Progress Report

GEOMECHANICAL STUDY OF BAKKEN FORMATION IN EASTERN WILLISTON BASIN, NORTH DAKOTA

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Abstract

Bakken Formation in Williston Basin was recently reassessed to have 200-400 billion barrels of original oil in place (OOIP), and 3.65 billion barrels recoverable oil under present technical and economic conditions. Considering the fact that, excluding the Bakken oil, the total discovered OOIP in USA since 1850s is less than 600 billion barrels, of which less than 200 billion barrels has been produced, a recovery factor of about 30%, the reassessed Bakken oil represents a huge potential for improving US oil supply security through increasing domestic oil production. It also means a great opportunity to state and regional economy in attracting new investments, creating new jobs, and generating new revenues.

The recent reassessment indicated that the recovery factor in the Bakken Formation is less than 2%, much lower than the national average level of 30%. This is because the Bakken oil is stored in the middle intervals of Bakken Formation, which are naturally fractured, extremely thin and highly heterogeneous inter-bedded shale, shaly siltstone, shaly sandstone, and carbonates (limestone and dolomite). These geological features make activities of drilling in and oil production from the Bakken Formation at high risk, resulting in low success rate.

This project is designated to investigate the geomechanical properties of the Bakken Formation for improving the successful rate of drilling and production, and eventually increase the recovery factor.

In this reporting period (July 01-December 31, 2008), we did the following:

1. Completed two papers on Bakken formation geomechanics:
    a. Geomechanical study of Bakken formation for improved oil recovery,
    b. Geomechanical stability assessment of Williston Basin formations for petroleum production and CO2 sequestration,
2. Estimated the average in-situ stresses (overburden pressure and horizontal stress) of the Bakken formation in North Dakota Williston Basin,
3. Developed and tested an alternative triaxial geomechanical testing method,
4. Built a portable Bakken shale core sampling system,
5. Completed observing and describing industrial partners' cored Bakken Formation rocks in all 22 Bakken wells.

Executive Summary

In this reporting period of time from July 01 to December 31, 2008, the research team has finished core observation and fracture description of all the twenty-two Bakken wells that belong to the industrial partners. These core description and microfracture observation set up the foundation for future in-depth study. Two papers on Bakken geomechanics were finished: one on Bakken stability related to oil production and CO2 sequestration, another on improved oil recovery. Using Bakken well logs, average Bakken formation in-situ stresses were estimated based on the results of all 22 Bakken wells. While this provides some lights in the in-situ stress fields, more detailed study is on going based on each of these 22 wells. One of the major components in this project is an alternative method for lab geomechanical tests under reservoir conditions (temperature, pore pressure, and in-situ stresses). This method has been successfully developed, tested and verified. A portable shale core sampling system was designed and built so as to be used in the NDGS Core Library for plugging 1-in diameter by 2-in long Bakken samples for geomechanical tests. The portable core sample system has been completed and tested using a reference shale sample. On going efforts are focused on obtaining the Bakken shale samples for the testing.

Attachments

1. ***Geomechanical Stability Assessment of Williston Basin Formations for Petroleum Production and CO_2 Sequestration***
2. ***Geomechanical study of Bakken formation for improved oil recovery***
3. ***Estimation of In-situ Stresses of the Bakken Formation in Eastern Williston Basin, North Dakota***
4. ***Development of an Alternative Methodology for Triaxial Geomechanical Testing***
5. ***Development of a Portable Bakken Shale Core Sampling System***
6. ***Core Observation of Bakken Wells in Eastern Williston Basin, North Dakota***
7. ***Analysis of Minor and Micro Fractures in Bakken Wells***

Attachment 1

Geomechanical Stability Assessment of Williston Basin Formations for Petroleum Production and CO_2 Sequestration

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Geomechanical Stability Assessment of Williston Basin Formations for Petroleum Production and CO_2 Sequestration

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ABSTRACT: The Williston Basin is characterized by relatively flat-lying strata, structural simplicity in comparison to other sedimentary basins, and is tectonically stable. The North Dakota portion of the basin is predominated by carbonate successions from the Cambrian through Cretaceous, followed by episodic glaciations through the Quaternary. Geomechanical characterization of these rock successions will be a critical element to the understanding of the subsurface when conducting petroleum production and anthropogenic CO_2 sequestration. Distributions of discontinuities such as faults and joints in the formations with significant influences on drilling, injection and production activities in the subsurface are identified through literature review and core sample examination. To address storage efficiency, evaluations of in-situ stress orientation and magnitude, abnormal pressures with consideration of potential fault initiation and reactivation due to oil production and CO_2 injection will be encompassed in preliminary site characterization activities.

Keywords: Williston Basin, In-situ stress, CO_2 geological sequestration, North Dakota

1. INTRODUCTION

The main purpose of this paper is to discuss the geomechanical stability of rock systems in the Williston Basin, with a focus on the Beaver Lodge oil field which may be suitable to serve as a site for CO_2 sequestration, as part an effort to limit anthropogenic CO_2 release into the atmosphere [1]. A large volume of CO_2 can be stored in a depleted oil reservoir or confined saline aquifer if the combination of temperature and pressure exists to ensure a supercritical state, 31.1°C and 7.38MPa or 88 F and 1070 psia. Supercritical CO_2 has high density but low viscosity, with the added advantage of a large quantity of CO_2 contained in a reduced volume with high injection efficiency [2]. Since CO_2 is less dense than water, the targeted injection site should be overlain by a formation which has low-permeability and high competence to withstand the upward buoyancy-driven force of the injected CO_2 [3]. Too high of injection pressure can cause irreversible mechanical fracturing which may open new flow paths through previously reliable cap rock [4]. The evaluation of suitable regions for large-scale CO_2 injection is a multidisciplinary subject that must consider many different factors. From the standpoint of geomechanics the premier concerns are the assessment of in-situ stress, fault initiation, and fault reactivation mechanisms.

2. REGIONAL GEOLOGY

The Williston Basin is a 500,000 square kilometer structural basin, not bounded by topography, in eastern Montana, western North Dakota, western South Dakota, southern Saskatchewan and southwestern Manitoba, shown in Fig. 1. It is a large elliptical downwarp with the deepest point (about 4800 m) near Watford City, North Dakota [5]. This basin is entirely situated within the North America Craton, which has remained relatively stable since the Precambrian. The earliest extensive deposition of sedimentary rock in this basin began in the late Cambrian [6].

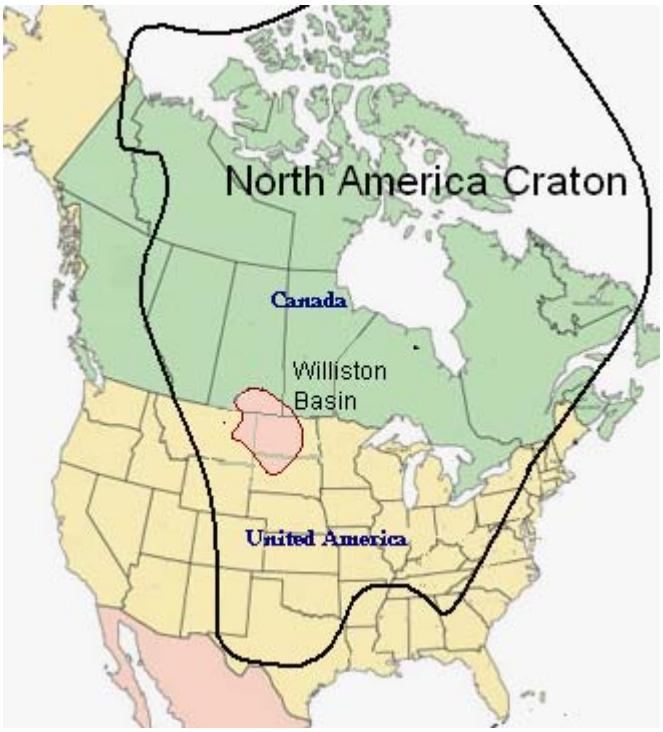

Fig. 1. Location of Williston Basin (shaded area) with respect to the North America Craton (modified from [5])

Due to the thickness of the sediment package in the basin, the nature of the Precambrian basement surface is not known. A common belief is that this basin is mostly underlain by the Trans-Hudson Orogen or Western Dakota Mobile Belt with two cratons (Superior Craton and Wyoming Craton) on the east and west edges (Fig. 2) [6] [7].

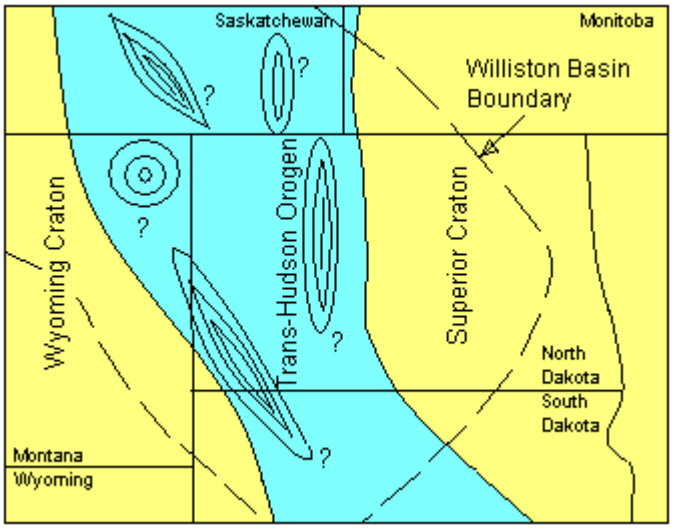

Fig. 2 Speculative basement geologic terrane of the Williston Basin (Modified from [7])

The mountains on the Trans-Hudson Orogen were entirely eroded long before the early Cambrian, when the basin started to form. However, the roots of these mountains remain and some may have significant relief. These mountain roots most likely have an overall north-south trend parallel to the Precambrian Orogenic activities [6].

The major geological structures in this basin include the Nesson Anticline, Billings Anticline, Cedar Creek Anticline and Poplar Dome (Fig.3) [8].

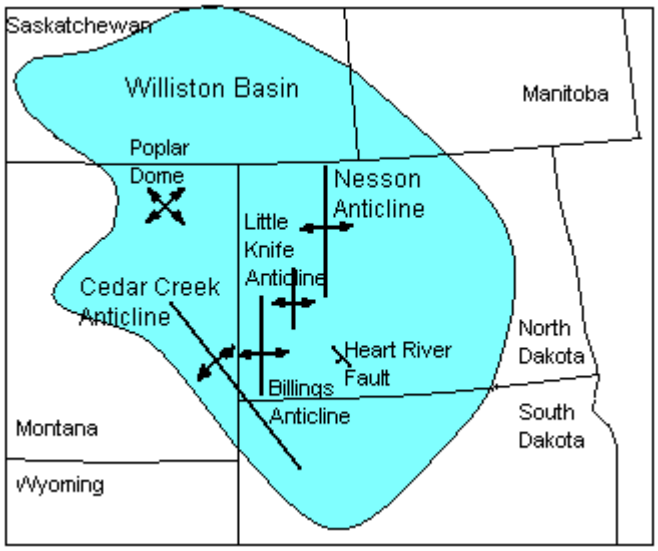

Fig. 3 Major geological structures in the Williston Basin (modified from [8])

Over the history of the basin shallow tropical or subtropical seas transgressed several times, which resulted in the accumulation of thick sedimentary package. The basin also experienced periods of erosion as the seas regressed, indicated by the many unconformities found between many rock formations [6].

The impact of recent Quaternary glacial events are constrained to shallow depths and have a limited influence on the geologic structure in this basin. Nevertheless, by removing a certain portion of overburden, a higher horizontal stress may be “locked” in place to make the stress estimation at shallow depths more complicated [9].

The left lateral shearing motion is thought to have created enough tension to develop a sag for this basin to form (Fig.4) [8]. The basement is dissected into blocks by a series of tectonic features referred as lineaments, which are believed to be responsible for the origin of structures and depositional patterns within this basin [5].

Figure 5 shows a cross section of this basin as well as its relationship to the Rocky Mountains. Since the Williston Basin is located relatively far inside the North America Craton, the Cordilleran Orogenic activity may have little obvious disturbance to this basin’s stability [10]. However, it may induce some

strike-slip faulting movements found in the west flank of this basin [11].

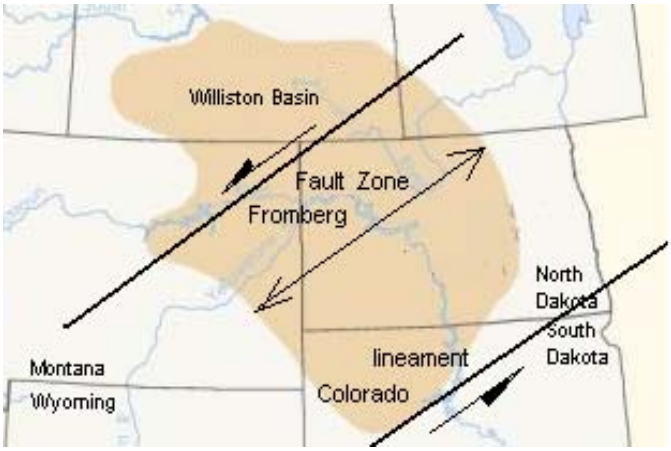

Fig. 4 Relationship of Fromberg-Colorado-Wyoming shear zones to Williston Basin (Modified after [8])

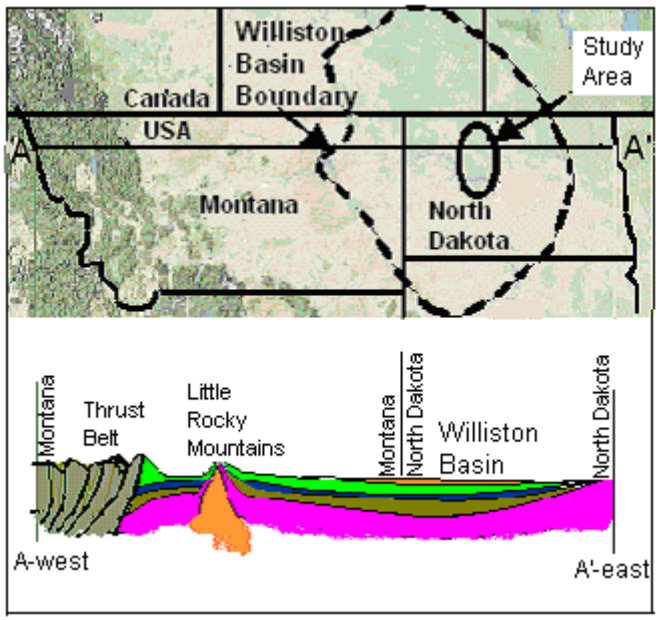

Fig. 5 Williston Basin cross-section and its relationship with Cordilleran Orogenic Belt (Modified after [10]).

The study area of focus in this paper is in the Beaver Lodge field in Williams County, North Dakota, as shown in Fig. 5. The major structure within this area is the Nesson Anticline [5].

3. IN-SITU STRESS ASSESSMENT

To assess the in-situ stress in this basin, the direction of the maximum principal stress needs to be identified.

3.1. Orientation of maximum principal stress

An anticline can be created in two different stress regimes: either in a tectonic or horizontal compressive stress regime or in an overburden, or a vertical compressive stress regime, as shown in Fig.6. The direction of the maximum principal stress dictates the stress regime [12].

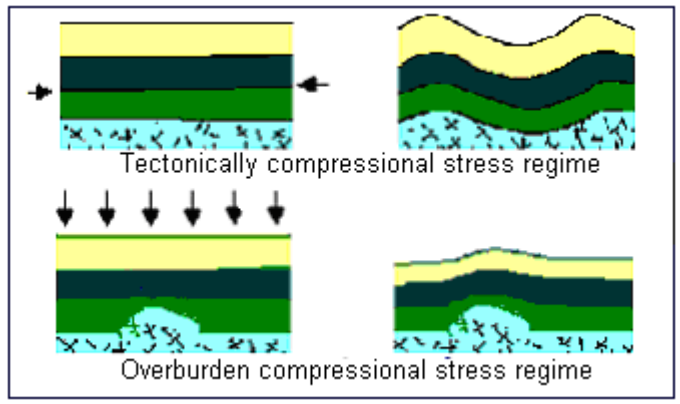

Fig. 6 Anticline creation mechanisms (case 1: Tectonic compression; case 2: Overburden compression)

In case 1, when the horizontal stress is the maximum principal stress, the rock layers are squeezed to form folds. This folding is commonly observed in mountain building areas where two tectonic plates converged. In this case, synclines and anticlines may also be found in parallel succession. Thrust faults are usually related to the folds and also signify the similar maximum principal stress orientation.

In case 2, when the vertical stress is the maximum principal stress, the sedimentary layers are compacted by gravity over geologic time after the initial deposition as flat layers. Since the crystalline rock basement terrain may not be flat, above the basement highs less subsidence occurs than above the basement lows. Depending on the basement terrain, an anticline may form above a ridge and a dome may form above a hummock. In this case, synclines are not related to anticlines and other parallel anticline may not be found. The associated normal faults may be steeply (vertically) dipping due to the differential compactions [12].

Uplift of the basement may also create an anticline [13]. The maximum principal stress in this case would be in the vertical direction. This can be considered as a variation of case 2.

The Nesson anticline, which is in the study area, is one of the largest structures in Williston basin. It was created by an overburden compressional stress regime [5] [12] [13].

Figure 7 is the stress map of North America. Comparing Figure 7 and Figure 1, the maximum stress distribution coincides with the boundary of the North America Craton. In the center of the

North America Craton, stress data is very scarce. Only two measurements of stress are found in the Williston Basin, located in the southeast corner of Saskatchewan [14]. These measurements indicate a maximum horiztonal stress in the north-south direction. Since the data are low quality (quality C and D) and fall outside of the study area, these measurements cannot be extended to the study area.

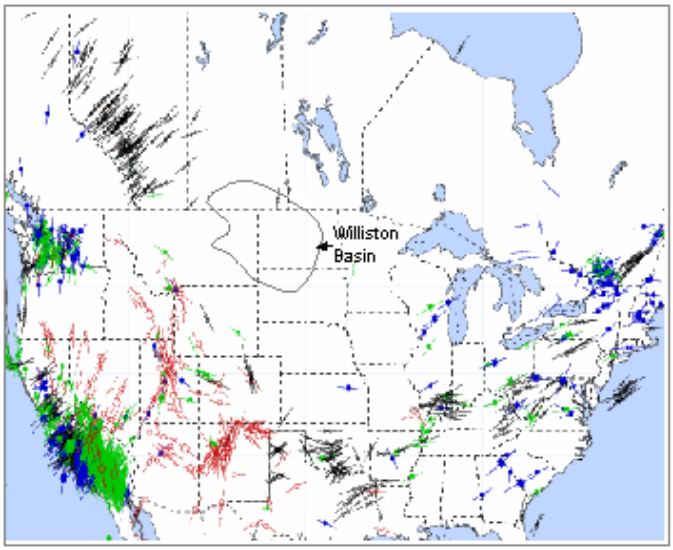

Fig. 7 Stress Map of North America and Williston Basin [14]

Figures 8 and 9 show core sample images taken from wells drilled in Nesson Anticline at depths of 3005 m and 3478 m. The horizontal fractures in Figure 8 were created along planes of weakness by the tensile force that is relieved after the removal of the overburden.

Fig. 8 Core sample cross section image (depth: 3005m, location: Latitude: 48.316263 Longitude: -103.004936) [15]

Figure 9 shows a colonial coral as indicated by the hexagonal pattern. This fossil has not undergone deformation in the plane of the thin section, which is assumed in the x-y plane. The stress for the rock did not exceed elastic limit since the fossil is still in the same shape as it would have grown. This supports the assumption that there is an isotopic distribution of stresses at this depth, which is a typical situation when the vertical stress is the maximum principal stress.

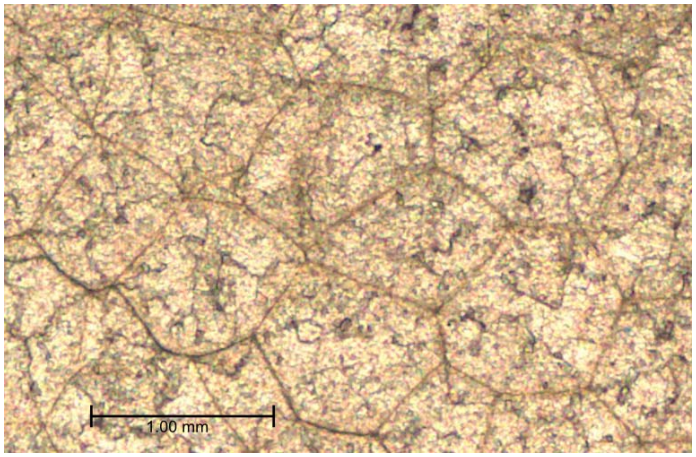

Fig. 9 Core sample plan view, thin section from NDIC well 25 (depth: 3478m, location: Latitude: 48.271398 Longitude: -102.954715) [15]

We conclude that the maximum principal stress in this basin is generally in a vertical direction based on the following understandings:

- This basin is situated within the North America Craton, which has remained in a stable state since the beginning of basin evolution.
- The basin is so large that the curvature of the earth must be taken into account. Even though the basin is deep in its center, the overall basement slope is less than 1° [6], and therefore the horizontal stress could only be transferred by the friction of the bedrock if it existed. However, there is no evidence of convergent movements of bedrock within this basin after the Precambrian.
- The energy generated by tectonic movement to the west has mostly been dissipated in the Cordilleran Orogenic Belt and East Montana Volcanic Intrusion. The west side of this basin accommodates some portion of the strike-slip movements not dissipated. The east side of this basin is less active than the west side.
- There may be some small strike-slip regimes due to shearing, especially on the west side of this basin. However, an alteration of non-tectonic regime basin-widely can not be justified [12]. Large-scale lineaments do not reflect shearing but reflect basement structures

and may be associated with ancient subsurface fluid flow systems [16].

- The distribution of major structures in this basin coincides with the rugged Trans-Hudson Orogen. These structures are the deformed expression of the basement terrain. Any maximum horizontal principal stress regime would have occurred before the basin was formed.
- Evidences from wells drilled in the Nesson Anticline indicate the existence of a Precambrian high underneath [5], supporting the assumption that vertical stress could potentially create this anticline.
- Minor faults related with anticlines were found to be almost vertical [5]. These faults may have been induced by the differential subsidence caused by gravity.
- The core sample images from this basin generally demonstrate textures that were formed in an overburden compressive stress regime [15].

The Williston Basin as a whole is in an overburden compressive stress regime, the maximum principal stress is the vertical stress, and our study area is believed to be no exception. However, horizontally compressive stress regimes can occur in some areas or depths due to burial or erosion history, shearing activities, or localized specific structures.

3.2. Maximum principal stress magnitude

If the rock at depth h in a rock mass of infinite lateral extent behaves as an isotropic elastic material, the in-situ stress, in the absence of tectonic stresses, can be estimated as [17]:

$$\sigma_z = \int_0^z \rho(h) g dh \qquad (1)$$

$$\sigma_x = \sigma_y = \frac{\nu}{1-\nu}\sigma_z \qquad (2)$$

where σ_x and σ_y are principal stresses in the horizontal plane, σ_z is the vertical stress caused by gravity, h is the depth of overlying rock, ν is Poisson's ratio, and ρ is the density of the rock.

Table 1 shows the estimates of in-situ stress for a rock column in the Beaver Lodge field at the Nesson anticline. The basic data was acquired from the North Dakota Geological Survey Circular No.210 [18], the missing layers were estimated based on references [6] and [19].

Table 1. Vertical stress estimation (ND Well No.1231: Latitude: 48.280176 Longitude: -102.983614)

Formation	Depth (m)	Density (kg/m^3)	σ_z (MPa)
Oahe	0	1700	0
Snow School	15	1900	0.25
Sentinel Butte	315	1950	5.84
Bullion Creek	515	2000	9.66
Slope-Ludlow	715	2000	13.58
Unnamed (Pliocene)	815	2100	15.54
Hell Creek	915	2100	17.60
Fox Hills	1065	2000	20.68
Greenhorn	1185	2000	23.04
Mowry	1278	2100	24.85
Inyan Kara	1400	2300	27.38
Piper	1722	2500	34.63
Spearfish	1809	2400	36.76
Otter	2065	2500	42.78
Kibbey	2239	2200	47.05
Charles	2286	2300	48.05
Mission Canyon	2480	2300	52.42
Lodgepole	2540	2300	53.77
Bakken	2933	2400	62.64
Three Forks	2966	2500	63.41
Birdbear	3025	2300	64.86
Duperow	3052	2400	65.47
Souris River	3167	2100	68.16
Dawson Bay	3268	2800	70.25
Prairie	3307	2000	71.33
Winnipegosis	3389	2500	72.94
Interlake	3476	2500	75.05
Stonewall	3488	2500	75.35
Stony Mountain	3806	2500	83.15
Red River	3862	2800	84.53
Roughlock	4032	2100	89.18
Black Island	4078	2200	90.12
Deadwood	4124	2800	91.11
Precambrian	4142	3200	91.61

Figure 10 was drawn based on Table 1, indicating that vertical stress can be approximated as having a gradient of 22.62 MPa/km (1.0psi/ft), that is:

$$\frac{d\sigma_z}{dh} = 22.62 \text{ MPa/km} \qquad (3)$$

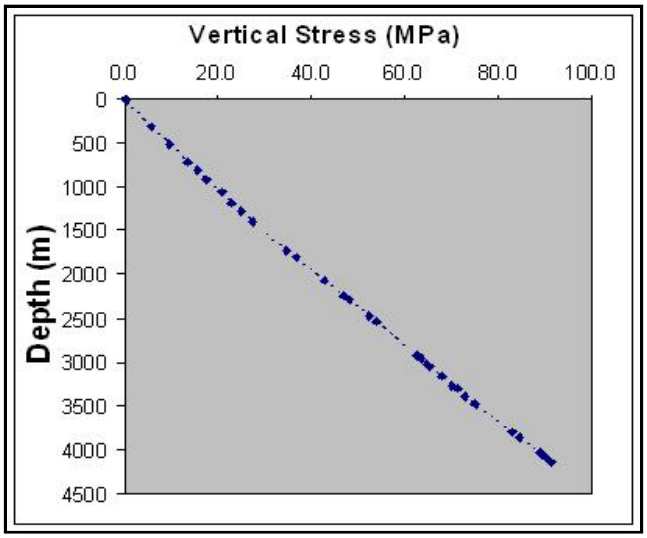

Fig. 10 In-situ vertical stress distribution along a rock column at the Beaver Lodge field in Williston Basin

Overall, the horizontal principal stress is a certain portion (0.3 to 0.7) of the vertical stress at shallow depth, and it will approach the vertical stress with the increase of depth. At the depth very close to the ground surface (<150m), there is the possiblity that the horizontal principal stress may be even greater than the vertical stress due to the past glaciations activities [9].

Currently, the information is too limited to allow a more accurate curve of horizontal stress to be compiled. Usually σ_x and σ_y are not equal but differ from place to place, which requires a case by case analysis that is not practical for an initial basin-wide evaluation [20].

Using Figure 10 and the geothermal gradient of 25-30°C/km, the minimum depth for CO_2 sequestration in the study area can be estimated. Because supercritical CO_2 must be stored under specific conditions, the minimum depth can be estimated based on the required pressure and temperature. Assuming a buffer of 1.38 MPa (200 psi) between the minimum in-situ stress and CO_2 pressure, then the required minimum horizontal in-situ stress is:

$$\sigma_{xmin} = 7.38 + 1.38 = 8.76 \text{ MPa} \quad (4)$$

For typical formations, $\nu = 0.25$ [16]. Applying this to Eq. (2), the horizontal in-situ stress is:

$$\sigma_x = 0.33\, \sigma_z \quad (5)$$

Combining Eqs (3) (4) and (5), the minimum depth corresponding to CO_2 critical pressure is:

$$h_{\min_P} = \frac{\sigma_z}{\left(\frac{d\sigma_z}{dh}\right)} = \frac{3\sigma_x}{\left(\frac{d\sigma_z}{dh}\right)} = \frac{3\sigma_{x\min}}{\left(\frac{d\sigma_z}{dh}\right)} = \frac{3\times 8.76MPa}{22.62MPa/km} = 1.162\,km \quad (6)$$

Similarly, the minimum formation temperature needs to be 32°C. Assuming a geothermal gradient of 25~30 °C /km [9], the minimum depth for a minimum formation temperature of 32°C is 1.07 to 1.28 km.

From the above calculations, a safe storage depth should be a minimum of 1300 m.

4. IMPLICATIONS OF FAULTS

In the Williston Basin, faults are hard to recognize, moment magnitudes for rupture events tend to be very small, and minor faults related with anticlines are almost vertical [5].

4.1. Fault initialization by dissolution of salt

As mentioned previously, the basin is in an overburden compressive stress regime with the maximum principal stress in the vertical direction. The differential subsidence of the rock layers has caused subtle vertically dipping faults. Also, since some formations are thick salt evaporites; the subsurface dissolution of these salts can initialize the development of fractures. This mechanism was considered as a major structure-forming process in south-central Saskatchewan [21].

The salt formations include Piper (Dunham salt, 1722m), Opeche (1900m) and Prairie (3300m) [19]. Among them, the Devonian Prairie Formation is the most extensive one.

A fault at shallow depth, due to the smaller horizontal stress, may extend upwards to a great degree before it is closed, or simply reaches the ground surface to form a rift. For a deep fault, there is the possibility that it may be closed before extending upward to a significant distance because of the isotropic distribution of stresses. However, if a fault occurs beneath the CO_2 container layer, the tremendous buoyancy driven force of CO_2 may come into play and alter the in-situ stress condition, thus hindering the closure of the otherwise small fault [4]. This steeply dipping fault caused by the collapse of salt layer underneath a CO_2 container

layer can form a potential pathway for CO_2 leakage. Such a hypothetical scenario is shown in Fig.11.

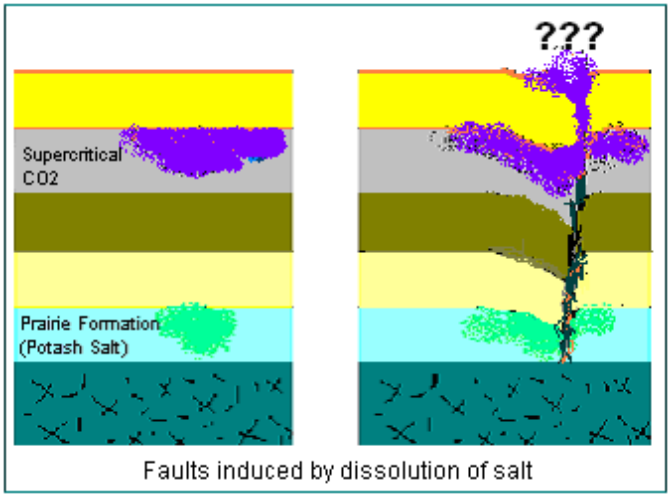

Fig. 11 Hypothetical scenario of fault creation and CO_2 breakthrough in Williston Basin

In the study area, the Prairie formation is at a depth of 3300 m, lying under most of the potential CO_2 storage layers. Its potential influence on the geomechanical stability of CO_2 sequestration requires further examination.

4.2. *Faults initialization by hydraulic fracturing*

Hydraulic fracturing of reservoir rocks is a common practice for the petroleum industry in this area. The minimum horizontal stress causes the hydraulic fractures to be developed vertically [9]. The production performance may be impaired by unfavorable fracture developing. A reservoir with high concentration of vertical fractures may also pose more challenges for CO_2 sequestration [22].

Please note that overpressure due to hydrocarbon generation in formations, such as Bakken, can cause hydraulic fractures to be developed horizontally [23].

Knowing hydraulic fracturing break-down pressure is very important to both effective petroleum reservoir stimulation and safe CO_2 sequestration injection. Based on the results of the in-situ stresses in the study area, the break-down pressure in a vertical well is [24]:

$$\begin{cases} p_{b,upper} = 2\sigma_x - p + T \\ p_{b,lower} = \dfrac{2\sigma_x - \dfrac{\alpha(1-2\nu)}{(1-\nu)}p + T}{2\left(1 - \dfrac{\alpha(1-2\nu)}{2(1-\nu)}\right)} \end{cases} \quad (7)$$

where p_{b_upper} and p_{b_lower} are the upper and lower boundaries of break-down pressures, p is formation pore pressure, T is formation tensile strength, and α is Biot coefficient of poroelasticity. Similarly, in a horizontal well, the break-down pressure is [24]:

$$\begin{cases} p_{b,upper} = 3\sigma_x - \sigma_z - p + T \\ p_{b,lower} = \dfrac{3\sigma_x - \sigma_z - \dfrac{\alpha(1-2\nu)}{(1-\nu)}p + T}{2\left(1 - \dfrac{\alpha(1-2\nu)}{2(1-\nu)}\right)} \end{cases} \quad (8)$$

4.3. *Faults reactivation*

In a very simple case, petroleum production reduces the pore pressure in place by removing oil and/or gas from the reservoir, thus the preexisting faults, joints, and fractures may be healed by the increased effective stress. Depending on the time and chemistry, a series of weak points may exist along a preexisting fracture. Also, many micro-fractures may be induced by the re-equilibrium of in-situ stresses, making the rock formations weaker than before [9] [20].

By injecting CO_2 into the reservoir, pore pressure builds up, resulting in a decrease of effective stress, often heterogeneously. This increased pore pressure will shift the Mohr's Circle left, and may approach the frictional failure envelope [25]. Once the envelope is reached, faults may be reactivated abruptly along preexisting fractures and may trigger early CO_2 breakthrough. The potential for this to occur should be evaluated on a site-specific basis as part of baseline characterization of CO_2 sequestration candidate sites.

5. CONCLUSION

The Williston Basin is thought to be geo-mechanically stable. It has been tectonically quiescent for the past 500 million years and will likely continue over the significant future.

- A typical intracratonic basin, the Williston Basin as a whole is in an overburden compressive stress regime. However, a local stress regime can be far more complicated than it appears to be due to possible shearing activities, burial and erosion history, diagenesis, salt dissolution features, and hydrocarbon generations.

- In the study area, the thick sedimentary rock layers below 1300m depth provide a series of candidates for CO_2 to be stored in a supercritical state. The vertical stress has a gradient of 22.62MPa/km (1.0psi/ft) and the horizontal stress is a function of the vertical stress. It approachs the vertical stress with depth, and will lead to an isotropic stress condition at certain depth.
- Within study area, the faults are minor and localized, mostly caused by the dissolution of salt. Anthropogenic faults may be caused by hydraulic fracturing during petroleum production. The deeper the fault, the easier it is to be closed due to a uniform stress condition.

This initial study demonstrates that further research is required. Further site characterization, numerical modeling, and lab testing are necessary to provide an accurate estimate of in-situ stress and an in-depth understanding of the fracture open-close mechanisms. Therefore this study must be considered as a primary reconnaissance endeavor.

ACKNOWLEGEMENTS

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Attachment 2

Geomechanical study of Bakken formation for improved oil recovery

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ISRM International Symposium on Rock Mechanics
"Rock Characterization, Modelling and Engineering Design Methods"

GEOMECHANICAL STUDY OF BAKKEN FORMATION FOR IMPROVED OIL RECOVERY

Paper No. 341

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ABSTRACT

The objective of this paper is to outline the methodology proposed to determine the in-situ stress field and geomechanical properties of the Bakken Formation in Williston Basin, North Dakota, USA to increase the success rate of horizontal drilling and hydraulic fracturing so as to improve the recovery of this unconventional crude oil resource from the current 1% to a higher level.

The Bakken Formation in the North Dakota Williston Basin is a thin layer (maximum thickness 145 ft) of interbedded, naturally fractured low permeability black shale, siltstone, silty sandstone and silty carbonate rocks at about 10,000 ft depth. Due to the high carbon content in the upper and lower shales, it is estimated to have 200 - 400 billion barrels original oil in place (OOIP). However, the US Geological Survey indicated that technical recoverable reserve is about 3.6 billion barrels representing 1% recovery, much lower than the normal recovery of 30%.

Horizontal drilling with hydraulic fracturing is the currently used well completion technique for economic exploitation of crude oil from this formation. The success of horizontal drilling and hydraulic fracturing depends on the local in-situ stress and geomechanical properties of formation rocks. Only limited information on these aspects is available. Currently some areas experienced success rate of less than 10% in drilling this type of wells due to wellbore instability and unsuccessful fracturing, each of these wells costing 3-6 million dollars.

We propose a proactive approach to determine the in-situ stress and related geomechanical properties of the Bakken Formation in representative areas through integrated analysis of field and well data, core sample and lab experiments. We plan to use Kaiser Effect technique to estimate in-situ stresses. CDISK method will be used to determined fracture toughness. Geomechanical properties will be measured following ISRM suggested methods. By integrating lab testing, core observation, numerical simulation, well log and seismic image, Intelligent Geomechanical Logging and Imaging methods are proposed to estimate geomechanical properties in locations where no results of lab testing and core observation are available.

Using the results from this research, the success rate of horizontal drilling and hydraulic fracturing is expected to be greatly increased. For each saved well, the direct impact is 3-6 million dollars. More importantly, optimized well alignment in the Bakken Formation will allow future application of enhanced oil recovery technology, such as CO2 flooding, which will greatly increase the ultimate recovery. An increase of 1% in recovery (a modest goal) will lead to an increase of 2 - 4 billion barrels of oil production.

Key Words: North Dakota, Williston Basin Bakken Formation, Naturally fractured reservoir, Kaiser Effect, CDISK method, Horizontal drilling, Hydraulic fracturing, Intelligent Geomechanical Logging and Imaging

Geomechanical Study of Bakken Formation for Improved Oil Recovery

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ABSTRACT

The objective of this paper is to outline the methodology proposed to determine the in-situ stress field and geomechanical properties of the Bakken Formation in Williston Basin, North Dakota, USA to increase the success rate of horizontal drilling and hydraulic fracturing so as to improve the recovery factor of this unconventional crude oil resource from the current 1% to a higher level. The success of horizontal drilling and hydraulic fracturing depends on knowing local in-situ stress and geomechanical properties of the rocks. We propose a proactive approach to determine the in-situ stress and related geomechanical properties of the Bakken Formation in representative areas through integrated analysis of field and well data, core sample and lab experiments. We plan to use Kaiser Effect technique to estimate in-situ stresses. CDISK method will be used to determined fracture toughness. Geomechanical properties will be measured following ISRM suggested methods. By integrating lab testing, core observation, numerical simulation, well log and seismic image, Intelligent Geomechanical Logging and Imaging methods are proposed to estimate geomechanical properties in locations where no results of lab testing and core observation are available.

1 INTRODUCTION

The Williston Basin is a roughly oval-shaped structural down-warp with a surface area between 120,000 and 240,000 square miles. The basin underlies most of North Dakota, western Montana, northwestern South Dakota, southeastern Saskatchewan and a small section of southwestern Manitoba. All sedimentary systems from Cambrian through Quaternary are presented in the basin, with a rock column more than 15,000 ft thick in the deepest section near Williston, North Dakota (Fig. 1). The basin became a major oil province in the 1950s when large oil fields were discovered in North Dakota.

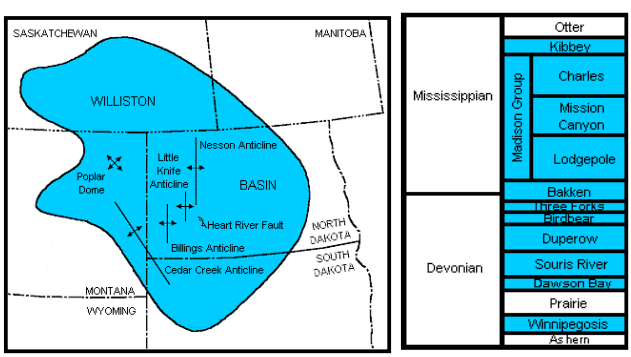


Figure 1: Williston Basin and part of its stratigraphic column.

The Bakken Formation is a thin (maximum thickness 145 ft), naturally fractured Upper Devonian-Lower Mississippian sedimentary unit. It can be divided into three intervals: the upper shale, the lithologically variable middle member, and the lower shale. The upper and lower shales have rich organic content, and are the source rocks for oil and gas in the Bakken Formation. In North Dakota, the middle member is mainly gray interbedded siltstones and sandstones with a maximum thickness of 85 ft occurring at depths of approximately 9,500 to 10,000 ft (Heck et al., 2002).

Although the Bakken Formation is very thin compared to other oil producing horizons, it has recently attracted much attention because its extremely high carbon content places it among the richest hydrocarbon source rocks in the world. Estimates of original oil in place (OOIP) range from 200 to more than 400 billion barrels (Price, 2000). For comparison, excluding these Bakken Formation reserves, so far the total US discovered OOIP is less than 600 billion barrels, of which only less than 200 billion barrels has been produced. With the growth rate of demand outpacing that of new reserves on oil and gas, the importance of these unconventional reserves in the Bakken Formation becomes increasingly important. Since 2001, a significant amount of oil has been successfully produced from the Bakken Formation in Richland County, Montana. However, application of similar well construction technologies to the Bakken Formation in the North Dakota part of the basin has not achieved the expected success. This paper presents part of the ongoing efforts in improving the successful rate of horizontal drilling and hydraulic fracturing in this thin, naturally fractured tight shale formation through geomechanical study.

2 STATEMENT OF THE PROBLEMS

From 1953 to 1987, vertical wells were drilled to recover the crude oil from Bakken Formation. Successful wells

were those that encountered natural fractures which displayed high production at the beginning and soon dropped rapidly to a steady, low level production rate. The Bakken shale is oil-wet, and could not be water-flooded. Acidizing is prohibited because the injected fluid may react with the pyrite present in the shales, forming an iron hydroxide precipitate.

From 1987 to 2001, horizontal drilling was extensively practiced in the Bakken Formation. Using horizontal drilling improved the performance, to a certain degree, especially with the successful production of oil from the upper shale. However, horizontal wells also encountered new challenges: borehole instability and wellbore interference. The large investment and high risk in drilling horizontal wells in the Bakken Formation kept the exploration and production activities at a low level until 2000 when new well construction technique was developed in Richland County, Montana (Lantz et al., 2007), which later extended to western North Dakota. This new technique combines horizontal drilling with hydraulic fracturing. However, in-situ stress field and geomechanical properties change not only along the axis of those horizontal wells that extended several thousand feet, but also form location to location in the basin. Well orientation with respect to the in-situ stresses is the controlling factor to the success of hydraulic fracturing and wellbore stability during drilling and production. Therefore, it is vitally important to know the in-situ stress field and fundamental geomechanical parameters for selecting the adequate orientation of horizontal wells and for designing successful hydraulic fracturing treatment.

3 GEOMECHANICAL STUDY

Geomechanical study of Bakken Formation is to estimate the in-situ stresses and determine mechanical properties so as to improve the success rate of horizontal drilling and hydraulic fracturing. The research involves lab testing, field data analysis, and numerical simulation using representative well logs and core samples of the study area. The methodology and part of the results are introduced below.

3.1 Geomechanical Lab Testing

Lab testing is the fundamental and direct means to get the geomechanical properties of the Bakken Formation. It is important to both determining the rock mechanical parameters and the in-situ stresses. Based on the concept that rocks “memorize” the peak load it experienced, Kaiser Effect technique was developed to determine in-situ stresses. Loading the rock specimen under lab conditions and recording the induced acoustic emissions (micro-seismic events) in the compression, we can find out the point corresponding to dramatic increase in acoustic emissions; this point is called the Kaiser point. The stress corresponding to the Kaiser point is the maximum in-situ stress in the specific direction the rock sample has ever been undergone.

Kaiser Effect method becomes one of the best technical choices for determining in-situ stresses due to several reasons. First, it can determine both the direction and the magnitude of the in-situ stresses if oriented core is available. If there are no oriented core samples, the directions can still be derived by combining the information of the well axis direction and the analysis of the discontinuities. Secondly, it uses small samples (1-in diameter by 2-in length), which is especially valuable to the petroleum industry.

Fracture toughness (K_{IC}) of the target and neighboring formations is one of the most important parameters for hydraulic fracturing design. There are different methods to determine rock fracture toughness, but most of them are hard to apply directly to the petroleum industry due to the fact that cylindrical cores retrieved from oil drilling are often not large enough to meet the geometric requirements of those methods. In order to overcome this difficulty, Zhao and Roegiers (1990) proposed a CDISK method which uses Chevron-notched disk specimens to measure K_{IC}. Zeng et al. (2004) further improved the method. It has two advantages: First, it can use small samples of 2-in in diameter. Secondly, it provides the possibility of measuring K_{IC} in any direction in the disk plane.

For other commonly tested geomechanical properties of the Bakken Formation, International Society for Rock Mechanics’ (ISRM) suggested methods and other related guidelines will be followed. These properties include uniaxial compressive and tensile strengths, triaxial strengths under different confining pressures, cohesion and angle of internal friction, Young’s modulus and Poisson’s ratio, Biot’s coefficient, and fracture gradient.

Petroleum geomechanics has two features: First, core samples are limited in both quantity and size, so the test specimens are small. Secondly, the rocks are in deep geological environment in which their mechanical properties are usually impacted by the coupling effect of thermal, in-situ stresses, pore pressure and fluids. Aiming at simulating the above features, we developed a multifunction petroleum geomechanical testing system (Zeng et al., 2008). Using this system, the tested sample can be under varied geological conditions, such as temperature, in-situ stresses, pore pressure, fluids, etc. All these geological conditions can be independently applied to the rock sample by means of this in-house developed system. The system mainly consists of the injection pumps, back pressure regulators (BPRs), triaxial acoustic core holder, air bath (oven), axial and radial in-situ stresses pumps, digital oscilloscope, data acquisition board, and control box. Steel tubing can carry the injected fluid and the confining pressure fluid up to 15,000 psi. Data lines connect cables from different subsystems, sensors, and transducers. Depending on where the cables are connected, they carry digital and analog signals. The control box was designed to carry multiple functions and serve as an interface between the electrical connections of the hardware components and a local computer. Fig.2 shows some pictures of the system and a tested sample as well as the stress-strain curves.

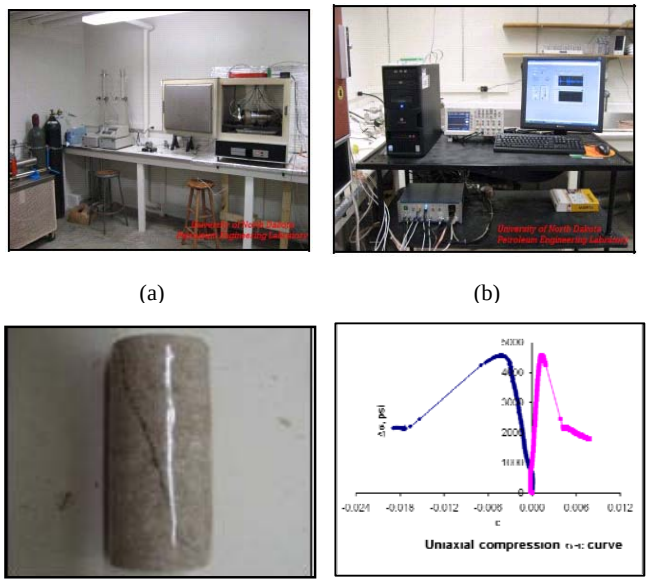


Figure 2: The multifunction petroleum geomechanical testing system (a, b), tested specimen (c), and stress-strain curves (d).

3.2 Core Samples Observation

Because the Bakken Formation in Williston Basin, North Dakota is at about 10,000 ft depth, no surface access is available. However, the North Dakota Geological Survey Core Library has a large collection of Bakken Formation core samples from the petroleum drilling activities. These include some oriented core samples. With the recent booming drilling in the Bakken Formation, more samples are being delivered. The Core Library, on the University of North Dakota campus, provides the best access for both observing core samples and cutting core specimens.

When the rock is subjected to load, it deforms. If the load exceeds a certain limit, it fractures or fails. The failure surface is called discontinuity of the rock. The failure plane and the stress orientation have a certain relationship (Narr et al., 2006). Following the structural geology principles, the feature of the discontinuities, i.e., tensile failure (joint), shear failure (fault), or bedding plane, can be identified from core sample observation. Using the relationship between the discontinuities and the principal stresses, part of the direction(s) of the principal stresses can be derived.

Cored samples are parts of the rock mass in the geological environment under in-situ stresses. These samples not only provide the lab testing materials but also express the characters of in-situ stresses through their minor and micro structures. By measuring and observing the minor/micro crack spacing, distinguishing the geologically originated cracks from the drilling induced ones, the orientation and value of in-situ stresses can be estimated via numerical simulation. Some researchers stated that drilling induced core damage contains certain in-situ stress information. Many reports demonstrated that it is possible to estimate the in-situ stress orientation and value by core discing pattern (Stacey, 1982; Kaga et al., 2003).

Discing (fracturing) in coring process can be simulated using numerical modeling. Numerical simulation has strong adaptability which can provide valuable results and 3-dimensional visualization to different fracturing processes. In this study we use elastic-plastic and strain softening constitutive model to express the post peak behavior and simulate the core discing process via this type of numerical experiment. By increasing the grid numbers, strain localization can be further simulated.

By modifying the input of in-situ stresses, different numerical simulation results can be obtained. Comparing the calculation and the observation of the core discs, the input that results in best match between the calculation and the observation are the optimized estimation of in-situ stresses. Figure 3 is the actual core discing photo and a 3-dimentional numerical model.

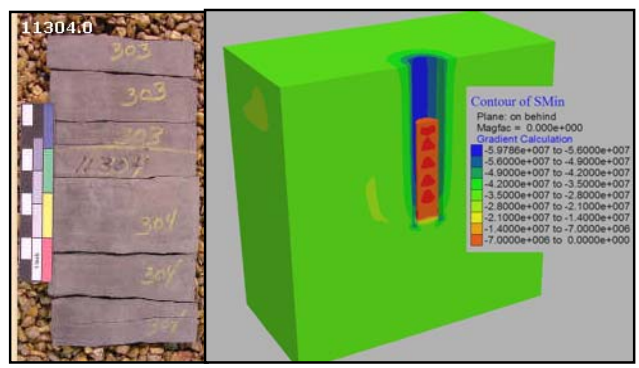


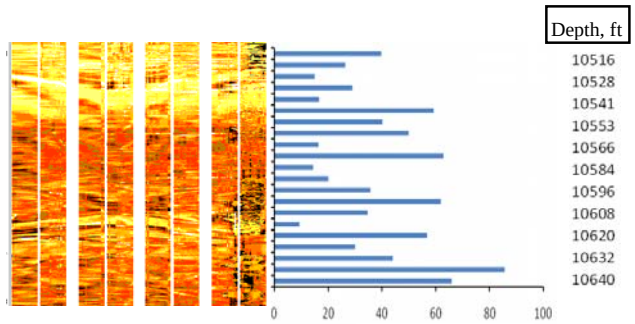
Figure 3: Observed and simulated core discs.

Petroleum geomechanics handles deep rocks which are different from those in shallow depth. However, there is no specific quality index to describe these deep rocks. In this paper, we use the commonly defined rock quality designation (RQD) index for deep rocks. Here the intact cores are defined as those that are 4-in (10cm) and longer; and the reference statistic length is 6-ft, i.e. 2-column of the core box. Although this definition is similar to the conventional RQD, there is an essential difference: while the conventional RQD is equivalent to the statistics of the geological structures, the deep rock RQD represents both the original cracks and unloading induced cracks, which include the impact of in-situ stresses.

It has practical significance to use RQD to characterize deep rock mechanical properties, especially those related to borehole stability. From the mechanics point of view, cracks in core from deep rock relate not only to existing geological structures, but also to rock mechanical properties and in-situ stresses. Because rock sample coring and regular drilling of deep formation are under the same geomechanical environmental conditions, there is an inherent connection between cored sample RQD and the borehole stability. In other words, RQD measured on cores recovered from deep rocks is a good expression for borehole instability. Figure 4 shows how RQD changes with depth in Well #15986.

3.3 Well log data study

There are abundant log data from Bakken oil and gas wells. These well logs directly or indirectly reflect all kinds of petrophysical and geomechanical properties of the formation and the regional geology, including discontinuities. In fact, these logs can be considered as the crops or exposures of the deep formation. Therefore, it is possible to derive Bakken Formation geomechanical properties using these well logs. This method is especially valuable in case that cores and/or lab testing are not available.



(a) FMI log (b) RQD(%)

Figure 4: FMI Log (a) and RQD (b) of Well #15986 in Williston Basin, North Dakota.

Conventional logs include porosity series (acoustic, neutron and density etc), resistivity series (dual lateral, dual induction and micro-spherical, etc), dipmeter log, long-spaced sonic log and natural gamma-ray spectral log. Methods to obtain reservoir parameters are mainly Archie's equation and other empirical formula, all based on uniformity volume model. Among these logs, sonic and density logs are closely related to rock mechanical parameters

These logs have played vital roles in previous fracture analysis, and will continue to be important means. However, each log has its limitation. For example, acoustic waves attenuate more rapidly in fractured zones than in intact zones; horizontal fractures damp down more seriously on S-wave than on P-wave; and high angle cracks affect P-wave more seriously than on S-wave. Experiments show that there are correlations between fracture dipping angles and attenuation of P- and S-waves. Therefore, these logs can't be used to identify fracture type, occurrence, and density.

To overcome the above limitations in characterizing fractures, formation micro imager log (FMI) was developed. FMI log collects stratigraphic information along the axial and/or radial direction of the side wall downward the hole by sensor-arrays, transmits the images signals to ground via data link system, and gets 2-dimensional images of the side wall or 3-dimensional images of the surrounding borehole with certain depth through image processing techniques. Imaging logging makes borehole fracture visible and more direct.

Using image logs, parameters of effective fractures can be calculated, including average hydraulic width, fracture length, fracture density, fracture apparent porosity, etc. Figure 4 is the image log of Well #15986. Identifying fractures using image log generally includes the following steps: (1) Distinguish actual fracture from false fractures through calibration using core observation. (2) Distinguish existing natural fractures and artificially induced fractures. The former include both high and low conductive fractures, the latter include fractures induced by drilling, by local stress concentration (compressional), and by in-situ stress unloading (tensional).

4 INTELLIGENT GEOMECHANICAL LOGGING AND IMAGING

Lab testing, core analysis, and well log correlation are three different methods that can be used to determine geomechanical properties. Each has its advantages and limitations. Lab testing is the most direct and reliable means to get the geomechanical properties. Because of the time, energy and samples needed in conducting these tests, only limited samples can be tested. Core analysis is direct method. But it can be conducted only in cored wells; many more wells are usually not cored. Well log is indirect method. It is difficult to quantify geomechanical properties based merely on well logs. However, because well logs are usually conducted in most wells, it is possible to use artificial intelligence technology to integrate lab testing, core observation, and well logging to form a new method to predict geomechanical properties in wells that have not been tested or cored.

This technique, termed Intelligent Geomechanical Logging, uses the results from the few tested samples and the limited cores to correlate and calibrate the well logs; using the calibrated logs, geomechanical properties in wells where their logs are not calibrated can be predicted using artificial intelligence technology. Using machine learning method, such as artificial neural network (ANN), to construct mechanics-well log relation model has been reported (Mohaghegh, 2000). Support Vector Machine (SVM) is an artificial intelligence method based on statistical learning theory developed after ANN. It follows the principle of minimized structural risk, and overcomes the difficulty of over-learning encountered in ANN. This paper constructs the geomechanics-well log model by adopting SVM method. Using the SVM-based geomechanics-well log model, information of lab tested and cored wells can be generalized to adjacent logged wells.

Compared to Bakken Formation region in the Williston Basin, the logged wells are distributed only in a small portion. It would be useful if we can estimate the geomechanical properties of the Bakken Formation where no logs are available before drilling. Following the same logic used in developing the Intelligent Geomechanical Logging, this could be solved using well log-seismic correlations to form a new technique (termed Intelligent Geomechanical Imaging). The following are three steps for the implementation of this Intelligent Geomechanical Imaging: (1) Establish a well log-seismic correlation based on the similarities of acoustic and seismic waves. (2) Develop a geomechanics-seismic

correlation based on results of logged wells. (3) Generalize geomechanical properties from known space to unknown space using geostatistics (Kelkar and Perez, 2002). (4) Improve the correlation and prediction model by comparing the generalized results with results from observation and numerical simulation using progressively accumulated data. Figure 5 illustrates the flowchart of how this Intelligent Geomechanical Imaging can be implemented for Bakken Formation rocks.

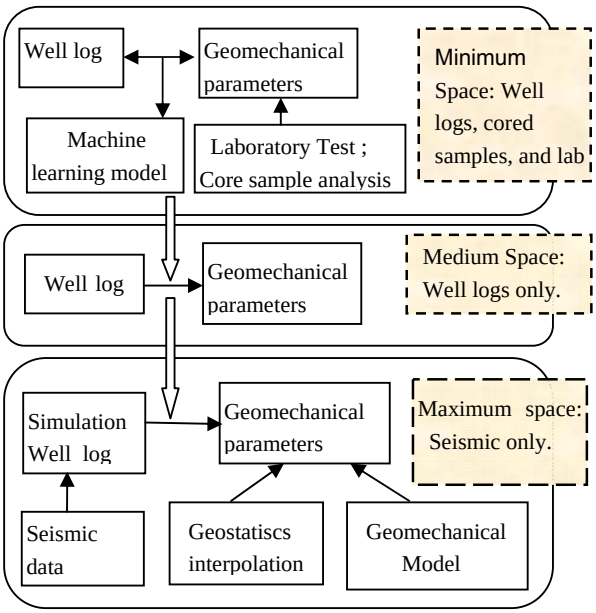


Figure 5: Flowchart of the Intelligent Geomechanical Imaging method for Bakken Formation study.

5 CONCLUSIONS

(1) Bakken Formation has huge crude oil reserve, but the current recovery factor is only about 1% because of its special geological characteristics. This paper outlines the methodology proposed to investigate in-situ stresses and geomechanical properties of the Bakken Formation.

(2) ISRM suggested methods will be followed to test conventional geomechanical properties. In-situ stresses will be estimated using Kaiser Effect method. Fracture toughness will be tested using CDISC method.

(3) RQD is extended to characterize deep rock quality and borehole stability. By comparing the observed core discing and the localization of an elastic-plastic strain-softening model, in-situ stresses could be estimated.

(4) An Intelligent Geomechanical Logging method is proposed. Using this method, geomechanical properties in untested, un-cored areas can be logged by applying SVM-based artificial intelligence technique.

(5) An Intelligent Geomechanical Imaging method is proposed by correlating well log information with seismic data. Geomechanical properties can be further estimated using a space integrated model, which can be improved with progressive accumulation of results from observation and numerical modeling.

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Attachment 3

Estimation of In-situ Stresses of the Bakken Formation in Eastern Williston Basin, North Dakota

Estimation of In-situ Stresses of the Bakken Formation in Eastern Williston Basin, North Dakota

By

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Introduction

Part of the Geomechanical Study of the Bakken Formation consisted of the determination of the in-situ stresses, which is composed of the vertical stress (usually called overburden pressure) and the maximum and minimum horizontal stresses. There are different methods in determining the in-situ stresses. In this report, a method based on elasticity combined with well log analysis is used to calculate the in-situ stresses based on information form 22 selected Bakken wells (Table 1). In some cases, neighboring wells are referred to in case of lack of some data. The twenty-two wells used in this analysis had gone through a previous core sample analysis. To determine overburden pressure, the pressure of each formation overlying the Bakken Formation was calculated for each well site. For this, both the thickness and the average density of each formation were calculated. The density was interpolated from Compensated Neutron Density (CND) well logs. The determination of the horizontal stress needed both the overburden pressure and Poisson's ratio. Poisson's ratio was determined using sonic information acquired from a variety of sonic well logs.

Table 1 Selected 22 Bakken wells for in-situ stress calculation

No.	Well /File No.	API No.	Operator
1	1202	33053001440000	Hess Corp.
2	1254	33053001590000	Hess Corp.
3	1343	33053002030000	Hess Corp.
4	1748	33053003120000	Hess Corp.
5	1780	33050032300000	Hess Corp.
6	7887	33007005810000	Whiting Oil & Gas
7	11617	33053020760000	St. Mary
8	12072	33007011090000	Whiting Oil & Gas
9	12160	33053021880000	St. Mary
10	12331	33007011400000	Whiting Oil & Gas
11	14974	33053025350000	St. Mary
12	15674	33105015270000	Hess Corp.

13	15845	33061004890000	Hess Corp.
14	15889	33061004900000	Hess Corp.
15	15923	33053026720000	Encore Op. LP
16	15986	33061004930000	Hess Corp.
17	16030	33101501551000	Marathon Oil Co.
18	16068	33061004950000	Whiting Oil & Gas
19	16083	33105015570000	Hess Corp.
20	16160	33061004980000	Hess Corp.
21	16333	33025005970000	Marathon Oil Co.
22	16433	33053027690000	Hess Corp.

Calculation Methods

Overburden Pressure Analysis

A Microsoft Office Excel spreadsheet was prepared for the twenty-two wells of interest which included the well file number, the API number, and the current operator of the well. The spreadsheet also contained the thickness of each formation and the interpolated density of each formation. The thickness of each formation at each of the twenty-two wells was determined directly from the North Dakota Industrial Commission (NDIC) website at www.dmr.nd.gov/oilgas. From the "Subscription Services" page and then the "Scout Ticket Data" page, the available information for any well in North Dakota could be reached. The formation tops were listed for all of the wells in the study and were used to determine the thickness of each formation. Some of the formation tops were missing from some of the well files while other formations had differing names between well files. This caused the well files to have formations which were listed as zero feet thick. The thickness of the formations were originally recorded in feet but had to be later converted to meters to calculate the overburden pressure in MPa.

Not all of the twenty-two wells had CND well logs available to us. Some of the wells that had CND well logs would not upload properly and therefore were not able to be used in any density analysis. The wells that did have CND well logs had graphical data along

with Log ASCII Standard (LAS) files. Most of the well logs that were available to us didn't cover the entire depth from Kelly Bushing through the Bakken Formation. Instead, they started towards the top of the Madison Formation and proceeded through the Bakken Formation. To determine the average density, the LAS files were used because it was more accurate than using the graphical data of the well logs. The LAS files had standard formation density readings for every half foot interval. For every twenty-five feet (fifty readings) an interpolated average density was determined and multiplied by twenty-five feet. When the formation wasn't a multiple of twenty-five feet, then the last reading would be multiplied by the number of feet which completed the formation. If the LAS file showed a spike, an average density reading was interpolated for the spike and multiplied by the thickness of the spike. This was performed so a more accurate density reading could be obtained. The interpolated density and interval thickness products were summed for the entire formation. This was then divided by the total thickness of the formation to get an overall average density for the formation at that particular site.

To be able to calculate the pressure of each formation, the thickness was converted from feet to meters and the density was changed from g/cm^3 to kg/m^3. The density, thickness, and $9.81 m/s^2$ were multiplied together and the product was divided by 10^6 to calculate the pressure of each formation in MPa, shown in Equation (1).

$$\boxed{\sigma_{overburden} = \frac{\rho * h * 9.81}{10^6}} \qquad (1)$$

The pressure of all overlying formations of the Bakken were added together to calculate the total overburden pressure. Once the overburden pressure was calculated in MPa, Equation (2) was used to convert the overburden pressure to psi.

$$\boxed{\sigma_{psi} = \frac{\sigma_{MPa} * 224.808943}{1.5500031}} \qquad (2)$$

Horizontal Stresses Analysis

The sonic information required to determine Poisson's ratio was determined from Borehole Compensated Sonic (BCS), Dipole Shear Sonic Imager (DSSI), and Sonic Scanner (SOS) well logs. To determine Poisson's ratio from sonic data, Equation (3) (Schlumberger, 1987) was used.

$$\boxed{\mu = \frac{\frac{1}{2} * (t_s * t_c)^2 - 1}{(t_s * t_c)^2 - 1}} \qquad (3)$$

where:

μ = Poisson's ratio,

t_c = slowness of compressive wave, μs/ft,

t_s = slowness of shear wave, μs/ft.

Well logs were only available for a fraction of the studied wells, so the sonic information that was obtained was extrapolated to the rest of the wells. The DSSI log was the only well log which had readings for both tc and ts while both BCS and SOS logs only had tc data. This made it extremely difficult to extrapolate ts data because only a small fraction of the wells studied had it available. Sonic data was only obtained for the Lodgepole, Bakken, and Three Forks formations. In turn, these three formations are the only ones which the horizontal stresses were calculated.

To determine the horizontal stress for a particular well, the overburden pressure was multiplied by a factor of the Poisson's ratio (Equation 4).

$$\boxed{m = \frac{\mu}{1 - \mu}} \qquad (4)$$

Conclusions

Overburden Pressure

Eleven of the twenty-two wells had CND logs which were able to be analyzed. All eleven of the wells had formation density information from the Mississippian – Base of Last Salt through the Bakken Formation. The wells with file numbers 15845 and 16433 had density information from the topsoil through the Bakken Formation. Two more wells, 15923 and 15986, had density readings that started in the Pierre Shale while well 16160 started in the Cretaceous – Greenhorn Formation. The remaining six had well logs starting between the Pennsylvanian – Tyler Formation and the Mississippian – Base of Last Salt. The well files all had similar density data except for well 16160 which may be an outlier. This well had density readings averaging 1.94 g/cm3 to 2.15 g/cm3 from the Cretaceous – Greenhorn Formation through the Mississippian – Base of Last Salt while the rest of the files' averages varied between 2.35 g/cm3 to 2.74 g/cm3 for that same interval. Below the Mississippian – Base of Last Salt the density readings were much higher and very close to the surrounding wells. It was not used for any interpolation because its readings were so far off the average.

The ten wells that had precise density readings were used to extrapolate data to six of the other wells. The twenty-two wells were identified on a map and the files with density information were identified apart from the files without density information. The data for the files without density information were extrapolated from the nearest wells with density information. If a well without data was close to just one other well with data, they were taken to have the same density information. If the well without data was about equal distances between wells with data, the densities were averaged before being applied to the well without its own data. Five of the wells that had no density information were located in the Elm Coulee-Billings Nose Assessment Unit (AU) and were approximately forty miles from the closest well with density information. Well 15088 wasn't one of the twenty-two analyzed wells, but it was within that assessment unit, so it was used to extrapolate data to the other five wells within that AU.

The overburden pressure on the Bakken Formation ranged from 68.8 MPa to 79.4 MPa, not including well 16160 which had an overburden pressure of 61.7 MPa. Once the

overburden pressures were converted to psi, they ranged from 9980 psi to 11500 psi with 16160 having an overburden pressure of 8950 psi.

Horizontal Stress

The calculated horizontal stress at each particular point was determined from a factor of Poisson's ratio and the overburden pressure. Poisson's ratio was calculated from the sonic data using equation 2. The factor of Poisson's ratio was multiplied by the overburden pressure to get the horizontal stress (equation 4). The horizontal stress was determined for the Lodgepole Formation, the upper, middle, and lower lithologies of the Bakken Formation, and the Three Forks Formation. Three different horizontal stresses were calculated for the three layers of Bakken because of the differing lithologies throughout the formation. The exception to this rule was with the five wells within the Elm Coulee-Billings Nose AU. The Bakken Formation in these wells was relatively thin, ranging from six to thirty-seven feet thick. An average horizontal stress on the entire Bakken Formation was used in this AU because well logs available for this AU didn't show any extreme lithologic changes. Well 7887 was the only well in this AU which had tc data and no wells in this AU had ts data. The tc data from well 7887 was extrapolated to the rest of the wells and the tc data used for these wells was just the average tc values from the four wells with tc data.

Four wells had both tc and ts data, while five wells had only tc data. The other thirteen wells had no sonic information available and had to be completely interpolated from the other nine wells. Horizontal stress ranged from 18 MPa to 28 MPa with one outlier showing the lower Bakken having a horizontal stress of 13.4 MPa.

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Attachment 4

Development of an Alternative Methodology for Triaxial Geomechanical Testing

Development of an Alternative Methodology for Triaxial Geomechanical Testing

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Introduction

Rocks at depth are exposed to an anisotropic stress field. In order to evaluate in-situ stability, it is of great value to know how the mechanical properties and the strength characteristics depend on external load conditions. The most commonly adapted experimental procedure for this purpose is the so-called triaxial test (Fjaer et al, 1992).

From the triaxial test data, it is possible to extract fundamental material parameters about the sample, including its angle of internal friction, apparent cohesion, and dilatancy angle. These parameters are then used in computer models to predict how the material will behave in a larger-scale engineering application. Triaxial tests are used along with other tests to make such engineering predictions (Vutukuri et al, 1974).

Usually triaxial tests are run using triaxial loading frames developed by commercial companies such as MTS, TerraTek, and etc. These loading frames request very high initial investment, and demand high level of specially-trained technicians in maintenance. Due to these reasons, a lot of users can't afford for that. To overcome these limitations, we developed an alternative triaxial testing system (Zeng et al, 2008). This report shows the methodology and the data processing, with tested results using this system.

Methodology

A typical triaxial test stress regime is shown in the following figure.

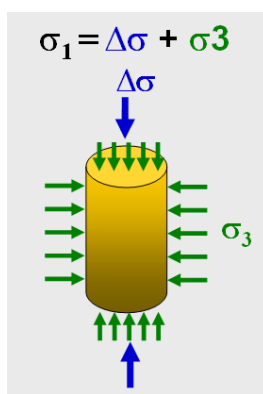


Figure 1 A typical triaxial stress regime

The axial stress σ_1 and the radial confining pressure σ_3 are simultaneously increased to a preset level, from which σ_1 will be increased further until failure occurs, while keeping σ_3

constant. By performing a series of tests at various confining pressures, it is possible to measure the entire failure envelope. The slope of the axial stress vs. axial strain curve gives Young's modulus and the radial vs. axial strain gives Poisson's ratio.

