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STRATIGRAPHY AND SEDIMENTOLOGY OF THE CRETACEOUS MOWRY SHALE IN THE NORTHERN BIGHORN BASIN OF WYOMING: IMPLICATIONS FOR UNCONVENTIONAL RESOURCE EXPLORATION AND DEVELOPMENT

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by

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STRATIGRAPHY AND SEDIMENTOLOGY OF THE CRETACEOUS MOWRY SHALE IN THE NORTHERN BIGHORN BASIN OF WYOMING: IMPLICATIONS FOR UNCONVENTIONAL RESOURCE EXPLORATION AND DEVELOPMENT

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University of Nebraska, 2016

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The Mowry Shale (Albian-Cenomanian) is an extensive mudrock dominated unit historically believed to represent a single, long-term deep water sequence within the Western Cordilleran Foreland Basin of North America. While the Mowry Shale has received study for almost a century, detailed stratigraphic context is still lacking. Such an understanding will be required as the formation is increasingly explored as an unconventional resource play.

This study examines the stratigraphy of the interval between the Muddy sandstone and the Frontier Formation, focusing on the Mowry Shale both at outcrop and in the subsurface of the Bighorn Basin of northwestern Wyoming. Detailed measured sections were compiled at outcrop, including acquisition of spectral gamma radioactivity data at 0.5 m spacing to emulate the response of the formation to subsurface wireline logs. Together, these data sets inform a detailed correlation of proximal to distal stratigraphic architectures across the Bighorn Basin. Bentonite beds throughout the succession show high total gamma counts (over 9000 cpm) with a high spectrographic signature from uranium (U) and thorium (Th), but relatively low potassium (K) counts when compared to local mudrocks. Basin floor organic-rich shales and mudrocks are prevalent in the lower parts of the succession, grading upward into platy to blocky, often silicified siltstones with subordinate interbedded sandstone of interpreted prodelta to distal delta front origin. The upper part of the Mowry Shale preserves several sandstone bodies up to 3 meters thick of interpreted delta front origin.

Several coarsening upwards cycles are preserved, in places capped by sandy units which are expected to contain the primary reservoir unit within the Mowry Shale. Our data suggest that these sandy zones thicken westward towards what was the emerging Rocky Mountain Highlands and thin distally to the southeast into the Mowry Sea. Data suggest a complex stacking pattern within the study interval with multiple high-frequency sequences recorded, some of which are up to 50 meters thick. Mapping these component intervals facilitates an improved understanding of stratigraphy and reservoir distribution within the Mowry Shale.

Acknowledgements

This has been quite an adventure. There never is much of a story when things go smoothly, but it never would have concluded without the influence, support and assistance from numerous organizations, educators, friends and family. I certainly didn't begin or remain an ideal student, and foremost thanks go to Dr. Fielding for the huge amount of help, assistance and patience he's given me over the years. Thanks to the Society of Sedimentary Geology and the American Association of Petroleum Geologists Norman H. Foster Memorial Grant for their help funding my field season. Thanks to the Iowa State Geological Field Camp, Jeremy Vinton for coming along to scout outcrops, and my wife Katy for helping me lug rocks all over. Finally, thanks to Dr. Caroline Burberry and Dr. Tracy Frank for your help and wonderful classes and for serving on my masters committee.

Introduction

The Mowry Shale is an extensive formation composed primarily of mudrocks that was deposited during the Albian and Cenomanian stages of the Cretaceous in the North American Western Cordilleran Foreland Basin (Davis et. Al, 1989). Despite being the topic of study for nearly a century, the depositional context of the Mowry Shale is not completely known. This study seeks to provide new data towards a stratigraphic and sedimentological framework for the Mowry Shale.

The Mowry Shale has long been considered an important source rock in several Rocky Mountain basins due to its extent, organic content, and hydrocarbon expulsion potential, and is thought to have charged numerous hydrocarbon traps (Schrayer and Zarella; 1968, Momper and Williams; 1984, Anna, 2009). Current technology including horizontal wells and multistage hydraulic fracturing has enabled the production of hydrocarbons from oil-bearing but historically unproductive formations such as the Mowry Shale. Despite its importance as a source rock and an unconventional reservoir, modern sedimentological and stratigraphic analysis of the formation is lacking, in part hindered by a severe shortage of drill core that is necessary to facilitate subsurface facies analysis and calibration of the significant well log archive.

This project aims to solve the problem of log interpretation, traditionally achieved by calibration against drill core, by instead calibrating outcrop gamma radioactivity measurements and thereby generating synthetic gamma profiles from continuous surface exposures. A facies analysis of outcrop sections allows correlation of the synthetic gamma ray profiles with lithofacies and facilitates detailed correlation into the subsurface of the Bighorn Basin. A new stratigraphic framework is proposed for the interval between the Muddy Sandstone to the base of the Frontier Formation, based upon this work, to supplant earlier internally inconsistent stratigraphic nomenclature.

The final goal of this work is to provide an assessment of petroleum system elements within the study area. As the Mowry Shale represents a collection of attributes necessary for an unconventional basin centered oil accumulation within the adjacent Powder River Basin (Anna, 2009), understanding the geology will be a key factor in exploration and successful development of Mowry Shale resources.

Background

Review of Literature

The first reference to the Mowry Shale was by Darton (1904), who delineated a 45 meter thick mudstone along the Eastern Bighorn Mountains near Buffalo, Wyoming. He classified the unit as a member of the Benton Formation and described the Mowrie Beds (his terminology at the time, after the Mowrie Creek type location) as a hard, light grey, ridge-forming shale with thinly bedded sandstones and fish scales, teeth and bones (Reeside and Cobban, 1959; Keefer, 1965). Areal limits were later defined by Darton (1905), and several other studies investigated the unit, notably Rubey (1929), who centered his work around exposures in the Black Hills of western South Dakota and northwestern Wyoming. He suggested that the Mowry Shale may be an impure oil shale, but early pyrolysis tests yielded less than 1 gallon per ton of rock. Rubey also defined the lower, softer unit between the Muddy Sandstone and the Mowry Shale as the Nefsy Shale (now the Shell Creek Shale), and renamed the unit as the Mowry Shale in 1931.

Reeside (1944) assigned age estimates to the Mowry Shale and continued to publish with co-author Cobban into the 1960's, among several contemporaneous revisions and iterations of the formation extents by other authors. Reeside and Cobban (1960) provides a highly detailed view of fossil assemblages present in the Mowry Shale and equivalent formations as well as paleoenvironmental interpretations from outcrops spanning the region.

In 1962, Eicher summarized many of the previous works on the Early Cretaceous in the Rocky Mountain Basins, focusing heavily on the Thermopolis Shale, which at the time included the Nefsy or Shell Creek Shale. Eicher built the case that the Muddy Sandstone should receive formation status, and for clarity the shale package above should be called the Shell Creek Shale – a new term at the time.

The first major study on source rock potential was conducted by Schrayer and Zarella (1968) who showed that organic carbon concentrations are highest in the Mowry Shale among all the Cretaceous sedimentary rocks in the northern half of Wyoming. By comparing organic content from outcrop and drill cores, they determined that outcrop samples provide reasonably accurate organic carbon data, although cuttings do not. They concluded that the Lower Cretaceous oil accumulations are concentrated in the zone of organic carbon-enriched Mowry Shale, which ranged from 0.90 to 4.90%, averaging 2.25%.

Byers and Larson (1979) recognized sedimentary structures and examined Mowry Shale mudrocks to better define the stratigraphy of the Cretaceous section in the Western Cordilleran Foreland Basin, focusing primarily in the Wind River and southern Powder River Basins. They differentiate the Mowry Shale into 3 facies; laminated mudstone, bioturbated mudstone and bioturbated sandstone, which they compare to oxygen availability, or 'biotropes', from modern seas.

In a major study, Momper and Williams (1984) collected nearly 300 oil samples from the Powder River Basin in Northeast Wyoming to analyze and evaluate source rocks in the region. Their results indicate that the Mowry Shale is a major source rock in the basin that began expelling oil during the Paleocene or early Eocene in the warmer parts of the basin and that many source beds remain overpressured today, although not sufficiently pressured to expel oil. By their calculations, the Mowry Petroleum System has expelled around 11.9 billion barrels of oil from its 10,500 square mile effective source area (assuming 3.0% organic carbon, 240 feet thickness, an oil generating capability of 105 barrels per acre foot and a 7% expulsion efficiency.) The oil window for the Mowry-generated oil is approximately 87.7 deg. C, found in the Powder River Basin at depths between 8,000 and 12,000 feet. Generated oils crack to gas and natural gas liquids at temperatures greater than the oil floor of 137.7 deg. C, found around 12,500 feet below surface.

Kirschbaum and Roberts (2005) illustrated the stratigraphic framework of the 'Mowry Total Petroleum System' in the southwestern Wyoming province, focusing on the Mowry Shale and Frontier Formation. They provided a thorough discussion of formation contacts and produced several cross-sections and isopach maps in the Greater Green River area based on core and petrophysical data.

The United States Geologic Survey performed an assessment of undiscovered hydrocarbon resources in the Powder River Basin, compiled by Anna (2009). The assessment defines a

'Mowry Total Petroleum System (TPS)' and suggests that the Mowry Shale has sourced adjacent traditional reservoirs as well as acting as a continuous reservoir itself. Anna (2009) strongly states that the Mowry Shale is capable of providing a source, reservoir and seal within a self-contained petroleum system, and that fracture networks and siltstone beds can provide storage within a permeable network.

Organic carbon contents were measured from the margins of the Bighorn Basin for the Mowry and Thermopolis Shales by Finn (2010) with the goal of applying modern measurements of source rock potential to the units. The study collected immature source rock samples in shallow portions of the basin to qualify source rock quality in support of undiscovered oil and gas resources. Results of the study determined that the Thermopolis Shale has poor to fair generating potential and that the Mowry Shale has poor to good generation potential for both oil and gas.

An extensive, modern study of the Mowry Shale and Frontier Formations in the Rocky Mountain Region was performed by Kirschbaum and Mercier (2013). Their paper presents the analysis of approximately 500 well logs and 29 cores which were used to generate regional isopach and paleoenvironmental maps. Sandstones within the Mowry Shale developed between high tide mark and storm wave base are traceable for 10s of miles. The paper provides a regional description of the Upper Mowry Sand, which they observe to prograde slightly around the Western Interior Seaway margins, with a considerably greater extent across the Bighorn Basin.

Stratigraphy

Numerous authors have described and presented stratigraphic nomenclature schemes for the Cretaceous succession in varying places throughout the Western Interior Seaway Basin. While some of these schemes have become obsolete, several disparities persist, namely; the formation or member status of the Clay Spur Bentonite and the Shell Creek Shale, the precise stratigraphic boundaries between the units, and the timing and context of the Albian-Cenomanian contact. Many of the units have analogous formations with different naming conventions by location (e.g. Thermopolis Shale to Skull Creek Shale), however the major stratigraphic information regarding the Mowry Shale is unclear (Figure 1).

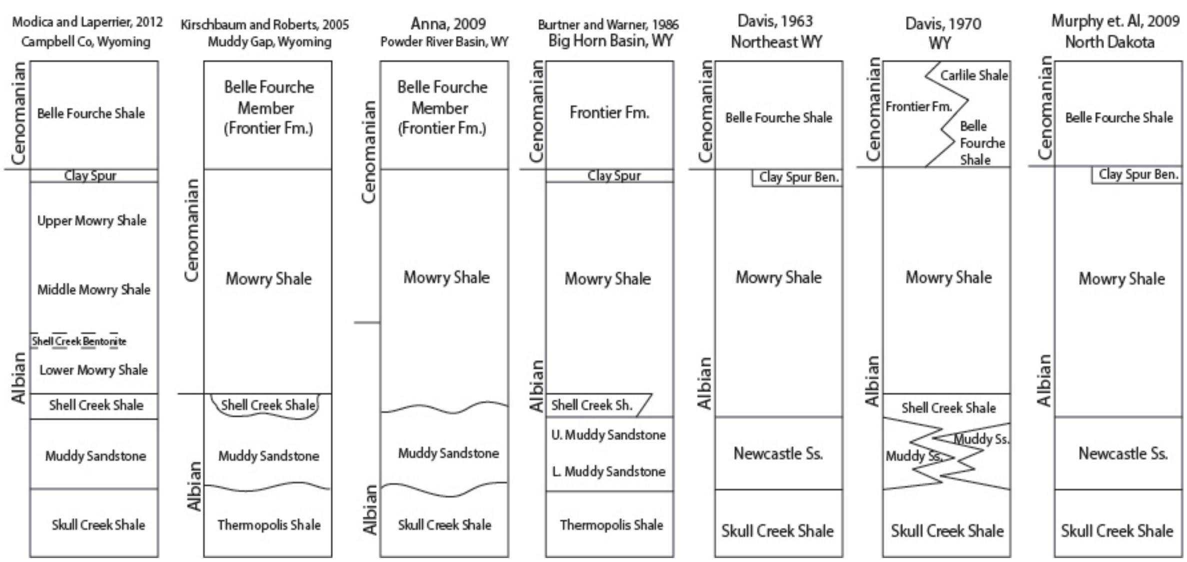


Figure 1: Compilation of stratigraphic schemes used for various locations in the Rocky Mountain Region over time. Within these schemes, there are notable differences in contacts, submembers, chronostratigraphic boundaries, and the definition of the Shell Creek Shale.

Albian-Cenomanian Boundary

Bentonite beds within the Frontier Formation, Mowry Shale, Shell Creek Shale and Thermopolis Shale enable chronological measurement through the Argon-Argon isotope method (Ar^{40}/Ar^{39}).

A large body of data regarding which was acquired and compiled by Weimer et al. (1997). Their work dated the basal Shell Creek Shale and post-Muddy Sandstone transgression at 99.25 Ma and an upper Shell Creek Bentonite at 97.17 Ma (+/- 0.69 Ma); indicating that the Shell Creek and Mowry Shale successions were deposited in approximately 2 million years (Obradovich, 1993; Weimer et al, 1997).

According to the current absolute timescale (Gradstein et al, 2012), the Albian-Cenomanian contact would therefore be placed in the Muddy Sandstone, wholly placing the Shell Creek and Mowry Shales within the Upper Cretaceous Cenomanian stage (Kirschbaum and Mercier, 2013), whereas historically it has been cited as wholly lower Cretaceous, more in agreement with Scott et al (2009), (Eicher, 1962; Haun and Barlow, 1962; Keefer, 1965; Momper and Williams, 1968; Burtner and Warner, 1986; Cluff, 1976; Davis, 1970; Davis et al, 1989; Anderson and Kowallis, 2005; Modica and Lapierre, 2012). Still other publications suggest that the Mowry Shale spans the Albian-Cenomanian boundary, and that it persists into the lower Cenomanian (Merewether, 1996; Kirschbaum and Roberts, 2005; Anna, 2009; Finn, 2010).

Status of Clay Spur Bentonite

Depending on the publication, the Clay Spur Bentonite is alternately defined as a member within the Mowry Shale, a unique geological formation, as a distinctive bed (Haun and Barlow, 1962; Davis, 1963; Cluff, 1976; Reeside and Cobban, 1960; Scott et al, 2009; Anna, 2009), or simply not acknowledged stratigraphically (Eicher, 1962; Keefer, 1965; Davis, 1970; Davis et al, 1989). Many articles cite the Clay Spur Bentonite as the Mowry-Frontier contact (Mills, 1956; Cluff, 1976; Byers and Larson, 1979; Weimer et al, 1997; Burtner and Warner, 1986; Kirschbaum and Roberts, 2005; Anna, 2009; Modica and Lapierre, 2012).

Status of Shell Creek Shale

Depending on the publication, the Shell Creek Shale is listed as a thin bed representing the transition from the Muddy Sandstone to the Mowry Shale (Modica and Lapierre, 2012), a portion of the stratigraphy with an ambiguous contact, or the entire non-silicified portion of the stratigraphy between the Muddy sandstone and the Frontier Formation (Eicher, 1962) (Figure 3). In many publications, however, it is completely disregarded and relabeled as the lower portion of the Mowry Shale (Mills, 1956; Davis, 1963; Reeside and Cobban, 1960; Anna, 2009; Finn, 2010), or known by a vintage name, proposed by Collier (1922); the Nefsy Shale (Cluff, 1976). The Shell Creek Shale is acknowledged by many workers as a formation, but included within the Mowry Shale (Burtner and Warner, 1986) or even as an upper part of the Thermopolis Shale (Mills, 1956; Haun and Barlow, 1962; Keefer, 1965). In other works it is identified as a formation in its own right (Eicher, 1962; Davis, 1970; Byers and Larson, 1979; Davis et al, 1989; Kirschbaum and Roberts, 2005; Scott et al, 2009; Kirschbaum and Mercier, 2013).

A compilation of these schemes, together with field observations was formed to describe the stratigraphy, presented in figure 2.

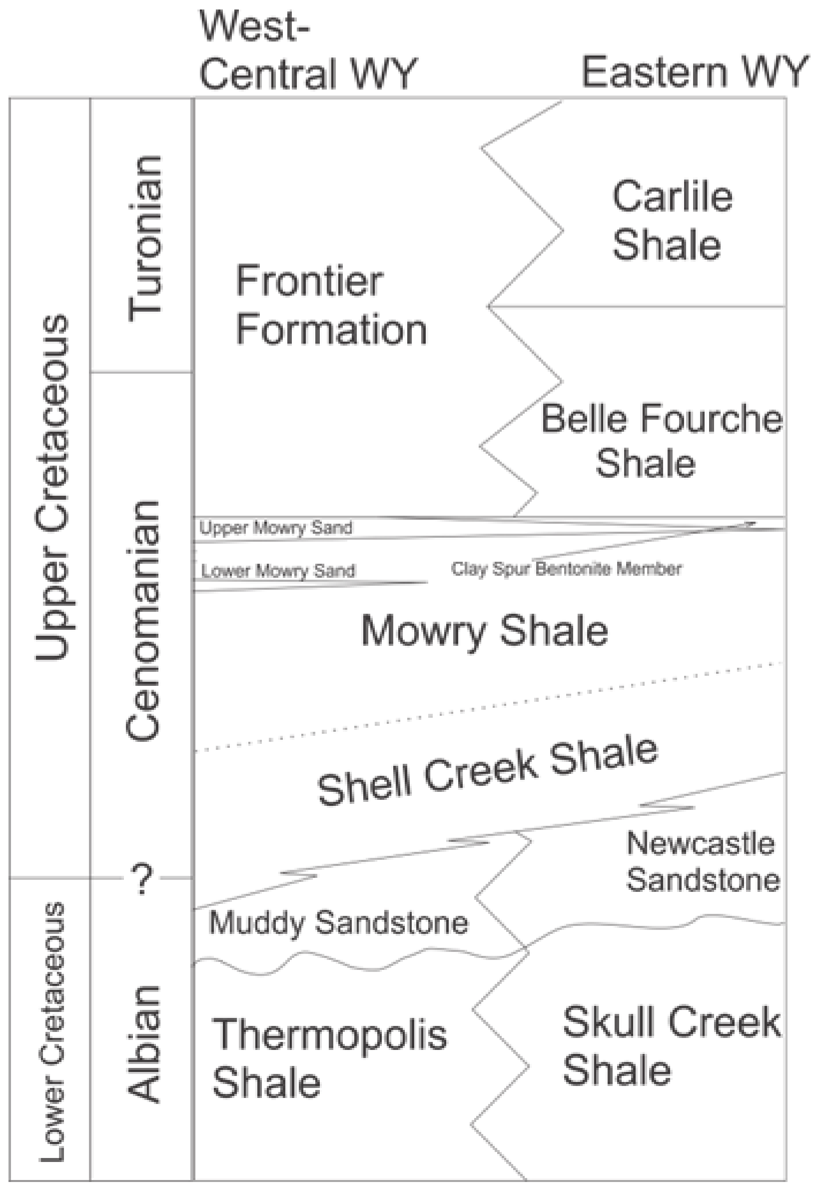


Figure 2: Stratigraphic nomenclature scheme developed and used in this document for the Bighorn Basin (west-central WY, left) and Powder River Basin (Eastern WY, right).

Stratigraphic Resolutions

- To explain the discrepancies between dated bentonite beds and stratigraphic continuity, we suggest that the Mowry Shale and Muddy Sandstone were likely deposited contemporaneously along the prograding Mowry seaway that persisted from the upper

Albian through Cenomanian times, and the Muddy Sandstone represents the proximal extension of the distal Shell Creek Shale.

- The stratigraphic context of the Mowry Shale to Frontier Formation contact at the Clay Spur Bentonite has been examined and regarded as a poor choice for the formational boundary, as it acts independently of the true contact definitions (Haun and Barlow, 1962; Davis, 1970). Field observations also depicted several meters of Mowry Shale section above the Clay Spur. Officially, the United States Geological Survey Stratigraphic Codex (2013) lists the Clay Spur Bentonite as a member of the Mowry Shale, a definition that will be adopted in this work.
- The United States Geological Survey Stratigraphic Codex (2013) currently lists the Shell Creek Shale as an unsynopsized geologic unit. Due to field observations and arguments presented in favor of its formation status, the Shell Creek Shale is herein regarded as a formation.

Stratigraphic Boundaries

Stratigraphic contacts have been a point of contention among previous works on the Mowry Shale and enclosing strata. Even among modern works, terminology and stratigraphic boundaries are defined in different ways. The primary data source for defining contacts in the modern era has been wireline logs, which, with the utilization of an outcrop gamma dataset can now be directly compared to downhole logs with the addition of observed facies.

The upper and lower contacts of the Muddy Sandstone are pronounced at both outcrop and in downhole logs. There is strong contrast on most logs between the fine to medium-grained porous sandstone and the dark grey shales above and below, although locally the upper contact may be gradational (Mills, 1956).

The contact between the Shell Creek Shale and Mowry Shale has long been ambiguous, leading to many authors combining the units together under the name Mowry Shale (e.g., McKenzie, 1965; Davis, 1970). The basal contact of the Mowry Shale, however, has been historically picked at the first evidence of silicification or lowest significant silicified bed, generally corresponding to an increased resistivity response in downhole logs (Mills, 1956; Nixon, 1973; Modica and Lapierre, 2012) (Figure 3). This high resistivity interval is coincident with the elevated gamma signature in Gamma Interval 4 discussed below, and its base will be used as the Shell Creek – Mowry Shale contact herein.

Historically, the contact between the Mowry Shale and Frontier Formation (or regionally, the Belle Fourche Shale) has been taken at the Clay Spur Bentonite – typically expressed as a major high gamma peak beneath the Peay Sandstone member of the Frontier Formation (Davis, 1963; Cluff, 1976; Modica and Lapierre, 2012). Mills (1956) elaborates on the contact being irregular and places the contact at the Clay Spur Bentonite because generally the underlying shales are more resistive and silicified. However, the sedimentological changes between the Mowry Shale and Frontier Formation do not seem particularly tied to the volcanic fallout event that sourced the Clay Spur, nor the silicification. Therefore, placing the boundary by either of these two criteria does not fully capture the complexity of the contact, and additionally, may be misleading as there are numerous bentonite beds within the Mowry Shale, any of which may be the Clay Spur – especially where the Clay Spur is thin, absent, lower in the stratigraphic succession, reworked and/or diluted, or otherwise atypical. The contact between the Mowry Shale and

Frontier Formation is picked gradationally just above to several meters above the Upper Mowry Sand, where present, or the top of Gamma Interval 5 discussed below, which corresponds at outcrop to an upward change from light grey, silicified mudrocks with bentonites of the Mowry Shale to dark grey, fissile shale of the basal Frontier Formation (Clark, 2010) (Figure 3).

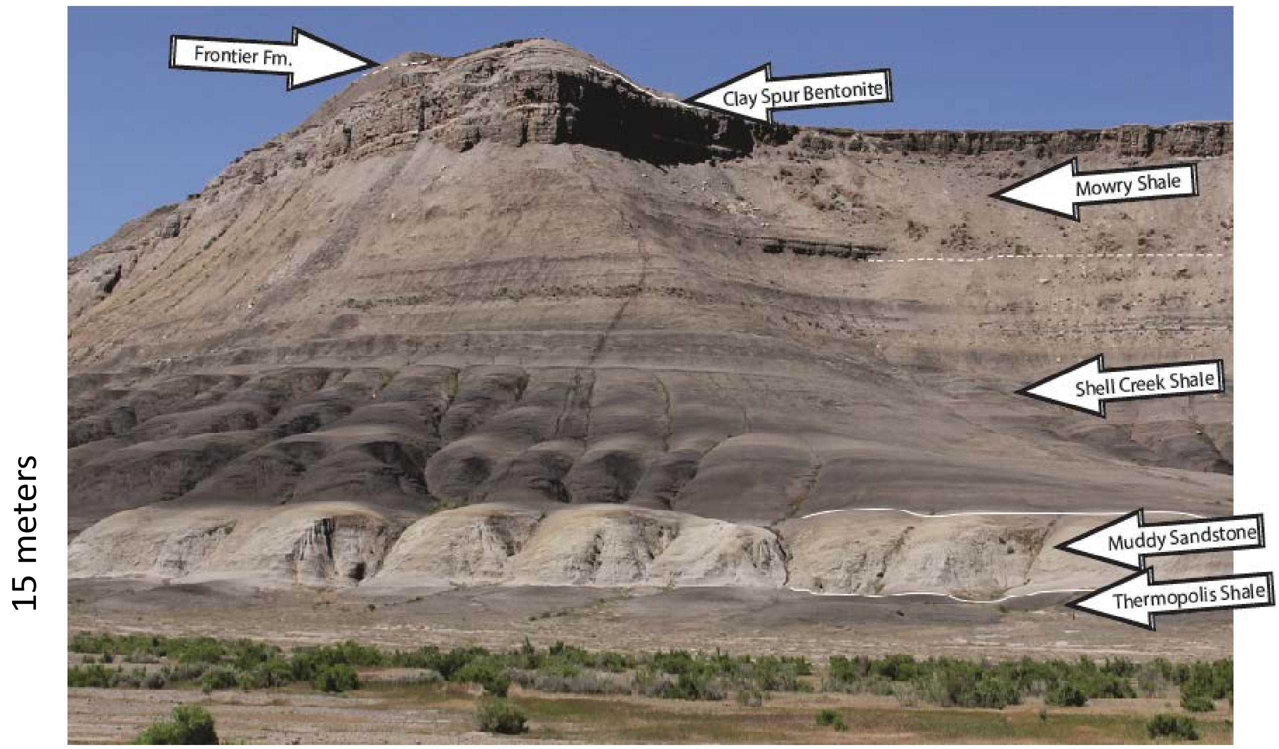


Figure 3: Annotated photograph of the stratigraphic section present along the southern Greybull Platform exposure. Approximately 120 meters of section is present at this location.

Geological Setting

The subduction of the Farallon Plate during the Middle Jurassic resulted in the development of the Rocky Mountain Cordillera and to the formation of a retroarc foreland basin on the eastern margins of the feature. Basin fill from primarily western derived clastic sediments continued from the Late Jurassic through the Paleocene (Plint, 2009).

During the Albian and Cenomanian stages, two major transgressive/regressive cycles are recorded in the Rocky Mountain Foreland Basin, often referred to as the Kiowa-Skull Creek Cycle and the Greenhorn Cycle, separated by an erosional surface (Scott et al, 2001; Fig. 3). Prior to formation of the Muddy Sandstone, the Kiowa –Skull Creek Seaway deposited a thick succession of primarily mud across the Rocky Mountain Foreland Basin, which was later partially eroded during the following regression.

This eroded surface was later flooded from the Northern Boreal Sea by the second phase of the epicontinental seaway, depositing and preserving the Muddy Sandstone as a complex series of fluvial, estuarine, deltaic and nearshore marine sands (Holbrook and Ethridge, 1996; Finn, 2010) (Figure 4). Sediments were primarily supplied to the basin from the emerging Sevier Highlands to the west, with lesser volumes arriving through fluvial systems to the east (Finn, 2010). As transgression continued, distal mudstones of the Shell Creek Shale began to accumulate in the seaway as mud with scattered accumulations of volcanic fallout (which lithified into bentonite beds). The Mowry Seaway expanded into the early Late Cretaceous, depositing primarily mud across the Rocky Mountain Foreland Basin that was later silicified during burial diagenesis to form the Mowry Shale.

