentrations of the aromatic compounds benzene and toluene. Benzene, and to a much lesser extent toluene, have the highest water solubilities of all liquid hydrocarbons and can migrate into the water films in the seal via diffusion, a migration mechanism not available to the saturated hydrocarbons, paraffins and naphthenes, which have extremely low water solubilities.

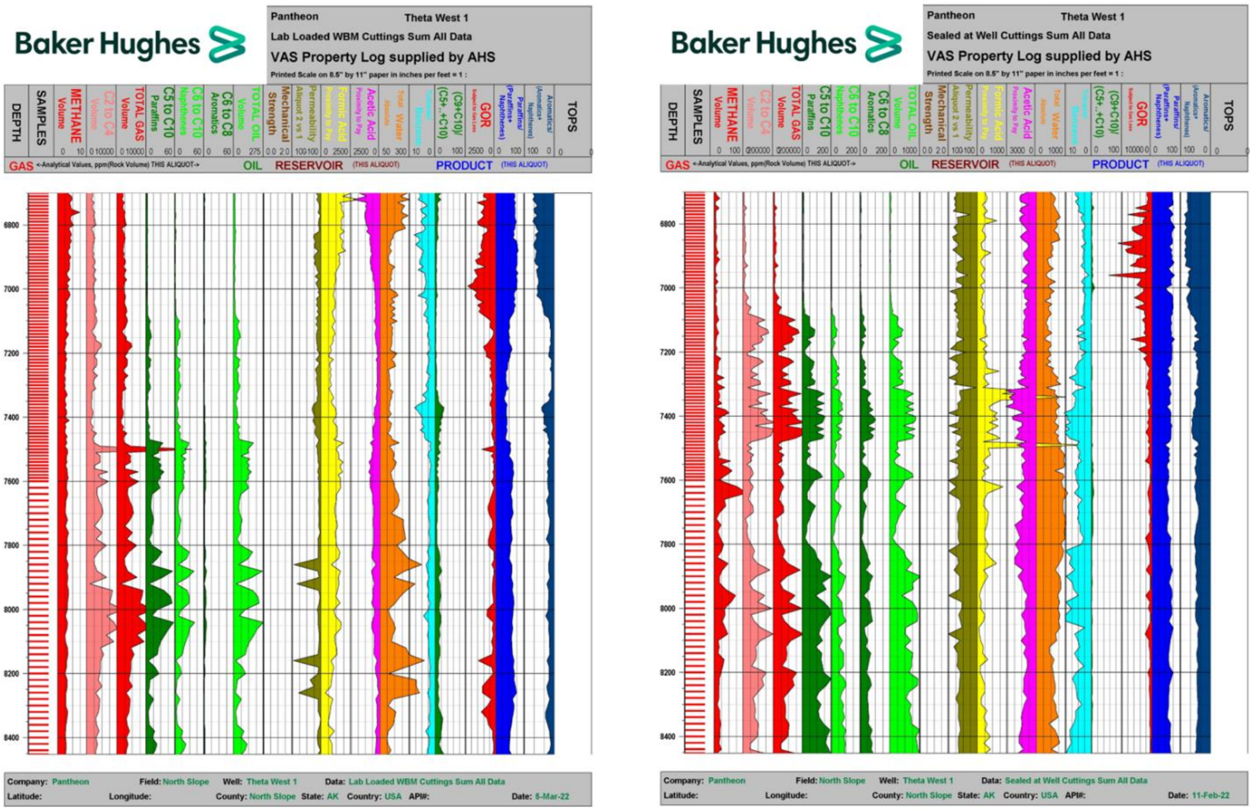

Figure 3. Pantheon Theta West 1 well's Lab-Loaded (left panel) and Sealed-at-Well (right panel) cuttings volatiles properties logs. Oil occurs continuously for 1360' in all samples deeper than 7070' to TD in both the lab-loaded and sealed-at-well analysis, demonstrating Theta West 1 drilled the top of a world class petroleum system. The three red curves to the left shows the amounts and composition of cuttings gas, the next four green curves show the amounts and compositions of cuttings oil. The middle olive curve shows a permeability index based on hexanes. The Sealed-at-Well permeabilities are consistently high while the Lab-Loaded permeabilities are consistently low. These permeability indices relate to the permeability of the pores that hold hexanes at the time of analyses. Appreciable amounts of the subsurface formation oil are preserved in the Sealed-at-Well samples that are sealed within minutes of coming to the surface, whereas the oil in the more permeable pores are lost from the Lab-Loaded samples that are loaded and analyzed some weeks later. Hence, the Sealed-at-Well high permeabilities are an accurate depiction of abundant high permeability rocks in the subsurface. The Lab-Loaded samples show that appreciable oil and gas are preserved in the rocks' tightest spaces, thus indicating the high oil saturations in the subsurface required to force oil into these very tight low permeability pores. The higher cuttings' GORs observed above 7070' in both the Sealed-at-Well and Lab-Loaded data sets are an indication that the seal at 7070' is essentially impervious to oil migration, but still open to some gas migration. Gas, at least in part, will migrate through the seal in solution in water like benzene does, in as much as methane and ethane both have higher water solubilities than benzene, and propane has about the same water solubility as benzene. Another indication of migration across the oil seal via diffusion in water is seen in both Sealed-at-Well and Lab-Loaded data sets in the right most column showing the Aromatics/(Aromatics+Naphthenes) ratio, A/(A+N), as a percentage. A/(A+N) is noticeably higher above 7070' than below in both data sets. This is a reflection of the greater water solubility of especially benzene, and to a lesser extent toluene, than the saturate hydrocarbons (naphthenes and paraffins). Benzene and Toluene migrate into the seal via diffusion through water, while this manner of migration is not available to the much more water insoluble naphthenes and paraffins.