Triaxial tests can also be run in extension: after applying a hydrostatic confining pressure σ_3, just like in the standard triaxial compression tests, the axial load σ_1 is decreased, keeping σ_3 constant. If failure does not occur until σ_1 reaches zero, σ_3 is increased. According to the Mohr-Coulomb criterion the shear strength τ should be the same in extension and compression (Fjaer et al, 1992).

Equipment

The system mainly consists of triaxial core holder, air bath (oven), axial and radial in-situ stress (confining pressure) pump, digital oscilloscope, data acquisition board, and control box, as shown in the following Figure 2.

(a) (b)

Figure 2 The UND in-house developed alternative triaxial testing system: (a) - pumps, core holder and oven; (b)-control and data acquisition system.

The central element of the testing system is the triaxial cell, or core holder. A triaxial cell contains the loading pistons, which are pressed against the sample. The sample is surrounded by a sleeve, which separates it from the confining fluid when radial (confining) pressure is applied. The sleeve is soft and smooth enough not to restrict the deformation of the sample. The following figure shows the principle sketch of the interior of a triaxial cell.

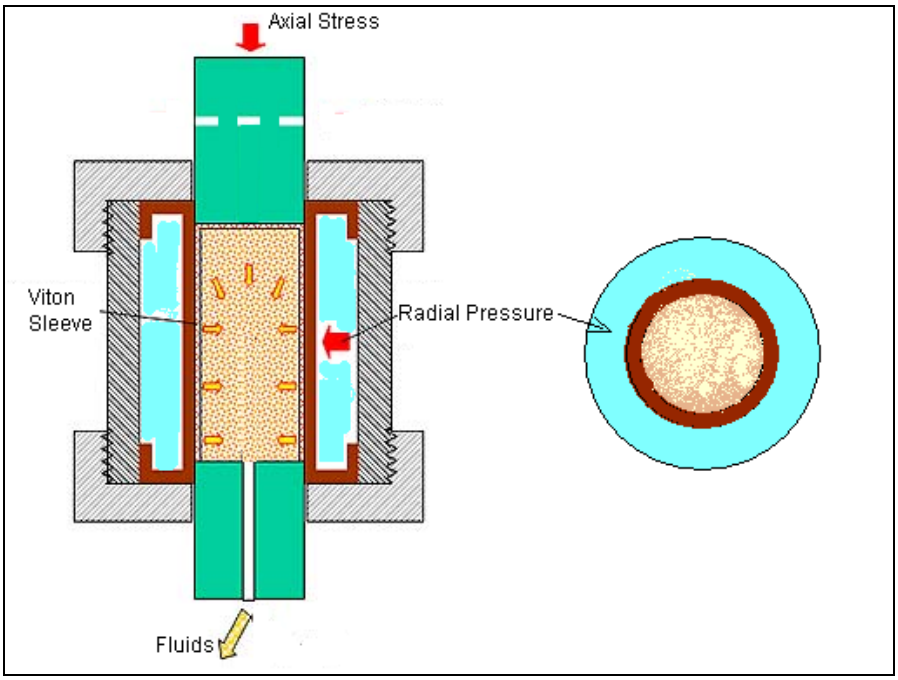


Figure 3 Principle of the interior of a triaxial cell (after Fjaer et al, 1992)

Experimental Procedures

The following is the procedures for running triaxial tests using this alternative testing system. "Axial pump" refers to the pump which applies axial pressure; similarly, "radial pump" for the pump which applies radial pressure, and "injection pump" for the pump which applies pore pressure and/or injects flooding fluids.

1) Measure the dimension of the specimen and weight it;
2) Load the specimen into the triaxial core holder;
3) Load the axial and radial pressures to the preset level using the axial and/or radial pump;
4) Start the LabView Data Acquisition program;
5) Leave the system for temperature equilibrium (about 19 hours);
6) Use radial pump to keep constant radial pressure;
7) Use injection pump to apply pore pressure, and inject the flooding fluid, if needed;
8) Start to increase the axial pressure at a constant flow rate using the axial pump;
9) Track the axial pressure with time until failure;

10) If post-failure behavior is needed, continue injection from axial pump until designed volume is injected.
11) Stop the axial pump when designed failure or compression is reached;
12) Stop LabView data acquisition system and save the data;
13) Release pressures from the system gradually, in the reverse order as they are applied;
14) Remove the specimen from the core holder;
15) Flush the system with deionized water to remove any dirt that may have been left.

Measurements and Results

This system is capable of conducting uniaxial (under very low confining pressure for measurement of radial deformation) and triaxial compression tests. During the test, time, pressure, remaining volume, injecting rate of the axial, radial and injection pumps are recorded at a preset interval. Temperatures of the inlet, outlet and body of the core holder are monitored. Corresponding to each rock test, a test on aluminum standard is also conducted under the same conditions.

Using the geometric specifications of the core holder and the sample (Figure 4), and the recorded pressures in the axial and radial pumps, axial and radial stresses on the sample can be calculated based on force equilibrium.

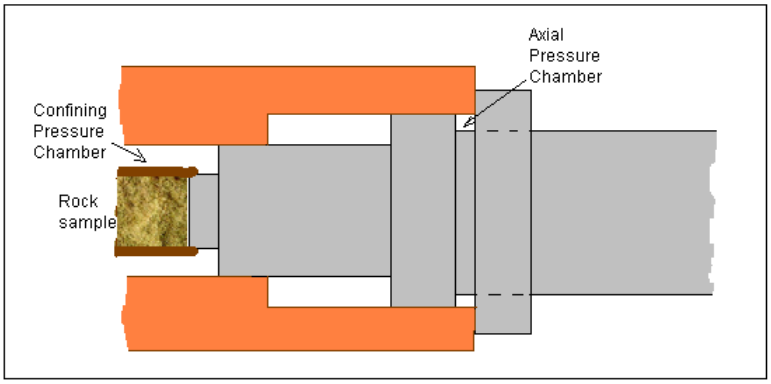


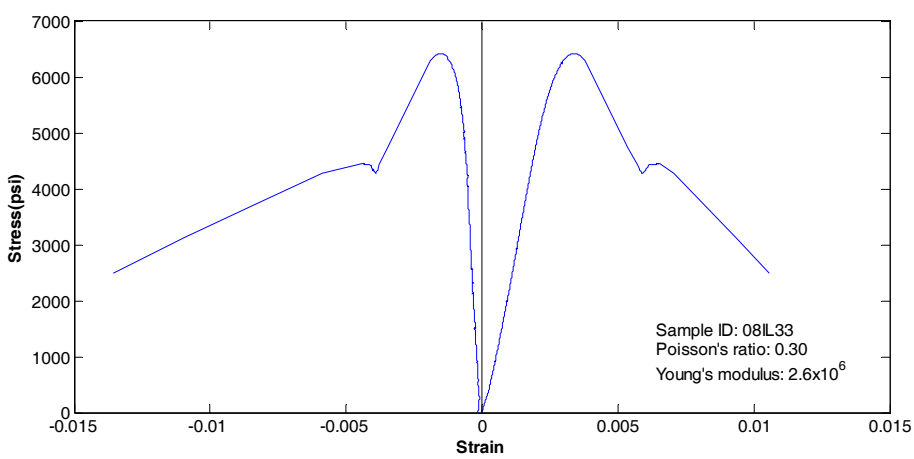
Figure 4 Core holder lay out

Gross deformations in the axial and radial directions of the sample corresponding to each axial stress can be calculated from the fluid volume in the axial and radial pumps. Using

the Young's modulus and Poison's ratio of the aluminum standard sample, the theoretical deformation of the aluminum standard sample corresponding to each axial and radial stress can be calculated. Difference between the gross deformation and theoretical deformation of the aluminum standard defines the system deformation under the specific axial and radial stresses. The true deformation of the sample is obtained by subtracting the system deformation from the gross deformation. This is how the axial and radial deformations are obtained. The using the initial length and radius of the sample, axial and radial strains under each stress can be calculated.

From these results, the stress-strain curves in the axial and radial directions can be drawn. Figure 5 shows a tested Indiana limestone sample, and the corresponding stress-stain curves. Using the stress-strain curves, Young's modulus, Poisson's ratio, and the strength of the tested sample can be defined (Jaeger and Cook, 1979).

(a)



(b)

Figure 5 Uniaxial compression of an Indiana limestone sample:
(a) Tested sample; (b) Stress-strain curves.

Cohesion, c, angle of friction, ϕ, are two of the most widely used parameters needed to define rock strengths under different confining pressures, based on Mohr-Coulomb criterion (Jaeger and Cook, 1979). They are determined using the linear portion of the failure envelop defined by several Mohr's circles. The Mohr's circles are based on experimental results of uniaxial and triaxial compressive strengths under different confining pressures (Roegiers, 1989). Figure 6 shows how the cohesion, c, and angle of friction, ϕ, of Indiana limestone are determined.

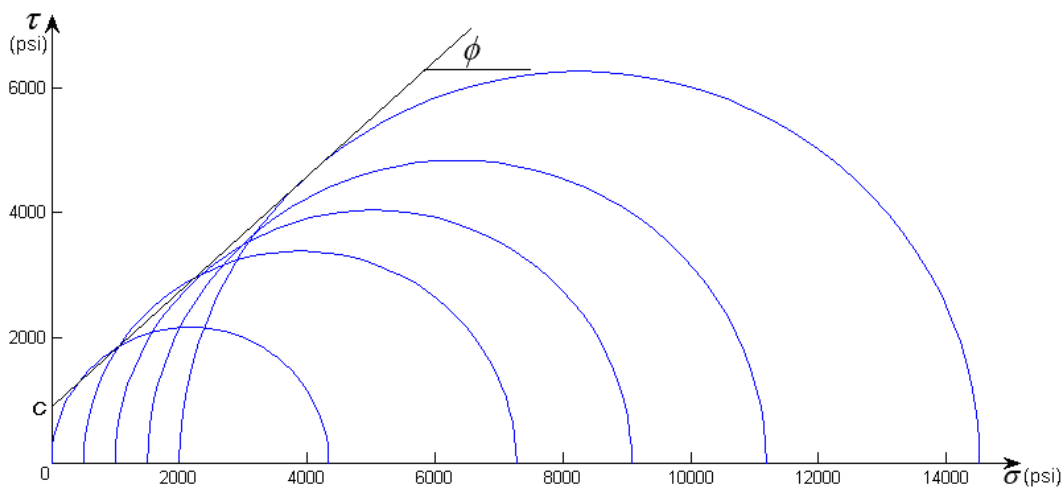


Figure 6 Determination of cohesion, c, and angle of friction, ϕ, of Indiana limestone.

Summary

An alternative triaxial testing system and experimental method are developed and tested. In comparing to traditional triaxial geomechanical testing system, this alternative system has the following features:

1. It is relatively small, and thus takes up small laboratory space. In addition, it needs shorter period of time to reach thermal equilibrium when a targeted temperature is set up.

2. It uses small rock samples: 1-in diameter by 2-in length. This has a practical value to situations where big samples are not available due to economic and technical reasons, such as in some deep petroleum reservoirs.
3. Axial and radial stresses, and pore pressure are independently controlled; pore fluids can be injected at required pressures and flow rates. These features allow full simulation of operations in petroleum production and CO2 sequestration.
4. During the axial compression and fluid injection, flow rate, pressures at the inlet and outlet ends, P- and S-waveforms are recorded. This allows the monitoring of the dynamic change of the core samples in permeability and seismic velocities during compression, flooding and reaction.
5. Safety features related to system temperature, axial and radial stresses, and pore pressures are implemented.
6. Via internet, operation status of the system can be remotely monitored, and interfered, if needed.

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Attachment 5

Development of a Portable Bakken Shale Core Sampling System

Development of a Portable Bakken Shale Core Sampling System

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Figure 1 Portable Bakken shale core sampling system in progress. The handle on the top and the two wheels at the lower left make it portable.

Figure 2 Completed portable Bakken shale core sampling system. The lower box collects the drilling fluid. The submerged pump in the container circulates the drilling fluids onto the drill bit.

Figure 3 Testing the portable Bakken shale core sampling system. Mineral oil is used as the drilling fluid.

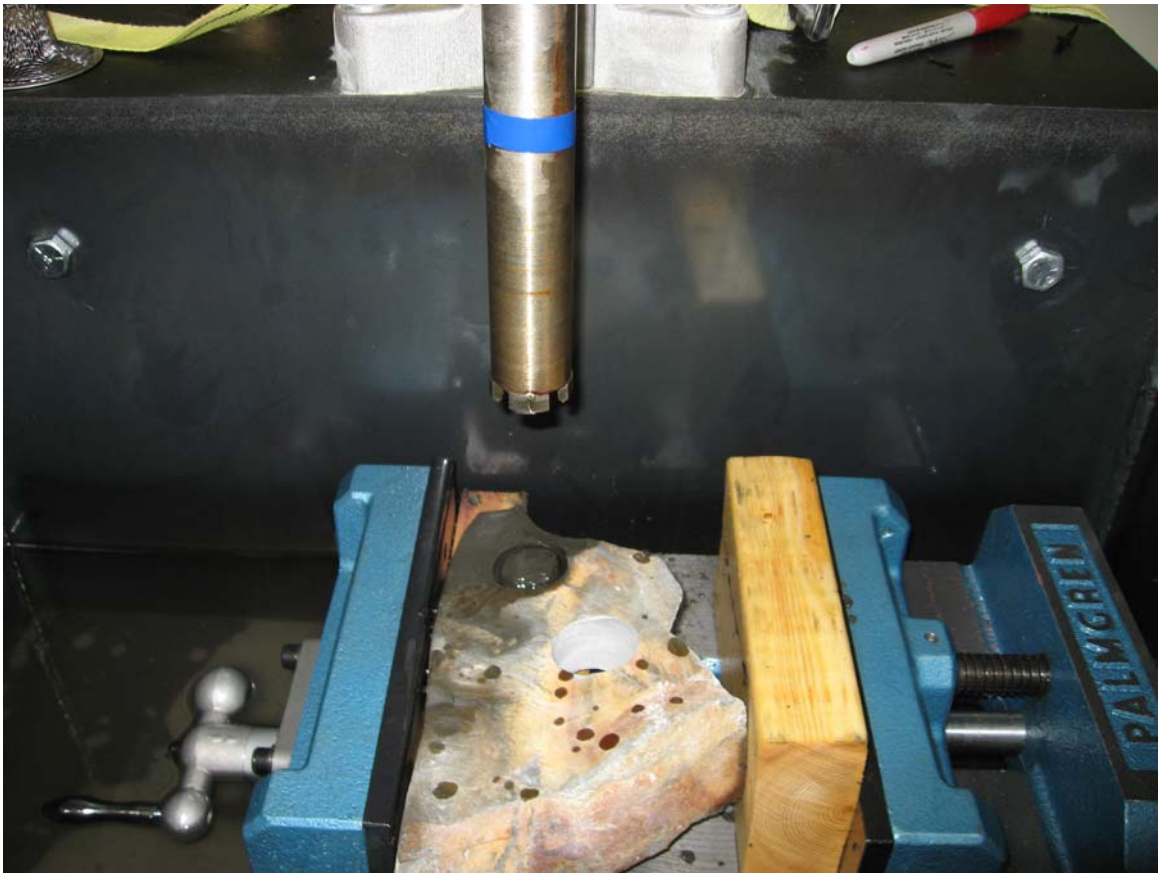

Figure 4 Testing the portable Bakken shale core sampling system. Core barrel and the drilled shale sample.

Figure 5. Testing the portable Bakken shale core sampling system. Drilled shale sample is retrieved from the core barrel.

Figure 6. Drilled shale sample before end cutting and grinding.

Attachment 6

Core Observation of Bakken Wells in Eastern Williston Basin, North Dakota

Core Observation of Bakken Wells in Eastern Williston Basin, North Dakota

By

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Introduction

Part of the Geomechanical Study of the Bakken Formation consisted of analyzing core samples for the twenty-two wells of study. The core analysis was focused on rock mechanics and fracture analysis. The fracture analysis consisted of determining the RQD, the fracture angles, the number of fracture sets, the types of fractures, the spacing between the fractures, and the minimum and maximum block size. During the core analysis, the recovery was calculated and the lithologies were determined. The core analysis was performed to help determine the status of in situ fracturing, the angles of the fractures, and the differences in fracturing between the Lodgepole Formation, the upper, middle, and lower Bakken, and the Three Forks formation.

Methods

Once a core sample analysis was completed, all of the information was recorded and then a core description file was created using Microsoft Office Word. The cores were not analyzed all at one, but instead were analyzed five to ten feet at a time, depending on the lithologic changes and the way the core was packaged.

The first step in the core analysis was to determine the lithologies of each formation. The Lodgepole Formation consisted entirely of limestone. The upper and lower members of the Bakken Formation were black shale. The middle member was a dolomitic siltstone. The Three Forks Formation was a noncalcareous siltstone which usually contained thin bands of illite.

The total recovery of each section of the core was calculated to help determine how much of the core was lost during the drilling process.

The Rock Quality Designation (RQD) was calculated for each interval to help determine the susceptibility of the rock to fracturing. The RQD calculated the percentage of core which had at least 10 cm between fractures. Some intervals of the core didn’t have any pieces of core which were longer than 10 cm, so an additional RQD was calculated for better comparison between all the cores. The other RQD used the percentage of core which had at least 5 cm between fractures. These were both used to better interpret the amount of fractures and spacing between fractures in the core.

The number of fracture sets and types of fracture sets were determined for every one to two foot interval. If only bedding joints were visible, then only one set of fractures were present. If both vertical fractures and bedding joints were visible, then two fracture sets were present. If only core chips were present for a certain portion of the core, it was assumed that there were more than two fracture sets there.

For every foot interval, the dip angle for every fracture was determined using a protractor. A table summarizing the data for the fracture angles and the 10cm RQD was developed. The table displayed the intervals in each core for which horizontal (0-15˚), vertical (75-90˚), and inclined (16-74˚) fracture sets were present (Table 1).

For every five to ten foot interval, the minimum and maximum spacing between fractures was determined. Also, the minimum and maximum block size was determined for every three to five foot interval.

The aperture was also analyzed for every core sample, but it wasn't analyzed as in situ. If there were fractures in the core sample that hadn't completely broke through the core, then their aperture was analyzed. Also, if any of these fractures had any filling that had precipitated out, then this was included in the core file.

A hand drawing for every core was completed to provide a visual of the fracture sets and spacing.

Observation Results

1 Well 1202

Well 1202 was operated by the Hess Corporation and was located in the Nesson - Little Knife Structural Assessment Unit (AU). The core sample began 10257 ft below KB in the Upper Bakken and proceeded to 10351 ft below KB in the Lower Bakken. It had three separate vertical fracture sets, one in the Upper Bakken and two in the Lower Bakken. It also had many separate inclined fracture sets spaced throughout the entire core. The RQD (>10cm) was 0% for both the Upper and Lower Bakken and was 22% for the Middle Bakken.

2 Well 1254

Well 1254 was operated by the Hess Corporation and was located in the Nesson - Little Knife Structural AU. The top of the core sample was 10450 ft below KB and bottom was 10467 ft below KB. It began in the Lower Bakken and proceeded to the Three Forks Formation. It had one vertical fracture set and one inclined fracture set, both in the Lower Bakken. The RQD (>10cm) was 28% for the Lower Bakken and 0% for the Three Forks.

3 Well 1343

Well 1343 was operated by the Hess Corporation and was located in the Nesson - Little Knife Structural AU. The core sample began 10340 ft below KB in the Lower Bakken and proceeded to 10400 ft below KB in the Three Forks. The core sample had four vertical fracture sets and two inclined fracture sets. The RQD (>10cm) was 0% for the Lower Bakken and 28% for the Three Forks Formation.

4 Well 1748

Well 1343 was operated by the Hess Corporation and was located in the Nesson - Little Knife Structural AU. The top of the core sample was at 10720 ft below KB while the bottom of the core was at 10750 ft below KB. The entire core was located in the Lower Bakken. The core had two vertical fracture sets and just one inclined fracture set. The entire core had an RQD of 12%.

5 Well 1780

Well 1780 was operated by the Hess Corporation and was located in the Nesson - Little Knife Structural AU. No fracture analysis was able to be performed on this core, because only core chips were retrieved from the well and not an entire core sample.

6 Well 7887

Well 7887 was operated by the Whiting Oil and Gas Corporation and was located in the Elm Coulee – Billings Nose AU. The core sample started 10823 ft below KB and ended 10838 ft below KB. It was located entirely within the Three Forks Formation. The core

had two vertical fracture sets and two inclined fracture sets. The entire core had an RQD of 58%.

7 Well 11617

Well 11617 was operated by the St. Mary Land & Exploration Company and was located in the Nesson – Little Knife Structural AU. The core sample began in the Middle Bakken at 10363 ft below KB and proceeded to the Three Forks where it ended at 10404 ft below KB. The entire core had only one vertical fracture set which was located in the Lower Bakken. It had two inclined fracture sets: one which was located in the Middle Bakken and one which was located in the Lower Bakken. The Middle Bakken had the highest RQD (>10cm) of the three formations at 64%. The Three Forks had an RQD of 30% while the Lower Bakken was 10%.

8 Well 12072

Well 12072 was operated by the Whiting Oil and Gas Corporation and was located in the Elm Coulee – Billings Nose AU. The core sample began in the Upper Bakken at 10388 ft below KB and ended in the Three Forks Formation at 10419 ft below KB. Of the two vertical fracture sets, one was located in the Upper Bakken while the other was present in the Middle Bakken, through the Lower Bakken, and ended in the Three Forks. The one inclined fracture set was also started in the Middle Bakken and extended all the way to the Three Forks. The Middle Bakken and Three Forks had relatively high RQD (>10cm) values at 66% and 69% respectively. The Upper Bakken and Lower Bakken had lower RQD values of 14% and 0% respectively.

9 Well 12160

Well 12160 was operated by the St. Mary Land & Exploration Company and was located in the Elm Coulee – Billings Nose AU. The core sample started in the Middle Bakken at 10754 ft below KB and ended in the Three Forks at 10782 ft below KB. The core sample had one vertical fracture set which was located in the Lower Bakken. It had two inclined fracture sets: one of which was in the Middle Bakken while the other overlapped between the Lower Bakken and the Three Forks. The Middle Bakken had an RQD

(>10cm) of 60% while the Three Forks was a little lower at 49%. The Lower Bakken had a very low RQD value of 0%.

10 Well 12331

Well 12331 was operated by the Whiting Oil and Gas Corporation and was located in the Elm Coulee – Billings Nose AU. The core sample began at 10209 ft below KB in the Lodgepole and proceeded to 10233 ft below KB in the Three Forks. There was only one vertical fracture set and it was located mainly in the Lodgepole with one foot of the fracture set being within the Bakken. The one inclined fracture set was located entirely within the Lodgepole. The Lodgepole and Three Forks had relatively high RQD (>10cm) values of 68% and 62% respectively. The Bakken had an RQD of 8.9%.

11 Well 14974

Well 14974 was operated by the St. Mary Land & Exploration Company and was located in the Elm Coulee – Billings Nose AU. The core sample was entirely within the Duperow Formation, but had two separate lengths of core. The first length started at 10978 ft below KB and ended at 10998 ft below KB. The second length of core began 11357 ft below KB and ended 11378 ft below KB. The core had two vertical fracture sets: one was in the upper section of the core while the other was in the lower section of core. The core also had two inclined fracture sets, but both of these were in the lower section of the core. The core had a very high RQD (>10cm) value of 87%.

12 Well 15674

Well 15674 was operated by the Hess Corporation and was located in the Nesson – Little Knife Structural AU. The top of the core sample was at 9720 ft below KB and the bottom was at 9810 ft below KB. It started in the Lodgepole and proceeded through the Upper Bakken and ended in the Middle Bakken. There were four vertical and four inclined fracture sets which were spread throughout the core. The Middle Bakken had the highest RQD (>10cm) value of 61% while the Lodgepole had a value of 23% and the Upper Bakken 7.0%.

13 Well 15845

Well 15845 was operated by the Hess Corporation and was located in the Eastern Expulsion Threshold AU. The core sample began in the Upper Bakken at 9616 ft below KB and ended in the Lower Bakken at 9679 ft below KB. Two vertical fracture sets were present in the core, with one of them being located in the Upper Bakken and one being located in the Middle Bakken. The core had three inclined fracture sets, with one overlapping between the Upper and Middle Bakken and the other two being entirely within the Middle Bakken. The Middle Bakken had an the highest RQD (>10cm) with a value of 55% while the Upper Bakken had a value of 26% and the Lower Bakken 4.0%.

14 Well 15889

Well 15889 was operated by the Hess Corporation and was located in the Nesson – Little Knife Structural AU. The core sample began in the Lodgepole at 10424 ft below KB and proceeded all the way through the Bakken and ended in the Three Forks at 10625 ft below KB. There were six different vertical fracture sets throughout this core and they were present in all five lithologies. There were eight different inclined fracture sets throughout the core extending through all three formations and the three members of the Bakken. The highest RQD (>10cm) value belonged to the Middle Bakken at 77%. The Three Forks had the lowest RQD at 13%. The other three all had RQD values between 19% and 30%.

15 Well 15923

Well 15923 was operated by the Encore Operating, L.P. and was located in the Central Basin – Poplar Dome AU. The top of the core was in the Upper Bakken at 10992 ft below KB and the end was in the Middle Bakken at 11048 ft below KB. The core had four vertical fracture sets and two inclined fracture sets. One of the vertical fracture sets was in the Upper Bakken and three were in the Middle Bakken while one inclined fracture set was in the Upper Bakken and one in the Lower Bakken. Both RQD (>10cm) values were relatively high with the Middle Bakken being 89% and the Upper Bakken being 63%.

16 Well 15986

Well 15986 was operated by the Hess Corporation and was located in the Eastern Expulsion Threshold AU. The core sample began in the Lodgepole at 10491 ft below KB and ended in the Middle Bakken at 10582 ft below KB. There was only one vertical fracture set in the core and it was located in the Upper Bakken. There were six inclined fracture sets and they were located throughout the entire core. The Lodgepole and Middle Bakken had similar RQD (>10cm) values of 76% and 79% respectively. The Upper Bakken had a much lower RQD value at 6.7%.

17 Well 16030

Well 16030 was operated by the Marathon Oil Company and was located in the Nesson – Little Knife Structural AU. The core sample was of the Upper and Middle Bakken and traveled from 9969 to 10023 ft below KB. The one vertical fracture set was located in the Middle Bakken while both the inclined fracture sets were also located in the Middle Bakken. The Middle Bakken had an RQD (>10cm) value of 78% while the Upper Bakken's RQD value was 38%.

18 Well 16068

Well 16068 was operated by the Whiting Oil and Gas Corporation and was located in the Eastern Expulsion Threshold AU. The core sample consisted of both the Upper and Middle Bakken and was from 10217 through 10279 ft below KB. There were five vertical and five inclined fracture sets that ranged throughout the entire core. The Middle Bakken had an RQD (>10cm) value of 83% and the Upper Bakken had an RQD value of 43%.

19 Well 16083

Well 16083 was operated by the Hess Corporation and was located in the Middle Sandstone Member AU. The core sample started in the Lodgepole at 9697 ft below KB and proceeded through all three layers of the Bakken and then ended in the Three Forks at 9851 ft below KB. There were four vertical fracture sets which were present in all formations except for the Lodgepole. There were nine different inclined fracture sets

which were spread throughout the entire core sample. The Lodgepole and Middle Bakken had similar RQD (>10cm) values of 73% and 78% respectively. The Three Forks' RQD value was slightly lower at 54%. The Upper Bakken and Lower Bakken and much lower RQD values of 10% and 11% respectively.

20 Well 16160

Well 16160 was operated by the Hess Corporation and was located in the Nesson – Little Knife Structural AU. The core sample traveled from the Lodgepole through all layers of the Bakken and ended in the Three Forks. It started at 9365 ft below KB and ended at 9590 ft below KB for a total core length of 225 ft. It had eleven vertical fracture sets and thirteen inclined fracture sets which both were present in all five different lithologies. The Lower Bakken had the lowest RQD (>10cm) value at 35% while the Middle Bakken had the highest at 85%.

21 Well 16333

Well 16333 was operated by the Marathon Oil Company and was located in the Nesson – Little Knife Structural AU. The core sample began in the Lodgepole at 10840 ft below KB and ended in the Middle Bakken at 10902 ft below KB. There was only one vertical fracture set and it occurs in the Lodgepole. There were two inclined fracture sets and they occur in the Upper Bakken and the Middle Bakken. The Lodgepole has an RQD (>10cm) value of 83%, the Middle Bakken a value of 63%, and the Upper Bakken 5.7%.

22 Well 16433

Well 16433 was operated by the Hess Corporation and was located in the Nesson – Little Knife Structural AU. The core sample starts in the Lodgepole, covers the three layers of the Bakken, and ends in the Three Forks. It starts at 10591 ft below KB and ends at 10713 ft below KB for a total core length of 122 ft. There were only two vertical fracture sets with one occurring in the Upper Bakken and the other in the Lower Bakken. Out of the five inclined fracture sets present, one of them was in the Upper Bakken while the other four were in the Three Forks. The Lodgepole had an RQD (>10cm) value of 95%

while the lowest value was 38% for the Upper Bakken. The other three layers had RQD values between 50% and 82%.

Summary

The core analysis was performed to determine the extent of the fracturing at each well site. The core analysis also established which well sites had vertical and inclined fracturing along with horizontal fracturing. By knowing which assessment units the wells are located in, it is possible to compare RQD values between the different assessment units. It may be possible to reach some hypotheses about which assessment units have the most extensive fracturing and which have vertical and inclined fracturing.

Attachment 7

Analysis of Minor and Micro Fractures in Bakken Wells

Analysis of Minor and Micro Fractures in Bakken Wells

By

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Abstract

In the petroleum industry, fractures in the reservoir formations are very important to both the hydrocarbon production and the success of drilling and hydraulic fracturing. These fractures usually can not be directly observed from the surface. Observation and analysis of minor and micro fractures in cores is an alternative way to understand these fractures.

Minor and micro fractures in the 22 Bakken wells have been measured and analyzed. This report presents the summary of the observation and analysis.

Analysis of minor and micro fractures

If a certain fracture orientation (horizontal, vertical, inclined) has spacing between its fractures of 4-ft or less, then it is counted as 1 fracture set.

Well/File No.	API No.	Operator	Interval of core sample (ft)	Horizontal Fracture Set (0-15˚) Intervals (ft)	Vertical Fracture Set (75-90˚) Intervals (ft)	Inclined Fracture Set (16-74˚) Intervals (ft)	RQD (>10cm)
1202	33053001440000	Hess Corp.	10257 - 10351	10257-10351	10257-10266, 10332-10333, 10343-10350	10258-10259, 10269-10270, 10275-10276, 10284-10290, 10298-10299, 10305-10306, 10311-10312, 10329-10332, 10346-10347	Upper Bakken (10257-10276) – 0% Middle Bakken (10276-10321) – 22% Lower Bakken (10321-10351) – 0%
1254	33053001590000	Hess Corp.	10450-10467	10450-10467	10451-10452	10451-10453	Lower Bakken (10450-10454) – 28% Three Forks (10454-10467) – 0%
1343	33053002030000	Hess Corp.	10340-10400	10340-10400	10342-10348, 10363-10368, 10374-10375, 10391-10392	10341-10345, 10360-10400	Lower Bakken (10340-10344) – 0% Three Forks (10344-10400) – 28%
1748	33053003120000	Hess Corp.	10720-10750	10720-10750	10720-10740, 10745-10750	10723-10748	Lower Bakken (10720-10750) – 12%
1780	33050032300000	Hess Corp.					
7887	33007005810000	Whiting Oil & Gas	10823-10838	10823-10838	10823-10824, 10836-10837	10825-10830, 10836-10837	Three Forks (10823-10838) – 58%
11617	33053020760000	St. Mary	10363-10407	10363-10407	10376-10404	10365-10369, 10376-10404	Middle Bakken (10363-10375) – 64% Lower Bakken (10375-10403) – 10% Three Forks (10403-10407) – 30%

File No.	API No.	Operator	Interval of core sample (ft)	Horizontal Fracture Set (0-15˚) Intervals (ft)	Vertical Fracture Set (75-90˚) Intervals (ft)	Inclined Fracture Set (16-74˚) Intervals (ft)	RQD (>10cm)
12072	33007011090000	Whiting Oil & Gas	10388-10419	10388-10419	10389-10393, 10399-10415	10397-10414	Upper Bakken (10388-10393) – 14% Middle Bakken (10393-10403) – 66% Lower Bakken (10403-10412) – 0% Three Forks (10412-10419) – 69%
12160	33053021880000	St. Mary	10754-10782	10754-10782	10767-10768	10754-10755, 10768-10779	Middle Bakken (10754-10767) – 60% Lower Bakken (10767-10770) – 0% Three Forks (10770-10782) – 49%
12331	33007011400000	Whiting Oil & Gas	10209-10233	10209-10233	10218-10222	10215-10218	Lodgepole (10209-10221) – 68% Bakken (10221-10226) – 8.9% Three Forks (10226-10233) – 62%
14974	33053025350000	St. Mary	10978-10998, 11357-11378	10978-10998, 11357-11378	10982-10984, 11367-11369	11361-11365, 11370-11378	Duperow (10978-10998) (11357-11378) – 87%
15674	33105015270000	Hess Corp.	9720-9810	9720-9810	9742-9744, 9749-9750, 9760-9762, 9778-9779	9720-9744, 9749-9750, 9758-9764, 9770-9786	Lodgepole (9720-9749) – 23% Upper Bakken (9749-9766) – 7.0% Middle Bakken (9766-9810) – 61%

File No.	API No.	Operator	Interval of core sample (ft)	Horizontal Fracture Set (0-15˚) Intervals (ft)	Vertical Fracture Set (75-90˚) Intervals (ft)	Inclined Fracture Set (16-74˚) Intervals (ft)	RQD (>10cm)
15845	33061004890000	Hess Corp.	9616-9679	9616-9679	9621-9622, 9643-9648	9616-9634, 9644-9652, 9664-9667	Upper Bakken (9616-9622) – 26% Middle Bakken (9622-9667) – 55% Lower Bakken (9667-9678) – 4.0%
15889	33061004900000	Hess Corp.	10424-10625	10424-10625	10424-10430, 10442-10444, 10452-10456, 10462-10464, 10548-10604, 10612-10624	10424-10456, 10462-10466, 10484-10486, 10494-10496, 10574-10590, 10596-10598, 10610-10614, 10620-10624	Lodgepole (10424-10456) – 26% Upper Bakken (10456-10478) – 19% Middle Bakken (10478-10549) – 77% Lower Bakken (10549-10598) – 30% Three Forks (10598-10625) – 13%
15923	33053026720000	Encore Op. LP	10992-11048	10992-11048	10998-10999, 11010-11012, 11018-11019, 11047-11048	10998-10999, 11014-11015	Upper Bakken (10992-11001) – 63% Middle Bakken (11001-11048) – 89%
15986	33061004930000	Hess Corp.	10491-10582	10491-10582	10517-10526	10495-10496, 10519-10520, 10525-10526, 10534-10540, 10549-10552, 10569-10570	Lodgepole (10491-10510) – 76% Upper Bakken (10510-10528) – 6.7% Middle Bakken (10528-10582) – 79%
16030	33101501551000	Marathon Oil Co.	9969-10023	9969-10023	9973-9996	9981-9986, 10015-10016	Upper Bakken (9969-9972) – 38% Middle Bakken (9972-10023) – 78%

File No.	API No.	Operator	Interval of core sample (ft)	Horizontal Fracture Set (0-15˚) Intervals (ft)	Vertical Fracture Set (75-90˚) Intervals (ft)	Inclined Fracture Set (16-74˚) Intervals (ft)	RQD (>10cm)
16068	33061004950000	Whiting Oil & Gas	10217-10279	10217-10279	10219-10220, 10245-10249, 10257-10262, 10267-10268, 10277-10278	10219-10220, 10227-10242, 10247-10249, 10260-10269, 10277-10278	Upper Bakken (10217-10226) – 43% Middle Bakken (10226-10279) – 83%
16083	33105015570000	Hess Corp.	9697-9851	9697-9851	9716-9717, 9732-9736, 9770-9813, 9826-9833	9699-9700, 9718-9727, 9732-9733, 9743-9744, 9775-9786, 9793-9794, 9800-9822, 9831-9840, 9850-9851	Lodgepole (9697-9704) – 73% Upper Bakken (9704-9722) – 10% Middle Bakken (9722-9771) – 78% Lower Bakken (9771-9794) – 11% Three Forks (9794-9851) – 54%
16160	33061004980000	Hess Corp.	9365-9590	9365-9590	9368-9369, 9395-9396, 9408-9410, 9424-9439, 9464-9465, 9491-9496, 9506-9507, 9528-9529, 9534-9535, 9551-9559, 9579-9580	9370-9379, 9384-9401, 9408-9410, 9415-9438, 9448-9449, 9459-9465, 9473-9474, 9480-9481, 9492-9496, 9517-9538, 9545-9546, 9559-9560, 9568-9587	Lodgepole (9365-9424) – 41% Upper Bakken (9424-9440) – 56% Middle Bakken (9440-9491) – 85% Lower Bakken (9491-9539) – 35% Three Forks (9539-9590) – 64%

File No.	API No.	Operator	Interval of core sample (ft)	Horizontal Fracture Set (0-15˚) Intervals (ft)	Vertical Fracture Set (75-90˚) Intervals (ft)	Inclined Fracture Set (16-74˚) Intervals (ft)	RQD (>10cm)
16333	33025005970000	Marathon Oil Co.	10840-10902	10840-10902	10843-10845	10862-10864, 10882-10884	Lodgepole (10840-10847) – 83% Upper Bakken (10847-10863) – 5.7% Middle Bakken (10863-10902) – 63%
16433	33053027690000	Hess Corp.	10591-10713	10591-10713	10601-10605, 10674-10676	10597-10606, 10679-10680, 10698-10700, 10706-10707, 10712-10713	Lodgepole (10591-10594) – 95% Upper Bakken (10594-10611) – 38% Middle Bakken (10611-10653) – 82% Lower Bakken (10653-10676) – 50% Three Forks (10676-10713) – 61%

Core Survey and Minor/Micro Fracture Sketch of Selected Bakken Wells

By

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Well #1202 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10257		Black Shale High Carbon Content	61.8	0	2.5	2	5, 0, 12, 7, 0, 10, 75, 10, 0, 5, 10	0.7 – 5.6	Bedding Joints & Vertical fractures	Tight	None	0.9x2x0.65 to 2x2x2.25
10258						1	0, 5, 15, 0, 0, 0, 25		Bedding Joints			
10259						1	5, 0, 0, 6, 0, 0, 0, 4, 10, 0, 5		Bedding Joints			
10260						1	3, 5, 0, 3, 4, 6, 4		Bedding Joints			
10261						1	10, 10, 75, 0, 0, 5, 7, 0, 3		Bedding Joints			
10262						1	4, 0, 0, 2, 5, 5, 3, 0, 0, 4, 0, 5		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10263		Black Shale High Carbon Content	61.8	0	2.5	1	3, 5, 0, 5, 5, 0, 0, 0, 0, 10	0.7 – 5.6	Bedding Joints	Tight	None	0.9x2x0.65 to 2x2x2.25
10264							4, 5,12, 5, 5, 2,10, 5		Bedding Joints			
10265						2	0, 4, 0, 5, 4, 80, 13, 5, 0		Bedding Joints & Vertical fractures			
10266						1	0, 4, 0, 10, 5, 3, 5		Bedding Joints			
10267						1	0, 10, 0, 0, 5, 0, 0, 3		Bedding Joints			
10268						1	10, 6, 0, 2, 0, 0, 5, 0		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10269		Black Shale High Carbon Content	82	0	6.9	1	15, 0, 10, 18, 10, 5, 0, 10, 5, 2	0.7 – 5.1	Bedding Joints	Tight	None	1.6x0.6x0.25 to 2x2x2
10270						1	0, 6, 5, 0, 2, 4, 4, 0, 0, 5, 0		Bedding Joints			
10271						1	7, 10, 5, 4, 3, 10, 15, 0, 5, 8 0		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10272		Black Shale High Carbon Content	63.9	10.6	21.9	1	0, 6, 6, 2, 0, 2, 2, 0, 0, 0	0.7 – 3.1	Bedding Joints	Tight	None	2x2x0.25 to 2x2x1.25
10273						1	10, 5, 4, 2, 6, 8, 5, 0, 10, 7, 2, 5		Bedding Joints			
10274						1	5, 10, 2, 2, 2, 6, 5, 0, 0, 0		Bedding Joints			
10275			51.4			1	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 20, 10	0.25 – 11.2	Bedding Joints			2x2x0.1 to 2x2x4.4
10276		Limestone No OIL				1	10, 6		Bedding Joints			
10277						1	10, 10		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10278		Limestone No OIL	59.7	36.9	62.6	1	9, 6, 3	0.8 – 12.7	Bedding Joints	Tight	None	2x2x0.3 to 2x2x5.2
10279						1	10, 5, 4		Bedding Joints			
10280						1	2, 10		Bedding Joints			
10281			40.3			1	4, 8	0.6 – 8.9	Bedding Joints			2x2x0.25 to 2x2x3.5
10282						1	5, 10		Bedding Joints			
10283						1	10, 5		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10284		Limestone No OIL	75	31	95.1	1	4, 20	2.5 – 14.2	Bedding Joints	Tight	None	2x2x1 to 2x2x5.75
10285						1	15, 7		Bedding Joints			
10286						1	15, 10, 8		Bedding Joints			
10287						1	10, 6, 14, 8, 6		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10288		Limestone No OIL	51.4	0	88.1	1	10, 15	4 – 9.4	Bedding Joints	Tight	None	2x2x1.6 to 2x2x3.7
10289						1	30, 22		Bedding Joints			
10290						1	6, 0		Bedding Joints			
10291						1	6, 4		Bedding Joints			
10292						1	4, 12		Bedding Joints			
10293						1	5, 5		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10294		Limestone No OIL	52.1	0	69.1	1	8, 4	1.8 – 8.2	Bedding Joints	Tight	None	2x2x0.75 to 2x2x3.25
10295						1	10		Bedding Joints			
10296						1	3, 6		Bedding Joints			
10297						1	10, 0, 8		Bedding Joints			
10298						1	10, 5, 17, 6		Bedding Joints			
10299						1	10, 11, 10, 6, 7		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10300		Limestone No OIL	54.9	10.1	80.9	1	4, 8, 0, 0	1.8 – 10.1	Bedding Joints	Tight	None	2x2x0.75 to 2x2x4
10301						1	6		Bedding Joints			
10302						1	5, 7		Bedding Joints			
10303						1	6, 5		Bedding Joints			
10304						1	10, 6		Bedding Joints			
10305						1	6, 10, 0, 10, 18		Bedding Joints			

Bakken Geomech. Core description File #:1202 Well API: 33053001440000 Operator: Hess

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10306		Limestone No OIL	52.1	24	85.2	1	5, 5	4.4 – 13.2	Bedding Joints	Tight	None	2x2x1.75 to 2x2x5.2
10307						1	0		Bedding Joints			
10308						1	10		Bedding Joints			
10309						1	4, 6, 4, 3		Bedding Joints			
10310						1	15, 5		Bedding Joints			
10311						1	22, 16		Bedding Joints			

Name: Smith & Naga 10/17 Date: 6-26-08

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10312		Limestone No OIL	59.0	20.8	64.8	1	7	1.1 – 11.7	Bedding Joints	Tight	None	2x2x0.45 to 2x2x4.6
10313						1	4		Bedding Joints			
10314						1	4, 10, 4, 4, 5, 5		Bedding Joints			
10315						1	2, 14		Bedding Joints			
10316						1	9, 5, 2, 6		Bedding Joints			
10317						1	5, 2, 12, 6		Bedding Joints			

Bakken Geomech. Core description File #:1202 Well API: 33053001440000 Operator: Hess

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10318		Limestone No OIL	48.6	40.4	62.0	1	11, 4, 9	0.6 – 12.7	Bedding Joints & Vertical fractures	Tight	None	2x2x0.25 to 2x2x5
10319						1	14, 13		Bedding Joints			
10320						1	9, 9		Bedding Joints			
10321		Black Shale High Carbon Content				1	10, 4, 2, 0, 2, 0, 4, 6, 2, 10, 12, 6, 5, 4		Bedding Joints	0.02		

Name: Smith & Naga 12/17 Date: 6-26-08

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10322		Black Shale High Carbon Content	40.3	0	10.3	1	0, 3, 4, 5, 4, 2, 0	0.25 – 7.6	Bedding Joints	Tight	None	2x2x0.1 to 2x2x3
10323						1	5, 7, 8, 0, 0		Bedding Joints			
10324						1	8, 12, 9, 0		Bedding Joints			
10325						1	10, 5, 5, 7, 14, 7, 0, 8		Bedding Joints			
10326						1			Bedding Joints			
10327						1	2, 7, 10, 8, 8, 4, 6, 8		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10328		Black Shale High Carbon Content	100	0	12.1	1	4, 0, 4, 5, 2, 15, 10, 8	0.25 – 6.6	Bedding Joints	0.02	None	2x2x0.1 to 2x2x2.6
10329						1	14, 6, 12, 14, 15, 4, 5, 4, 2, 5, 0, 12, 7, 5, 16, 4, 5, 7		Bedding Joints	0.02		
10330						1	10, 10, 8, 2, 4, 14, 16, 2, 0, 0, 5, 0, 7, 12, 7		Bedding Joints	0.01		
10331						1	10, 0, 0, 0, 6, 7, 20, 0, 10, 0, 0		Bedding Joints	0.01		
10332						2	85, 0, 4, 4, 4, 2, 0, 2, 7, 5, 12		Bedding Joints & Vertical fractures	Tight		
10333						1	6, 8, 14, 5, 5, 7, 4, 2, 0, 5, 0, 15, 12, 5		Bedding Joints	0.01		

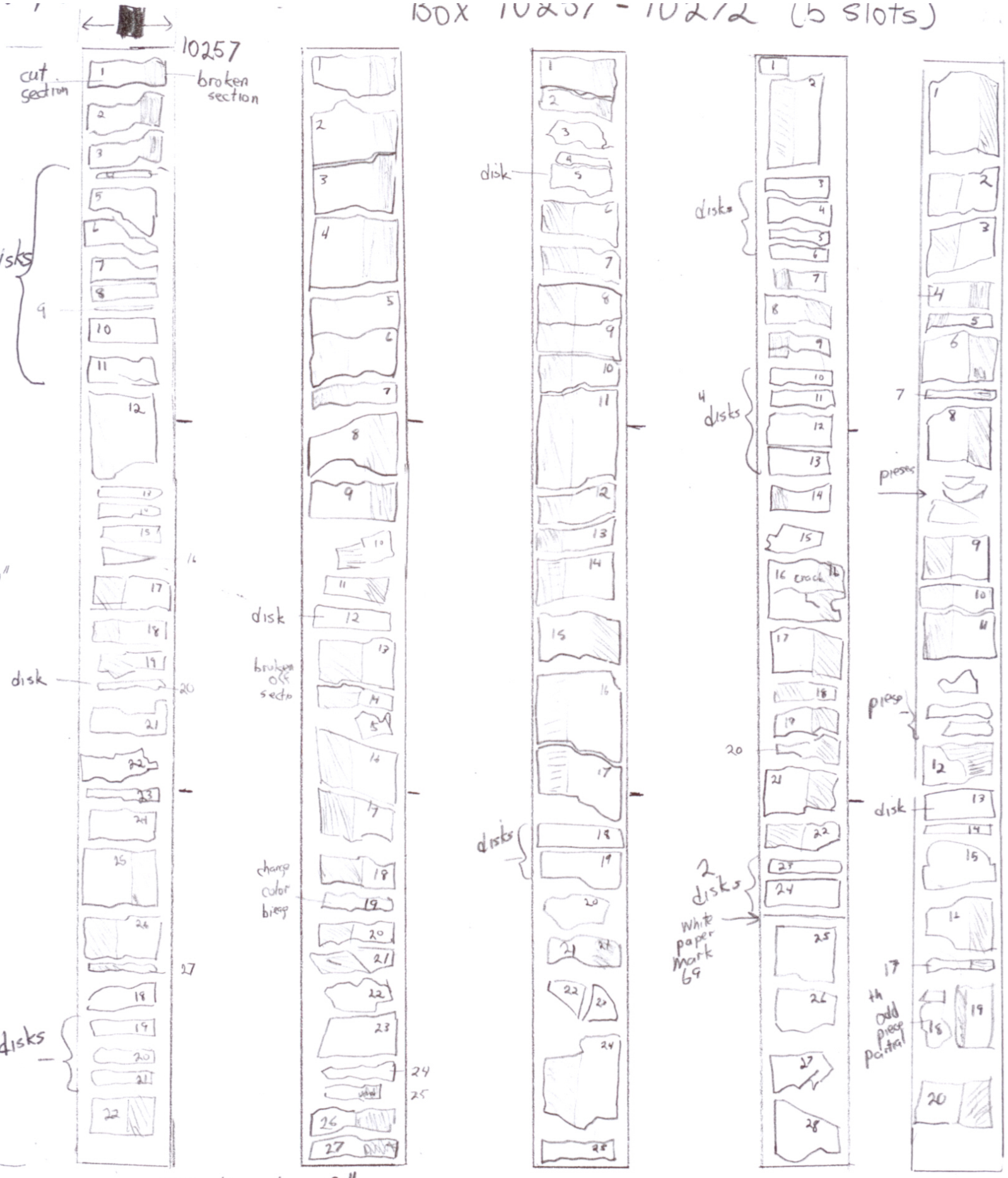
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10334		Black Shale High Carbon Content	65.8	0	11.1	1	10, 3, 0, 4, 2, 0	0.5 – 6.3	Bedding Joints	Tight	None	2x2x0.5 to 2x2x2.4
10335						1	7, 5, 2, 8, 0, 4, 8, 0		Bedding Joints	Tight		
10336						1	5, 0, 8, 2, 5, 2, 6, 4		Bedding Joints	0.02		
10337						1	0, 0, 0, 0, 0, 2		Bedding Joints	Tight		
10338						1	0, 0, 3, 4, 4, 0		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10339		Black Shale High Carbon Content	44.8	0	4.5	1	0, 5, 2, 5, 10, 12	1 – 4.5	Bedding Joints	0.04	None	1x2x0.2 to 2x2x2.4
10340						1	2, 10, 0, 5, 2, 4, 15, 0		Bedding Joints	Tight		
10341						1	0, 0, 5, 15		Bedding Joints	Tight		
10342						1	5, 7		Bedding Joints	Tight		
10343						2	90, 90, 90, 2, 5, 90, 90, 90, 75		Bedding Joints & Vertical fractures	Tight		
10344						1	10, 3, 0, 5		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10345		Siltstone With illite	44.8	0	4.5	1	7, 10, 2, 6	1 – 4.5	Bedding Joints	Tight	None	1x2x0.2 to 2x2x2.4
10346						2	2, 70, 2, 85, 0, 90, 0, 75		Bedding Joints & Vertical fractures	Tight		
10347						1	4, 0, 5, 4		Bedding Joints	Tight		
10348						2	5, 0, 5, 3, 90, 5		Bedding Joints & Vertical fractures	0.01		
10349			100	0	48.1	2	15, 5, 0, 85, 4, 0, 0, 90	1.25 – 5.7	Bedding Joints & Vertical fractures	Tight		0.75x0.5x0.6 to 2x2x2.5
10350						1	0, 2, 10, 7, 8, 4, 7		Bedding Joints	Tight		

Well #1202 fracture sketch

BOX 10257 - 10272 (5 slots)



core diameter 2"

Project Name: Bakken Geomechanics

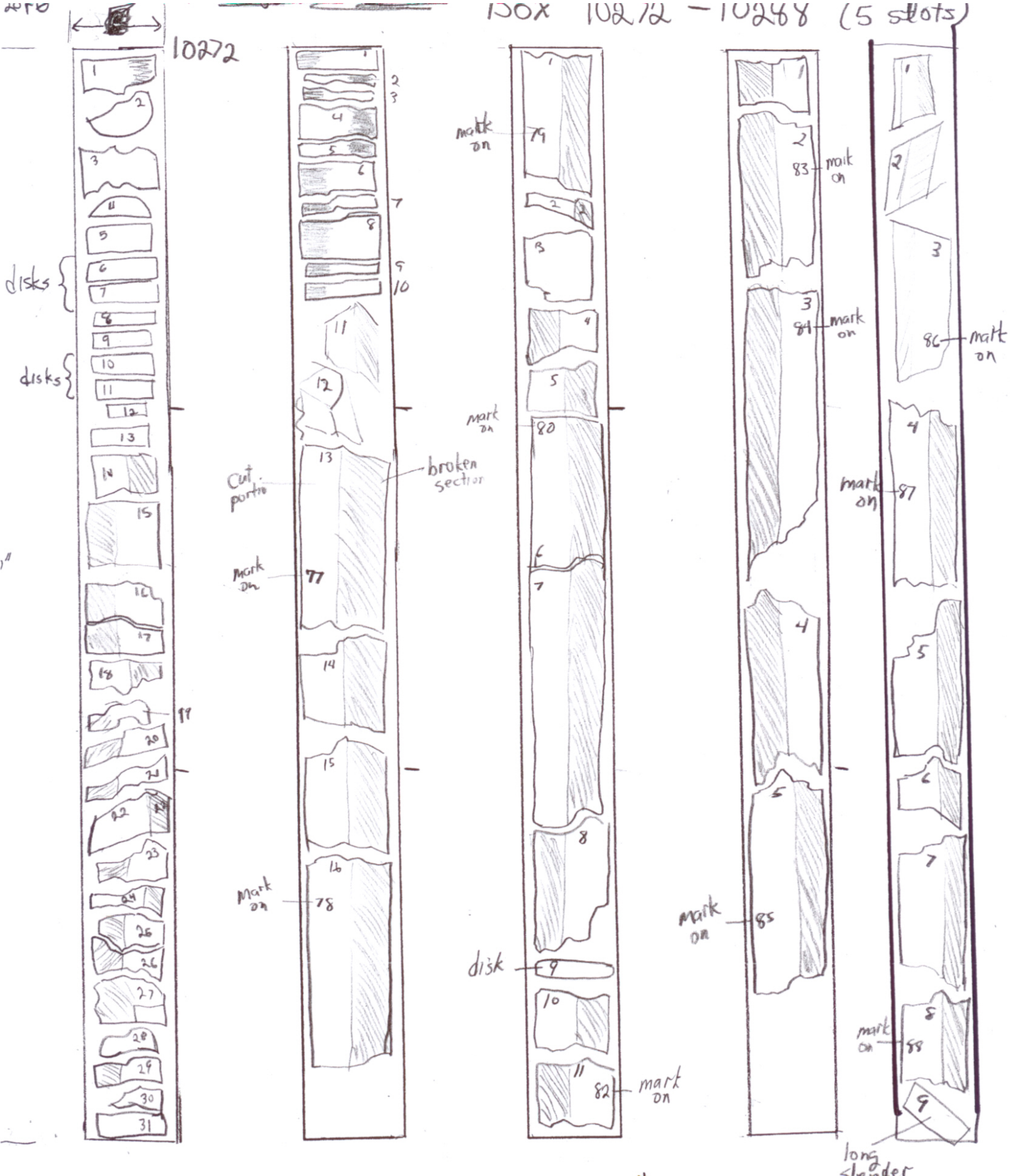
Drawing by: Jill Holwerda

API # 33053001440000

Well Map # 1202

disk diameter 2"

Box 10272 – 10288 (5 slots)



Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

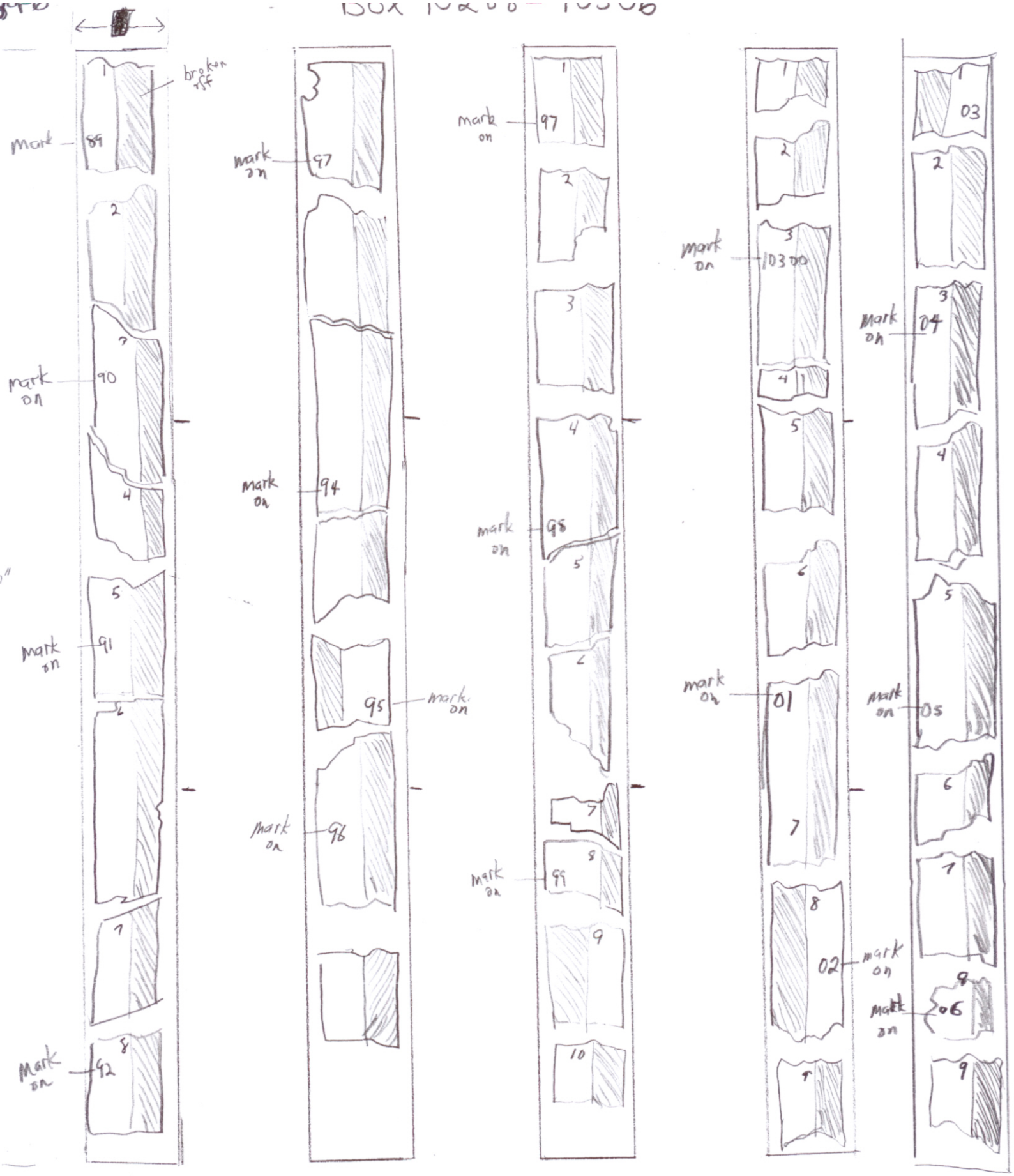
Dated: 6-26-08

API # 33053001440000

Well Map # 1202

scale (ratios) disk diameter 2"

Box 10200 - 10308



Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

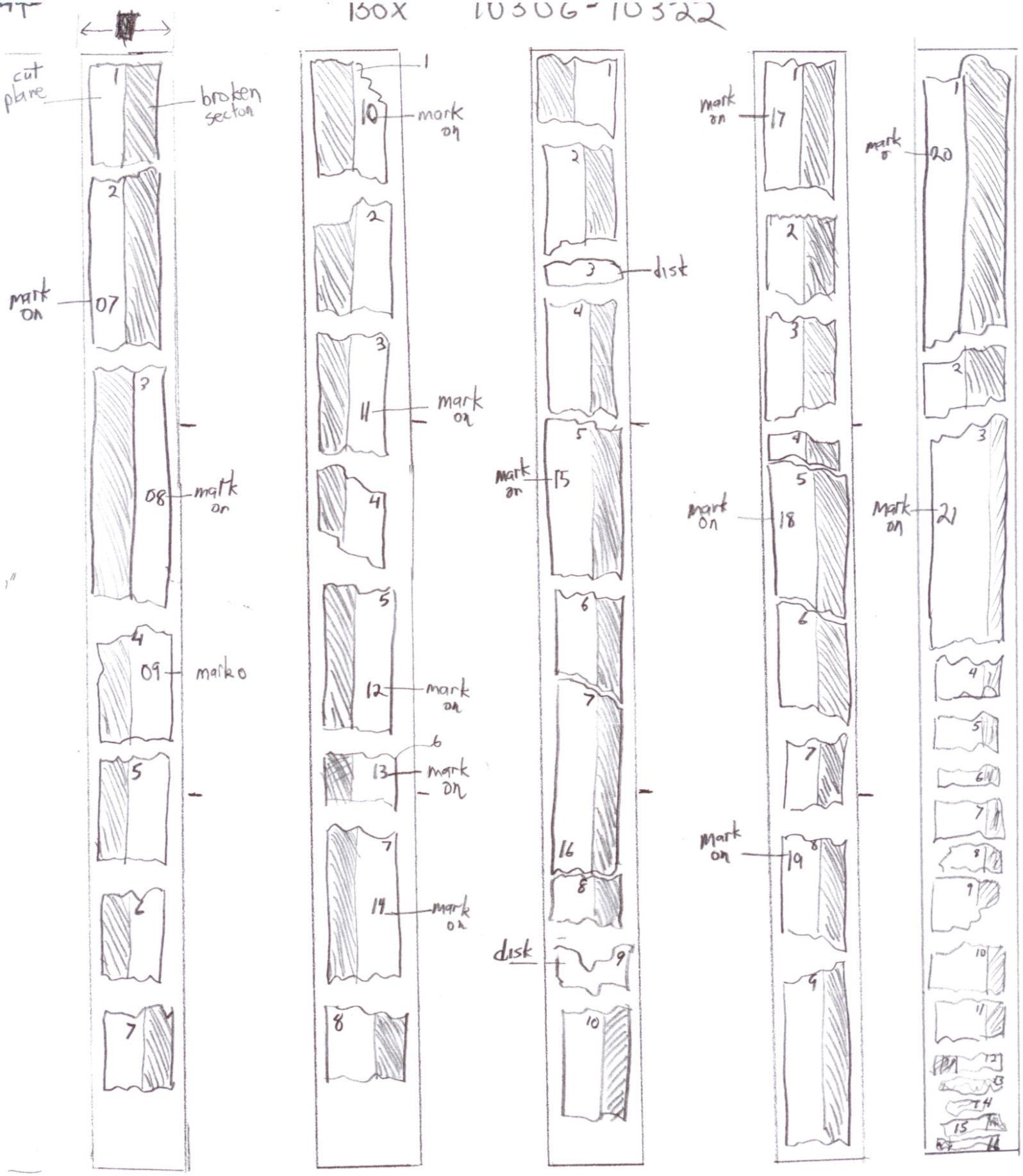
Dated: 6-26-08

API # 3305300 1440000

Well Map # 1202

scale (ratios) disk diameter-2"

150X 10306-10322



Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

Dated: 6-26-08

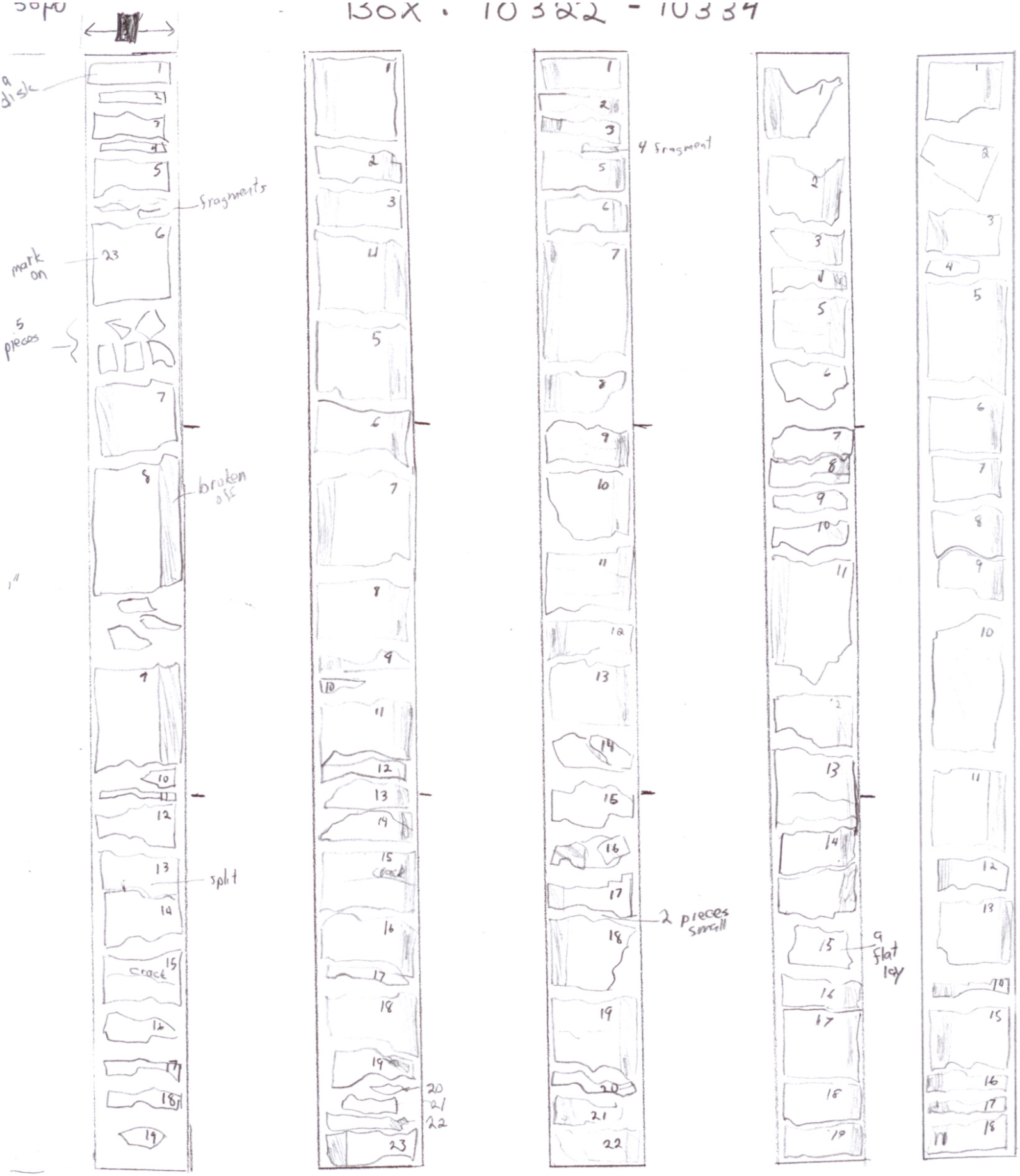
API # 33053001440000

Well Map # 1202

scale (ratios) disk diameter 2"

Soho

Box: 10322 - 10334



Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

Date: 6-26-08

API # 33053001440000

Well Map # 1202

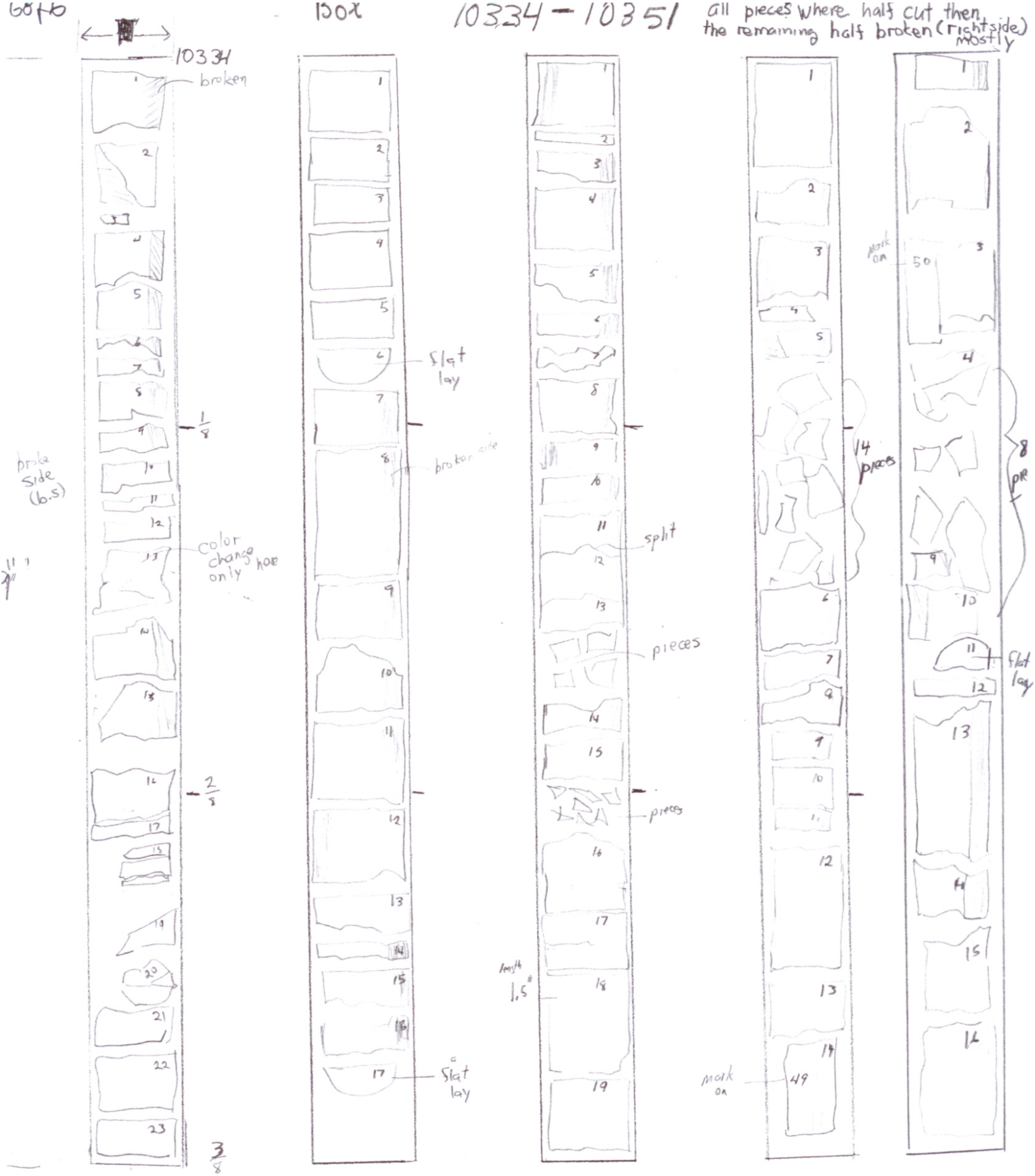
Scale (rating) disk diameter 2"