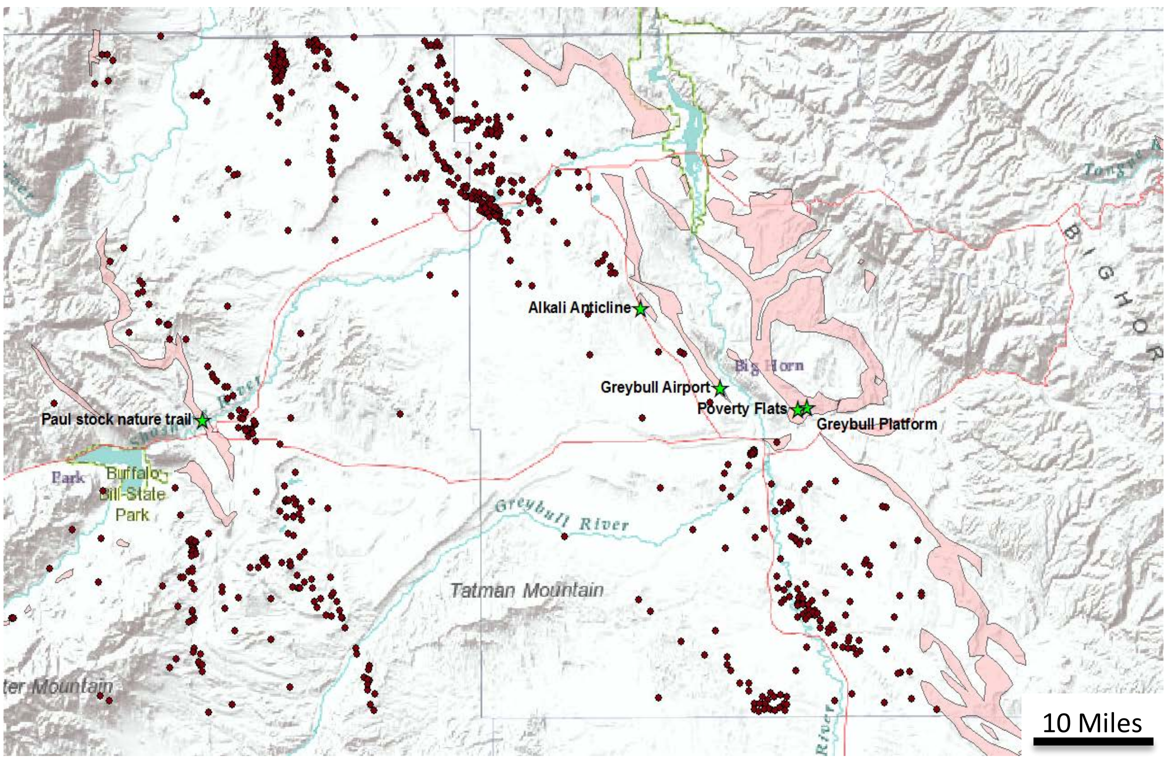
As the Greenhorn Cycle continued, a consistent connection from the Northern Boreal Sea and the Southern Proto-Gulf of Mexico was established, and tectonically, the very beginnings of the Laramide Orogeny began to develop. The culmination of these factors led to the deposition of the Frontier Formation in the study area. Coincident with this boundary in many places is the Clay Spur Bentonite, but the top boundary is more realistically defined as a shift from silicified

Mowry Shale to the more widespread, fissile, soft, normal marine salinity Belle Fourche Shale (or Belle Fourche Member of the Frontier Formation) (Eicher, 1967).

Figure 4: Paleogeographical interpretation of the extents of the Mowry Sea, from Plint et al (2009). The seaway originated along the Western Cordilleran Foreland Basin, flooded from connection to the Boreal Ocean and spread primarily eastward across the continent before finally breaking through to the Tethyan Ocean and forming the Western Interior Seaway.

Methods

A study area was selected in the Bighorn Basin due to prevalence of exposed, accessible outcrop, and data availability. A series of outcrops was determined from geologic maps and from noted outcrop locations (Davis, 1970; Cluff, 1976; Davis, Byers and Pratt, 1989)



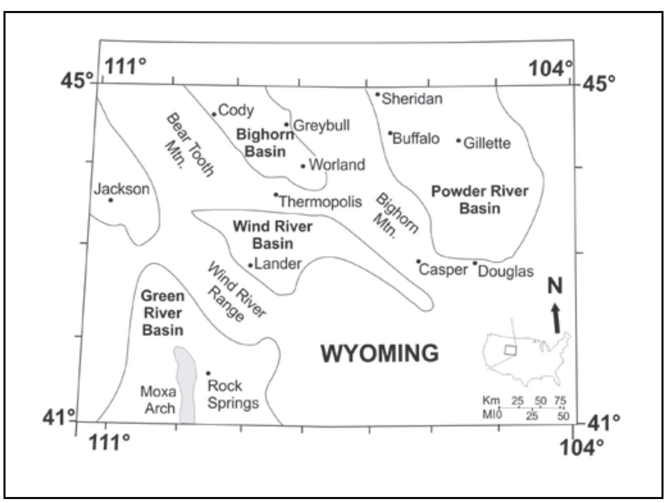


Figure 5: Above - Map of the study area in the Bighorn Basin, North-Central Wyoming. Pink shaded areas represent outcrops, from USGS geological map shape files. Red circles depict logged wells that penetrate the Mowry Shale. Green stars are locations of logged sections.

Left – Index map showing basin outlines in Wyoming.

Sites exposing clear, accessible vertical sections through the Mowry Shale were visited and logged. Lithology, grain size, texture, physical sedimentary structures and trace fossils were all recorded to produce a facies analysis for the formation (Figure 5). Spectral gamma signatures were also collected using a Radiation Solutions RS-230BGO Bismuth Germanium Oxide gamma spectrometer (Appendix A). Outcrop gamma ray measurements were made by digging shallow pits to expose fresh rock every 0.5 meters (1.7 feet) vertically up the section and setting the device in direct contact with the fresh rock for a 2 minute assay time (Figure 6). The meter records concentration of uranium (U) and thorium (Th) in parts-per-million and percent weight of potassium (K) as well as total counts of gamma radiation per minute. While API radiation standards used for downhole tools and gamma scintillation devices measure the same phenomenon and therefore should correlate well and methods have been proposed to calculate one from the other (e.g. Ellis and Singer, 2008), no numerical conversion was attempted at this time.

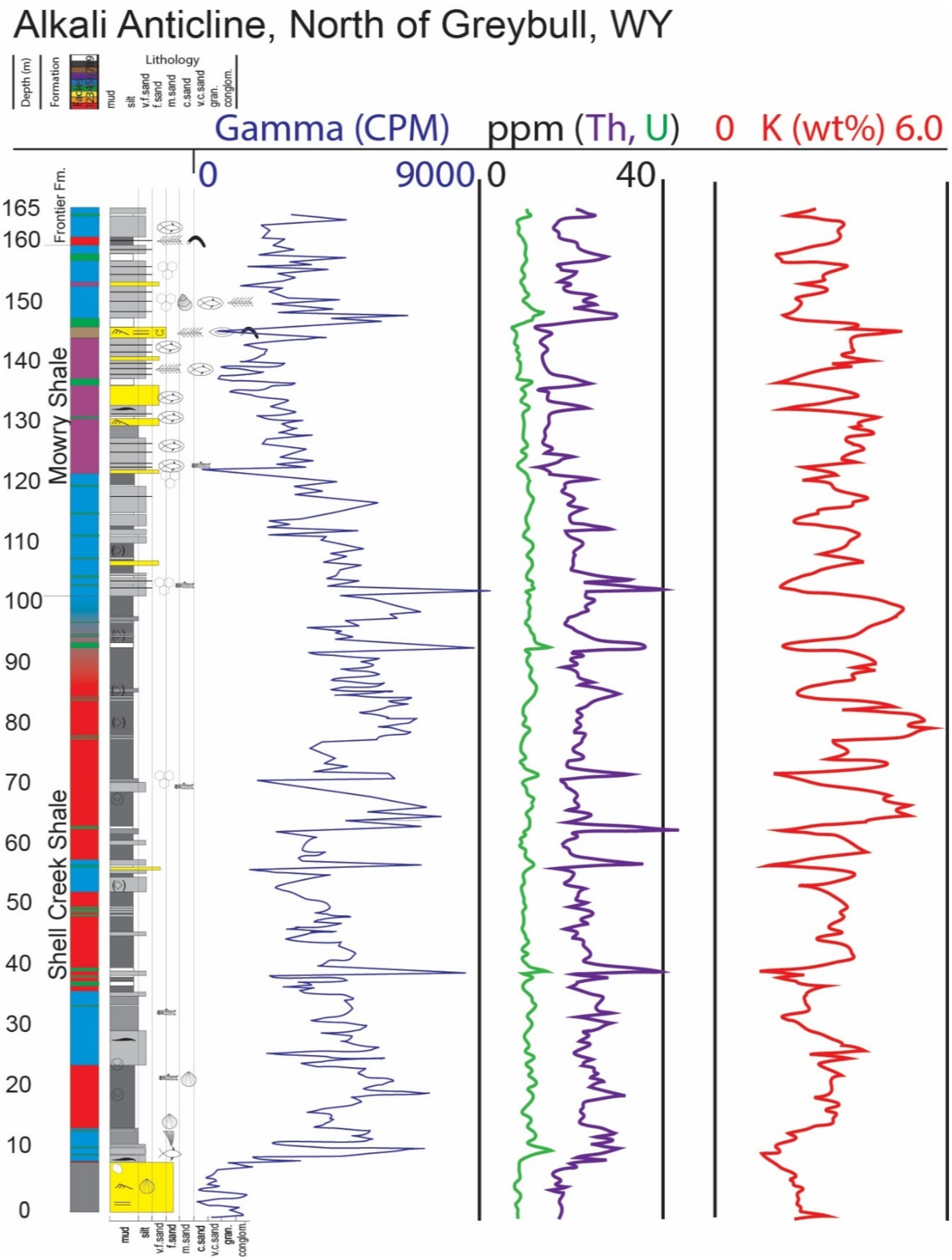
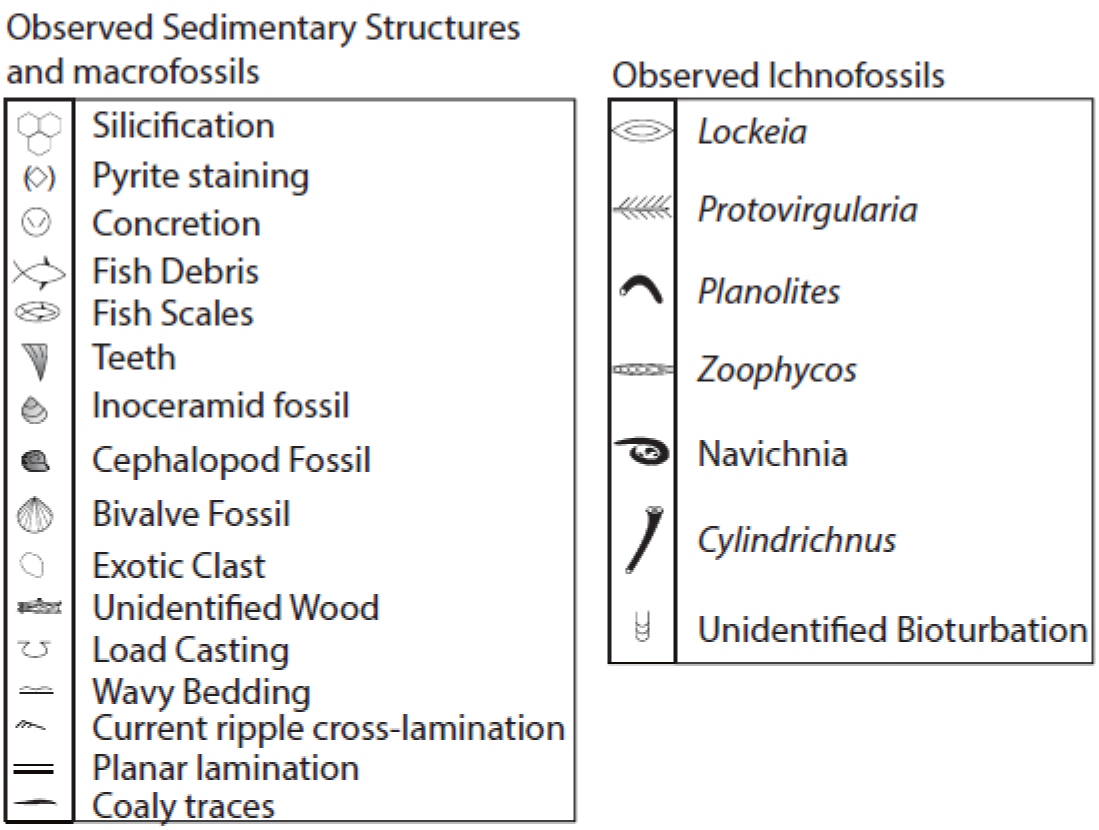

Alkali Anticline, North of Greybull, WY
Depth (m)
Formation
Lithology
mud
silt
v.f.sand
f.sand
m.sand
c.sand
v.c.sand
gran.
conglom.
Gamma (CPM)
ppm (Th, U)
0 K (wt%) 6.0
0
9000
0
40
Frontier Fm.
Mowry Shale
Shell Creek Shale
165
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

Figure 6: Log of data collected from the Alkali Anticline exposure. This log shows (from left to right) the interpreted facies (table 3), the logged lithology, sedimentary structures and trace fossils, the total gamma radiation measurement in counts per second (blue), the concentration of Uranium (green) and Thorium (purple), and the concentration of Potassium in % weight (red). Symbol key below.



Alkali Anticline

A full vertical section (165 m) from the bottom of the Muddy Sandstone into the basal Frontier Formation was measured along the southwest flank of the Alkali Anticline, north of Greybull, Wyoming. The Muddy Sandstone was approximately 8 m thick and the first silicified beds occurred at 92 m above the base of the section. The Mowry Shale here was 54 m thick and was composed largely of silicified siltstone with interbedded siltstone and very fine-grained sandstone which coarsened upwards into fine-grained sandstone capped by the Clay Spur Bentonite (Figure 7).

Greybull Platform

A section at the southern end of the Greybull Platform, east of Greybull, Wyoming was measured for lithology and spectral gamma. In total, the outcrop exposed 170 m of section from the bottom of the Muddy Sandstone to the lower Frontier Formation. The Muddy Sandstone at this location was 12.5 m thick and the Shell Creek Shale was 98 m thick. The Mowry Shale was 40 m thick and was composed largely of interbedded siltstone and very fine grained sandstone. The large bluff had almost no observable dip and was capped by the Upper Mowry Sand and the Clay Spur Bentonite, with a remnant hill on the bluff top which continued up to the Peay Member of the Frontier Formation (Figure 7).

Paul Stock Nature Trail Section

A vertical section along the Shoshone River along the Paul Stock Nature Trail in Cody, Wyoming was measured. The section between the Muddy Sandstone and the Lower Mowry Sand was poorly exposed, and therefore the thickness was measured with a laser rangefinder. The Muddy Sandstone was approximately 4 meters thick at this location, followed by 71 m of mostly covered Shell Creek Shale. The remaining 73 m of Mowry and Lower Frontier Formation outcrop was logged and measured for spectral gamma emissions. The Mowry Shale at this location contained 3 fine-grained sandstone beds approximately 10, 2 and 9 m thick from base to top. The thicker sandstone beds are interpreted to represent the upper and lower Mowry Sands (Figure 7).

A bentonite bed nearly 2 m thick is present between the middle and upper sandstone bodies with the highest gamma measurements encountered during this study; over 16,000 counts per minute. The enclosing silicified siltstones also showed very high counts, either due to contamination from the bentonite or by the emitted gamma rays travelling through the siltstone. This was the only thick bentonite bed fount at the Cody location and is interpreted to be the Clay Spur Bed, albeit at a different stratigraphic position than was encountered at the locations on the eastern side of the basin.

Poverty Flats Section

A recently exposed bentonite pit was logged at the Poverty Flats site, just west of the Greybull Platform location, west of Greybull, Wyoming. Thirteen meters of strata exposed in the pit wall were logged in 2013, with the remainder of the section logged by Dr. C. R. Fielding in 2012 and 2014. Only lithologic descriptions were acquired at the site, which consisted of 225 m of vertical section, covering the uppermost Thermopolis Shale up to the basal Frontier Formation. The Muddy Sandstone at this location is abnormally thin compared to the other sites, measuring only 5 m thick. The Shell Creek Shale is 117 m thick and composed of fissile mudstone with local interbedded siltstones and a thin, very fine-grained sandstone. Numerous bentonite beds are also present within the Shell Creek Shale interval. The Mowry Shale measured just over 60 m thick and displayed prominent siltstones and bentonite beds as well as several sandy intervals. The uniquely fresh exposures at the Poverty Flats site provided some of the best detail in stratigraphic descriptions (Figure 7).

Subsurface Gamma Logs

The basin center has few penetrations due to a burial depth of the study interval to over 14,000 feet, but for the remainder of the basin, well data were gathered on the order of 10-15 km spacing or less. Each of the 696 wells penetrating the Mowry Shale in the study area in the Wyoming Oil and Gas Commission's online database were accessed and located in ArcGIS. A refined database of 128 wells was selected to remove clusters of closely spaced data (Figure 8).

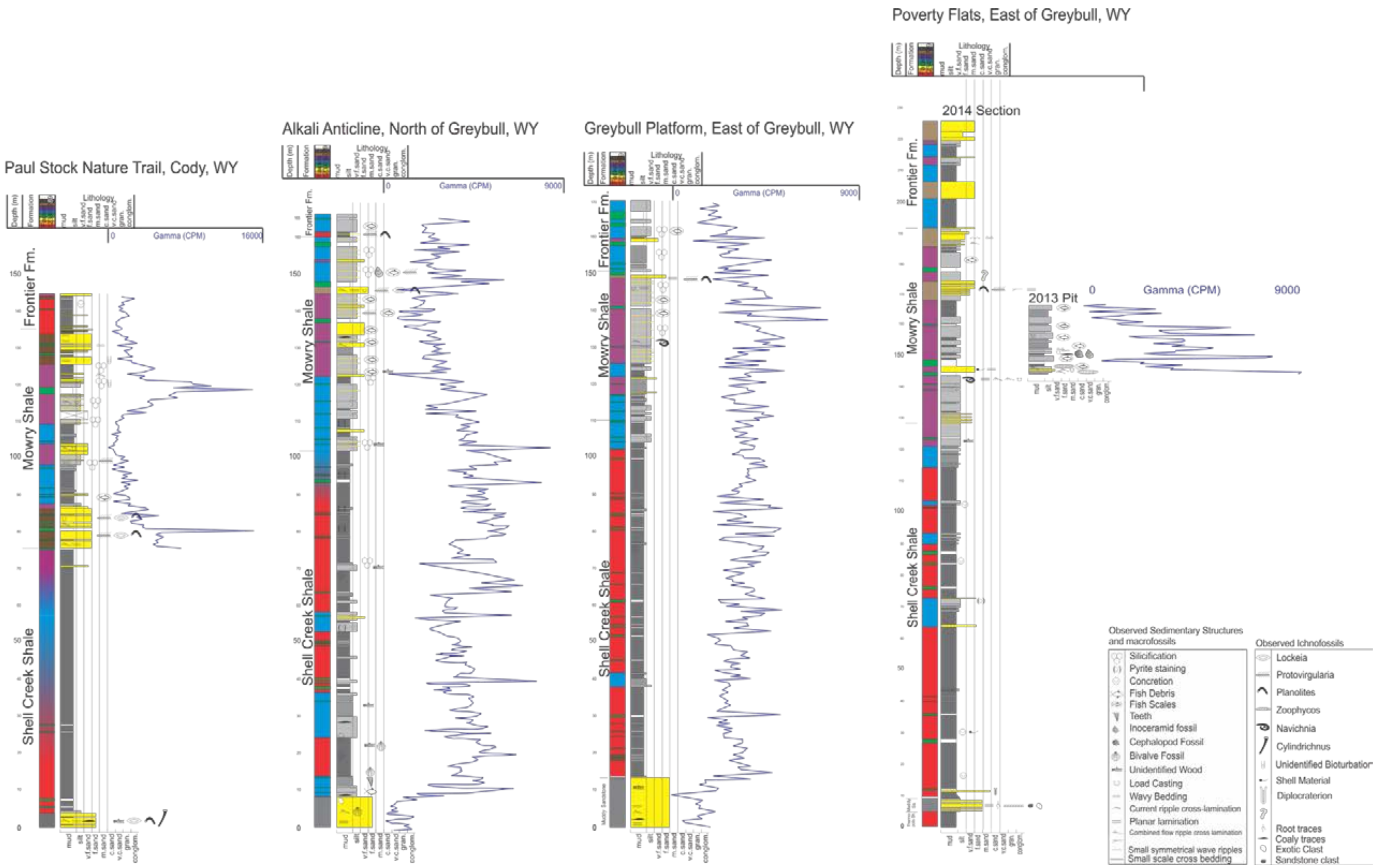


Figure 7: Logged sections of the four investigated sections from west to east displaying the interpreted facies, grain size, sedimentary structures and ichnofossils and gamma measurements. Color key is presented in table 3.

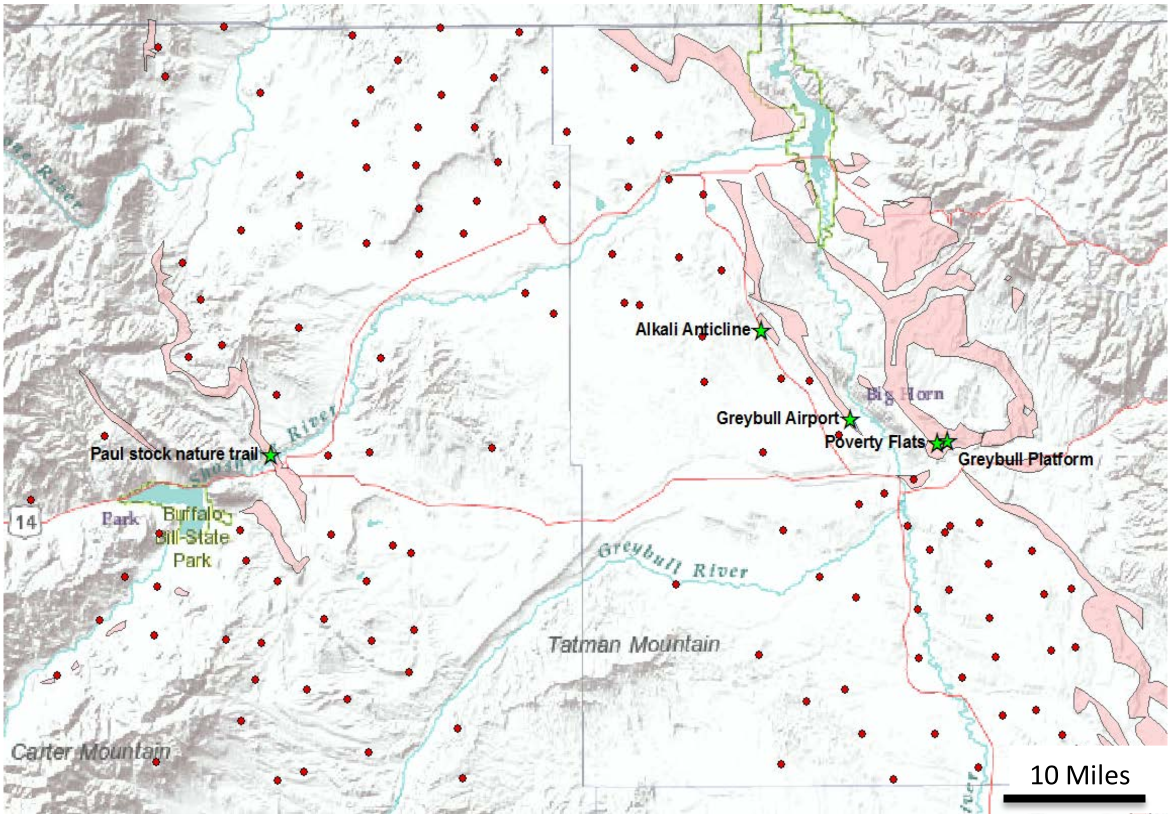


Figure 8: Refined well data set of 128 wells after clusters were removed. Red dots indicate the location of a well log that was analyzed and picked with the gamma intervals discussed above.

Total Organic Carbon Content

The amount of preserved total organic carbon (TOC) within a source rock is a key component in the rock's ability to generate and expel hydrocarbons. As a general guideline, rocks with less than 0.5% by weight TOC are considered to have poor generative potential, 0.5 to 1% is considered fair, up to 2% is considered a good source rock, and greater than 2% is excellent (Finn, 2010). There have been several studies that analyzed the source rock characteristics for the Mowry Shale in attempts to quantify various aspects of the total petroleum system. Most applicable to this study, Finn (2010) analyzed chip samples from the shallow portions of the Bighorn Basin and observed several trends in organic distribution; that clastic dilution was higher along the western shoreline of the Western Interior seaway, that greater volumes of organic matter exist in the central seaway, and biodegradation of organic matter occurred near the basin margins.

Studies by Nixon (1973), Shrayer and Zarella (1963, 1968), Momper and Williams (1984) and Modica and Lapierre (2012) have also examined TOC in the Mowry Shale, and concluded that oil generation occurs at a minimum burial depth of 7,000 feet. Measured values from different studies determined an average TOC of 3%, which was used to estimate a hydrocarbon expulsion of 11.9 billion barrels.

Twenty-nine samples were collected for TOC analysis (5 from Poverty Flats and 24 from the Greybull Platform section) during the 2013 field season. Samples were acquired from shallow pits dug to expose fresh rock for the primary purpose of taking gamma readings. TOC analysis was performed to assess facies and/or gamma correlation with TOC, which is known to be an important factor in the viability of unconventional reservoirs (Modica and Lapierre, 2012). Rock fragments were disaggregated through mechanical means and pulverized into a fine powder using a shatter-box and stored in airtight vials until ready for testing.

Analysis was performed using a UIC inc. Coulometer, which combusts pulverized samples at 935°F in an oxygen environment in order to convert organic carbon to carbon dioxide, but leaves carbonates behind (if present).

Results

Bentonite beds exhibited the strongest gamma signals and contributed to high counts even in adjacent beds, reworked beds and/or in beds as thin as 1 centimeter. The spectral character of bentonite beds was notably high in total counts, but especially high in Thorium, recording concentrations up to 40 ppm with Uranium up to 10 ppm. Potassium concentrations in bentonites were in contrast low, often less than 1% by weight. In the more typical shales and organic shales in the area, the total count, Uranium and Thorium were much lower, but Potassium content was often on the order of 3%.

Uranium is often correlated with total organic carbon due to its accumulation in reducing conditions, but this was not found to be the case for the samples analyzed herein (Figure 9). This lack of correlation may indicate that TOC and uranium are not simply related in the Mowry Shale at the study sites, or the collection and analysis of outcrop samples may alter either of the two variables.

Schrayer and Zarella (1968) suggest that outcrop samples can be suitable for TOC measurement, and it is expected that little volatilization or loss of carbon should have occurred in the relatively fresh rock sampled. Contrasting with this is the higher TOC values in samples collected from fresh rock in the recently exposed bentonite pit at Poverty Flats. While the higher values may correspond to higher TOC contents in the interval, they may also represent a difference in TOC from variable weathering between the two nearby sample sites.

Table 1: Reported ranges in total organic contents within the study area from previous studies.

Author	Basin	TOC average	TOC minimum	TOC maximum
Finn, 2010	Bighorn	1.8%	~1.1%	~2.8%
Schrayer and Zarella, 1968	Multiple	2.26%	0.51%	4.95%
Momper and Williams, 1984	Powder River	3.0		
Modica and Lapierre, 2012	Powder River	~3%		>5%
This study	Bighorn	1.1%	0.4%	2.3%

Table 2: Total organic content measurements collected for this study.