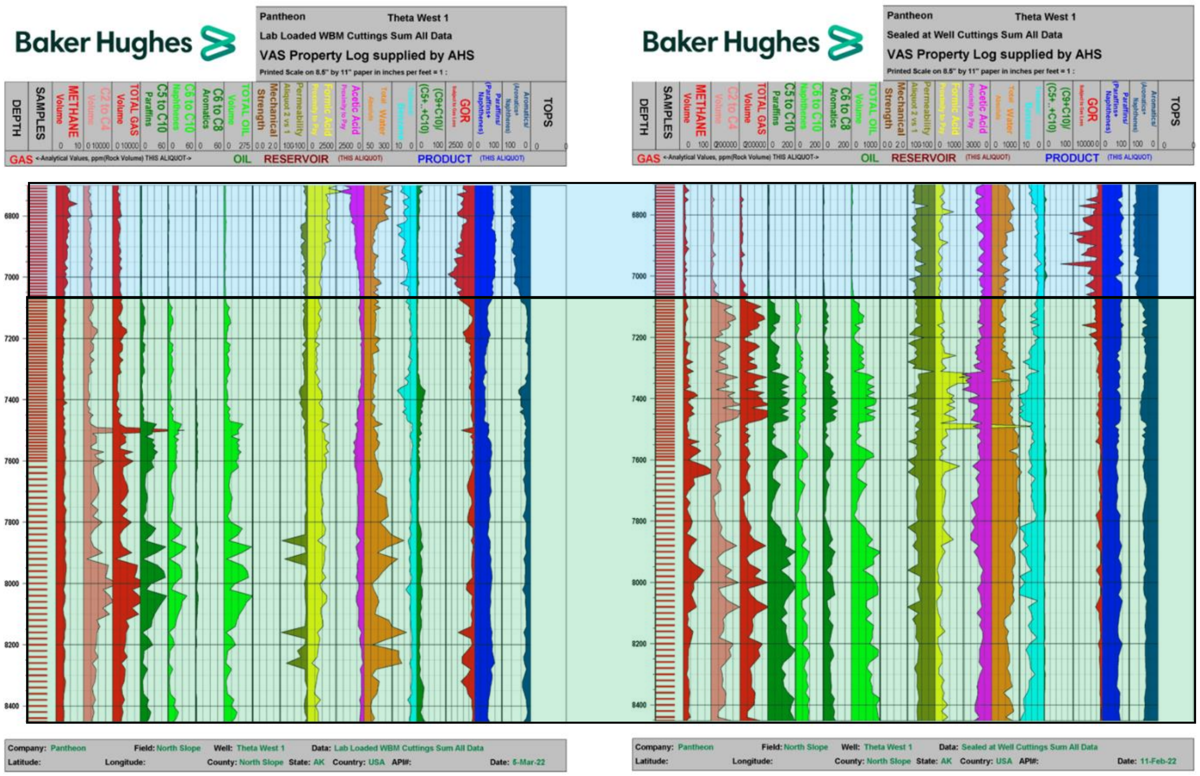

Figure 4. Pantheon Theta West 1 well's Lab-Loaded (left panel) and Sealed-at-Well (right panel) cuttings volatiles properties logs. Oil occurs continuously for 1360' in all samples deeper than 7070' to TD in both the lab-loaded and sealed-at-well analysis, demonstrating Theta West 1 drilled the top of a world class petroleum system. The blue shaded area above 7070' shows no oil migration, indicating an ultimate seal at 7070', but does show elevated concentrations of the aromatics/(aromatics + naphthenes) ratio as a percentage (rightmost column in both panels). Benzene, and to a much lesser extent toluene, are the lightest aromatic compounds and have the highest water solubilities of all liquid hydrocarbons and can migrate into the water films in the seal via diffusion, a migration mechanism not available to the saturated hydrocarbons, paraffins and naphthenes, which have extremely low water solubilities. High cuttings GOR are also observed in the blue shaded seal in both panels in as much as gaseous C1-C4 hydrocarbons are lighter and smaller than liquid hydrocarbons, and also have higher water solubilities than most of the liquid hydrocarbons. Propane and benzene have very similar water solubilities, as do butanes and toluene.

__Petroleum System Analyses:__ For a single well, such as Theta West 1, AHS's experience is that the single most important measure of a petroleum systems' strength is the total length of continuous oil-bearing rocks as determined by volatiles analyses of the cuttings.

AHS's research has shown that the amount of oil in any given cuttings sample, either high or low, is not a good indication of petroleum system strength. Great oil wells often contain cuttings with very low oil contents. And poor performing wells often contain cuttings with high oil contents. And vice versa.

The amount of oil in any cuttings sample is a result of several factors: oil saturation in the subsurface; oil quality especially C1-C5 content; reservoir quality; the interaction of the cuttings with the drill bit and the mud system. These are the primary natural controls. In addition these differences can be amplified and more fully exploited depending on whether the cuttings are Sealed-at-Well within minutes of coming to the surface in AHS tubes, or if the cuttings are Lab-Loaded for analyses at a later time. The best interpretation of the subsurface comes from having both the Sealed-at-Well and Lab-Loaded data, as we do in Theta West 1.

Sealed-at-Well cuttings retain more of their oil and gas, and much of that oil and gas has compositions that remain unaltered, or nearly so. The Sealed-at-Well cuttings are our best tool for most accurately understanding the resource as it exists in the reservoir. Accurate API gravities are calculated from these data. The volume of oil elsewhere in unconventional tighter rocks can often be volumetrically extrapolated to calculate accurate EURs for laterals.

Sealed-at-Well cuttings are bought to the surface, collected, and hermetically sealed in AHS tubes often within a half hour of disaggregation from the parent formation. This makes AHS's Sealed-at-Well cuttings samples have the most virgin-conditions possible of any samples of subsurface fluids and reservoir rocks that are possible to collect on a well.