60 to

Box

10334 – 10351

all pieces where half cut then the remaining half broken (right side) mostly



Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

Date: 6-26-08

API # 3305300144 0000

Well Map # 1202

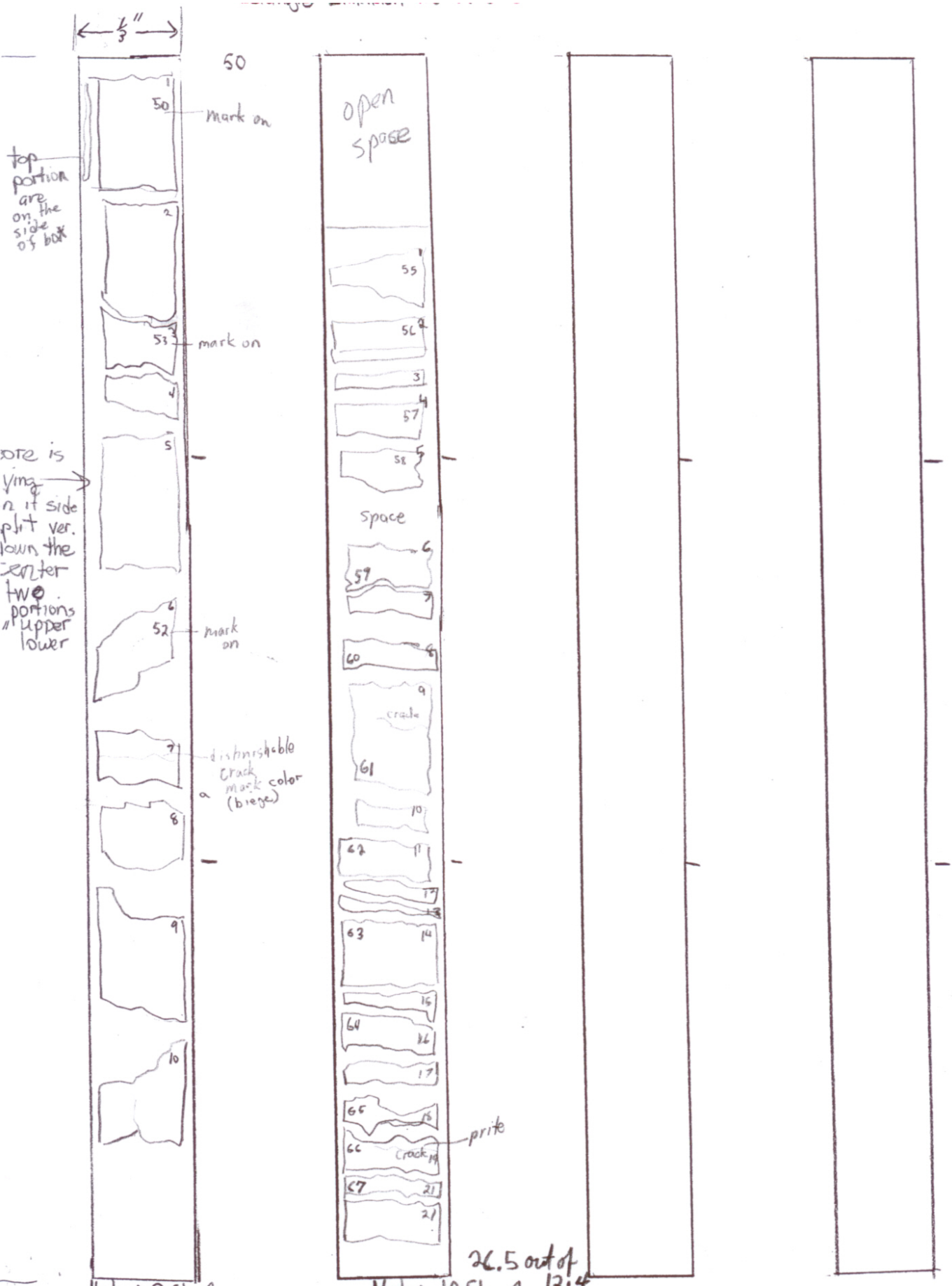
scale (ratio) disk diameter 2"

Well #1254 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10450		Black Shale High Carbon concentration	86.1	27.9	54.5	1	3 5 15 8	3.1 – 10.8	Bedding Joints	Tight	none	4x4x1.25 to 4x4x4.4
10451						2	5 0 85 20 26		Bedding Joints & vertical fractures	0.04		
10452						1	0 4 13 26 7		Bedding Joints	Tight		
10453												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10455		Siltstone with illite No OIL	18.3	0	10.5	1	3 10 0 0	0.7 – 6.7	Bedding Joints	Tight	none	4x4x0.25 to 4x4x2.75
10457							0 0 0 0		Bedding Joints	Tight		
10459							0 7 0		Bedding Joints	0.01		
10461							0 3 0 0		Bedding Joints	0.01	Clay	
10463							5 2 0		Bedding Joints	Tight	None	
10465							0 3 5 6		Bedding Joints	0.02	Clay	

Well #1254 fracture sketch



Note: 3ft of core
Missing 2ft

Note: 12ft of core
Missing 26.5 out of 12.4
144-26.5 = 117.7

Project Name: Bakken Geomechanics

Drawing by: Jill Holwerda

Date: 6-26-08

API # 3305300159000D

Well Map # 1254

scale (ratios) 9"/3' length width 0.33"/2"

Well #1343 Core survey

Bakken Geomech. Core description File # : 1343 Well API: 33053002030000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10340		Black Shale High Carbon Content	83	0	29	1	5, 8, 2, 2, 10, 5, 2, 0, 5, 0, 10, 6, 10, 4	Bedding Joints	0.5 – 9.5	0.05	none	1.25x1.8x0.2 To 4x4x3.75
10341						2	5, 0, 65, 1, 6, 0, 0, 1	Bedding Joints & Vertical Fractures		0.02		
10342						2	3, 2, 3, 6, 5, 65, 0, 8, 4, 2, 90, 90	Bedding Joints & Vertical Fractures		0.02		
10343						1	9, 4, 2	Bedding Joints		0.01		1.8x1.9x0.8 To 4x4x3
10344		Siltstone with illite				2	1, 70, 90, 10, 6, 0, 3, 5, 1	Bedding Joints & Vertical Fractures		0.04		
10345						1	3, 6, 12, 3, 0	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10346		Siltstone with illite	84	7	42	2	2, 1, 10, 0, 0, 75, 3	Bedding Joints & Vertical Fractures	1.3 – 10.2	0.1	None	2.6x2.5x0.6 To 4x4x4
10347						2	2, 75, 0, 0, 0, 80, 0, 3	Bedding Joints & Vertical Fractures		Tight		
10348						1	5, 0, 2, 4	Bedding Joints		Tight		
10349						1	2, 8, 0, 1	Bedding Joints		Tight		4x4x0.5 To 4x4x2.25
10350						1	2, 9, 6, 2, 4, 5, 2	Bedding Joints		0.02		
10351						1	0, 1, 2, 6, 2	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10352		Siltstone with illite	94	12	69	1	4, 2, 5, 0	Bedding Joints	2 – 10.9	Tight	none	4x4x0.8 To 4x4x4.3
10353						1	2, 6, 0, 3, 3	Bedding Joints		Tight		
10354						1	2, 6, 6, 10, 3, 0	Bedding Joints		Tight		
10355						1	9, 2, 7, 5	Bedding Joints		Tight		4x4x1 To 4x4x3.9
10356						1	5, 3, 3	Bedding Joints		0.01		
10357						1	1, 2, 5, 8, 2	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10358		Siltstone with illite	100	31	68	1		Bedding Joints	0.8 – 11.4	Tight	None	4x4x0.4 To 4x4x4.5
10359						1		Bedding Joints		0.02		
10360						1		Bedding Joints		Tight		
10361						1		Bedding Joints		0.01		1.75x3x1 To 4x4x5.6
10362						1		Bedding Joints		0.02		
10363						2		Bedding Joints & Vertical Fractures		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10364		Siltstone with illite	100	22	64	1	1, 2, 2, 3	Bedding Joints	1.3 - 14	0.01	None	4x4x0.8 To 4x4x3.75
10365						1	4, 3, 4, 0, 8	Bedding Joints		0.01		
10366						2	3, 5, 4, 6, 1, 53, 2	Bedding Joints & Vertical Fractures		Tight		
10367						2	1, 0, 85, 9, 9	Bedding Joints & Vertical Fractures		Tight		2x2.3x0.6 To 4x4x5.5
10368						1	2, 7, 16	Bedding Joints		Tight		
10369						1	3, 3, 5, 1, 13, 4	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10370		Siltstone with illite	94	45	81	1	8, 3, 8	Bedding Joints	3.8 – 20.1	Tight	None	4x4x1.5 To 4x4x7.5
10371						1	2, 7, 18	Bedding Joints		Tight		
10372						1	3, 4, 5, 2	Bedding Joints		Tight		
10373						1	2, 18	Bedding Joints		Tight		1.3x3.5x3.8 To 4x4x7.9
10374						2	22, 80	Bedding Joints & Vertical Fractures		0.02		
10375						1	10, 5, 1, 8, 0	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10376		Siltstone with illite	100	46	79	1		Bedding Joints	2.5 – 21.8	Tight	none	4x4x1.2 To 4x4x5.1
10377						1		Bedding Joints		Tight		
10378						1		Bedding Joints		Tight		
10379						1		Bedding Joints		0.02		1.5x1.8x1 To 4x4x8.6
10380						2		Bedding Joints & Vertical Fractures		0.01		
10381						1		Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10382		Siltstone with illite	97	42	70	1	7, 0, 10	Bedding Joints	1.5 – 17.8	Tight	None	4x4x1.6 To 4x4x6.5
10383						1	11, 5, 9, 1	Bedding Joints		Tight		
10384						1	4, 5, 5, 5	Bedding Joints		0.1		
10385						1	25, 9	Bedding Joints		Tight		4x4x0.6 To 4x4x7
10386						1	17, 22, 30	Bedding Joints		Tight		
10387						1	10, 7, 0, 1, 0, 0	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 1343 Well API: 33053002030000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10388		Siltstone with illite	100	35	72	1	0, 12, 7, 15, 6, 20	Bedding Joints	1.9 – 10.4	Tight	None	4x4x0.75 To 4x4x4.1
10389						1	5, 11, 30, 5, 6	Bedding Joints		Tight		

Name: ***Smith*** 9/12 Date: July, 18, 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10390		Siltstone with illite	100	28	61	1	10, 22, 6	Bedding Joints	1.3 – 17.1	Tight	None	2.3x4x0.75 To 4x4x6.75
10391						2	3, 0, 0, 90, 50, 6, 85, 15, 5	Bedding Joints & Vertical Fractures		0.01		
10392						1	0, 0, 4, 4, 2, 10	Bedding Joints		Tight		
10393						1	25, 15	Bedding Joints		Tight		4x4x0.5 To 4x4x5.25
10394						2	3, 3, 6, 60, 0, 0	Bedding Joints & Vertical Fractures		0.01		
10395						1	12, 2, 3, 2, 0, 4, 1	Bedding Joints		Tight		

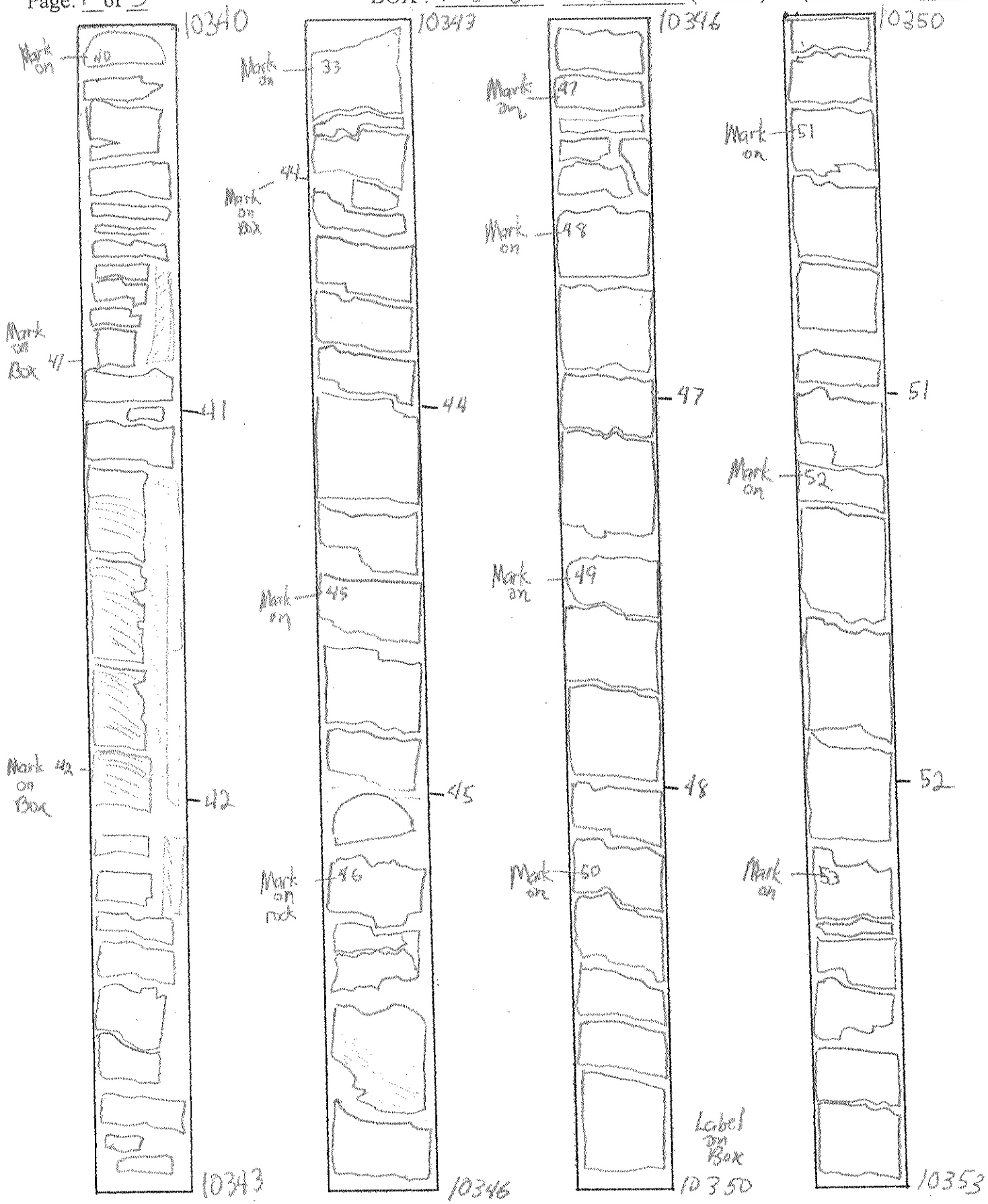
Bakken Geomech. Core description File # : 1343 Well API: 33053002030000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10396		100	100	9	58	1	3, 4, 10, 2	Bedding Joints	0.5 - 13	0.02	None	4x4x0.2 To 4x4x5.1
10397						1	4, 4, 8, 0, 4	Bedding Joints		0.01		
10398						1	2, 0, 5, 0, 7, 0, 1	Bedding Joints		Tight		
10399						1	2, 2, 2, 0, 1, 7, 11, 40	Bedding Joints		0.04		

Name: ***Smith*** 11/12 Date: July, 18, 2008

Well #1343 fracture sketch

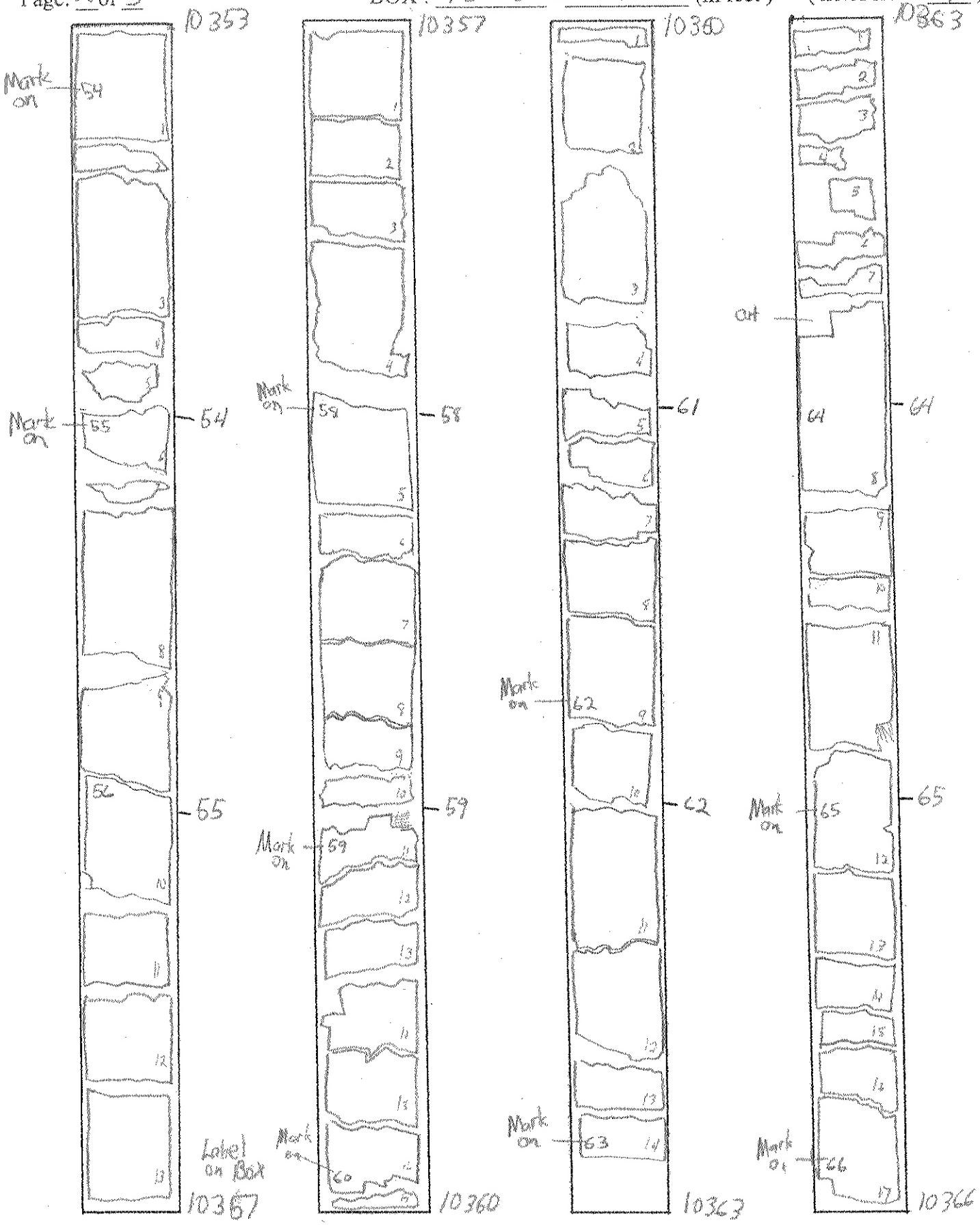
Page: 1 of 5 BOX : 10340 - 10353 (in feet) (no.of slots : NA)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 1343 Operator : Hess
API no. : 33053002030000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

Page: 2 of 5 BOX : 10353 - 10366 (in feet) (no.of slots : N/A)



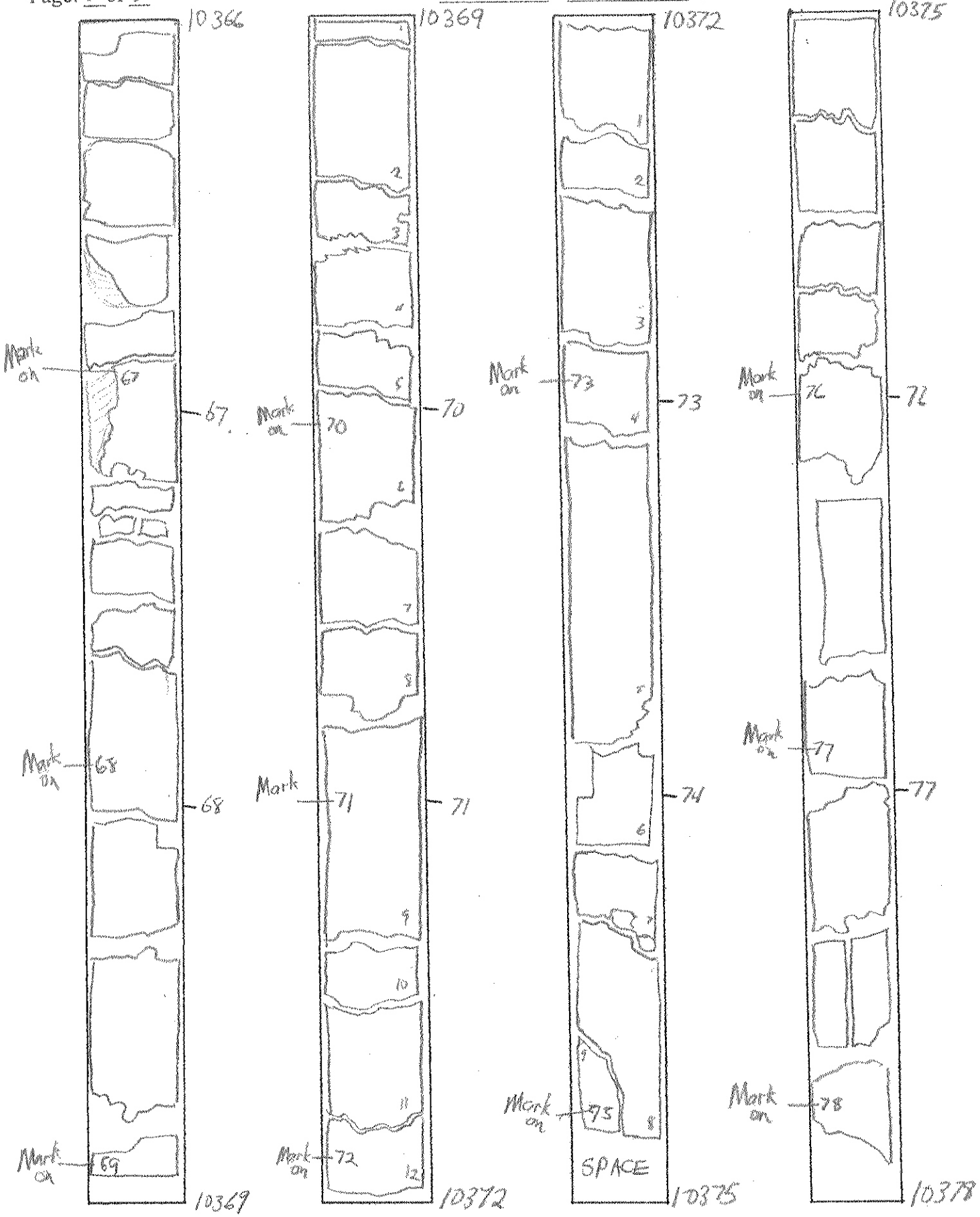
Project name : BAKKEN GEOMECHANICS File no. : 1343 Operator : Hess

Drawing by : Jill Holwerda API no. : 33053002030000

Date : 7-18-08 Scale (ratio) : length width Core diameter : 4"

9"/3ft 0.35"/4"

Page: 3 of 5 BOX : 10366 - 10378 (in feet) (no.of slots : N/A)

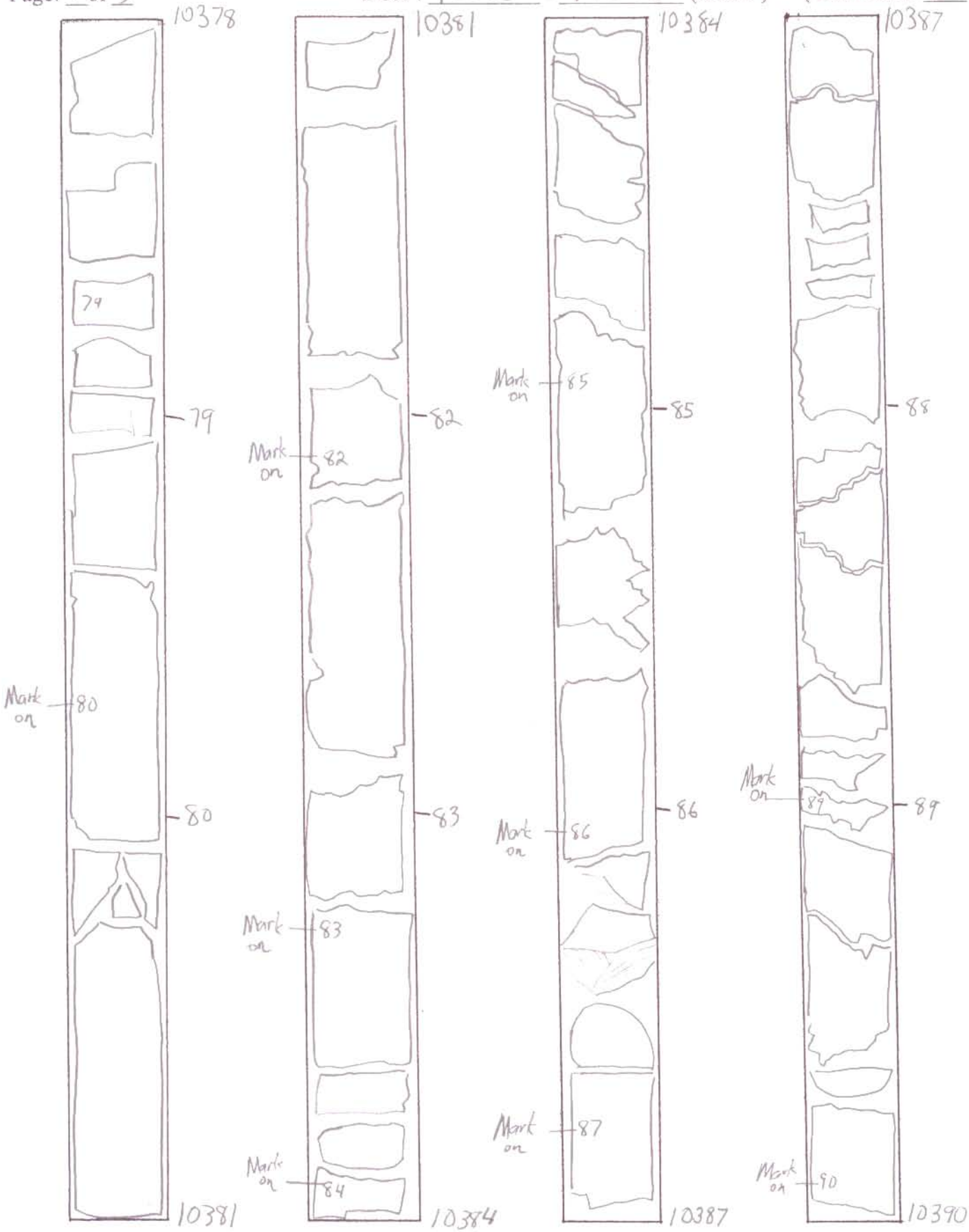


Project name : BAKKEN GEOMECHANICS File no. : 1345 Operator : Hess

Drawing by : Jill Holwerda API no. : 33053002030000

Date : 7-18-08 Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

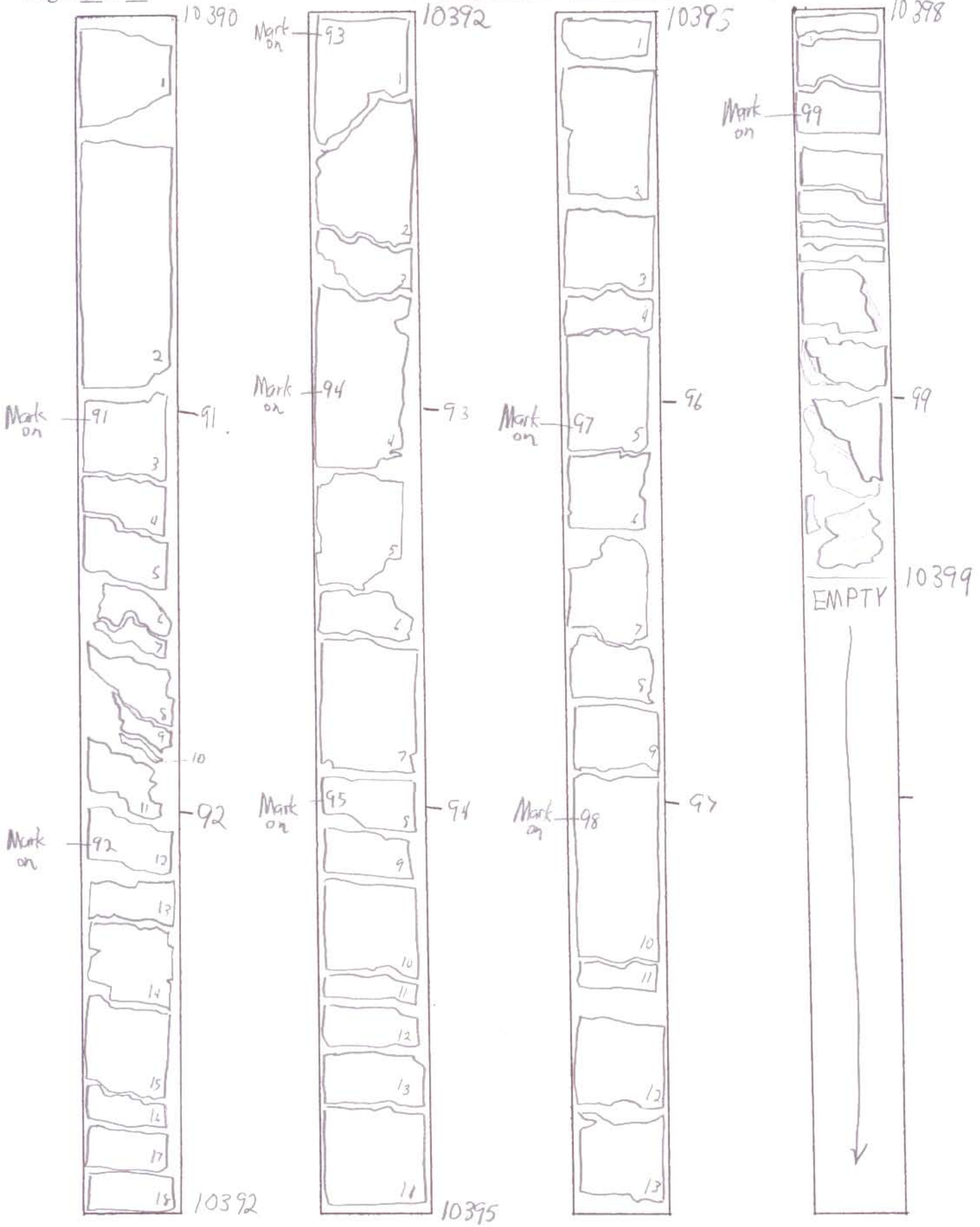
BOX : 10378 - 10390 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 1343 Operator : Hess
API no. : 33053002030000
Scale (ratio) : length width Core diameter : 4"
9"/3ft 0.33"/4"

BOX : 10390 - 10399 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 1343 Operator : Hess
API no. : 33053002030000
Scale (ratio) : length 9"/3ft 0.33"/4" Core diameter : 4"

Well #1748 Core survey

Bakken Geomech. Core description File # : 1748 Well API: 33053003120000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10720		Black Shale	67	0	33	2	7, 2, 6, 9, 80, 7, 11, 80, 90	Bedding Joints & Vertical Fractures	1.5 – 7.6	Tight	None	2.6x2.4x0.8 To 4x4x3
10721						1	7, 4, 2, 2	Bedding Joints		0.02		
10722						1	6, 4, 4, 4	Bedding Joints		0.01		
10723						2	5, 8, 85, 2, 6, 5, 2, 5, 70	Bedding Joints & Vertical Fractures		0.01		3.5x1.8x0.7 To 4x4x2.5
10724						2	7, 2, 85, 3	Bedding Joints & Vertical Fractures		Tight		
10725						1	5, 5, 4, 7, 3, 4	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10726		Black Shale	41	0	44	1	4, 7, 6	Bedding Joints	1.5 – 7.9	0.02	None	2.1x2.2x0.6 To 4x4x2.3
10727						2	2, 5, 5, 85, 70, 7	Bedding Joints & Vertical Fractures		0.02		
10728						1	6, 13, 11	Bedding Joints		Tight		
10729						1	20	Bedding Joints		0.02		4x4x1.5 To 4x4x3.1
10730						0				Tight		
10731						1	20, 0	Bedding Joints		Tight		

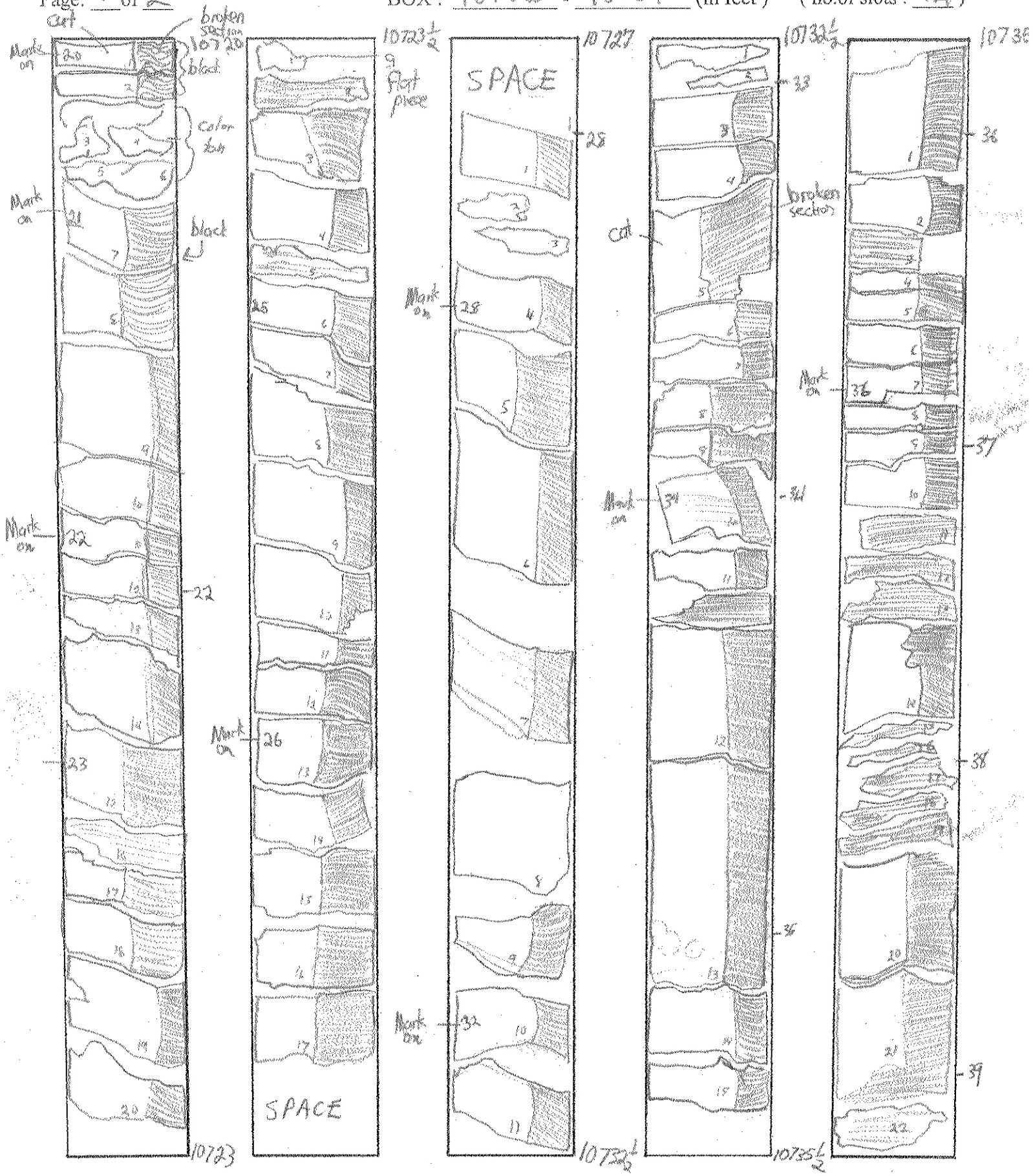
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10732		Black Shale	69	10	39	2	5, 6, 85, 60, 13, 7	Bedding Joints & Vertical Fractures	1.3 – 12.1	0.01	None	2.4x2.1x0.5 To 4x4x3.3
10733						1	4, 12, 5, 5, 3, 0, 11	Bedding Joints		Tight		
10734						2	4, 3, 27, 85, 8, 6	Bedding Joints & Vertical Fractures		Tight		
10735						1	6, 3, 4	Bedding Joints		Tight		2.5x1.9x1 To 4x4x4.75
10736						2	6, 0, 75, 85, 5, 1	Bedding Joints & Vertical Fractures		0.04		
10737						2	4, 1, 6, 3, 90, 8, 3, 70, 2	Bedding Joints & Vertical Fractures		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10738		Black Shale	61	34	67	2		Bedding Joints & Vertical Fractures	0.6 – 14.5	0.01	None	3.5x1.7x0.25 To 4x4x5.2
10739						2		Bedding Joints & Vertical Fractures		Tight		
10740						1		Bedding Joints		Tight		
10741						1		Bedding Joints		0.01		4x4x1.2 To 4x4x5.7
10742						1		Bedding Joints		0.02		
10743						1		Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10744		Black Shale	53	11	37	1		Bedding Joints	0.8 – 10.9	0.01	None	4x2.5x1 To 4x4x2.5
10745						2		Bedding Joints & Vertical Fractures		Tight		
10746						2		Bedding Joints & Vertical Fractures		0.01		
10747						2+		Bedding Joints & Multiple Vertical Fractures		Tight		0.2x0.2x0.2 To 4x4x4.3
10748						2+		Bedding Joints & Multiple Vertical Fractures		Tight		
10749						2+		Bedding Joints & Multiple Vertical Fractures		Tight		

Well #1748 fracture sketch

Page: 1 of 2 BOX : 10720 - 10739 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS File no. : 1748 Operator : HOS

Drawing by : Jill Howerda API no. : 33053003120000 Date : 7-21-2008

Scale (ratio): 4" x 30" (size of box) drawing 1"/4" Core diameter : 4"

Page: 2 of 2 BOX : 10737 - 10753 (in feet) (no.of slots : N/A)

Project name : BAKKEN GEOMECHANICS File no. : 1748 Operator : Hess

Drawing by : Jill Holwerda API no. : 33053003120000 Date : 7-21-2008

Scale (ratio): 5" x 30" size of Box My drawing 1"/8" Core diameter : 4"

Well #1780 Core survey

Well #1780 has only very small pieces of drilling cuttings.

Core recovery is zero.
RQD is zero.
No fracture sketch is done.

Well #1780 fracture sketch

Well #1780 has only very small pieces of drilling cuttings.

Core recovery is zero.
RQD is zero.
No fracture sketch is done.

Well #7887 Core survey

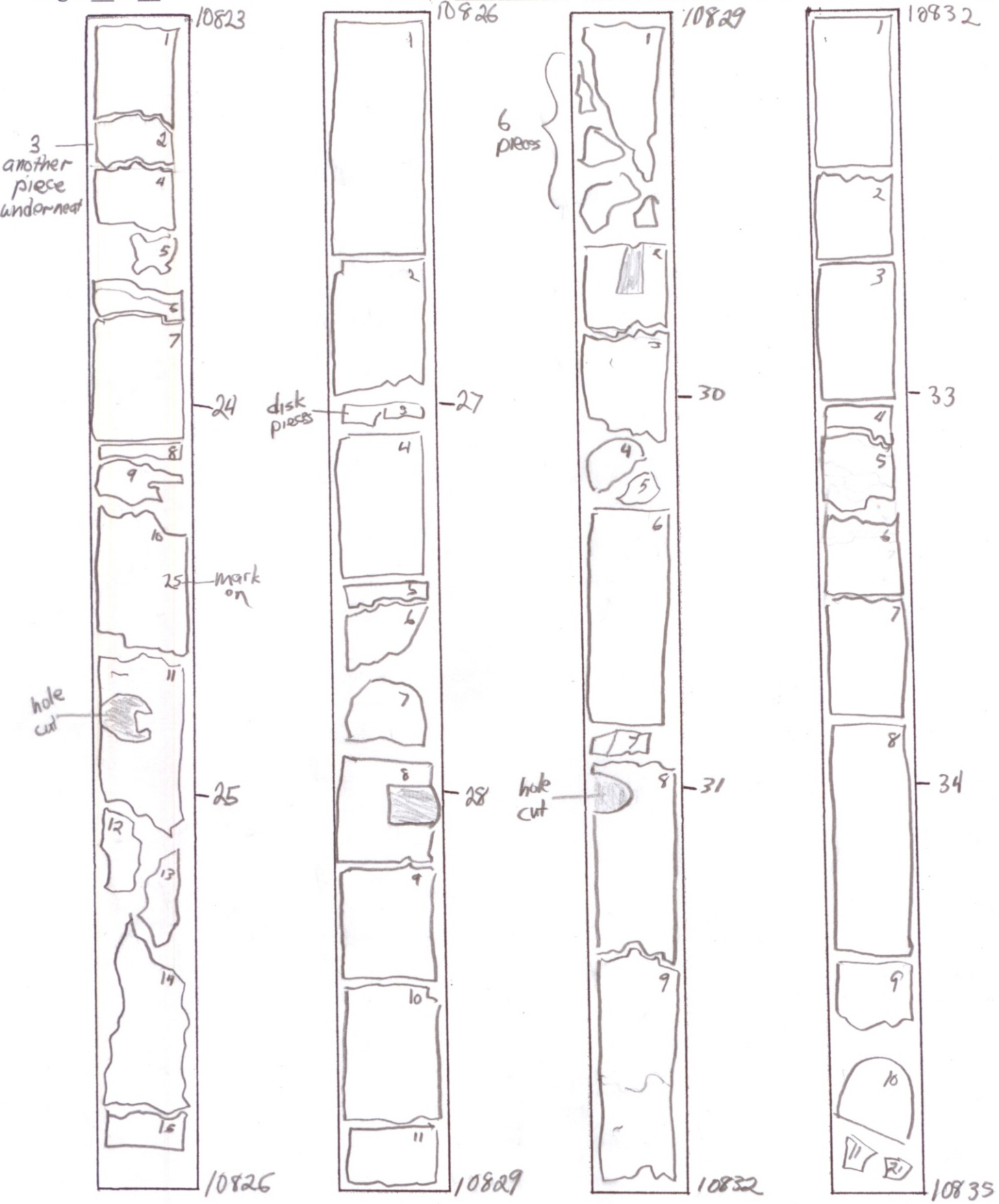
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10823		Siltstone	81	63	79	2	3, 6, 5, 5, 75, 10	0.6 – 29.2	Bedding Joints & Vertical Fractures	0.02	None	2.4x0.6x0.9 to 4x4x4.8
10824						1	8, 12		Bedding Joints	Tight		
10825						2	7, 55, 68		Bedding Joints & Vertical Fractures	Tight		
10826						1	3, 1		Bedding Joints	Tight		4x4x0.5 to 4x4x11.5
10827						1	2, 2, 3		Bedding Joints	Tight		
10828						1	12, 6, 3, 4		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10829		Siltstone	78	62	89	2	2, 59, 10	1.9 – 26.2	Bedding Joints & Vertical Fractures	Tight	None	2.75x0.3x0.6 to 4x4x8
10830						1	3, 4		Bedding Joints	Tight		
10831						1	2, 3		Bedding Joints	Tight		
10832						1	0		Bedding Joints	Tight		4x4x1.1 to 4x4x10.3
10833						1	9, 3, 2		Bedding Joints	Tight		
10834						1	2, 11		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10835		Siltstone	83	39	84	1	2, 13	0.2 – 20.1	Bedding Joints	Tight	None	0.7x0.2x0.5 to 4x4x7.9
10836						Multiple Sets	Varies from 0-90		Bedding Joints & Multiple Vertical Fracture Sets	Tight		
10837						1	5, 10, 3, 2		Bedding Joints	Tight		
10838												

Well #7887 fracture sketch

Page: 1 of 2 BOX : 10823 - 10835 (in feet) (no.of slots : N/A)

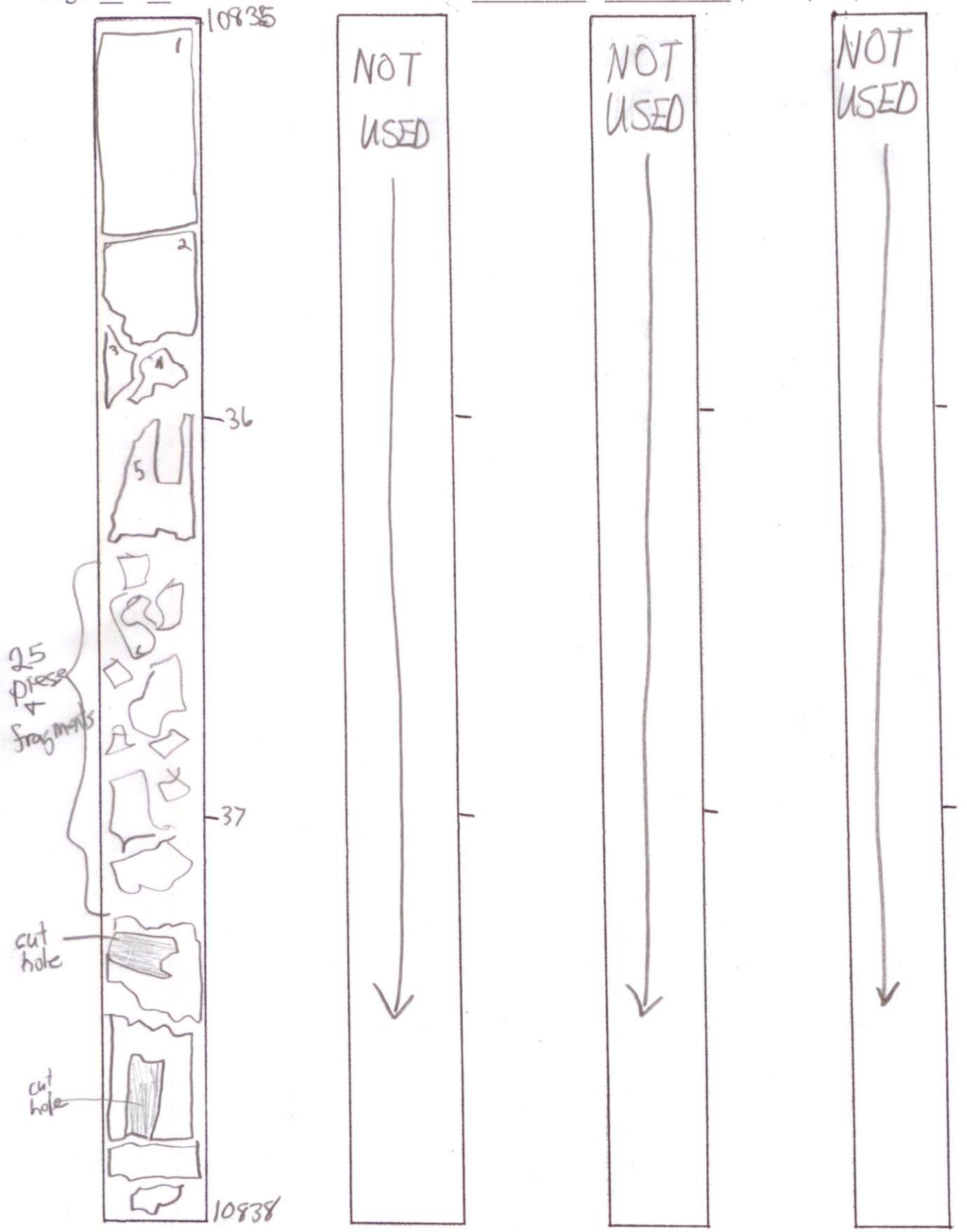


Project name : BAKKEN GEOMECHANICS File no. : 7887 Operator : Tenneco Oil Co

Drawing by : Jill Holwerda API no. : 3300700581 0000

Date : 7-3-08 Scale (ratio) : length 9"/3ft width 0.033"/3.0" Core diameter : 3.0"

Page: 2 of 2 BOX : 10835 - 10838 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-3-08

File no. : 7887 Operator : Tenneco Oil Co
API no. : 33007005810000
Scale (ratio) : length 9"/3ft width 0.033"/3.0" Core diameter : 3.0"

Well #11617 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10363		Limestone No OIL	86.8	68.5	95.0	1	10, 5, 15	5.1 – 17.8	Bedding Joints	Tight	None	4x4x2.6 to 4x4x7.0
10364						1	6, 3		Bedding Joints			
10365						1	16, 0		Bedding Joints			
10366						1	3, 8, 11		Bedding Joints			4x4x2 to 4x4x6
10367						1	2, 9		Bedding Joints			
10368						1	24, 5, 2		Bedding Joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10369		Limestone No OIL	93.1	59.3	88.1	1	10, 10, 5	4.8 – 21.3	Bedding Joint	Tight	None	4x4x2.25 to 4x4x7.3
10370						1	6, 2		Bedding Joint			
10371						1	0, 6		Bedding Joint			
10372						1	9, 2, 2		Bedding Joint			4x4x1.5 to 4x4x8.4
10373						1	5, 10		Bedding Joint			
10374						1	6, 5, 7		Bedding Joint			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10375		Black Shale High Carbon Content	100	13.1	38.3	1	10, 7, 2, 0	0.3 – 13.2	Bedding Joints	0.02	none	1.75x1.1x0.2 to 4x4x5.2
10376						2	10, 85, 5, 80, 7, 85, 85, 3, 70, 90, 4, 5		Bedding Joints & Vertical Fractures	0.04		
10377						2	5, 80, 10, 0, 7, 3, 85		Bedding Joints & Vertical Fractures			
10378						2	0, 0, 90, 5, 6, 5, 80, 10, 65, 0, 5, 90, 0, 90, 5		Bedding Joints & Vertical Fractures	0.01		1.75x1.5x0.5 to 4x4x4
10379						1	4, 10, 0		Bedding Joints			
						2	10, 85, 35		Bedding Joint & Vert. Fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10380		Black Shale High Carbon Content	100	11.0	49.9	1	12, 10, 5, 5, 0, 0	1.8 – 10.6	Bedding Joints	Tight	none	1.75x4x0.9 to 4x4x4.25
10381						2	90, 0, 10, 80, 0, 10, 75		Bedding Joints & Vertical Fractures	0.02		
10382						2	0, 2, 90, 0, 2, 6, 82, 7, 3, 85, 2, 20		Bedding Joints & Vertical Fractures	Tight		
10383						2	5, 2, 5, 90, 0, 83, 6		Bedding Joints & Vertical Fractures	Tight		1.8x4x0.5 to 4x4x3.8
10384						2	5, 0, 0, 5, 90, 0, 4		Bedding Joints & Vertical Fractures	0.01		
10385						2	15, 7, 9, 4, 2, 80		Bedding Joints & Vertical Fractures	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10386		Black Shale High Carbon Content	100	5.9	47.0	2	7, 0, 10, 7, 88, 24, 7, 85	1.25 – 10	Bedding Joints & Vertical Fractures	0.01	none	1.7x4x0.7 to 4x4x3.8
10387						2	15, 5, 90, 0, 5, 0, 6, 78, 3, 2, 85		Bedding Joints & Vertical Fractures	0.01		
10388						2	0, 6, 85, 4		Bedding Joints & Vertical Fractures	0.01		
10389						2	0, 0, 85, 0, 7, 80, 5, 8, 85, 8, 10, 85		Bedding Joints & Vertical Fractures	0.02		1.6x1.4x0.75 to 4x4x3.25
10390						2	10, 14, 75, 8, 6, 90, 5, 10, 78, 10, 3, 90, 55, 85, 14, 10, 80		Bedding Joints & Vertical Fractures	tight		

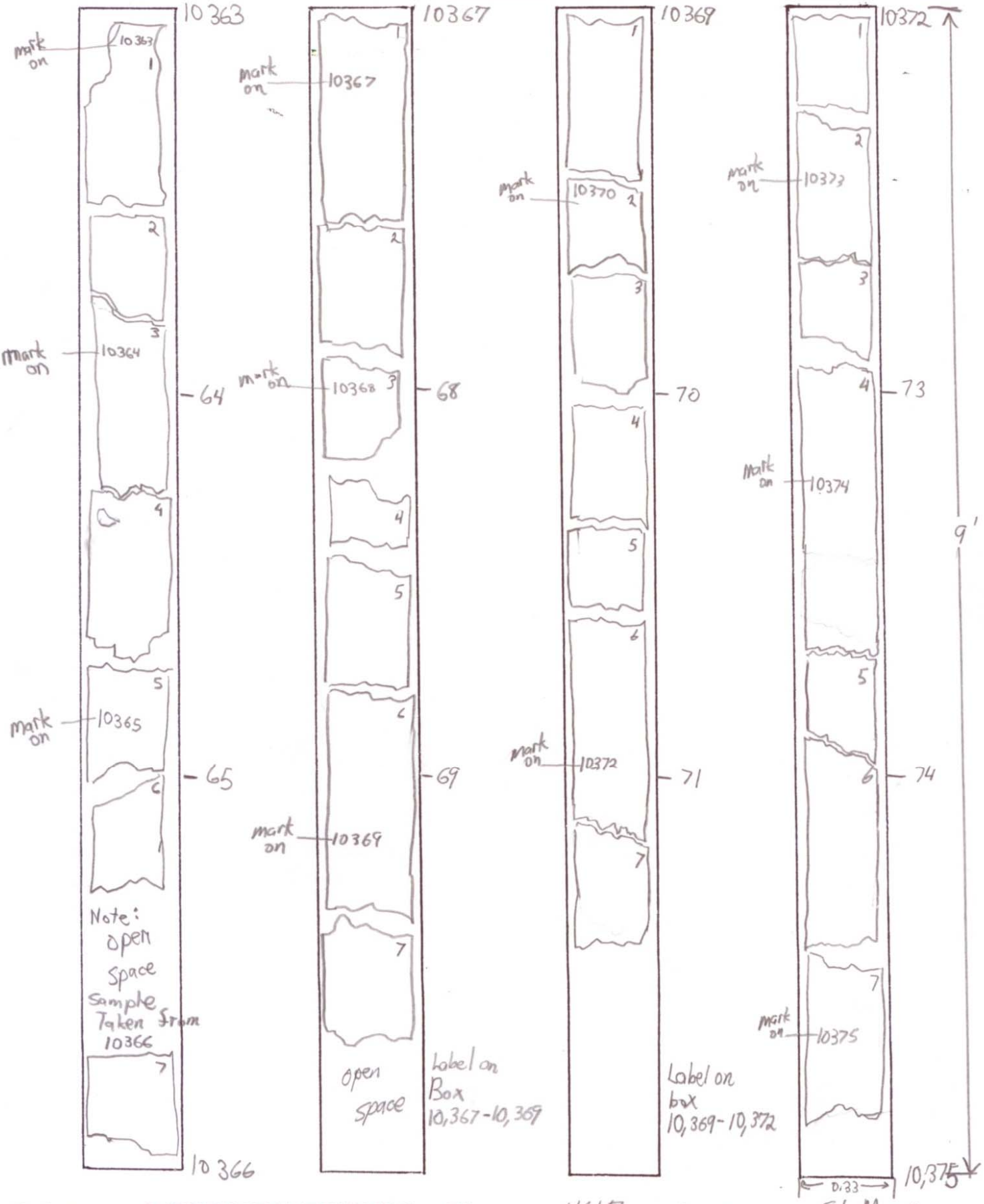
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10391		Black Shale High Carbon Content	97.2	0	14.6	2	0, 10, 12, 10, 70	0.2 – 8.1	Bedding Joints	0.02	none	Minimal (0.1x0.1x0.1) to 4x4x3.2
10392						2	2, 5, 85, 15, 10, 85, 10, 90, 15		Bedding Joints & Vertical Fractures			
10393						Multiple Sets Many Small Blocks of Core	Many Fracture Orientations		Bedding Joints & Different Vertical Fractures			
10394												Minimal (0.1x0.1x0.1) to 2.2x4x3.2
10395												
10396												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10397		Black Shale High Carbon Content	93.1	18.5	57.6	2	5, 20, 75, 14, 10, 85	0.7 – 20.4	Bedding Joints & Vertical Fractures	0.01	none	1.5x3.4x0.55 to 3.6x4x4.4
10398						2	0, 10, 87, 73, 10, 13		Bedding Joints & Vertical Fractures	Tight		
10399						2	2, 10, 90, 20, 14, 90, 0, 18, 65		Bedding Joints & Vertical Fractures			
10400						2	8, 12, 2, 87, 2, 12, 85, 0, 40, 8, 4, 72		Bedding Joints & Vertical Fractures	0.01		2.2x2.75x0.3 to 4x4x8
10401						2	5, 12, 70, 5, 20, 76		Bedding Joints & Vertical Fractures			
						1	7		Bedding Joints	Tight		
10402						2	6, 4, 20		Bedding Joints & Vertical Fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10403		Siltstone with illite	70.3	29.6	72	2	20, 0, 90	1.2 – 12.8	Bedding Joints & Vertical Fractures	Tight	none	1x3.5x1.4 to 4x4x5.2
10404						1	0, 3, 0		Bedding Joints			
10405						1	0, 8, 14		Bedding Joints			
10406						1	4, 5, 3, 4		Bedding Joints			
10407												

Well #11617 fracture sketch

Page: 1 of 4 BOX : 1 - 4 (in feet) (no.of slots : N/A)

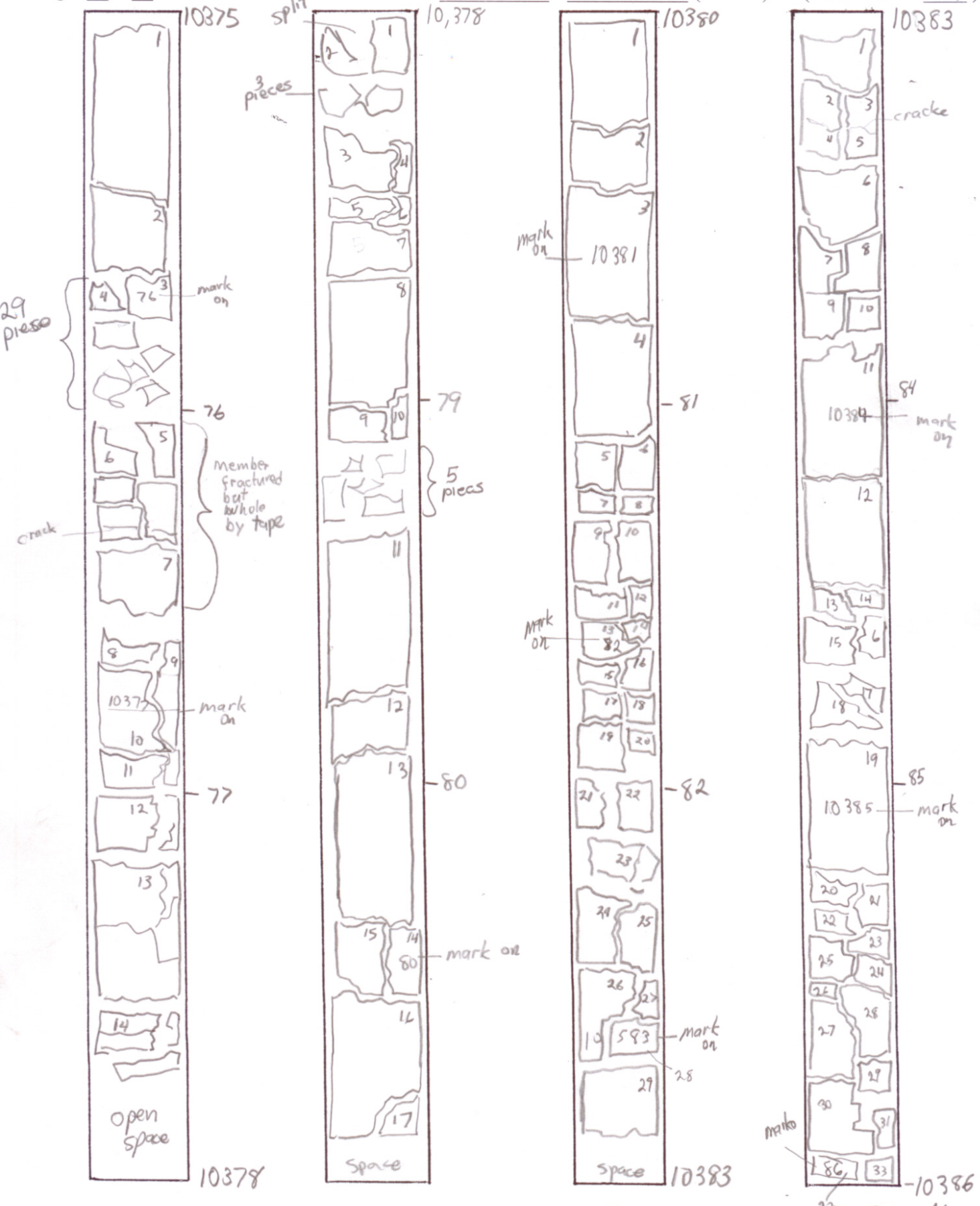


Project name : BAKKEN GEOMECHANICS File no. : 11617 Operator : St Mary

Drawing by : Jill Holwerda API no. : 33053020760000

Date : 6-27-08 Scale (ratio) : length 9.0 in/37 width 0.33/4" Core diameter : 4"

Page: 2 of 4 BOX : 5 - 8 (in feet) (no.of slots : N/A)

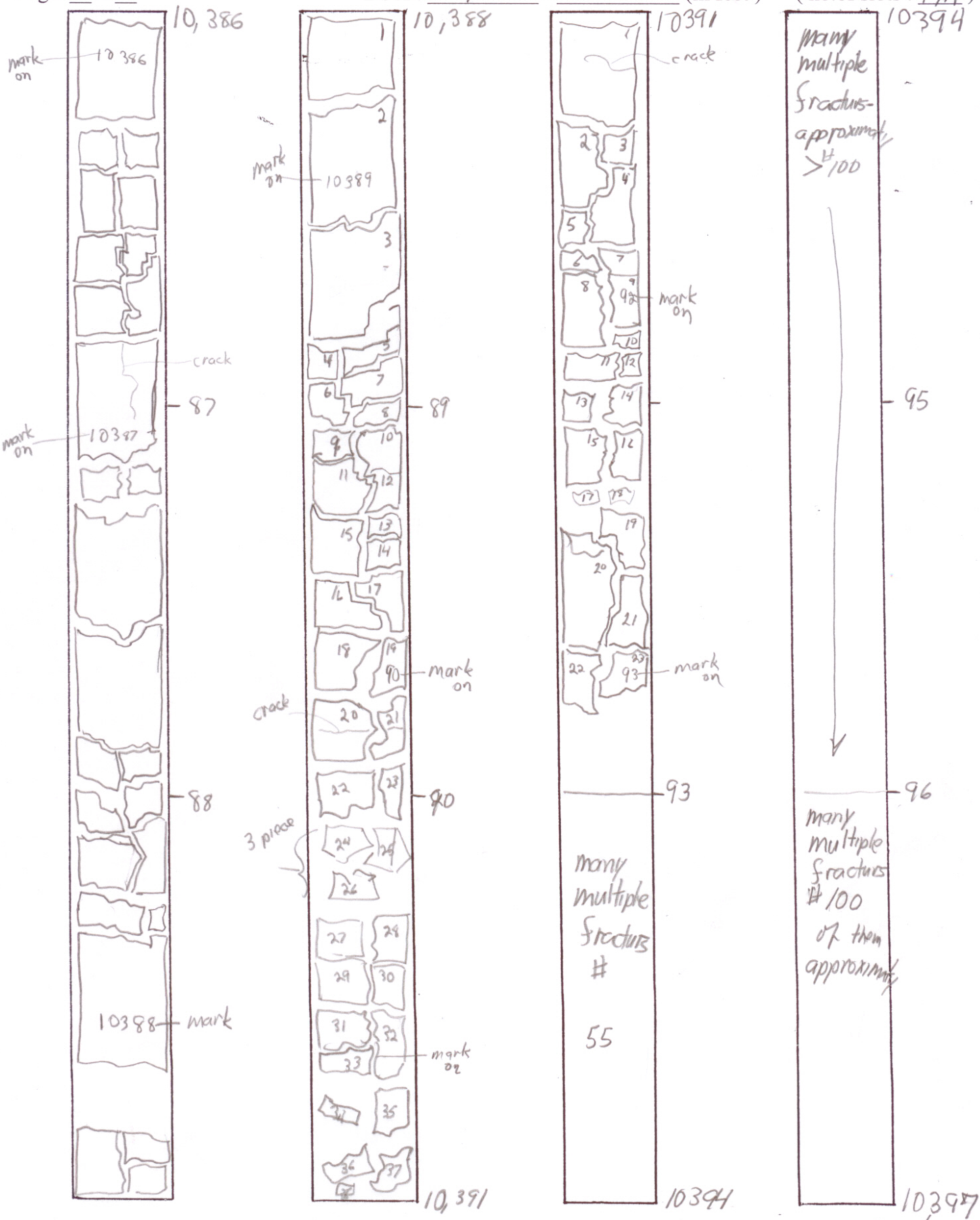


Project name : BAKKEN GEOMECHANICS File no. : 11617 Operator : St. Mary

Drawing by : Jill Holwerda API no. : 33053020760000

Date : 6-27-08 Scale (ratio) : length 9.0in/39 width 0.33/4" Core diameter : 4"

Page: 3 of 4 BOX : 9 - 12 (in feet) (no.of slots : NA)

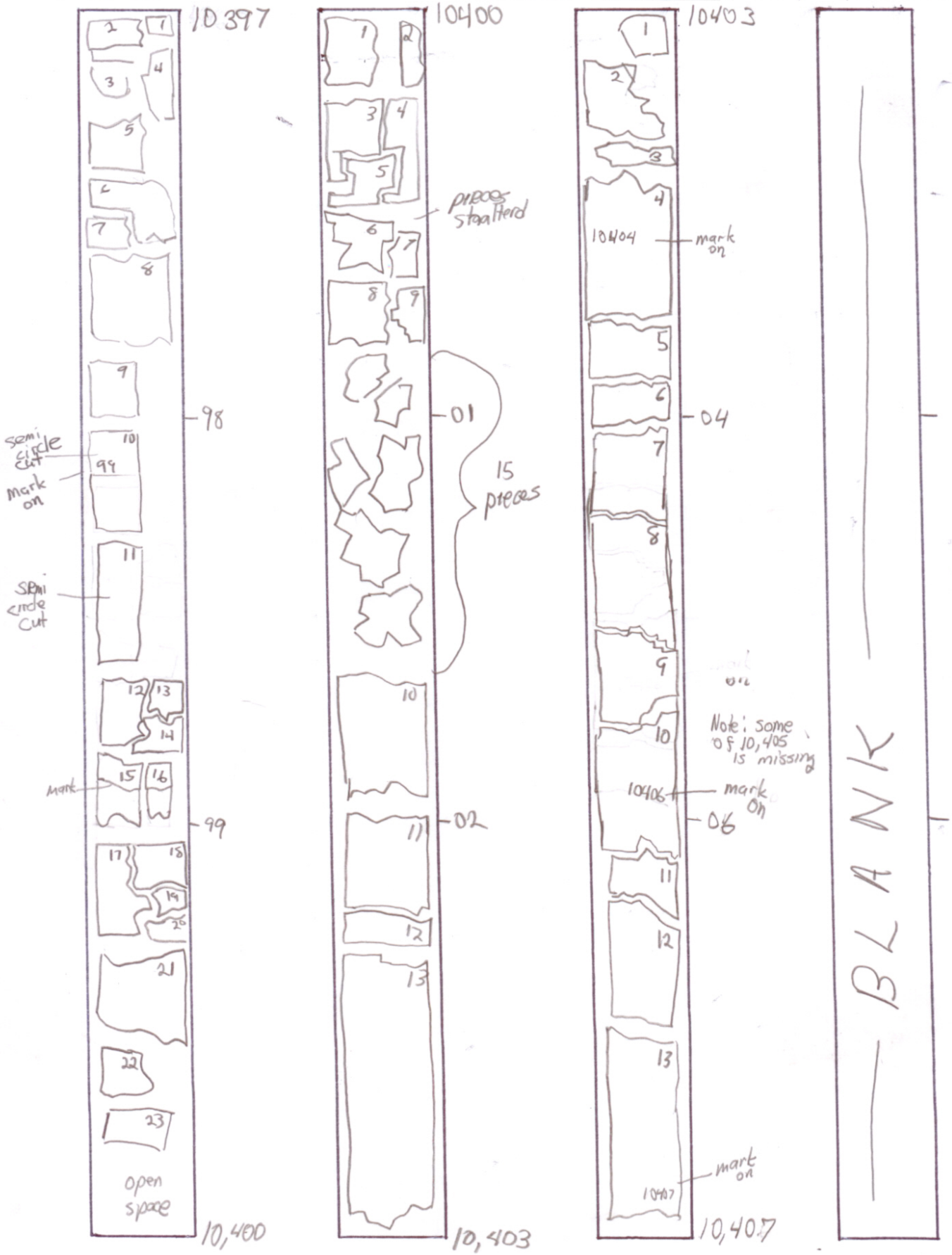


Project name : BAKKEN GEOMECHANICS File no. : 11617 Operator : St. Mary

Drawing by : Jill Holwerda API no. : 33053020760000

Date : 6-27-08 Scale (ratio) : length 9.0in/35 width 0.33/4" Core diameter : 4"