Sample No.	Stratigraphic Location	TOC (% wt)	Lithology
Poverty Flats 1	142.0	1.0	Platy Shale
Poverty Flats 2	144.0	1.1	Shale
Poverty Flats 3	147.0	2.1	Platy Shale
Poverty Flats 4	152.0	2.3	Platy Shale
Poverty Flats 5	156.0	2.3	Platy Shale
Greybull Platform 1	14.0	1.1	Shale
Greybull Platform 2	16.0	1.1	Black Shale
Greybull Platform 3	24.5	0.9	Shale
Greybull Platform 4	29.8	0.6	Siltstone
Greybull Platform 5	33.0	0.6	Shale
Greybull Platform 6	36.5	1.0	Platy Shale
Greybull Platform 7	40.5	0.4	Laminated Siltstone
Greybull Platform 8	47.5	1.0	Blocky Shale
Greybull Platform 9	49.5	0.9	Blocky Shale
Greybull Platform 10	54.0	1.0	Blocky Shale
Greybull Platform 11	58.0	0.8	Fissile Shale
Greybull Platform 12	63.0	0.8	Shale
Greybull Platform 13	67.5	0.8	Shale
Greybull Platform 14	74.5	0.8	Shale
Greybull Platform 15	79.5	1.6	Shale
Greybull Platform 16	81.0	1.2	Platy Siltstone
Greybull Platform 17	84.5	0.9	Fissile Shale
Greybull Platform 18	98.0	0.9	Shale
Greybull Platform 19	102.5	0.7	Platy Siltstone
Greybull Platform 20	110.5	1.5	Platy Siltstone
Greybull Platform 21	115.0	0.9	Platy Siltstone
Greybull Platform 22	119.5	1.8	Platy Siltstone
Greybull Platform 23	123.5	1.1	Platy Shale
Greybull Platform 24	150.5	0.5	Platy Shale

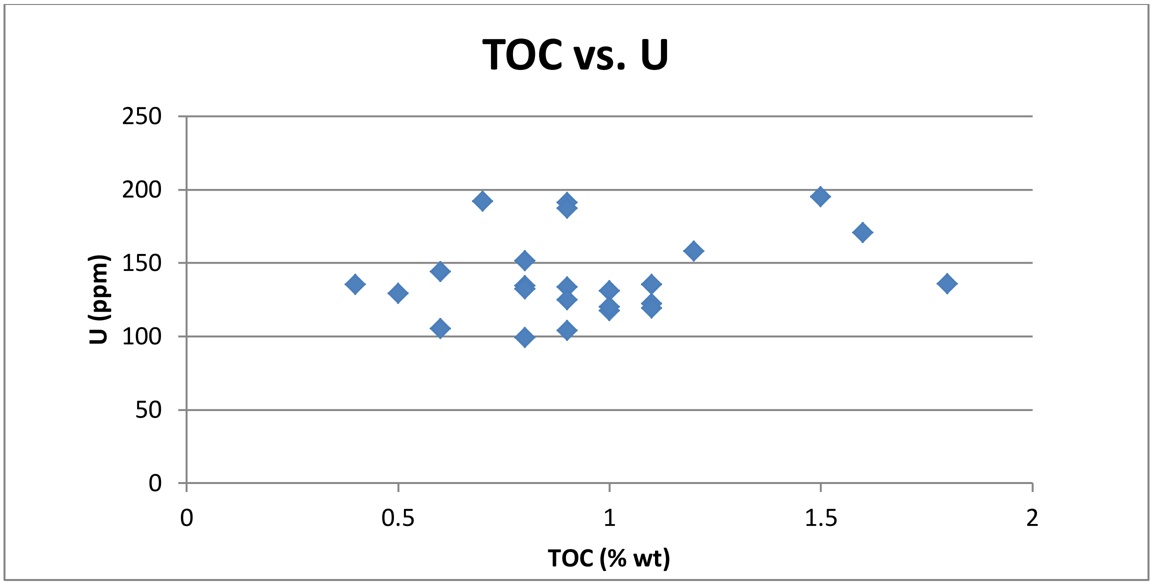


Figure 9: Chart comparing total organic content (from coulometer) to Uranium (from gamma spectrography) for each of 29 samples. Correlation between the two measurements is poor, suggesting a complex relationship.

Facies Analysis

Nine lithofacies were defined on the basis of lithology, physical sedimentary structures and trace fossil occurrences. These facies are interpreted to represent a range in environment from a quiet, deep water basin to delta-front;

Facies 1 – Shale

This facies consists of dark grey to black, fissile shale and claystone with up to 10% thin silty laminations. The rocks were largely devoid of fossil material, but rarely fish scales and teeth, ammonites, shell fragments and macerated plant debris were found. Shales were especially prevalent in the lower Shell Creek Shale, but were present throughout all of the measured sections. Fissile shales are largely slope-forming, and commonly required 0.25 to 0.5 m deep pits to reach fresh rock. Locally the surface presented purple lithified fragments as loose aggregates, likely representing disaggregated ferruginous concretions. The highest quality shale exposures were in newly-excavated bentonite pits. Shales are expected to have been deposited in a relatively calm, deep water environment.

Facies 2 – Organic-rich, Fossiliferous Shale

Occasionally exposed shales were black, organic rich and fossiliferous with a waxy texture. Fossil inoceramid bivalves, ammonites and plant debris were preserved in these beds. Only one thin bed of this carbonaceous shale was encountered, in the bentonite pit exposure at Poverty Flats, measuring approximately 3 cm thick. Observation of these beds were rare, and difficult to put into stratigraphic context or correlate to downhole logs.

Facies 3 – Concretionary Carbonate Masses

Rarely within the shale facies, isolated brown to grey well-cemented, irregularly shaped carbonate masses were encountered. Locally, these concretions are richly fossiliferous with ammonites, fish spines, scales and teeth. Other concretions are barren in hand sample, even in the vicinity of fossiliferous concretions. The encountered concretions were up to 1-2 m in diameter and 0.5 m thick and were found at both the Alkali Anticline and Greybull Platform locations. As with facies 2, observation of these beds were rare, and difficult to put into stratigraphic context or correlate to downhole logs. Fossiliferous masses within the Mowry Shale matching these descriptions were investigated thoroughly by Reeside and Cobban (1960).

Facies 4 – Bentonite

Numerous beds of bentonite were encountered within the Shell Creek and Mowry Shales ranging from <1 cm to 1.5 m thick accumulations (such as the Clay Spur Bentonite). These beds are chalky white to pale yellow and green and typically lack stratification. Locally, such as in the

Poverty Flats Bentonite pit, beds preserve aggradational wave ripples, with flat and low-angle laminations indicating some degree of reworking. Rare plant debris was also encountered within bentonite beds. Bentonites are extensively mined in the study area, often providing high quality, temporary exposures.

It is widely accepted that bentonite deposits are the product of volcanic fallout into stagnant water, and that the bentonite beds in the Shell Creek and Mowry Shales are largely the product of contemporaneous volcanism in western Wyoming and Idaho (Slaughter and Earley, 1965). The presence of well-preserved near-shore sedimentary structures and the presence of reworked beds indicate that bentonites were also deposited and transported from at least the fore-shore into shallow water depositional systems.

Facies 5 – Laminated Siltstone

Thick successions of interlaminated siltstone, silty shale and shale with variable fissile parting were encountered which preserved linsen and lenticular bedding, sheath folds and soft-sediment deformation structures. This facies has been diagenetically altered with varying degrees of siliceous cement that causes the rock to break into platy fragments. The trace fossils *Phycosiphon*, *Helminthopsis* and other indeterminate traces were encountered, as were various resting traces. Fish scales are very common, and, more rarely, well preserved bivalves and macerated plant debris were found. Shales in the lower portion of the succession grade upward into the laminated siltstone facies in all of the observed sections and are thought to represent a general shallowing of the basin environment and an increased capacity for sediment size transport.

Facies 6 – Interbedded Sandstone/Siltstone

Facies 6 comprises interlaminated to thinly interbedded very fine-grained sandstone and siltstone with local shale partings, also displaying variable silicification. This facies preserves several sedimentary structures including flat and low-angle laminations, linsen, lenticular and wavy bedding, current and combined-flow ripple cross-laminations, symmetrical wave ripples, scour surfaces, load casts, syneresis cracks and other soft sediment deformation structures. Ichnogenera identified were *Zoophycos, Planolites, Lockeia, Protovirgularia, Teichichnus* and possible *Asterosoma* and navichnia. Rare shell fragments, fish teeth, woody debris and macerated plant debris were found along with abundant fish scales. The laminated siltstone facies tends to grade upwards into the interbedded sandstone/siltstone facies and represents further shallowing of the system and sediment load possibly suggesting prodelta to distal delta front environments.

Facies 7 – Thinly Bedded to Massive Sandstone

Sharply-based, thinly bedded to massive, quartzo-feldspathic fine-grained sandstones were found within the Mowry Shale succession. These sandstones contained current and combined-flow ripple cross-lamination and flat and low-angle bedding with common *Protovirgulari*a trace fossils. *Planolites*, *Lockeia, Zoophycos* and *Thalassinoides* were also encountered, along with fish scales and rare shell and plant debris. Sandstones were found at each of the visited sites, and were thicker and more plentiful in the western study area. Two sand bodies were found in the eastern Bighorn Basin which are thought to correlate to the Upper and Lower Mowry Sands. Sandstones are interpreted to have been deposited in a nearshore environment, possibly as part of a delta front, or less likely as a poorly preserved shoreline.

Facies 8 – White, Quartz-Lithic Sandstone (Muddy Sandstone)

The Muddy Sandstone showed a unique character and ichnofossil suite. The unit is composed of a fine to medium grained quartzo-feldspathic sandstone occasionally interbedded within thin mudrock partings. The unit as a whole is erosionally based on top of the Thermopolis (and/or Skull Creek) Shale and displays flat and low angle stratification, cross-bedding, ripple cross-lamination, symmetrical wave ripples and siltstone and coal clasts. *Planolites, Lockeia, Cylindrichnus, Diplocraterion,* and *Teichichnus* trace fossils were identified, along with common coaly plant debris and *in-situ* plant roots. It is recognized that the Muddy Sandstone contains elements of fluvial, coastal and nearshore marine environments, and represents the continental and shoreline deposits of the transgressing Mowry Sea.

Facies 9 – Conglomerate

Directly on top of the Muddy Sandstone, a poorly sorted granule to pebble conglomerate and pebbly sandstone composed of fossil debris and chert clasts was observed. The unit was too thin to preserve sedimentary structure, but crocodile teeth, fish teeth and bone fragments were excavated from this zone. This deposit is interpreted as a transgressive lag deposit, where the nearshore to continental Muddy Sandstone was drowned into a deeper water setting resulting in a period of depositional inactivity.

Table 3: Facies scheme developed through field observations. The color code (left track) is used throughout the outcrop diagrams to display interpreted lithofacies.

Lithofacies	Interpretation	Lithology	Sedimentary Structures	Biota
1	Basinal	Dark grey to black, fissile claystone (shale), rarely with up to 10% siltstone laminae. Locally platy.	Fissile parting	Rare fish scales and teeth, ammonites, shell fragments, macerated plant debris
2	Abrupt deepening of depositional surface	Organic-rich, fossiliferous shale with waxy texture	Fissile parting	Inoceramid bivalves, ammonites, plant debris
3	Possible methanic seep deposits	Well-cemented, irregular masses of richly fossiliferous carbonate minerals	None observed	Ammonites, fish spines, scales and teeth.
4	Volcanic fallout, settled through water column and variably redistributed by waves and currents	Bentonite, varying from silt to sand grade. Variable thickness from mm to >1 m.	Most occurrences lack stratification, local flat and low-angle lamination, symmetrical wave ripples and aggradational wave ripples	Local plant debris
5	Offshore	Interlaminated siltstone, silty shale and shale (silicified in Mowry Shale).	Fissile parting, linsen and lenticular bedding, sheath folds, soft-sediment deformation structures	*Phycosiphon*, *Helminthopsis*, resting traces (B.I. = 0-2). Common fish scales, rare bivalves, indeterminate burrows (B.I. = 0-2), macerated plant debris
6	Prodelta to distal delta front	Interlaminated and thinly interbedded very fine-grained sandstone and siltstone, local shale partings (all silicified in Mowry Shale).	Flat and low-angle lamination, linsen, lenticular and wavy bedding, current and combined-flow ripple cross-lamination, symmetrical wave ripples, scour surfaces, load casts, syneresis cracks, soft-sediment deformation including sheath folds	*Navichnia*(?) , small *Zoophycos, Planolites, Lockeia,Protovirgulari a,*small *Teichichnus, ?Asterosoma,* (B.I. = 0-4) Common fish scales, teeth, shell fragments, macerated plant debris and some intact axes
7	Delta Front	Sharply-based, thinly bedded to massive, quartzo-feldspathic, fine-grained sandstone	Current and combined-flow ripple cross-lamination, flat and low angle lamination	*Protovirgularia, Planolites, Lockeia, Zoophycos, Thalassinoides* (B.I. = 1-3) Fish scales, shell debris, plant debris

8	Fluvial, coastal and nearshore marine environments	Erosionally-based, fine- to medium-grained quartzo-feldspathic sandstone. Locally interbedded with thin mudrock partings	Flat and low angle stratification, cross-bedding, local ripple cross-lamination, symmetrical wave ripples, siltstone clasts	*Planolites, Lockeia, Cylindrichnus,* Small *Diplocraterion, Trichichnus,* small *Teichichnus* (B.I. = 0-2) Coaly plant debris, *in situ* plant roots
9	Transgressive lag deposit	Poorly sorted, granule to pebble conglomerate and pebbly sandstone composed of fossil debris and chert clasts	None observed	Crocodile teeth, fish teeth, bone fragments

Interpretation of Facies Assemblage and Depositional Environment

Previous interpretations of the Mowry Sea paleoenvironment depict the Boreal Seaway opening up and flooding the Rocky Mountain Foreland Basin, first along the foredeep, then spreading eastward across the continental interior. The seaway later broke through into the Gulf of Mexico, ending the behavior of the Mowry Sea and beginning the Cretaceous Interior seaway proper (Cluff, 1976; Davis, Byers and Pratt, 1989). The emerging Rocky Mountain highlands to the west supplied the majority of clastic sediment through a fluvial drainage network with a lesser volume coming from established systems to the east, which were progressively drowned over time. Periodic volcanism to the west provided fallout that settled through the water column and accumulated to form bentonite beds.

Fossil and Ichnofossil Evidence

While some portions of the Mowry Shale have been described as devoid of life other than disaggregated fish parts (primarily scales) and *Nasselaria* and *Spumellaria* radiolarians (Rubey, 1929; Cluff, 1976), places within the study areas contained a much broader biota of both trace and body fossils. Observed trace fossils include *Protovirgularia, Cylindrichnus, Lockeia, Planolites*, navichnia and *Zoophycos*, which are more thoroughly described below. Body fossils other than prominent fish scales are rare, but ammonite, inoceramid, and other bivalves were discovered. Ammonites approximately 3 centimeters in diameter were particularly prevalent in some concretionary carbonate lenses throughout the Shell Creek Shale interval in the Eastern Bighorn Basin with larger specimens found associated with thin organic/coaly shales. Fossilized teeth, fin spines and bone (likely also from fish) and coaly plant debris were also found in the Muddy Sandstone transition into the Shell Creek Shale, within concretionary lenses in the Shell Creek Shale, and scattered within the Mowry Shale.

Identified ichnofossils in the Mowry Shale represent the *Zoophycos* and *Cruziana* Ichnofacies, suggesting water depths beneath fair-weather wave base to beneath storm-wave base. The Muddy Sandstone, on the other hand, preserves trace fossils more representative of the *Skolithos* Ichnofacies, suggesting shallower water depth within the tidal range. While nearly all occurrences of ichnofossils presented only a single genus of fossils (i.e. minimal diversity), the bioturbation index was commonly high (MaEachern et al, 2007).

Internal Stratigraphy of the Study Interval

Key Log Intervals

Six internal stratigraphic intervals were differentiated using outcrop sections and subsurface gamma ray logs from the Muddy Sandstone, Shell Creek Shale, Mowry Shale and the lowermost Frontier Formation (Figure 10). The gamma logs proved difficult to correlate at high resolution due to a combination of variable log fidelity, inconsistent quality of marker beds such as bentonites, and lateral facies variability. In spite of this, six gamma intervals show consistent gamma ray character that correlates over the west-east cross-section of the Bighorn Basin.

Interval 1

On top of the Muddy Sandstone, a 3 to 4 meter abrupt increase in gamma signature is recorded at Alkali Anticline. The gamma signature then abruptly decreases to the more consistent baseline that defines interval 2. Interval 1 corresponds in outcrop to the lag surface coupled with the basal Shell Creek Bentonite and irregularities in the slightly gradational top of the Muddy Sandstone. In previous studies, this interval has been included in the Muddy Sandstone, or either a portion of or the entire Shell Creek Shale (Eicher, 1962; Modica and Lapierre, 2012). Based on the presence of the lag surface and the sedimentary character, Interval 1 is defined as the basal Shell Creek Shale.

Interval 2

The second interval is an approximately 41 m thick series at Alkali Anticline of up to three low amplitude, individually symmetrical, sinuous rising and falling gamma cycles. Together, the three cycles display an overall decreasing gamma trend. The upper boundary of the interval is the inflection in increasing gamma to a higher baseline zone with numerous thin, high amplitude peaks. This interval is interpreted as basinal and offshore deposits composed of shale with local siltstone/claystone beds. These sediments are interrupted by thin bentonite beds and are wholly within the Shell Creek Shale.

Interval 3

Interval 3 is a 30 meter thick package at Alkali Anticline characterized by numerous thin, high gamma amplitude beds. This series appears to contain three decreasing gamma trends that are interrupted by the spikes. As many as 9 of these spikes are clustered in the middle of the interval. The top of the zone is marked by a shift to a higher baseline where the average gamma increases from ~90 to ~130 gAPI. The zone is interpreted to represent prodelta and delta front deposits in the west, grading into offshore deposits in the east. This zone is the upper portion of the Shell Creek Shale.

Interval 4

Zone 4 is an interval containing several closely-spaced bentonite beds that show a characteristically higher gamma baseline than the surrounding rocks (Figure 10). Individual peaks often reach 150 or more gAPI. The zone is approximately 13 m thick at Alkali Anticline and is topped by a decrease in the number of gamma peaks and a return to more ‘normal’ gamma baseline (90 to 100) for the Mowry/Shell Creek study interval. Where present, it is expected that the Lower Mowry sand either comprises the top of this zone or straddles it. Interval 4 is thought to record delta front deposits with interbedded bentonite grading into distal delta front and offshore deposits eastward. This interval is extensive and its base is an approximation to the Mowry Shale/Shell Creek Shale boundary. It also correlates sedimentologically at outcrop with the Shell Creek to Mowry Shale contact as defined herein. Additionally, Interval 4 is suggested by Modica and Lapierre (2012) to correspond to the Mowry Sea highstand and the time of minimum terrigenous input, therefore the best source rock interval in the Mowry Shale.

Interval 5

Above the high gamma values of Interval 4, the baseline decreases to lower values with a corresponding decrease in high gamma spikes. This zone is a long-term decreasing gamma interval approximately 47 m thick at Alkali Anticline. The basal interval is approximately 120 gAPI, decreasing to 100 gAPI before a characteristic sharp, high amplitude drop and spike that top the interval. Interval 5 is interpreted to correspond to prodelta and distal delta front facies that coarsen upwards into the low amplitude delta-front Upper Mowry sand. The spike corresponds to the Clay Spur Bentonite in the eastern portion of the Bighorn Basin. This zone represents the upper portion of the Mowry Shale.

Interval 6

Above the high gamma spike the values become variable, but overall gamma decreases upwards culminating in a drop down to 75 gAPI or less. Interval 6 corresponds to basinal to offshore marine lithologies that coarsen upward into sands such as the Peay Sandstone Member of the Frontier Formation. Depending on the publication, the Mowry Shale to Frontier Formation contact is defined either at the base of this zone (the Clay Spur Bentonite) or somewhere within this zone that does not constitute a definitive log pick (Davis, 1970; Scott et al, 2009).

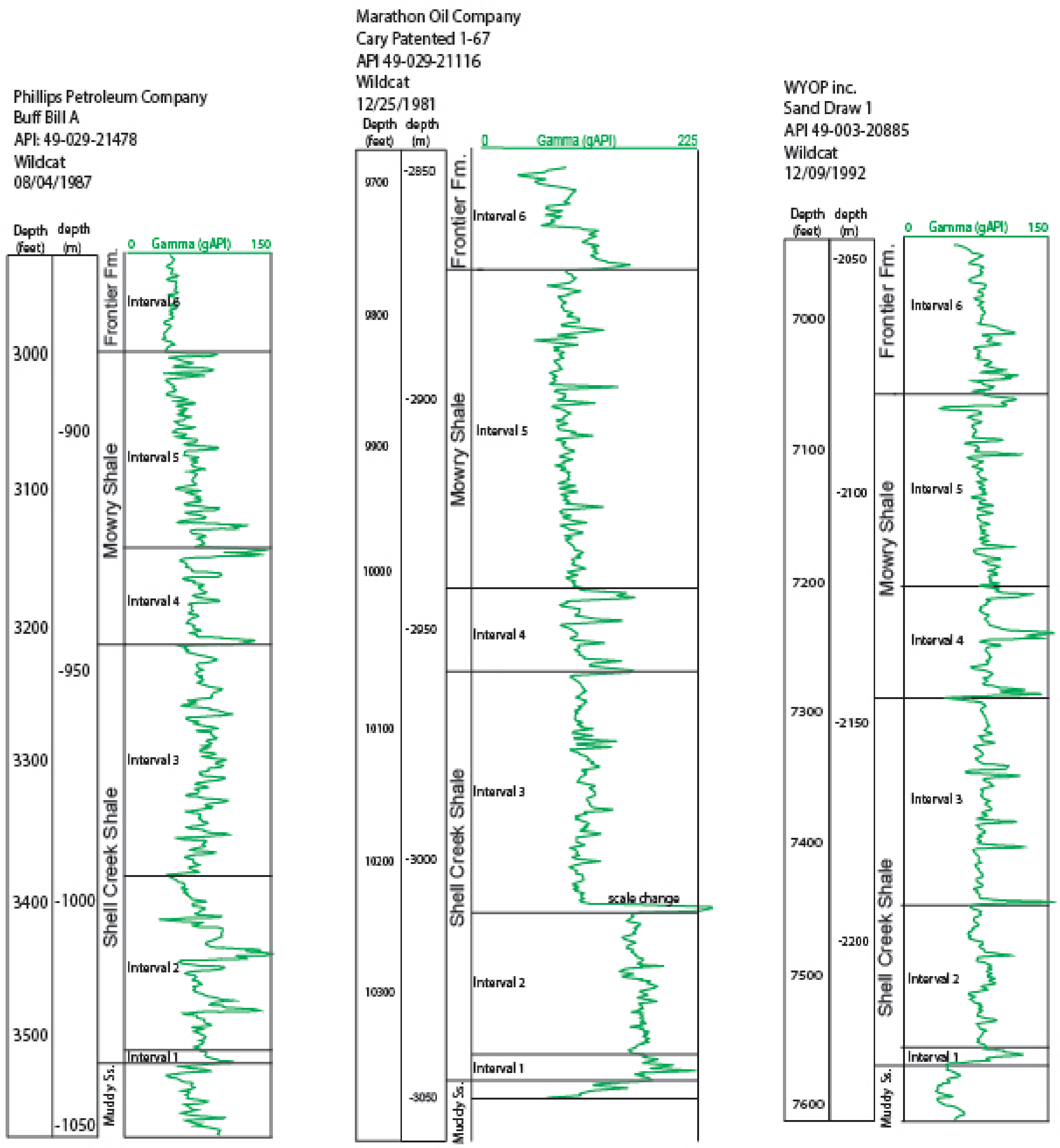


Figure 10: Downhole gamma ray logs from the western (left), central (middle) and eastern (right) Bighorn Basin. The logs have been annotated with log picks by their interpreted gamma zone.

Log to Facies Calibration

Deconstructing the gamma logs into component intervals enabled correlation between the downhole log dataset and the outcrop dataset. By observing trends in the gamma signature in the downhole logs and comparing the behavior of the linked gamma-facies measurements at outcrop, an inferred lithology may be projected into the basin subsurface (Figure 11). The best correlations were available for the eastern Bighorn Basin where complete gamma and outcrop logs were collected.

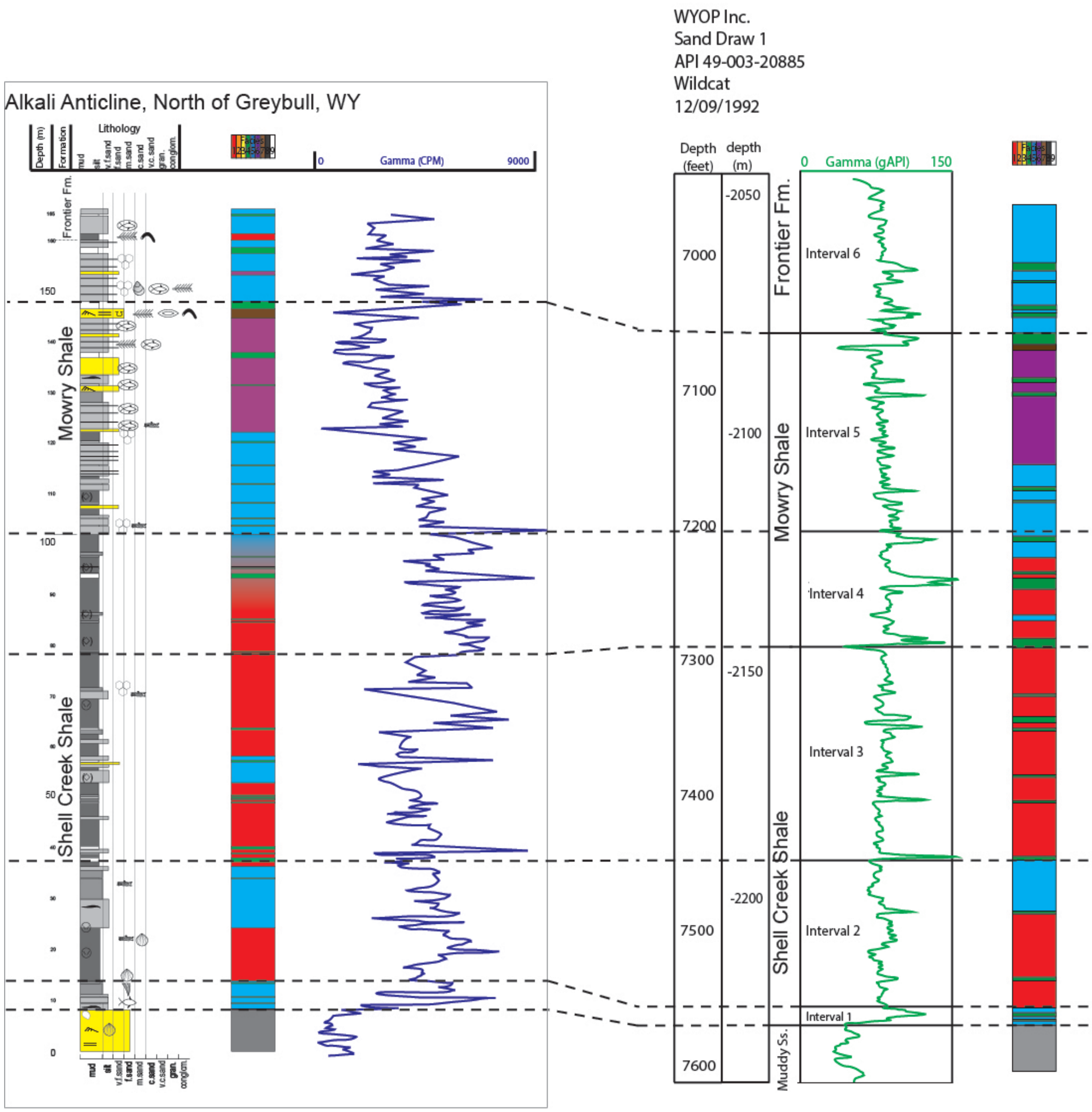


Figure 11: Image depicting the workflow to develop facies from gamma logs by comparing them to the outcrop dataset.