Lab-Loaded cuttings continue to lose oil and gas until loaded in the lab. These analyses give us a more detailed look at reservoir quality and formation water volumes. Given more time for volatiles to escape, the lab-loaded cuttings analysis amplifies the distinction between permeable and tight reservoir rocks. The tighter rocks continue to hold onto more of their oil and gas, while good reservoir rocks continue to lose more of their oil and gas. In a section of a well showing continuous cuttings oil, the zones showing low oil are usually the best reservoir rocks, whereas the cuttings showing the highest amounts of oil are the tightest rocks. The water data from the Lab-Loaded analysis provides insights into oil versus water saturation, and also into oil versus water wetness. In general, low AHS lab loaded water volumes correlates well with high oil and gas volumes. Also, Oil-Wet rocks lose their water easily and more water is analyzed in our 20 millibar extraction, while Water-Wet rocks are more tightly bound to water and lose more water in the 2 millibar extraction. Both the 20 and 2 millibar extractions are performed on every rock sample analyzed providing another estimate of permeability as well as oil versus water wetness.

The combination of both Sealed-at-Well and Lab-Loaded analysis, as we have on Theta West 1, allows a more detailed understanding of reservoir quality by allowing us to calculate a quantity we call movability. Movability is the ratio of oil volumes between the Sealed-at-Well analyses versus the Lab Loaded analyses for the same sample depth. The greater the amount of oil lost between the Sealed-at-Well versus Lab-Loaded samples, the greater the formations movability. An the better the movability the better the reservoir quality.

Oil Saturation in the Subsurface: Of course, the amount of oil in a cuttings sample can not be greater than the subsurface oil saturation of its parent formation at point of extraction. This is especially true in the light hydrocarbon C1-C10 range in which AHS works. So, the upper limit for the volume of oil in a cuttings sample is the volume of oil in the formation that sourced that cuttings sample. However, cuttings practically always contain much less oil, especially if the oil is light as in Theta West 1, compared to the amount of oil in contained in the cuttings parent rock before the drill bit ripped the cuttings pieces from the parent formation. The amount of oil lost, and the fractionation of the cuttings' residual oil compositions, provides valuable and unique information to both oil quality and reservoir quality, as discussed below.

Oil Quality, Especially C1-C5 Contents: In the subsurface oils contain appreciable amounts of C1-C5 compounds dissolved in the oil. The loss of pressure as cuttings samples travel from their parent formation's depth to the surface results in the loss of almost all their gaseous C1-C4 compounds and an appreciable amount of their C5 compounds. As those C1-C5 compounds dissolved in oil undergo phase transition to gas they undergo a volume increase of a factor of 1,000, which equals a 100,000% increase in volume. These volatile compounds comprise several percent of light oil, as we have in Theta West, in the subsurface. If these compounds comprise 5% of an oil, then the transition of these C1-C5 hydrocarbons from the liquid to gas phase results in a net volume increase of the original oil by a factor of 50 times, or 5,000%, compared to the original oil volume. If the original volume of these compounds dissolved in oil is only 0.5%, a volume increase over the volume of the original oil of 5 times, which equals 500%, is realized. Given a rock with 100% oil saturation, 10% porosity, and containing oil having 5% of its dissolved compounds convert to gas, that rock realizes a hydrocarbon volume increase of 5 times the host rock's volume, which equals 500% of the host rock's volume. This incredible volume increase is the main drive for the loss of oil from cuttings between their drilled depth and the surface. Not only are the C1-C5 liquid components lost because of their phase change to gas, but the higher carbon number liquid hydrocarbons are also displaced from the cuttings because of this incredible loss-of-pressure driven volumetric expansion.

API Gravity of Theta West 1 Oil: AHS calculates the API gravities of the Theta West Oils analyzed in our Sealed-at-Well samples to be between 37 to 39 degrees API gravity.

AHS analyzes the C1-C10 hydrocarbons, out of these the C5-C10 hydrocarbons are known as the gasoline fraction. 1000's of whole oil samples have been analyzed for both the volume of their gasoline fractions and their whole oil API gravities. From these published data AHS has derived an equation that calculates whole oil API gravity from AHS's analyzed C5-C10 gasoline fraction.