Page: 4 of 4 BOX : 13 - 15 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS File no. : 11617 Operator : St Mary

Drawing by : Jill Holwerda API no. : 33053020760000

Date : 6-27-08 Scale (ratio) : length Width Core diameter : 4"

9.0in / 3ft 0.33/4"

Well #12072 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10388		Black Shale High Carbon Content	100	14	46	1	0, 0, 3, 2, 2, 10	1.2 – 13.5	Bedding Joints	Tight	None	2.1x3x0.5 to 4x4x3.4
10389						2	0, 5, 5, 7, 85, 90, 5, 3, 2, 6		Bedding Joint & Vertical Fractures	0.02		
10390						2	3, 2, 6, 2, 90, 2, 0, 90, 3, 1		Bedding Joint & Vertical Fractures	0.01		
10391						1	0, 6, 2, 2, 5		Bedding Joint	0.02		1.5x3.5x0.7 to 4x4x5.3
10392						2	85, 2, 5, 4, 1, 4, 6		Bedding Joint & Vertical Fractures	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10393		Limestone	100	89	97	1	15, 5, 8	7 – 18.8	Bedding Joints	Tight	None	4x4x2.75 to 4x4x7.4
10394						1	2, 3		Bedding Joint			
10395						1	3, 10		Bedding Joint			
10396						1	6, 6, 2		Bedding Joint			3x0.9x1.75 to 4x4x7
10397						1	3, 4, 19		Bedding Joint			
10398						2	32, 9, 70		Bedding Joint & Vertical Fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10399		Limestone	100	36	46	2	4, 75, 3, 90	0.5 – 15.2	Bedding Joints & Vertical Fractures	Tight	None	3.8x2.25x1 to 4x4x5.1
10400						1	1, 2		Bedding Joint			
10401						1	14, 7		Bedding Joint			
						Multiple Sets	Varies from 0 - 90		Bedding Joints and Fractures in many orientations			0.25x1.25x0.75 to 4x2.4x0.8
10402												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10403		Black Shale High Carbon Content	100	0	All fractures less than 5 cms apart 0%	Multiple Sets	Varies from 0 - 90	0.2 – 4.6	Bedding Joints and Fractures in many orientations	Tight	None	1x0.5x0.25 to 2.6x1.2x1.4
10404												
10405												1.1x0.5x0.4 to 3.8x1.5x1.7
10406												

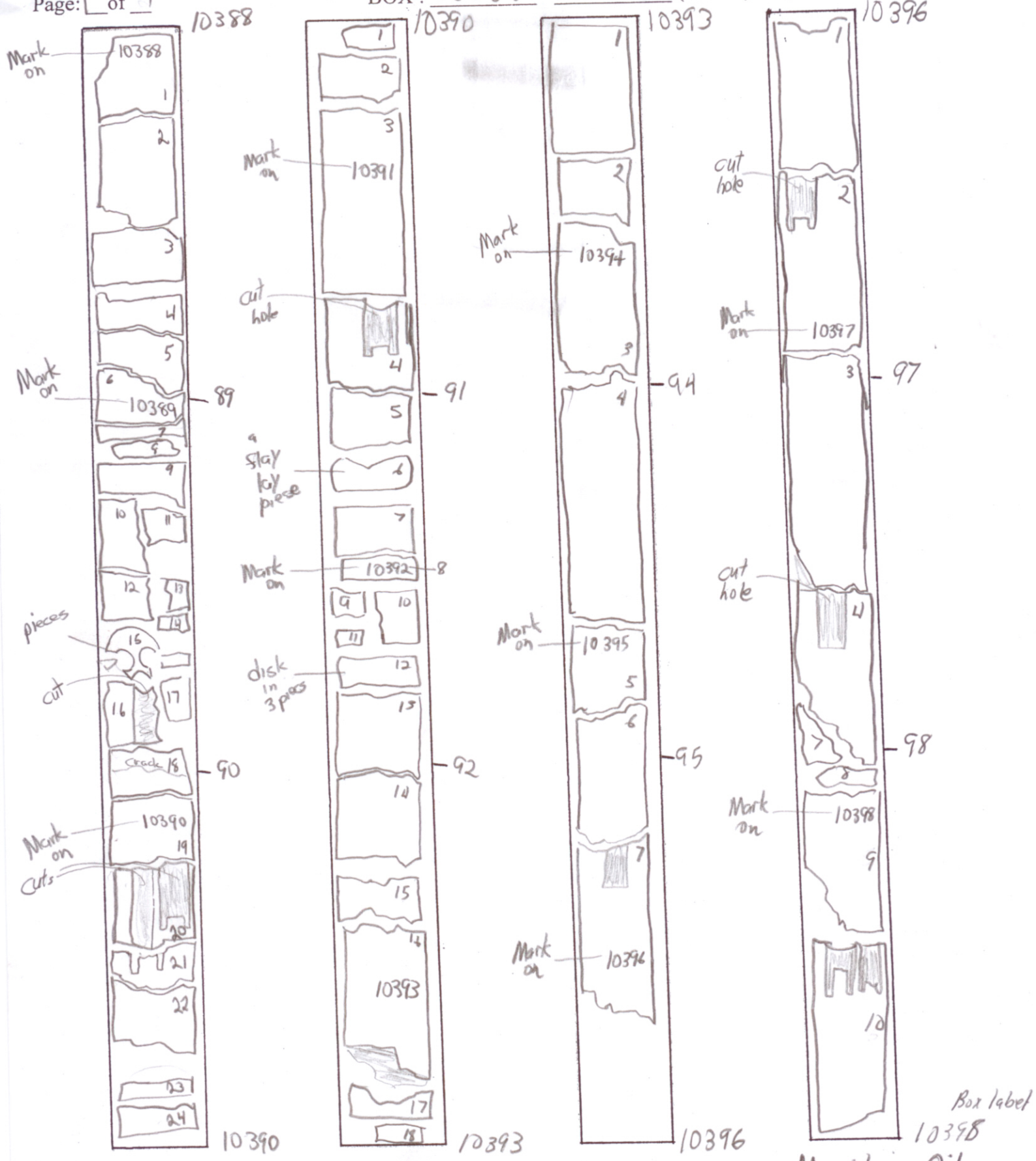
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10407		Black Shale High Carbon Content	89	21	39	Multiple Sets	Varies from 0 - 90	1.3 – 12.1	Bedding Joints and Fractures in many orientations	Tight	None	1.5x2.6x0.4 to 4x4x3
10408												
						1	0, 5, 2		Bedding Joint			
10409						2	2, 90, 0, 90, 2, 17, 10		Bedding Joint & Vertical Fractures			
10410						1	6, 14, 9, 9, 5, 21, 4		Bedding Joint			2.25x1.1x0.5 to 4x4x4.75
10411						2	0, 90, 1, 4, 3, 2		Bedding Joint & Vertical Fractures			
10412						2	7, 10, 38		Bedding Joint & Vertical Fractures			
		Siltstone										

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10413		Siltstone	100	68	83	2	3, 0, 70, 90, 0, 12, 2, 7	1.9 – 19.4	Bedding Joints & Vertical Fractures	Tight	None	3x1x0.75 to 4x4x7.5
10414						2	0, 2, 0, 40, 10, 5		Bedding Joint & Vertical Fractures			
10415						1	5, 0		Bedding Joint			
10416						1	4, 5, 6		Bedding Joint			4x4x1.25 to 4x4x5.7
10417						1	10, 5, 3, 0		Bedding Joint			
10418 10419						1	2, 11		Bedding Joint			

Well #12072 fracture sketch

Page: 1 of 4

BOX : 10388 - 10398 (in feet) (no.of slots : N/A)



Box label

Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 12072

Operator : Meridian Oil

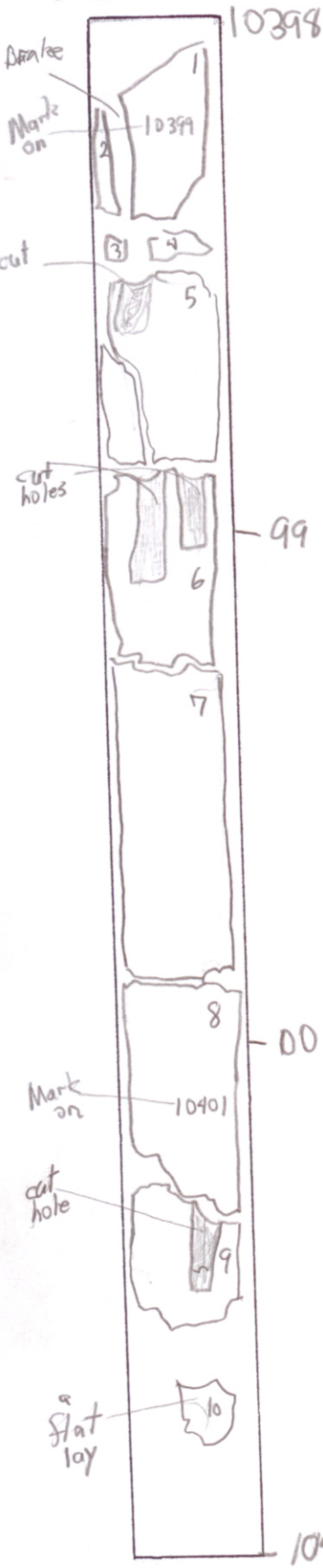
API no. : 3300701109000 0

Scale (ratio) : length width 9"/3ft 0.33"/4"

Core diameter : 4"

Page: 2 of 4

BOX : 10398 - 10407 (in feet) (no.of slots : N/A)



10401	10403	10405
Pieces layed in aluminum foil wrap (3 of them)	Pieces layed in aluminum foil wrap (3 of them)	Pieces layed in box
Description	Description	Description
They are disk cuts broken into weldges.	They are disk cuts broken into weldges.	They are disk cuts broken into semi cut and weldges
Multiple smaller chips and fragements	Multiple smaller chips and fragments	Multiple smaller chips and fragments
approx 150 pieces	approx 100 pieces.	approx 125 pieces
space	space	

99 00 02 03 04 05 06 07

10407

Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 12072

API no. : 3300701109000 0

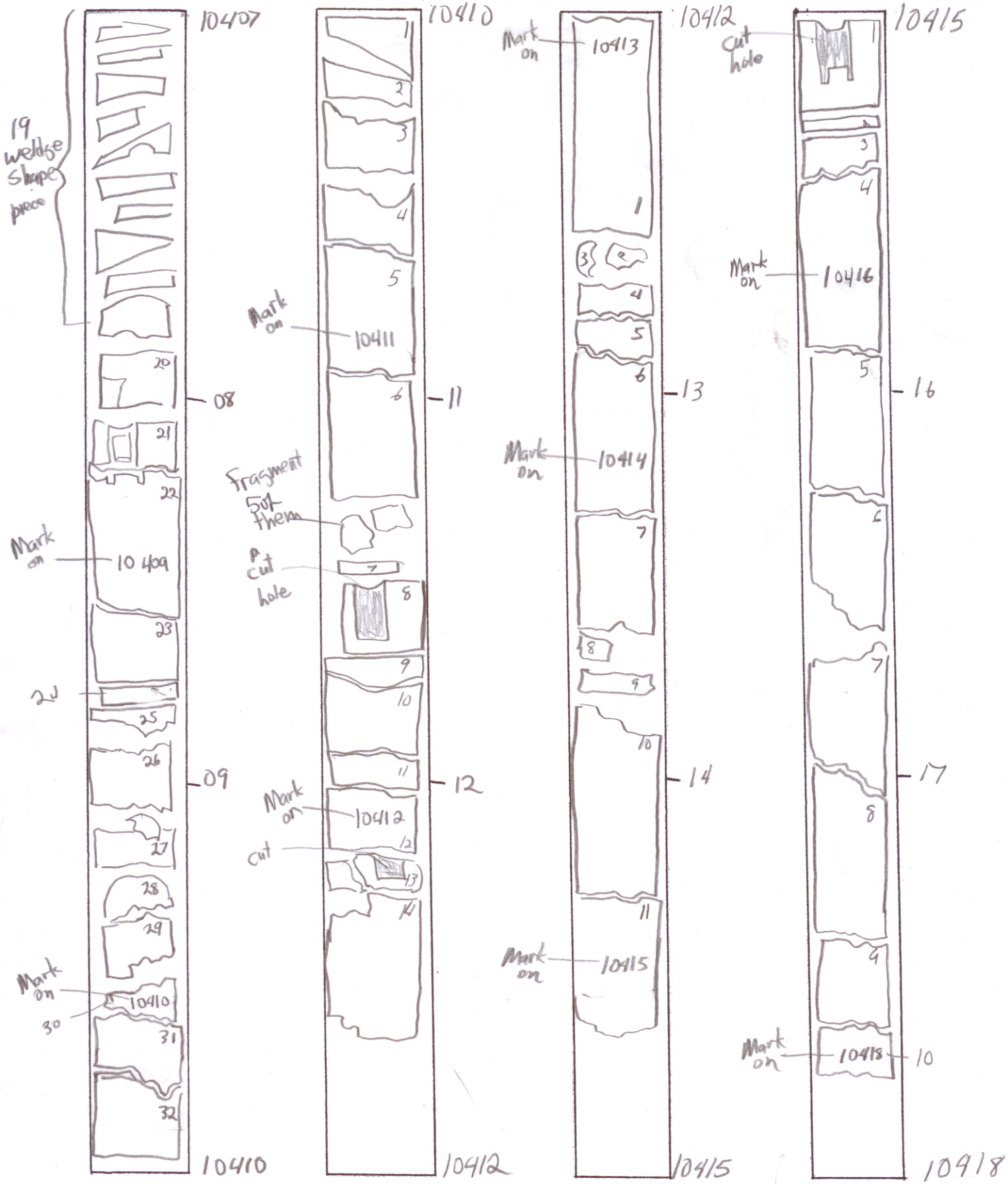
Operator : Meridian Oil

Scale (ratio) : length wide 9"/3ft 0.33"/4"

Core diameter : 4"

Page: 3 of 4

BOX : 10407 - _____ (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 12072

Operator : Meridian Oil

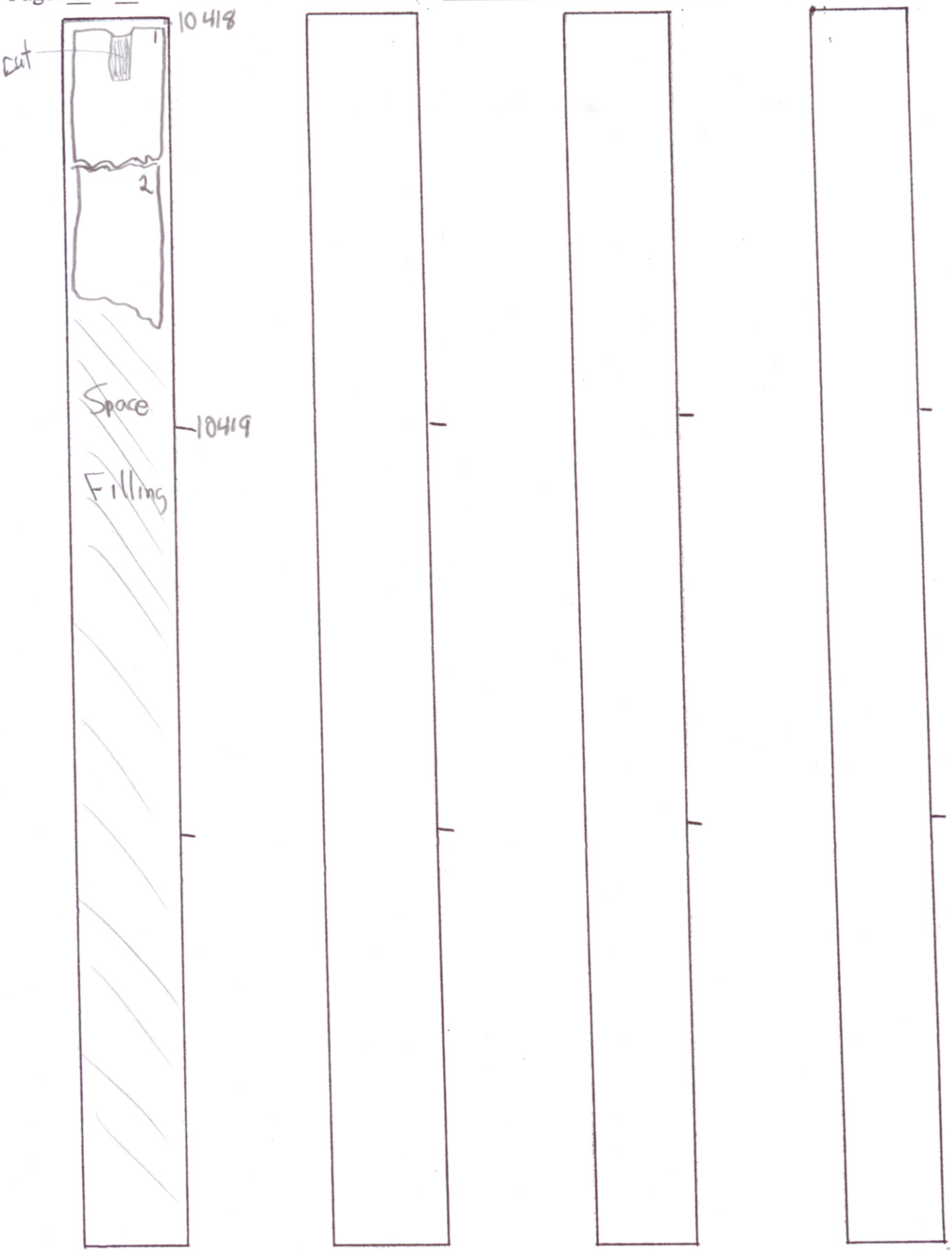
API no. : 33007 011 090000

Scale (ratio) : length 9"/35ft width 0.33"/4"

Core diameter : 4"

Page: 4 of 4

BOX : 10418 - 10419 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 12072

Operator : Meridian Oil

API no. : 3300701109000

Scale (ratio) : length width

9"/3ft 0.33"/4"

Core diameter : 4"

Well #12160 Core survey

Bakken Geomech. Core description File # : 12160 Well API: 33053021880000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10754		Limestone	100	31	74	1	35,5,3,5, 0,2	Bedding joints	1.8-24.1	0.01	None	4x4x0.5 To 4x4x3.8
55							2,3,0,2,6, 2,7			0.02		
56							2,4,2,6,3			0.01		
57							4,3,2,1			0.01		4x4x1 To 4x4x9.5
58							4,6,2			tight		
59							9,6			tight		

Bakken Geomech. Core description File # : 12160 Well API: 33053021880000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10760		Limestone	85	90	100	1	10,5,2	Bedding joints	7.6-27.2	0.01	None	4x4x4.25 To 4x4x10.7
61							15,3,6			tight		
62							7					
63							8,3					4x4x3 To 4x4x5.75
64							6,14					
65												

Bakken Geomech. Core description File # : 12160 Well API: 33053021880000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10765		Limestone	90	35	62	1	6,2	Bedding joints	0.6-17.8	tight	None	4x4x2.5 To 4x4x7
66						1	3,4,0,2					
67		Black Shale with High CARBON content				2	2,4,1,2, 90,3,1,4, 4	Bedding joints & Vertical Fractures		0.02		
68						2	7,0,1,3, 46,3,11,2, 0,0,4,40			Tight		2.1x3x0.4 To 4x4x2.9
69						1	11,4,4,0, 2,2,4,4,	Bedding joints		0.01		
70												

Name: *Smith & Naga* 3/5 Date: July, 7 , 2008

Bakken Geomech. Core description File # : 12160 Well API: 33053021880000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10770		Siltstone	83	69	93	1	2,3	Bedding joints	3.81-20.8	Tight	None	4x4x1.5 To 4x4x5.6
71							0,10			Tight		
72							3,7			0.02		
73							8,36,6			Tight		4x4x2.1 To 4x4x8.2
74							5,0,20			0.02		
75							3,19			0.01		

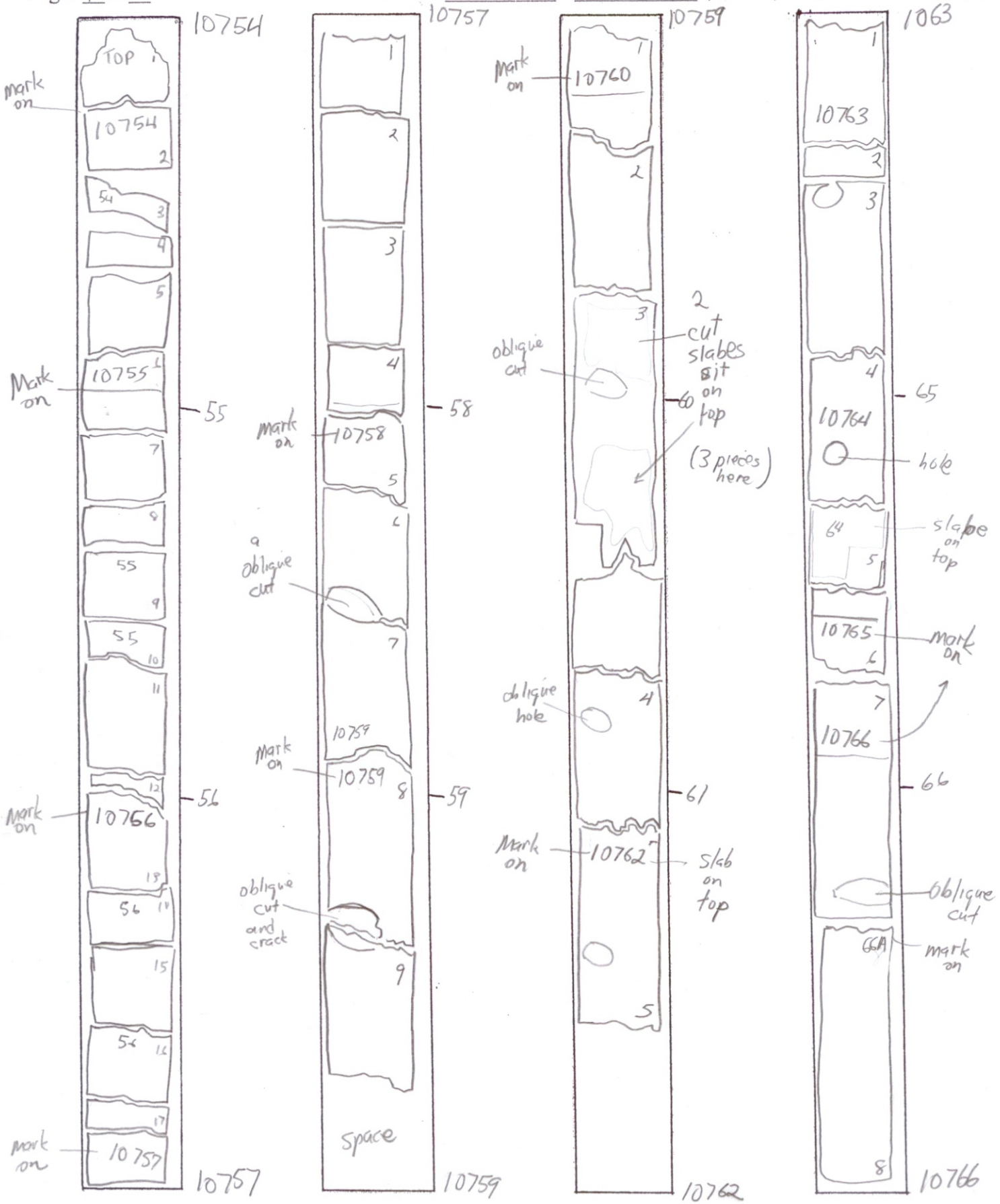
Name: *Smith & Naga* 4/5 Date: July, 7 , 2008

Bakken Geomech. Core description File # : 12160 Well API: 33053021880000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10776		Siltstone With Illite	98	33	91	1	0,10,0,2	Bedding joints	1.8-14	0.01	None	2x3.5x0.5 To 4x4x3.6
77						1	7,2,0,1			0.04		
78						2	2,0,56,3, 1,3	Bedding joints & Vertical Fractures		0.02		
79						1	4,2,7,10	Bedding joints		0.04		4x4x0.7 To 4x4x5.5
80						1	5,5			Tight		
81						1	6,9,1			0.02		

Well #12160 fracture sketch

Page: 1 of 3 BOX : 10754 - 10766 (in feet) (no.of slots : N/A)

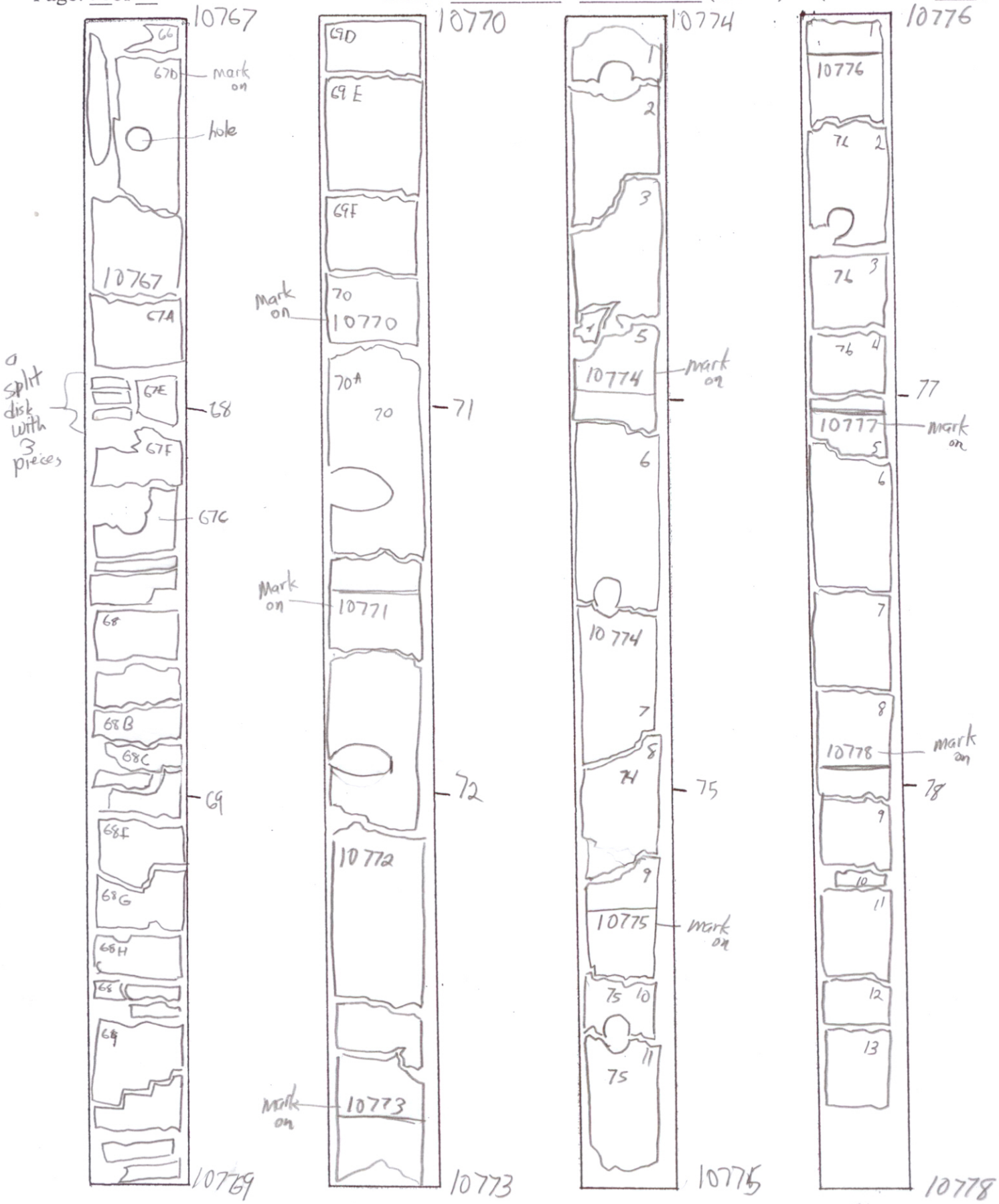


Project name : BAKKEN GEOMECHANICS File no. : 12160 Operator : St Mary

Drawing by : Jill Holwerda API no. : 33053021880000

Date : 7-7-08 Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

Page: 2 of 3 BOX : 10767 - 10778 (in feet) (no.of slots : N/A)

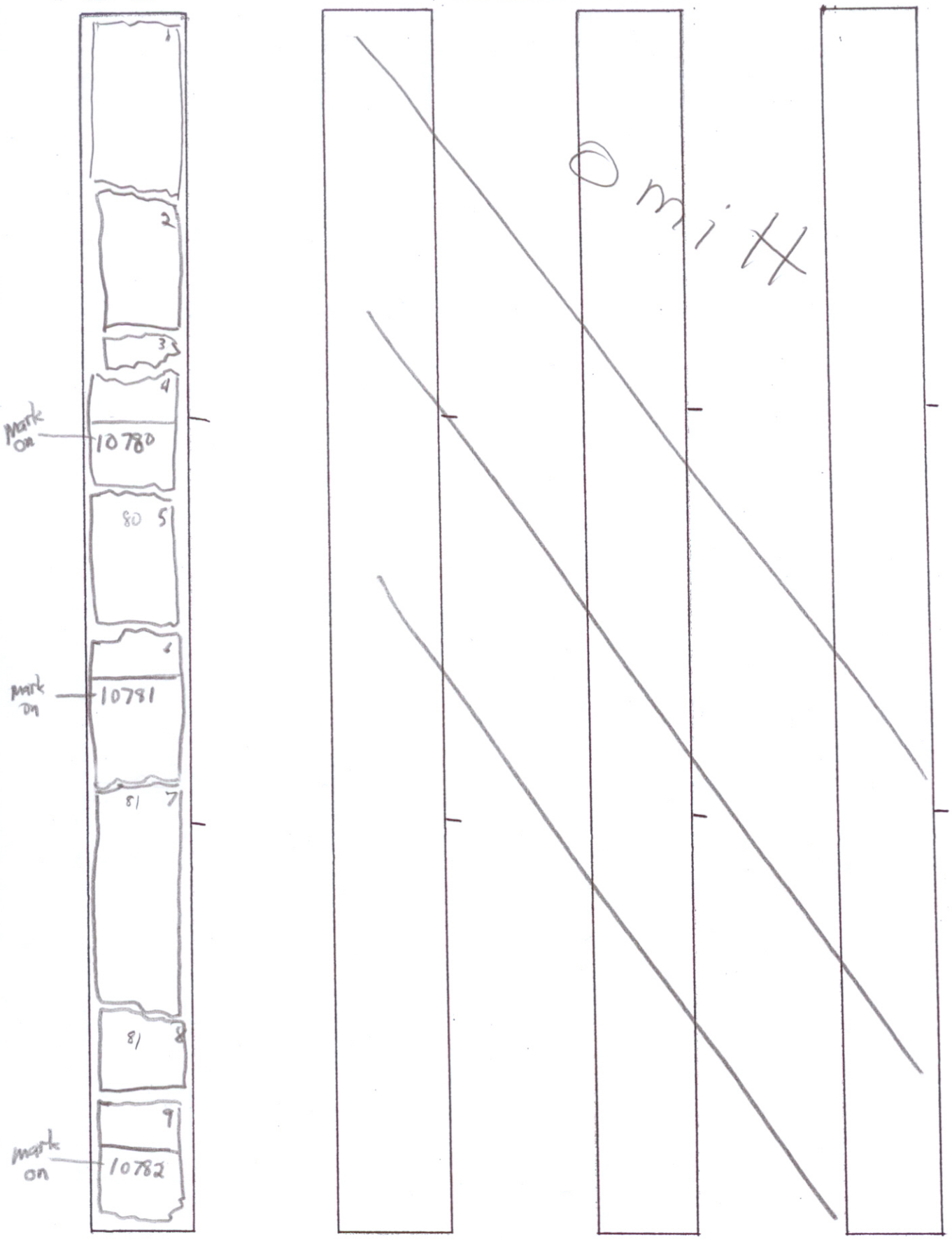


Project name : BAKKEN GEOMECHANICS File no. : 12160 Operator : St Mary

Drawing by : Jill Holwerda API no. : 33053021880000

Date : 7-7-08 Scale (ratio) : length 9"/37 width 0.33"/4" Core diameter : 4"

BOX : 10779 - 10782 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 12160 Operator : St Mary
API no. : 33053021880000
Scale (ratio) : length 9"/37 width 0.33"/4" Core diameter : 4"

Well #12331 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10209		Limestone	99	48	80	1	1, 0, 0	1 -18.8	Bedding Joints	Tight	None	3.5x3.5x0.4 to 3.5x3.5x6.75
10210						1	3, 3, 6		Bedding Joints	0.01		
10211						1	2, 2, 3, 7, 2, 1, 4		Bedding Joints	Tight		
10212						1	2, 2, 4, 0		Bedding Joints	Tight		3.5x3.5x1.3 to 3.5x3.5x7.4
10213						1	3, 10, 15		Bedding Joints	Tight		
10214						1	5, 4, 10		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10215		Limestone	98	911	96	1	10, 17	6.9 – 27.2	Bedding Joints	Tight	None	3.5x3.5x2.7 to 3.5x3.5x5.8
10216						1	6, 10, 9		Bedding Joints	Tight		
10217						1	2, 16		Bedding Joints	Tight		3.5x3.5x5.7 to 3.5x3.5x10.8
10218						2	10, 80		Bedding Joints & Vertical Fractures	Tight		
10219						1	8		Bedding Joints	Tight		
10220												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10220		Limestone	97	30	80	1	3, 6	1.27 – 33.0	Bedding Joints	Tight	None	2.5x3.5x0.8 to 3.5x3.5x13
10221		Black Shale High Carbon Content				2	0, 2, 2, 4, 0, 2, 85		Bedding Joints & Vertical Fractures	Tight		
10222						1	4, 2, 2, 0		Bedding Joints	0.01		
10223						1	2, 1, 5, 0, 0		Bedding Joints	Tight		3.5x3.5x0.5 to 3.5x3.5x3.3
10224						1	1, 0, 4, 1, 0		Bedding Joints	Tight		
10225						1	3, 0, 11, 11, 1, 4, 2		Bedding Joints	Tight		

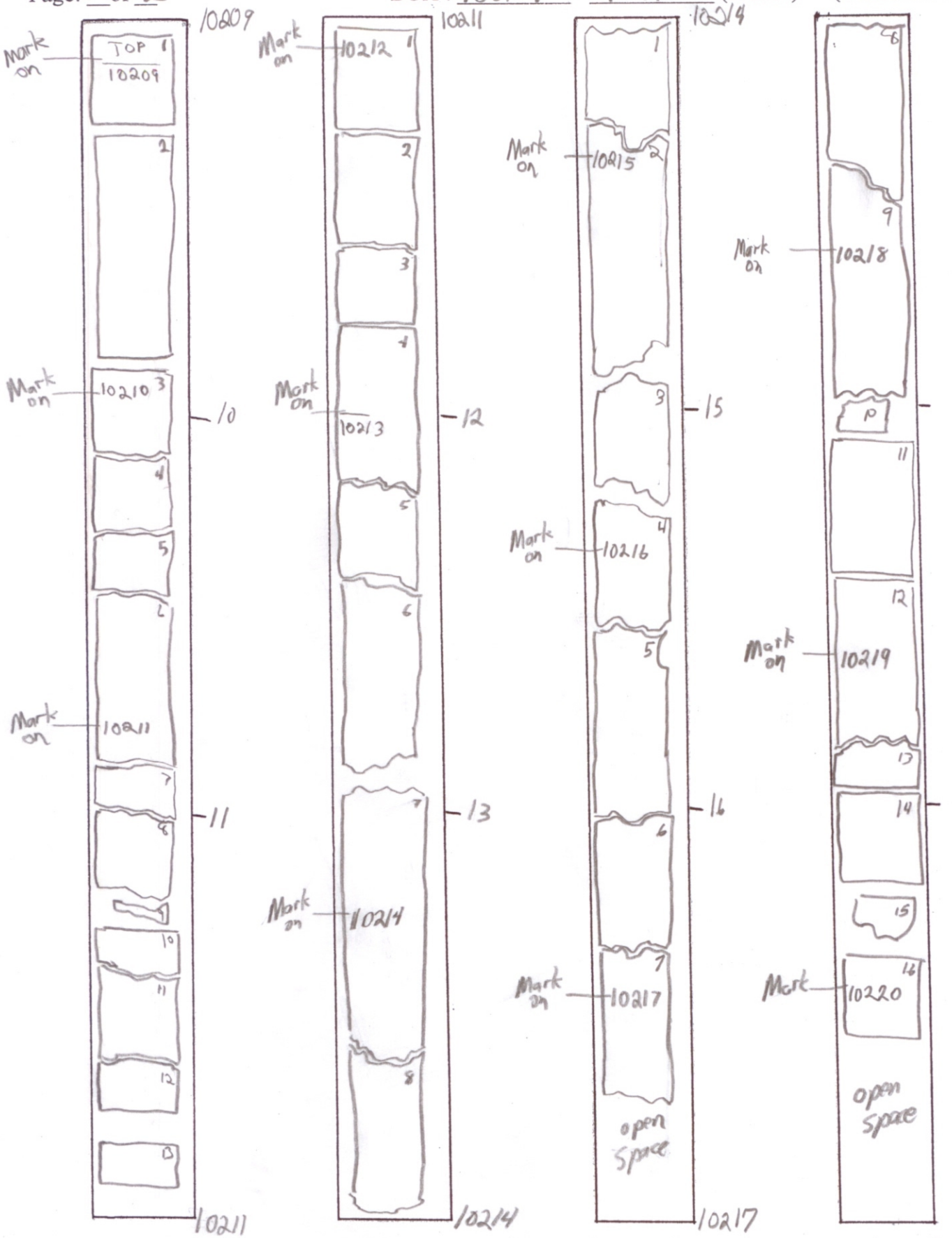
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10226		Siltstone	89	66	79	1	9, 1, 0, 3	3.1 – 20.8	Bedding Joints	0.02	None	3.5x3.5x1.2 to 3.5x3.5x7.2
10227						1	2, 0		Bedding Joints	0.02		
10228						1	6		Bedding Joints	0.04		
10229						1	8, 5		Bedding Joints	0.04		3.5x3.5x1.8 to 3.5x3.5x8.2
10230						1	3, 8		Bedding Joints	0.02		
10231						1	4, 2, 4, 6, 8		Bedding Joints	0.04		

Bakken Geomech. Core description File #:12331 Well API: 33007011400000 Operator: Whiting

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10232		Siltstone	100	40	85	1	6, 2, 6, 9	3.2–12.2	Bedding Joints	0.04	None	3.5x3.5x1.25 to 3.5x3.5x4.8
10233												

Well #12331 fracture sketch

Page: 1 of 2 BOX : 10209 - 10211 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS File no. : 12331 Operator : Whiting Oil & Gas

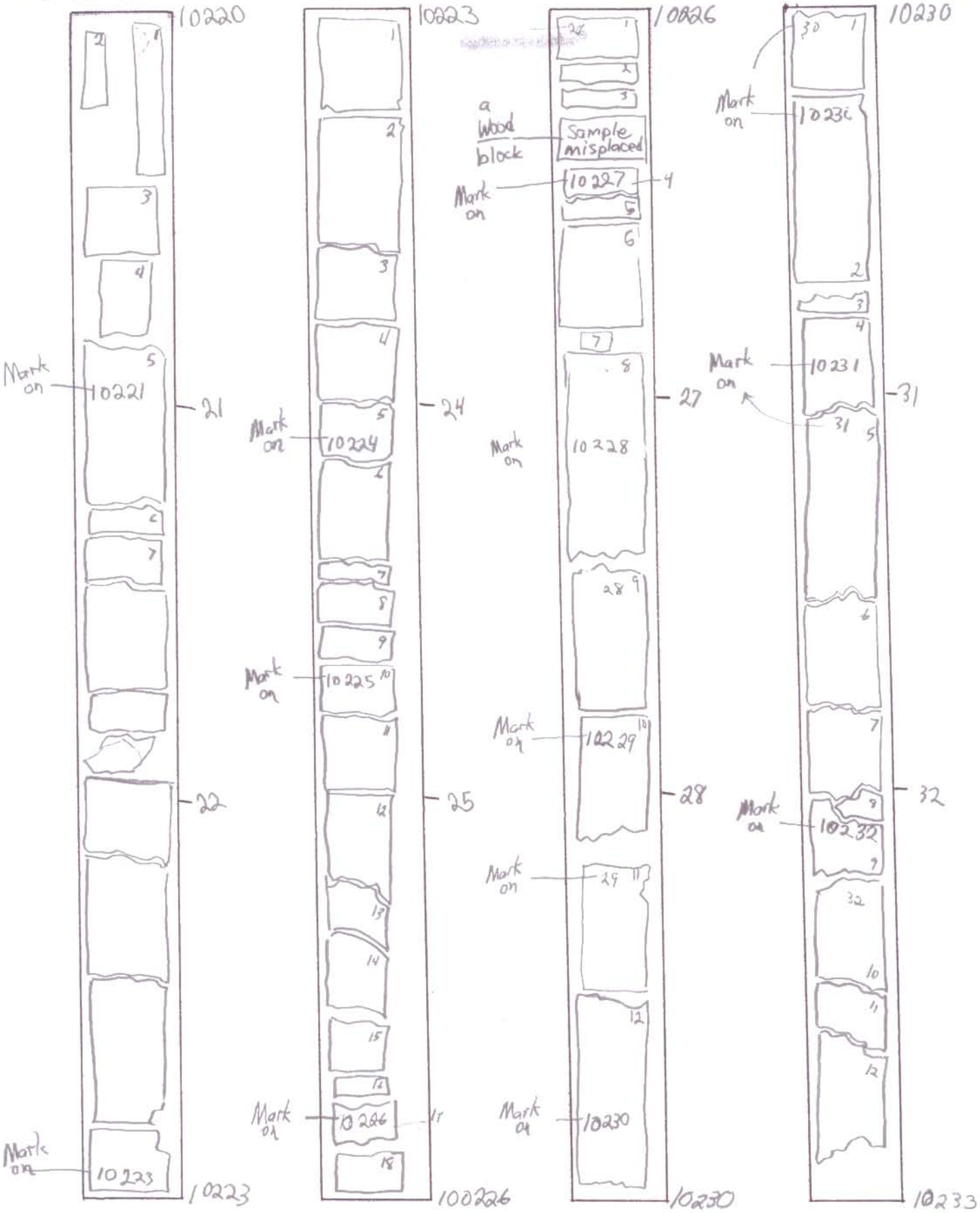
Drawing by : Jill Holwerda API no. : 33007011400000

Date : 7-3-08 Scale (ratio) : length width Core diameter : 3.0"

9" /3ft .033"/3.0"

Page: 2 of 2

BOX : 10220 - 10233 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-3-08

File no. : 12331 Operator : Whiling Oil + Gas
API no. : 33007011400000
Scale (ratio) : length width 9"/35ft .039"/3.0" Core diameter : 3"

Well #14974 Core survey

Bakken Geomech. Core description File # : 14974 Well API: 33053025350000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10978		Siltstone	100	88	98	1	15,5,1,4,	Bedding joints	8.4-29.8	Tight	None	2x2x3.3 To 2x2x11.75
80						1	0,9,5,0					
82						2	2,80,5,3	Bedding joints & Vertical Fractures				
84						1	3,14,2	Bedding joints				
86						1	4,0					
87												

Bakken Geomech. Core description File # : 14974 Well API: 33053025350000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10987		Siltstone	100	93	99	1	10,2,6,10, 10,12,4	Bedding joints	7.6-21.9	tight	None	2x2x3 To 2x2x8.6
89							6,5,8,9					
91							10,3,7,4					
93							0,0,11,4, 4					
95							6,6,8					
96												

Bakken Geomech. Core description File # : 14974 Well API: 33053025350000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10996		Siltstone	100	84	94	1	10,4,8,5, 9,0,6	Bedding joints	2.54-18.3	tight	None	2x2x1 To 2x2x7.25
10998												
Core is MISSING												
11357		Siltstone	100	82	100	1	3,4	Bedding joints	6.6-23.9	tight	none	2x2x3.1 To 2x2x9.4
59						1	5,2,4,2, 12,0					

Bakken Geomech. Core description File # : 14974 Well API: 33053025350000 Operator: **St. Mary**

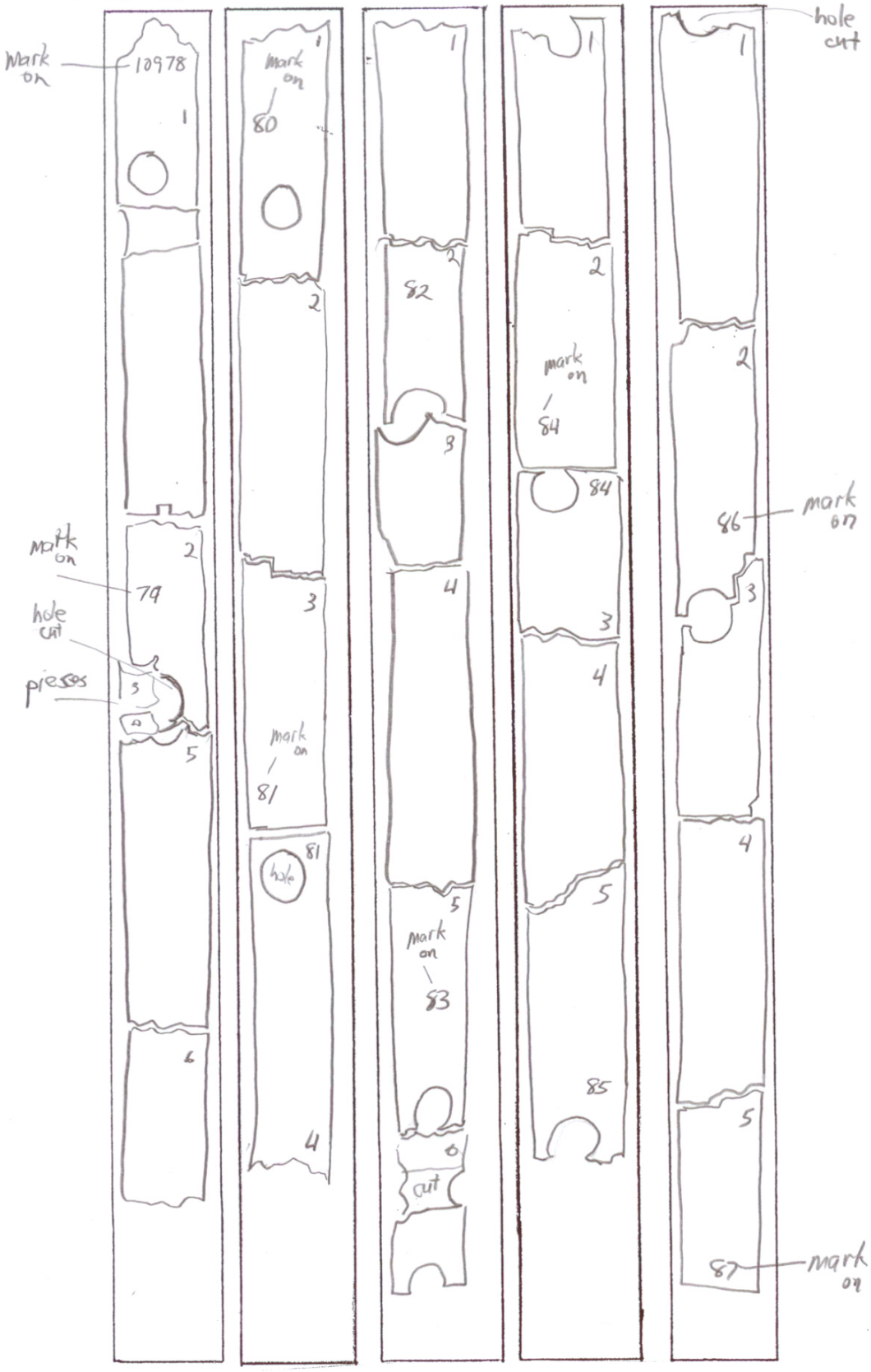
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11361		Siltstone	100	83	96	1	9, 6, 25, 10	Bedding joints	4.9 - 23.1	tight	None	2x2x1.9 To 2x2x9.1
11363						1	0, 9, 16, 7, 0	Bedding joints				
11365						1	7, 15, 7, 2	Bedding joints				
11367						2	14, 10, 6, 80, 3, 0	Bedding joints & Vertical Fractures				
11369						1	10, 4, 0	Bedding joints				
11370												

Bakken Geomech. Core description File # : 14974 Well API: 33053025350000 Operator: **St. Mary**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11370		Siltstone	82	86	100	1	26, 12, 6, 10, 10, 28	Bedding joints	6.1 -22.9	tight	None	2x2x2.4 To 2x2x9.0
11372						1	12, 4, 6, 7, 5	Bedding joints				
11374						1	3, 2	Bedding joints				
11376						1	10, 13, 37, 6	Bedding joints				
11378												

Well #14974 fracture sketch

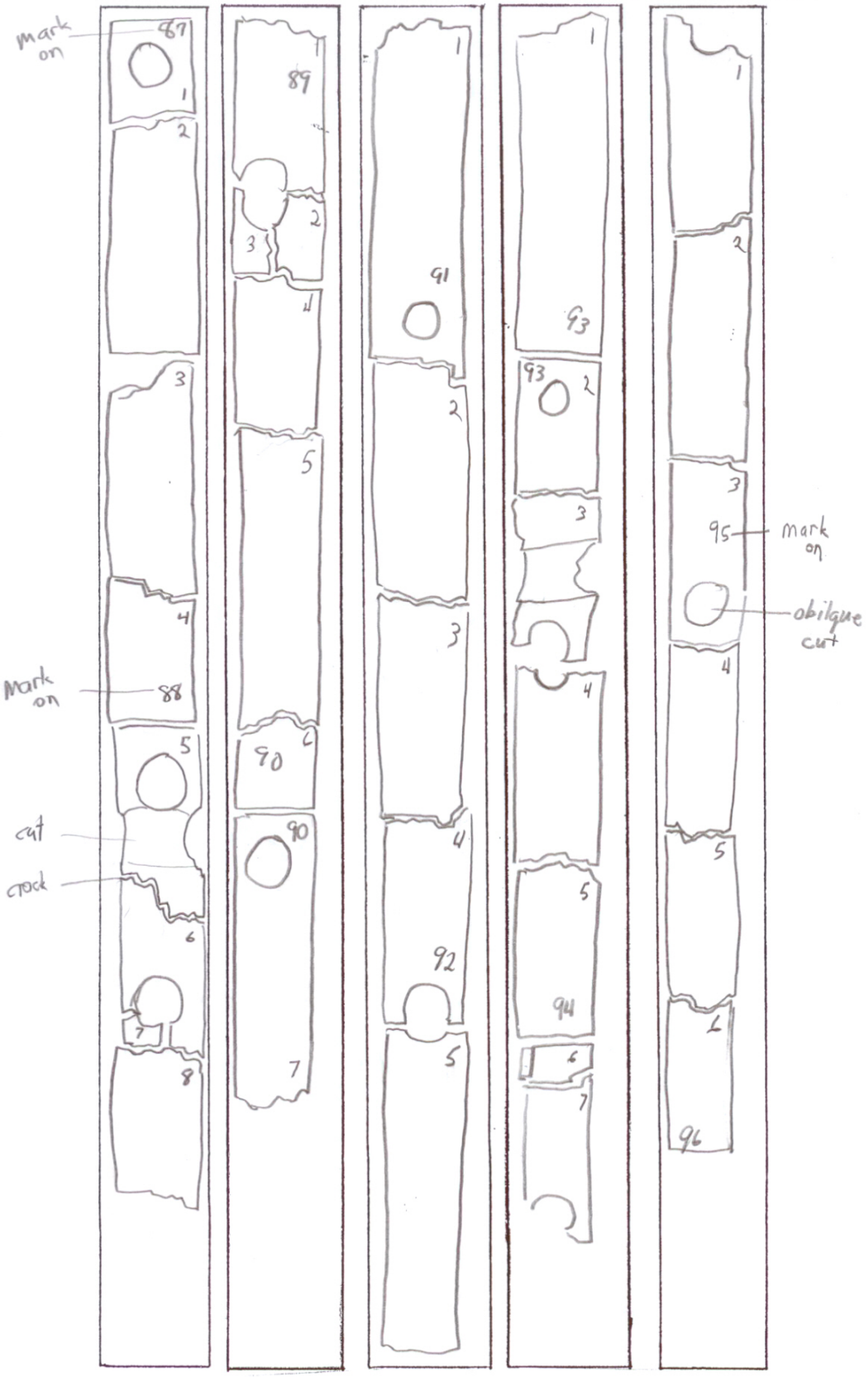
Page: 1 of 5 BOX : 10978 - 10987 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 14974 Operator : St. Mary
API no. : 33053025350000
Scale (ratio) : length 9"/3ft width 0.33"/2" Core diameter : 2"

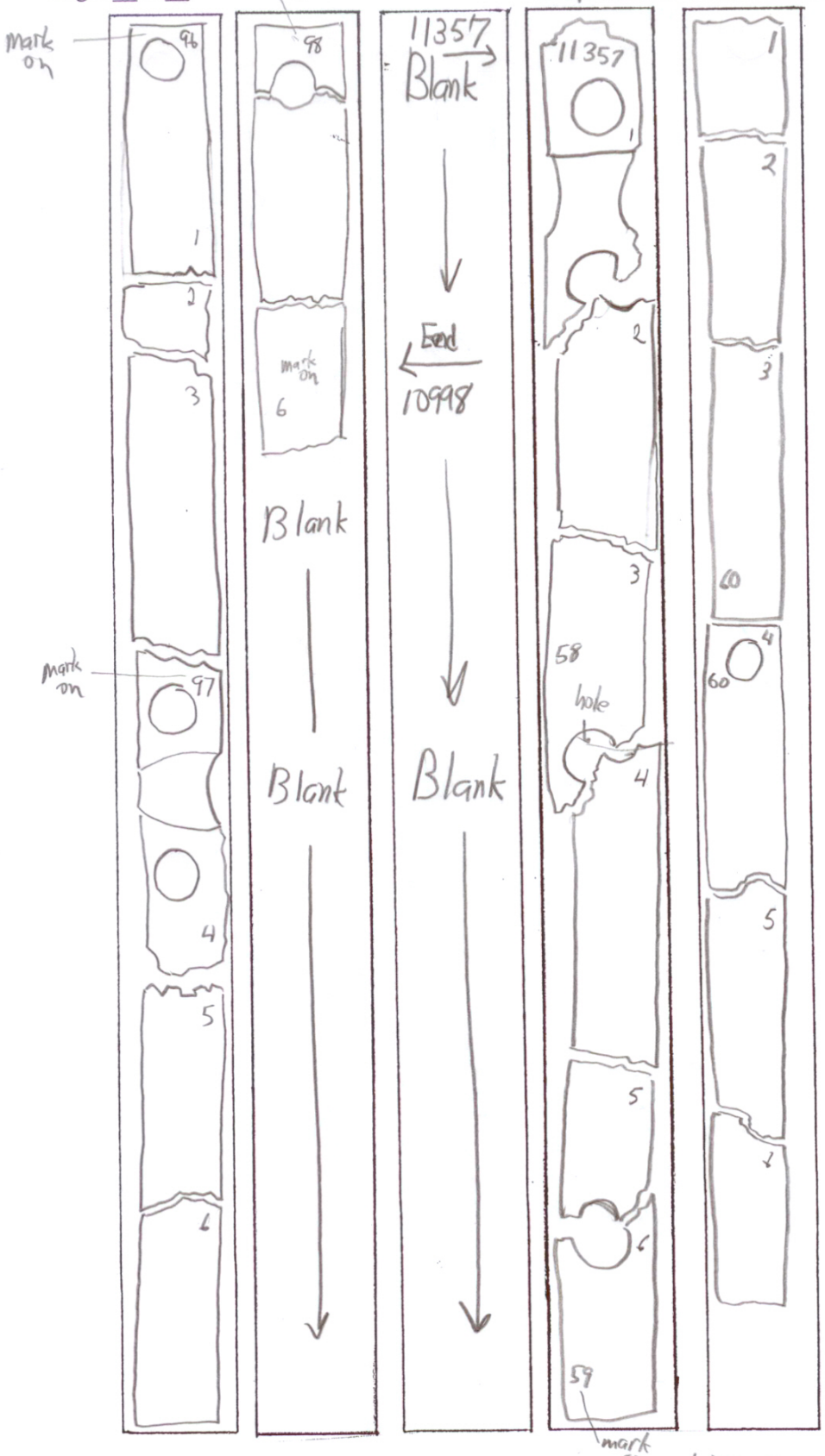
Page: 2 of 5 BOX : 10987 - 10996 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 14974 Operator : St. Mary
API no. : 33053025350000
Scale (ratio) : length width Core diameter : 2"
9"/3ft 0.33"/2"

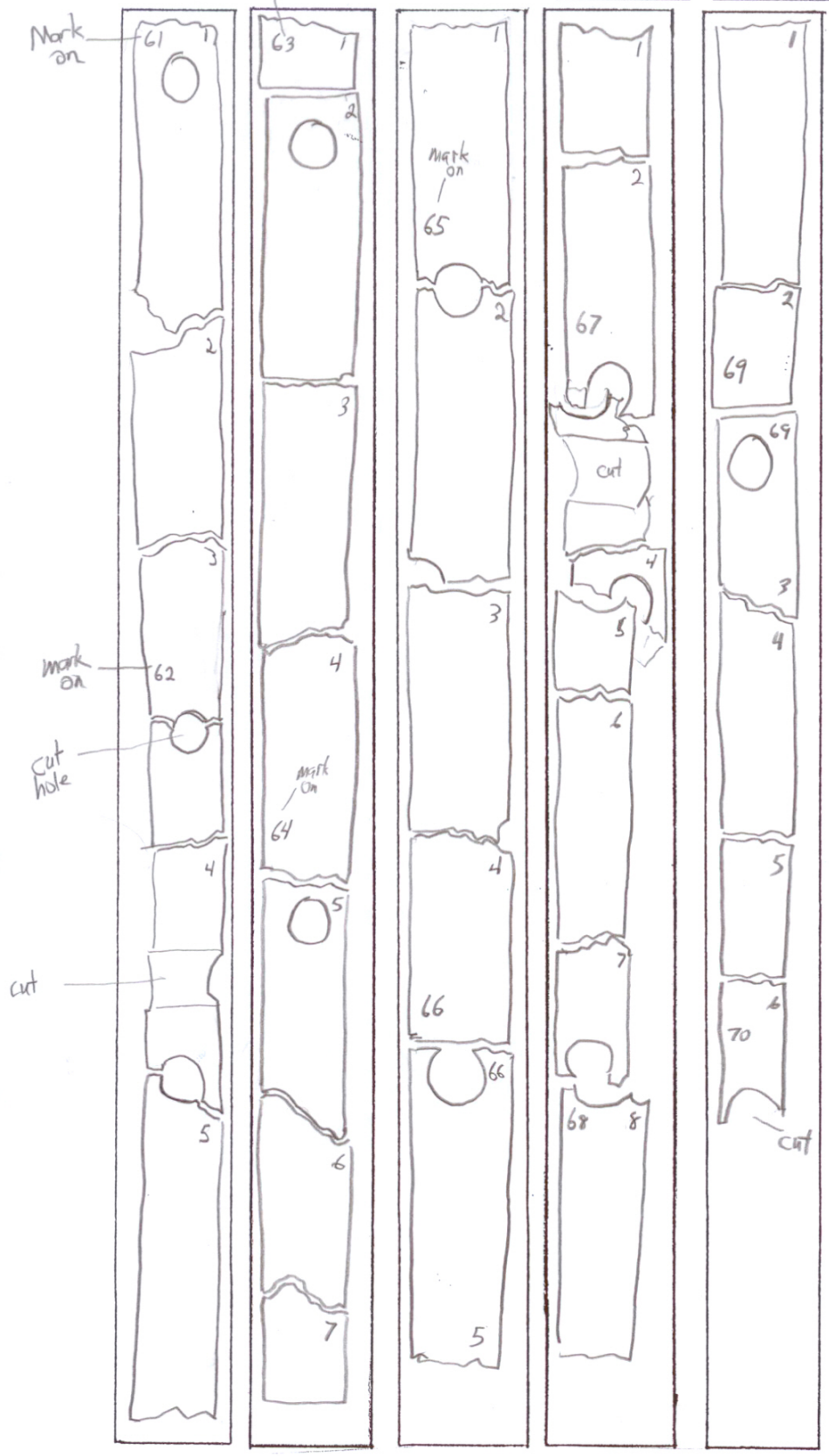
Page: 3 of 5 BOX : 10,996 - 11360 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 14974 Operator : St. Mary
API no. : 33053025350000
Scale (ratio) : length 9"/3ft width 0.33"/2" Core diameter : 2"

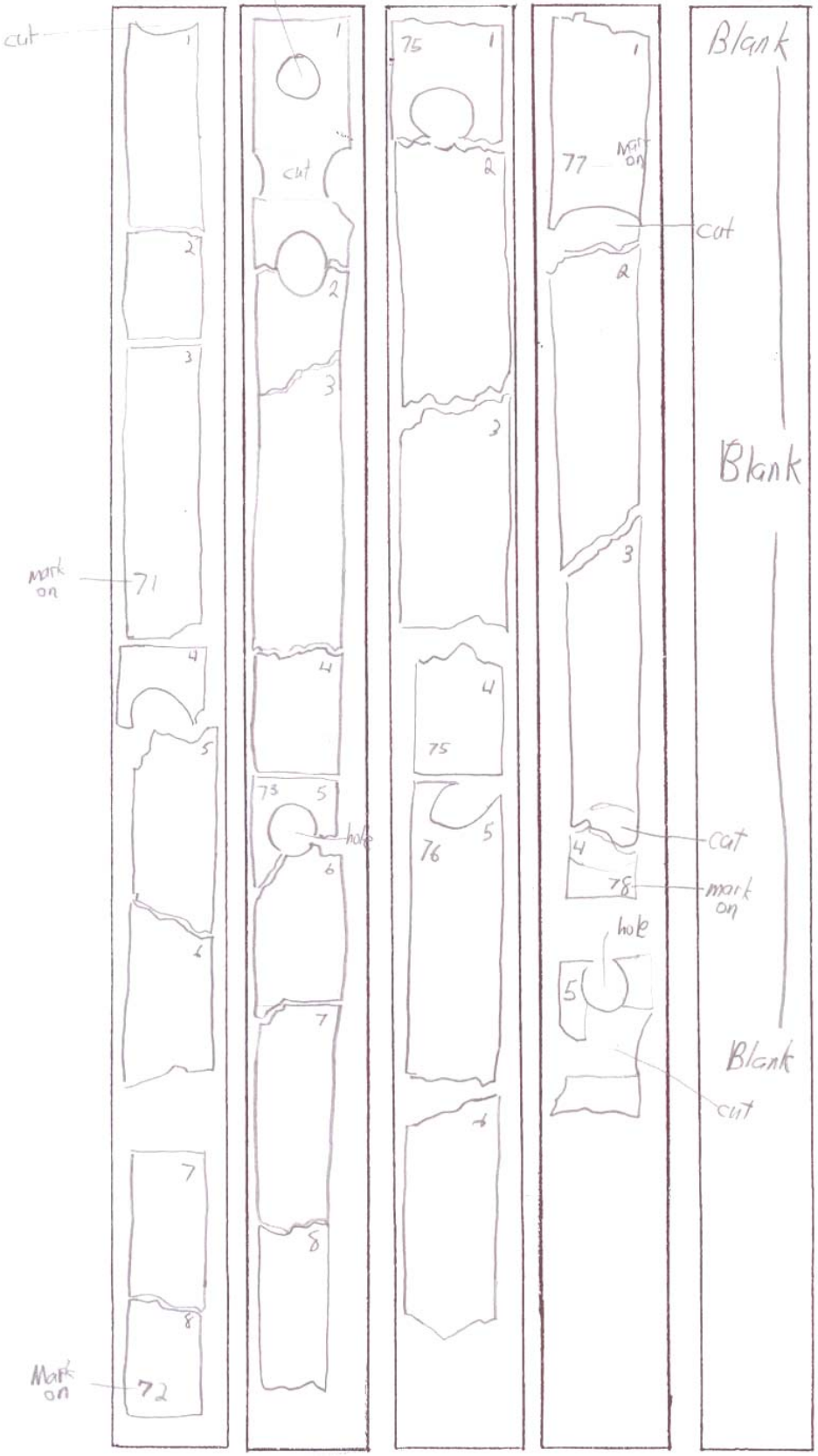
Page: 4 of 5 BOX : 11360 - 11370 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : _____

File no. : 14974 Operator : St. Mary
API no. : 3305302350000
Scale (ratio) : length 9"/3ft width 0.33"/2" Core diameter : 2"

Page: 5 of 5 BOX : 11370 - 11378 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 14974 Operator : St. Mary
API no. : 3205302535 0000
Scale (ratio) : length width Core diameter : 2"
9"/3ft 0.33"/2"
2x2

Well #15674 Core survey

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9720		Limestone	100	14	59	1	5, 15, 15, 3, 7, 21, 0, 3, 5, 4, 1, 3, 2, 20	Bedding Joints	0.5 – 10.7	0.01	None	4x4x0.2 To 4x4x4.2
9722						1	2, 10, 3, 1, 7, 2, 1, 2, 0, 7, 1, 10, 8, 5, 0	Bedding Joints		0.02		
9724						1	10, 6, 6, 0, 3, 5, 5, 2, 3	Bedding Joints		0.02		
9726						1	4, 5, 0, 0, 3, 14, 15, 16, 0, 5	Bedding Joints		0.04		
9728						1	7, 3, 10, 0, 3, 10, 15, 5, 4, 1, 2, 3, 11	Bedding Joints		0.02		

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9730		Limestone	100	20	65	1	15, 9, 8, 6, 3, 2, 5, 3, 13, 8, 8	Bedding Joints	0.77 – 17.8	0.02	None	4x4x0.3 To 4x4x7
9732						1	2, 0, 17, 35, 22, 0, 2, 4, 2, 0, 0, 2, 7	Bedding Joints		0.01		
9734						1	0, 4, 2, 10, 5, 5, 12, 5, 9	Bedding Joints		0.01		
9736						1	3, 6, 1, 12, 7, 15, 0, 15, 20, 9, 1, 5, 2, 12, 4	Bedding Joints		0.02		
9738						1	8, 9, 8, 5, 4, 2, 6, 2, 1	Bedding Joints		0.01		

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9740		Limestone	100	34	70	1	13, 18, 23, 4, 1, 10	Bedding Joints	0.76 – 17.2	0.01	None	1x3x0.4 To 4x4x6.75
9742						2	9, 0, 9, 14, 6, 6, 3, 11, 0, 18, 80	Bedding Joints & Vertical Fractures		0.03		
9744						1	7, 4, 9, 3, 5, 7, 8, 2, 6, 3, 3	Bedding Joints		0.04		
9746						1	8, 5, 13, 5, 10, 0, 15, 7, 5, 10, 14, 4	Bedding Joints		0.02		
9748						1	6, 0, 5, 6, 5	Bedding Joints		0.02		
		Black Shale				2	50, 2, 0, 4, 3, 2, 3, 2, 2, 90, 4, 5, 75	Bedding Joints & Vert. Frac.				