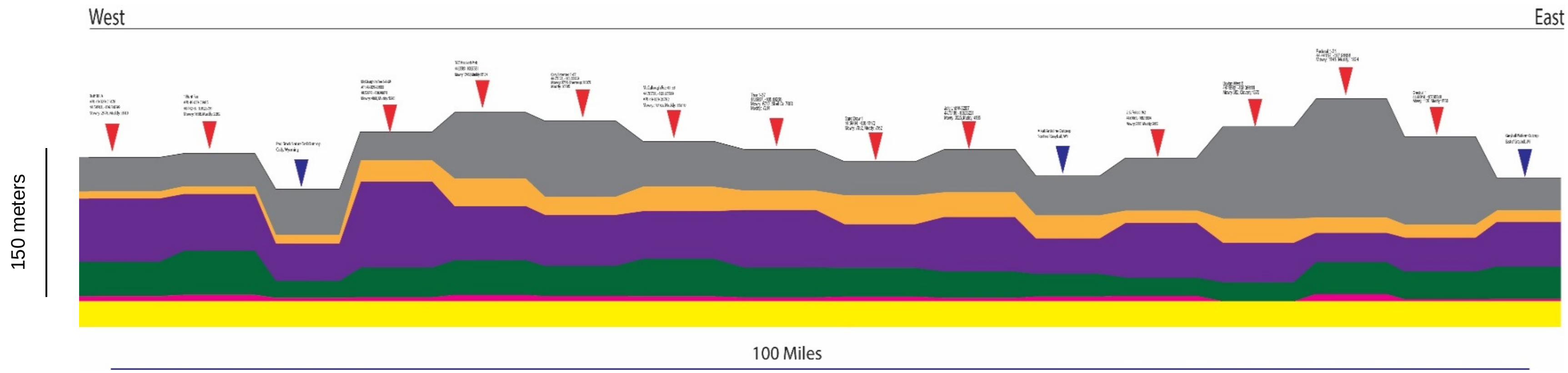
East-West Cross Section

A cross-section was generated incorporating downhole and outcrop gamma logs and highlighting the gamma zones documented above. It is apparent that the thicknesses of outcrop sections do not coincide with those of nearby subsurface sections which results as a problem with geometry. The dip of the beds is unknown in the subsurface and logs therefore record an apparent thickness which is exaggerated by traveling through the formation at an oblique angle, which was impossible to correct at this time. This apparent thickness is most evident in the most steeply dipping portions of the basin that are only slightly basinward from the measured outcrops near Cody.

The Muddy Sandstone was chosen as the datum for the cross-section since it can be readily traced across the basin. Most strikingly, the thickness of each gamma interval is remarkably consistent - no significant distal thinning is evident over the area that would be expected if the western shoreline was providing the majority of the sediment via deltas. Rather, it appears that the basin filled uniformly. This could perhaps be due to a dominance of hypopycnal plumes which would disperse sediment relatively evenly.

Alternatively, the study area may have received relatively consistent sediment supply from an adjacent, and currently unknown delta, as interpreted by facies analysis due to sediment coarsening upwards, ichnofossil zone shallowing upwards and the presence of sedimentary structures such as ripple and combined flow cross laminations . If the northern Bighorn Basin received distal deltaic sediments from an unknown delta in southern Montana, for instance, the stratal geometry could potentially appear sheet-like traversing east-west at the regional scale.

While no significant thinning is observed across this east-west cross section, it is expected that the formation would eventually thin eastward through the Powder River and Williston Basins. Reported maximum thicknesses do seem to decrease across the Powder River Basin (Modica and Lapierre 2012).



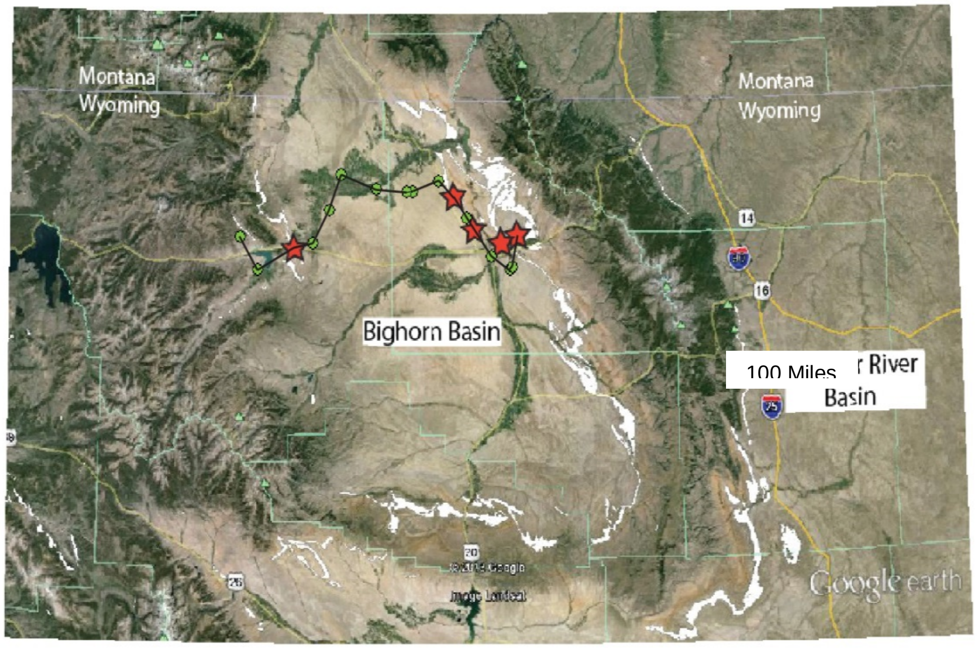


Figure 12: (Above) East-west cross section depicting gamma intervals 1-5, where yellow corresponds to the Muddy Sandstone (datum, arbitrary thickness), Magenta to interval 1, green to interval 2, purple to interval 3, orange to interval 4, and grey to interval 5. Red triangles represent data points resulting from well logs and blue triangles from outcrop sections.

(left) Location of cross section data points where green dots are from well logs and red stars are outcrop locations. Only the Paul Stock Nature Trail, Alkali Anticline and Greybull Platform locations were used.

Boundary Depth and Isochore Maps

Each gamma interval depth was incorporated into IHS Petra software and used to generate structure-depth and isochore maps for each horizon and interval to assess the cross-sectional geometry and their stratal stacking patterns. The structure-depth maps show very little detail regarding the Mowry Shale, instead showing the location of the Mowry Shale in the current basin arrangement (Figure 13). The deepest portions of the basin are expected to continue southwestward where there are no wells that penetrate deep enough to encounter the Mowry Shale, but as an artifact of the algorithm, this trend is not continued.

The isochore maps differ considerably from each other in the spatial patterns that they show, and each Interval appears to preserve different depositional trends within the study area. Log Interval 1 (Muddy Sandstone to Lower Shell Creek Shale Transition Zone) appears to be thicker in the western and southern sides of the study area and to thin towards the east. Variation within this zone may be exaggerated, however, due to the overall thin nature of the unit, and occasional ambiguity in precise boundary placement.

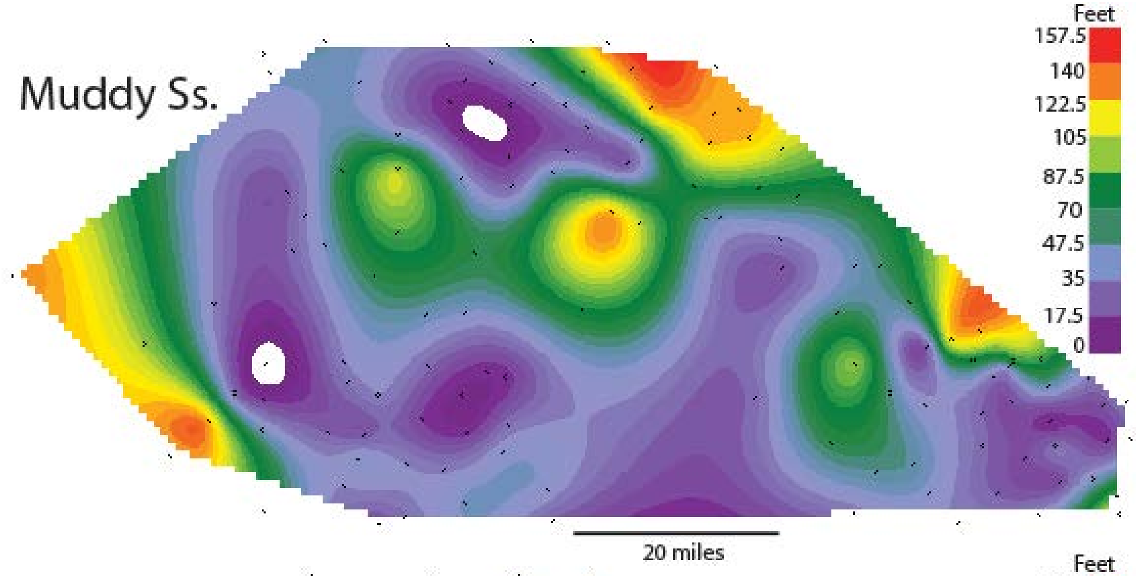
The Lower Shell Creek Shale (Gamma interval 2) isochore map shows that the unit is thickest in the east of the study area. The north-south linear trends to the west are expected to be the result of dip-related apparent thickness. The unit is composed primarily of mudstone, so it is possible that this unit may present a limited accommodation setting in the early Mowry Sea, or perhaps an easterly derived sediment source. If the Shell Creek Shale is indeed a distal expression of the contemporaneous Muddy Sandstone, then the thickest portions would be tied to the activity of the shoreline.

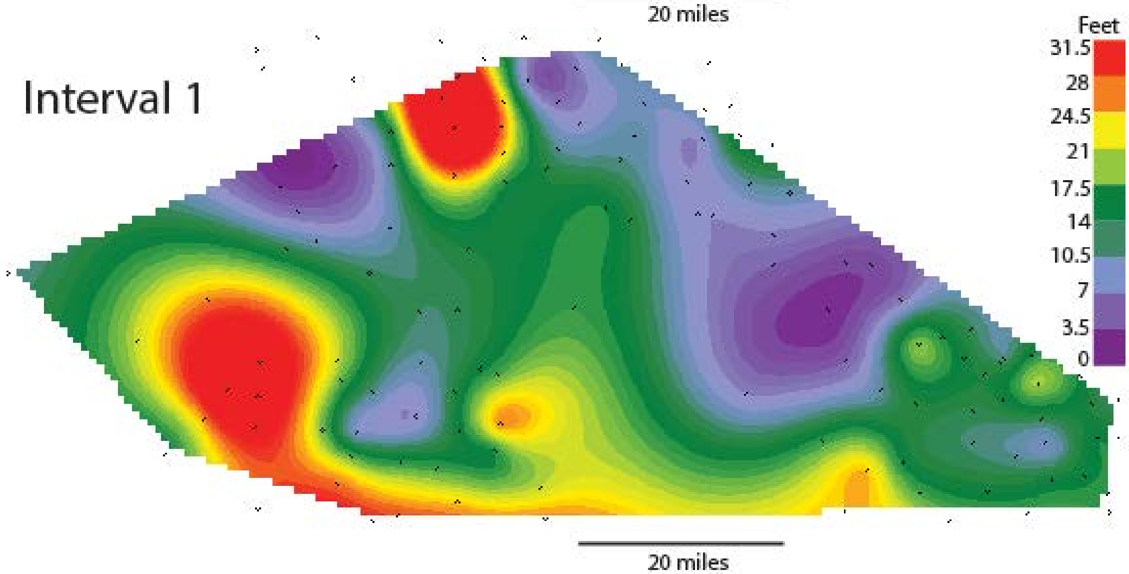
The Upper Shell Creek Bentonite Series (Gamma interval 3) is thickest in the central study area and thins towards the basin margins. Judging by the extent and character of the numerous bentonite beds within the interval, it is expected that the zone would be reasonably consistent, but the accumulation of thicker sediments in the basin center perhaps suggests either increased bypass at the basin margins, or some transport method that created a higher accumulation rate in the central basin.

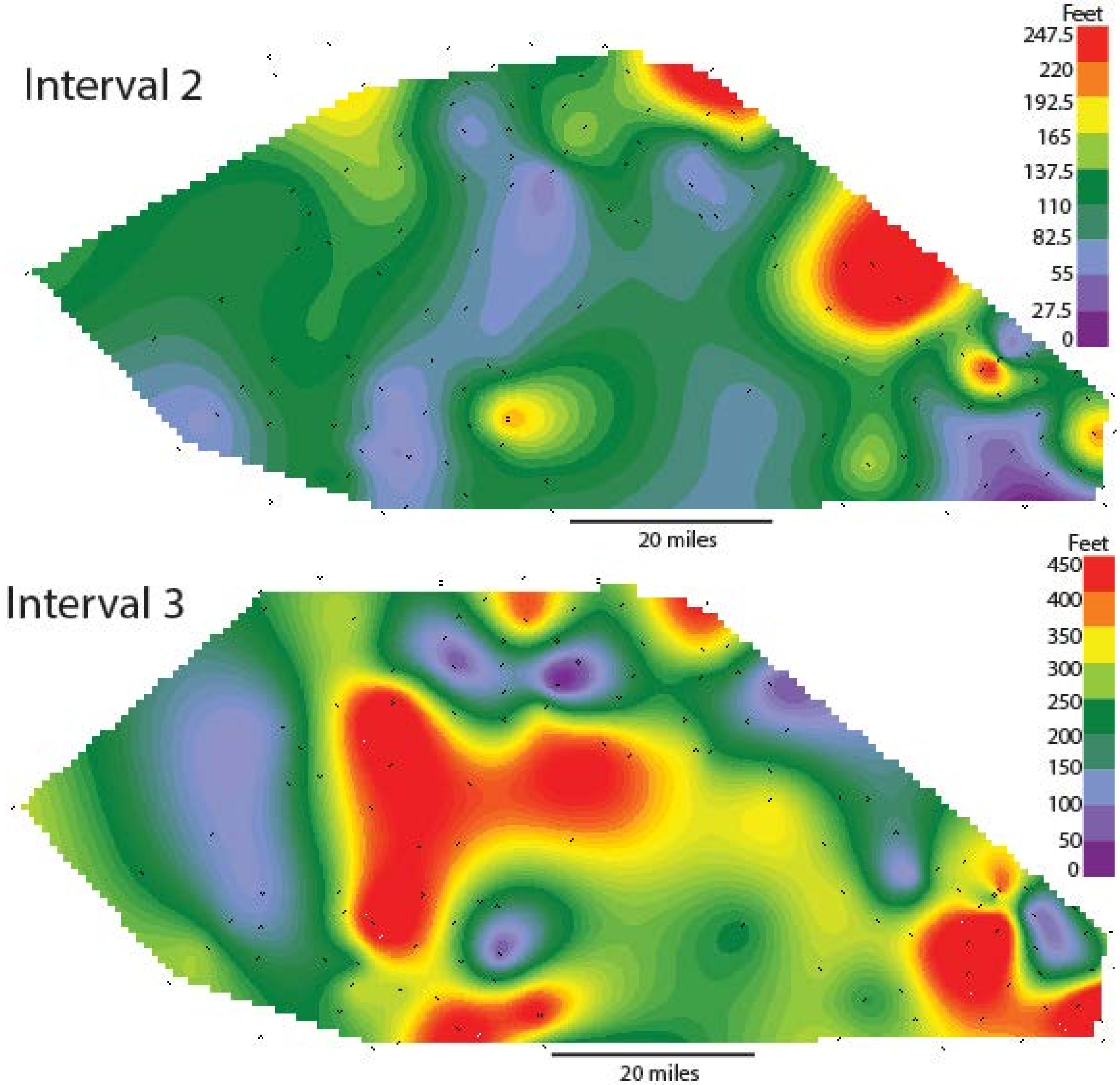
Interval 4, the high gamma zone remained consistent in thickness across the interval. Only a slight increase in thickness in the basin center is observed. This supports the highstand interpretation of the interval with consistent accumulation rates across the area, although the lithology tends to be platy siliceous siltstone rather than fissile basinal shales.

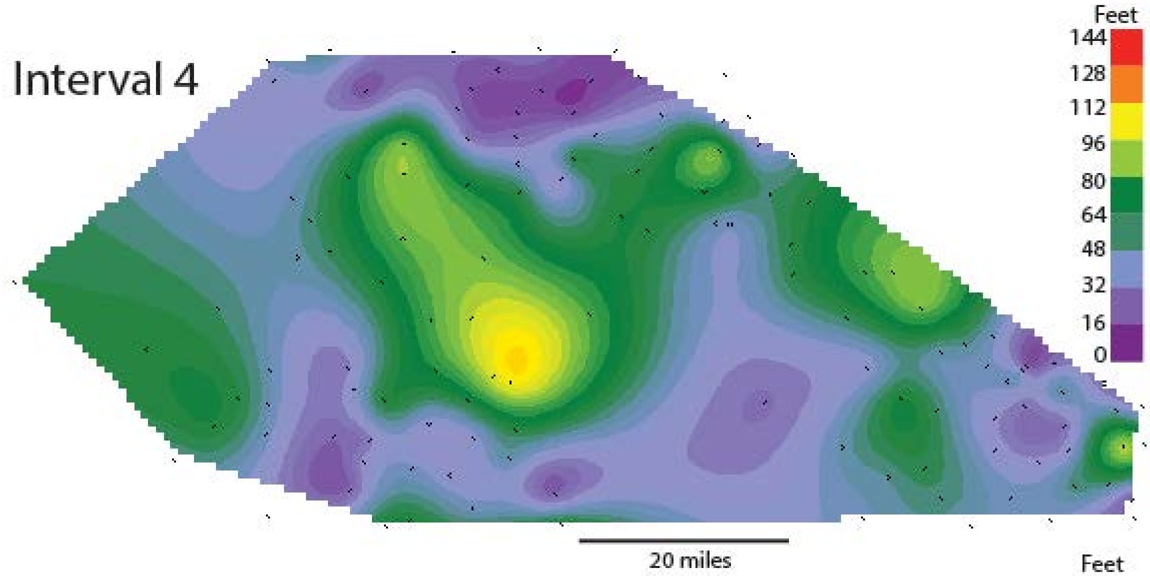
The coarsening upwards series (Gamma interval 5) above the high gamma zone is significantly thicker in the western study area and thins to the east. This is a product of a western sediment source and eastward progradation into the basin during deposition of the Upper Mowry Shale. This zone shows a coarsening upwards from distal delta front interbedded siltstone and sandstone into delta front sandstones, which were notably thicker to the west. This may represent a small deltaic depocenter, but further investigation would be required to address this hypothesis. The Upper Mowry Sand which lies on the top of this interval appears to be thickest around the edges of the coarsening package. A thicker interval of Upper Mowry Sand is also present to the southwest of the study area, although this is likely an exaggerated thickness caused by steep dip.

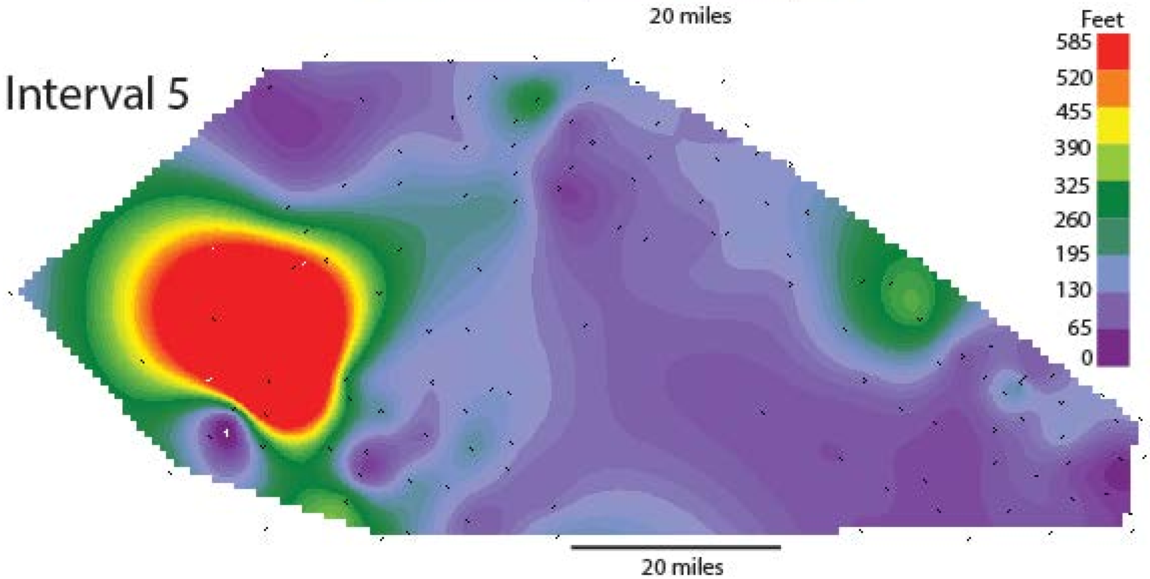
The Clay Spur Bentonite is also consistent across the study interval. The area of maximum thickness on the westward portion of the map is an artifact of the algorithm, which extrapolated a thickening trend towards an area of little to no data. A slight increase in thickness is present in the basin center, which may be a product of increased preservation or increased supply from the basin edges to the quieter basin center. Alternatively, it could be a product of several coalesced bentonites in an area of minimal sediment supply other than from volcanic fallout sources.


Muddy Ss.
Feet
157.5
140
122.5
105
87.5
70
47.5
35
17.5
0
20 miles


Interval 1
Feet
31.5
28
24.5
21
17.5
14
10.5
7
3.5
0
20 miles


Interval 2
Feet
247.5
220
192.5
165
137.5
110
82.5
55
27.5
0
20 miles
Interval 3
Feet
450
400
350
300
250
200
150
100
50
0
20 miles


Interval 4
Feet
144
128
112
96
80
64
48
32
16
0
20 miles


Interval 5
Feet
585
520
455
390
325
260
195
130
65
0
20 miles

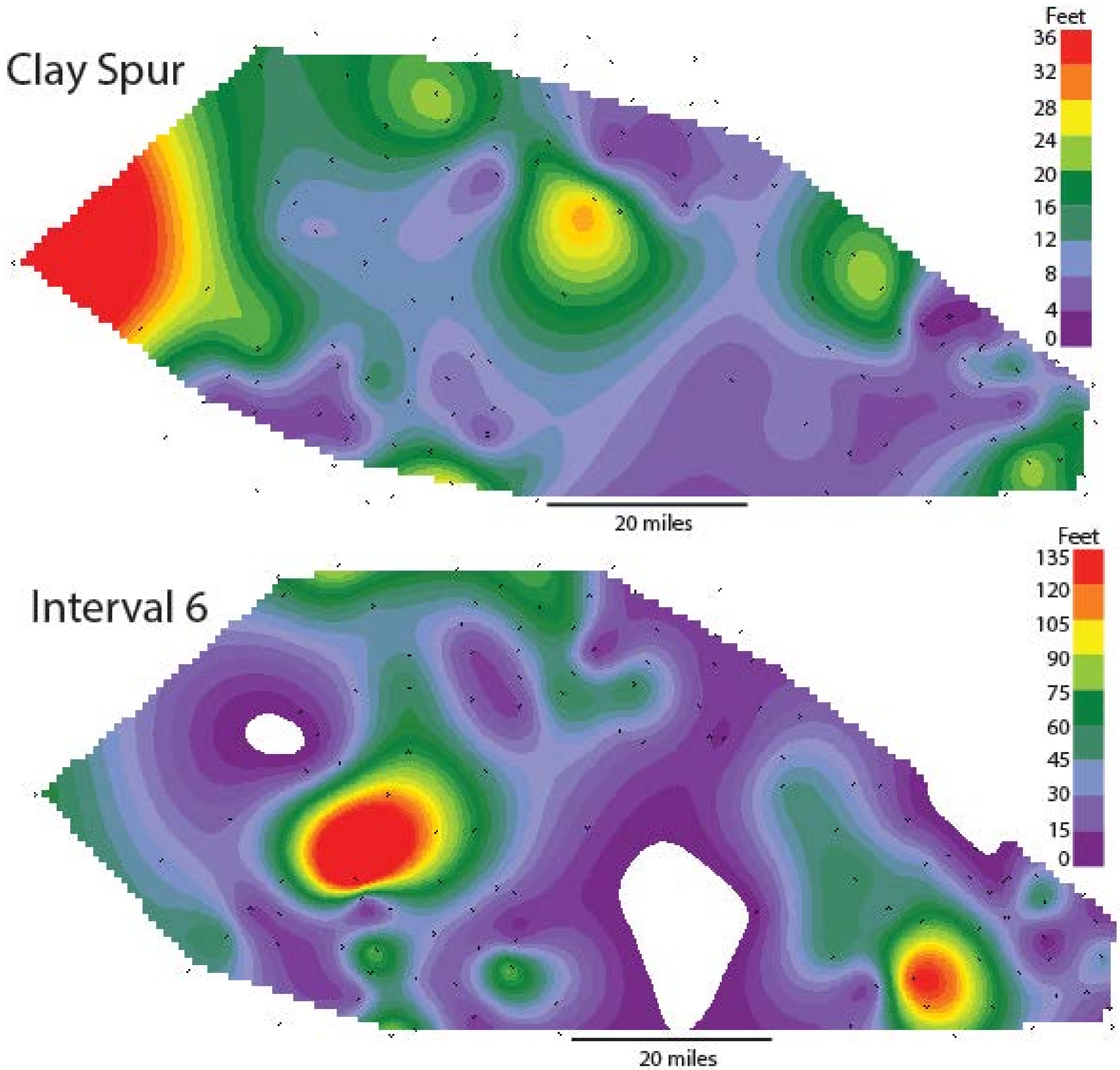


Figure 13: Isochore maps of each gamma interval from bottom (Muddy Sandstone) to top (Gamma Interval 6).

Implications for Development

Numerous bentonite beds within the Mowry and Shell Creek Shales present difficulties to utilizing logs for fine scale characterization. Use of spectral gamma tools may help, as the spectral character of bentonite (low potassium, high uranium, very high thorium) was noticeably different than surrounding mudrocks (higher potassium, low uranium and thorium).

The Mowry Shale is expected to enter the oil production window at approximately 2,050 m depth and exit the oil window at approximately 3,800 m (Anna, 2009). The Bighorn Basin's structural setting comprises an outer rim of relatively shallow dip followed by a sharp change in dip where the Mowry Shale plunges several hundred meters over a very short distance. For example, the Mowry Shale is exposed at the surface at the Paul Stock Nature Trail outcrop location, but plunges to over 1,400 m below surface within 6 km to the east. 14.5 km further into the basin, the Mowry Shale is at 3,630 m depth. The average dip over this line would therefore be 10-13°. Unfortunately, the oil window in this location is areally limited by the steep plunge, thus, assuming an average dip of 10°, the modern window is only 12 km wide.

Sandstone beds within the Mowry Shale have potential for migration and storage, however it is likely that the prevalent silica cement in the unit has also depleted or restricted the sandstone's ability to receive or store oil charge. Pinch-outs of sand beds in the eastern Bighorn Basin were not observed, and sandy beds are expected to continue into the Powder River Basin. Petrography on sandstone beds would be important for assessing the reservoir quality and contribution of the sandstone beds to the Mowry Petroleum System.

The majority of lithology between the Muddy Sandstone and the Lower Frontier formation is tight and likely compartmentalized. It is possible that there are undiscovered resources in tight reservoir plays where generated oil failed to expel or failed to migrate out of the Mowry Shale.