Formation Water Behavior in Cuttings: On a related note, of the three fluid types in the subsurface, oil gas and water, it is only water that increases in density with decreasing subsurface depth. So, the original formation water held in tight pores and microcracks in cuttings actually slightly shrinks as the cuttings come to the surface. Formation water in tight pores and microcracks in cuttings is preserved during the drilling, handling, and storage processes, and AHS has invented technology to analyze that water, even for samples drilled with Water Based Muds and even if cleaned by rinsing with water.

Reservoir Quality: Reservoir quality is the major factor in determining how much oil is preserved, and how its composition is altered, in cuttings compared to its parent rock in the subsurface. Tight rocks hold onto more oil and gas in cuttings than do more permeable rocks. Of course, rocks have an immense variety of pore sizes and pore throat sizes, and pore tortuosity. In general, the tighter the rock the more oil and gas are preserved in the cuttings.

Often hydrocarbon compositions observed in cuttings have no analogues in produced oils. This is attributable both to fractionation processes in the subsurface as well as fractionation processes as oil and gas escape the cuttings after drill bit disaggregation of the host rock.

The best reservoir rocks lose the most oil and gas following drill bit disaggregation of the host rock. The tightest rocks lose the least oil and gas. However, our data suggests even the tightest rocks generate cuttings that lose about 90% of their original oil and gas.

Figure 5 shows our picks for best reservoirs below the Hue Shale. The upper 2 zones show low oil responses for the Sealed-at-Well, right panel, analysis, suggesting good reservoir rocks that lose their oil between the drill bit and the surface. The deepest zone shows high Sealed-at-Well oil, but low Lab-Loaded oil, indicating the cuttings are tight enough not to lose their oil between the drill bit and the surface, but permeable enough to lose for these cuttings to lose their oil before being loaded in the lab. AHS uses the term Movability to describe the loss of oil in the Lab-Loaded cuttings compared to the Sealed-at-Well cuttings. The deepest picked reservoir zone has excellent Movability, having high Sealed-at-Well oil but low Lab-Loaded oil.