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9750		Black Shale High Carbon Content	100	12	22	1	2, 3, 10, 2, 3, 2, 3, 6, 2, 0, 4, 4, 2, 15, 2, 5, 5, 5, 0, 4, 3, 5, 10, 12, 14, 5, 15, 3	Bedding Joints	0.5 – 15.3	0.01	None	4x4x0.2 To 4x4x6
9752						1	6, 0, 5, 6, 7, 7, 2, 6, 2, 6, 7, 0, 1, 2, 0, 2, 0, 1, 2, 7, 4, 3, 9, 3, 3, 1, 5	Bedding Joints		0.01		
9754						1	3, 0, 0, 4, 1, 1, 2, 2, 1, 0, 2, 1, 0, 2, 7, 8, 0, 4, 2, 4, 0, 0, 0, 1, 4, 0, 4, 2, 3, 2	Bedding Joints		0.01		
9756						1	2, 1, 0, 2, 1, 3, 4, 0, 2, 3, 8, 4, 1, 8, 5, 0, 10, 7, 4, 7	Bedding Joints		0.01		
9758						1	13, 10, 2, 5, 2, 3, 3, 18, 14, 8, 5, 17, 3, 10, 0, 5, 10, 7	Bedding Joints		0.02		

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9760		Black Shale High Carbon Content	100	25	43	2	2, 6, 12, 4, 8, 12, 6, 4, 6, 12, 90, 12, 4, 15, 3, 5, 5, 8, 16, 2, 14, 4, 1, 1, 5, 7, 2	Bedding Joints & Vertical Fractures	0.25 – 21.3	0.01	None	0.6x3x0.5 To 4x4x8.4
9762						1	4, 2, 2, 7, 10, 4, 3, 8, 6, 7, 2, 4, 2, 19, 9, 15, 2, 6, 1, 3	Bedding Joints		0.02		
9764						1	3, 12, 2, 1, 3, 15, 4, 1, 6, 4, 2, 6, 4, 3, 4, 6, 6, 7, 12, 14	Bedding Joints		0.02		
9766		Siltstone				1	4, 2, 2, 5, 13, 3, 6, 3, 6, 6, 2, 3, 1	Bedding Joints		0.01		
9768						1	6, 14, 8, 7, 4, 3, 6	Bedding Joints		0.01		

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9770		Siltstone	96	59	76	1	22, 14, 16, 12, 14, 18, 4, 6, 16, 27, 16, 27, 32, 17, 21	Bedding Joints	0.1 – 20.3	0.01	None	0.3x0.3x0.3 To 4x4x8
9772						1	10, 16, 12, 19, 14, 21, 17, 18, 14, 16, 12, 23, 19	Bedding Joints		0.02		
9774						1	26, 19, 28, 24, 24, 27, 5, 4, 6	Bedding Joints		Tight		
9776						1	2, 19, 3, 2	Bedding Joints		Tight		
9778						Mult-iple	0, 1, 2, 85, 75, 85	Bed. Jts. & Mult. Vrt. Frc.		Tight		
						1	7, 20	Bedding Joints				

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9780		Siltstone	100	72	94	1	3, 2, 19, 27, 10, 7, 4	Bedding Joints	1 – 27.3	Tight	None	4x4x0.4 To 4x4x10.75
9782						1	7, 4, 2, 7, 3	Bedding Joints		Tight		
9784						1	6, 17, 13, 16, 21, 6	Bedding Joints		0.02		
9786						1	8, 14, 13, 2, 8	Bedding Joints		Tight		
9788						1	12, 6, 10, 10, 3, 6, 8	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9790		Siltstone	100	26	70	1	7, 9, 3, 11, 4, 6, 3, 2, 4, 1	Bedding Joints	0.25 - 13	0.02	None	4x4x0.1 To 4x4x5.1
9792						1	8, 2, 1, 4, 2, 2, 0, 1, 1, 0, 0, 1	Bedding Joints		0.02		
9794						1	4, 11, 3, 8, 6, 7, 8, 4, 2, 10, 4, 1	Bedding Joints		0.01		
9796						1	8, 11, 4, 13, 9,9 4, 4, 3, 5, 1, 2, 0, 2	Bedding Joints		0.02		
9798						1	1, 0, 4, 5, 2, 1, 4, 5, 5, 4, 6	Bedding Joints		0.02		

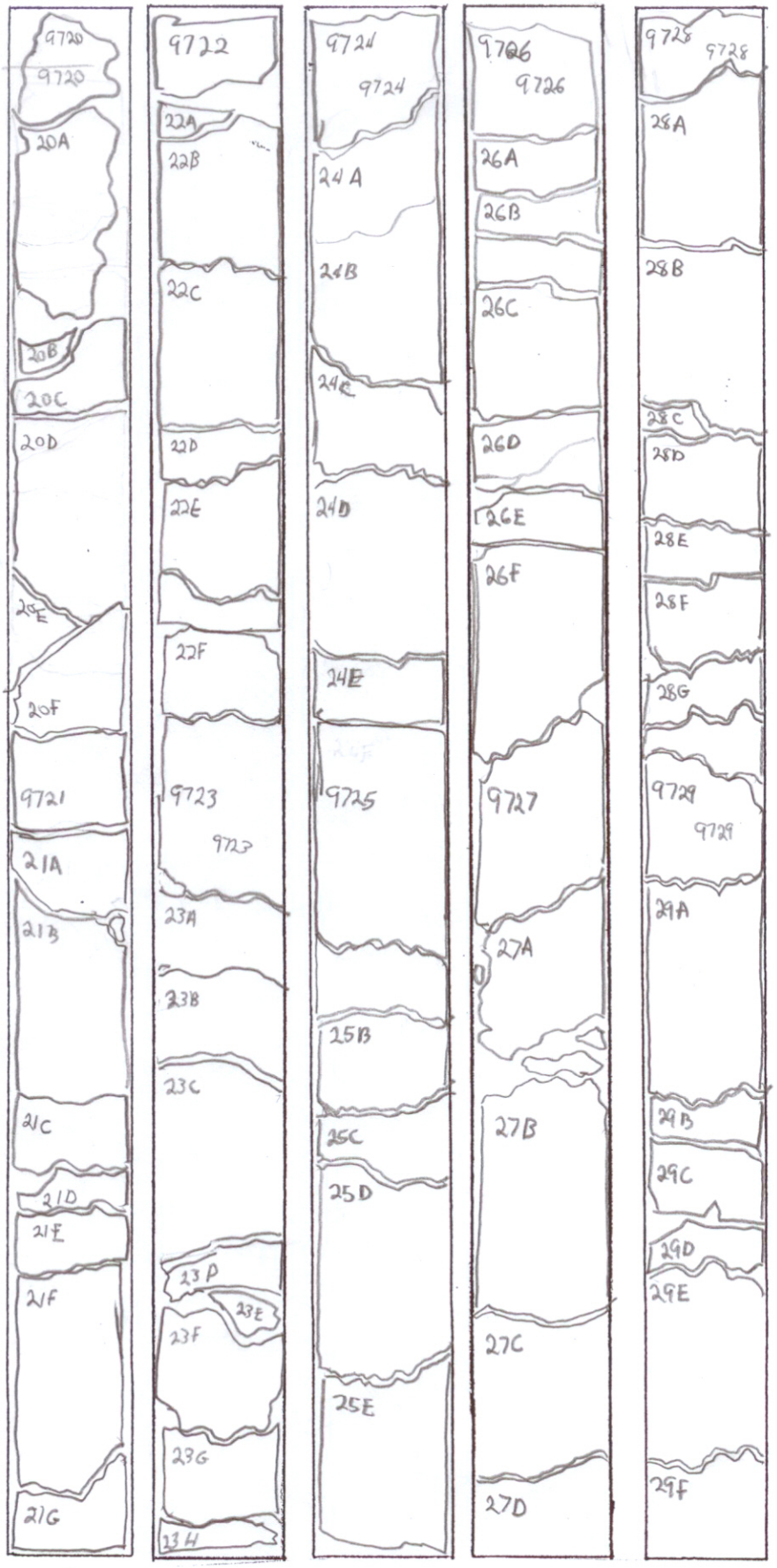
Bakken Geomech. Core description File # : 15674 Well API: 33105015270000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9800		Siltstone	100	87	100	1	6, 2, 6, 4, 2, 3	Bedding Joints	3.2 – 24.9	Tight	None	4x4x1.25 To 4x4x9.8
9802						1	0, 0, 5	Bedding Joints		Tight		
9804						1	1, 3, 1, 2	Bedding Joints		Tight		
9806						1	4, 0, 3, 7, 2	Bedding Joints		Tight		
9808						1	0, 6, 6, 2, 5	Bedding Joints		0.01		
9809												

Name: ***Smith & Naga*** 9/9 Date: July, 15 , 2008

Well #15674 fracture sketch

Page: 1 of 9 BOX : 9720 - 9730 (in feet) (no.of slots : 5)

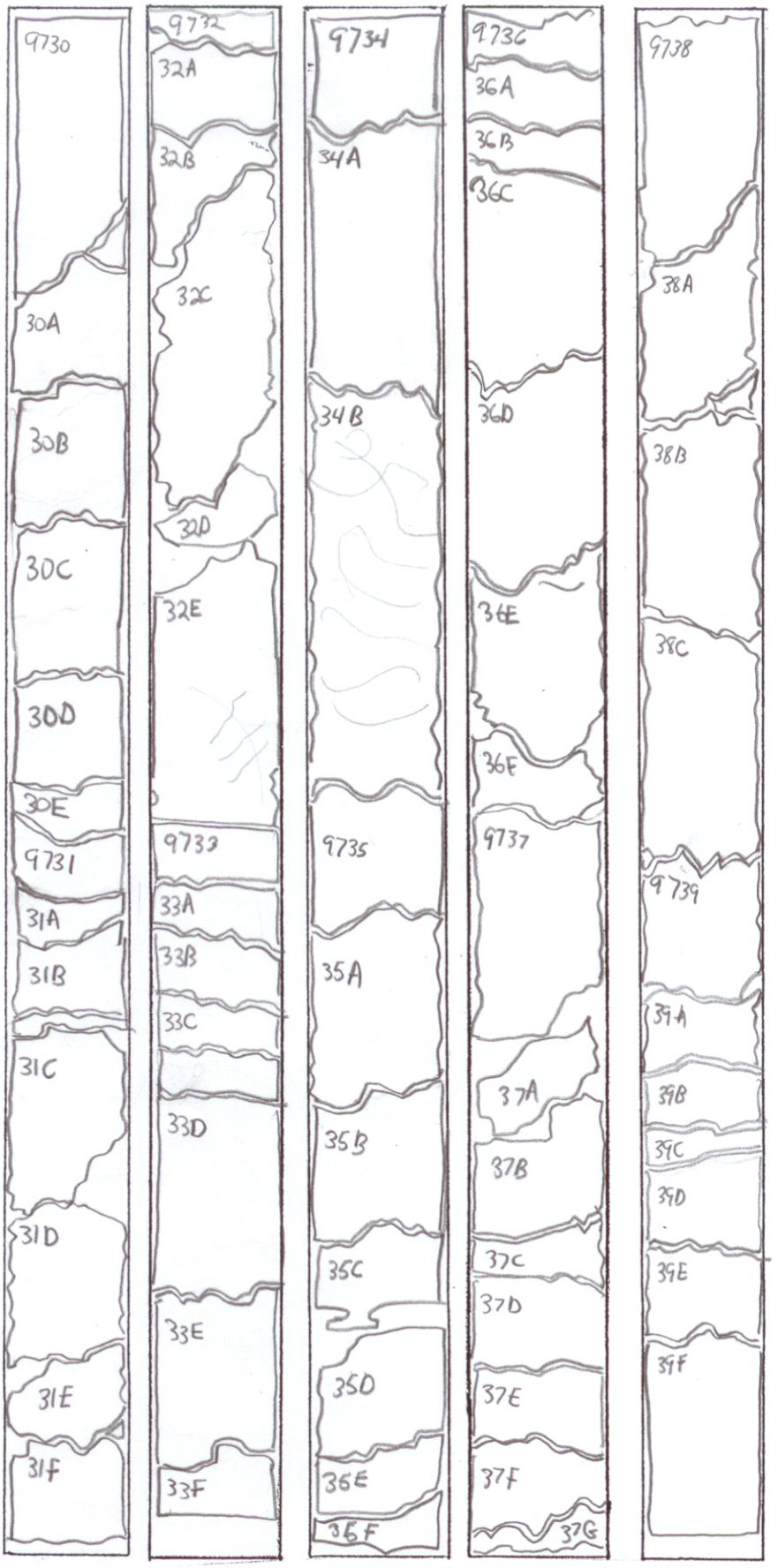


Project name : BAKKEN GEOMECHANICS File no. : 15674 Operator : Hess

Drawing by : Jill Holwerda API no. : 33105015270000

Date : 7-15-08 Scale (ratio) : N/A Core diameter : 4"

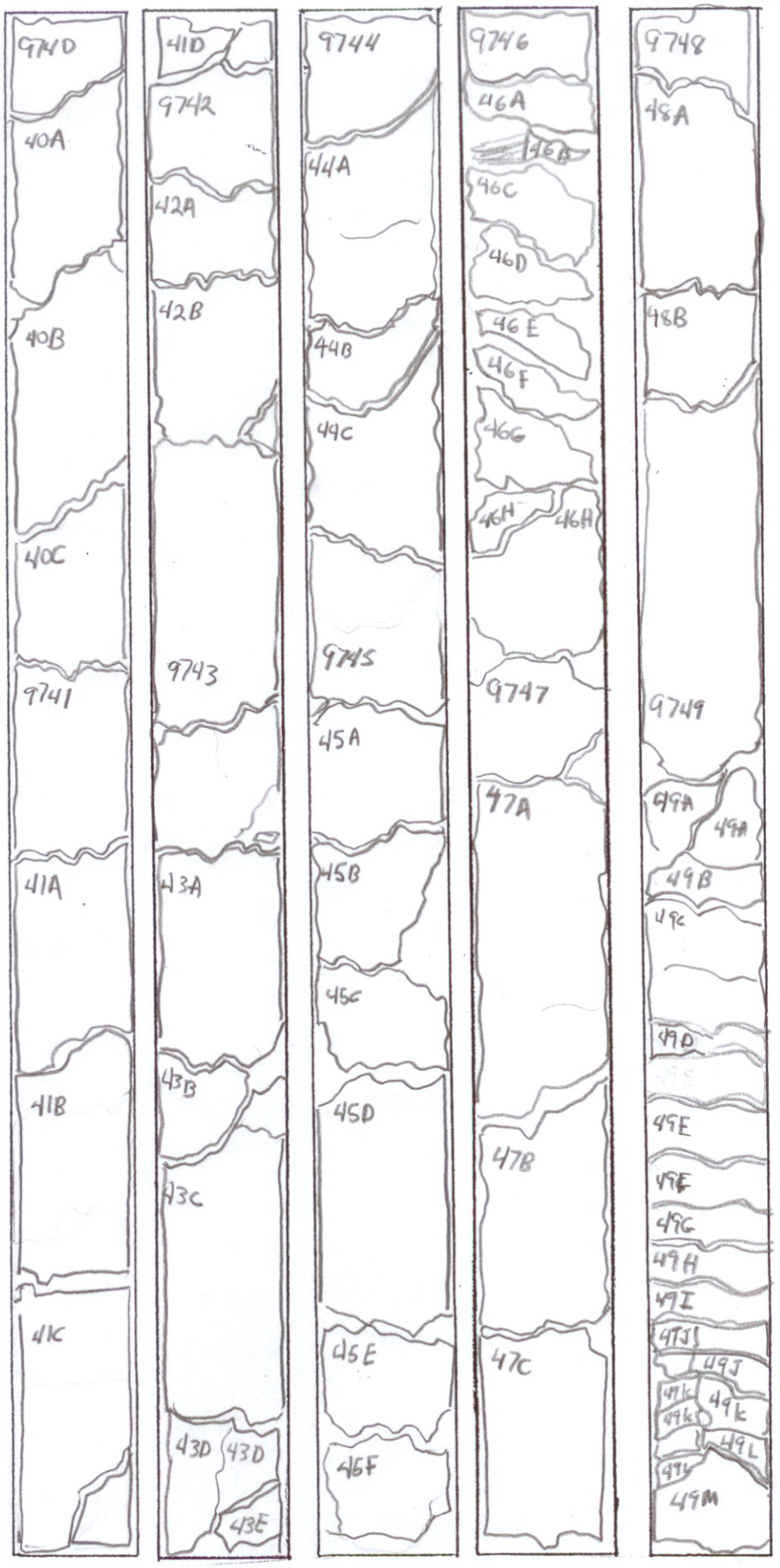
BOX : 9730 - 9740 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 15674 Operator : Hess
API no. : 33105015270000
Scale (ratio) : N/A Core diameter : 4"

Page: 3 of 9 BOX : 9740 - 9750 (in feet) (no.of slots : 5)

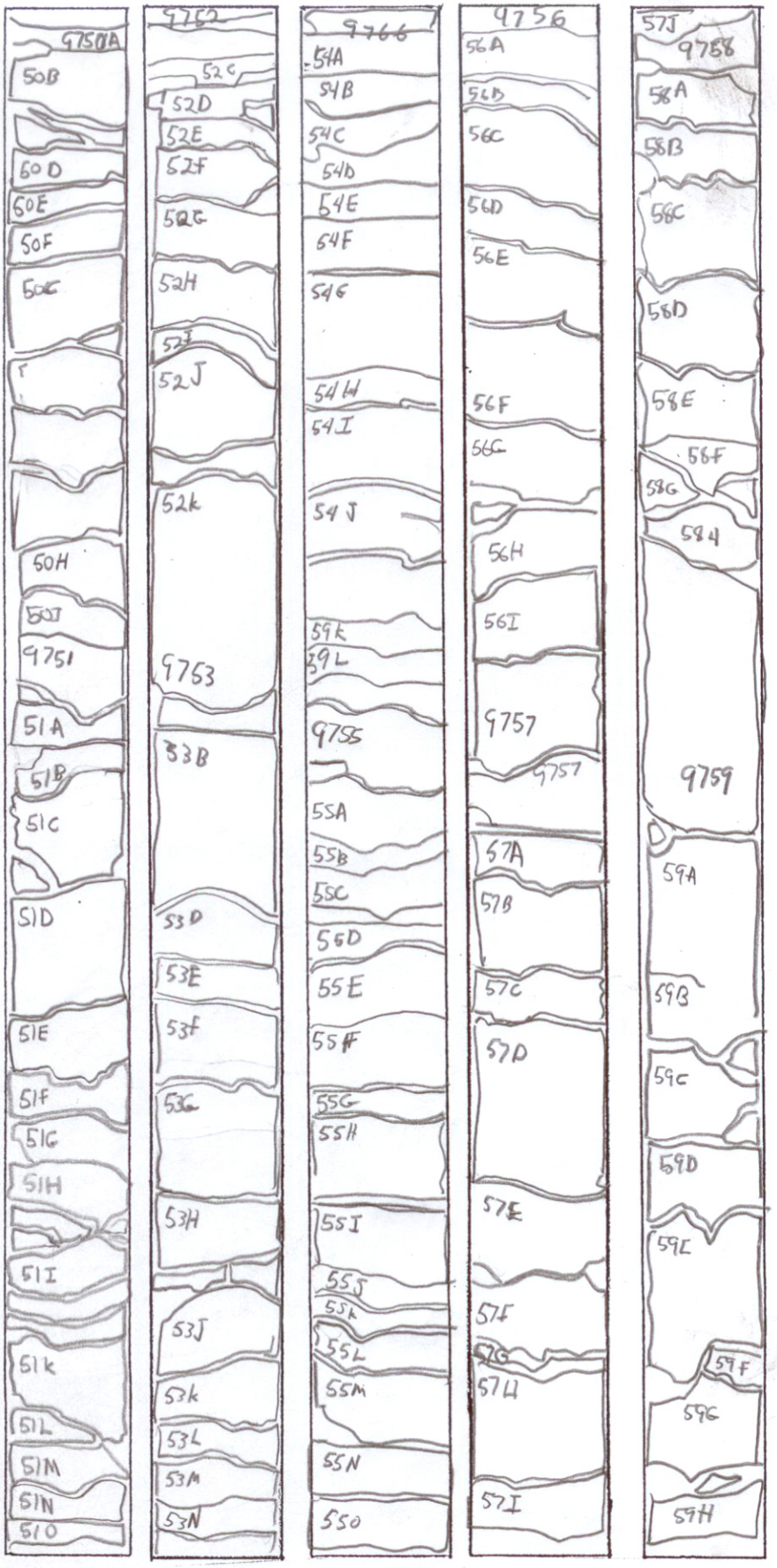


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 15674 Operator : Hess
API no. : 33105015270000
Scale (ratio) : N/A Core diameter : 4"

BOX : 9750 - 9760 (in feet) (no.of slots : 5)

A counting mistake



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-15-08

File no. : 15674

Operator : Hess

API no. : 33105015270000

Scale (ratio) : N/A

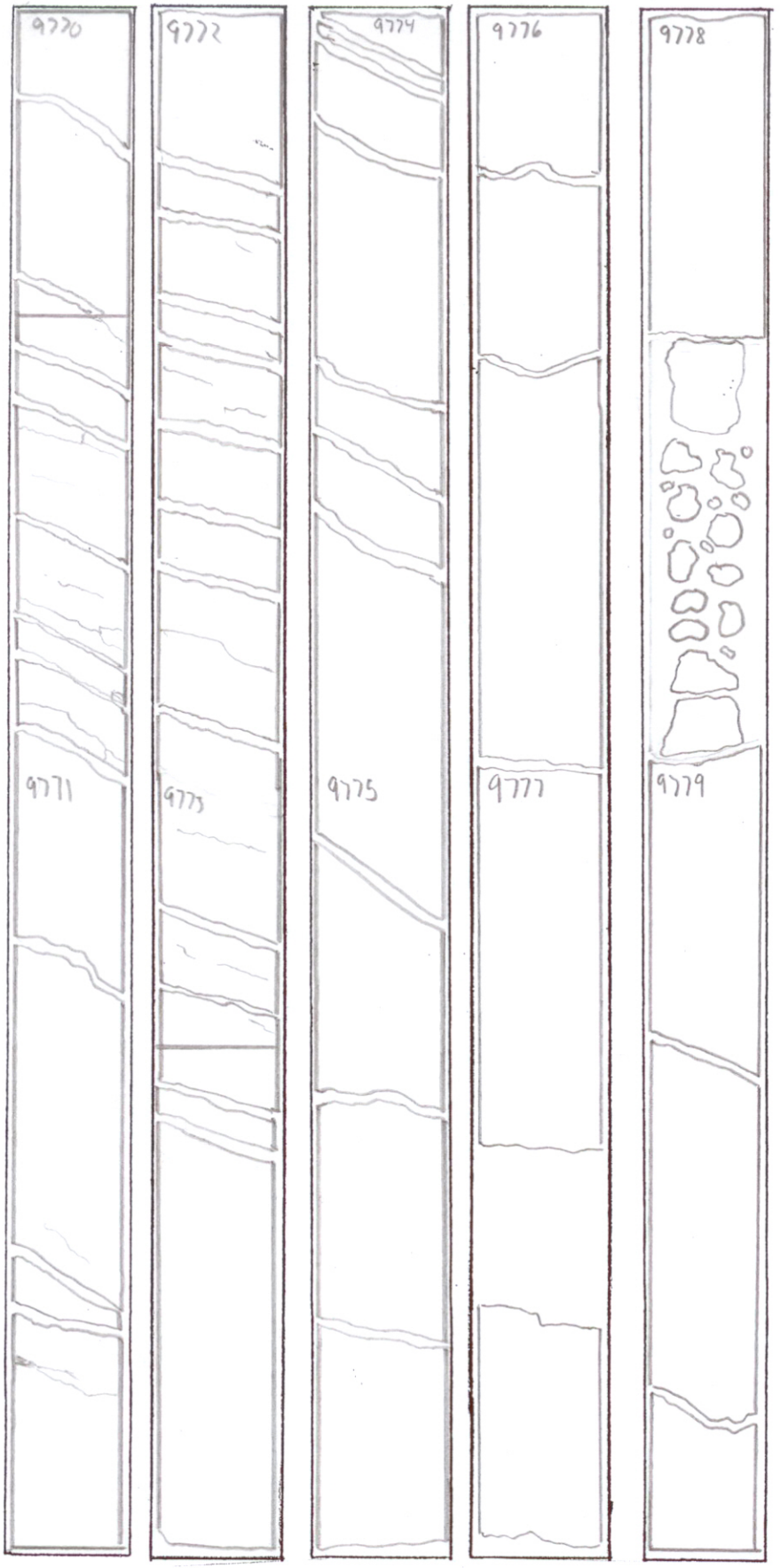
Core diameter : 4"

BOX : 9760 - 9770 (in feet) (no.of slots : 5)

Project name : BAKKEN GEOMECHANICS
Drawing by : [redacted] Noga
Date : 07-15-08

File no. : 15674 Operator : Hess
API no. : 33105015270000
Scale (ratio) : N/A Core diameter : 4"

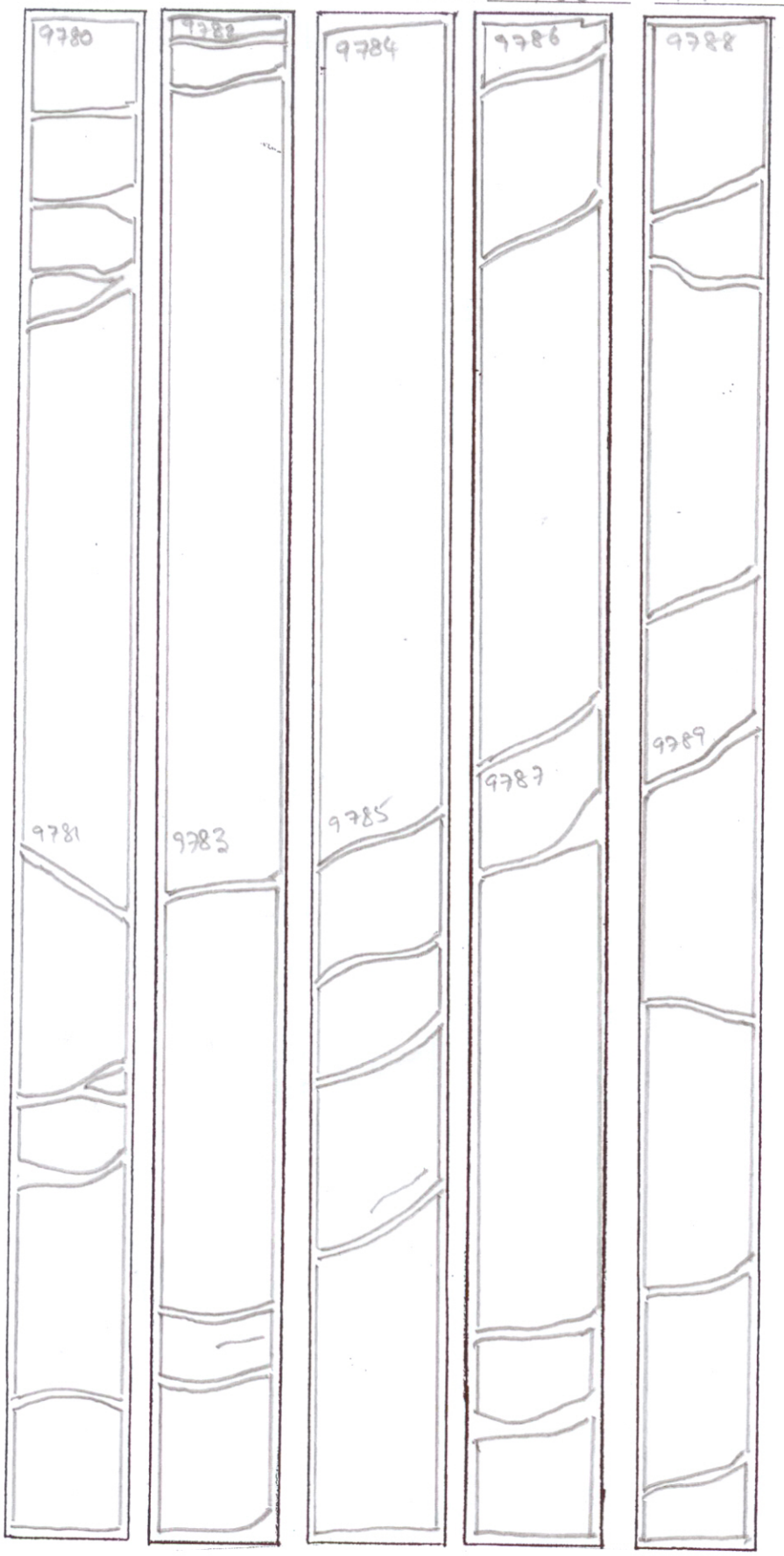
BOX : 9770 - 9780 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : [redacted] Daniel Smith
Date : 7-15-2008

File no. : 15674
Operator : Hess
API no. : 33/050/5270000
Scale (ratio) : N/A
Core diameter : 4"

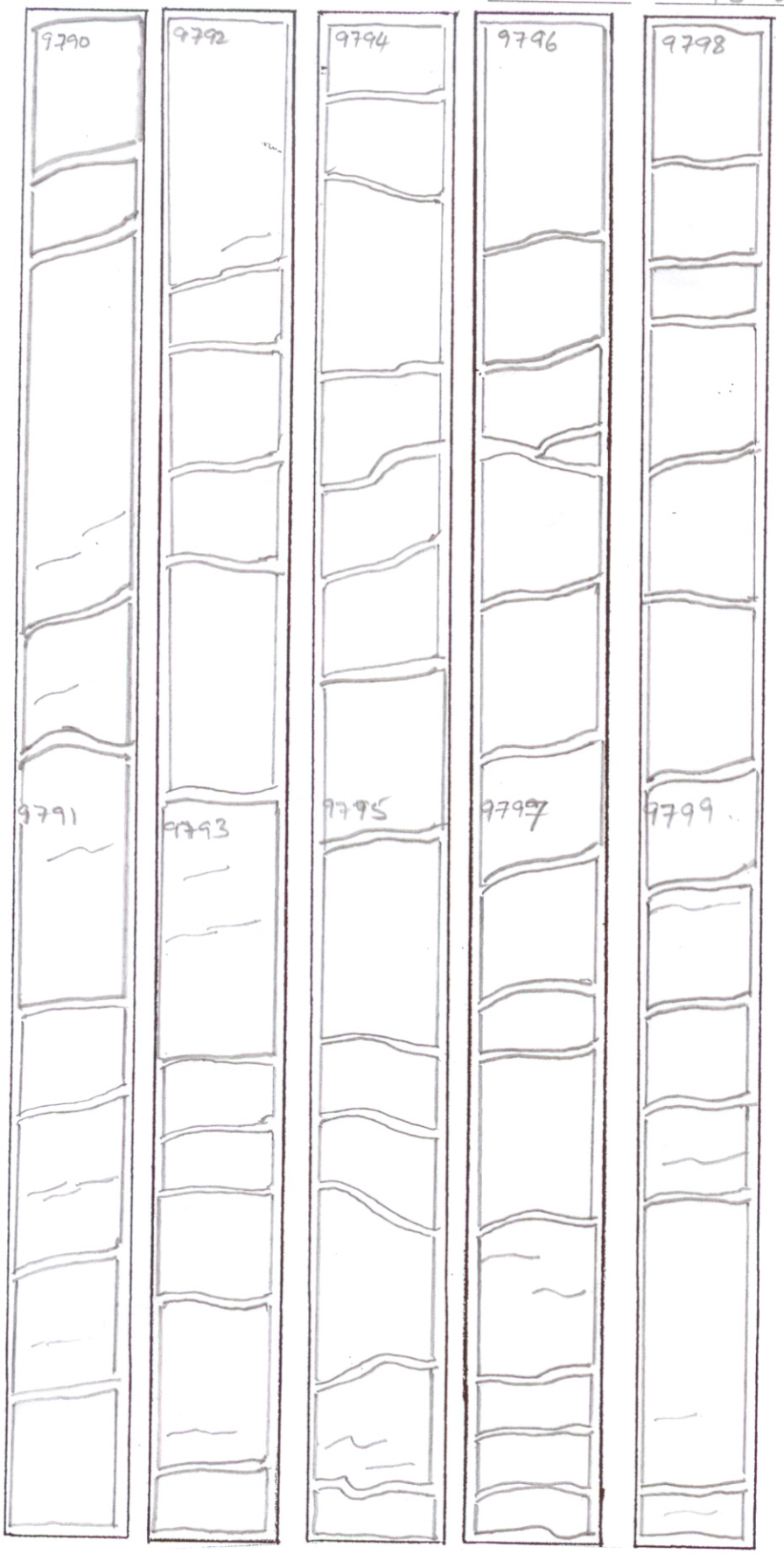
BOX : 9780 - 9790 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : [redacted] Naga
Date : 07/15/08

File no. : 15674
Operator : Hess
API no. : 33/050/52700000
Scale (ratio) : N/A
Core diameter : 4"

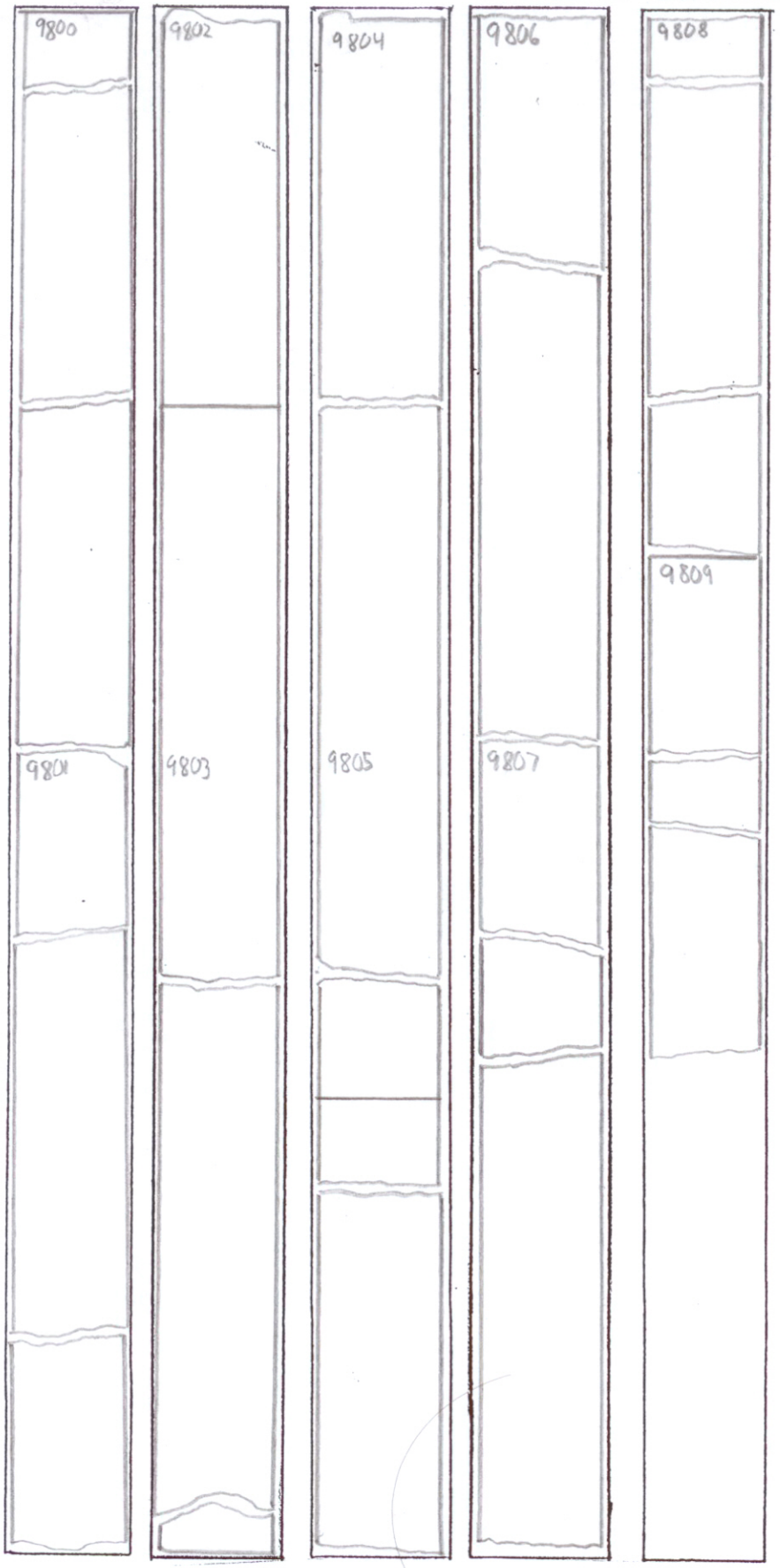
BOX : 9790 - 9800 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : [redacted] Naga
Date : 07/15/08

File no. : 15674 Operator : Hess
API no. : 33105012700 00
Scale (ratio) : N/A Core diameter : 4"

BOX : 9800 - 9809.7 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Daniel Smith
Date : 7-15-2008

File no. : 15674
Operator : Hess
API no. : 3310501270000
Scale (ratio) : N/A
Core diameter : 4"

Well #15845 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9616		Dark Shale	100	11.1	56.25	1	0-40	1.2 – 10.2	Bedding joints	Tight	None	3.75x4x0.6 To 4x4x4
9617												
9618							0-10					

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>1 inch.) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9619		Dark Shale Some OIL	100	56.8	81.8	1	0-20	0.4 – 17.4	Bedding joints	.02	None	.8x2.75x1.8 To 4x4x6.4
9620						2	0-20 & 70-90		Bedding joints + vertical fractures	.04		
9621						1	0-20		Bedding joints	.04		
9622		Dolomite Small presence of OIL				1	0-10	2.8-17.4	Bedding Joints	tight		2.5x2.5x2.25 To 4x4x6.75
9623						1	30-50					
9624						1	0-40					

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9625		dolomite Some amounts of OIL	92	49	89.7	2	0-10 & 70	2.54 – 17.6	Bedding joints & vertical	.02	None	1x1.5x1 To 4x4x6.9
9626						1	0-30		Bedding joints			
9627												
9628		Dolomite no OIL	93			1	0-10	4.7-24.2	Bedding joints	tight		4x4x1.75 To 4x4x9.4
9629												
9630												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9631		dolomite no OIL	100	57.4	88.5	1	0-10	1 – 18	Bedding joints	.01	None	4x4x0.5 To 4x4x7
9632							10-45					
9633												
9634		Dolomite no OIL	92			1	0-10	1.5-14.2	Bedding joints	tight		4x4x0.75 To 4x4x5.75
9635												
9636												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9637		dolomite no OIL	92	45.7	79.7	1	0-15	0.5-15	Bedding joints	.02	None	4x4x0.25 To 4x4x6
9638												
9639												
9640		Dolomite no OIL	81			1	0-15	1.3-19	Bedding joints	tight		0.25x1.25x0.3 To 4x4x7.5
9641												
9642							80-90		Vertical fracture			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9643		dolomite no OIL	93	62.8	77.8	1	90	1.75-18	vertical	tight	None	1x3.5x0.5 To 4x4x7.25
							0-15		Bedding joints			
9644							50-90		vertical			
9645							0-15		Bedding joints			
9646		Dolomite no OIL	95			1	0-15	3.5-12.25	Bedding joints	tight		1x1.5x1.25 To 4x4x5
9647							50-90		vertical			
9648							0-15		Bedding joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9649		dolomite no OIL	96	45.6	84.3	1	0-20	1.6-11	Bedding joints	.02	None	4x4x0.75 To 4x4x6.75
9650												
9651												
9652		Dolomite no OIL	92			1	0-10	1.7-17.7	Bedding joints	tight		4x4x0.85 To 4x4x7
9653												
9654												

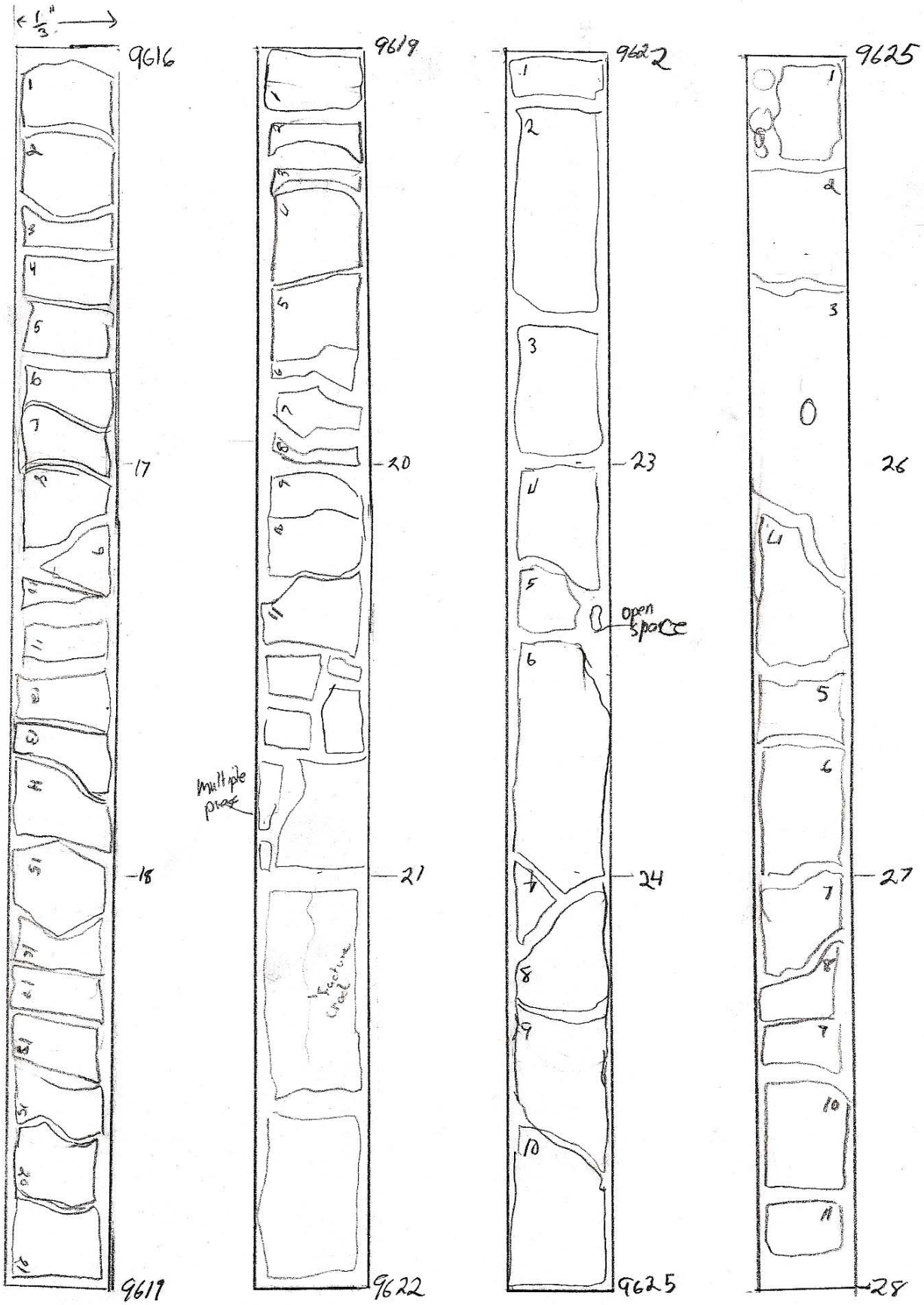
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9655		dolomite no OIL	100	68.5	94.5	1	0-10	4.8-17.5	Bedding joints	tight	None	4x4x1.75 To 4x4x7
9656												
9657												
9658		Dolomite no OIL	98					1-20				4x4x0.75 To 4x4x7.5
9659												
9660												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9661 9662 9663		dolomite no OIL	100	49.5	82	1	0-15	2-23.5	Bedding joints	tight	None	4x4x0.75 To 4x4x9.5
9664 9665 9666		Dolomite May be presence of some amounts of OIL	91				0-25	1.2-10				4x4x0.75 To 4x4x3.8

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9667		Dark shale OIL saturated	100	0	55.9	1	0-10	1-10	Bedding joints & vertical	.02 Very tight	None	4x4x0.5 To 4x4x3.5
9668												
9669												
9670							0-15	1-4				
9671												
9672												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (> 5 cms) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9673		Dark shale OIL saturated	100	8	35.1	1	0-15	1-4	Bedding joints	tight	None	4x4x0.5 To 4x4x3
9674												
9675												
9676							0-10	1-7				
9677												
9678												

Well #15845 fracture sketch



Project Name: BaKken Geo Mechanical

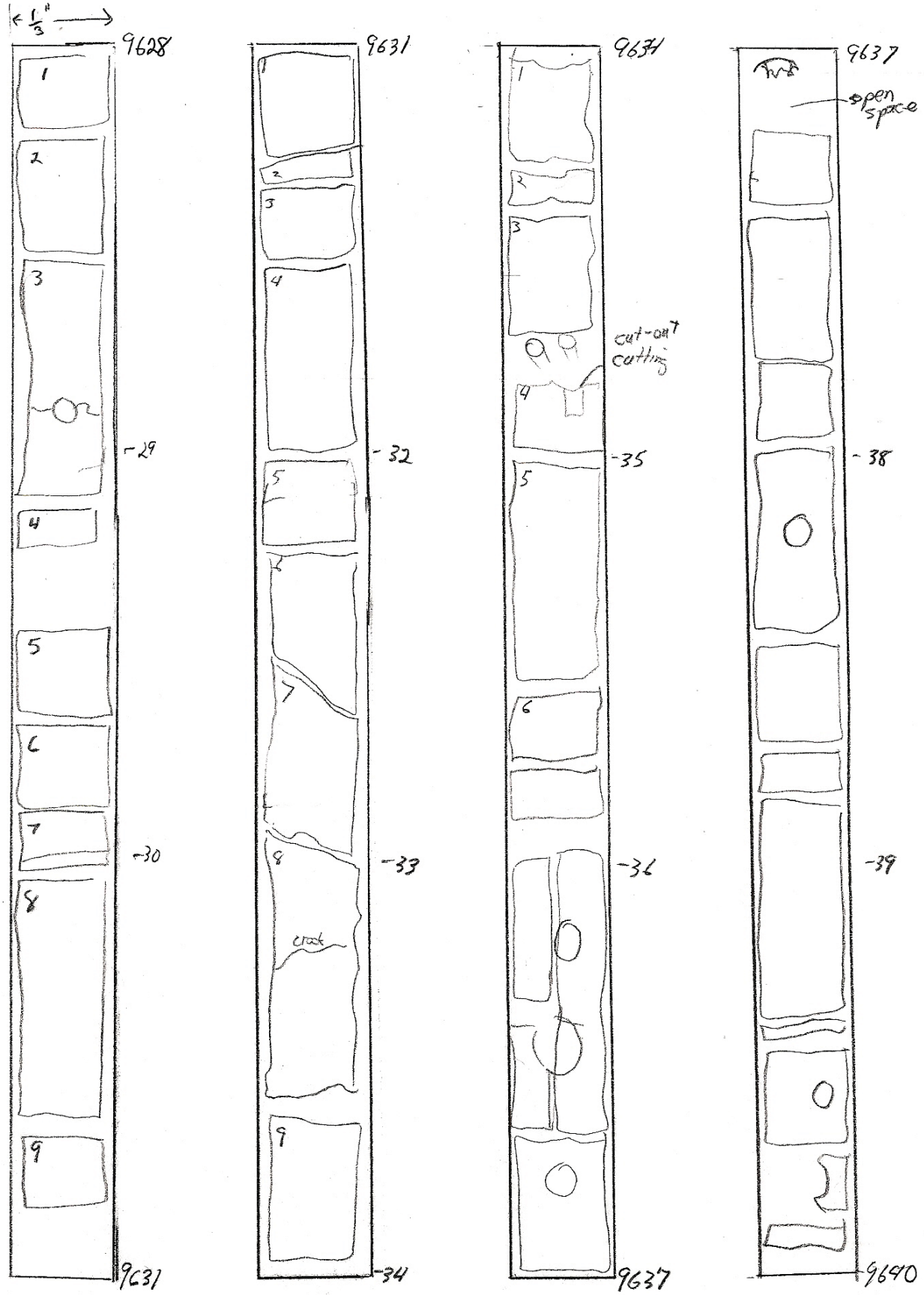
Drawing by: Jill Hohverda

Dated: 6-24-08

API # 3306100c890000

Well Map # 15845

scale (ratios) Length 9.0"/3ft Width 0.33"/3.5'



Project Name: Bakken Geomechanical

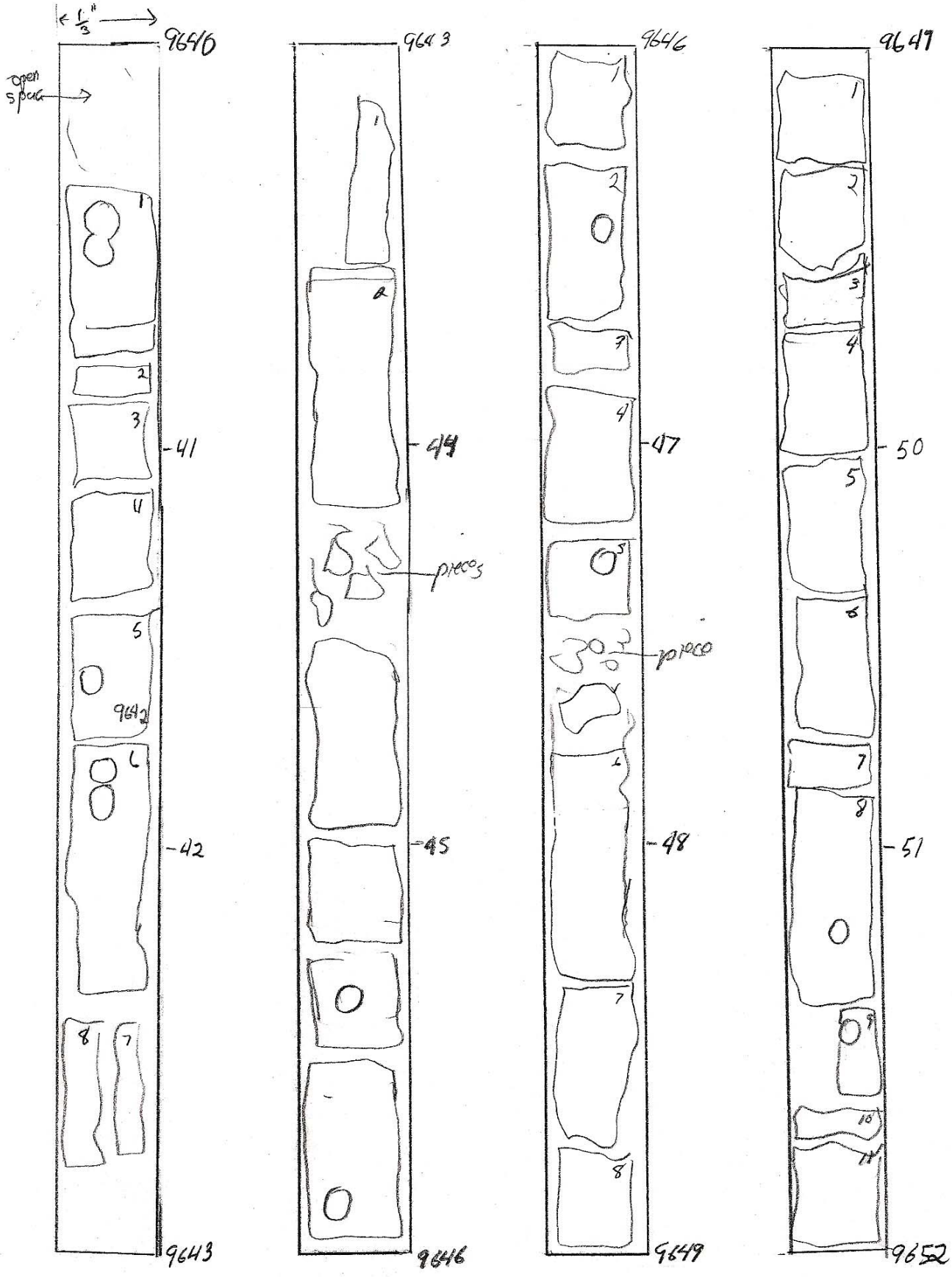
Drawing by: Jill Holwerda

Dated: 6-24-08

API # 33061004890000

Well Map # 15845

scale (ratios)	Length	Width
	9.0"/3'	0.33/3.5"



Project Name: Bakken Geomechanical

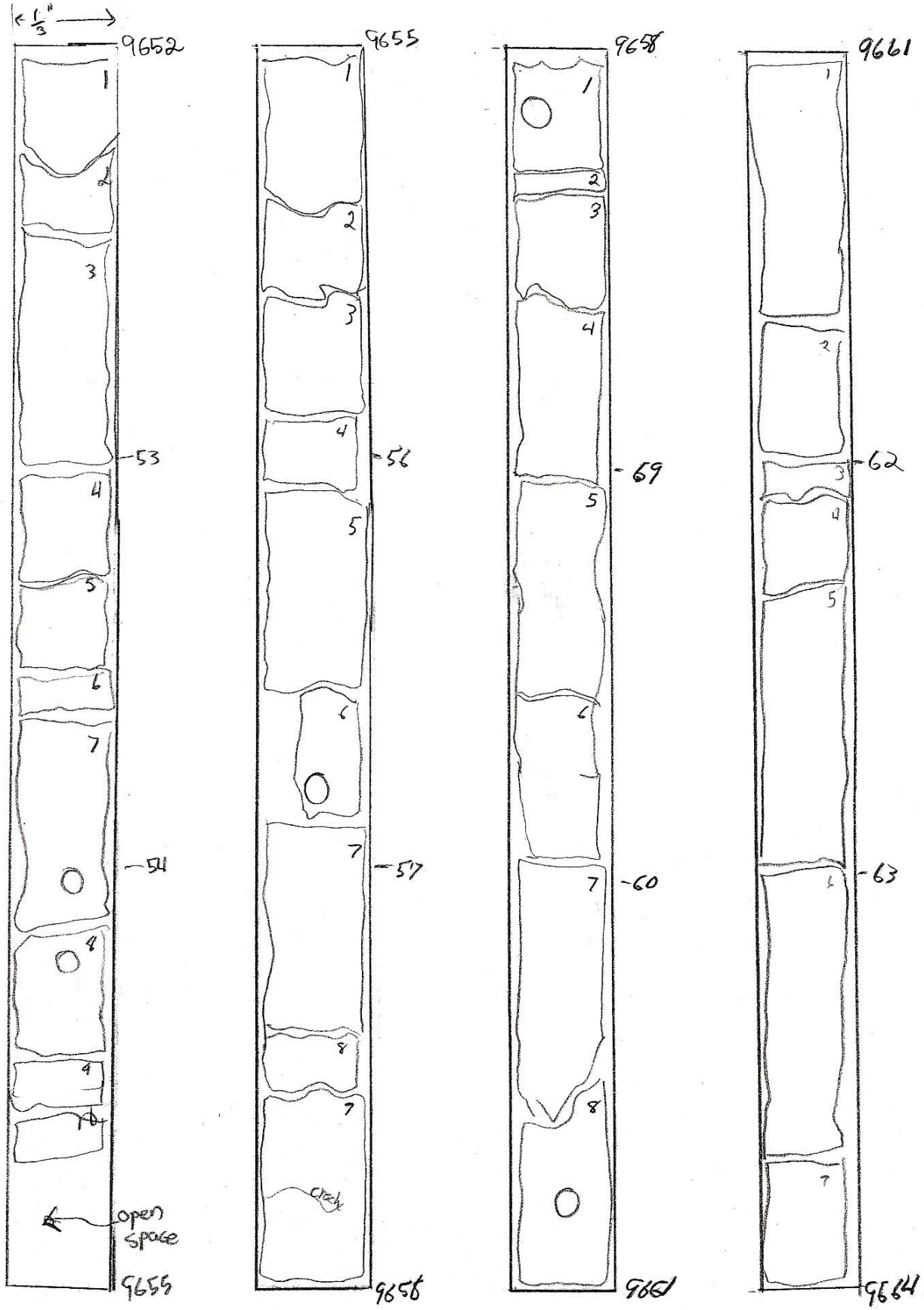
Drawing by: Jill Holwerda

Dated: 6-24-08

API # 33061004890000

Well Map # 15845

scale (ratios) Length 9.0"/3' Width 0.33"/3.5"



Project Name: Bakken Geomechanical

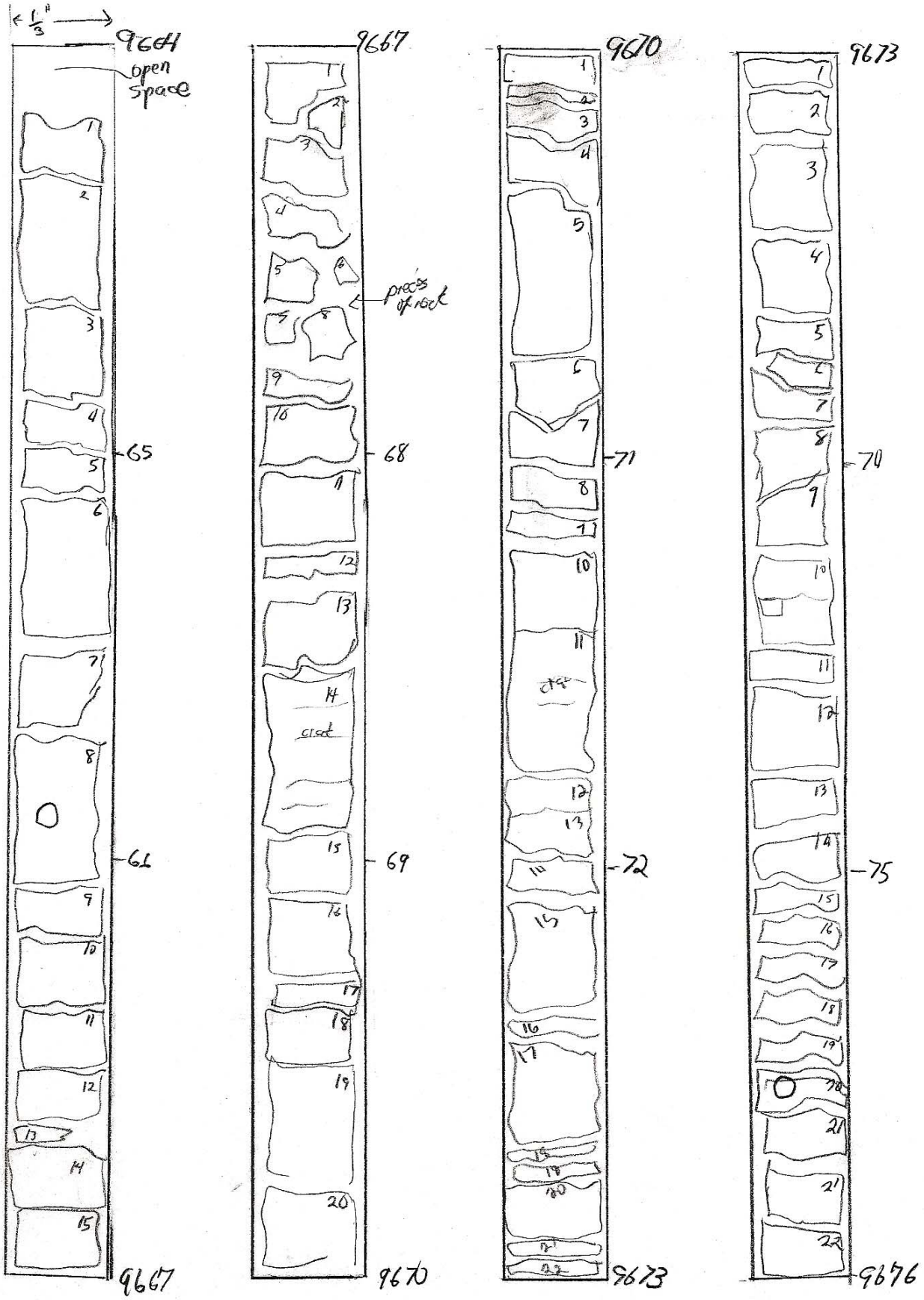
Drawing by: Jill Holwerda

Dated: 6-24-08

API # 33061004890000

Well Map # 15845

	Length	Width
scale (ratios)	9.0"/3'	0.33"/3.5"



Project Name: Bakken Geomechanical

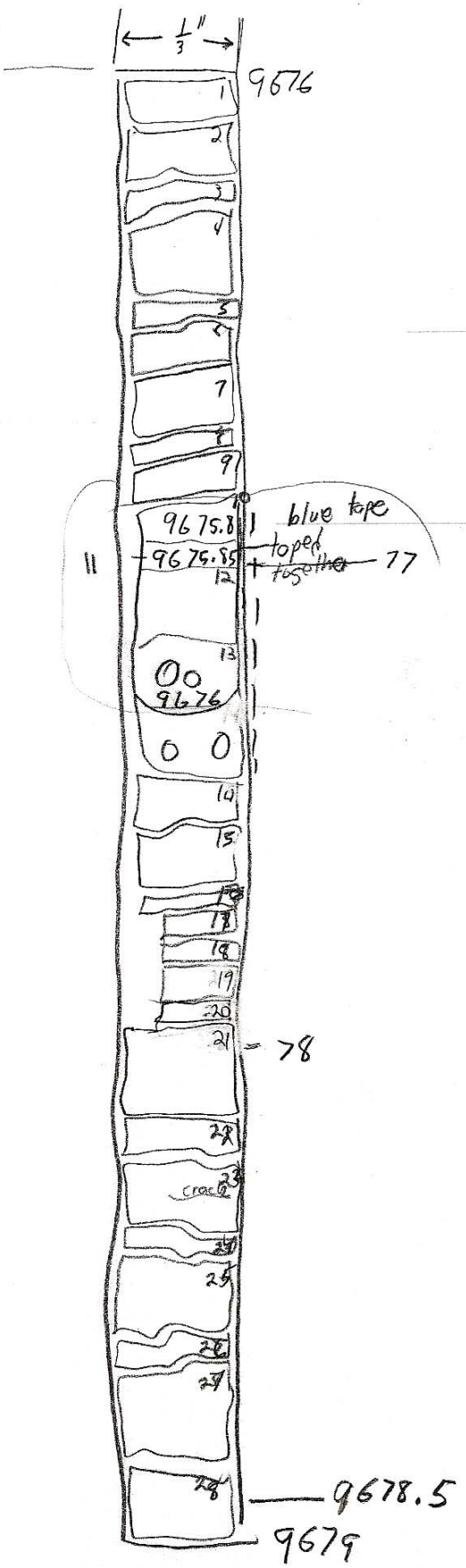
Drawing by: Jill Holwerda

Dated: 6-24-08

APT# 33061004890000

Well Map # 15845

scale (ratios) Length 9.0"/3' Width 0.33"/3.5"



Project Name : Bakken Geomechanical
Drawing by : Jill Holwerda
Dated : 6-24-08
API # 33061004890000
Well Map # 15845 scale (ratios) Length 9.0"/3' Width 0.33"/3.5"

Well #15889 Core survey

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10424		Limestone	98	18	51	2+	90, 70, 12, 9, 1, 6, 4, 2, 2, 4, 2, 0, 4, 4, 2, 10	Bed. Jts. & Mult. Vrt. Frac.	0.5 - 13	0.04	None	2.6x0.8x0.3 To 4x4x5.1
						1		Bedding Joints				
10426						1	15, 2, 3, 3, 3, 13, 20, 5, 4, 2, 6, 1	Bedding Joints		0.02		
10428						1	2, 4, 3, 7, 0, 0, 18, 16, 22, 90, 60, 70, 2, 10	Bedding Joints		0.01		
						2+		Bed. Jts. & Mult. Vrt. Frac.				
10430						1	15, 5, 1, 4, 6, 3, 4, 5, 3, 12, 5, 0, 12, 10, 5, 1	Bedding Joints		0.04		
10432						1	5, 1, 4, 5, 5, 12, 25, 5, 7, 8, 11, 11	Bedding Joints		0.02		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10434		Limestone	94	9	46	1	3, 30, 19, 4, 7, 0, 1, 3, 5, 15, 10, 5	Bedding Joints	0.8 – 14.7	0.02	None	2x3x0.75 To 4x4x5.8
10436						1	4, 10, 15, 5, 6, 8, 6, 5, 2, 3, 7, 8, 11, 0, 5, 20, 10, 1	Bedding Joints		0.01		
10438						1	1, 4, 11, 14, 9, 4, 12, 5, 6, 6, 4, 20, 22	Bedding Joints		0.02		
10440						1	5, 1, 1, 2, 4, 14, 6, 7, 11, 9, 12, 15	Bedding Joints		0.01		
10442						2	8, 16, 10, 13, 15, 5, 8, 75, 2, 10, 25, 12, 7	Bedding Joints & Vertical Fractures		0.02		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10444		Limestone	94	53	88	2	2, 7, 0, 1, 1, 7, 40, 70, 3	Bedding Joints & Vertical Fractures	1.3 - 16	0.01	None	2.5x2.8x1.6 To 4x4x6.2
10446						1	2, 25, 0, 5, 0, 18, 4, 5	Bedding Joints		0.01		
10448						1	7, 10, 12, 17, 0, 0, 10, 2, 5	Bedding Joints		0.04		
10450						1	6, 2, 5, 5, 0, 6	Bedding Joints		Tight		
10452						2	1, 2, 6, 5, 4, 30, 85	Bedding Joints & Vertical Fractures		0.01		

Name: ***Smith & Naga*** 3/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10454		Limestone	90	9	54	2	10, 8, 80, 70, 8, 4, 8	Bedding Joints & Vertical Fractures	0.75 – 11.7	0.02	None	1x2x0.25 To 4x4x4.6
10456		Black Shale				1	3, 5, 2, 3, 3, 0, 3, 3, 2, 0, 0, 4, 0, 0, 2, 0	Bedding Joints		Tight		
10458						1	3, 1, 0, 0, 2, 3, 5, 2, 0, 2, 0	Bedding Joints		0.01		
10460						1	1, 1, 0, 2, 0, 4, 0, 3, 4, 0, 2	Bedding Joints		0.02		
10462						2	1, 0, 0, 75, 5, 4, 15, 16, 10, 8, 6, 3, 5, 60	Bedding Joints & Vertical Fractures		0.02		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10464		Black Shale	100	20	56	2	5, 70, 4, 3, 2, 3, 3, 0, 2, 4, 1, 2, 2, 0, 6, 4, 0, 0, 3	Bedding Joints & Vertical Fractures	0.25 – 11.2	Tight	None	1.75x3x0.1 To 4x4x4.4
10466						1	2, 0, 3, 1, 3, 2, 2, 1, 10, 0, 0, 0, 1, 4, 8	Bedding Joints		Tight		
10468						1	3, 3, 5, 6, 4, 2, 5, 0, 3, 4, 3	Bedding Joints		0.01		
10470						1	3, 2, 4, 5, 10, 6, 0, 1, 5	Bedding Joints		Tight		
10472						1	1, 1, 8, 3, 2, 0, 4, 2, 3, 5, 1, 5, 3	Bedding Joints		0.01		

Name: ***Smith & Naga*** 5/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10474		Black Shale	100	44	80	1	3, 5, 4, 4, 2, 7, 0, 6, 3, 1, 6	Bedding Joints	0.8 – 20.8	0.02	None	4x4x0.3 To 4x4x8.2
10476						1	6, 4, 8, 1, 2, 6, 8, 4, 3, 10	Bedding Joints		0.02		
10478		Siltstone				1	3, 8, 6, 2, 3, 2, 0, 4, 11	Bedding Joints		0.01		
10480						1	2, 3, 0, 6, 4, 2, 5, 1, 6, 8, 2, 6, 3	Bedding Joints		0.02		
10482						1	2, 2, 8, 1, 4, 0, 3, 2, 4	Bedding Joints		0.02		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10484		Siltstone	96	82	94	1	16, 4, 6, 6, 2, 1, 2, 0, 3, 1	Bedding Joints	1.3 – 37.3	0.02	None	4x4x0.5 To 4x4x14.7
10486						1	2, 4, 2, 3, 2, 14	Bedding Joints		0.01		
10488						1	3, 4, 4, 7	Bedding Joints		0.02		
10490						1	7, 4, 2	Bedding Joints		Tight		
10492						1	3, 4, 2, 4, 1	Bedding Joints		Tight		

Name: ***Smith & Naga*** 7/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10494		Siltstone	100	57	87	1	4, 2, 16, 1	Bedding Joints	0.25 – 22.9	Tight	None	4x4x0.1 To 4x4x9
10496						1	3, 2, 6, 4, 2, 2, 1, 1	Bedding Joints		Tight		
10498						1	1, 4, 7, 2, 6, 4, 2, 1, 3	Bedding Joints		0.01		
10500						1	6, 9, 11, 7, 11, 4, 2, 6	Bedding Joints		Tight		
10502						1	1, 2, 3, 2, 4, 2, 0	Bedding Joints		0.01		

Name: ***Smith & Naga*** 8/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10504		Siltstone	100	81	92	1	2, 7, 4, 2, 6, 1	Bedding Joints	1 – 19.7	0.01	None	4x4x0.4 To 4x4x7.75
10506						1	4, 2, 0, 4, 2, 3	Bedding Joints		0.01		
10508						1	5, 6, 0, 1, 2, 0, 0	Bedding Joints		Tight		
10510						1	4, 1, 6, 0, 4	Bedding Joints		Tight		
10512						1	2, 3, 0, 4, 1, 1, 2	Bedding Joints		Tight		

Name: ***Smith & Naga*** 9/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10514		Siltstone	100	100	100	1	0, 2, 7	Bedding Joints	15.2 – 25.4	0.01	None	4x4x6 To 4x4x10
10516												

Name: ***Smith & Naga*** 10/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10516		Dolomitic Siltstone	98	80	94	1	1, 5, 7, 6	Bedding Joints	1.5 – 28.7	0.01	None	4x4x0.6 To 4x4x11.3
10518						1	6, 11, 4, 6, 5	Bedding Joints		0.02		
10520						1	2, 3, 3, 7, 5, 10, 1	Bedding Joints		0.01		
10522						1	4, 0, 0, 1, 2, 2	Bedding Joints		0.01		
10524						1	3, 1, 2	Bedding Joints		Tight		