Conclusions

This thesis documents a stratigraphic and sedimentological study of the Mowry Shale and enclosing formations in the northern Bighorn Basin of north-central Wyoming utilizing outcrop sections, synthetic spectral gamma logs of outcrops and downhole gamma logs from subsurface intersections.

Historical stratigraphic framework and nomenclature schemes were reviewed and updated based on field observations for the northern Bighorn Basin. This scheme (Figure 2) better explains the regional stratigraphy of the Shell Creek and Mowry Shales as a product of deposition, resolves nomenclature problems and labels key features and contacts. Specifically, it is recommended that the Shell Creek Shale be regarded as a formation comprising the unsilicified portion of the stratigraphy between the Muddy Sandstone and the Mowry Shale. The upper and lower Mowry Sands and the Clay Spur Bentonite are herein regarded as members of the Mowry Shale. The Albian-Cenomanian contact is difficult to define and likely spans the depositional system of the Muddy Sandstone and Mowry Shale by location.

Five outcrop locations were visited and measured vertical sections logged. From outcrop observations a facies scheme consisting of 9 lithofacies was developed; 1. Fluvial/Nearshore Marine Sandstone, 2. Transgressive Lag, 3. Fissile Shale, 4. Organic rich shale 5. Carbonate Cemented concretions, 6. Laminated siltstones, 7. Interbedded siltstone and sandstone, 8. Delta-front sandstone, and 9. Bentonite. These facies were tied to a series of 6 component gamma intervals.

The stratigraphy in the study area appears to be laterally extensive across the central Basin traversing east-west with gamma-log defined zones extending across the entire Bighorn Basin. Most packages are remarkably consistent in character and exhibit very little thinning across the east-west cross section generated. Gamma intervals were identified through outcrop and downhole gamma, which were used to create isochore maps of each component interval as well as form facies correlations. Component intervals were shown to have a fairly complex interplay; some depositing thicker in the central basin, some depositing thicker around the basin edges, and some depositing relatively consistently across the area.

Lithology clearly varies from east to west, especially in the Mowry Shale, where an increased number and thickness of sand bodies occurred in the west (Figure 7). Despite significant changes in lithology, gamma-ray defined intervals appear to correlate. Fine scale sequence stratigraphic relationships were difficult to diagnose within the interval in the Northern Bighorn Basin. It is likely that the Mowry Seaway incurred several changes in sea level and therefore sequence boundaries, however no clear evidence was presented in outcrop or in downhole gamma ray logs.

Total organic content values were around 1% at the Greybull Platform outcrop and 2% at the nearby Poverty Flats location. No clear correlation between TOC and gamma or uranium-spectral gamma as present as hypothesized, however implications made by previous work (Modica and Lapierre, 2012, e.g.) that identify the high gamma zone to contain higher TOC, and that TOC generally increases eastward are likely and supported by the small investigation performed.

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Appendix A: Gamma Scintillometer Data

Introduction

The Radiation Solutions RS-230BGO gamma scintillometer constructs a data file in onboard memory when collecting data assays. Each assay consisted of a 2-minute collection time in which the unit was placed in contact with fresh rock; either placed in a shallow pit in the instance of weathered surface rock or directly against competent, relatively fresh rock. The report file lists the date and time, total counts per minute (CPM), and both counts per minute and calculated prevalence of Potassium, Thorium and Uranium in weight percentage.

Alkali Anticline Section

Id	Date	Time	Temp	Stabilized	Total[ppm]	Total[cpm]	K[%]	K[cpm]	U[ppm]	U[cpm]	Th[ppm]	Th[cpm]
16	5/25/2013	12:16:07	21.7	1	891.9	3443.3	1.3	338.9	3.6	93.8	13.3	117.4
17	5/25/2013	12:24:53	22.7	1	1027.9	3968.2	2.2	514.9	4	101.2	13.8	121.6
18	5/25/2013	12:29:33	23.9	1	969.6	3743.1	1.5	386.6	3.4	90.2	13.9	122.1
19	5/25/2013	12:32:36	24.5	1	1013.8	3913.8	1.6	401.9	4.1	101.7	13.6	119.5
20	5/25/2013	12:35:30	25.3	1	911.2	3517.6	1.5	384.4	3.6	95.4	14.1	123.6
21	5/25/2013	12:38:28	25.9	1	831.2	3209.1	1.3	344.5	3.5	91.2	12.9	113.6
22	5/25/2013	12:42:00	26.6	1	999.2	3857.4	1.5	385.6	4.2	103.3	13.1	115.3
23	5/25/2013	12:44:46	27	1	1043.5	4028.5	1.5	391.9	4.5	110.6	13.8	122.1
24	5/25/2013	12:47:51	27.4	1	945.1	3648.6	1.4	376.5	4	103.2	14.9	131
25	5/25/2013	12:51:14	27.7	1	835.9	3226.9	1.5	361.3	3.2	80.7	11.4	100.1
26	5/25/2013	12:54:18	28	1	925.7	3573.7	1.5	370.7	3.1	88.6	15.2	133
27	5/25/2013	12:57:14	28.4	0	877.3	3386.8	1.3	342.5	3.3	84.9	12	105.3
28	5/25/2013	13:00:24	28.4	1	910.1	3513.4	1.3	350.3	3.8	99	14.6	128.3
29	5/25/2013	13:03:54	28.6	1	872	3366.3	1.2	334.6	4.1	100.6	12.6	111.6
30	5/25/2013	13:06:43	28.6	1	906.4	3499.4	1.4	359.3	3.8	93.3	11.9	105.3
31	5/25/2013	13:09:40	28.6	1	917.6	3542.5	1.3	349.9	4	98.5	12.8	112.6
32	5/25/2013	13:13:21	28.6	1	918.9	3547.6	1	299.2	4.2	110.1	15.6	137.2
33	5/25/2013	13:17:06	28.4	1	1068.3	4124.1	0.9	288.9	4.5	120.6	18	158.3

b

34	5/25/2013	13:19:58	28.5	1	959.9	3705.7	0.9	286.7	4.3	110.6	15.3	135.2
35	5/25/2013	13:23:23	28.6	1	1278.2	4934.5	0.6	257.6	5.3	150.5	24.7	217
36	5/25/2013	13:26:20	28.6	1	1078.1	4162.2	0.6	253.3	6	145.2	17.6	156.2
37	5/25/2013	13:29:09	29	1	1459.3	5633.8	0.5	284.5	8	198.3	24.9	220.8
38	5/25/2013	13:32:09	29.2	1	1825.1	7045.9	1	437.5	11.6	266.7	27.4	245.2
39	5/25/2013	13:34:59	29.6	1	1729.5	6676.7	0.8	376	9.9	239.4	28.5	253.5
40	5/25/2013	13:37:43	29.8	1	1157.9	4470.3	0.9	320.3	5.7	146.2	19.9	175.6
41	5/25/2013	13:40:30	30.2	0	1577.6	6090.4	0.9	340.1	6.6	177.3	26.8	236
42	5/25/2013	13:44:45	30.6	1	1595.3	6158.6	1.4	468	8.2	203	26.1	230.8
43	5/25/2013	13:48:20	30.9	1	1511.8	5836.3	1.4	444.9	8.5	198.8	22	195.7
44	5/25/2013	13:51:23	31	1	1539.9	5944.9	1.1	397.7	6.9	184.1	27.2	240.2
45	5/25/2013	13:54:07	31.3	0	1579.8	6098.8	1.6	480.6	7.2	180.5	24	211.9
46	5/25/2013	13:56:53	31.4	1	1346	5196.3	1.8	493.2	6	148.9	19.4	170.9
47	5/25/2013	13:59:36	31.4	1	1390.2	5367	2.3	579.8	6.4	152.1	18.3	162
48	5/25/2013	14:22:29	29.4	1	1432	5528.4	2.3	583.6	6.5	154.2	18.4	162.6
49	5/25/2013	14:25:03	30	1	1400.3	5405.8	2.2	569.9	6.6	158.9	19.6	173
50	5/25/2013	14:27:40	30.5	1	1421.7	5488.7	2.4	594.6	5.2	135.9	20.1	176.2
51	5/25/2013	14:30:17	30.8	1	1307.1	5046	2.1	540.3	5.5	136.3	17.9	157.8
52	5/25/2013	14:33:47	31.2	1	1436.5	5545.5	2.4	600.4	6	147.4	19	167.8
53	5/25/2013	14:37:27	31.2	1	1463.5	5650.1	2.4	608.3	6.2	153.2	19.8	174.7
54	5/25/2013	14:40:18	31.6	1	1543.5	5958.6	2.4	615.7	7.1	170	20.3	179.9
55	5/25/2013	14:45:23	31.6	1	1497.1	5779.8	2	552.8	7.2	174.7	21.7	192
56	5/25/2013	14:48:08	31.6	1	1688.1	6516.9	1.7	515.4	6.7	185.8	29.5	259.7
57	5/25/2013	14:50:47	31.8	1	1839.5	7101.6	2.3	631.6	7.9	198.5	26.8	236.2
58	5/25/2013	14:53:18	32	1	1561.7	6028.9	2.3	604.2	6	157.9	23.4	205.6
59	5/25/2013	14:55:49	32.4	1	1570.4	6062.6	2.4	637.2	7.7	180.5	20.4	181
60	5/25/2013	14:58:32	32.4	1	1630.1	6293	2.2	599	8.3	195.2	22.1	196.2
61	5/25/2013	15:01:08	32.6	0	1688.7	6519.4	2.4	636.3	8	195.2	24.5	216.1
62	5/25/2013	15:03:44	32.6	1	1658.3	6402	2.3	593.7	6.7	162.1	20.1	177.8

c

63	5/25/2013	15:06:24	32.4	1	1553.7	5998.1	2.6	654.5	5.9	155.3	23.3	204.6
64	5/25/2013	15:09:31	32.6	1	1528.7	5901.5	2.3	615.7	7.5	178.9	21.5	190.4
65	5/25/2013	15:12:43	32.9	1	1574.3	6077.7	2.4	618.4	6.9	170.5	22.1	195.1
66	5/25/2013	15:15:39	33.2	1	1374.1	5304.8	2.2	566.2	6.1	147.9	18.4	162.6
67	5/25/2013	15:18:22	33.2	1	1278.6	4936.2	1.9	509.3	5.6	141.5	19.1	168.7
68	5/25/2013	15:20:57	33.4	1	1648.1	6362.8	2.6	677.1	7.8	186.8	22.2	196.2
69	5/25/2013	15:23:43	33.6	1	1576.4	6085.8	2.8	684.9	7.1	165.3	18.7	165.8
70	5/25/2013	15:26:24	33.7	1	1133.5	4375.8	1.7	451.1	4.7	120.6	16.9	148.8
71	5/25/2013	15:28:54	33.6	1	1565.1	6042.3	3.2	750.4	6	144.3	18.4	162.1
72	5/25/2013	15:40:24	34.9	1	1624.1	6269.9	3	718	6.7	158.5	19.1	168.4
73	5/25/2013	15:42:59	35	1	1541.6	5951.3	2.5	636.7	6.9	167.4	21	185.2
74	5/25/2013	15:45:41	35	1	1497.3	5780.5	2.6	639.2	6	142.7	17.6	154.7
75	5/25/2013	15:48:51	35	0	1455.6	5619.4	2.3	588.8	5.7	144.3	19.7	173.6
76	5/25/2013	15:51:38	34.8	1	1509.6	5827.7	2.2	575.8	5.8	147.9	20.7	182
77	5/25/2013	15:54:08	34.9	1	1369.9	5288.7	2	542.5	7	165.2	18.9	167.2
78	5/25/2013	15:57:09	34.6	1	1549.2	5980.6	1.7	489.4	5.9	156.4	23.5	206.7
79	5/25/2013	15:59:47	34.4	1	1572.2	6069.7	1.5	456.4	8	189.4	21.7	193
80	5/25/2013	16:02:17	34.4	1	1544.7	5963.4	1.4	459.6	7.9	199.4	26.5	234.5
81	5/25/2013	16:05:09	34.2	1	1331.3	5139.7	1.4	416.8	6.9	164.1	18.7	166.2
82	5/25/2013	16:07:48	34.2	1	1390.8	5369.3	0.9	327.4	5.5	159.5	27	237.6
83	5/25/2013	16:10:29	34	1	1465.2	5656.5	1.5	458.5	7.3	181	23.5	208.2
84	5/25/2013	16:13:00	34	1	1493.2	5764.6	1.8	509.8	6.9	170.5	22.1	195.6
85	5/25/2013	16:15:38	34	1	1512.4	5838.7	1.7	499.4	7.3	179.4	22.5	199.3
86	5/25/2013	16:18:22	34	1	1473.1	5686.8	1.6	483.6	8.3	195.7	22.2	197.2
87	5/25/2013	16:20:56	34	1	1463.4	5649.4	1.7	494.1	6.8	173.6	23.9	210.8
88	5/25/2013	16:23:32	34	1	1516.3	5853.8	1.6	477.3	8	191.5	22.8	202.5
89	5/25/2013	16:26:15	34.1	1	1498.2	5784.1	1.7	497.8	6.8	175.7	24.4	215.6
90	5/25/2013	16:28:53	33.8	1	1271	4906.7	1.6	454.4	6.2	148.4	17.9	158.3
91	5/25/2013	16:31:30	33.8	1	1352.5	5221.5	1.9	493.3	5.6	141.6	19.4	170.9

d

92	5/25/2013	16:34:11	33.6	1	1211	4675.2	2.2	548	4.9	120.6	15.8	138.9
93	5/25/2013	16:36:44	33.7	1	1332.8	5145.3	1.4	413.2	6.2	153.2	19.8	174.6
94	5/25/2013	16:39:22	33.8	1	1265.5	4885.4	1.5	425.1	5.5	138.9	18.7	165.1
95	5/25/2013	16:41:54	33.8	1	1484.6	5731.2	0.9	346.9	7.7	194.1	25.3	223.9
96	5/25/2013	16:44:33	34	1	1143.2	4413.6	1.7	449.6	4.8	120.1	16.1	141.5
97	5/25/2013	16:47:07	34.2	1	2004.8	7739.6	0.4	347.4	10.9	279.9	37.9	335.5
98	5/25/2013	16:51:33	34.5	1	1537.2	5934.4	2.2	579	6.8	171	22.7	199.8
99	5/25/2013	16:57:51	34.8	1	1355.3	5232.2	1.8	495.4	5.8	148.4	21	184.5
100	5/25/2013	17:00:40	35	1	1399.5	5403	2.5	608.6	5.1	130.6	18.5	162.5
101	5/25/2013	17:03:22	35.4	1	1455	5617.1	2.7	663.2	4.8	131.7	21.1	185.1
102	5/25/2013	17:05:52	35.8	1	1509.1	5825.9	2.9	684.3	4.4	126.5	21.9	191.4
103	5/25/2013	17:08:43	35.8	1	1531	5910.4	2.8	695.8	6.4	157.9	20.7	182.5
104	5/25/2013	17:12:03	35.6	1	1473.3	5687.7	2.9	683.7	4.8	129.6	20.7	180.9
105	5/25/2013	17:14:32	35.4	1	1469.6	5673.4	2.7	662.2	5.9	146.9	19.4	171
106	5/25/2013	17:19:25	35	1	1442.2	5567.6	2.8	681.5	5.4	136.9	18.9	165.7
107	5/25/2013	17:24:17	35	1	1469	5671.1	2.2	580	6.4	155.8	19.9	175.7
108	5/25/2013	17:27:00	35.2	1	1218.7	4704.9	1.9	494.1	5.7	136.3	16.4	145.2
109	5/25/2013	17:29:34	35.3	1	1312.3	5066.2	2.5	618.3	5.7	137.4	17	149.9
110	5/25/2013	17:32:12	35.3	1	1431.7	5527.1	2.7	641.1	4.8	123.8	18.2	159.4
111	5/25/2013	17:34:43	35.2	1	1219.9	4709.5	2.2	539.7	4.8	116.9	14.6	129
112	5/25/2013	17:37:19	35.2	1	1427.4	5510.4	2.3	588.3	5.3	138	20.5	179.9
113	5/25/2013	17:39:52	35.4	1	1458.6	5631.1	2.4	593.5	5.5	142.7	20.5	179.9
114	5/25/2013	17:42:26	35.4	1	1342.9	5184.5	2.6	632	5.1	128.5	17.9	157.3
115	5/25/2013	17:45:05	35	1	1507.8	5820.8	2.7	664.9	5.5	142.7	21	184.1
116	5/25/2013	17:47:44	34.4	1	1490.7	5754.8	2.6	643.4	5.1	138	21.8	191.4
117	5/25/2013	17:50:15	33.8	1	1344.7	5191.1	2.4	591.6	4.4	123.2	20.4	178.7
118	5/25/2013	17:52:48	33.4	1	1416.1	5467	2.8	670	6.1	141.6	16.2	143.2
119	5/25/2013	17:55:16	33	1	1397.8	5396.4	2.6	647.4	5.8	142.7	18.8	165.7
120	5/25/2013	17:57:52	32.6	1	1391	5370	2.5	612.3	5.1	135.3	20.5	179.8

e

121	5/25/2013	18:00:22	32.4	1	1345.5	5194.5	2.3	587	6	142.6	17.4	153.6
122	5/25/2013	18:02:57	32	1	1283.1	4953.5	2.3	571.1	4.9	125.3	18	158.3
123	5/25/2013	18:05:18	31.8	1	1243.2	4799.6	2.2	538.1	4.7	121.1	17.5	154.1
124	5/25/2013	18:08:13	31.6	0	1229.9	4748.2	2	503	4.6	126.4	20	175.6
125	5/25/2013	18:10:48	31.3	1	1172.7	4527.3	1.4	381	5.1	126.9	16.4	145.2
126	5/25/2013	18:14:00	31	1	1242.5	4796.8	2.5	593.6	4.6	112.2	14.7	129
127	5/25/2013	18:17:03	30.6	1	1268.9	4898.6	2.4	595.7	5.6	135.3	16.9	148.9
128	5/25/2013	18:20:20	30.4	1	1313.5	5071	2.8	649.6	4.9	120.1	15.7	137.9
129	5/25/2013	18:22:54	30.5	1	1417.5	5472.3	2.9	697.1	5.6	134.8	16.9	148.9
130	5/25/2013	18:26:40	30.6	1	1368.7	5284	2.6	638.8	5.9	138.9	16.2	142.6
131	5/25/2013	18:29:14	30.9	1	1059.9	4092	1.9	478.2	5.7	125.8	12.4	110.1
132	5/25/2013	18:31:45	31	1	1816.5	7012.6	0.6	325.2	8.2	224.2	34.1	300.8
133	5/26/2013	11:52:48	23.7	1	1494.9	5771.1	1.3	425.5	7.1	183.1	25.7	226.6
134	5/26/2013	11:56:22	24.7	1	1296.8	5006.3	1.6	448.2	6	151.5	20.6	181.9
135	5/26/2013	11:59:01	25.3	1	1269.2	4899.8	2.6	610.9	5.1	122.2	14.9	131.1
136	5/26/2013	12:01:53	25.7	1	1396	5389.3	3.2	748.4	5.5	131.7	16.8	147.4
137	5/26/2013	12:04:40	26.1	0	1285.1	4961.3	3	690.5	5.7	130	14.3	126.3
138	5/26/2013	12:07:24	26.5	1	1291.4	4985.6	3	686.4	4.3	105.9	14.2	124.8
139	5/26/2013	12:10:09	26.6	1	1290.4	4981.8	2.9	666	4.7	114.9	15.2	133.7
140	5/26/2013	12:12:47	27	1	1322.3	5104.9	2.6	629.9	5.5	129	15.2	133.7
141	5/26/2013	12:15:48	27.4	1	1356.6	5237.2	2.5	594.5	4.6	121.2	18.4	161
142	5/26/2013	12:18:37	27.6	1	1328.2	5127.5	2.2	565.1	6.1	144.2	17.2	152.1
143	5/26/2013	12:21:24	27.8	1	1314	5072.9	1.9	481.8	5	127.5	17.6	154.7
144	5/26/2013	12:24:09	28	1	1163	4489.8	1.9	475.8	4.5	114.8	16.1	141.5
145	5/26/2013	12:27:07	28	1	1812.3	6996.5	1	404.5	6.9	204.8	35.4	310.8
146	5/26/2013	12:29:58	27.8	1	1544.7	5963.4	3.4	795	6.7	155.3	17.9	157.9
147	5/26/2013	12:32:39	28	1	1469.4	5672.9	3.1	725.6	6.1	139	15	132.7
148	5/26/2013	12:35:17	28.2	1	1900.8	7338.1	4.4	1007.1	7	166.5	20.5	180.1
149	5/26/2013	12:38:16	28.2	1	1690.8	6527.6	3.9	893.1	5.3	137	20.4	178.4

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150	5/26/2013	12:40:59	28.4	1	1572.5	6070.7	3.9	880.9	6.5	144.8	15.4	135.4
151	5/26/2013	12:43:45	28.4	1	1837.3	7093	4.1	944.8	7.5	170.6	19	167.4
152	5/26/2013	12:46:31	28.8	1	1818.6	7020.7	4.3	992.5	7.3	165.9	18	158.5
153	5/26/2013	12:49:41	29	1	1682.9	6496.8	3.7	874.2	7.5	167.4	17	150.1
154	5/26/2013	12:52:13	29.3	1	1667.3	6436.7	3.6	861.6	7.9	174.7	17.6	155.8
155	5/26/2013	12:55:00	29.4	0	1587.9	6130.1	3.8	876.2	5.8	141.7	18.8	164.7
156	5/26/2013	12:57:45	29.8	1	1597.8	6168.5	3.4	802.8	6.5	150.6	17.6	154.8
157	5/26/2013	13:00:27	30	1	1352	5219.5	2.9	680.7	5.2	128.5	16.9	148.9
158	5/26/2013	13:03:07	30.2	1	1248.3	4819	2.1	524.5	6.2	140	14.3	126.9
159	5/26/2013	13:05:50	30.5	1	1137.8	4392.7	1.7	441.8	4.6	116.9	16.5	145.2
160	5/26/2013	13:08:33	30.6	1	1094.9	4227.1	1.8	459.5	5.6	126.9	13.3	118.5
161	5/26/2013	13:11:48	31	1	1699.3	6560.3	0.8	354	8.1	207.9	28.6	253
162	5/26/2013	13:15:54	31.4	1	1672.9	6458.2	0.8	360.9	8.9	226.8	30.2	267.2
163	5/26/2013	13:18:58	31.8	1	1336.8	5160.9	2.3	574.9	5.3	133.7	18.1	159.4
164	5/26/2013	13:21:50	31.8	1	1484.3	5730.2	3.5	793.2	5.2	125.4	16	140.1
165	5/26/2013	13:24:39	32	1	1488.2	5745.2	3.8	856	5.1	121.2	15.5	135.3
166	5/26/2013	13:27:29	32	1	1379.1	5324.2	3.4	754	4.2	106	15.5	135.8
167	5/26/2013	13:30:10	32.2	1	1434.4	5537.6	2.1	549.6	6	148	19.1	168.4
168	5/26/2013	13:32:42	32.2	1	1428.2	5513.5	2.6	636	5	130.1	19.4	170.5
169	5/26/2013	13:35:20	32.5	1	1375.9	5311.7	2.9	691.3	5	128.5	18.4	161
170	5/26/2013	13:38:20	32.6	0	1385.2	5347.6	2.6	627.9	4.9	121.7	16.5	145.2
171	5/26/2013	14:01:54	34.6	1	1320.9	5099.3	2.5	608.8	4.9	123.2	17.1	149.9
172	5/26/2013	14:04:39	34.6	1	1346	5196.4	2.3	563.9	4.8	128.5	19.6	171.9
173	5/26/2013	14:07:17	34.5	1	1383.6	5341.5	2.3	573.6	5.4	132.7	17.5	153.7
174	5/26/2013	14:10:00	34.4	1	1613.4	6228.4	4.1	920.7	5.2	134.9	20.1	175.7
175	5/26/2013	14:12:46	34.2	1	1649.2	6367	4.3	981	5.7	144.3	20.6	180.4
176	5/26/2013	14:15:32	34	1	1698.5	6557.1	4.3	977.9	6.8	154.3	16.7	147.4
177	5/26/2013	14:18:19	33.6	1	1770.7	6835.8	4.8	1067.2	6.4	150.1	18.4	161.6
178	5/26/2013	14:21:10	33.4	1	1618.6	6248.8	4.2	944.8	4.8	124.9	19.5	170

g

179	5/26/2013	14:24:11	33	1	1730.6	6681.2	4.4	995.7	6.3	145.4	17.2	151.1
180	5/26/2013	14:26:59	32.8	1	1789.6	6908.7	4.7	1039.9	6	144.9	18.8	164.2
181	5/26/2013	14:29:53	32.6	1	1652.9	6381.1	4.4	973.1	5	129.1	19.5	170
182	5/26/2013	14:32:44	32.2	1	1668.2	6440	4.5	992.6	5.8	137	17.4	152.2
183	5/26/2013	14:35:41	32.1	1	1548.8	5979.1	2.5	622.5	5.5	139.6	19.2	168.9
184	5/26/2013	14:38:36	31.8	1	1663.7	6422.9	4	900.3	5.3	133.8	18.9	165.2
185	5/26/2013	14:41:51	31.7	1	1671.5	6452.8	3.6	826.5	5.6	142.2	20.5	179.4
186	5/26/2013	14:44:31	31.4	1	1751.1	6760.2	3.3	789.4	6.4	159	21.4	188.4
187	5/26/2013	14:47:18	31.3	1	1647.1	6358.8	1.6	484.9	7.3	185.8	25.2	222.5
188	5/26/2013	14:50:01	31	1	1770.8	6836.2	1.5	484.7	8.5	213.7	28.1	248.8
189	5/26/2013	14:52:47	30.8	1	1431.7	5527	1.5	462.6	7.8	184.6	21.5	190.4
190	5/26/2013	14:55:21	30.6	1	1686.5	6510.6	1.5	477.7	8.3	202.6	24.9	220.4
191	5/26/2013	14:58:00	30.4	1	1417.1	5470.6	1.8	508.7	8.3	185.2	18.2	162.1
192	5/26/2013	15:00:35	30.4	1	1650.5	6371.8	2.3	624.8	8.1	192.1	22.3	197.8
193	5/26/2013	15:03:27	30.2	1	1559.2	6019.4	2.9	717.9	7.5	170	18.1	160
194	5/26/2013	15:06:23	30.2	1	1420.7	5484.8	2.7	665.8	6.9	160.5	18.4	162.6
195	5/26/2013	15:10:04	30.2	1	1469.8	5674.3	2.9	712.6	6.8	158.4	18	159.5
196	5/26/2013	15:14:24	30.2	1	1629.6	6291.1	3.5	813.9	7.1	160.6	17.3	153.2
197	5/26/2013	15:17:06	30.2	1	1461.6	5642.6	2.8	675.9	7.5	163.7	15	133.3
198	5/26/2013	15:19:50	30.2	1	1591.5	6143.9	3.5	823.3	6.8	158.5	18.7	164.7
199	5/26/2013	15:22:40	30.2	1	1600.4	6178.4	3.5	808.1	6.8	153.2	16.4	144.8
200	5/26/2013	15:25:26	30.2	1	1544	5960.8	3.3	766.1	6.2	143.8	16.5	145.3
201	5/26/2013	15:29:34	30	1	1631.7	6299.5	3	729.5	6.8	162.7	20.2	177.8
202	5/26/2013	15:33:12	30.1	1	1543.2	5957.5	3.1	745.1	7.3	159.5	14.9	132.2
203	5/26/2013	15:36:02	30	0	1311.7	5063.9	2.4	585.4	5.2	126.9	16	140.5
204	5/26/2013	15:40:23	29.8	1	2045.4	7896.5	1.3	499.7	11.4	280	34.7	307.8
205	5/26/2013	15:44:15	29.8	1	1764.1	6810.5	1	403.9	7.2	204.2	33.3	292.9
206	5/26/2013	15:47:57	30	1	1578.9	6095.5	1.1	400.4	8.4	206.7	26	230.3
207	5/26/2013	15:51:15	30.2	1	1431.9	5528	1.6	475.2	7.5	176.3	20	177.3