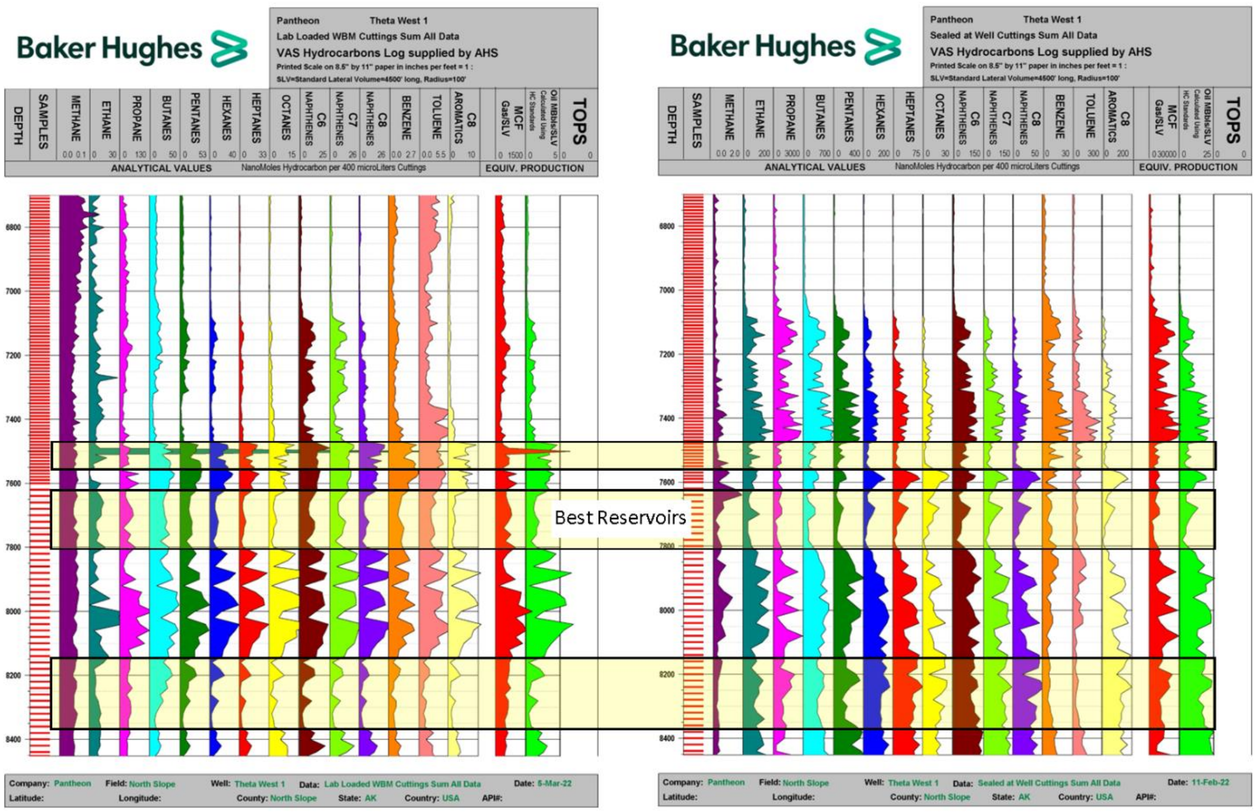

Figure 5. AHS's best reservoir picks below the Hue Shale based on cuttings volatiles. The upper 2 zones are chosen because of the low oil contents of the Sealed-at-Well cuttings, indicating these cuttings are so permeable as to lose their oil between the drill bit and the surface. The deepest zone has high Sealed-at-Well cuttings oil, but low Lab-Loaded cuttings oil, indicating that these cuttings are permeable enough so to lose their oil before being loaded in the lab. While this deepest zone is probably not as permeable as the upper 2 zones, it is showing what AHS terms as excellent Movability where Movability is the measure of oil lost from Lab-Loaded cuttings compared to the Sealed-at-Well cuttings.

Seals: As noted in Figures 1-4, the ultimate seal to the petroleum system drilled by Theta West 1 occurs at 7070'. Below 7070' every Sealed-at-Well cuttings sample and every Lab-Loaded cuttings sample contains oil. Above 7070' no cuttings sample of either the Sealed-at-Well or Lab-Loaded analysis contains oil.

Another major seal is indicated at about 7480' (Figure 6). On the Sealed-at-Well data we have inserted arrows to show the relative abundance of oil compounds in the lower "Oil B" zone compared to the shallower "Oil A" zone for the more oil rich samples. Hexanes, heptanes, octanes, C7 naphthenes, C8 naphthenes, and C8 aromatics all show higher amounts in the oil-rich lower "Oil B" zone than in the oil-rich upper "Oil A" zone. Benzene and Toluene, in contrast, show higher amounts in the oil-rich upper "Oil A" zone than in the oil-rich lower "Oil B" zone. Restricting this comparison to the oil-rich Sampled-at-Well samples diminishes the effects of varying rock petrophysics on this comparison. The high oil responses for ethane, propane, butanes, pentanes, and C6 naphthenes are similar in both the shallower "Oil A" and the deeper "Oil B" compartments. The fact that these compounds are similar between both the "Oil A" and "Oil B" compartments, while the other compounds differ from "Oil A" to "Oil B" suggests the observed differences represent differences in oil composition and is not an artifact of varying petrophysics.

The differences in composition of the oil-rich samples indicate that the shallower "Oil A" is distinct in composition from the deeper "Oil B". This chemical compartmentalization indicates a seal at 7480' where the "Oil A" and "Oil B" compartments meet based on the Sealed-at-Well data.

Elevated Helium is also observed. Because of the extremely small size of elemental Helium, and its very light mass, atomic weight is 4, the presence of elevated Helium in the Theta West samples is another indication of the excellent seal quality encountered by Theta West.