Name: ***Smith & Naga*** 11/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10526		Dolomitic Siltstone	98	87	97	1	1, 4, 5, 2	Bedding Joints	4.4 – 32.3	Tight	None	4x4x1.75 To 4x4x12.7
10528						1	4, 4, 14, 3, 12, 7	Bedding Joints		Tight		
10530						1	4, 10, 10	Bedding Joints		0.02		
10532						1	2, 6, 4, 1, 5	Bedding Joints		Tight		
10534						1	5, 4, 3	Bedding Joints		0.01		

Name: ***Smith & Naga*** 12/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10536		Dolomitic Siltstone	99	85	98	1	7, 5, 4, 2, 3	Bedding Joints	4.4 – 26.9	Tight	None	4x4x1.75 To 4x4x10.6
10538						1	10, 8, 10, 5, 3	Bedding Joints		Tight		
10540						1	6, 3, 7, 3	Bedding Joints		Tight		
10542						1	2, 9, 6, 4	Bedding Joints		Tight		
10544						1	4, 3, 6, 3	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10546		Dolomitic Siltstone Black Shale High Carbon Content	97	21	50	1	12, 7, 5, 2, 0, 2, 3, 5, 6, 7, 6, 5, 10, 7, 4, 3, 4, 2, 2, 1, 12	Bedding Joints	0.25 – 18.5	0.01	None	0.7x1x0.2 To 4x4x7.3
10548						2	1, 6, 2, 5, 3, 4, 3, 4, 5, 2, 2, 7, 4, 6, 7, 5, 10, 4, 4, 3, 8, 7, 1, 2, 1, 0, 85	Bedding Joints & Vertical Fractures		0.02		
10550						2	4, 5, 90, 2, 4, 6, 10, 5, 6, , 90, 3, 6, 90, 3, 2, 85, 2, 9, 9, 6, 5	Bedding Joints & Vertical Fractures		0.01		
10552						2	2, 3, 4, 0, 2, 85, 5, 1, 90, 1, 5, 3, 0, 77, 3	Bedding Joints & Vertical Fractures		Tight		
10554						2	2, 85, 5, 3, 5, 4, 90, 6, 4, 1, 5, 5, 90, 6, 6, 6, 3	Bedding Joints & Vertical Fractures		0.01		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10556		Black Shale High Carbon Content	100	7	59	2	2, 6, 5, 5, 4, 8, 9, 90, 4, 90, 2, 3, 1, 8, 5, 7, 5, 3	Bedding Joints & Vertical Fractures	0.7 – 11.7	0.02	None	0.8x1x0.2 To 4x4x4.6
10558						2	3, 90, 7, 3, 5, 7, 5, 0, 4, 4, 6, 4, 1, 8, 6, 5	Bedding Joints & Vertical Fractures		0.01		
10560						2	7, 3, 0, 4, 8, 2, 0, 5, 1, 0, 3, 6, 3, 3, 90	Bedding Joints & Vertical Fractures		0.01		
10562						2	4, 3, 7, 4, 5, 0, 10, 1, 90, 3, 1	Bedding Joints & Vertical Fractures		0.02		
10564						2	7, 9, 10, 4, 7, 0, 0, 90, 1, 5, 5	Bedding Joints & Vertical Fractures		0.01		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10566		Black Shale High Carbon Content	100	44	83	2	2, 6, 90, 4, 3, 4, 2, 90, 4, 2, 5	Bedding Joints & Vertical Fractures	1 - 21	0.01	None	0.5x0.8x0.1 To 4x4x8.25
10568						2	7, 0, 85, 2, 5, 90, 5	Bedding Joints & Vertical Fractures		0.01		
10570						2	2, 3, 90, 3, 4, 2, 1, 1, 0	Bedding Joints & Vertical Fractures		0.01		
10572						1	3, 4, 2, 3, 6, 6	Bedding Joints		Tight		
10574						2	3, 16, 1, 10, 3, 5, 4, 3, 2, 90, 6, 2, 5, 2, 5, 7	Bedding Joints & Vertical Fractures		0.02		

Name: ***Smith & Naga*** 16/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10576		Black Shale High Carbon Content	97	41	69	2	8, 85, 12, 6, 14, 90, 8, 11, 12, 15, 22	Bedding Joints & Vertical Fractures	0.5 – 21.8	0.02	None	0.5x0.3x0.2 To 4x4x8.6
10578						2	38, 52, 47, 75, 22, 20, 45	Bedding Joints & Vertical Fractures		0.02		
10580						2	8, 23, 32, 17, 65, 6, 3, 5, 6, 2	Bedding Joints & Vertical Fractures		0.01		
10582						2	3, 85, 2, 7, 12, 2, 9, 12, 6, 15, 6, 2, 0	Bedding Joints & Vertical Fractures		0.02		
10584						1	1, 2, 3, 2, 1, 2, 6, 1, 1	Bedding Joints		0.01		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10586		Black Shale High Carbon Content	98	43	79	2	8, 9, 85, 20, 7, 3, 90, 7, 3, 5	Bedding Joints & Vertical Fractures	0.8 – 16.5	0.02	None	0.5x0.2x0.2 To 4x4x6.5
10588						2	17, 37, 44, 75, 14, 6, 7, 12, 10, 2, 1	Bedding Joints & Vertical Fractures		0.01		
10590						2	2, 5, 2, 3, 1, 6, 1, 4, 90, 3, 2, 82, 6, 1, 7	Bedding Joints & Vertical Fractures		0.01		
10592						2	90, 2, 1, 1, 1, 8, 4, 5	Bedding Joints & Vertical Fractures		0.01		
10594						1	3, 2, 2, 1, 1, 2, 3, 2, 8, 4, 2	Bedding Joints		0.01		

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10596		Black Shale High Carbon Content	100	19	64	2	1, 90, 3, 2, 1, 2, 2, 1, 2, 4, 2, 90, 6, 7, 26, 16, 65, 6, 3, 90, 2, 7, 4, 2	Bedding Joints & Vertical Fractures	0.8 – 15.5	0.02	None	0.4x0.3x0.5 To 4x4x6.1
10598		Siltstone with illite				1	2, 3, 2, 4, 4, 3, 2, 3, 4, 4, 6, 2	Bedding Joints		Tight		
10600						1	4, 2, 2, 3, 8, 2, 4, 0, 3, 2, 2, 4, 8, 0, 10	Bedding Joints		Tight		
10602						2	5, 7, 2, 1, 2, 85, 3, 2, 0, 90, 2, 0, 6, 5, 2, 4	Bedding Joints & Vertical Fractures		0.02		
10604						1	3, 1, 8, 4, 6, 1, 2, 9, 1, 0, 2, 6	Bedding Joints		0.02		

Name: ***Smith & Naga*** 19/21 Date: July, 16, 2008

Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10606		Siltstone with illite	100	13	41	1		Bedding Joints	0.5 – 20.3	0.02	None	0.8x0.5x0.2 To 4x4x8
10608						1		Bedding Joints		0.02		
10610						1		Bedding Joints		0.01		
10612						2		Bedding Joints & Vertical Fractures		0.04		
10614						2		Bedding Joints & Vertical Fractures		0.04		

Name: ***Smith & Naga*** 20/21 Date: July, 16, 2008

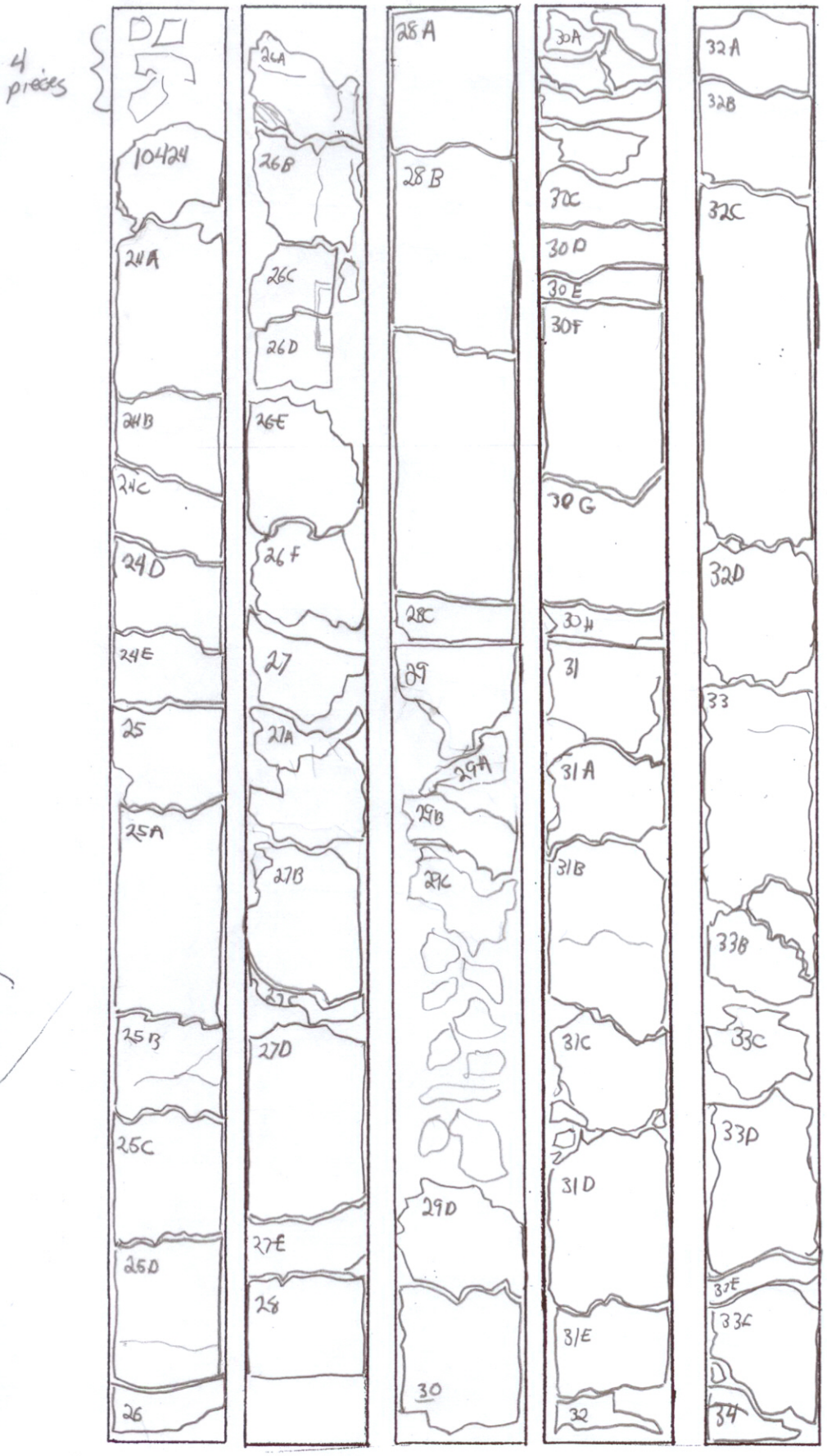
Bakken Geomech. Core description File # : 15889 Well API: 33061004900000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10616		Siltstone with illite	100	4	47	2	4, 11, 3, 5, 4, 2, 7, 7, 5, 9, 9, 5, 90, 2, 3, 6, 2, 0, 4	Bedding Joints & Vertical Fractures	0.5 – 10.1	0.04	None	1x0.8x0.3 To 4x4x
10618						1	0, 1, 3, 0, 2, 1, 4, 2, 6, 4, 6, 2, 0, 4, 2, 6, 4, 2, 4, 6, 5, 1	Bedding Joints		0.04		
10620						2	2, 8, 5, 10, 1, 11, 2, 1, 20, 2, 1, 1, 2, 7, 90, 3	Bedding Joints & Vertical Fractures		0.02		
10622						2	4, 4, 75, 7, 6, 4, 2, 4, 8, 10, 5, 20, 3	Bedding Joints & Vertical Fractures		0.04		
10624						1	1, 3, 12, 5	Bedding Joints		0.01		
10624.5												

Name: ***Smith & Naga*** 21/21 Date: July, 16, 2008

Well #15889 fracture sketch

Page: 1 of 22 BOX : 10424 - 10434 (in feet) (no.of slots : 5)

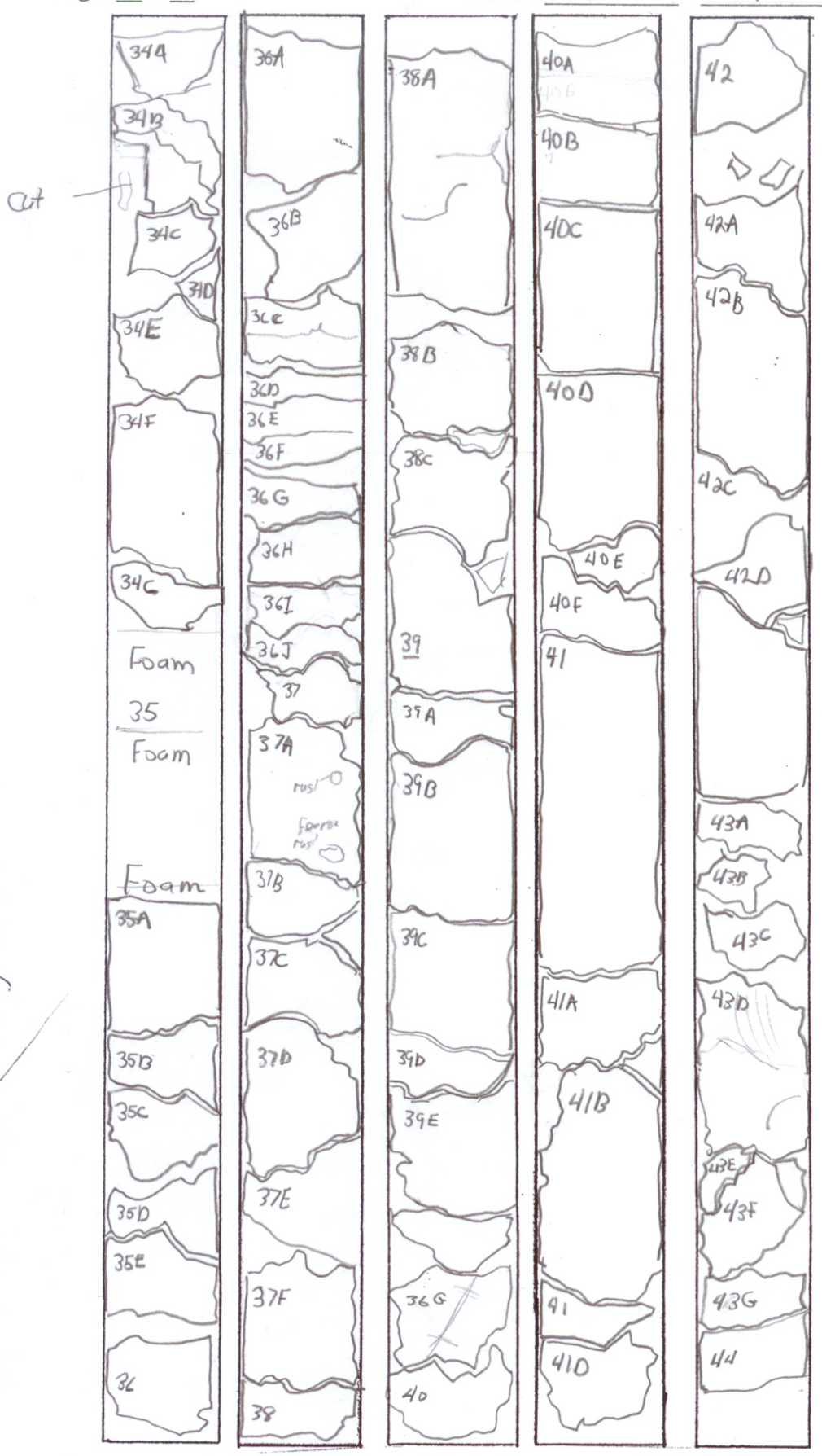


Project name : BAKKEN GEOMECHANICS File no. : 15889 Operator : Hess

Drawing by : Jill Holwerda API no. : 33061004900000

Date : 7-16-08 Scale (ratio) : _____ Core diameter : 4"

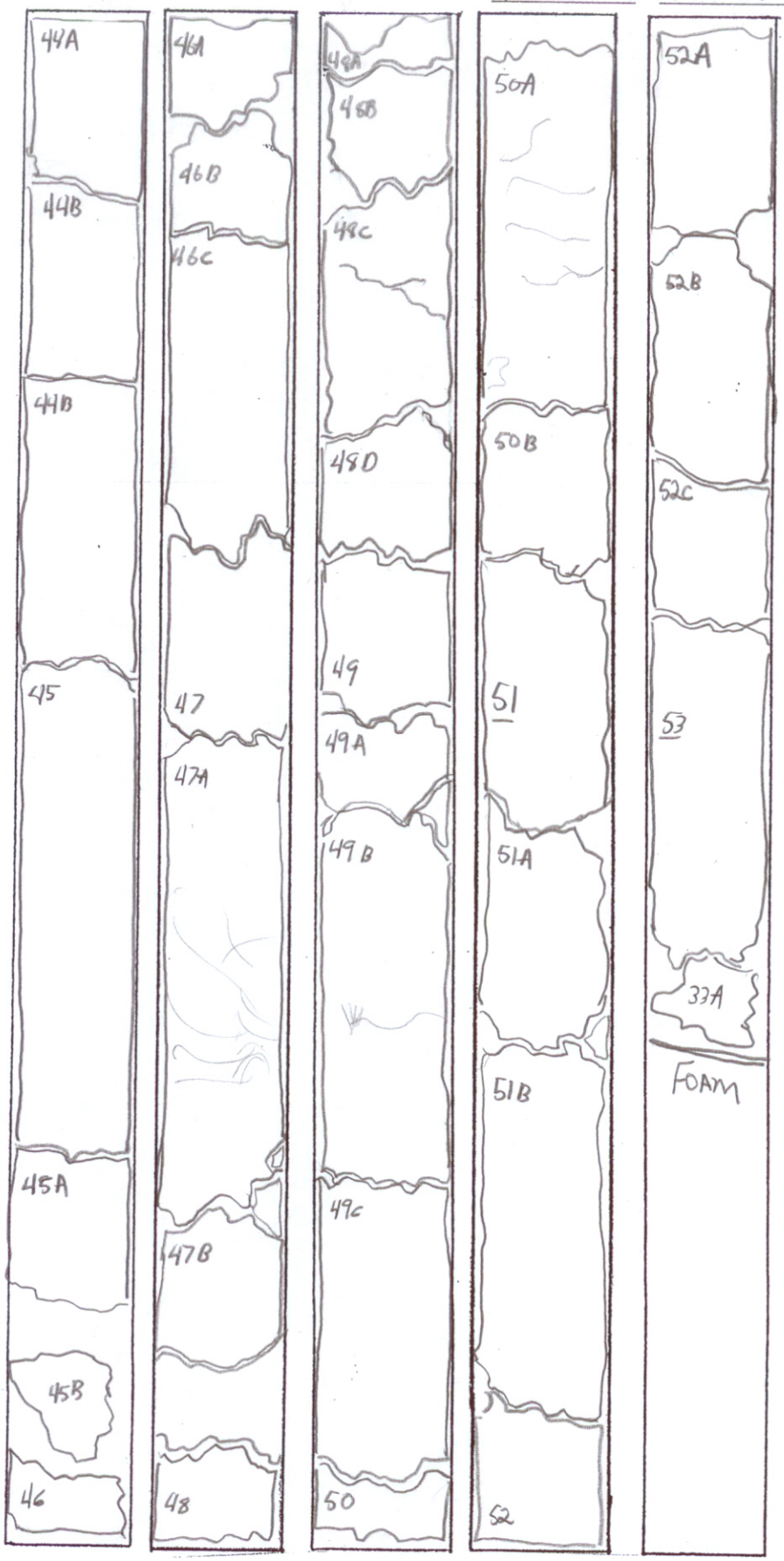
BOX : 10434 - 10444 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889 Operator : Hess
API no. : 33061004900000
Scale (ratio) : Core diameter : 4"

BOX : 10444 - 10454 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

BOX : 10454 - 10464 (in feet) (no.of slots : 5)

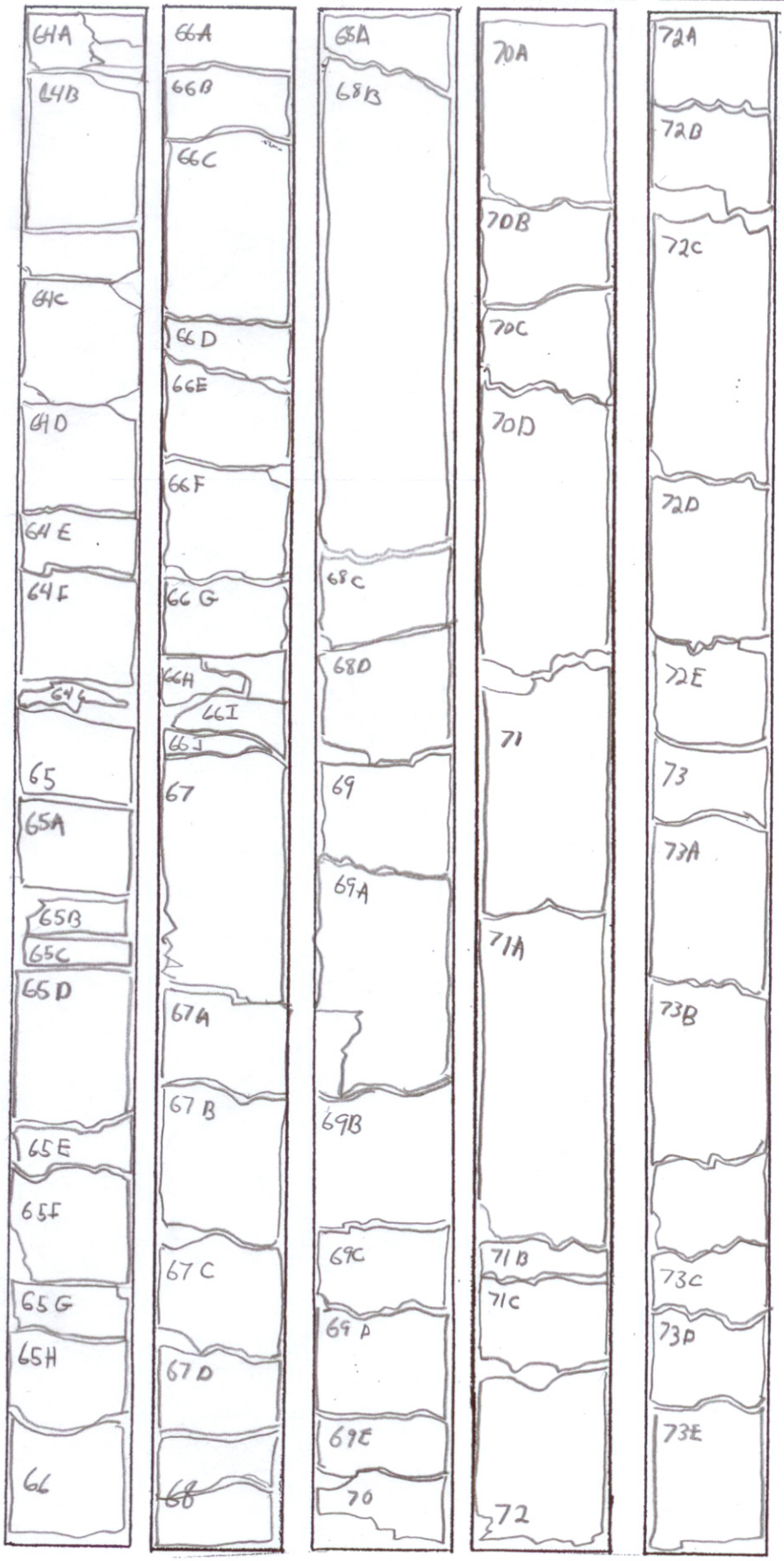
Drawings are not proportioned to true size.

Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889
API no. : 33061004900000
Scale (ratio) : N/A

Operator : Hess
Core diameter : 4"

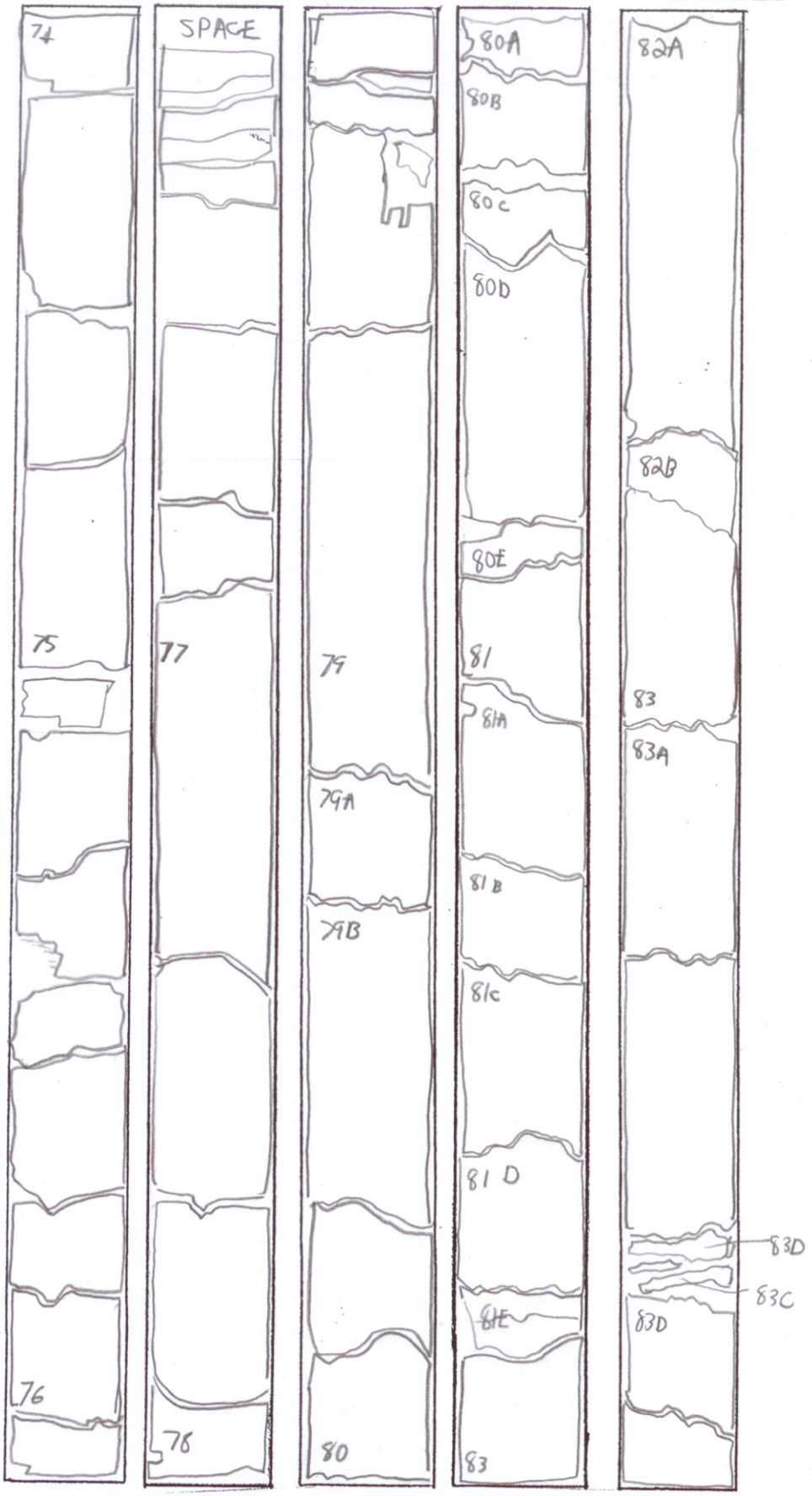
BOX : 10464 - 10474 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889 Operator : Hess
API no. : 33061004400000
Scale (ratio) : Core diameter : 4"

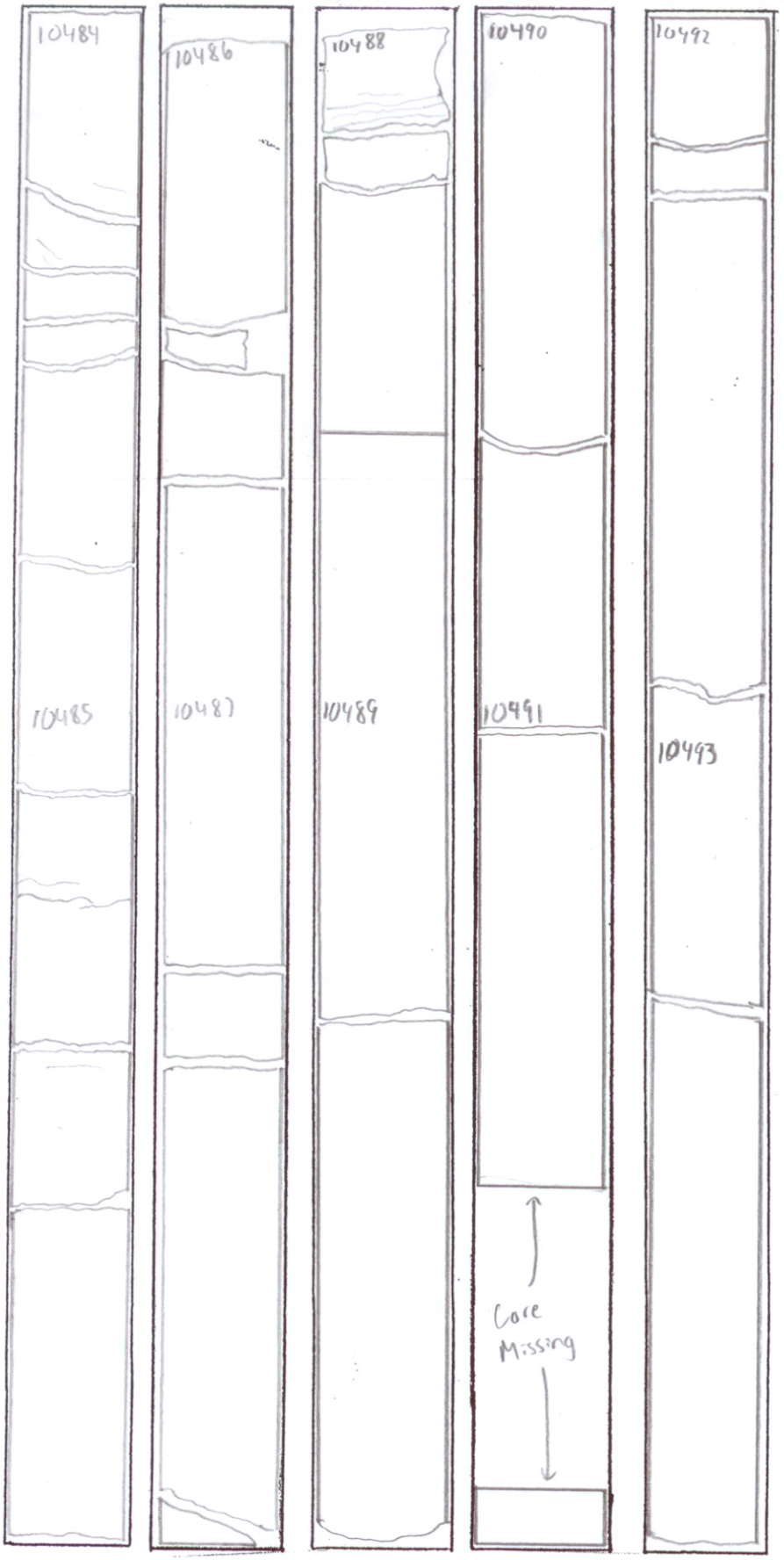
BOX : 10474 - 10484 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889 Operator : Hess
API no. : 33061 00490 0000
Scale (ratio) : Core diameter : 4"

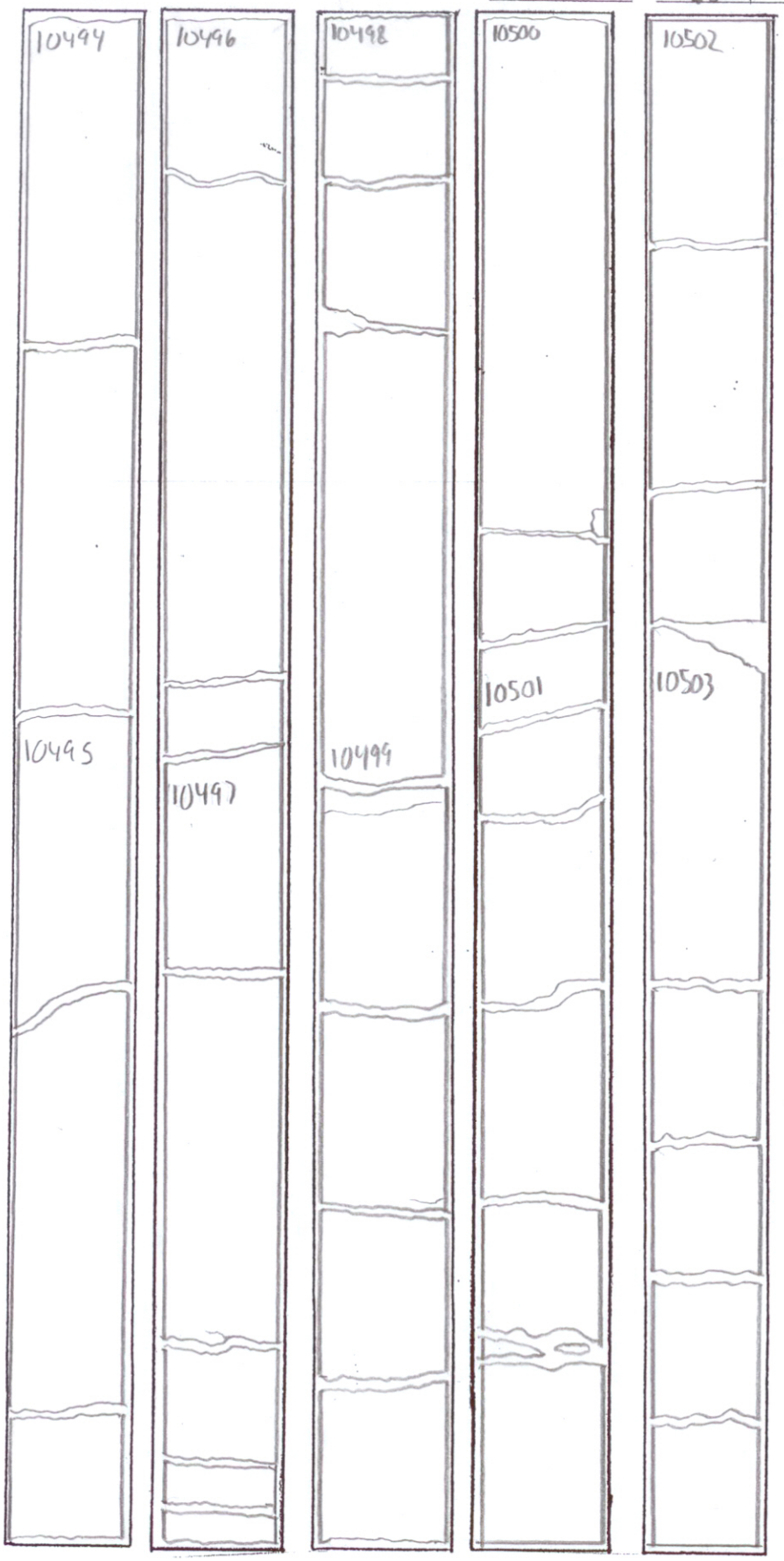
BOX : 10484 - 10494 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Daniel Smith
Date : 7-16-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

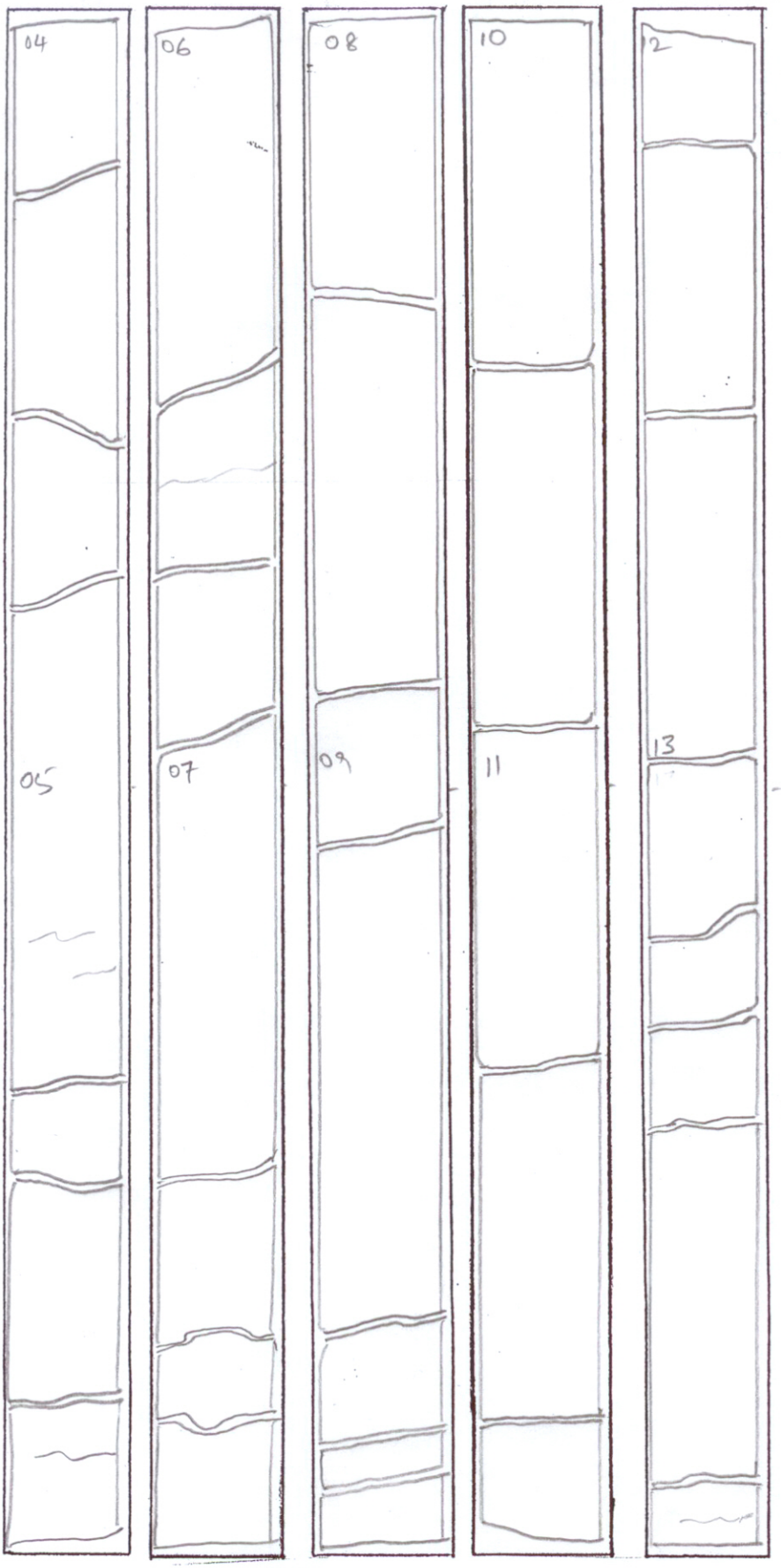
BOX : 10494 - 10504 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Daniel Smith
Date : 7-16-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

BOX : 10504 - 10514 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS

Drawing by : ~~Jill Holwerda~~ Naga

Date : 07-16-08

File no. : 15889

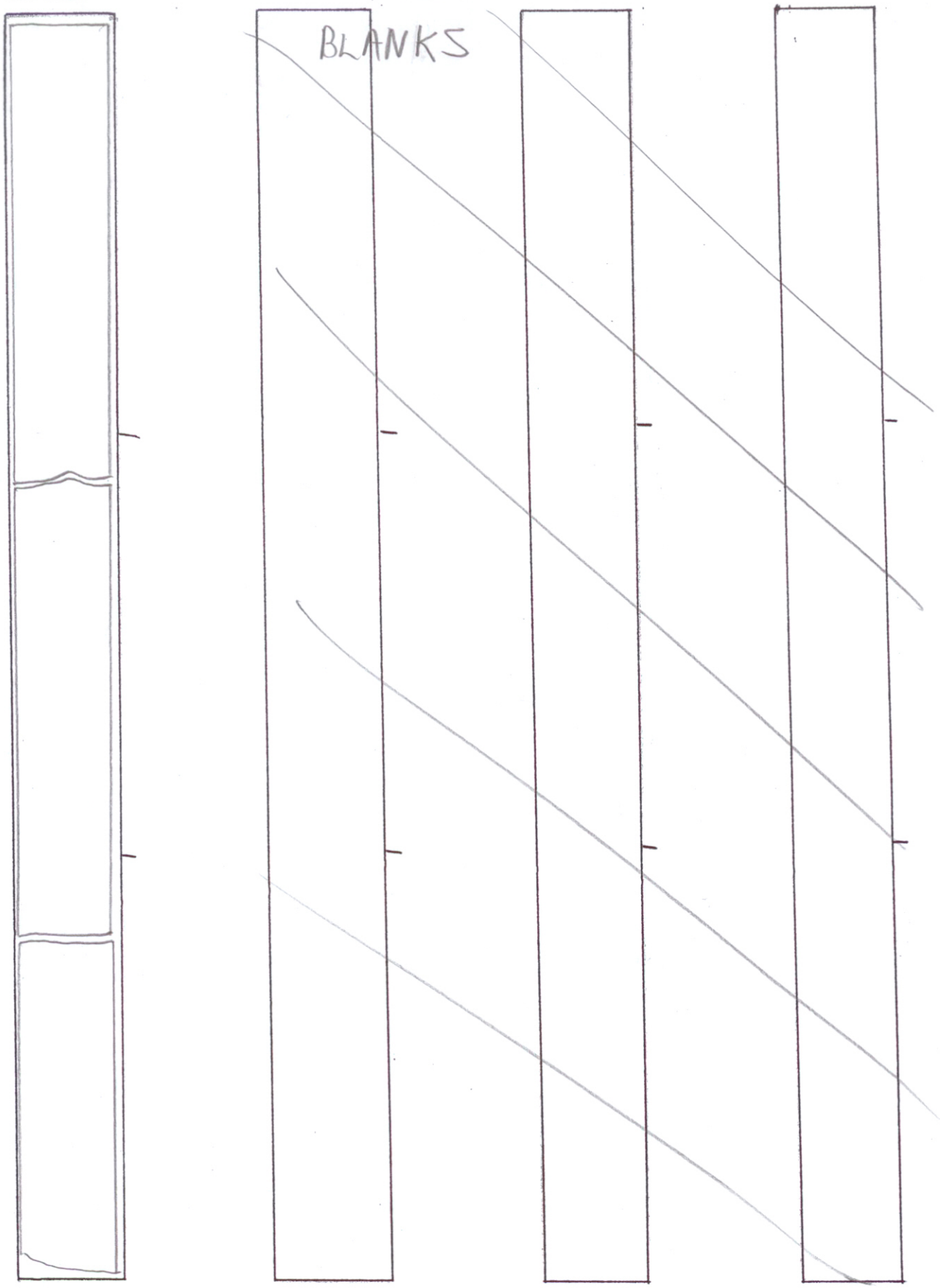
API no. : 33061004900000

Scale (ratio) :

Operator : Hess.

Core diameter : 4"

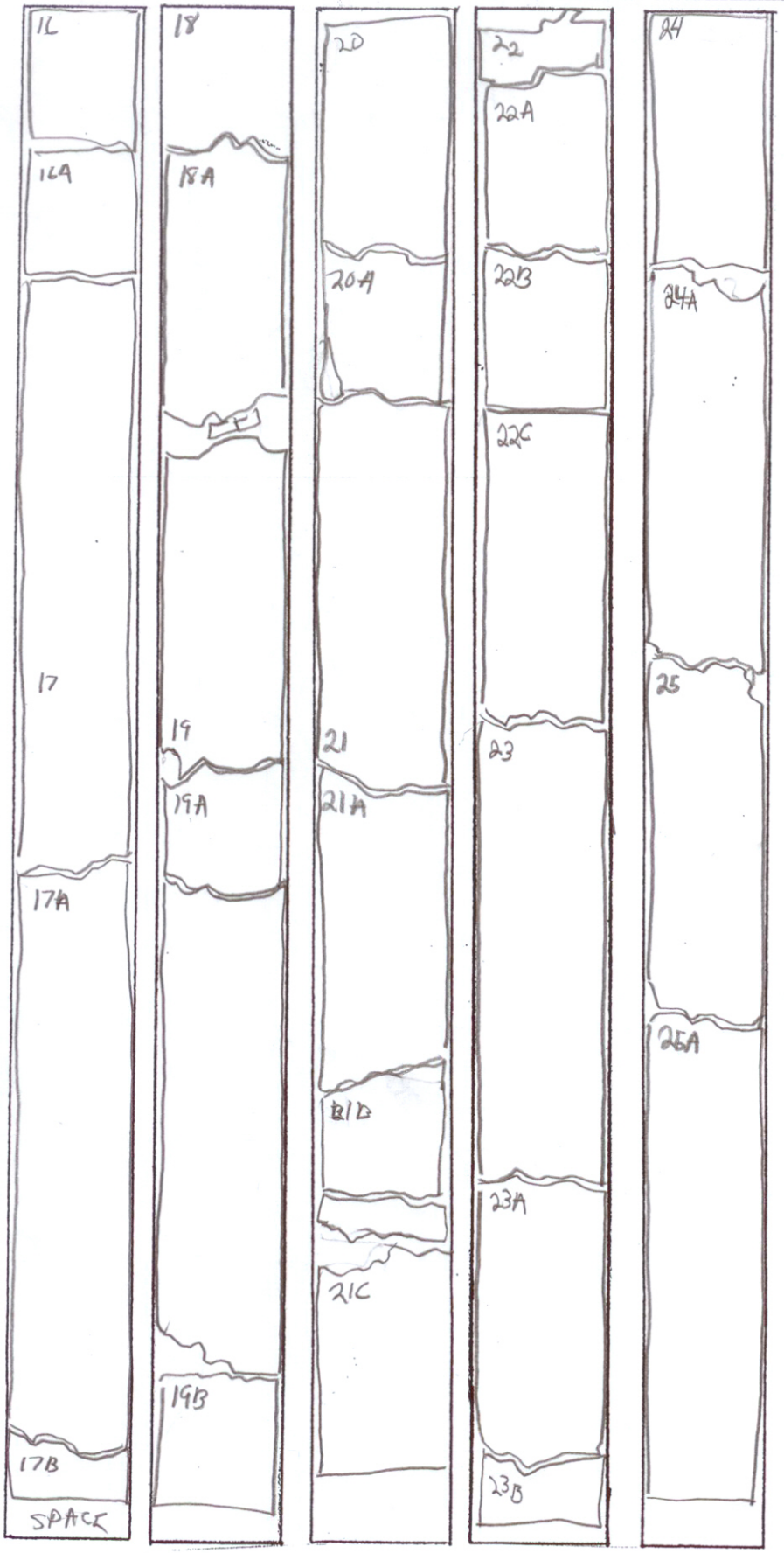
BOX : 10514 - 10516 (in feet) (no.of slots : 1)



Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Naga
Date : 07/16/08

File no. : 15889 Operator : Hess
API no. : 33061004900000
Scale (ratio) : Core diameter : 4"

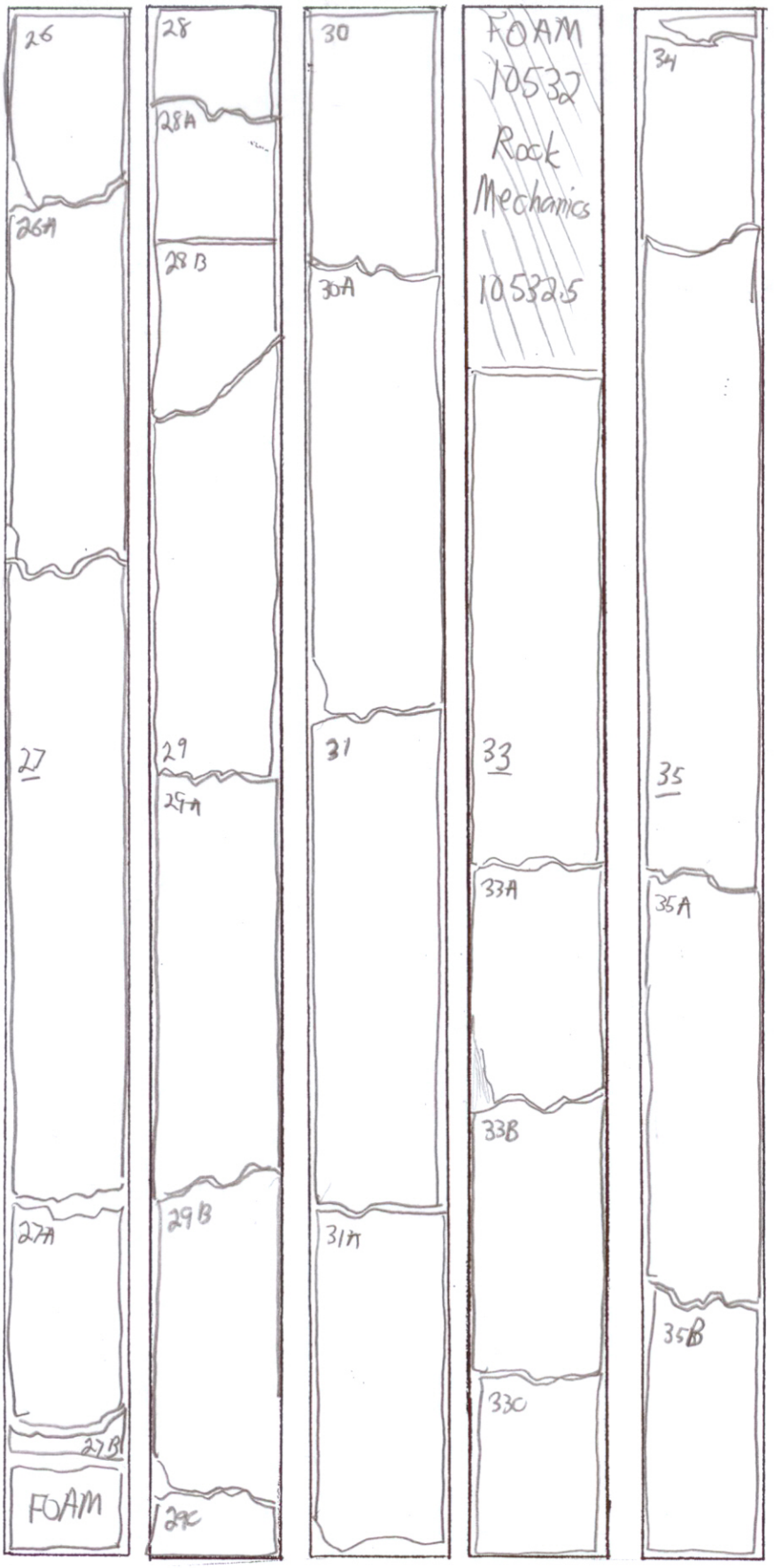
BOX : 10516 - 10526 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

BOX : 10526 - 10536 (in feet) (no.of slots : 5)

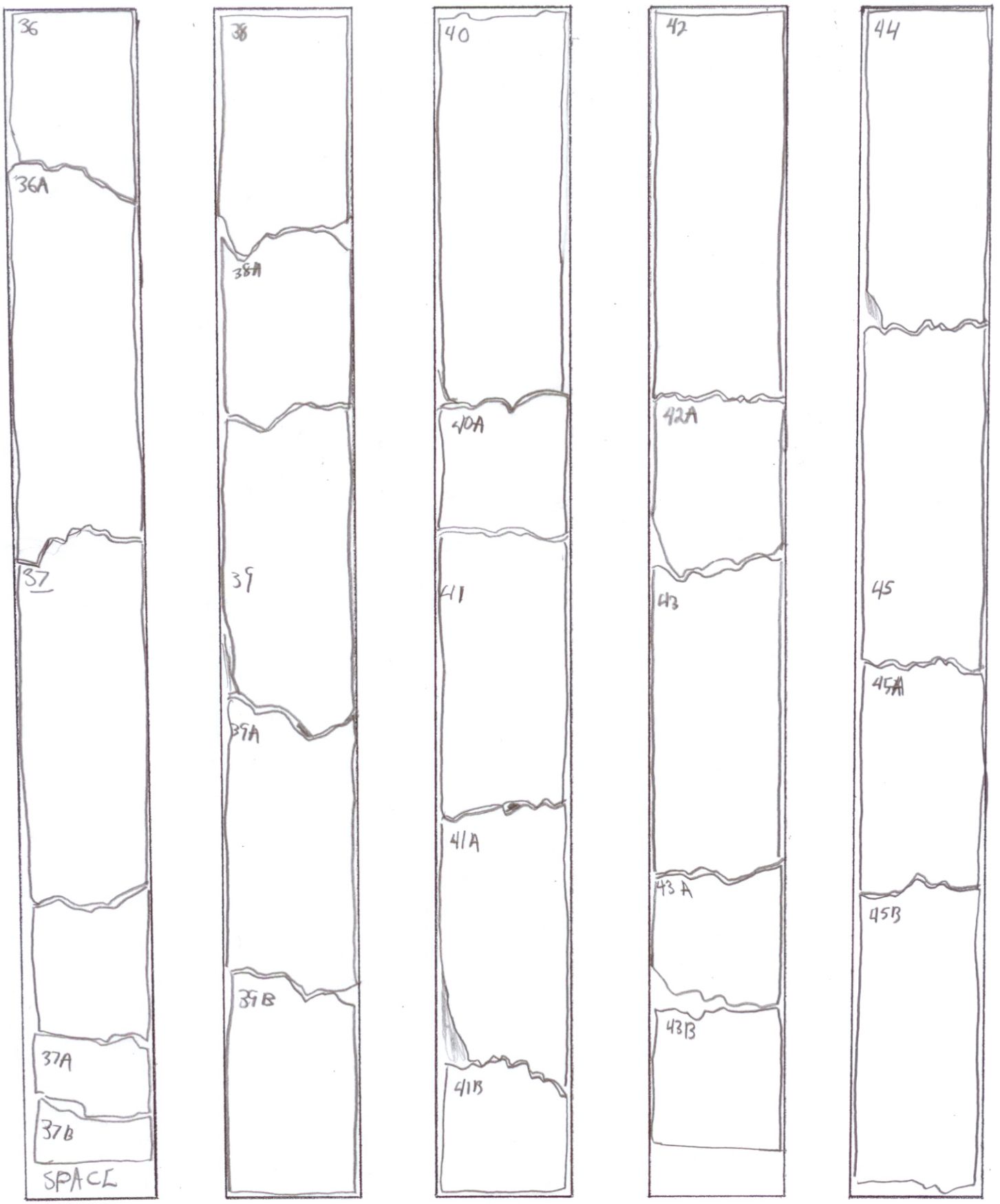


Project name : BAKKEN GEOMECHANICS File no. : 15889 Operator : Hess

Drawing by : Jill Holwerda API no. : 33061004900000

Date : 7-17-08 Scale (ratio) : Core diameter : 4"

BOX : 10536 - 10546 (in feet) (no.of slots : 5)

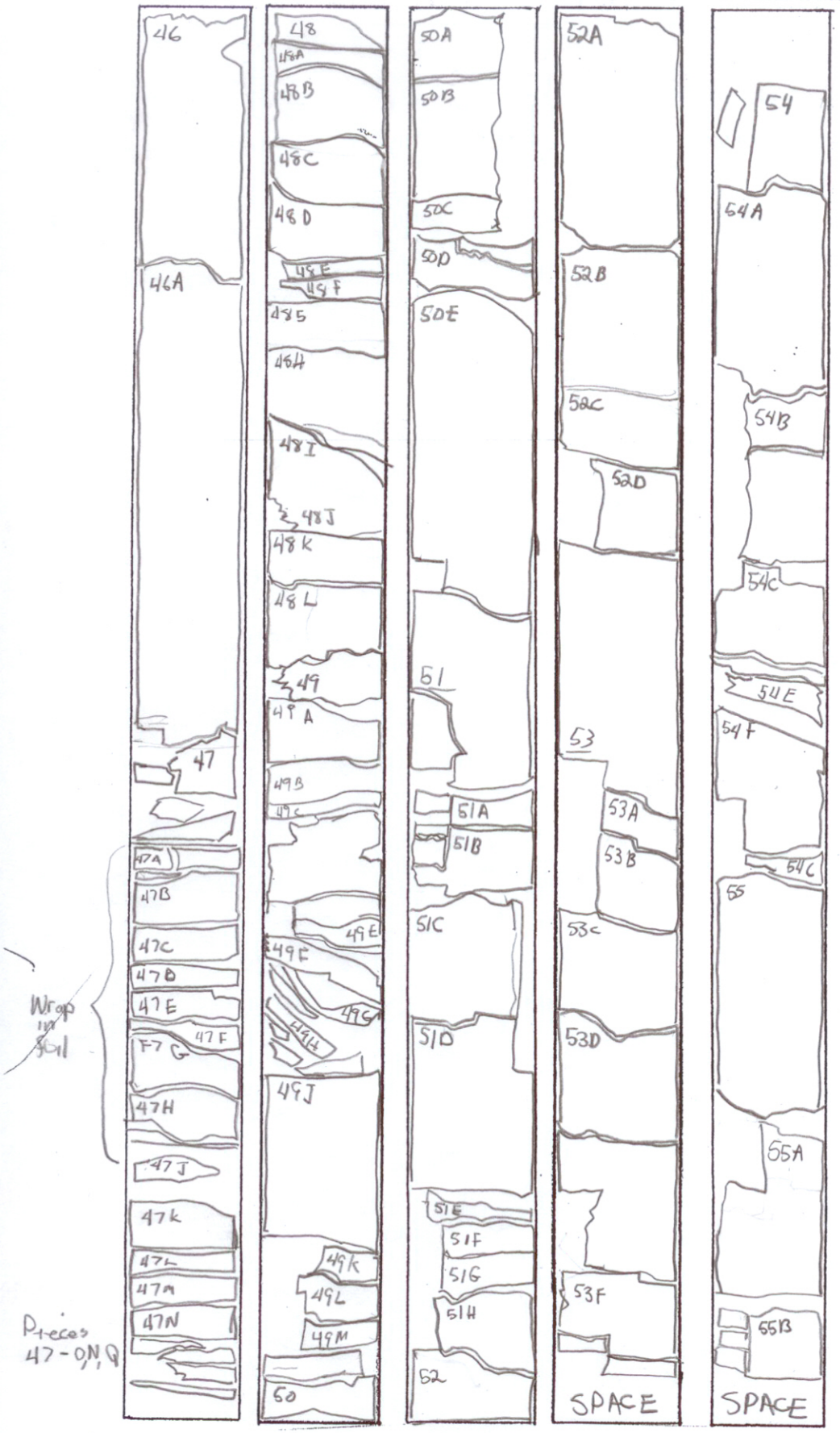


Project name : BAKKEN GEOMECHANICS File no. : 15889 Operator : Hess

Drawing by : Jill Holwerda API no. : 33061004900000 Date : 7-17-08

Scale (ratio): Core diameter : 4"

BOX : 10546 - 10556 (in feet) (no.of slots : 5)

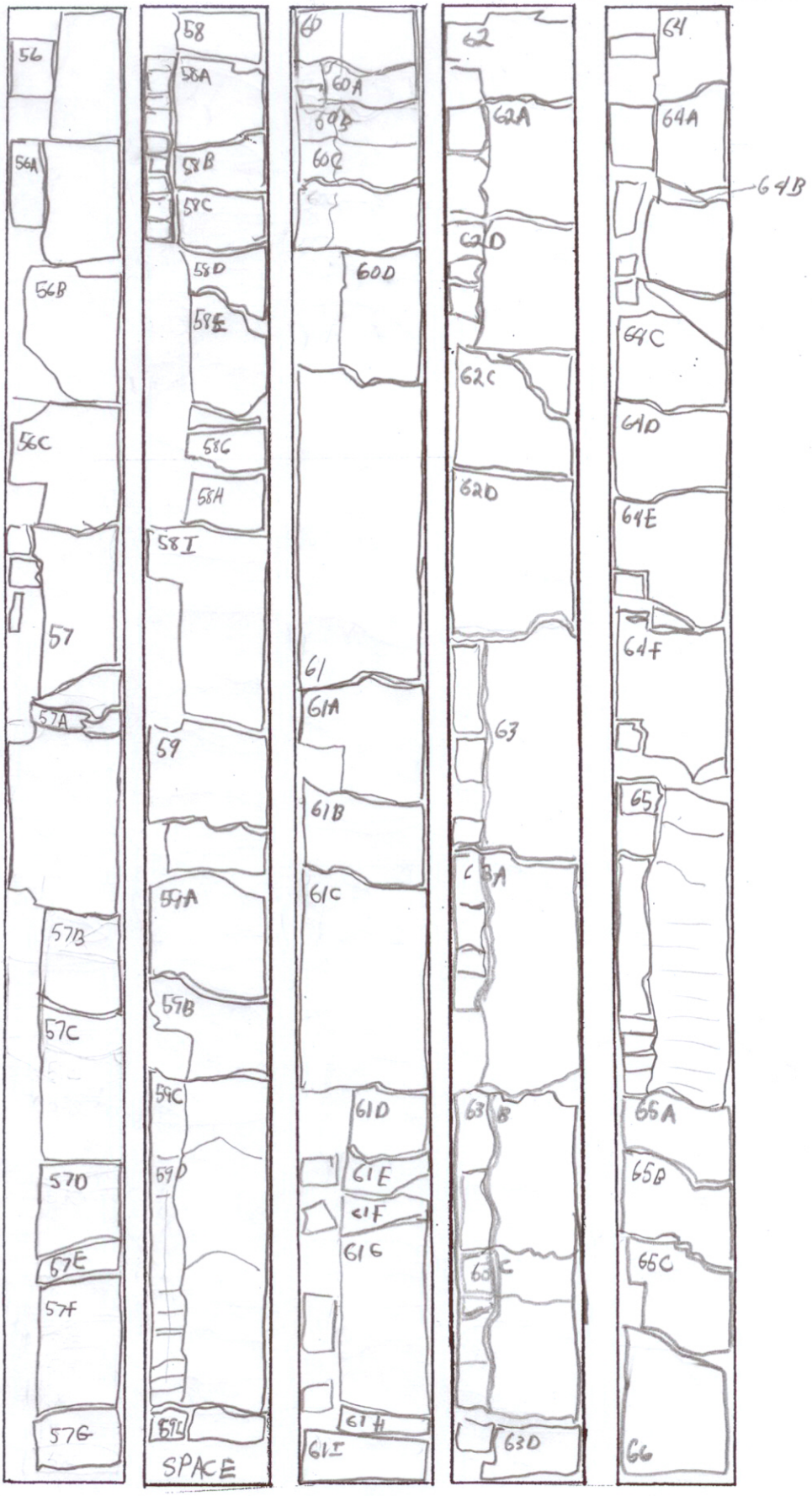


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
API no. : 33061004900000
Scale (ratio) :

Operator : Hess
Core diameter : 4"

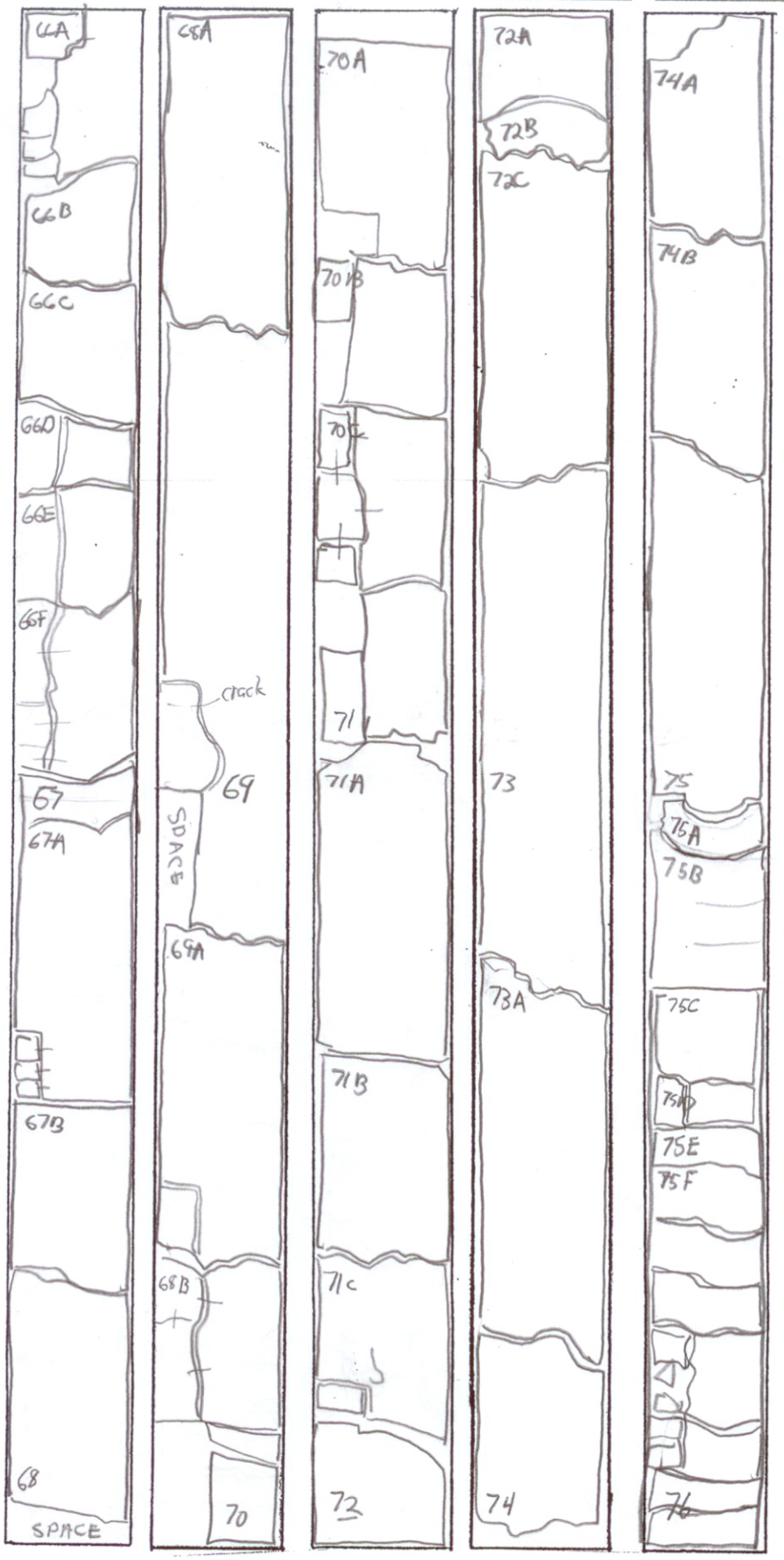
BOX : 10556 - 10566 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889 Operator : Hess
API no. : 33061004900000
Scale (ratio) : _____ Core diameter : 4"

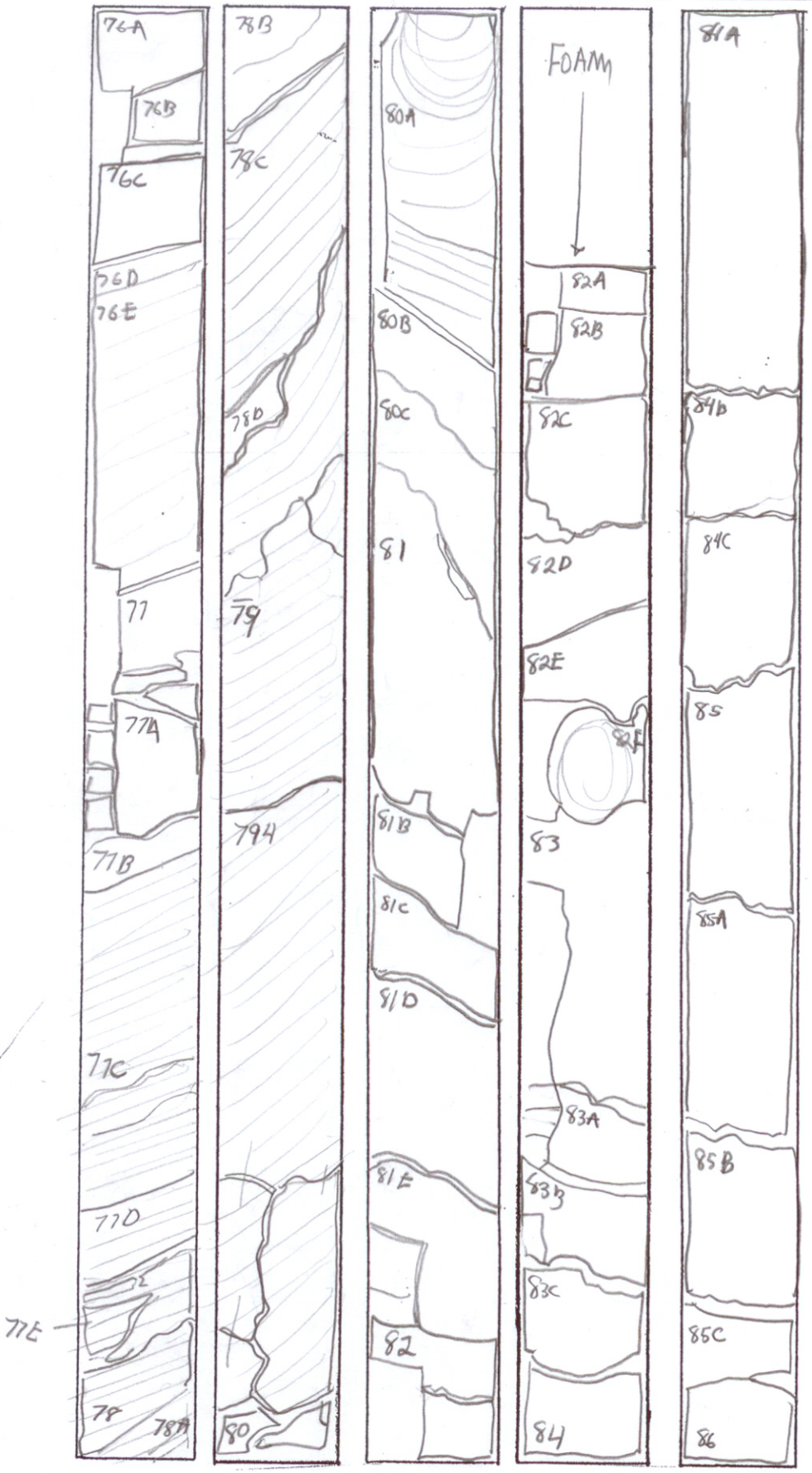
BOX : 10566 - 10576 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-16-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