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208	5/26/2013	15:54:49	30.5	1	1514.5	5846.7	2.4	613.1	7.7	175.2	18.3	162.6
209	5/26/2013	15:59:39	30.6	1	1437.3	5548.7	3.1	735.1	6.4	151.6	18.5	163.1
210	5/26/2013	16:03:20	30.5	1	1460.2	5637.2	3.2	750.6	6.9	154.2	15.5	137.4
211	5/26/2013	16:06:48	30.4	1	1310.4	5058.8	3.1	716.2	5.8	132.1	14.3	125.8
212	5/26/2013	16:10:14	30.2	1	1536.6	5932	3.8	854.6	5.8	135.9	16.2	142.7
213	5/26/2013	16:13:56	30.2	1	1481.5	5719.6	3.7	846.1	6.6	147.4	15	132.7
214	5/26/2013	16:17:43	30	1	1710.1	6602	4.1	948	7.5	169.5	18.4	162.1
215	5/26/2013	16:28:45	29.3	1	1672.1	6455.4	3.8	876.8	6.1	145.4	18.1	159
216	5/26/2013	16:32:26	29	1	1813.6	7001.6	4.2	958.6	6.4	158.6	21.7	190
217	5/26/2013	16:36:14	28.6	1	1776.2	6857	4.1	940.9	7.3	168.5	18.9	166.3
218	5/26/2013	16:40:00	28.2	1	1698.9	6558.8	3.6	849.1	6.7	161.6	20.5	180.5
219	5/26/2013	16:44:20	27.8	1	1697	6551.2	3.7	858.5	5.6	147	22.3	195.2
220	5/26/2013	16:48:24	27.7	1	1605.7	6198.9	3.2	773.5	6.9	162.1	19	167.3
221	5/26/2013	16:52:10	27.4	1	1585.8	6121.9	3	740.5	6.9	166.3	20.5	180.5
222	5/26/2013	16:55:36	27.4	1	1455.4	5618.7	2.2	551.7	5.3	138	19.7	173.6
223	5/26/2013	16:59:12	27.4	1	2115.6	8167.5	1.5	527.7	8.3	235.4	38.8	341.5
224	5/26/2013	17:03:43	27.7	1	1455.4	5618.8	1.8	494.6	6.6	164.7	21.4	188.8
225	5/26/2013	17:07:26	28	1	1397.8	5396.3	1.2	407.1	8.3	189.4	19.1	170.5
226	5/26/2013	17:11:33	28.2	1	1538.2	5938.4	0.9	352.2	6.3	182.6	30.6	269.1
227	5/26/2013	17:15:08	28.4	1	1391.1	5370.3	1.4	424.4	6.9	166.8	20.2	178.8
228	5/26/2013	17:18:27	28.5	1	1434.6	5538.2	1.5	443.3	7.1	171.6	21	186.2
229	5/26/2013	17:22:10	28.2	1	1442.3	5568.3	2.3	601	7.6	168.4	15.9	141.7
230	5/26/2013	17:26:44	28	1	1455.6	5619.5	2.2	575.3	7.1	162.6	17.7	156.9
231	5/26/2013	17:29:53	27.8	1	1538.8	5940.5	3.2	775.6	8.2	178.4	16.6	148
232	5/26/2013	17:35:23	27.4	1	1549.2	5980.8	2.9	723.2	7.7	171.6	16.9	150.1
233	5/26/2013	17:38:44	27.2	1	1380.1	5327.8	2.5	626.5	7.3	162.6	15.9	141.1
234	5/26/2013	17:42:17	26.9	1	1487.1	5740.9	2	521.9	5.7	138.5	17.5	154.2
235	5/26/2013	17:45:30	26.6	1	1411.1	5447.7	2.2	582.1	7.6	168.9	16.7	148.4
236	5/26/2013	17:48:45	26.1	1	1431.2	5525.1	2.6	639.7	6.8	155.8	16.5	146.3

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237	5/26/2013	17:52:05	25.5	1	1558	6014.8	2.7	683.3	7.9	180.5	19.2	170
238	5/26/2013	17:55:18	25.3	1	1525.4	5888.9	2.7	681.2	7.1	166.3	19.3	171
239	5/26/2013	17:58:39	24.9	1	1456.7	5623.5	2.8	680.1	6.8	158.4	17.8	157.4
240	5/26/2013	18:02:10	24.5	1	1370.5	5291	3	700.2	5	120.6	15.7	137.9
241	5/26/2013	18:05:41	24.1	1	1394.3	5382.6	2.7	649.5	6.6	150	15.6	138.5
242	5/26/2013	18:09:45	23.7	1	1140	4401	1.9	485.2	5.2	122.2	14	123.7
243	5/26/2013	18:13:39	23.5	1	1535.8	5928.9	1.4	438.6	7.1	184.7	25.8	228.2
244	5/26/2013	18:16:13	23.3	1	1133.5	4375.9	1.4	398.3	6.2	144.7	15.7	139.9
245	5/26/2013	18:19:00	23.1	1	1232.9	4759.5	1.3	402	6.7	157.8	17.5	155.7
246	5/26/2013	18:22:09	22.9	1	1143.1	4413.1	1.5	423.4	6.1	140.5	15.3	136.3
247	5/26/2013	18:24:39	22.9	1	1282.1	4949.7	2	513.1	6.2	142.6	15.8	140
248	5/26/2013	18:27:10	22.9	1	1278	4933.7	1.8	487.5	7	158.9	16.1	143.7
249	5/26/2013	18:29:44	22.9	1	1425.4	5502.8	2	539.2	6.6	159.5	19.8	175.2
250	5/26/2013	18:32:14	22.9	1	1451.7	5604.2	3	724.7	7.3	159	14.9	132.2
251	5/26/2013	18:35:26	22.8	0	1500.8	5794.1	2.6	650.3	7.5	169.5	17.2	152.7
252	5/26/2013	18:38:01	22.7	1	1623.7	6268.5	3	731.6	7.6	170.5	17.4	154.2
253	5/26/2013	18:40:41	22.5	1	1547.1	5972.8	3.2	753.5	6.7	156.4	17.8	157.4
254	5/26/2013	18:43:13	22.5	1	1368	5281.4	2.7	648.9	6.5	146.3	15.1	133.7
255	5/26/2013	18:47:54	22.3	1	1257	4852.8	2.5	612	6	135.8	14.1	124.8
256	5/26/2013	18:50:53	22.1	1	1384.9	5346.3	2.3	586.2	6.6	150.5	16.1	142.7
257	5/26/2013	18:53:23	22.1	1	1281.3	4946.4	2.4	585.4	5.7	131.6	14.7	130
258	5/26/2013	18:55:53	22	1	1247.3	4815.1	2.2	554.4	6.3	143.6	15.2	135.2
259	5/26/2013	18:59:38	21.7	1	1442.9	5570.2	1.5	451.1	6.7	166.8	21.5	189.9
260	5/26/2013	19:02:43	21.7	1	1195.6	4615.8	2.5	595.2	6.5	134.2	10.4	92.8
261	5/26/2013	19:05:48	21.7	1	1051.5	4059.3	2.1	515	5.2	113.8	10.6	93.9
262	5/27/2013	13:20:10	26.1	1	1038.6	4009.7	2.2	530.1	5	114.3	12.4	109.6
263	5/27/2013	13:24:56	26.6	0	849.5	3279.6	1.6	385.3	3.8	84.4	8.5	74.9
264	5/27/2013	13:27:59	26.5	1	1308.6	5052.1	3	691.7	5.4	125.3	14.7	129.5
265	5/27/2013	13:30:55	25.5	1	1169.6	4515.1	2.4	560.6	4.8	108	11.7	103.3

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266	5/27/2013	13:33:26	24.5	1	1338.3	5166.7	2.6	638.8	6.1	143.7	17.2	152
267	5/27/2013	13:35:50	23.5	1	1188.8	4589.5	2.7	627.6	6.1	129.5	11.4	101.2
268	5/27/2013	13:38:17	22.5	1	1231.3	4753.6	3.1	700.4	4.7	103.3	10.6	93.4
269	5/27/2013	13:40:52	21.7	1	1305.8	5041.1	3.2	724	5.3	119.5	12.8	112.7
270	5/28/2013	14:26:50	27.2	1	1304.2	5034.9	3	697.9	6.4	133.2	10.4	92.8
271	5/28/2013	14:29:23	27.2	1	1156.1	4463.3	2.6	600.9	5.5	118	10.4	92.3
272	5/28/2013	14:31:46	27.4	1	1109.8	4284.3	2.6	593.5	4.9	105.9	9.8	87.1
273	5/28/2013	14:34:55	27.7	1	1131.2	4367.2	2.7	611.9	4.9	107.5	10.3	91.2
274	5/28/2013	14:38:01	27.7	1	1334.9	5153.6	3.4	760.2	5.9	125.3	11.2	99.6
275	5/28/2013	14:40:27	27.4	0	1175.2	4537	3.1	696.7	4.8	102.8	9.6	85
276	5/28/2013	14:43:32	27.4	1	1183.2	4567.7	2.8	647.8	5	109.6	10.8	95.4
277	5/28/2013	14:46:12	27.4	1	1273.1	4914.9	3.1	715.1	5.8	125.8	11.6	102.8
278	5/28/2013	14:48:52	27.6	1	1192.3	4603	2.9	663.2	5.1	112.2	10.9	96.5
279	5/28/2013	14:51:54	27.4	1	1295.6	5001.9	3.4	761.7	5.7	122.2	11.3	100.2
280	5/28/2013	14:54:57	27.6	1	1233.6	4762.3	3.1	706.7	4.8	109.1	12	105.9
281	5/28/2013	14:58:01	27.7	1	1089.2	4204.9	2.3	545.9	4.9	109.1	11.2	99.1
282	5/28/2013	15:00:45	27.8	1	1269.3	4900.1	1	344.5	6.9	166.2	19.8	175.6
283	5/28/2013	15:04:58	28.2	1	1244.9	4806	1.3	401.5	6.3	152.5	18.9	167.2
284	5/28/2013	15:07:24	28.4	1	1139.9	4400.8	2.3	540.7	5	111.7	11.4	101.2
285	5/28/2013	15:09:47	28.6	1	1146.1	4424.4	2.4	570.5	5.2	113.3	11	97.5
286	5/28/2013	15:13:01	28.9	1	1236.6	4773.9	3	688.9	4.8	109.1	12.2	107
287	5/28/2013	15:15:28	28.8	1	1233.2	4760.7	2.8	650.6	6.2	130.5	11.1	98.6
288	5/28/2013	15:17:55	28.8	1	1157.3	4467.8	2.5	592.5	4.9	110.6	12	105.9
289	5/28/2013	15:20:30	29	1	960.6	3708.5	2.1	485.8	4.2	91.7	9	79.7
290	5/28/2013	15:22:56	28.8	1	1035.2	3996.3	1.1	323.4	4.7	115.3	14.5	128.4
291	5/28/2013	15:25:48	28.8	1	1270.1	4903.1	0.9	325.2	6.9	171.5	21.5	190.8
292	5/28/2013	15:28:15	28.6	1	1266	4887.4	1.4	424	7	165.1	19	168.8
293	5/28/2013	15:30:49	28.5	1	913.1	3525.1	1.5	381.7	3.8	93.8	12.3	108.4
294	5/28/2013	15:35:58	28.8	1	930.5	3592.2	1.9	447.6	3.8	89.6	10.9	95.9

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295	5/28/2013	15:38:36	29	0	950.3	3668.7	2	471.7	3.9	91.7	10.7	94.3
296	5/28/2013	15:41:57	29	1	1126.9	4350.6	2.9	647	4.4	100.7	11.5	101.2
297	5/28/2013	15:44:20	29	1	924.7	3570	2.2	516.1	4.2	93.3	9.7	85.4
298	5/28/2013	15:46:48	29	1	1217.1	4698.8	3.3	728.6	4.4	100.2	11.2	98.6
299	5/28/2013	15:49:40	29	1	1008.6	3893.6	2.5	563.4	3.5	82.8	10.1	88.6
300	5/28/2013	15:52:10	29.3	1	1094.3	4224.5	2.8	635.9	4.3	93.9	9.6	84.4
301	5/28/2013	15:55:08	29.4	1	1131.6	4368.7	2.9	651.1	3.4	82.4	11.4	99.1
302	5/28/2013	15:57:58	29.4	1	1118.1	4316.5	2.7	619.1	4.1	96	11.5	100.7
303	5/28/2013	16:00:26	29.4	1	1137.8	4392.7	2.9	660.5	4.5	102.3	11	97
304	5/28/2013	16:02:53	29.4	1	1018.2	3930.9	2.8	618.8	3.5	78.7	8.7	76
305	5/28/2013	16:05:18	29.8	1	1110.1	4285.5	2.8	631.2	3.6	85.5	11.2	97.5
306	5/28/2013	16:07:55	30	1	1158.7	4473	3.1	687.3	4.1	96.5	11.8	103.8
307	5/28/2013	16:10:30	30.5	1	1396.1	5389.7	4.1	889.1	4.2	101.2	13.7	119.6
308	5/28/2013	16:13:07	30.9	1	947.1	3656.4	2.8	600.4	2.8	65.6	8.2	71.8
309	5/28/2013	16:15:47	31	1	912.3	3521.9	2.6	569.9	3.4	76.5	8.4	73.9
310	5/28/2013	16:19:12	31	1	925.2	3571.7	2.9	617	2.2	57.7	9.6	83.3
311	5/28/2013	16:23:36	30.9	1	1315.2	5077.4	1.7	475.9	6.2	150	18.1	159.9
312	5/28/2013	16:26:04	30.8	1	1635.8	6315.2	1.2	442.9	8.8	221.9	29.5	260.7
313	5/28/2013	16:29:17	30.9	1	1411.7	5450.1	1	356.2	6.5	172.6	25	220.2
314	5/28/2013	16:31:44	30.9	1	1751.4	6761.4	1.4	489.7	10.1	239.8	27.8	246.6
315	5/28/2013	16:34:29	30.8	1	1183.5	4569.1	1.4	399.9	6.5	149.9	15.8	140.5
316	5/28/2013	16:37:42	31	1	1434.1	5536.5	1.5	452.1	7.1	176.2	23	203.5
317	5/28/2013	16:40:07	30.9	1	1326.5	5121.1	1.6	447.2	5.8	147.9	20.1	177.2
318	5/28/2013	16:42:28	30.9	1	1151.4	4445	1.3	375.3	4.3	116.9	18.4	161.9
319	5/28/2013	16:44:54	31	1	1456.8	5624	1.5	459	7.4	181	22.6	200.4
320	5/28/2013	16:50:03	31.3	1	1229.4	4746.2	1.9	482.1	5.5	132.1	16.3	144.1
321	5/28/2013	16:52:26	31.4	1	1234.5	4766	2.1	526.6	5.9	137.9	15.8	139.4
322	5/28/2013	16:55:00	31.4	1	1140.9	4404.7	2.1	512.4	4.5	110.1	14.1	123.7
323	5/28/2013	16:57:24	31.4	1	1207.3	4661	1.5	414.6	5.4	136.8	18.4	162.5

324	5/28/2013	16:59:52	31.2	1	1017.4	3927.7	2.1	492.3	3.6	89.7	12.4	109
325	5/28/2013	17:02:13	31.3	1	1205.2	4652.8	2	504	5.2	127.9	16.5	145.7
326	5/28/2013	17:04:36	31.2	1	1222.2	4718.4	1.9	502.5	5.4	134.7	18.1	159.8
327	5/28/2013	17:06:57	31	1	1267.7	4894.2	2.3	565.9	4.5	120.1	18.7	164
328	5/28/2013	17:09:23	30.8	0	1174.5	4534.4	2.5	594.1	4.6	110.6	14.1	124.2
329	5/28/2013	17:11:51	30.6	1	1406.3	5429.1	2.7	628.8	5.3	122.7	14.1	124.3
330	5/28/2013	17:14:15	30.4	1	1049.7	4052.5	1.4	378.4	5.2	121.6	13.6	120.6
331	5/28/2013	17:16:57	30.2	1	1331.9	5141.9	0.9	333.1	6.7	175.7	24.7	218.1
332	5/28/2013	17:19:23	30.2	1	1231.9	4755.7	1	335.6	5.4	143.7	21.5	189.2
333	5/28/2013	17:21:53	30.6	1	1479.2	5710.4	1	358.9	6.4	173.7	26.4	232.9
334	5/28/2013	17:24:30	30.6	1	1097.9	4238.6	0.8	287.8	5.8	141.5	17.4	154.6
335	5/28/2013	17:37:49	31	1	1213.4	4684.5	1.3	395.7	5.9	145.7	18.9	167.2
336	5/28/2013	17:40:12	31.4	1	1260.3	4865.4	1.6	452.8	5.9	145.7	18.5	163.5
337	5/28/2013	17:45:03	31.6	1	1174.2	4533	2.2	544.4	4.8	123.7	17.7	155.1
338	5/28/2013	17:47:27	31.4	1	1155.7	4461.7	2.4	564.3	4.3	102.3	12.6	111.1
339	5/28/2013	17:49:54	31.2	1	1219.5	4707.9	2.5	598.8	5.1	120.1	14.3	125.8
340	5/28/2013	17:52:14	30.9	1	1117.1	4312.8	2.4	546.4	3.6	91.3	12.9	113.2
341	5/28/2013	17:54:42	30.6	1	1118.6	4318.4	2.5	589.3	4.5	105.4	12.8	112.2
342	5/28/2013	17:57:05	30.4	1	1143.3	4413.8	2.6	596.7	4.5	107	13.1	114.8
343	5/28/2013	18:04:20	29.7	1	1154.4	4456.7	2.7	614	4.3	104.9	13.8	121.1
344	5/28/2013	18:06:36	29.4	1	1104.2	4263	2.4	547.4	3.8	94.4	13.1	114.8
345	5/28/2013	18:08:57	29	1	1336.4	5159.1	1.9	511.1	5.7	144.7	19.9	175.1
346	5/28/2013	18:11:31	28.6	1	1485.1	5733.3	1.1	386.2	7.3	180.5	23	203.5
347	5/28/2013	18:13:55	28.5	1	1240.4	4788.6	1.9	490.4	6	143.1	17	150.4

Cody Section – Paul Stock Nature Trail

Id	Date	Time	Temp	Stabilized	Total[ppm]	Total[cpm]	K[%]	K[cpm]	U[ppm]	U[cpm]	Th[ppm]	Th[cpm]

												m
360	6/3/2013	11:09:07	17.5	1	1777.3	6861.3	2	579.9	8.9	216.2	26.9	237.7
361	6/3/2013	11:13:31	17.9	1	1503.5	5804.3	2.6	645	6.9	160.5	18.2	161
362	6/3/2013	11:17:38	17.7	1	1448.1	5590.5	3.3	766.2	5.5	132.7	17.1	150.5
363	6/3/2013	11:21:25	17.6	1	1496.1	5775.7	3	718.7	5.9	146.9	19.7	173.6
364	6/3/2013	11:26:28	17.3	1	1478	5705.8	3	722.8	5.9	142.7	18	158.4
365	6/3/2013	11:30:54	17.2	1	1511.5	5835.3	3.1	739.8	6.5	152.7	17.8	157.4
366	6/3/2013	11:34:39	17.2	1	1576	6084.1	4.3	967.9	6.2	137.5	14.7	129.6
367	6/3/2013	11:38:07	17.1	1	1478.3	5707.2	3.6	822.4	5.9	135.3	15.4	135.3
368	6/3/2013	11:46:43	17.1	1	1550.4	5985.4	1.7	513.5	8.2	196.2	23.1	205.1
369	6/3/2013	11:49:37	17.1	1	2144.8	8280.1	1.3	505.7	10.8	274.8	36.9	326.8
370	6/3/2013	11:53:04	17.3	1	1355.5	5232.8	1.9	506.9	6.3	154.2	19.3	170.9
371	6/3/2013	12:01:32	17.2	1	1319.4	5093.5	2.2	565.5	6.6	151.5	16.3	144.7
372	6/3/2013	12:05:09	17.1	1	1323.7	5110.2	2.5	616.7	6.1	143.1	16.9	149.4
373	6/3/2013	12:09:00	16.9	1	1190.2	4594.8	2.4	581.5	5.2	123.7	15.3	135.2
374	6/3/2013	12:13:31	16.9	1	1172.7	4527.1	2.4	576.3	4.6	117.4	16.5	144.7
375	6/3/2013	12:17:55	16.7	1	1313.2	5069.8	2.4	596.3	6.7	151	15.7	139.4
376	6/3/2013	12:22:03	16.8	1	1242.8	4797.9	2.1	531.3	5.7	138.9	17.3	152.5
377	6/3/2013	12:26:28	16.7	1	1461.4	5642	2.2	571.1	7	167.3	19.7	174.7
378	6/3/2013	12:29:37	16.7	1	1061.5	4098.1	1.9	462	4	101.2	14.3	125.2
379	6/3/2013	12:33:32	16.9	1	1247	4814.2	2.4	585.7	5.4	130	15.9	139.9
380	6/3/2013	12:37:09	16.7	1	1396.7	5392.1	2.8	674.6	5.7	134.8	16.2	142.6
381	6/3/2013	12:41:19	16.7	1	1340.7	5175.8	2.7	644.6	5.2	124.3	15.4	135.3
382	6/3/2013	12:45:26	16.7	1	1142	4408.8	2.1	521.8	6.1	133.7	12.4	110.6
383	6/3/2013	12:48:59	16.5	1	1178	4547.6	2.3	559	5.1	122.2	14.7	130
384	6/3/2013	13:08:41	16.5	1	979.6	3781.7	2	476	4.6	105.9	12	105.8
385	6/3/2013	13:12:42	16.9	1	1165.7	4500.4	1.7	460.6	5.9	140	16.3	144.1
386	6/3/2013	13:19:13	16.9	1	1168.6	4511.5	1.4	392	5.7	140	18	158.8
387	6/3/2013	13:23:26	17.2	1	1115.2	4305.1	1.2	367.4	6.1	144.1	16.2	143.6
388	6/3/2013	13:27:49	17.3	1	968.2	3737.9	1.5	391.8	4.6	110	13.5	118.9

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389	6/3/2013	13:31:12	17.6	1	1053	4065.2	1.8	450	5.2	117.9	12.3	109.5
390	6/3/2013	13:35:49	17.9	1	1083.2	4181.8	2.1	525.4	5.9	128.9	11.7	104.3
391	6/3/2013	13:40:06	18.1	1	1145.4	4421.8	2.4	581	5.2	121.1	14.2	125.3
392	6/3/2013	13:49:16	18.9	1	1092.4	4217.1	2.4	556.8	4.7	104.3	10.7	94.4
393	6/3/2013	13:54:43	19.3	1	1176.2	4540.8	2.5	594.6	4.4	107	14.2	124.8
394	6/3/2013	13:58:38	19.6	1	1054.7	4071.9	2.4	566.6	4.2	100.1	12.5	110.1
395	6/3/2013	14:03:46	19.5	1	1261.1	4868.7	1.7	464.4	7.4	163	15.5	138.4
396	6/3/2013	14:06:38	19.5	1	1061.4	4097.7	2	499.2	5.4	119.5	12	106.4
397	6/3/2013	14:10:48	19.7	1	1140.3	4402.1	2.3	564.8	6.1	131.1	11.9	105.9
398	6/3/2013	14:14:12	19.7	1	1077.5	4159.9	2.1	503.9	5.2	114.8	11.5	101.7
399	6/3/2013	14:21:03	20.1	1	1189.3	4591.5	2.5	585.7	4.8	109.1	11.9	105.4
400	6/3/2013	14:25:45	20.4	1	1038.7	4009.9	2.2	526.3	4.5	104.3	12.1	106.9
401	6/3/2013	14:48:12	20.3	1	952.2	3676.1	1.8	433	4.3	99	10.6	93.8
402	6/3/2013	14:52:18	20.4	1	1100.1	4247.2	1.2	350.6	5.6	136.3	16.4	145.7
403	6/3/2013	14:56:25	20.3	1	964.5	3723.5	1.7	434.5	4.4	104.8	12.7	112.1
404	6/3/2013	15:02:40	20.1	1	1031	3980.4	2.1	508.4	4.3	101.1	11.8	104.3
405	6/3/2013	15:06:06	19.9	1	1149.2	4436.5	2.6	603	3.6	92.8	13.7	120
406	6/3/2013	15:11:45	19.5	1	1057.7	4083.3	2.4	553.6	3.9	100.1	14.2	124.7
407	6/3/2013	15:16:55	19.3	1	1104.5	4264	2.4	551.1	4.1	98.6	12.6	110.6
408	6/3/2013	15:21:22	19.2	1	1001	3864.4	2.3	531.9	3.9	94.9	12.2	107.4
409	6/3/2013	15:27:33	18.9	1	989.5	3820.1	2.1	494.7	4	95.9	12.2	107.4
410	6/3/2013	15:33:42	18.9	1	971.5	3750.6	2	474.2	3.8	93.3	12.6	110.5
411	6/3/2013	15:41:48	20.4	1	965.3	3726.8	2	481.1	4.4	103.2	11.9	104.8
412	6/3/2013	15:46:32	21.5	1	908.6	3507.8	1.9	440.8	3.2	77.1	9.7	85.4
413	6/3/2013	15:51:37	22.5	1	985	3802.5	2.3	524.5	3.2	81.2	12	104.8
414	6/3/2013	15:55:43	22.7	1	971.3	3749.7	2.2	503	4	91.2	10.3	91.2
415	6/3/2013	15:59:05	22.9	1	1000.4	3862.2	2.3	522.9	3.3	84.4	12	105.3
416	6/3/2013	16:05:15	22.5	0	1017	3926	2.1	482.2	3.1	80.7	12.3	107.9
417	6/3/2013	16:08:23	22.1	1	998.3	3854.1	2	474.3	3	82.3	13.3	116.3

o

418	6/3/2013	16:12:13	21.9	1	1033.8	3990.9	2.2	518.4	3.8	98.5	14.2	124.7
419	6/3/2013	16:16:58	22.1	1	944.5	3646.1	1.9	453.3	3.2	83.9	12.6	110.5
420	6/3/2013	16:23:33	22.8	1	1055	4072.8	2.2	520.6	4.2	101.2	12.8	112.7
421	6/3/2013	16:26:41	22.9	1	1013.4	3912.1	2.2	525.8	4.2	103.8	13.5	118.9
422	6/3/2013	16:30:23	23.3	1	1033.4	3989.5	2.3	547.1	4.4	108	13.9	122.1
423	6/3/2013	16:33:59	23.5	1	1031	3980.2	2.2	520	3.8	94.9	13.3	116.3
424	6/3/2013	16:37:39	23.7	1	1001.3	3865.7	2.3	540.2	3.6	91.2	13.3	116.3
425	6/3/2013	16:41:38	24.1	1	994.4	3839	2.2	520.3	4.3	101.1	11.7	103.2
426	6/3/2013	16:47:52	24.4	1	1028.2	3969.6	2.2	514.7	3.2	86.5	13.7	120
427	6/3/2013	16:53:23	24.4	1	1097.2	4235.7	2.3	532.1	3.6	93.3	13.6	119.5
428	6/3/2013	16:57:49	24.4	1	1058.3	4085.6	2.3	537.8	4	102.7	15.2	133.1
429	6/3/2013	17:53:46	22.5	1	1089.7	4206.8	2	499.8	4.8	114.3	14	123.2
430	6/3/2013	17:58:49	23.1	1	1362.2	5258.8	2.9	670.6	5.1	123.7	16.1	141.5
431	6/3/2013	18:01:43	23.3	1	1129.8	4361.8	2.2	545.3	4.8	119	15.5	136.8
432	6/3/2013	18:05:22	23.5	1	1260.3	4865.4	3	701.4	4.7	117.4	16.4	143.6
433	6/3/2013	18:08:42	23.5	1	1375.8	5311.4	3.4	776.4	5.5	131.1	16.2	142.1
434	6/3/2013	18:12:14	23.7	1	1448.8	5593.3	3.6	804.3	4.6	114.3	15.9	138.9
435	6/3/2013	18:15:58	24.1	1	1425.1	5501.6	3.5	798.4	5.7	136.3	17.2	151.5
436	6/3/2013	18:20:17	24.8	1	1384	5343.1	3.3	769	5.4	128.4	15.8	138.9
437	6/3/2013	18:23:32	25.2	1	1417.2	5471	3.4	783.8	5.4	125.9	15.2	133.2
438	6/3/2013	18:27:56	25.3	1	1735.3	6699	2.5	670.3	9.7	212.5	19.4	173.1
439	6/3/2013	18:31:35	25.6	1	1633	6304.1	1.4	443.3	6.4	177.3	28.1	247
440	6/3/2013	18:34:59	25.5	1	1686.9	6512.2	1.4	460.1	5.7	181	35	306.3
441	6/4/2013	11:41:00	18.5	1	1812.2	6996.1	1.5	484.6	6.4	195.8	35.8	313.8
442	6/4/2013	11:46:34	17.9	1	2642.9	10203	2.6	821.5	16.9	368.1	32.1	288.2
443	6/4/2013	11:50:33	17.7	1	1684.7	6503.9	2.7	687.6	6.5	166.9	23.3	205.1
444	6/4/2013	11:55:14	17.3	1	2149.5	8298.1	2.9	819.3	13.6	292.5	24.8	222.7
445	6/4/2013	12:02:37	16.3	1	1924.1	7427.9	3	782.2	8.7	211.1	26	230
446	6/4/2013	12:08:23	15.9	1	1907	7362.1	3	769.5	8.3	201.6	25.5	225.2