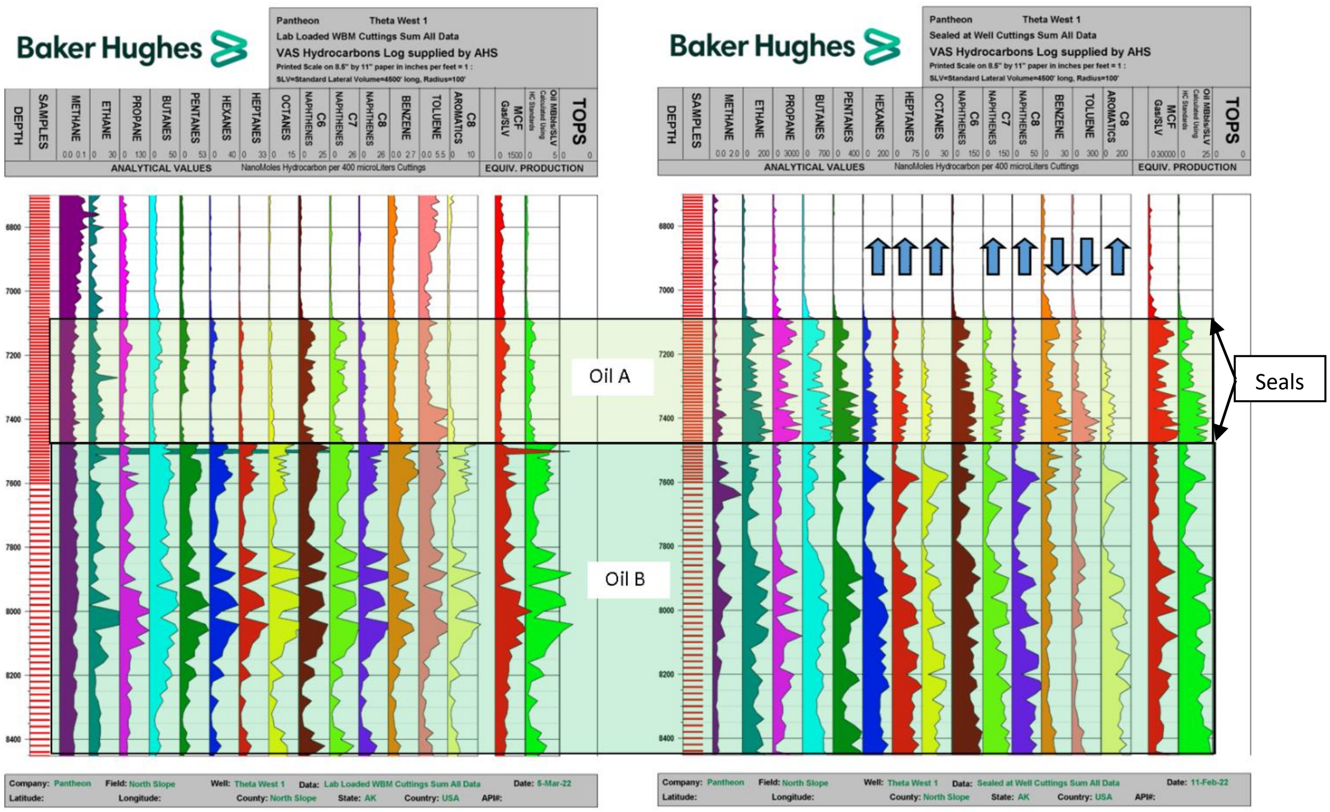

Figure 6. AHS's cuttings Sealed-at-Well volatiles data is best interpreted as indicating that the zone below 7070' contains 2 compositionally distinct oils. "Oil A" occurs above 7480' and "Oil B" occurs below 7480'. The arrows on the Sealed-at-Well log (left panel) show how compounds differ in amounts between the lower "Oil B" zone, and the upper "Oil A" zone.

Conclusions: Great Bear Pantheon's Theta West 1 drilled a world-class petroleum system comprised of:

1) A 1360' thick continuous column of oil-bearing cuttings. The actual length of the oil column is unquestionably greater than 1360', as the base of the analyzed cuttings' oil column is the TD of the well, and the oil in the cuttings shows no sign of tapering off.
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