BOX : 10576 - 10586 (in feet) (no.of slots : 5)



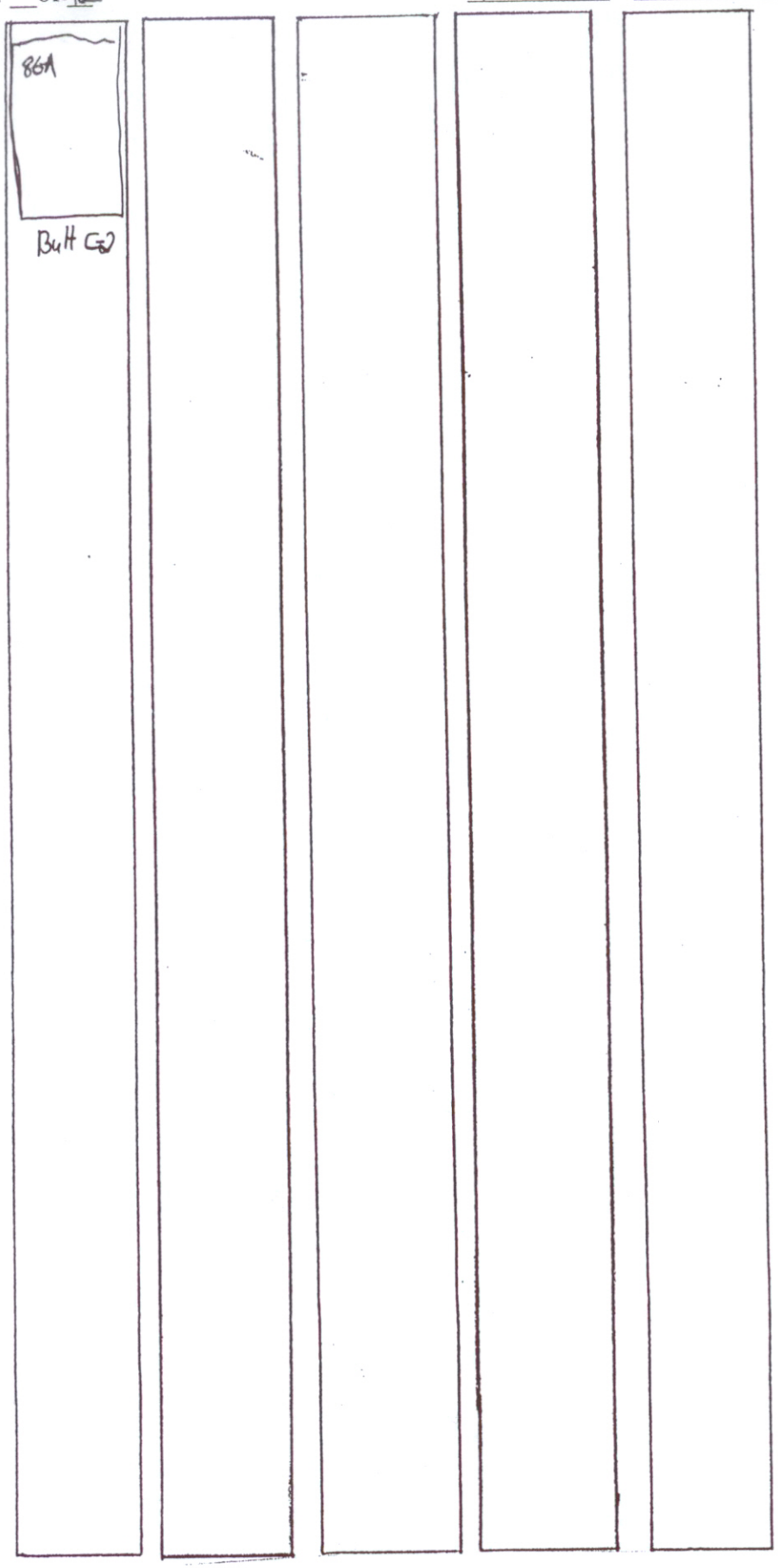
Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) :
Core diameter : 4"

Page: 18 of 22

BOX : 10586 - 10586.4 (in feet) (no.of slots : 5)

Note : 10,586.41



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-17-08

File no. : 15889

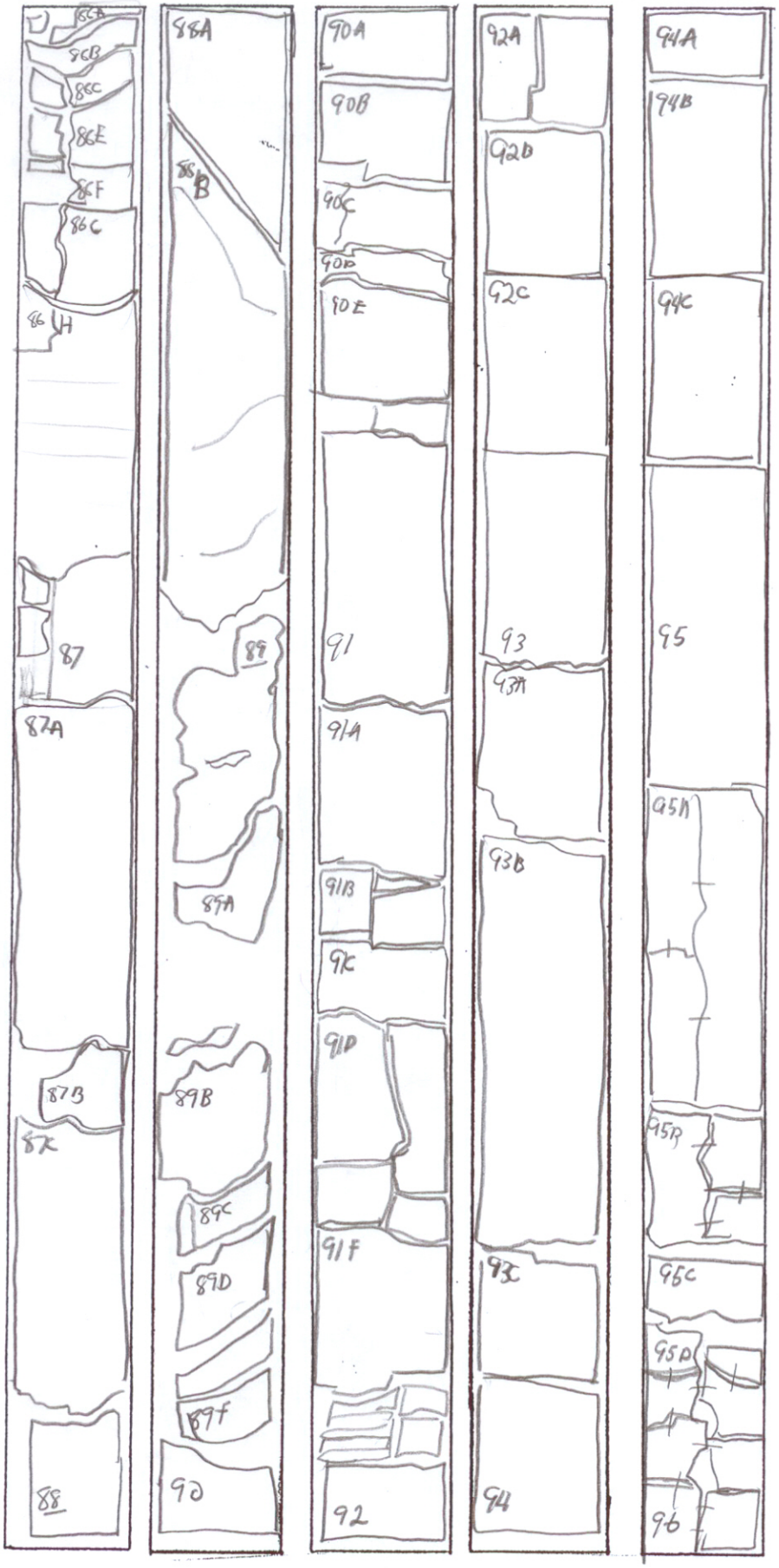
API no. : 33061004900000

Scale (ratio) :

Operator : Hess

Core diameter : 4"

BOX : 10586 - 10596 (in feet) (no.of slots : 5)

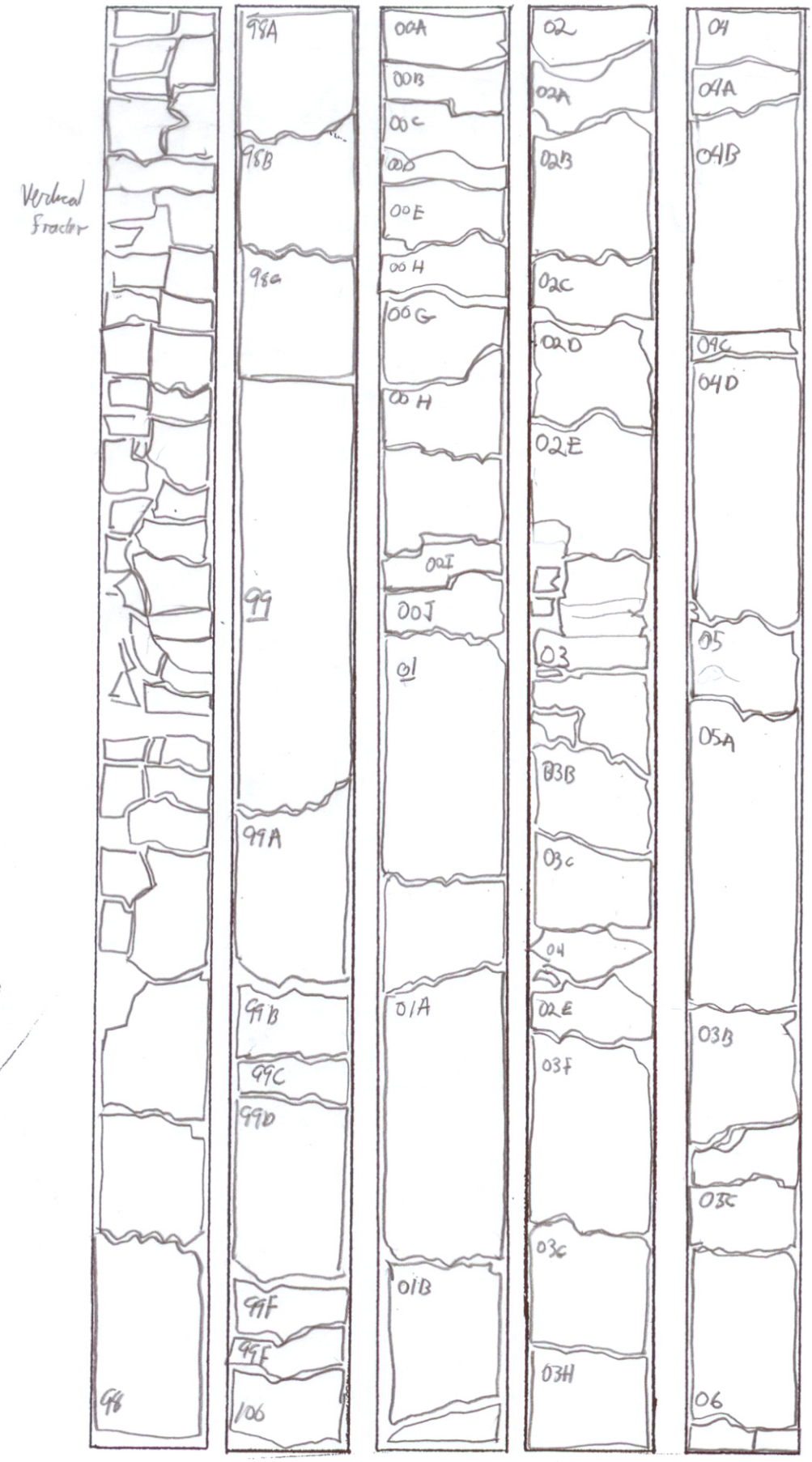


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
API no. : 33061004900000
Scale (ratio) :

Operator : Hess
Core diameter : 4"

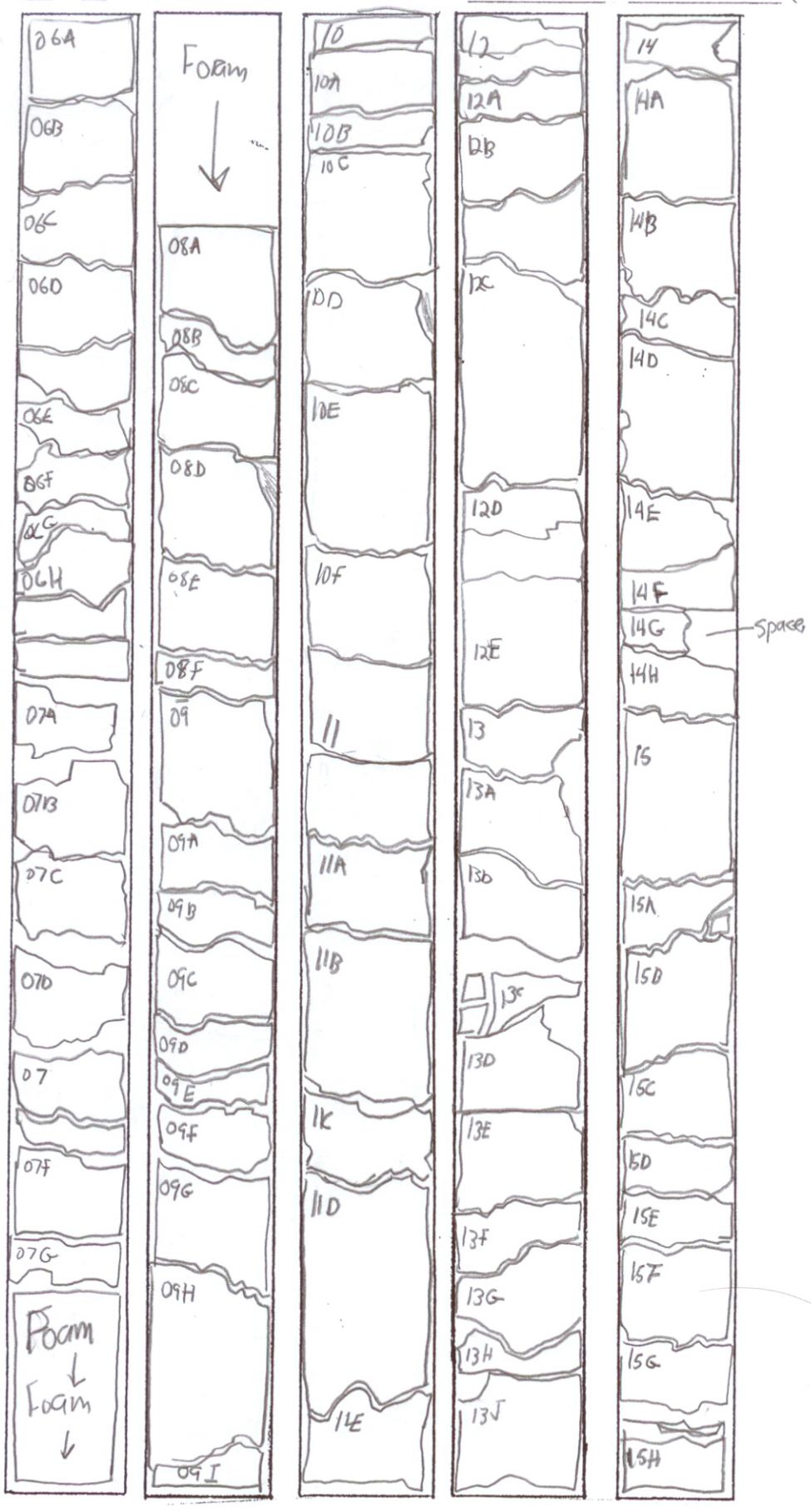
BOX : 10396 - 10606 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
Operator : Hess
API no. : 33061004900000
Scale (ratio) : _____
Core diameter : 4"

BOX : 10606 - 10616 (in feet) (no.of slots : 5)

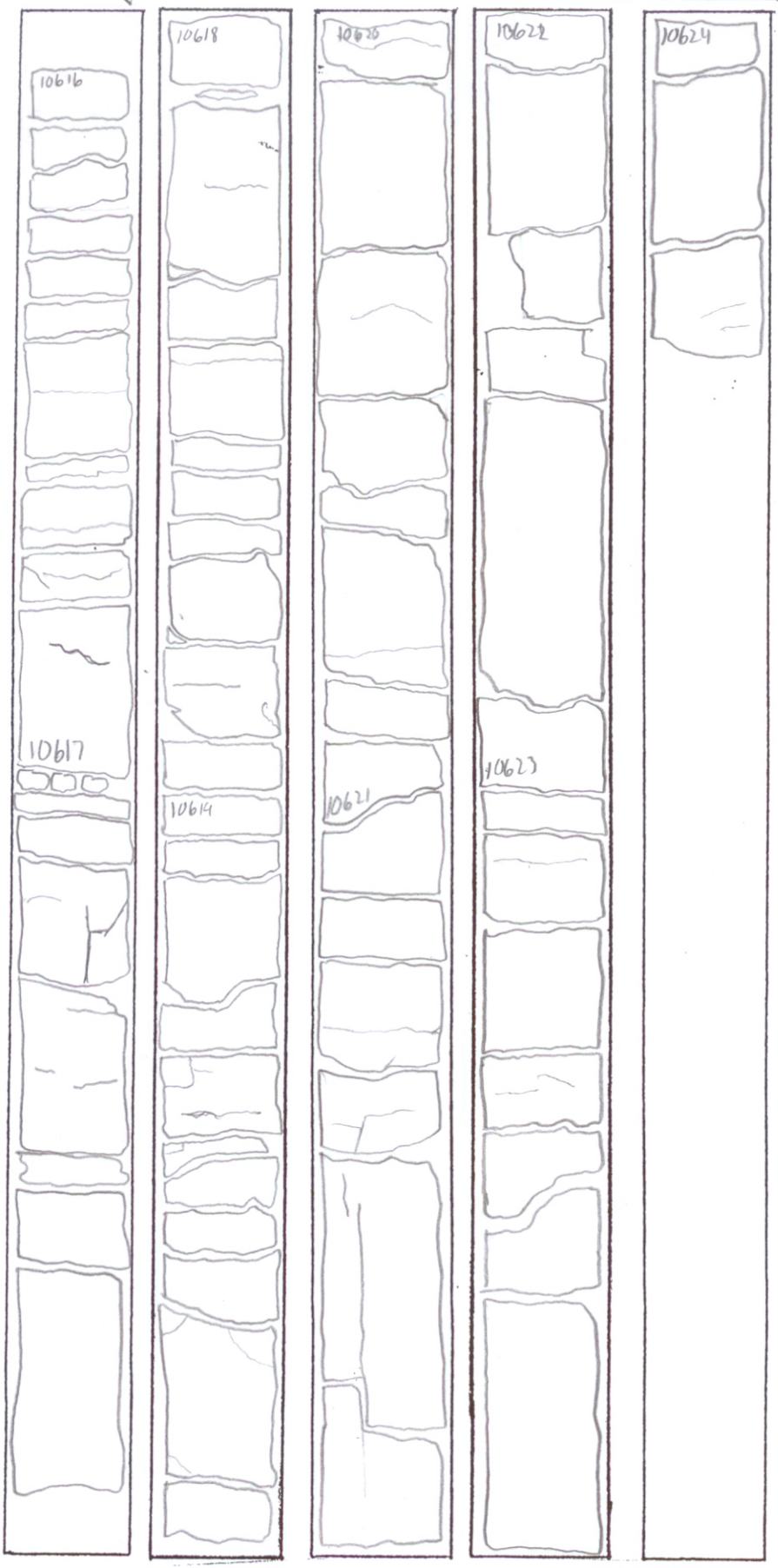


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15889
API no. : 33061004900000
Scale (ratio) :

Operator : Hess
Core diameter : 4"

BOX : 10616 - 10624.5 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-17-08

File no. : 15884
Operator : Hess
API no. : 33061009900000
Scale (ratio) :
Core diameter : 4"

Well #15923 Core survey

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10992		Black Shale	98	63	86	1	4, 0, 4, 0	Bedding Joints	1 – 21.6	Tight	None	4x4x1 To 4x4x5.6
10993						1	5, 3, 0	Bedding Joints		Tight		
10994						1	0, 3, 0	Bedding Joints		Tight		
10995						1	0, 0	Bedding Joints		Tight		4x4x0.4 To 4x4x8.5
10996						1	3, 7	Bedding Joints		Tight		
10997						1	0, 4, 1, 4	Bedding Joints		Tight		

Name: ***Smith*** 1/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10998		Black Shale	100	75	96	2	3, 1, 60, 75, 2	Bedding Joints & Vertical Fractures	1.3 – 26.7	Tight	None	3.5x3x0.3 To 4x4x6.5
10999						1	1, 3, 3	Bedding Joints		Tight		
11000						1	0	Bedding Joints		Tight		
11001		Limestone				1	2	Bedding Joints		0.02		4x4x2.3 To 4x4x10.5
11002						1	2, 6	Bedding Joints		0.04		
11003						1	2	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11004		Limestone	97	99	99	1	6	Bedding Joints	10.4 – 42.7	Tight	None	4x4x6.2 To 4x4x16.8
11005						0				0.02		
11006						1	4, 4	Bedding Joints		Tight		
11007						1	3	Bedding Joints		0.01		4x4x4.1 To 4x4x12.5
11008						1	6, 1	Bedding Joints		Tight		
11009						1	7	Bedding Joints		0.02		

Name: ***Smith*** 3/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11010		Limestone	100	78	97	2	5, 10, 15, 90	Bedding Joints & Vertical Fractures	7 - 54	Tight	None	4x4x3.1 To 4x4x21.25
11011						2	80, 5, 2	Bedding Joints & Vertical Fractures		Tight		
11012						0				Tight		
11013						1	2, 0	Bedding Joints		0.04		4x4x2.75 To 4x4x9
11014						2	60, 3	Bedding Joints & Vertical Fractures		0.02		
11015						1	6, 3, 7	Bedding Joints		0.02		

Name: ***Smith*** 4/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11016		Limestone	96	90	96	1		Bedding Joints	2.3 – 38.4	0.04	None	4x4x4.25 To 4x4x15.1
11017						1		Bedding Joints		0.01		
11018						2		Bedding Joints & Vertical Fractures		Tight		
11019						1		Bedding Joints		0.04		4x4x0.9 To 4x4x5.75
11020						1		Bedding Joints		0.01		
11021						1		Bedding Joints		0.01		

Name: ***Smith*** 5/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11022		Limestone	98	88	93	1	2, 3	Bedding Joints	8.3 – 28.2	0.01	None	4x4x3.25 To 4x4x11.1
11023						0				0.02		
11024						1	2, 7, 5	Bedding Joints		0.01		
11025						1	4	Bedding Joints		Tight		4x4x5 To 4x4x10.8
11026						1	4	Bedding Joints		Tight		
11027						1	1, 3	Bedding Joints		Tight		

Name: ***Smith*** 6/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11028		Limestone	97	92	96	1	5	Bedding Joints	3.8 – 36.6	0.01	none	4x4x1.5 To 4x4x14.4
11029						1	5, 5	Bedding Joints		0.02		
11030						1	3, 1	Bedding Joints		0.02		
11031						1	4	Bedding Joints		Tight		4x4x7.5 To 4x4x12.5
11032						1	2	Bedding Joints		Tight		
11033						1	2	Bedding Joints		0.04		

Name: ***Smith*** 7/10 Date: July, 17-18, 2008

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11034		Limestone	97	93	98	1	3, 1	Bedding Joints	8.4 – 34.9	0.01	None	4x4x5 To 4x4x10.6
11035						1	3	Bedding Joints		Tight		
11036						1	2, 7	Bedding Joints		Tight		
11037						1	5	Bedding Joints		Tight		4x4x3.3 To 4x4x13.75
11038						1	5	Bedding Joints		Tight		
11039						1	1, 3, 5	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11040		Limestone	98	89	100	1		Bedding Joints	9.4 – 41.3	Tight	None	4x4x3.7 To 4x4x10.6
11041						1		Bedding Joints		Tight		
11042						1		Bedding Joints		Tight		
11043						1		Bedding Joints		Tight		4x4x8.75 To 4x4x16.25
11044						1		Bedding Joints		Tight		
11045						1		Bedding Joints		Tight		

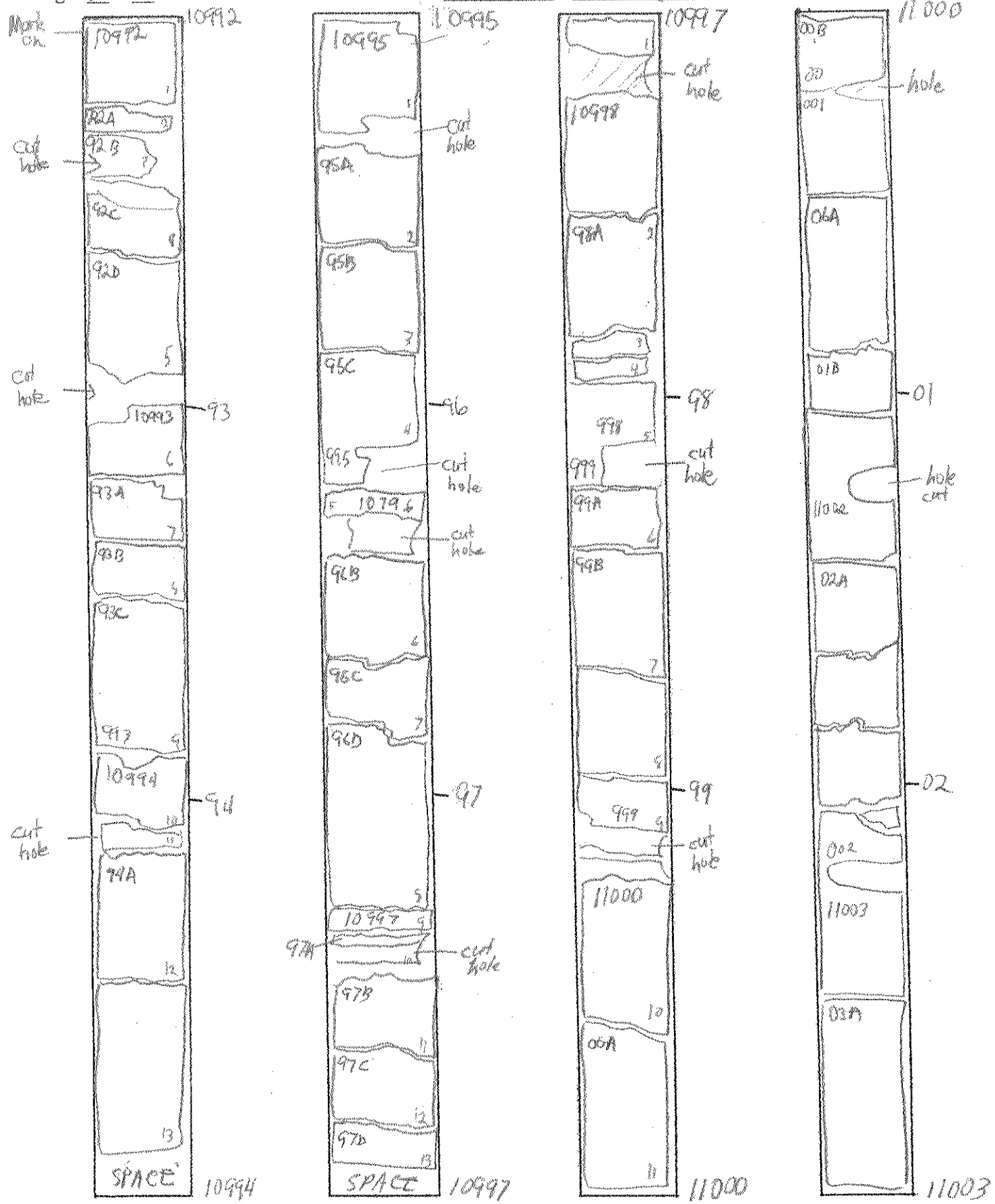
Bakken Geomech. Core description File # : 15923 Well API: 33053026720000 Operator: **Encore**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
11046		Limestone	100	82	93	1		Bedding Joints	2.3 – 28.7	Tight	none	3.75x2.1x0.9 To 4x4x11.3
11047						2		Bedding Joints & Vertical Fractures		Tight		
11048												

Name: ***Smith*** 10/10 Date: July, 17-18, 2008

Well #15923 fracture sketch

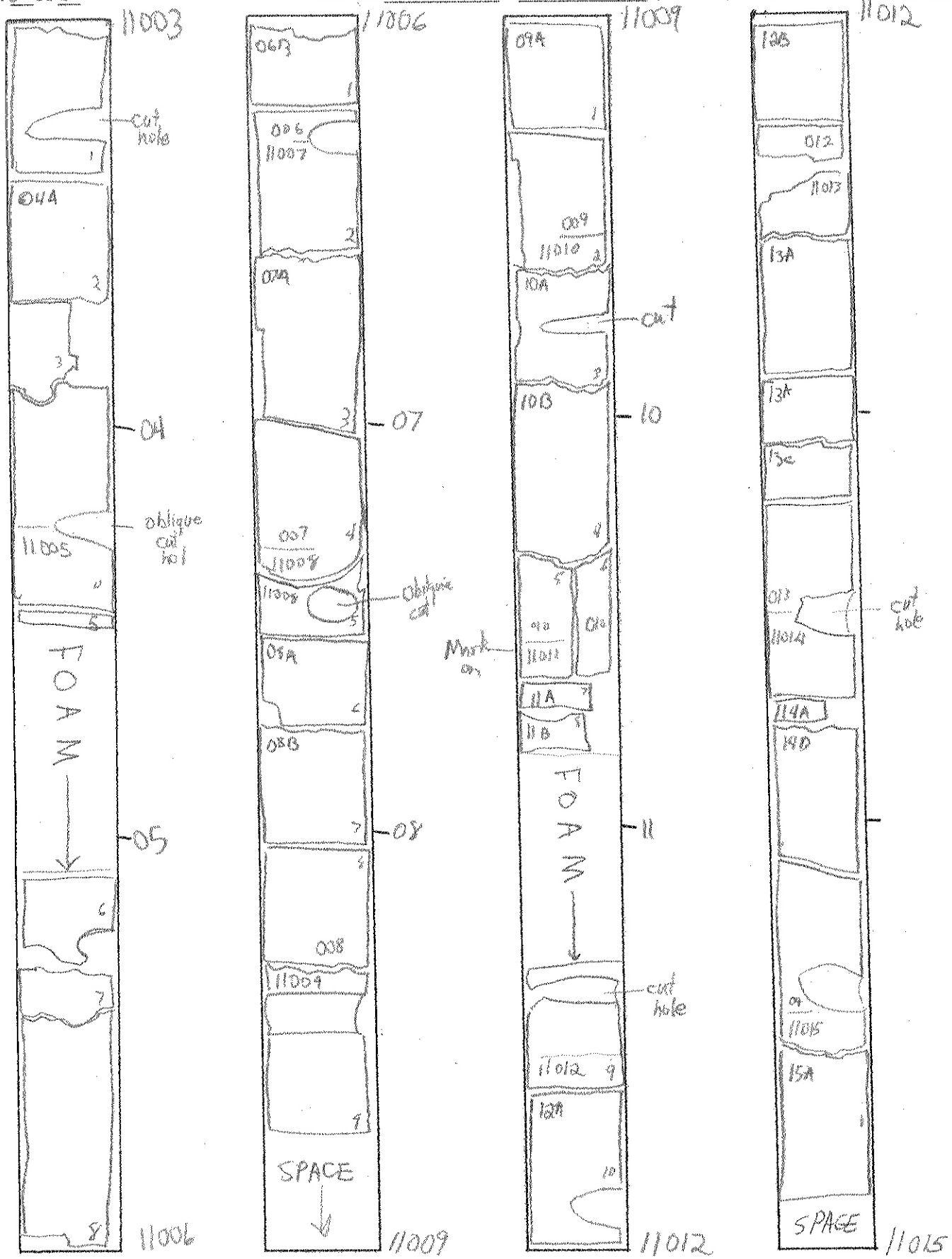
Page: 1 of 5 BOX : 10992 - 11003 (in feet) (no.of slots : NA)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 15923 Operator : Envoro
API no. : 330530267200000
Scale (ratio) : length 9"/ft width 0.33"/4" Core diameter : 4"

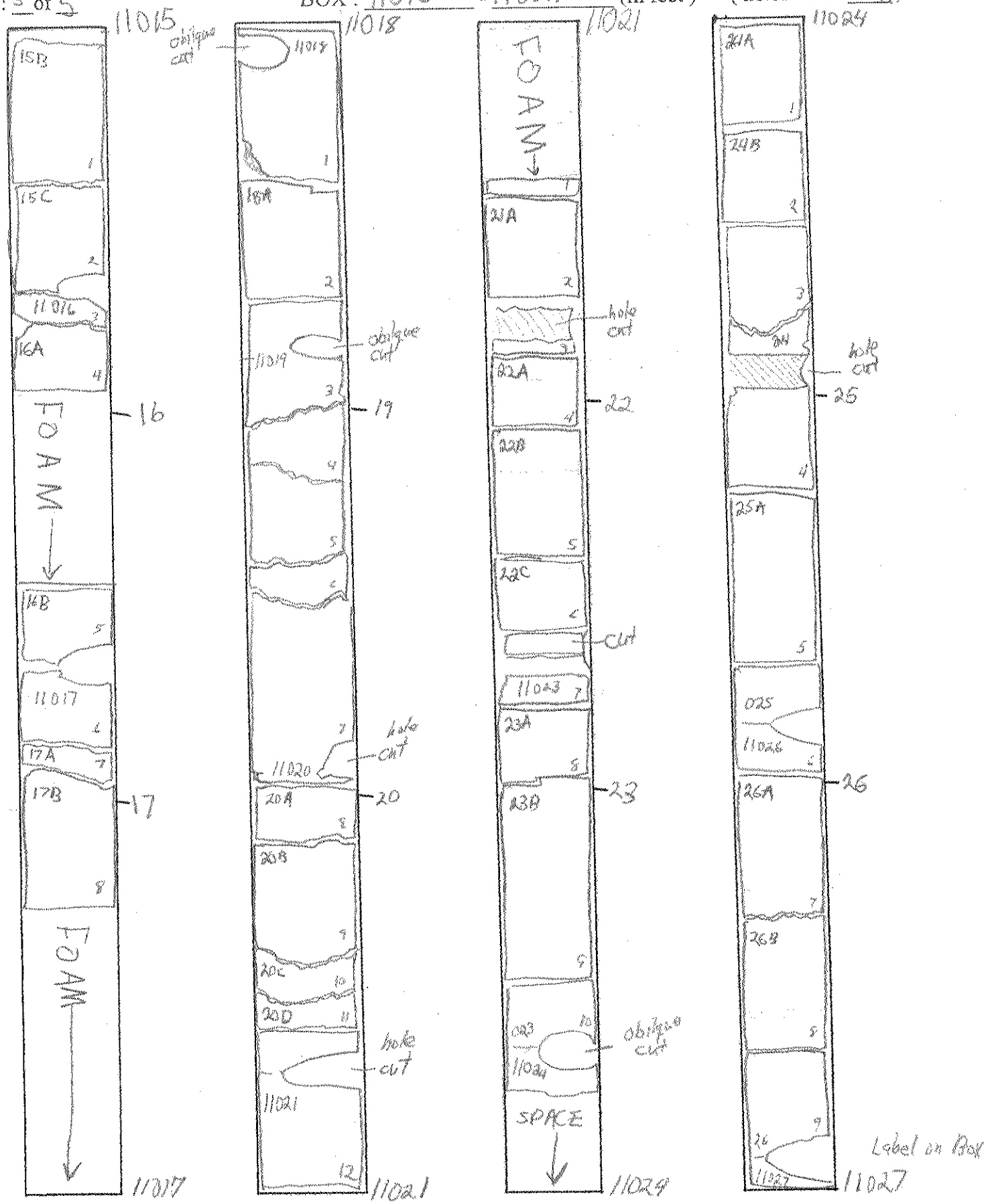
Page: 2 of 5 BOX : 11003 - 11015 (in feet) (no.of slots : NA)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 15923 Operator : Encore
API no. : 33053026720000
Scale (ratio) : length width 9"/sft 0.35"/4" Core diameter : 4"

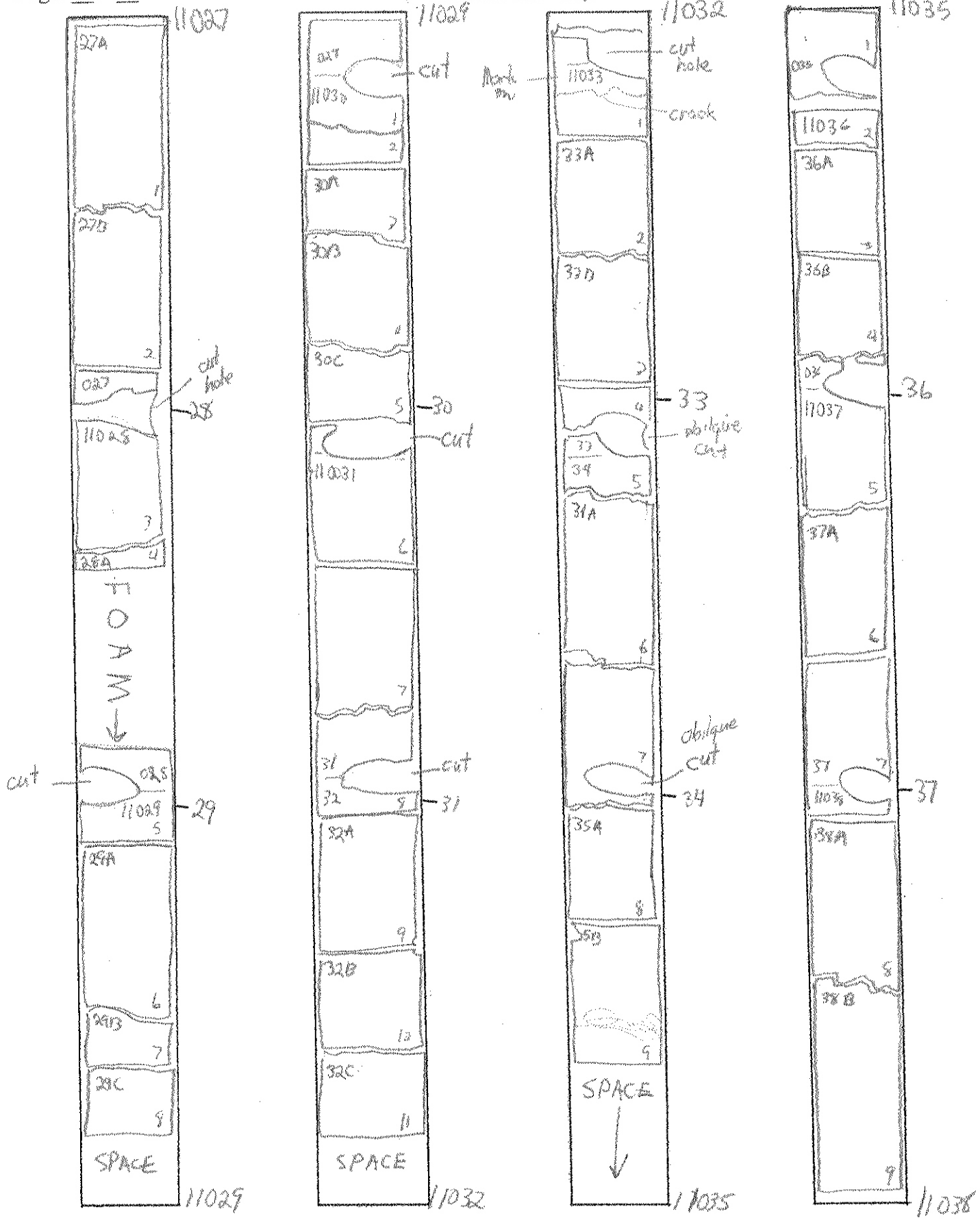
Page: 3 of 5 BOX : 11015 - 11027 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 15923 Operator : Enrore
API no. :
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

Page: 4 of 5 BOX : 11027 - 11038 (in feet) (no.of slots : N/A)

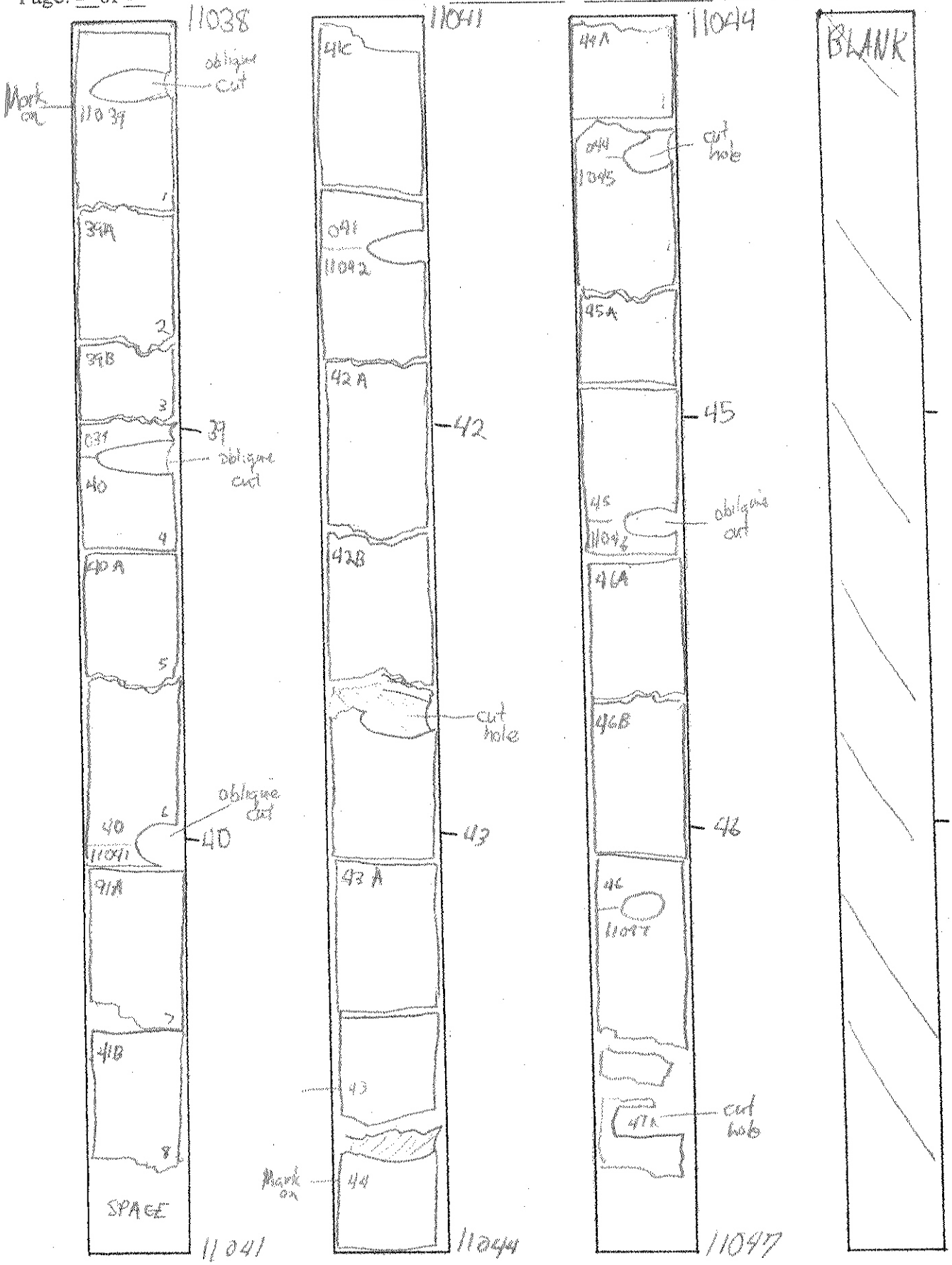


Project name : BAKKEN GEOMECHANICS File no. : 15523 Operator : Encore

Drawing by : Jill Holwerda API no. : 33053026720000

Date : 7-18-08 Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

Page: 5 of 5 BOX : 11038 - 11047 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-18-08

File no. : 15923 Operator : Encore
API no. : 33053 02672 0000
Scale (ratio) : length 9"/3ft width 0.33"/1" Core diameter : 4"

Well #15986 Core survey

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10491		Limestone	100	61	97	1	15, 7, 4, 0	Bedding joints	4.1 – 17.8	0.02	None	4x4x1.6 To 4x4x6.75
10492						1	3, 6, 7	Bedding joints		Tight		
10493						1	4, 0, 3, 2, 2	Bedding joints		0.02		4x4x2.25 To 4x4x7
10494						1	3, 0, 6	Bedding joints		0.01		
10495						1	7, 12, 17	Bedding joints		0.02		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10496		Limestone	92	81	99	1	7, 7	Bedding joints	6.4 - 26	tight	None	4x4x3.5 To 4x4x10.25
10497						1	5, 12, 9	Bedding joints		tight		
10498						1	6	Bedding joints		tight		
10499						1	7, 0	Bedding joints		tight		4x4x2.5 To 4x4x9.5
10500						1	9, 7	Bedding joints		0.02		
10501						1	12, 8, 3, 6	Bedding joints		0.02		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10502		Limestone	100	77	100	1	3, 6, 3	Bedding joints	5.1 – 23.9	tight	None	4x4x2.1 To 4x4x9.4
10503						1	5, 6, 2	Bedding joints		0.01		
10504						1	4, 5, 4	Bedding joints		0.01		
10505						1	2	Bedding joints		Tight		4x4x2 To 4x4x9.25
10506						1	1, 3	Bedding joints		Tight		
10507						1	7, 6, 11	Bedding joints		tight		

Name: *Smith & Naga* 3/16 Date: July, 7 , 2008

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10508		Limestone	99	40	60	1	7, 8	Bedding joints	1.9 – 21.6	0.02	None	4x4x4.5 To 4x4x8.5
10509						1	3, 7	Bedding joints		0.01		
10510		Black Shale High Carbon Content				1	2, 11, 3, 3, 6, 0	Bedding joints		Tight		
10511						1	4, 4, 2, 2, 3	Bedding joints		0.01		4x4x0.75 To 4x4x3.9
10512						1	2, 4, 2, 6, 2, 1	Bedding joints		0.02		
10513						1	2, 8, 4, 6, 4, 2, 3, 0, 3, 4	Bedding joints		Tight		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10514		Black Shale High Carbon Content	100	0	48	1	1, 1, 3, 2, 4	Bedding joints	0.5 – 8.6	0.02	None	4x4x0.2 To 4x4x3.4
10515						1	2, 4, 5, 6, 5, 2	Bedding joints		0.01		
10516						1	3, 2, 4, 3, 4, 1, 3, 3, 1, 4, 6	Bedding joints		Tight		
10517						2	10, 15, 90, 3, 2, 0, 6, 85, 4, 2, 7	Bedding joints & Vertical Fractures		0.01		1.6x4x0.6 To 4x4x2.8
10518						2	5, 80, 4, 0, 5, 0, 3, 4	Bedding joints & Vertical Fractures		Tight		
10519						1	2, 15, 6, 0, 21, 2	Bedding joints		0.01		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10520		Black Shale High Carbon Content	79	8	73	1	8, 5, 5, 7	Bedding joints	0.8 – 11.9	0.01	None	4x4x1.4 To 4x4x3.2
10521						1	4	Bedding joints		Tight		
10522						2	5, 2, 80, 6, 4	Bedding joints & Vertical Fractures		Tight		
10523						1	5	Bedding joints		0.01		2.5x4x2.4 To 4x4x4.7
10524						1	3, 1, 0, 0, 3	Bedding joints		Tight		
10525						2	3, 8, 77, 25, 3, 0, 15	Bedding joints & Vertical Fractures		Tight		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10526		Black Shale High Carbon Content	96	61	91	1	2, 0, 6	Bedding joints	3.8 -34.5	tight	None	4x4x1.5 To 4x4x4.8
10527						1	1, 3, 3, 1	Bedding joints		0.02		
10528		Siltstone				1	11, 0	Bedding joints		0.04		
10529						1	5, 11, 5	Bedding joints		Tight		4x4x3.3 To 4x4x13.6
10530						1	0	Bedding joints		0.02		
10531						1	5	Bedding joints		0.02		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10532		Siltstone	93	52	60	1	0	Bedding joints	5 – 25.7	0.04	None	4x4x2 To 4x4x4.7
10533						1	4, 7, 3	Bedding joints		0.02		
10534						1	25, 7, 7	Bedding joints		0.02		
10535						1	3, 2, 0	Bedding joints		0.02		4x4x2 To 4x4x10.1
10536						1	3	Bedding joints		0.01		
10537						1	0, 0, 3	Bedding joints		0.05		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10538		Limestone	88	80	92	1	5, 4, 0, 6	Bedding joints	3.8 – 25.7	tight	None	4x4x1.5 To 4x4x10.1
10539						1	11, 23, 3	Bedding joints		tight		
10540						1	5	Bedding joints		tight		
10541						1	2	Bedding joints		tight		4x4x2 To 4x4x6.25
10542						1	0, 4, 0	Bedding joints		tight		
10543						1	8, 1	Bedding joints		tight		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10544		Limestone	77	89	99	1	9	Bedding joints	5.6 – 27.4	tight	None	4x4x2.2 To 4x4x9.7
10545						1	9	Bedding joints		tight		
10546						1	6, 6	Bedding joints		tight		
10547						1	4	Bedding joints		0.02		4x4x2.75 To 4x4x10.8
10548						1	6	Bedding joints		0.01		
10549						1	3, 20	Bedding joints		tight		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10550		Limestone	100	85	93	1	5, 10, 20	Bedding joints	1.8 – 22.1	0.04	None	4x4x1.4 To 4x4x8.1
10551						1	17	Bedding joints		0.04		
10552						1	14, 5, 12	Bedding joints		Tight		
10553						1	7, 11, 4, 9	Bedding joints		0.01		4x4x0.7 To 4x4x8.7
10554						1	3, 0, 0	Bedding joints		0.02		
10555						1	0	Bedding joints		Tight		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10556		Limestone	90	76	95	1	8, 0	Bedding joints	2.8 – 26.2	tight	None	4x4x2.8 To 4x4x7.6
10557						1	1, 2	Bedding joints		0.01		
10558						1	3, 12	Bedding joints		0.02		
10559						1	5, 4	Bedding joints		0.04		4x4x1.1 To 4x4x10.3
10560						1	2, 2, 3	Bedding joints		0.04		
10561						1	0, 2, 6	Bedding joints		0.02		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10562		Limestone	97	78	94	1	0, 4	Bedding joints	5.8 – 24.1	0.02	None	4x4x2.3 To 4x4x9.3
10563						1	10, 7, 0	Bedding joints		0.04		
10564						1	5, 4	Bedding joints		0.04		
10565						1	0	Bedding joints		0.01		4x4x2.5 To 4x4x9.5
10566						1	0, 2, 0	Bedding joints		Tight		
10567						1	2, 6	Bedding joints		0.01		

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10568		Limestone	98	84	87	1	5	Bedding joints	3.6 – 25.4	0.02	None	4x4x1.4 To 4x4x10
10569						1	5, 18, 4, 7	Bedding joints		0.05		
10570						1	4	Bedding joints		0.04		
10571						1	3, 0, 9, 5	Bedding joints		0.04		4x4x2.25 To 4x4x8.5
10572						1	9	Bedding joints		Tight		
10573						1	10, 3	Bedding joints		Tight		

Name: *Smith & Naga* 14/16 Date: July, 7 , 2008

Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10574		Limestone	88	89	93	1	8	Bedding joints	4.3 – 29.5	0.01	None	4x4x1.7 To 4x4x11.6
10575						1	3	Bedding joints		0.01		
10576						1	1, 2, 4, 2, 8	Bedding joints		Tight		
10577						1	5, 0	Bedding joints		0.01		4x4x4.4 To 4x4x10.6
10578						1	9	Bedding joints		Tight		
10579						1	2, 8	Bedding joints		Tight		

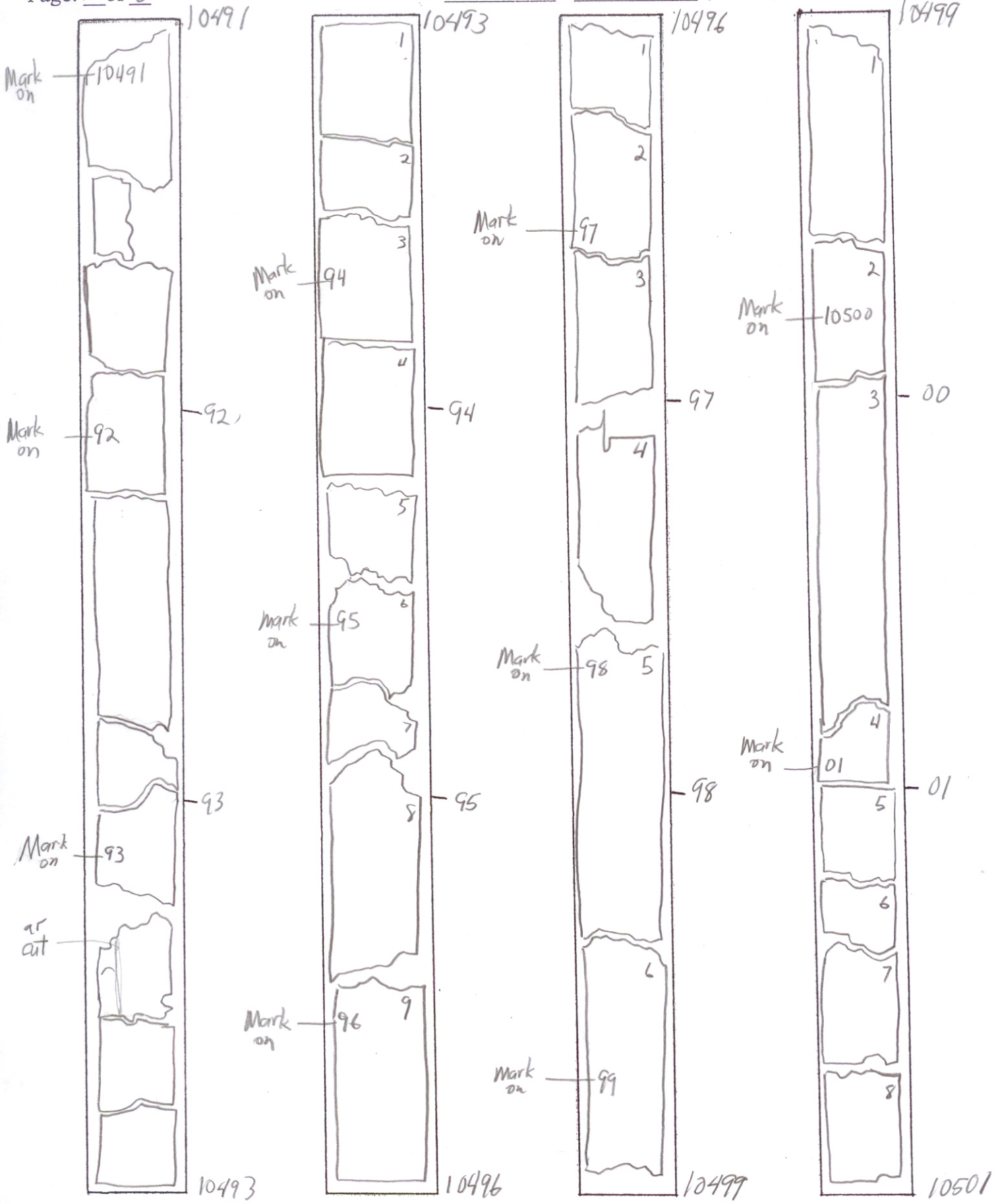
Bakken Geomech. Core description File # : 15986 Well API: 33061004930000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10580		Limestone	85	84	97	1	9, 8	Bedding joints	2 – 25.7	tight	None	4x4x0.8 To 4x4x10.1
10581						1	10, 0	Bedding joints		tight		
10582												

Name: *Smith & Naga* 16/16 Date: July, 7 , 2008

Well #15986 fracture sketch

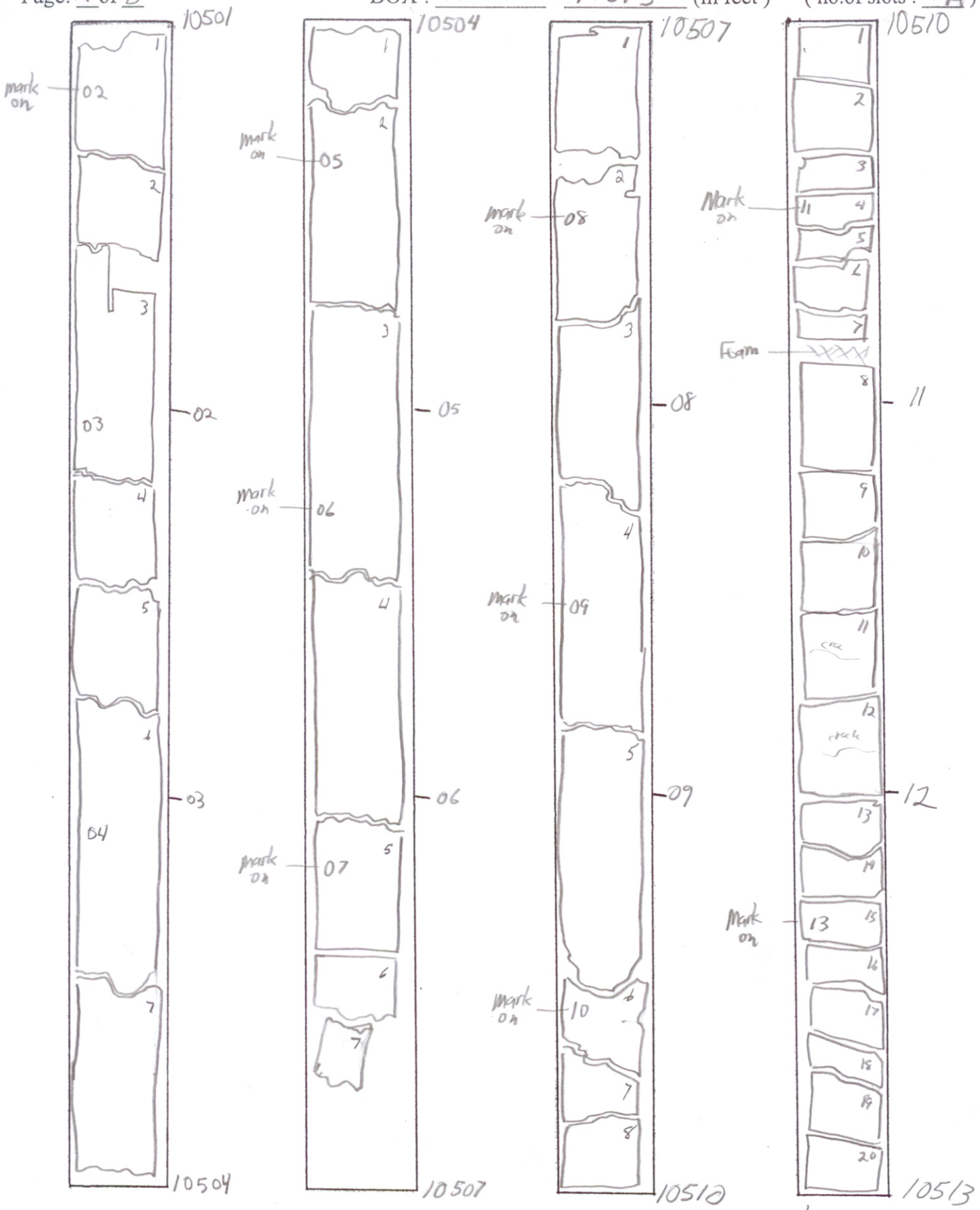
Page: 1 of 8 BOX : 10491 - 10501 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 15986 Operator : Hess
API no. : 33061004930000
Scale (ratio) : length 9"/3' width 0.33"/4" Core diameter : 4"

Page: 2 of 8 BOX : 10501 - 10513 (in feet) (no.of slots : N/A)

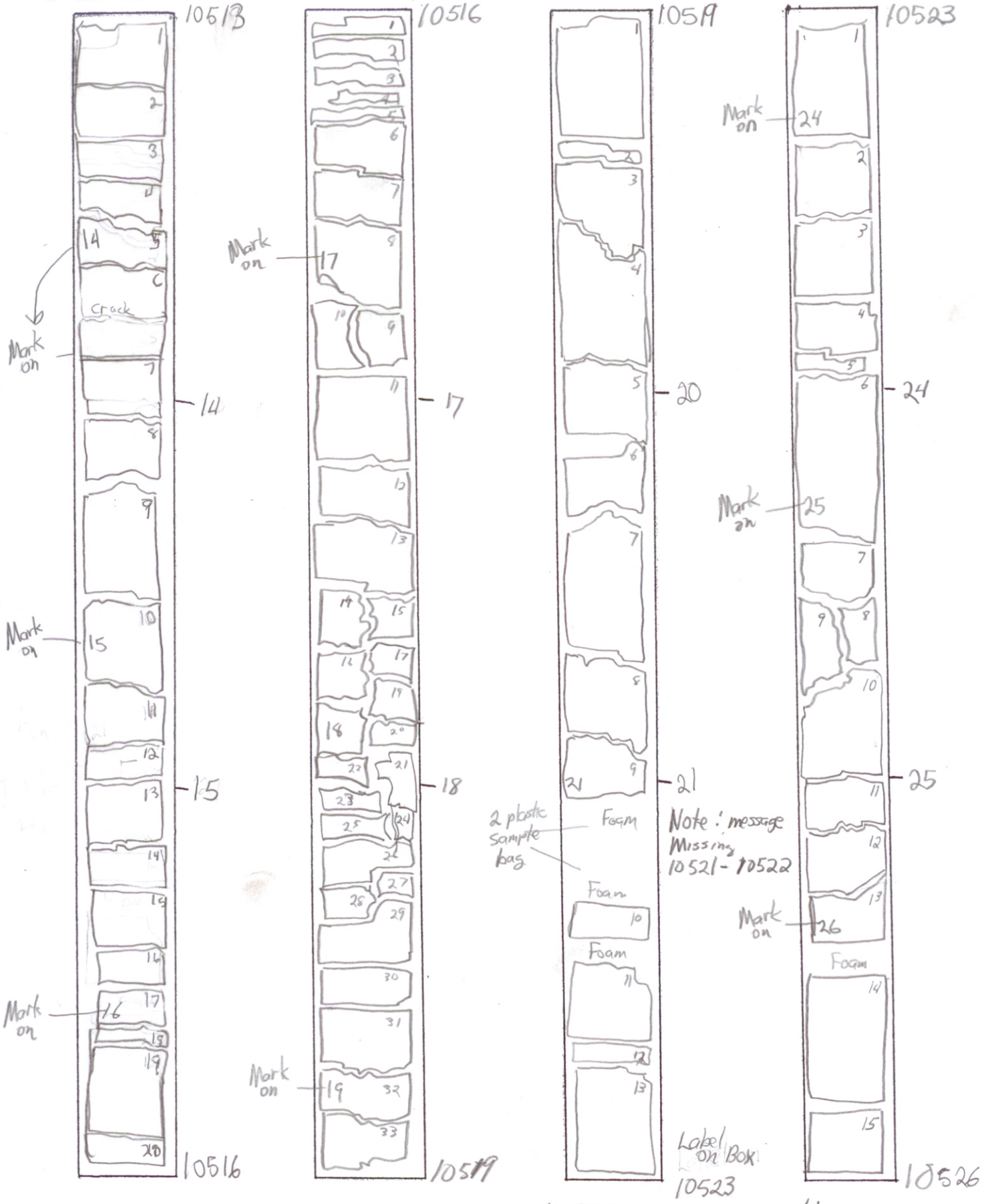


Project name : BAKKEN GEOMECHANICS File no. : 15986 Operator : Hess

Drawing by : Jill Holwerda API no. : 3306100493 0000

Date : 7-7-08 Scale (ratio) : length 9"/3' width 0.33"/4" Core diameter : 4"

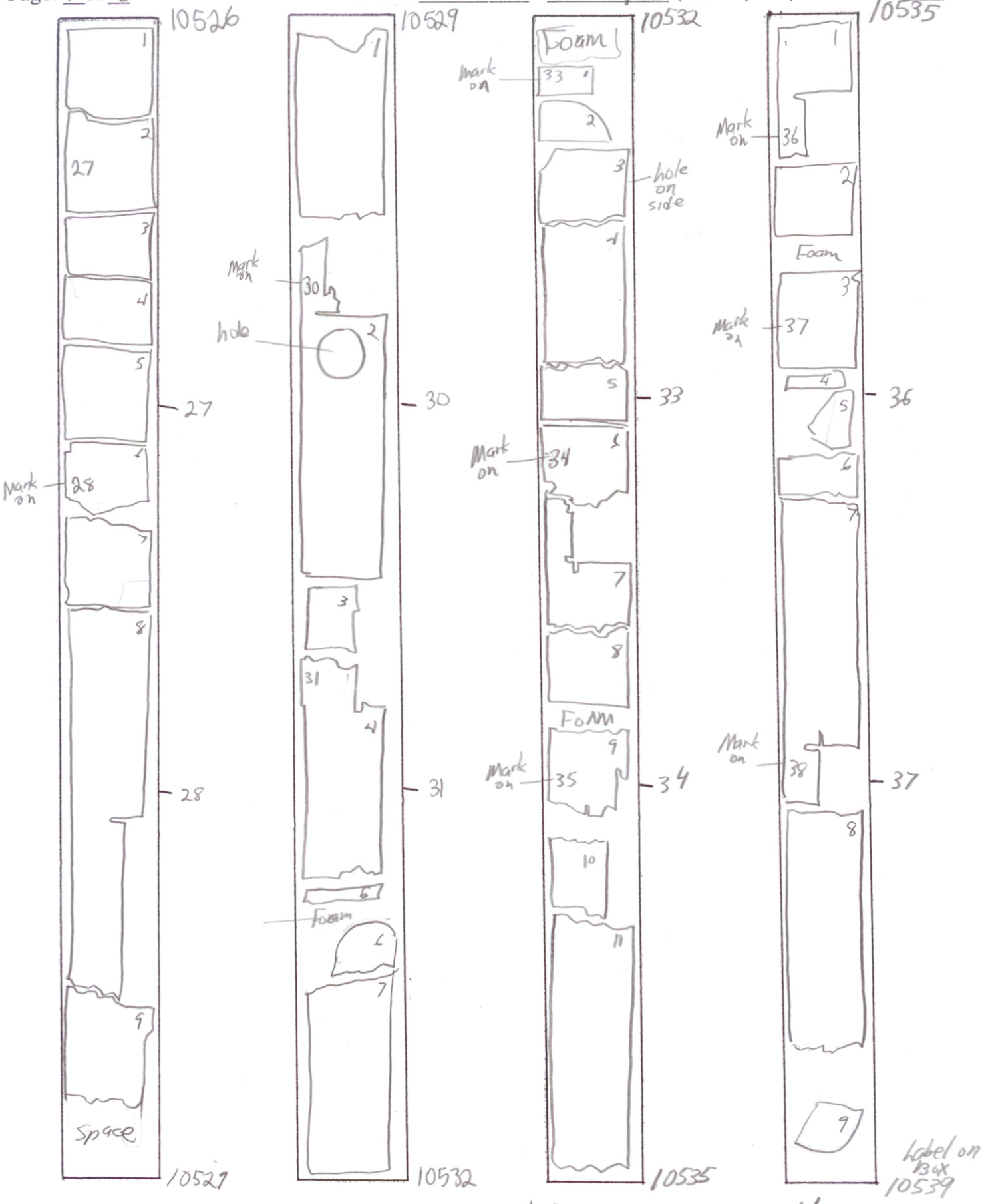
Page: 3 of 8 BOX : 10513 - 10526 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-7-08

File no. : 15986 Operator : Hess
API no. : 33061004930000
Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

Page: 4 of 8 BOX : 10526 - 10539 (in feet) (no.of slots : N/A)