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447	6/4/2013	12:11:31	15.7	1	1367.8	5280.5	2.2	566.6	6.3	154.7	19.7	173.5
448	6/4/2013	12:19:21	15.3	1	1283.8	4956.2	2.7	647	4.9	121.6	16.4	143.6
449	6/4/2013	12:24:11	15.3	1	1325.7	5118	2.5	605.6	4.6	118.5	17.4	152.5
450	6/4/2013	12:29:04	15.1	1	1133.8	4377.1	2.4	565.3	4.2	108.5	16.2	142
451	6/4/2013	12:33:02	15.2	1	1323.5	5109.5	2	535.7	5.6	145.8	21.2	186.1
452	6/4/2013	12:37:13	14.9	0	1418	5474.1	2.4	597.7	6.2	150	18.9	166.8
453	6/4/2013	12:42:49	14.9	1	1477.4	5703.5	2.2	581.1	7	174.7	23.3	205.6
454	6/4/2013	12:46:53	14.9	1	1374.5	5306.2	2.2	559.8	6.3	153.6	19.7	173.5
455	6/4/2013	12:49:40	14.9	1	1290.5	4981.9	2.5	613	5.6	136.8	17.3	152
456	6/4/2013	12:55:46	15.1	1	1190.3	4595.1	2.5	593	4.6	112.2	14.6	128.4
457	6/4/2013	12:59:59	15.1	1	1188.3	4587.4	2.2	540.7	4.6	113.8	15.3	134.2
458	6/4/2013	13:03:14	15.2	1	1019.6	3936.1	1.9	469.8	4	98.6	13.2	116.3
459	6/4/2013	13:07:38	15.2	1	1199.5	4630.9	1.6	423.4	5	127.4	17.7	155.7
460	6/4/2013	13:12:28	14.9	1	1150.8	4442.8	2.2	538.1	4.3	113.8	17.5	153
461	6/4/2013	13:16:42	14.9	1	1129.7	4361.4	2.1	506.1	3.7	103.8	17.7	154.6
462	6/4/2013	13:20:04	14.7	1	1094.5	4225.3	2	479.4	3.7	100.7	16	140.5
463	6/4/2013	13:23:48	14.8	1	1170.9	4520.2	2.1	521.8	4.3	111.2	16.2	142
464	6/4/2013	13:27:35	14.7	1	1198.8	4628.1	2.6	605.1	4.8	116.4	15.2	133.7
465	6/4/2013	13:35:40	14.9	1	1015.9	3921.8	2.3	540.3	3.8	98	14.2	124.7
466	6/4/2013	13:40:51	15.1	1	1264.1	4880.3	2.7	627.6	3.7	100.2	16.3	142.6
467	6/4/2013	13:44:50	15.2	1	1181.6	4561.6	2.3	548	4.4	111.7	15.8	138.9
468	6/4/2013	13:49:15	14.9	1	1108.2	4278.1	1.7	453.7	5.5	130	15.3	135.7
469	6/4/2013	13:52:42	14.5	1	1143.2	4413.6	2.2	525	3.9	107.5	17.3	151.5
470	6/4/2013	13:55:57	14.4	1	1073.4	4143.8	2.1	506.1	4.4	108.5	14	123.2
471	6/4/2013	13:59:50	14.1	1	1043	4026.4	2	488.7	4.3	105.4	14	123.2
472	6/4/2013	14:02:51	13.9	1	955.6	3689.2	2	473.8	3.6	90.1	12.7	111.6
473	6/4/2013	14:06:25	13.7	1	1057.4	4082.2	2.5	572	3.9	98.1	13.5	118.5
474	6/4/2013	14:10:13	13.6	1	1063.8	4107	2.1	502.4	3.8	101.7	15.7	137.3
475	6/4/2013	14:27:51	13	1	998.2	3853.5	2	472.9	3.2	86.5	13.7	120

q

476	6/4/2013	14:30:58	13	1	1004.2	3876.9	2	463.9	3	83.9	13.8	120.5
477	6/4/2013	14:34:06	12.8	1	1002.3	3869.6	2.2	516.3	4	94.4	11	97
478	6/4/2013	14:39:59	12.8	1	1029	3972.5	2.3	527.8	3.2	89.6	15.4	134.6
479	6/4/2013	14:43:00	12.8	0	1063.9	4107.3	2.2	523.2	3.2	88.1	14.7	128.4
480	6/4/2013	14:49:14	12.8	1	1158.9	4474.2	2	491.5	4.4	114.8	16.7	146.7
481	6/4/2013	14:52:33	12.8	1	1129.9	4362	1.8	473.1	4.2	116.4	19.2	168.2
482	6/4/2013	14:55:49	12.8	1	1108.9	4280.9	1.5	407.2	4.2	114.8	18.1	158.8
483	6/4/2013	14:59:15	13	1	1040	4015.1	1.8	450.5	3.9	104.3	16	140.4
484	6/4/2013	15:02:23	13	1	1081.9	4176.8	2.1	497.7	2.6	86	17.9	155.6
485	6/4/2013	15:05:45	12.8	1	1027.8	3967.8	2	489.1	3.4	93.8	15.5	135.7
486	6/4/2013	15:09:07	12.8	1	1099.6	4245.1	2.1	513.9	3.4	99.1	17.6	153.5
487	6/4/2013	15:12:21	12.8	1	1070.8	4133.7	2	481.4	3.9	99.6	14	122.6
488	6/4/2013	15:16:51	12.8	1	1132.1	4370.4	2	506.6	3.8	109.1	18.9	165.1
489	6/4/2013	15:20:06	12.8	1	1225	4729	2.3	548.6	4.1	108.6	16.6	145.2
490	6/4/2013	15:22:48	12.8	1	1068.9	4126.4	2.1	513.8	4.6	111.6	13.9	122.1

Poverty Flats Section

Id	Date	Time	Temp	Stabilized	Total[ppm]	Total[cpm]	K[%]	K[cpm]	U[ppm]	U[cpm]	Th[ppm]	Th[cpm]
491	6/5/2013	14:55:27	26.5	1	2168.3	8370.8	2	624.4	8.8	244.4	39	343.1
492	6/5/2013	14:58:19	26.9	1	2182.4	8425.3	1.8	595	10.3	269.6	38.2	336.8
493	6/5/2013	15:01:32	27	1	1827.4	7054.7	1.8	553.4	8.3	210	28.5	252
494	6/5/2013	15:04:46	26.9	1	1520.7	5870.7	1.8	532.4	8.5	195.7	20.7	184.1
495	6/5/2013	15:07:50	26.6	1	1537.2	5934.3	2	551.3	7.6	182	21.9	194.1
496	6/5/2013	15:11:05	26.1	1	1391.6	5372.3	2	526.5	6.6	158.4	19.2	169.9
497	6/5/2013	15:14:30	26.1	1	1579.5	6097.8	2.5	637.8	6.4	163.2	22.8	200.9
498	6/5/2013	15:17:16	26.1	1	1370.5	5291	2.1	538.3	6.7	155.7	17.1	151.5
499	6/5/2013	15:21:22	26.1	1	1390.8	5369.2	2.1	555.8	6.8	157.3	17.4	154.2
500	6/5/2013	15:24:52	26.1	1	1173.6	4530.6	1.6	436.5	5.3	130	16.5	145.7

r

501	6/5/2013	15:29:46	26.9	1	1247.8	4817	1.7	460.7	6.3	148.4	17.2	152
502	6/5/2013	15:43:33	28.2	1	2000.3	7722.5	0.9	406.7	7.5	226.4	40.5	356
503	6/5/2013	15:46:52	28.6	1	2038.2	7868.7	1.2	480.2	10.6	267.9	35.1	310.9
504	6/5/2013	15:51:34	29	1	1523.1	5880.1	1.3	439.1	8.2	197.3	23.7	210.3
505	6/5/2013	15:54:16	29.4	1	1389.8	5365.3	1.5	449	7	171	21	186.2
506	6/5/2013	15:56:48	29.8	1	1544	5960.7	1.7	506.7	8.8	204.1	21.9	195.1
507	6/5/2013	15:59:29	29.8	1	1548.8	5979.3	1.7	507.2	7.7	187.8	23	203.5
508	6/5/2013	16:02:09	29.4	1	1697.5	6553.2	1.1	407.9	8.7	211.5	25.8	229.3
509	6/5/2013	16:05:37	28.8	1	1739.1	6713.8	1.2	445.8	10.4	247.3	27.9	248.3
510	6/5/2013	16:09:38	28.5	1	1523.5	5881.4	1.8	521.9	10.2	214.5	16.6	149.5
511	6/5/2013	16:14:17	28	1	1596.8	6164.5	1.2	408.8	7.4	195.2	28	247.1
512	6/5/2013	16:19:06	27.8	1	1434.7	5538.9	1.8	512.9	9	192	15.6	140.6
513	6/5/2013	16:22:10	28	1	1573.5	6074.6	2.6	673.4	8.9	188.9	15.4	138
514	6/5/2013	16:25:59	28.2	1	1599	6172.9	2.7	691.8	10	206.2	14.5	130.7
515	6/5/2013	16:30:07	28.4	1	1578.5	6093.8	2.4	638.3	9.3	198.3	16.7	149.5
516	6/5/2013	16:34:28	28.6	1	1374.9	5307.8	2.4	604.9	7.4	160.5	14.4	128.5
517	6/5/2013	16:38:12	28.6	1	1312.6	5067.5	2	524.2	7.2	154.7	13	116.4
518	6/5/2013	16:42:32	28.9	1	1942.4	7498.7	1.4	504.9	10.1	249.5	31.6	279.9
519	6/5/2013	16:45:52	28.8	1	1520.6	5870.3	2	549.7	8.2	186.2	19.1	170
520	6/5/2013	16:48:45	28.8	1	1483.3	5726.2	2.6	641.4	7.9	170	14.9	132.7
521	6/5/2013	16:52:13	28.6	1	1462.7	5646.8	2.5	628.8	7.1	159	16.3	144.8
522	6/5/2013	16:58:19	28.4	1	1667.6	6438	1.8	538.9	8.4	200.5	23.4	207.8
523	6/5/2013	17:01:55	27.8	1	1828.9	7060.5	1	416	9	228.4	30.3	268.2
524	6/5/2013	17:05:05	27.2	1	1426.6	5507.4	1.7	483.6	6.2	156.3	21.1	186.2
525	6/5/2013	17:08:59	27.3	1	1282.2	4949.8	1.5	441.9	7	162.5	17.6	156.2
526	6/5/2013	17:12:48	27.6	1	1250.3	4827	1.5	437.1	7.8	168.3	14.3	128.4
527	6/5/2013	17:24:18	28.4	1	1384.8	5346	2.3	586.2	7.5	166.8	16	142.7
528	6/5/2013	17:29:18	28.2	1	1270.6	4905.3	2.2	558.6	6.5	145.7	14.9	132.1
529	6/5/2013	17:33:31	28.2	1	1213.6	4685	1.9	495.7	5.9	133.7	14.1	125.3

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530	6/5/2013	17:37:09	28.2	1	1127	4350.8	1.8	469.5	6.4	140.5	12.8	114.3
531	6/5/2013	17:41:35	28.2	1	1261.1	4868.5	2.2	552.3	5.6	130.6	15.2	134.2
532	6/5/2013	17:45:38	28	1	1306.7	5044.7	2.3	569.1	6.5	143.1	13.9	123.7
533	6/5/2013	17:49:35	27.8	1	1478.2	5706.9	2.7	668	7.6	168.9	16.6	147.4
534	6/5/2013	17:53:45	27.8	1	1114.7	4303.5	2	515	6.1	136.3	13.3	118
535	6/5/2013	17:59:44	28.2	1	1274.2	4919.2	1.9	499.4	6.3	144.7	15.4	136.8
536	6/5/2013	18:04:48	28.6	1	1446.3	5583.6	2	540.7	8.5	185.7	16.5	147.4
537	6/5/2013	18:07:55	28.6	1	1191.5	4599.8	1.9	506.7	6.6	148.9	15.3	135.8
538	6/5/2013	18:10:44	28.8	1	1085.2	4189.3	1.8	456.4	5.1	116.4	12.1	107
539	6/5/2013	18:14:22	28.9	1	1191.5	4599.7	2	500.9	6.2	138.9	13.7	122.2

Greybull Platform

Id	Date	Time	Temp	Stabilized	Total[ppm]	Total[cpm]	K[%]	K[cpm]	U[ppm]	U[cpm]	Th[ppm]	Th[cpm]
540	6/7/2013	10:30:26	19.3	0	1096.1	4231.7	0.2	186.2	10.3	195.9	7.4	70.8
541	6/7/2013	10:33:31	20.3	1	1072.2	4139.1	1.8	451.5	4.5	110.1	14.3	125.8
542	6/7/2013	10:36:43	20.8	1	856.5	3306.8	2	448.6	2.8	70.2	10.2	89.1
543	6/7/2013	10:39:18	20.9	1	822.3	3174.4	1.8	411.4	3.2	73.9	8.6	75.5
544	6/7/2013	10:41:49	20.9	1	1025.4	3958.7	1.8	451.6	4	99.6	13.2	115.8
545	6/7/2013	10:44:11	20.9	1	978.9	3779.1	1.9	449.3	3.7	92.3	12.2	106.9
546	6/7/2013	10:47:22	20.9	1	962.3	3715.1	1.9	463.3	3.9	95.9	12.8	112.6
547	6/7/2013	10:50:46	21.1	1	1048.4	4047.3	2	489.8	4.4	109	14.5	127.9
548	6/7/2013	10:54:30	21.2	1	1150.1	4440.2	1.9	479.4	4.7	115.9	15.4	135.2
549	6/7/2013	10:58:09	21.3	0	1053.2	4066.1	1.9	456.8	3.5	94.4	14.8	130
550	6/7/2013	11:01:20	21.3	1	986.9	3810	1.9	456.2	4.1	101.2	13.5	118.9
551	6/7/2013	11:05:12	21.6	1	1000.8	3863.8	1.8	454.1	4.4	104.3	12.8	112.7

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552	6/7/2013	11:08:53	21.7	1	955.7	3689.6	1.9	447.2	2.9	75.5	11.6	101.1
553	6/7/2013	11:13:05	21.9	1	1014.4	3916.3	2	469.8	3.5	91.2	13.3	116.9
554	6/7/2013	11:16:29	21.9	1	1024.6	3955.5	2	465.6	3.7	91.7	12.5	110
555	6/7/2013	11:20:06	22.1	1	946.6	3654.3	1.9	442.9	3.3	84.9	12.2	106.9
556	6/7/2013	11:22:58	22.3	1	953.7	3682	2	471.2	2.8	78.1	13.4	117.3
557	6/7/2013	11:26:12	22.4	1	716.5	2766.3	1.6	377.4	2.6	64	8.7	76.5
558	6/7/2013	11:29:39	22.5	1	914.7	3531.1	2	467.5	3.1	81.8	12.1	106.3
559	6/7/2013	11:32:14	22.7	1	1150.8	4442.9	1.8	470.5	5.1	124.3	15.6	137.9
560	6/7/2013	11:34:49	22.9	1	1175.5	4538.2	2.1	517.7	3.9	103.8	15.9	139.4
561	6/7/2013	11:37:31	23.2	1	1154.6	4457.6	1.9	461.6	3.8	104.4	16.4	144.1
562	6/7/2013	11:40:08	23.5	1	984.9	3802.4	1.8	432.6	4.3	100.6	11.3	100.1
563	6/7/2013	11:42:46	23.7	1	1056.2	4077.5	2.1	492.5	3.1	91.8	16.4	143.6
564	6/7/2013	11:45:18	24.1	1	1045.8	4037.2	1.7	435.9	4.3	104.9	13.3	116.9
565	6/7/2013	11:48:07	24.5	1	1484	5728.9	1.2	391.4	6	161.6	24.2	213
566	6/7/2013	11:50:39	24.9	1	1227.1	4737.5	1.4	412.5	6.6	159.3	19.3	170.8
567	6/7/2013	11:53:25	25.5	1	1119.1	4320.2	2	494.1	4.9	122.2	16.5	145.2
568	6/7/2013	11:56:20	25.9	1	1691.8	6531.4	1.6	499.7	8.1	205.8	27.8	245.6
569	6/7/2013	11:59:21	26.8	1	1517.1	5856.8	1.5	461.1	7	175.2	22.8	201.9
570	6/7/2013	12:03:11	27.4	1	1378.7	5322.5	1.9	507.1	6.7	161	19.2	169.9
571	6/7/2013	12:05:50	27.8	0	1361.5	5256.1	2.2	549.5	5.4	135.3	18.3	161.5
572	6/7/2013	12:08:32	28.5	1	1490.9	5755.7	2.3	594.2	6.7	168.4	22.4	197.2
573	6/7/2013	12:11:12	28.8	1	1388	5358.4	2.1	558.5	6.1	152.1	19.9	175.2
574	6/7/2013	12:13:50	29	1	1284.6	4959.1	2.1	528.2	5.2	131.6	17.8	156.7
575	6/7/2013	12:16:16	29.4	1	1263.2	4876.6	2.3	551.3	4.8	120.6	16.8	147.8
576	6/7/2013	12:20:08	30.1	1	1427.8	5512.2	1.8	478.9	4.8	129.6	20.1	176.8
577	6/7/2013	12:37:36	32.2	1	1379.1	5323.9	2.1	532	5.2	131.1	18	158.3
578	6/7/2013	12:40:08	32.2	1	1307.2	5046.7	1.9	504.7	5.5	138.9	18.7	165.1
579	6/7/2013	12:42:43	32.2	1	1402.6	5414.8	2.1	530.1	5.6	136.9	17.2	151.6
580	6/7/2013	12:45:17	32.4	1	1407.6	5434	2	514.9	5.8	138	16.6	146.3

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581	6/7/2013	12:47:48	32.5	0	1446.8	5585.6	2	509.2	5.7	140.1	18.1	160
582	6/7/2013	12:50:27	32.6	1	1419	5478.1	2.3	577.7	6.1	149.5	19	167.3
583	6/7/2013	12:53:08	32.6	1	1308.9	5053.3	2.2	544.5	5.2	127.4	16.5	145.2
584	6/7/2013	12:55:37	32.6	1	1407.1	5432	2.1	539.5	5.5	142.2	20	176.2
585	6/7/2013	12:58:15	32.5	1	1399.2	5401.9	2.1	537.9	5	132.7	20.1	176.2
586	6/7/2013	13:00:55	32.5	1	1410.2	5444.1	2.3	584.1	5.6	140.1	18.8	165.2
587	6/7/2013	13:03:38	32.4	1	1231.7	4755.1	2.2	547	4.4	115.9	17.3	151.5
588	6/7/2013	13:06:20	32.5	1	1223.9	4724.8	2.3	557	3.7	103.8	17.4	152.5
589	6/7/2013	13:09:10	32.6	1	1221.5	4715.6	2.1	514	4.7	118	15.9	140
590	6/7/2013	13:11:54	32.8	0	1302.3	5027.8	1.9	470.7	4.5	113.8	15.8	138.9
591	6/7/2013	13:14:26	33	1	1219.7	4708.6	1.3	396.7	6.2	148.9	18	159.3
592	6/7/2013	13:17:31	33.4	1	1311.7	5064	1.3	394.3	6.7	162.5	19.8	175.6
593	6/7/2013	13:23:27	33.8	1	1152.5	4449.2	1	311.4	4.7	127.4	19.2	169.3
594	6/7/2013	13:27:22	33.8	1	1284.6	4959.4	1.2	379.1	5.8	149.5	20.6	181.9
595	6/7/2013	13:30:04	34	1	1175.3	4537.3	1.7	426.1	4	107	16.7	146.2
596	6/7/2013	13:32:43	34	1	1260.9	4867.8	1.7	459.6	4.6	127.4	20.2	177.7
597	6/7/2013	13:35:12	34.4	1	1194.2	4610.4	2.1	525	3.8	108	18.5	161.4
598	6/7/2013	13:39:35	34.9	1	1067.3	4120.4	1.8	446.4	4.1	105.4	15	132.1
599	6/7/2013	13:43:10	35.2	1	1773.2	6845.6	0.5	322.5	8.7	230.5	33.4	295
600	6/7/2013	13:46:17	35.4	1	1220.6	4712.3	1.6	451.7	6.1	145.2	17	150.4
601	6/7/2013	13:49:44	35.4	1	1156.6	4465.3	1.9	472.1	4.6	118.5	16.7	147.3
602	6/7/2013	13:53:42	35.3	1	1190.2	4594.8	1.5	409.3	4.8	122.2	17.1	150.4
603	6/7/2013	13:56:37	35.2	1	1224.6	4727.8	2	502	4.8	118.5	15.4	135.2
604	6/7/2013	13:59:53	35.2	0	1293.2	4992.3	2	493.7	3.6	107	19	166.1
605	6/7/2013	14:03:09	35.4	1	1238.7	4782	2.2	552.3	5.9	144.2	18.2	160.4
606	6/7/2013	14:06:38	35.8	1	1265.7	4886.3	2.3	551.2	4	112.2	18.4	161.4
607	6/7/2013	14:10:15	36.1	1	1247.8	4817.3	2.1	524	4.8	122.2	17.2	150.9
608	6/7/2013	14:13:25	36.2	1	1205.1	4652.3	2.1	511.9	4.3	110.6	15.6	137.3
609	6/7/2013	14:16:29	36	1	1183.3	4568.1	2.1	510.3	3.1	93.4	17.6	153.6

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610	6/7/2013	14:19:30	36	1	1210.8	4674.4	2.1	516.6	3.7	105.9	18.2	159.3
611	6/7/2013	14:24:21	35.7	1	1269.1	4899.6	2.2	536	4.9	124.3	17.4	153
612	6/7/2013	14:27:24	35.6	1	1216.8	4697.4	2.2	540.2	4.7	117.4	15.6	137.3
613	6/7/2013	14:30:57	35.8	1	1237	4775.6	2.1	517.7	5	126.4	17.5	153.6
614	6/7/2013	14:33:50	35.6	1	1291.1	4984.4	2.3	556.5	4.3	112.7	16.7	146.2
615	6/7/2013	14:39:22	35.4	1	1282.6	4951.6	2.3	558	4.8	121.1	17.1	149.9
616	6/7/2013	14:42:33	35.3	1	1248.7	4820.6	2.3	565.3	4.7	121.1	17.3	152
617	6/7/2013	14:45:52	35.3	1	1133.3	4375.1	1.8	460	5.5	127.4	13.8	122.7
618	6/7/2013	14:49:07	35.2	1	1482.1	5721.5	2.1	558.6	7.3	174.7	21	185.7
619	6/7/2013	14:52:04	35.4	1	1288.2	4973	2.1	533	5.4	136.3	18.9	166.7
620	6/7/2013	14:55:35	35.4	1	1385.6	5349.3	2.4	598.6	5.2	135.3	19.5	170.9
621	6/7/2013	14:57:59	35.4	1	1211.7	4677.6	2.3	558.5	5.2	124.3	15.5	136.3
622	6/7/2013	15:00:29	35.6	1	1140.1	4401.4	2	501.4	4.7	114.3	14.5	127.4
623	6/7/2013	15:03:13	35.7	1	1385.6	5349.1	2.5	605.9	5.3	134.3	18.4	162
624	6/7/2013	15:05:56	35.7	1	1290.4	4981.7	2.5	599.4	3.6	106.5	19.2	167.2
625	6/7/2013	15:08:24	35.7	1	1294.7	4998.4	2.5	601.5	5.6	131.1	15.3	135.2
626	6/7/2013	15:10:56	35.8	1	1385.3	5347.9	2.6	646.7	6.8	158.4	17.9	158.3
627	6/7/2013	15:13:58	36	1	1222	4717.6	2.1	518.2	3.5	102.8	18.3	159.9
628	6/7/2013	15:16:48	36	1	1294.7	4998.4	2.6	615.6	4.1	114.3	18.9	165.1
629	6/7/2013	15:19:43	36.2	1	1476.2	5699.1	2.6	646	6	148.5	19.3	169.9
630	6/7/2013	15:22:46	36.5	1	1385.2	5347.7	2.4	600.6	5.3	137.4	20.2	177.7
631	6/7/2013	15:25:34	36.6	1	1419.9	5481.7	2.8	677.8	5.5	134.8	17.8	156.8
632	6/7/2013	15:28:08	36.6	1	1452.1	5606.1	2.9	695.1	6	141.6	16.7	147.4
633	6/7/2013	15:31:12	36.5	1	1314.2	5073.5	2.5	608.8	6.3	146.3	16.1	142.6
634	6/7/2013	15:33:43	36.2	1	1328.7	5129.4	2.3	567.5	5.3	131.1	17.5	154.1
635	6/7/2013	15:36:15	35.8	1	1293.6	4993.9	2.2	561.2	5.4	134.2	17.6	155.2
636	6/7/2013	15:38:46	35.6	1	1136.3	4386.7	1.8	467.4	4.6	117.4	16.1	142
637	6/7/2013	15:41:23	35.3	1	1162.9	4489.5	1.8	462.7	5.3	131.1	17	150.4
638	6/7/2013	15:44:09	35	1	1197.8	4624	2	519.2	5.5	133.7	16.9	148.8

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639	6/7/2013	15:46:54	35	1	1166	4501.3	2.3	543.8	4.5	110.6	14.7	129.5
640	6/7/2013	15:49:56	35	1	1170.6	4519.2	2.3	538.1	4.1	104.9	15.4	134.7
641	6/7/2013	15:53:20	35.3	1	1072.4	4140.1	1.9	483.5	4.9	117.4	14.3	126.3
642	6/7/2013	15:55:57	35.4	1	1281.7	4948.2	1.1	349.2	5.7	145.2	20.1	177.2
643	6/7/2013	15:58:32	35.7	1	1678.6	6480.4	1	403.7	8.1	216.2	31.9	281.2
644	6/7/2013	16:01:01	35.8	1	1320.3	5097.1	1.7	470.7	5.5	145.8	21.8	191.8
645	6/7/2013	16:03:34	36.2	1	1357.5	5240.7	2.8	650.8	4.8	122.2	17.5	153.1
646	6/7/2013	16:06:16	36.4	1	1466.4	5661.2	3.6	797.2	4.4	111.8	16.3	142.7
647	6/7/2013	16:08:49	36.8	1	1448.1	5590.4	3.5	790.4	4.7	120.1	17.3	151.6
648	6/7/2013	16:11:36	37	1	1240.6	4789.5	2.7	616.1	4.4	105.4	13.4	117.4
649	6/7/2013	16:14:10	37.2	1	1455.5	5618.9	2.7	654.4	6	149.5	19.7	173.6
650	6/7/2013	16:16:41	37.3	1	1404.1	5420.6	2.2	558.9	6.1	150.5	19.7	173.6
651	6/7/2013	16:19:29	37.4	1	1565.9	6045.4	3.1	746.7	6.8	155.3	16.9	149
652	6/7/2013	16:22:13	37.2	1	1625.3	6274.4	3.4	804.4	7.1	162.7	18.1	159.5
653	6/7/2013	16:24:57	37.2	1	1386.7	5353.4	2.6	625.7	5.7	135.8	16.3	144.2
654	6/7/2013	16:27:42	37	1	1788.3	6903.6	3.6	859.2	7.3	174.2	21.3	187.9
655	6/7/2013	16:30:20	36.8	1	1513.2	5842	3	699.5	5.5	134.3	17.4	153.2
656	6/7/2013	16:34:07	36.8	1	1251	4829.4	2.2	541.2	5.3	125.8	14.7	130
657	6/7/2013	16:37:06	36.4	1	1373.7	5303.4	2.1	545.7	6	147.9	19.4	170.9
658	6/7/2013	16:40:06	35.8	1	1205.8	4655	2.1	528.7	5.3	124.8	14.3	126.3
659	6/7/2013	16:43:02	35.4	1	1175.1	4536.6	1.9	476.8	5.1	119.5	13.6	120.1
660	6/7/2013	16:45:42	34.8	1	1621.1	6258.3	0.7	333.3	9	219.8	26.6	236.6
661	6/7/2013	16:49:29	34.5	1	1525.5	5889.3	1.8	515.1	7.2	175.7	22.2	196.2
662	6/7/2013	16:52:13	34.2	1	1426.4	5506.7	3.2	731.1	4.6	119.6	17.8	155.7
663	6/7/2013	16:54:52	33.8	1	1423.1	5493.8	3.7	816.3	4	103.9	15.7	136.8
664	6/7/2013	16:57:28	33.6	1	1523.5	5881.7	3.7	841.8	5.6	135.3	17.5	153.1
665	6/7/2013	17:00:16	33.3	1	1516	5852.4	3.8	858.1	5.5	132.2	17.3	151.6
666	6/7/2013	17:02:59	33	1	1447.8	5589.4	2.2	581.5	7.5	167.3	16.7	149
667	6/7/2013	17:05:27	32.8	1	1295.5	5001.4	2.3	566.4	5.8	139.4	16.9	149.4

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668	6/7/2013	17:08:02	32.6	1	1424.9	5501	2.8	668.8	4.6	124.8	20.3	177.2
669	6/7/2013	17:10:49	32.4	1	1309.4	5054.9	2.7	631.9	4.8	121.1	16.8	147.3
670	6/7/2013	17:13:28	32	1	1315.6	5078.9	2.6	614.1	4.5	115.9	16.9	148.3
671	6/7/2013	17:16:03	31.6	1	1242.7	4797.5	2.6	616.1	4.4	115.9	17.2	150.9
672	6/7/2013	17:18:47	31.2	1	1289.2	4977	2.6	607.7	3.8	103.3	16.6	144.7
673	6/7/2013	17:21:12	30.8	1	1421.8	5489.1	2.3	583	5.8	144.8	19.5	171.5
674	6/7/2013	17:23:50	30.5	1	1343.2	5185.4	2	532	6.4	151.5	18.1	159.9
675	6/7/2013	17:26:29	30.1	1	1219.6	4708.4	1.7	470.6	6.1	146.3	17.7	156.7
676	6/8/2013	10:31:13	19.1	0	1329.4	5132.4	0.6	258.1	8.3	173	12.4	112.8
677	6/8/2013	10:34:48	20.1	1	1516.5	5854.7	2	543.4	6.8	172.6	23.9	210.3
678	6/8/2013	10:39:40	20.9	1	1454	5613.4	2.8	681.7	6.3	148.5	17.7	155.8
679	6/8/2013	10:43:53	21.7	1	1580.8	6102.7	3.5	812.3	5.4	139.6	20.9	182.6
680	6/8/2013	10:47:42	22.1	1	1282.4	4950.9	2.8	668	5.7	130.6	14.3	126.3
681	6/8/2013	10:50:26	22.5	1	1346.1	5196.8	3.5	796.4	5.5	129.5	15.6	137.4
682	6/8/2013	10:52:55	22.9	1	1529.3	5904	4.3	961	5.6	129.6	15.4	134.8
683	6/8/2013	10:55:44	23.3	1	1629.3	6289.9	4.6	1011.9	5.3	126	15.9	139
684	6/8/2013	10:58:26	23.7	1	1658.9	6404.2	5	1091.1	4.9	117.6	16	139
685	6/8/2013	11:02:30	24.1	1	1499.4	5788.7	3.2	730.5	5	124.4	16.7	146.9
686	6/8/2013	11:05:58	24.5	1	1592.1	6146.2	3.9	863.1	4.1	112.3	18.8	163.7
687	6/8/2013	11:09:34	24.8	1	1610.4	6217	4.3	941.7	5.4	126	15.3	134.3
688	6/8/2013	11:12:14	24.9	0	1517.3	5857.6	4.2	914.6	3.9	99.2	15.1	131.7
689	6/8/2013	11:15:54	25.1	1	1442.1	5567.3	4.1	892	3.4	88.7	14.3	124.3
690	6/8/2013	11:19:17	25.1	1	1283.8	4956.2	3.2	716.7	3.8	94.9	13.7	119.5
691	6/8/2013	11:22:56	25.1	1	1182.2	4564	2	491	5	114.3	12.3	109.1
692	6/8/2013	11:25:34	25.1	1	1231.4	4753.7	2.4	593.6	6.8	143.6	11.5	102.8
693	6/8/2013	11:28:07	25.1	1	1711.2	6606.2	2.7	720.4	11.7	236.7	15.2	138.1
694	6/8/2013	11:30:53	24.9	1	1334.6	5152.1	2	546.3	10.2	203.4	11.7	107.5
695	6/8/2013	11:35:19	24.5	1	1696.2	6548.4	1.4	447.3	7.8	197.9	26.6	235.1
696	6/8/2013	11:38:16	24.4	1	1726.2	6664.2	0.6	348.3	11.3	268.3	30.3	270.3

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697	6/8/2013	11:41:11	24.4	1	1775.6	6854.8	1.1	432.8	9.6	233.1	28.3	250.9
698	6/8/2013	11:44:35	24.7	1	1237.7	4778.4	1.7	462.3	8.3	170.4	11.9	107.5
699	6/8/2013	11:47:08	24.9	1	1162.3	4487.1	1.8	464.3	6.9	144.2	11.3	101.2
700	6/8/2013	11:49:44	25.3	1	1505.6	5812.3	0.9	361.1	8.5	205.1	24.3	215.6
701	6/8/2013	11:52:17	25.5	1	1253.2	4837.9	2.1	536.6	7.5	157.8	12.3	110.6
702	6/8/2013	11:54:52	25.7	1	1352.1	5219.7	2.6	630.5	6.5	139	12	107
703	6/8/2013	11:57:20	25.9	1	1444.9	5578.1	3	713	6.3	140.6	14.1	124.9
704	6/8/2013	12:00:01	26	0	1417.3	5471.5	3	709.9	7.1	150.6	12.8	113.9
705	6/8/2013	12:02:36	25.9	1	1360.3	5251.6	3	707	6.3	141.6	14.5	128
706	6/8/2013	12:05:57	26.4	1	1123.1	4335.6	1.9	484.7	6.2	138.4	14	124.2
707	6/8/2013	12:09:06	26.6	1	1788.9	6906.3	1.3	453.8	8	208.5	29.6	260.9
708	6/8/2013	12:12:46	27	1	1655.2	6390.1	1.3	443.1	6.9	191.1	30.5	268.2
709	6/8/2013	12:16:53	27.7	1	1671.7	6453.9	1.1	419.6	8.9	219.4	27.4	243
710	6/8/2013	12:20:08	27.8	1	1187.5	4584.5	1.8	469.5	6.2	142.1	15	133.7
711	6/8/2013	12:23:12	28.2	1	1238.6	4781.8	1.8	487.9	6.8	149.9	13.9	124.3
712	6/8/2013	12:26:20	28.4	1	1607	6203.9	2	550.8	7.1	175.8	22.7	200.9
713	6/8/2013	12:29:51	28.2	1	1313	5069	2.2	565.5	6.9	156.3	15.9	141.6
714	6/8/2013	12:33:00	28.2	1	1159.5	4476.5	2.3	555.9	5	112.7	11.7	103.8
715	6/8/2013	12:36:17	28.2	1	1348.3	5205.2	2.7	635.7	4.9	123.8	17.6	154.6
716	6/8/2013	12:39:33	28.4	0	1379.9	5327.4	2.5	624.8	6.1	143.2	17	150
717	6/8/2013	12:42:38	28.4	1	1299.6	5017	2.9	669.1	4.6	112.8	14.8	130
718	6/8/2013	12:45:37	28.2	1	1360.4	5251.7	2.5	614.3	5.5	131.1	16.1	142.1
719	6/8/2013	12:48:54	28.4	1	1401	5408.8	2.4	598.2	6.3	150	18.2	161
720	6/8/2013	12:51:30	28.6	1	1373.6	5302.9	2.6	630.1	6	144.2	18.1	159.4
721	6/8/2013	12:54:13	28.8	1	1455	5616.9	2.7	642.4	5.6	134.9	16.8	147.9
722	6/8/2013	12:56:49	29	1	1535.1	5926.3	2.8	691.7	7	166.8	19.9	175.7
723	6/8/2013	13:00:11	29.4	1	1491.8	5759.2	2.6	645	6.7	159.5	18.9	166.8
724	6/8/2013	13:04:23	30.1	1	1430.8	5523.9	2.7	656.4	5	128.5	18.6	163.1
725	6/8/2013	13:07:36	30.2	1	1472.6	5684.9	2.8	685.9	5.7	143.2	19.8	174.1

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726	6/8/2013	13:11:13	30.6	1	1452.2	5606.4	2.7	665.4	6.5	150.6	16.6	146.9
727	6/8/2013	13:14:22	30.9	1	1469.4	5672.7	3	726.7	5.9	146.9	19.5	171.5
728	6/8/2013	13:17:38	31.2	1	1450.1	5598.2	3	711.4	5.9	141.6	17.6	155.2
729	6/8/2013	13:20:06	31.4	0	1648.6	6364.6	3.2	766.2	7.4	167.4	17.5	154.8
730	6/8/2013	13:22:47	31.4	1	1624.6	6272	3.1	731.1	6.3	149.6	18.1	159.5
731	6/8/2013	13:25:22	31.4	1	1466.1	5659.9	2.8	683.7	5.9	146.9	19.7	173.1
732	6/8/2013	13:27:58	31.7	1	1622.1	6262.3	3.5	812.8	5.8	143.8	19.7	173.1
733	6/8/2013	13:30:32	31.7	1	1562.9	6033.8	3.5	799.6	5.5	132.8	16.9	148.5
734	6/8/2013	13:33:06	31.6	1	1418.8	5477.5	2.7	646.9	5.2	130.1	18.1	158.9
735	6/8/2013	13:35:43	31.4	1	1407.7	5434.6	3.1	718.5	5.1	124.8	16.7	146.3
736	6/8/2013	13:38:40	31	0	1308.2	5050.3	2.9	661.7	4	103.8	15.5	135.2
737	6/8/2013	13:41:11	31.2	1	1366.1	5274	2.4	582.7	5.6	134.8	16.6	146.3
738	6/8/2013	13:43:42	31.2	1	1383.4	5340.6	2.2	579.4	6.6	158.4	18.9	167.3
739	6/8/2013	13:46:14	31	1	1511.4	5834.8	1.7	487.3	6.9	173.7	23.3	205.6
740	6/8/2013	13:48:44	31	1	1526.4	5892.7	2.1	564.4	7.1	167.9	19.7	174.7
741	6/8/2013	13:51:19	31.2	1	1470.2	5675.6	2.1	556.5	7	164.7	19	168.4
742	6/8/2013	13:54:31	31.3	1	1375.2	5309.1	2	530.7	5.9	144.3	18.6	164.2
743	6/8/2013	13:57:36	31.4	1	1447.8	5589.3	1.4	442.8	6.9	174.7	23.5	207.7
744	6/8/2013	14:00:44	31.7	1	1558.5	6016.6	1.5	466.4	7.6	192	25.3	224
745	6/8/2013	14:03:53	31.8	1	1329.6	5133	1.3	404.3	6.8	162.6	19	168.8
746	6/8/2013	14:08:57	32	1	1382.8	5338.4	1.8	490.8	7.4	169.4	18.1	161
747	6/8/2013	14:12:48	32.1	1	1453.4	5611	2	546	7.9	176.8	17.5	156.3
748	6/8/2013	14:15:51	32.4	1	1338.8	5168.4	1.7	474	6.7	158.4	18.2	161
749	6/8/2013	14:18:51	32.6	1	1305	5037.9	1.9	507.9	6.9	159.9	17.7	156.8
750	6/8/2013	14:22:00	32.9	1	1483.5	5727	1.6	481	7.2	175.2	21.9	194.1
751	6/8/2013	14:25:15	33	1	1517.8	5859.4	1.2	415.5	7.9	194.1	24	212.4
752	6/8/2013	14:28:33	33.2	1	1384.7	5345.7	1.8	493.5	6.8	162.1	19.4	172
753	6/8/2013	14:31:32	33.3	1	1324.6	5113.6	2.1	543.6	7.3	158.9	14.2	126.9
754	6/8/2013	14:34:51	33.4	1	1571.2	6065.9	2.4	613.1	6.8	163.7	19.8	175.2

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755	6/8/2013	14:38:01	33.7	1	1515.2	5849.5	2.3	612.6	8.1	179.4	17.5	155.8
756	6/8/2013	14:41:11	33.8	1	1702.2	6571.4	2.7	698.8	8.9	193.1	17.3	154.8
757	6/8/2013	14:44:28	33.8	0	1587	6126.8	2.5	657.7	9.5	199.3	15.5	139.1
758	6/8/2013	14:47:37	33.8	1	1616	6238.6	2.9	710.2	8.4	176.8	14.4	128.6
759	6/8/2013	14:51:28	33.8	1	1244.7	4805.3	1.8	486.3	7.8	160.4	11.1	100.7
760	6/8/2013	14:54:55	33.6	1	1519.6	5866.5	1.9	545.5	8.7	195.1	19.4	173.1
761	6/8/2013	14:58:43	33.7	1	1656.1	6393.3	2.1	591.2	8.3	195.2	22	195.2
762	6/8/2013	15:02:08	33.8	1	1458.6	5631.1	2.1	564.3	7	166.8	19.9	176.2
763	6/8/2013	15:05:32	33.8	1	1324.2	5112.1	2.4	591.7	5.9	140.5	16.6	146.8
764	6/8/2013	15:08:36	33.8	1	1330.8	5137.8	1.7	472.4	6	145.3	18	158.9
765	6/8/2013	15:12:00	34	1	1314.1	5073.3	1.7	462.3	4.9	132.1	20.2	177.7
766	6/8/2013	15:15:12	34.1	1	1201.3	4637.8	1.5	421.9	6.2	148.3	17.7	157.2
767	6/8/2013	15:18:24	34	1	1308.8	5052.7	1.6	459.1	6.5	158.8	19.9	176.1
768	6/8/2013	15:24:56	34.2	1	1468.9	5670.9	2.1	557	7	167.3	19.9	176.2
769	6/8/2013	15:29:11	34.2	1	1526.6	5893.5	2.5	641.9	8.4	187.3	18.3	162.6
770	6/8/2013	15:32:56	34.2	1	1453.7	5612	2.5	632.3	7.7	169.9	16.2	144.3
771	6/8/2013	15:36:26	33.8	1	1456.9	5624.3	2.5	621.8	7.1	159.5	16.2	143.7
772	6/8/2013	15:40:34	33.8	1	1269.8	4902.2	2.4	594.1	5.6	134.7	16.5	145.2
773	6/8/2013	15:43:53	33.8	1	1304.8	5037.1	2.3	565.9	5.6	134.2	16.4	144.7
774	6/8/2013	15:48:12	34.2	1	1631.1	6297	2.6	676.7	8.6	192.6	19.2	171
775	6/8/2013	15:51:38	34.5	1	1332.8	5145.4	2.6	634.5	5.5	133.2	16.6	146.3
776	6/8/2013	15:56:36	34.6	1	1274.1	4918.8	2.2	542.9	5.8	135.8	15.3	135.2
777	6/8/2013	16:00:21	34.6	1	1487.7	5743.5	2.7	672.7	6.5	153.7	17.9	157.9
778	6/8/2013	16:04:12	34.6	1	1423.5	5495.5	2.7	650	5.7	135.9	16.9	148.9
779	6/8/2013	16:07:42	34.9	1	1469.9	5674.8	2.5	611.9	6.7	150.6	15.3	135.9
780	6/8/2013	16:11:56	35.4	1	1809.2	6984.6	3.2	798.7	8	191.1	22.8	201.6
781	6/8/2013	16:17:06	35.8	1	1701.3	6568	2.8	721.4	8.8	193.7	18.3	162.7
782	6/8/2013	16:23:48	36.1	1	1182.3	4564.4	2.3	548.6	4.8	110.6	12.7	112.2
783	6/8/2013	16:27:30	36.2	1	1560.7	6025.1	2.7	676.6	7.5	170.5	18.2	161.1

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784	6/8/2013	16:31:08	36.2	1	1239.6	4785.5	2.3	555.9	5.2	121.1	14	123.2
785	6/8/2013	16:34:41	36.2	1	1632.7	6303.3	2.6	653.6	6.9	161.6	18.8	165.8
786	6/8/2013	16:38:31	36.2	1	1239.7	4786.1	2.4	566.4	5.1	119	14	123.7
787	6/8/2013	16:42:09	36.1	1	1260.5	4866.1	3	680.5	4.7	109.6	13.1	115.3
788	6/8/2013	16:46:10	36	1	1347.9	5203.5	2.9	677.5	5.7	131.6	14.7	130
789	6/8/2013	16:49:31	36	1	1458.9	5632.2	3.1	723.9	5.6	137.4	17.9	157.3
790	6/8/2013	16:53:12	36.2	1	1352.8	5222.6	2.9	681.2	5.6	128.5	14.4	127.4
791	6/8/2013	16:57:31	36.6	1	1663.2	6420.7	3.4	818.6	7.2	166.3	18.8	166.3
792	6/8/2013	17:05:00	36.4	1	1312.1	5065.3	2.6	616.1	5.9	131.6	13.6	120.1
793	6/8/2013	17:09:34	36.8	1	1813.4	7000.7	3.7	882	9.2	198.4	17.9	159.6
794	6/8/2013	17:14:16	35.8	1	1597.6	6167.7	3.3	779.2	7.6	160.5	13.3	118.6
795	6/8/2013	17:18:50	35	1	1675.1	6466.8	3.7	875.2	7.2	164.7	18	159
796	6/8/2013	17:22:00	34.2	1	1516.2	5853.4	3.4	772.4	5.8	130.1	13.4	118.6
797	6/8/2013	17:26:23	33.4	1	1810.1	6988.2	3.4	833.3	8.8	194.8	18.7	166.4
798	6/8/2013	17:30:20	32.6	1	1711.7	6608	3.6	850.7	8.8	186.8	15.6	139.6
799	6/9/2013	11:45:48	28.6	1	1710.8	6604.5	3.5	833	7.8	171.1	16.5	146.4
800	6/9/2013	11:48:45	29.6	1	1560.1	6023	3.1	743.6	7.6	158.4	12.8	114.4
801	6/9/2013	11:51:38	30.1	1	1543.8	5959.9	3.5	814.8	7.5	159	13.4	119.1
802	6/9/2013	11:55:23	30.2	1	1587.6	6128.8	3.2	759.4	7.6	165.8	15.7	139.6
803	6/9/2013	11:58:10	30.4	1	1575.2	6081.3	3.4	777.1	6.6	142.2	12.8	113.4
804	6/9/2013	12:00:52	30.8	1	1435.9	5543.4	3.1	721.3	5.7	129.1	14.3	125.9
805	6/9/2013	12:07:41	31.2	1	1427.5	5511	3	717	7.3	150.5	11.5	103.3
806	6/9/2013	12:10:09	31.3	1	1329.7	5133.2	2.4	576.4	6.1	135.3	13.2	117.5
807	6/9/2013	12:12:46	31.4	1	2221.6	8576.5	1.6	570.8	10.7	271.7	36.5	322.6
808	6/9/2013	12:18:12	32	1	1575.7	6083.2	2.6	649.3	6.2	148	18.1	160
809	6/9/2013	12:21:10	32.2	1	1448.6	5592.6	2.9	690.9	7	152.1	13.7	122.2
810	6/9/2013	12:23:39	32.2	1	1493.5	5765.9	3	709.5	6.9	151.6	14.5	128.6
811	6/9/2013	12:31:14	32.1	1	1179.3	4552.8	2.2	536.5	4.7	111.7	13.3	116.9
812	6/9/2013	12:35:45	32.2	1	1886.6	7283.3	1	411.3	9	232.6	31.9	281.9

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813	6/9/2013	12:38:09	32.6	1	2158.1	8331.3	1.2	476.7	9.6	261.7	40	352.5
814	6/9/2013	12:41:03	32.9	1	1522.1	5876.2	1.9	535	7.5	176.3	20.1	177.8
815	6/9/2013	12:43:38	32.9	1	1239	4783.3	2.3	553.8	5.6	127.9	13.7	121.6
816	6/9/2013	12:47:49	33.2	1	1398.5	5398.8	2.7	653.6	5.9	136.9	15.4	135.8
817	6/9/2013	12:54:15	33.4	1	1293.5	4993.5	3.1	713	5.1	115.4	12.6	111.2
818	6/9/2013	12:57:28	33.2	1	1696.3	6548.8	4.2	951.2	7.4	162.1	16.1	142.2
819	6/9/2013	13:00:19	32.8	1	1632.7	6303	4.1	928.6	6.9	148.5	13.7	121.2
820	6/9/2013	13:03:41	32.5	1	1625.7	6275.9	4.2	929.1	6.2	132.3	11.9	105
821	6/9/2013	13:06:38	32.2	1	1612.8	6226.4	4.3	957.4	6	137.5	15.8	139
822	6/9/2013	13:10:30	32.1	1	1592.3	6147.3	4	910.8	6.7	146.9	14.7	129.6
823	6/9/2013	13:13:05	32	1	1505.9	5813.8	3.9	886.9	6	137.4	15.4	135.9
824	6/9/2013	13:16:23	32.2	1	1542.8	5956.1	3.9	879.1	6	136.4	15.1	133.2
825	6/9/2013	13:21:20	32.4	1	1360.3	5251.4	3.4	765.4	4.8	118.5	16.5	144.2
826	6/9/2013	13:26:45	32.2	1	1463.6	5650.4	3.7	834.8	5.2	123.8	15.3	134.3
827	6/9/2013	13:30:21	32.1	1	1340.5	5175	3.5	782.1	4.9	110.6	12.5	109.6
828	6/9/2013	13:33:12	31.8	1	1121.8	4330.8	2.9	659.5	4.2	97.5	11.6	101.7
829	6/9/2013	13:45:42	33.8	1	1369.2	5285.7	1.4	423.2	5.9	152.1	21	185.1
830	6/9/2013	13:49:04	34	1	1652.6	6379.9	1.1	417.3	8.3	212.5	28.8	255
831	6/9/2013	13:51:48	34	1	1351.9	5218.9	1.2	367.6	5.1	142.7	23	201.8
832	6/9/2013	13:54:59	34	1	1102.4	4255.8	1.4	386.2	4.5	121.1	18.2	160.4
833	6/9/2013	13:58:06	34	1	1477.5	5703.9	1.4	441.2	7.2	179.4	23.4	207.2
834	6/9/2013	14:01:12	34	1	1176.8	4543	1.4	392.5	5.3	137.3	19.7	173.5
836	6/9/2013	14:29:44	34.6	1	1336.3	5158.7	1.6	466.6	6.7	162.5	19.6	173.5
837	6/9/2013	14:32:06	34.6	1	1470.9	5678.3	1.5	465.3	7.9	186.7	21.6	192
838	6/9/2013	14:34:33	34.8	1	1682.8	6496.4	1.5	498	9.7	226.1	25	222.4
839	6/9/2013	14:36:59	34.8	1	1413.6	5457.3	1.6	461.4	7.4	175.7	20	177.7
840	6/9/2013	14:40:09	34.8	1	1214.5	4688.6	2	503	5	123.7	16.3	143.6
841	6/9/2013	14:43:05	34.8	1	1190.1	4594.3	1.9	491.5	5.1	129	17.8	156.7
842	6/9/2013	14:45:28	34.6	1	1287.6	4970.8	2.1	532.9	4.9	124.8	17.7	155.1

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843	6/9/2013	14:47:48	34.6	1	1263	4876	2.2	554.3	5.1	127.9	17.6	154.6
844	6/9/2013	14:50:13	34.5	1	1369.8	5288.2	2.5	619.9	5.5	136.9	18.5	163
845	6/9/2013	14:52:43	34.4	1	1157.2	4467.4	2.1	528.6	5.2	122.7	14.4	127.4
846	6/9/2013	14:55:50	34.2	1	1342.2	5181.7	1.7	467.1	6	146.3	18.3	162
847	6/9/2013	14:59:31	34.2	1	1472.1	5683.2	1.6	480.4	7.5	184.6	23.5	208.2
848	6/9/2013	15:01:58	34.1	1	931.6	3596.4	1.5	367.1	3.6	90.7	12.4	109.5
849	6/9/2013	15:04:55	34	1	1012.3	3908.1	1.8	435.8	3.9	99.1	13.6	119.5
850	6/9/2013	15:09:13	33.8	1	1616.7	6241.4	2.2	599.5	8.4	194.1	21.3	189.4
851	6/9/2013	15:14:08	34	1	1095.3	4228.5	2.4	569.9	4	101.7	14.2	124.2
852	6/9/2013	15:16:29	34.1	1	1259.2	4861.2	2.8	654.3	5	117.4	14.1	123.7
853	6/9/2013	15:18:55	34	1	1243.3	4800	2.3	565.3	5.5	127.4	14.2	125.3
854	6/9/2013	15:21:18	34	1	1266.8	4890.4	1.8	476.9	4.4	122.2	19.6	171.9
855	6/9/2013	15:23:46	34	1	1354.8	5230.2	1.8	477	6	146.3	18.6	164.1
856	6/9/2013	15:26:41	33.8	1	1327.4	5124.5	1.7	458.1	5.5	141	19.5	171.9
857	6/9/2013	15:29:34	33.8	1	1165.2	4498.2	2.1	526.5	5.1	120.6	14.6	128.4
858	6/9/2013	15:32:44	33.8	1	973.4	3757.8	2.1	503.6	4.1	97.5	11.9	104.8
859	6/9/2013	15:36:25	33.8	1	1112.8	4296	2.7	610.7	4.6	105.4	11.7	102.8
860	6/9/2013	15:39:47	33.8	1	1194.4	4611	2.3	561.1	5.1	117.4	13.2	116.9
861	6/9/2013	15:42:18	33.8	1	1208.5	4665.4	2.2	555.9	5.4	131.6	16.7	147.3
862	6/9/2013	15:44:43	34	1	1077.2	4158.7	2.1	496.9	4.6	105.3	11.8	104.3
863	6/9/2013	15:47:21	34	1	1127.6	4353.2	2	489.3	4.8	116.4	14.8	130.5
864	6/9/2013	16:00:09	33.4	1	1165.8	4500.8	1.7	451.1	5.2	127.4	16	141
865	6/9/2013	16:02:33	33.6	1	995.7	3843.9	1.8	450.4	4.5	103.8	11.8	104.3
866	6/9/2013	16:05:14	33.8	1	1133.6	4376.4	2.6	605	4.8	112.2	13.2	116.4
867	6/9/2013	16:07:35	34.2	1	1182.1	4563.7	2.4	582	4.9	118	14.7	129.5
868	6/9/2013	16:11:10	34.5	1	1121.6	4329.9	2.1	512.9	4	101.2	14	123.2