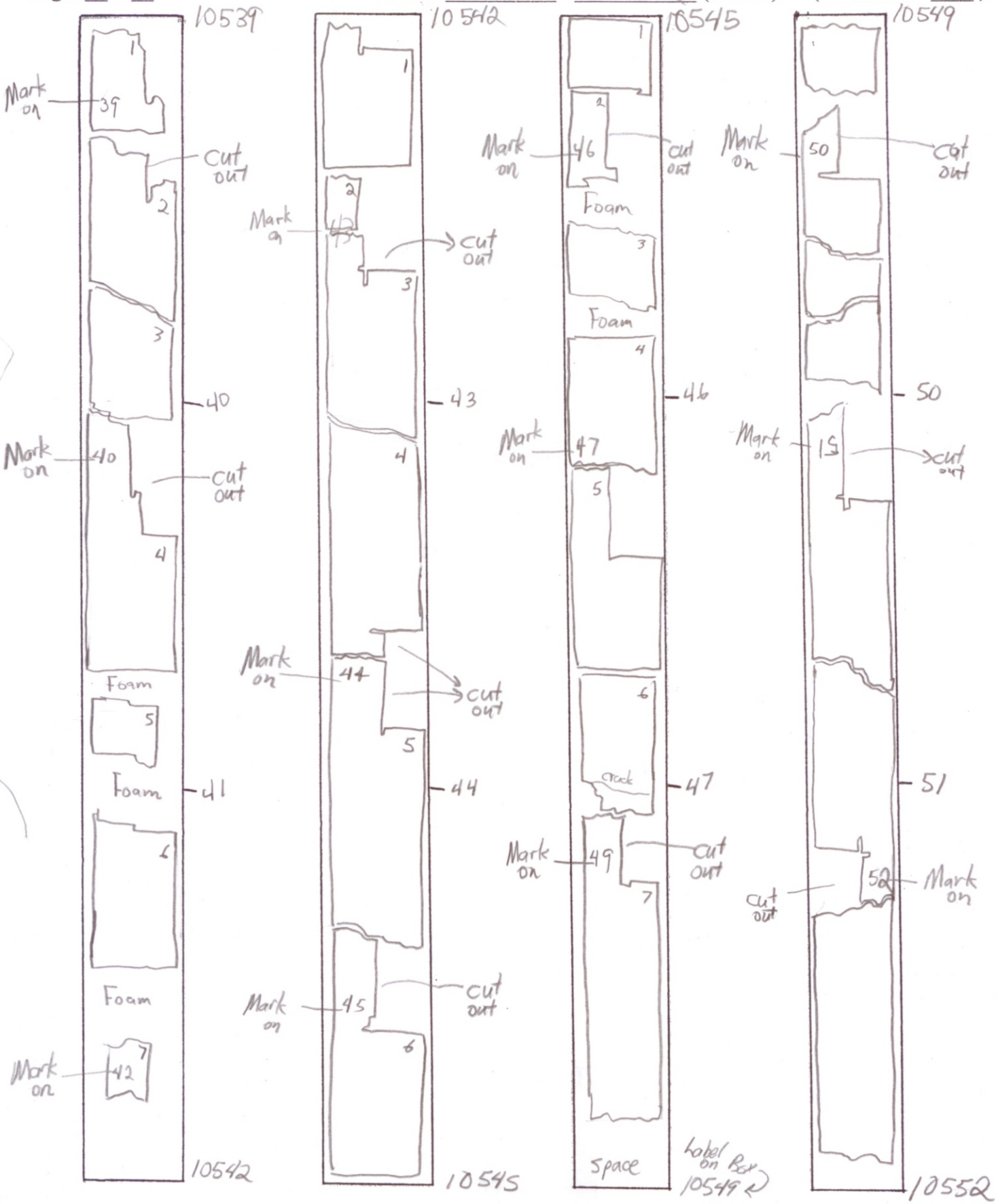


Project name : BAKKEN GEOMECHANICS File no. : 15986 Operator : Hess

Drawing by : Jill Holwerda API no. : 33061004930000

Date : 7-7-08 Scale (ratio) : length 9"/37 width 0.33"/4" Core diameter : 4"

Page: 5 of 8 BOX : 10539 - 10542 (in feet) (no.of slots : N/A)



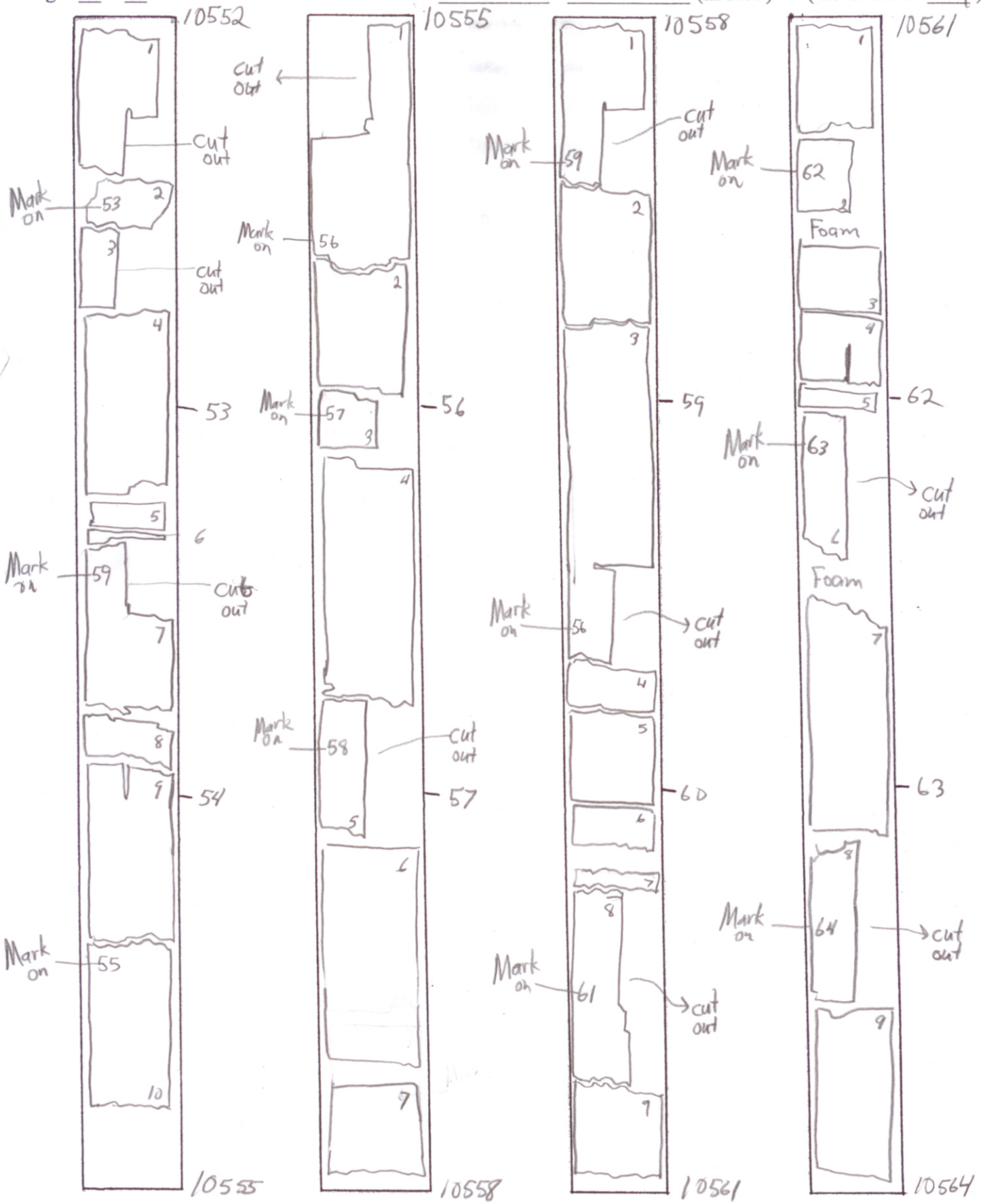
Project name : BAKKEN GEOMECHANICS File no. : 15986 Operator : Hess

Drawing by : Jill Holwerda API no. : 33061004930000

Date : 7-8-08 Scale (ratio) : length width Core diameter : 4"

9"/38' 0.33"/4"

BOX : 10552 - 10555 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-8-08

File no. : 15986

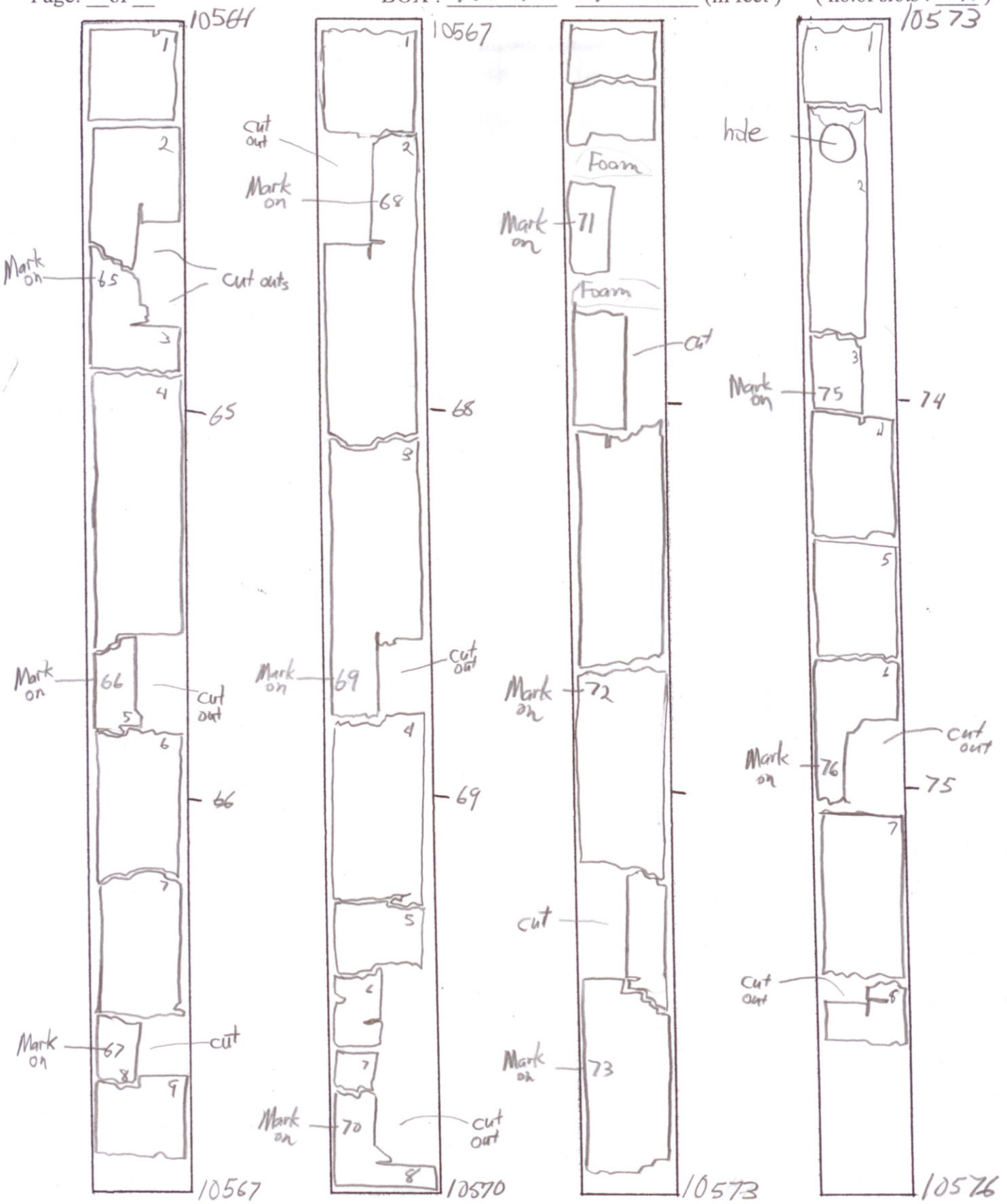
Operator : Hess

API no. : 33061004930000

Scale (ratio) : length 9"/3' width 0.33"/4"

Core diameter : 4"

BOX : 10564 - 10576 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-8-08

File no. : 15986

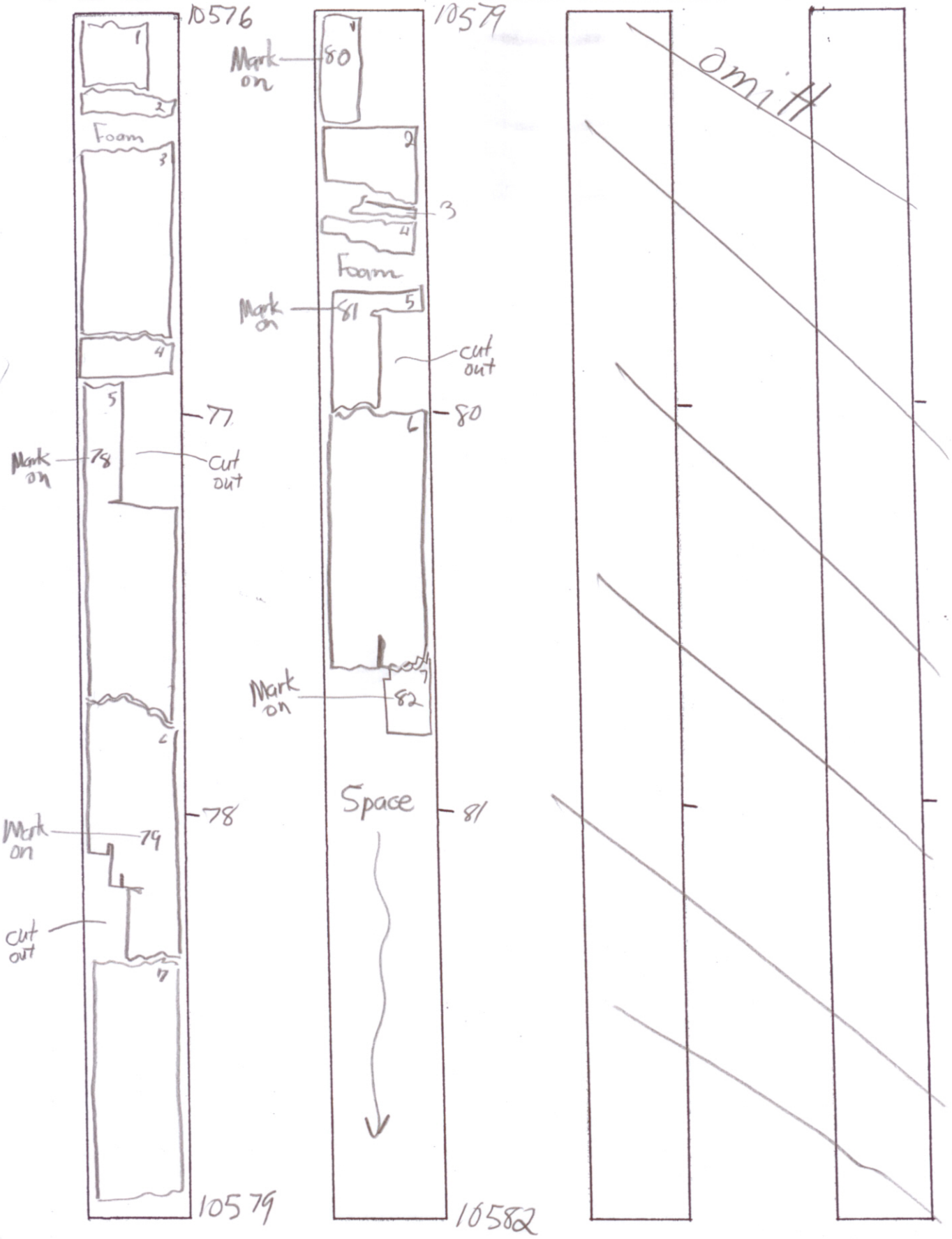
Operator : Hess

API no. : 33061004193000

Scale (ratio) : length 9"/3' width 0.33"/4"

Core diameter : 4"

BOX : 10576 - 10582 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-8-08

File no. : 15986

Operator : Hess

API no. : 33061004930000

Scale (ratio) : length width 9"/3' 0.33"/4"

Core diameter : 4"

Well #16030 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9969		Shale OIL saturated	96	41.7	91.4	1	10 0 0	0.5-19.1	Bedding joint	0.01 tight	no	4x4x0.25 To 4x4x7.5
9970						1	5 5 8					
9971						1	0 5 5 0 0					
9972		Silty lime stone No OIL	97.3			1	5 0 15 0	1-19.1				2.75x2.5x0.25 To 4x4x7.5
9973						2	10 85 15 10					
9974						2	5 5 85 7 10		Bedding joints + Vertical fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9975		Silty lime stone No OIL	100	59.5	81.1	2	10 4 15 75	0.5-29.85	Bedding joints + Vertical fractures	tight	NO	4x4x1.25 To 4x4x11.75
9976						1	0 5		Bedding joints	tight		
9977						1	3 0 10 5 0		Bedding joints	0.04 tight		
9978		Silty lime stone No OIL	89.6			1	5 0 5 5	1-12	Bedding joints	0.02 tight		1.5x2.25x0.5 to 4x4x4.75
9979						2	0 0 0 80 5 10		Bedding joints + Vertical fractures	tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9980		Silty lime stone No OIL	98.7	64	83.3	1	5 2 0 10	2.5-14.6	Bedding joints	0.02 tight	No	4x4x1 To 4x4x5.75
9981						2	45 0 0 0 5		Bedding joints + Vertical fractures			
9982						1	5 3 2 0		Bedding joints			
9983		Silty lime stone No OIL	80.5			1	10 5 2	1-17.2	Bedding joints	0.01 tight		4x3.5x0.4 To 4x4x6.75
9984						2	10 0 85 80		Bedding joints + Vertical fractures			
9985						2	5 0 65 15		Bedding joints + Vertical fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9986		Silty lime stone No OIL	77.8	70.4	93.4	2	5 0 5 85	2-18.4	Bedding joints + Vertical fractures	0.01 tight	No	3x4x0.75 To 4x4x7.25
9987						1	8 5 3		Bedding joints			
9988						1	5					
9989			79.2			1	0 0 2	1.5-25.4	Bedding joints	0.04 tight		2.25x3.5x2.25 To 4x4x10
9990						2	85 0		Bedding joints + Vertical fractures	0.02 tight		
9991						2	85 4 5 5 0 5		Bedding joints + Vertical fractures			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9992		Silty lime stone No OIL	100	84.7	94.7	1	7 10 3	4.5-19.7	Bedding joints	0.02 tight	No	4x4x1.75 To 4x4x7.75
9993						2	10 13 10 3		Bedding joints + Vertical fractures			
9994						2	5 80		Bedding joints + Vertical fractures			
9995		Silty lime stone No OIL	89			2	0 10 90	1.5-22.25	Bedding joints + Vertical fractures	Tight		1.5x2.75x0.6 To 4x4x8.75
9996						1	0 2		Bedding joints			

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
9997		Silty lime stone No OIL	96	80	95	1	0 7 0	8.1-20.2	Bedding joints	tight	No	4x4x3.5 To 4x4x8
9998							5 5					
9999							0 0 2					
10000		Silty lime stone No OIL	97				3 5	11.4-19.7				4x4x4.5 To 4x4x7.75
10001							0 0					
10002							5 8 3					

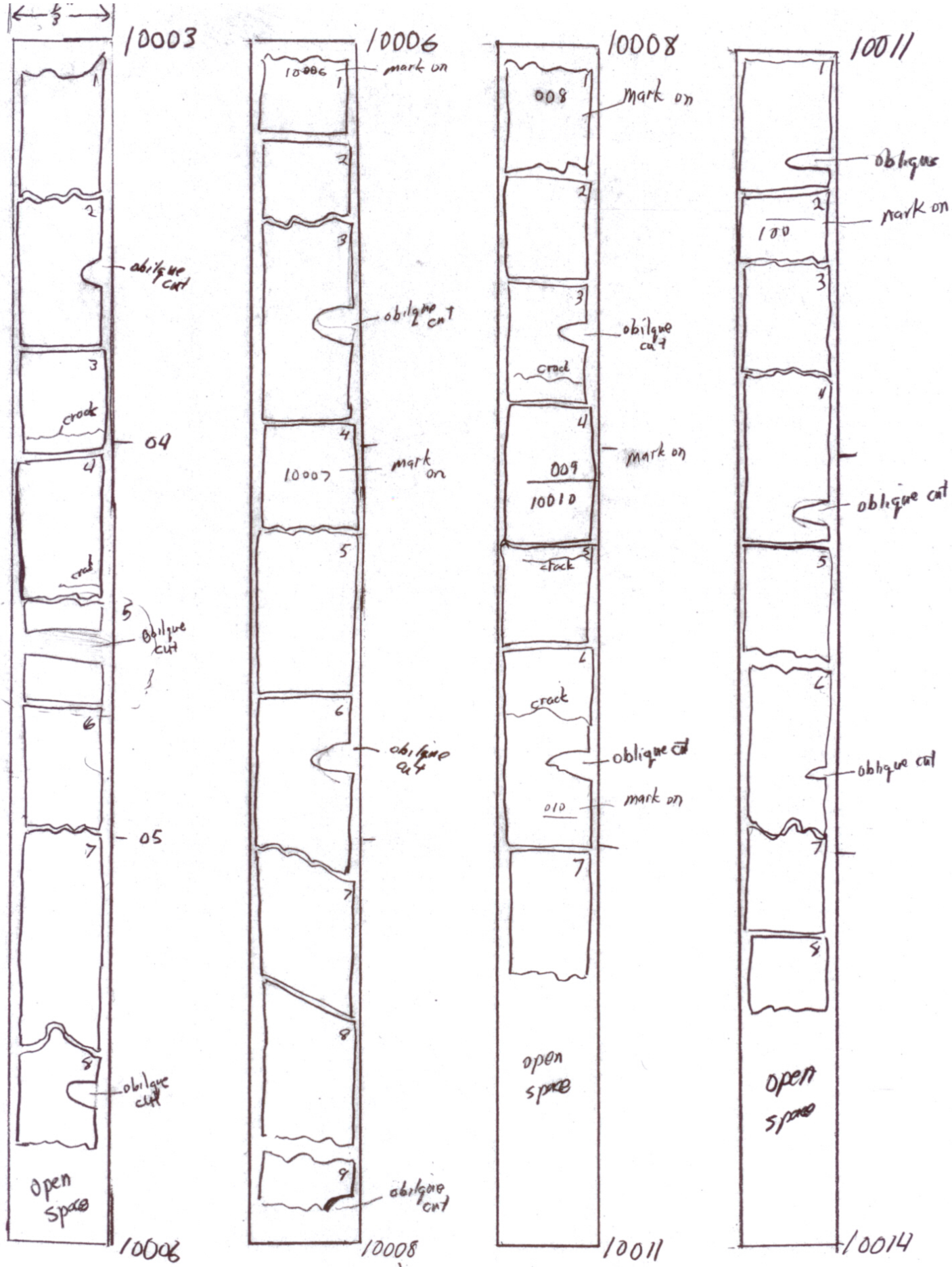
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10003		Silty lime stone No OIL	87.5	87.8	97.7	1	3 0 0	9.7-17.8	Bedding joints	tight	no	4x4x3.75 To 4x4x5.5
10004							0 0					
10005							5 0					
10006		Silty lime stone No OIL	100				5 3 3	6.6-22				4x4x2.75 To 4x4x8.75
10007							10 5 10					

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10008		Silty lime stone No OIL	85	87.6	98.4	1	5 5 5	8.8-25	Bedding joints	tight	No	4x4x3.5 To 4x4x10
10009							0 0					
10010							5					
10011			89				0 3	9-21				4x4x3.25 To 4x4x8.75
10012							6					
10013							0 4 5					

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10014		Silty lime stone No OIL	100	94.3	100	1	0 5 15 5	2-20.8	Bedding joints	tight	No	4x4x0.6 To 4x4x8.25
10015						2	5 70 0 0		Bedding joints + Vertical fractures			
10016						1	0 0 5		Bedding joints			
10017		Silty lime stone No OIL	90			1	5	5-21.8	Bedding joints			4x4x2 To 4x4x8.75
10018							0					

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Bloc size (XYZ, inch)
10019		Silty lime stone No OIL	93	83.9	95.8	1	0 0 5 10	5-19	Bedding joints	tight	no	4x4x2 To 4x4x7.75
10020												
10021							5 10					
10022			73				5 10	7.5-13.8				4x4x3 To 4x4x5.5
10023												

Well #16030 fracture sketch



Project Name: Bakken Geomechanical

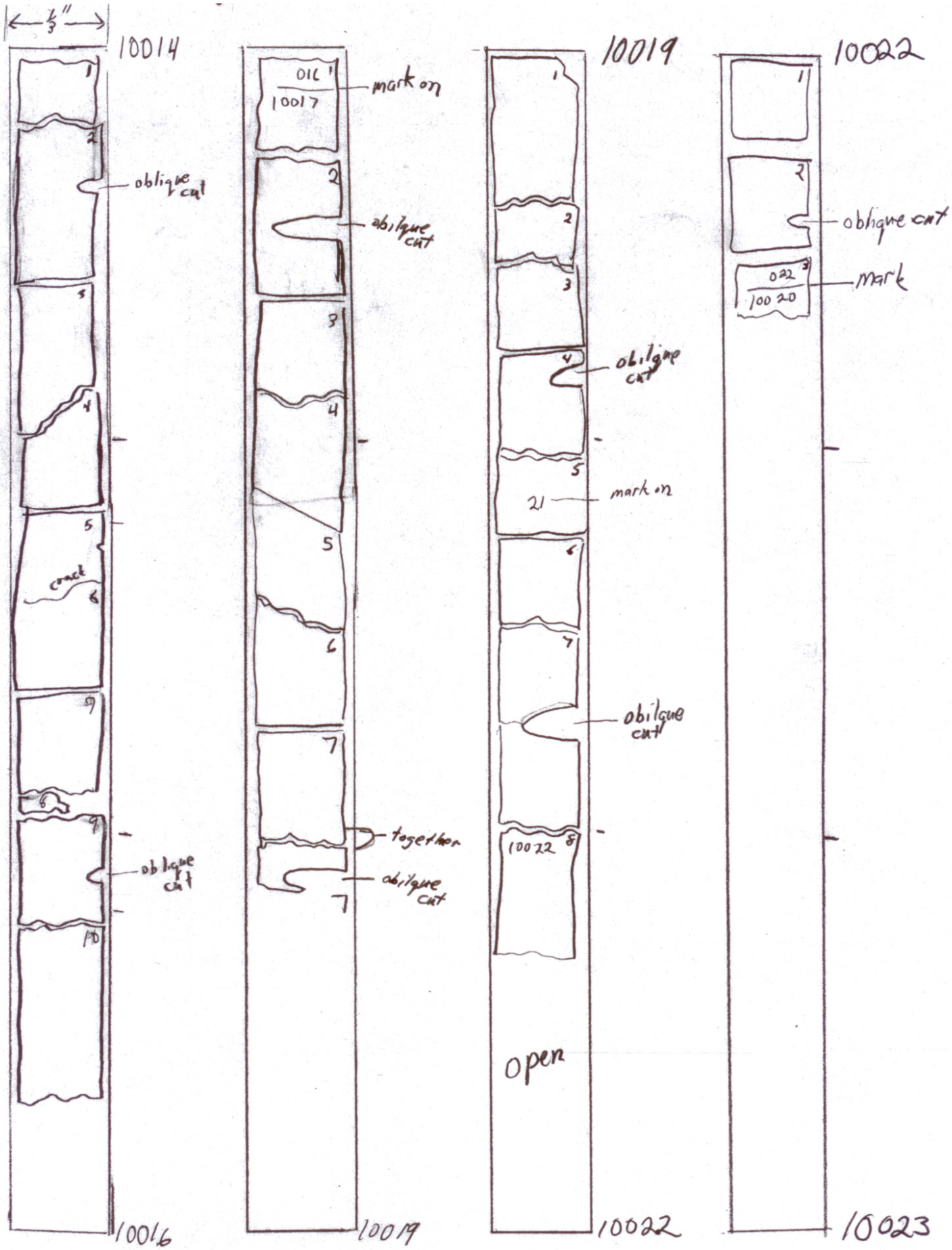
Drawing by: Jill Holwerda

Date: 6-25-08

API # 33105015510000

Well Map # 16030 PDC corp

Length width



Project Name: Bakken Geomechanical

Drawing by: Jill Holwerda

Dated: 6-25-08

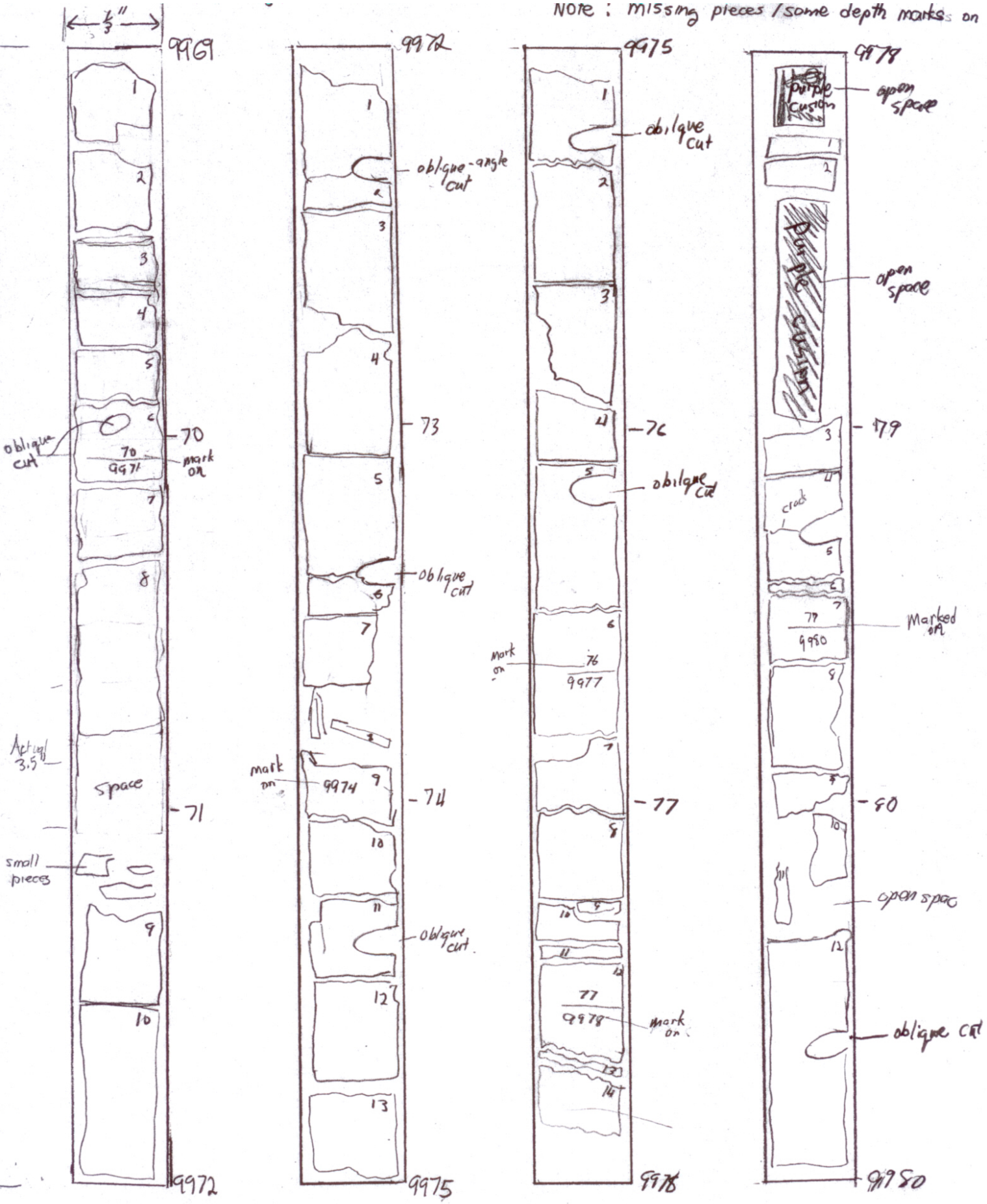
API# 33105015510000

Well Map# 16030

PDC Corp Violet 01-505

scale (ratios) Length 60"/3' Width 0.23"/3.5"

Note: missing pieces / some depth marks on individual



Project Name: Bakken Geomechanical

Drawing by: Jill Holwerda

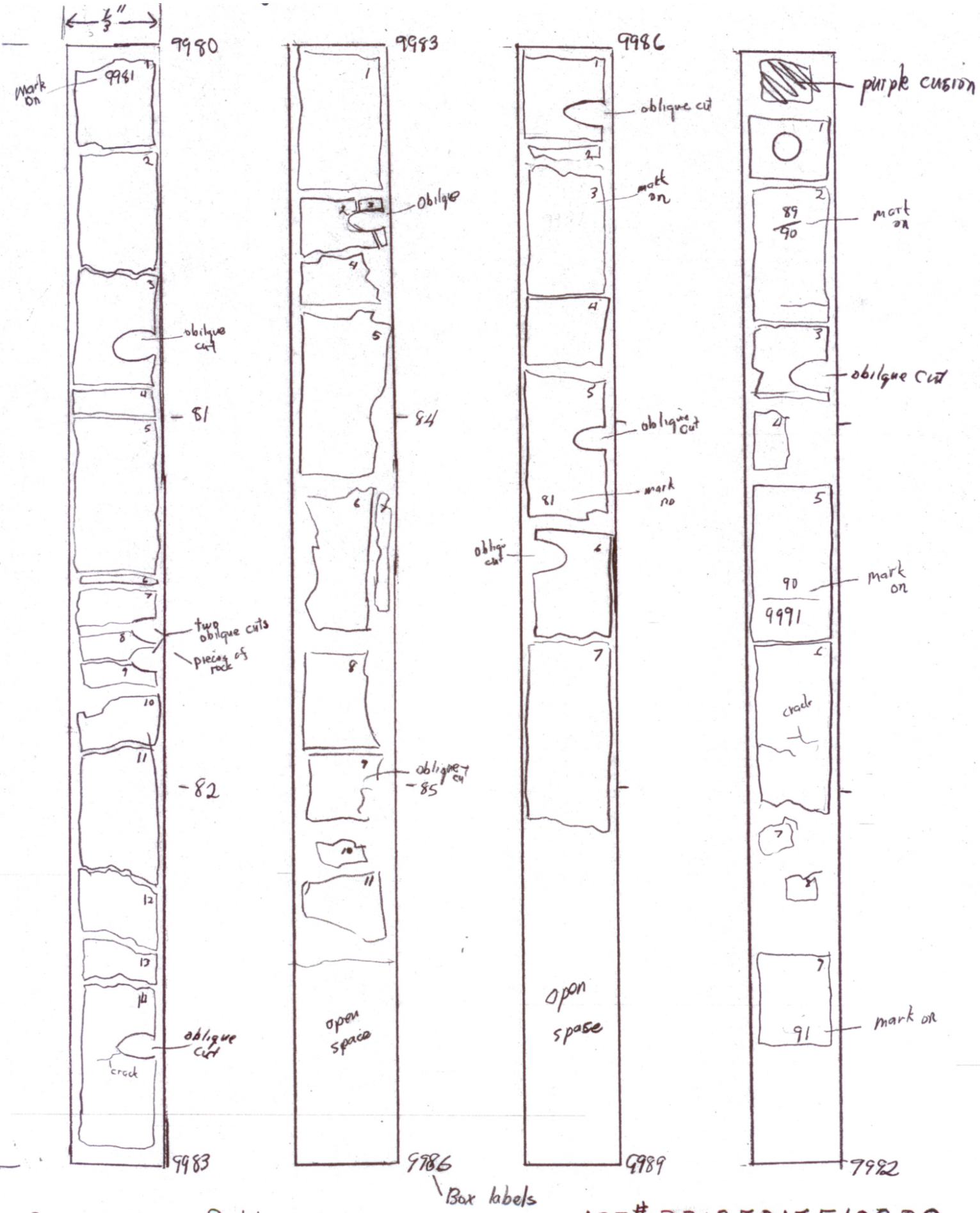
Dated: 6-25-08

API # 33105015510000

Well Map # 16030

PDC Corp

scale (ratios) Length 9.0"/3' Width 0.33"/3.5"



Project Name: Bakken Geomechanical

Drawing by: Jill Holwerda

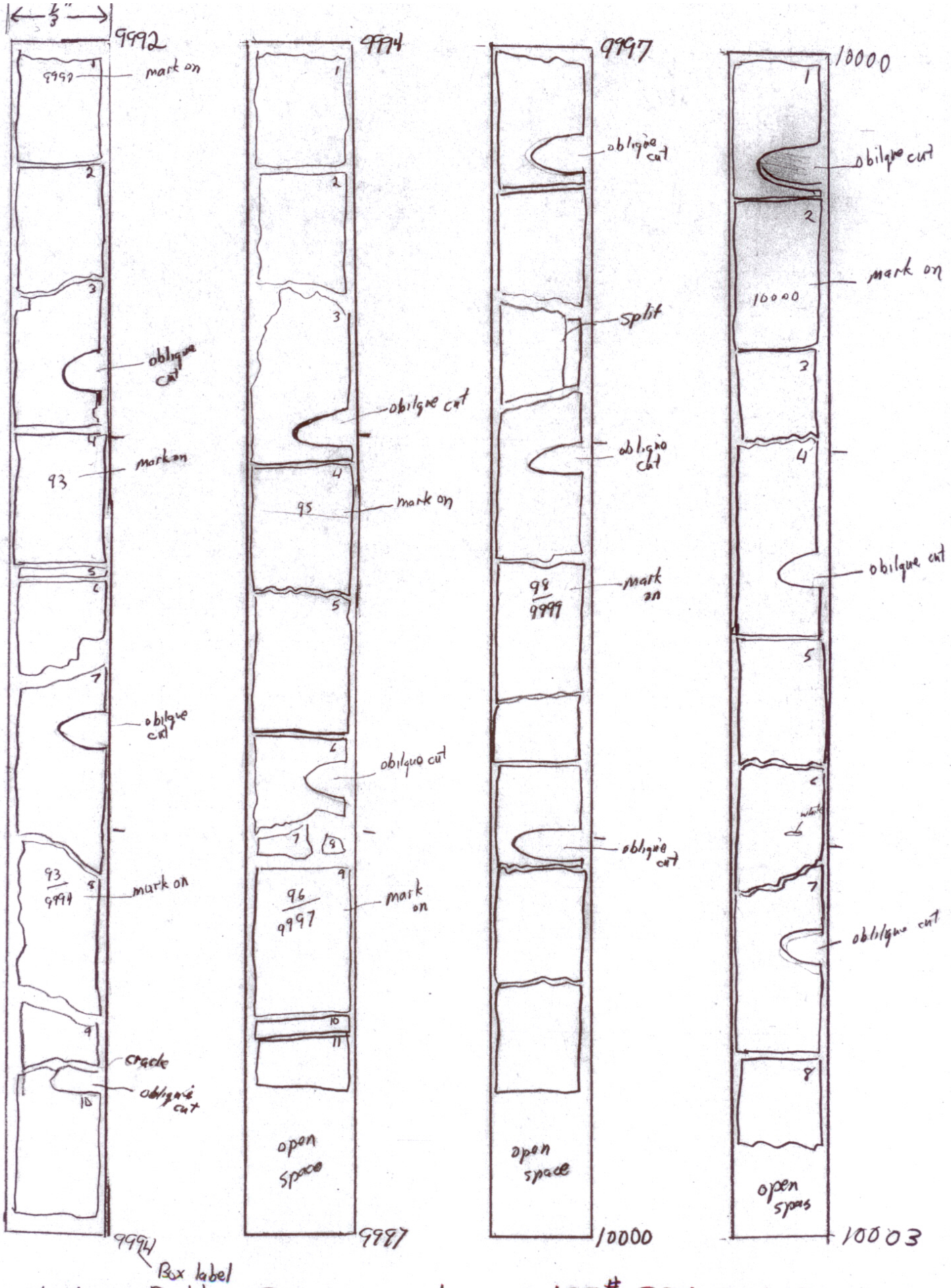
Dated: 6-25-08

API # 33105015510000

Well Map # 16030

PDC corp

scale (ratios) Length 90"/3' Width 0.33"/3.5"



Project Name: Bakken Geomechanical

Drawing by: Jill Holwerda

Dated: 6-25-08

API # 33105015510000

Well Map # 16030

PDC corp

Scale (ratio) Length 20"/3' width 0.25"/3.5"

Well #16068 Core survey

Bakken Geomech. Core description File # : 16068 Well API: 33061004950000 Operator: **Whiting**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10217		Black Shale High Carbon Content	100	27	77	1	10, 5, 5, 7, 6, 7, 5, 6, 2	Bedding Joints	0.5 -14.5	0.01	None	0.9x3x0.5 To 4x4x3.1
10218						1	8, 6, 10, 3, 7, 9, 9	Bedding Joints		0.02		
10219						2	6, 11, 5, 65, 21, 20, 75, 5, 35	Bedding Joints & Vertical Fractures		0.01		
10220						1	6, 5, 9	Bedding Joints		0.01		4x4x2 To 4x4x5.7
10221						1	3, 7, 12	Bedding Joints		0.02		
10222						1	2, 6, 5, 4	Bedding Joints		Tight		

Name: ***Smith & Naga*** 1/11 Date: July, 8 , 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10223		Black Shale High Carbon Content	100	76	94	1	4	Bedding Joints	0.6 – 18.8	0.01	None	4x4x0.25 To 4x4x7.4
10224						1	10, 10, 14	Bedding Joints		0.01		
10225						1	9, 13, 10, 3, 9	Bedding Joints		0.02		
10226		Limestone				1	15, 6, 11	Bedding Joints		0.02		4x4x0.6 To 4x4x6.4
10227						1	15, 19, 14, 12	Bedding Joints		0.04		
10228						1	10, 9, 0, 7	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10229		Limestone	100	90	95	1	14, 11	Bedding Joints	1 – 34.3	0.01	None	4x4x0.4 To 4x4x7.75
10230						1	9, 13, 14	Bedding Joints		Tight		
10231						1	3, 14	Bedding Joints		Tight		
10232						1	17, 6	Bedding Joints		0.02		4x4x5.5 To 4x4x13.5
10233						1	13, 20	Bedding Joints		Tight		
10234						1	3	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10235		Limestone	100	89	100	1	9, 10	Bedding Joints	5 – 22.9	0.01	None	4x4x3.75 To 4x4x9
10236						1	11, 14, 14	Bedding Joints		0.02		
10237						1	23, 35	Bedding Joints		0.04		
10238						1	22, 22, 7	Bedding Joints		Tight		4x4x2 To 4x4x9
10239						2	21, 68	Bedding Joints & Vertical Fractures		0.01		
10240						1	33, 7, 16	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10241		Limestone	100	82	99	1	17, 19	Bedding Joints	3.6 – 32.4	Tight	None	4x4x2 To 4x4x6.7
10242						1	7, 34, 2	Bedding Joints		Tight		
10243						1	11, 24, 6	Bedding Joints		Tight		
10244						1	9, 14, 2	Bedding Joints		Tight		3.1x0.9x2 To 4x4x12.25
10245						2	4, 11, 82, 9, 11	Bedding Joints & Vertical Fractures		Tight		
10246						1	3	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10247		Limestone	100	72	88	Multiple	Angles vary from 0 – 90	Bedding Joints & Multiple Vertical Fractures	3.8 – 23.9	Tight	None	0.5x0.5x0.5 To 4x4x8.5
10248						2	16, 4, 75, 3, 14, 85	Bedding Joints & Vertical Fractures		Tight		
10249						1	3, 4, 7	Bedding Joints		Tight		
10250						1	13, 4, 0	Bedding Joints		Tight		4x4x1.5 To 4x4x9.4
10251						1	9, 12	Bedding Joints		Tight		
10252						1	4, 6	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10253		Limestone	100	78	93	1	6, 3, 2	Bedding Joints	3.8 – 38.8	Tight	None	4x4x1.5 To 4x4x15.25
10254						0				Tight		
10255						1	2, 2, 5	Bedding Joints		Tight		
10256						1	2, 1, 7	Bedding Joints		Tight		1.4x1.2x1.4 To 4x4x6.5
10257						2	12, 8, 6, 85	Bedding Joints & Vertical Fractures		0.04		
10258						2	2, 14, 78	Bedding Joints & Vertical Fractures		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10259		Limestone	84	90	95	1	2, 6, 7	Bedding Joints	1.5 – 29.8	Tight	None	2x1.5x0.6 To 4x4x7
10260						2	75, 12	Bedding Joints & Vert. Frac.		Tight		
						Multiple	Angles vary from 0 – 90	Bedding Joints & Multiple Vertical Fractures				
10261										Tight		
						1	14	Bedding Joints				
10262						1	6	Bedding Joints		Tight		4x4x3.5 To 4x4x11.25
10263						1	7, 6	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10264		Limestone	100	97	100	1	6, 4	Bedding Joints	5.7 – 22.6	Tight	None	4x4x2.25 To 4x4x8.4
10265						1	4, 2	Bedding Joints		Tight		
10266						2	12, 4, 62	Bedding Joints & Vertical Fractures		Tight		

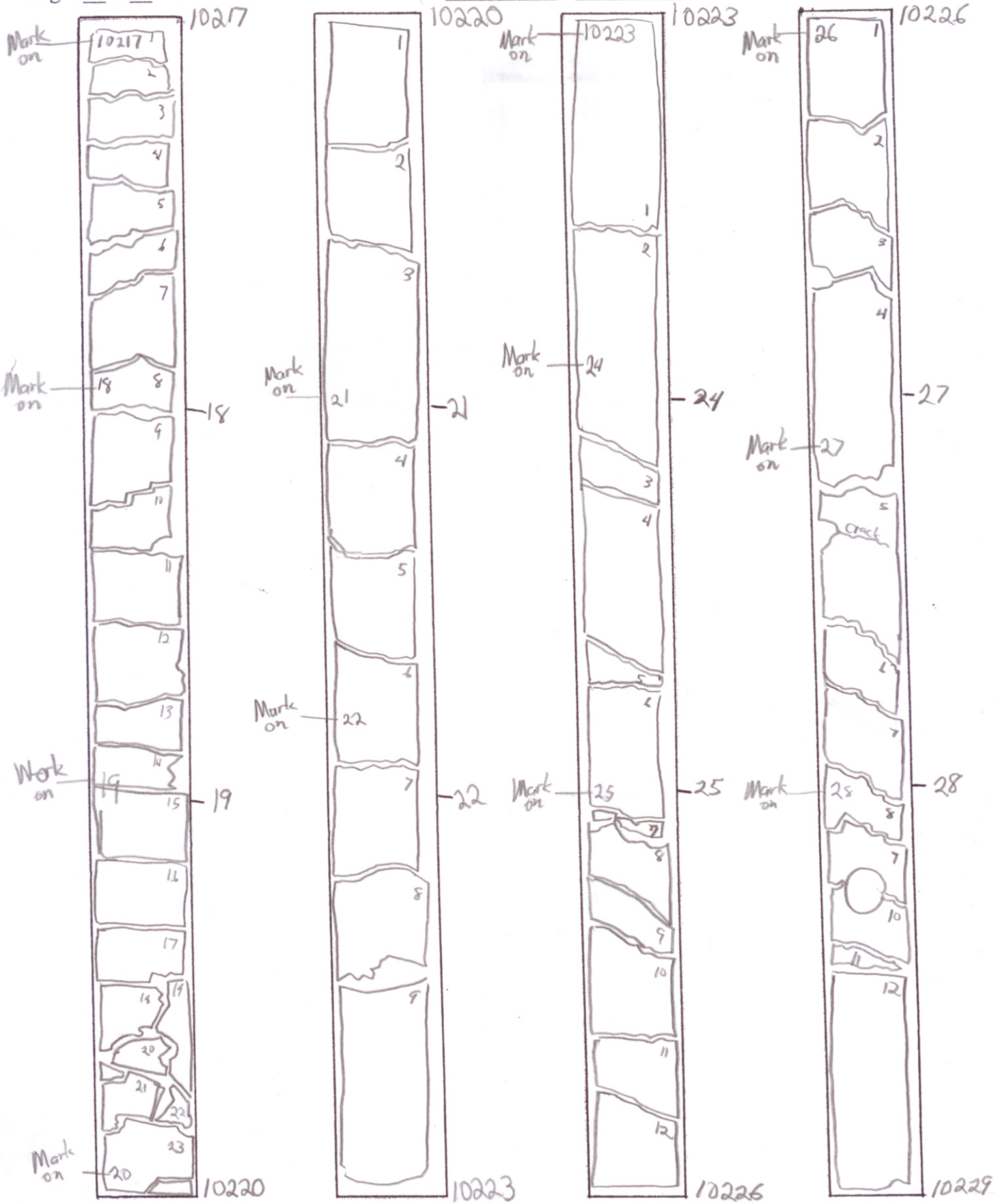
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10267		Limestone	100	90	98	2	16, 6, 77	Bedding Joints & Vertical Fractures	5.1 – 43.2	Tight	None	3x2.75x2.6 To 4x4x17
10268						2	23, 2, 47, 3	Bedding Joints & Vertical Fractures		Tight		
10269						1	4	Bedding Joints		Tight		
10270						1	6, 6	Bedding Joints		Tight		4x4x2 To 4x4x17
10271						1	2	Bedding Joints		0.01		
10272						1	3	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
10273		Limestone	100	82	99	1	4, 2	Bedding Joints	1.3 -25.4	Tight	None	4x4x3.5 To 4x4x8.5
10274						1	6, 6	Bedding Joints		0.01		
10275						1	6, 7	Bedding Joints		Tight		
10276						1	3, 2	Bedding Joints		Tight		3x0.5x3.1 To 4x4x10
10277						2	11, 16, 70, 15, 77	Bedding Joints & Vertical Fractures		Tight		
10278						1	2, 3, 4	Bedding Joints		Tight		

Well #16068 fracture sketch

Page: 1 of 6

BOX : 10217 - 10229 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-8-08

File no. : 16068

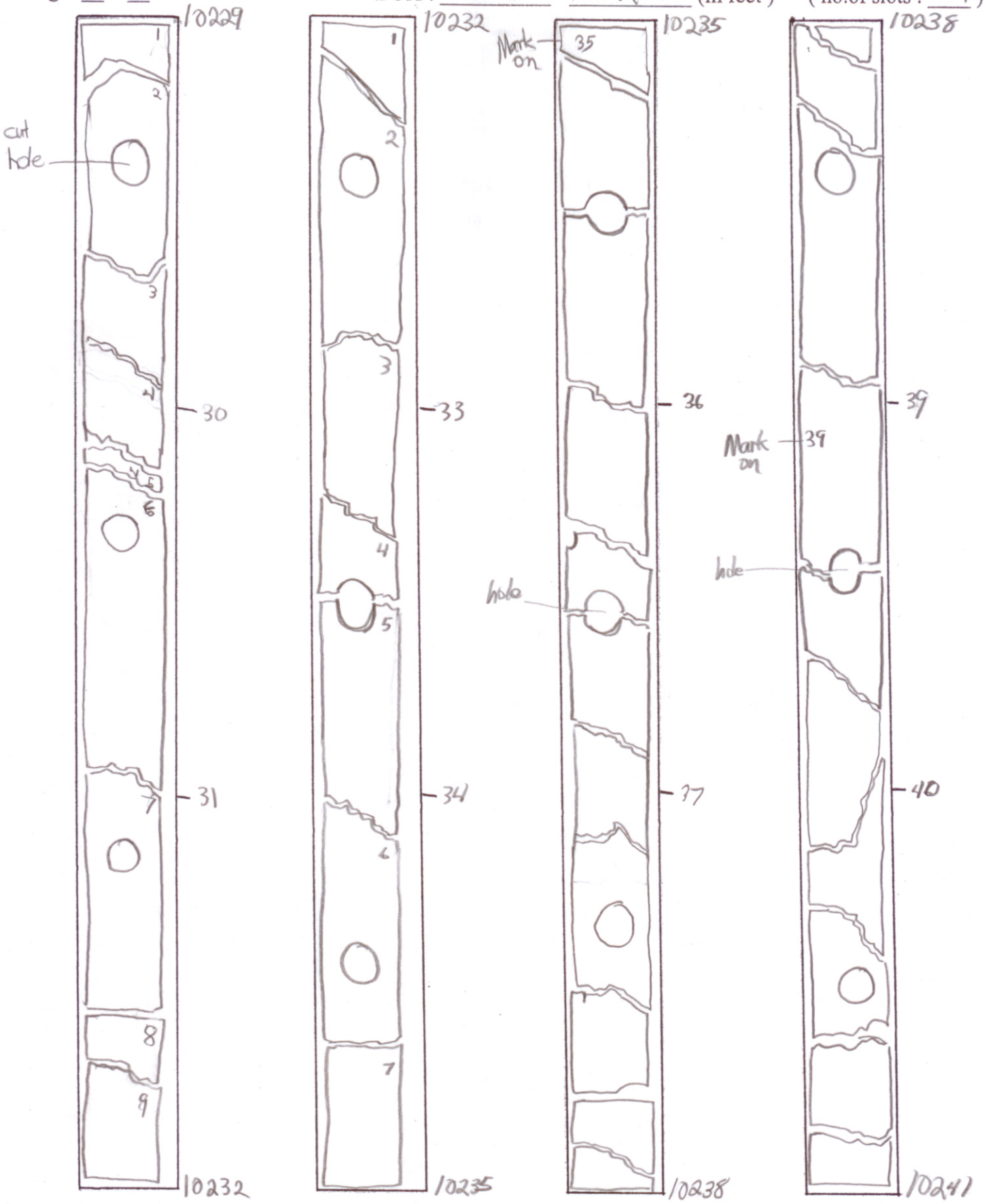
Operator : Whiting Oil

API no. : 33061004950000

Scale (ratio) : length 9"/3' width 0.33"/4"

Core diameter : 4"

BOX : 10229 - 10241 (in feet) (no.of slots : N/A)

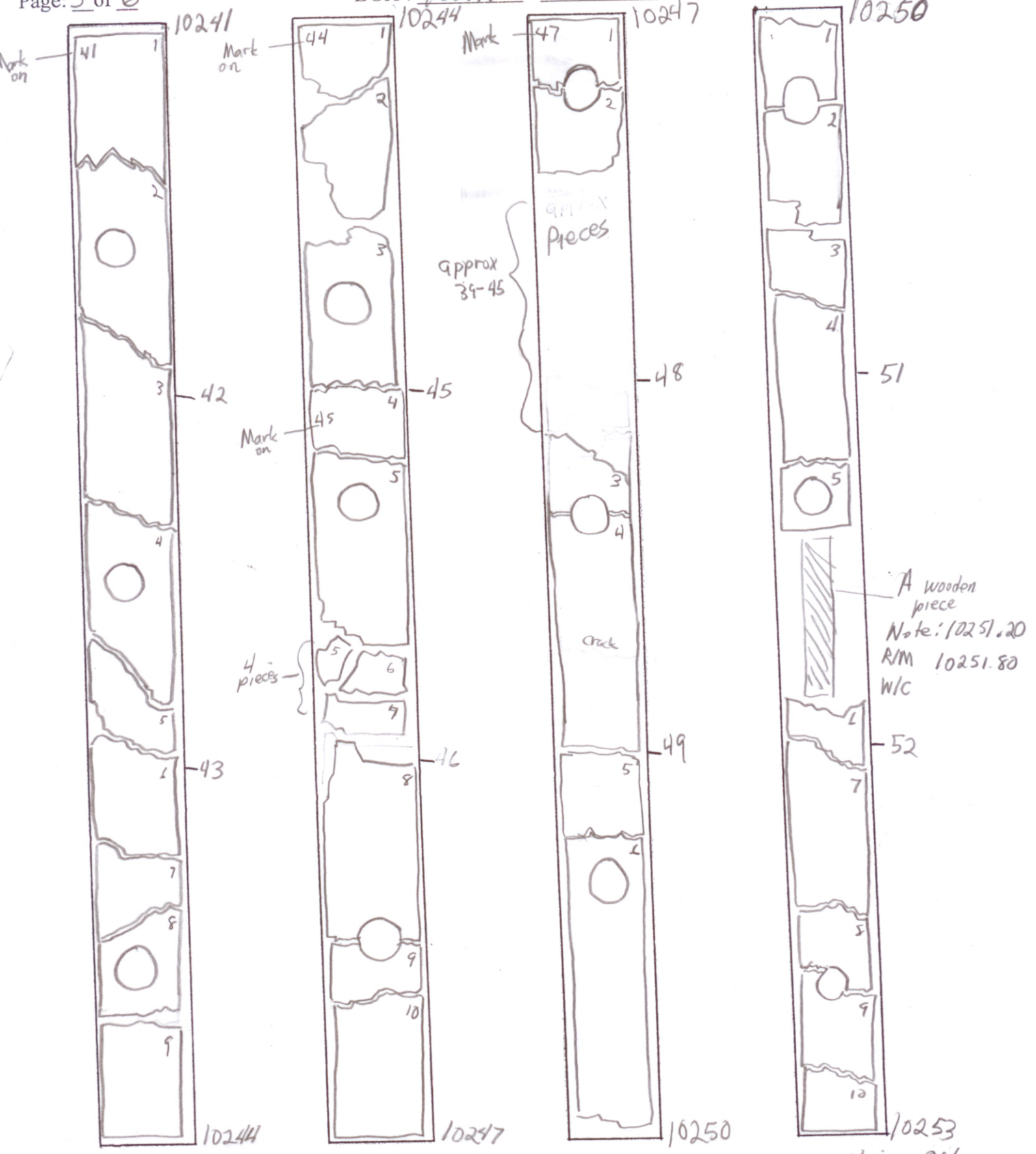


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-8-08

File no. : 16068
Operator : Whiting Oil
API no. : 33061004950000
Scale (ratio) : length 9"/3' width 0.33"/4"
Core diameter : 4"

Page: 3 of 6

BOX : 10241 - 10253 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-8-08

File no. : 16068

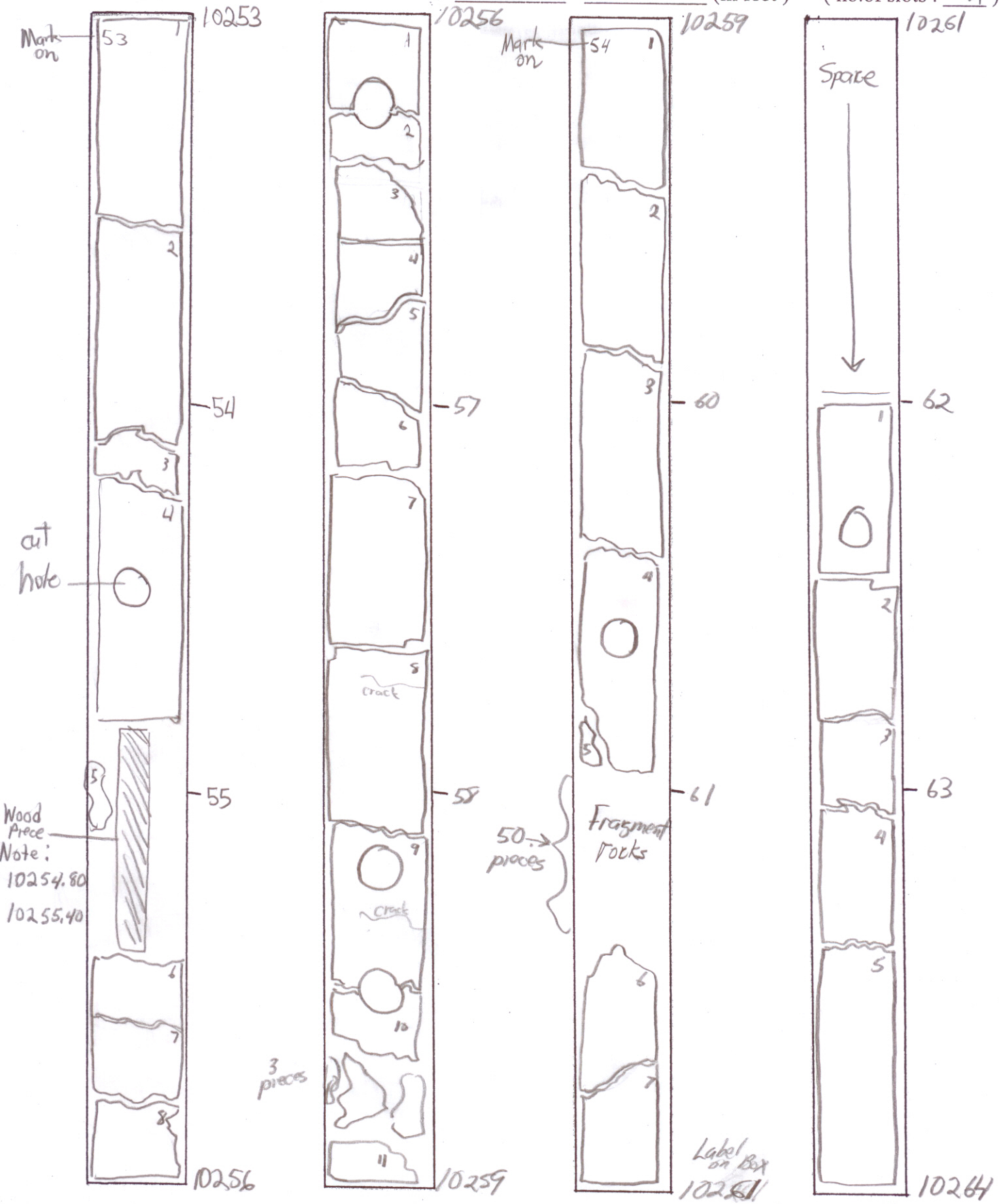
Operator : Whiting Oil

API no. : 33061004950000

Scale (ratio) : length 9"/3' width 0.33"/4"

Core diameter : 4"

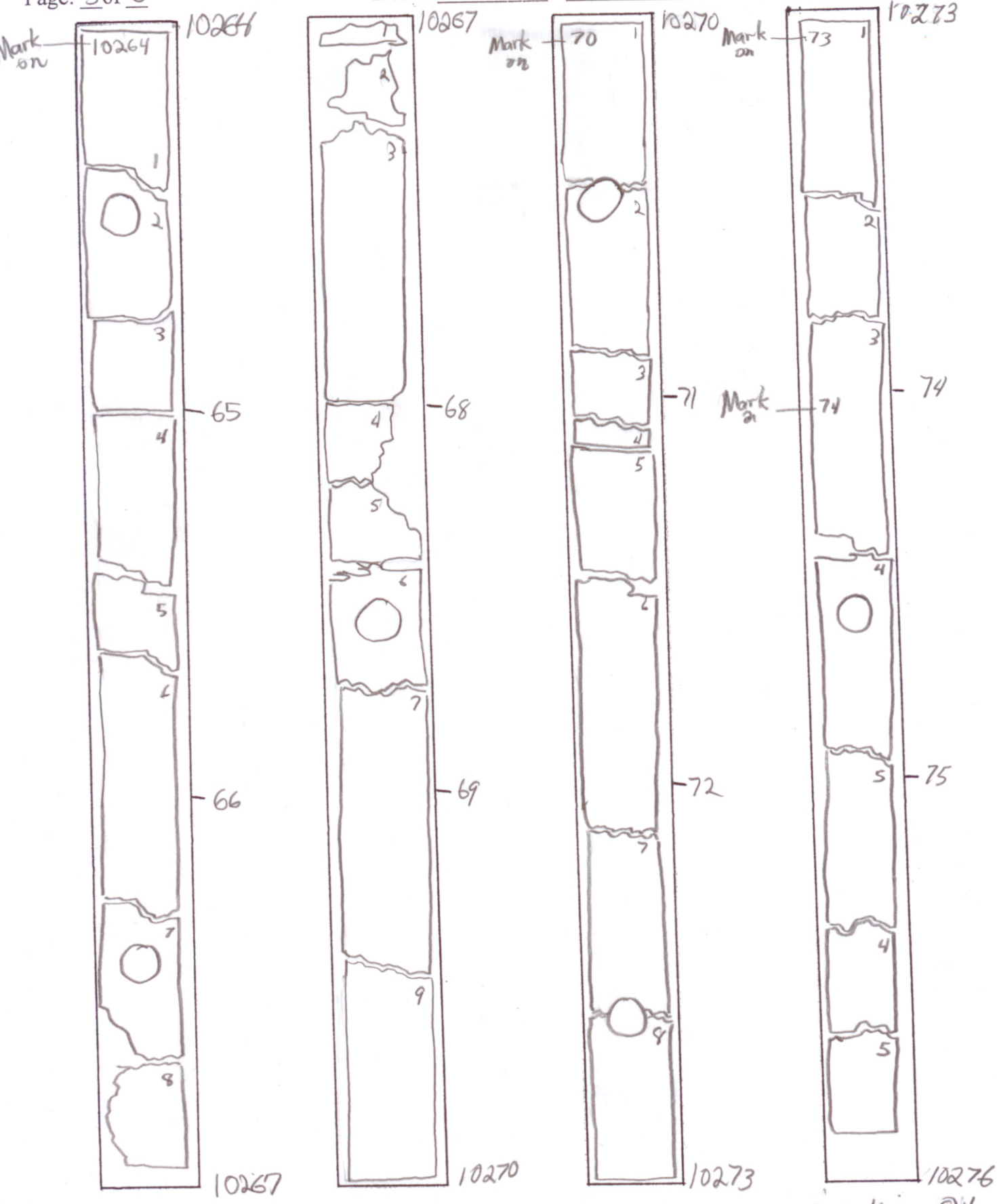
BOX : 10253 - 10264 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-8-08

File no. : 16068
Operator : Whiting Oil
API no. : 33061004950000
Scale (ratio) : length 9"/3' width 0.33"/4"
Core diameter : 4"

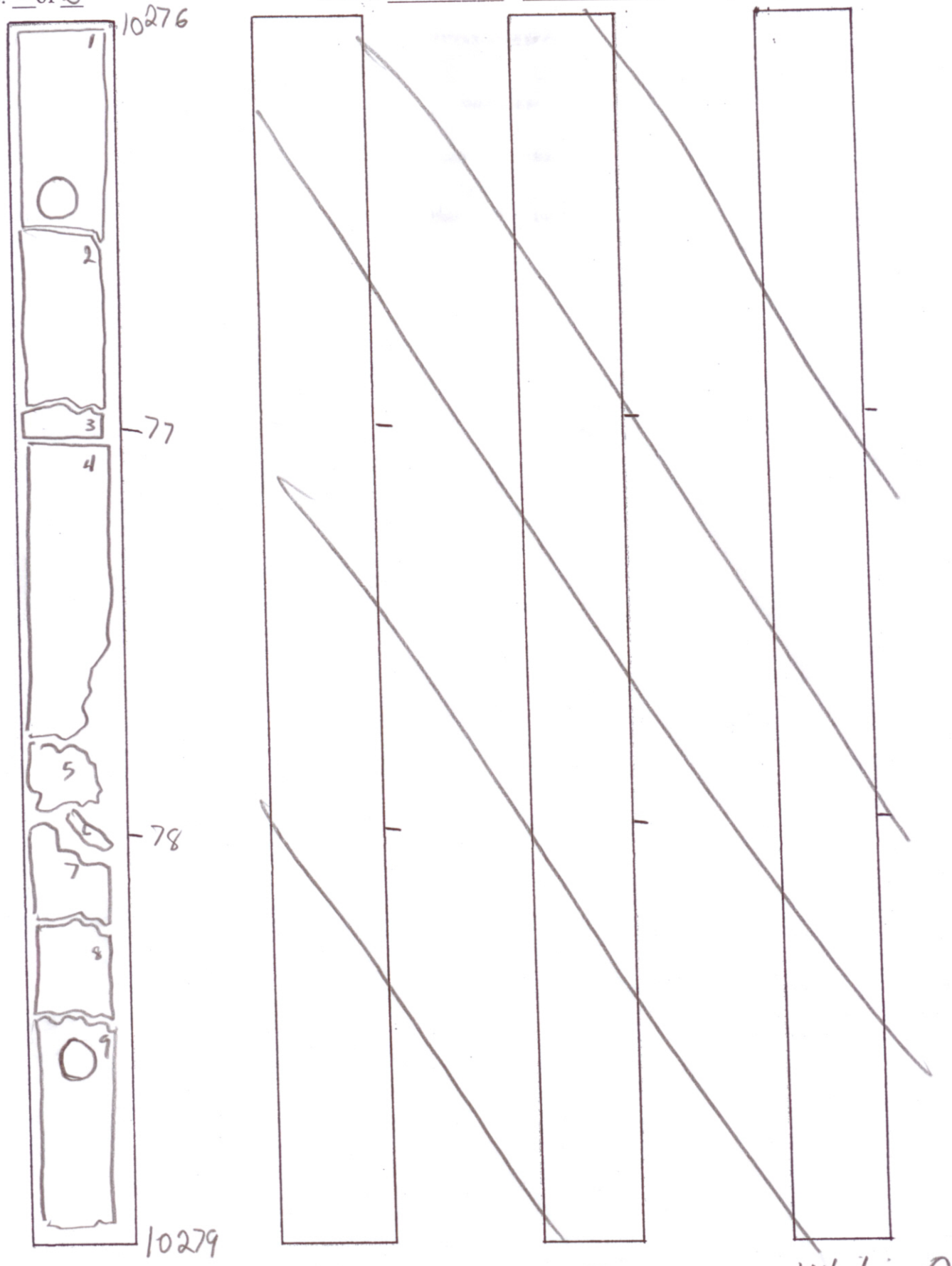
BOX : 10264 - 10276 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-8-08

File no. : 16068
Operator : Whiting Oil
API no. : 33061004950000
Scale (ratio) : length 9"/3' width 0.33"/4"
Core diameter : 4"

BOX : 10276 - 10279 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-8-08

File no. : 16068
Operator : Whiting Oil
API no. : 33061004950000
Scale (ratio) : length width
9"/3' 0.33"/4"
Core diameter : 4"

Well #16083 Core survey

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9697		Limestone	100	80	96	1	7, 4	Bedding Joints	7.6 – 46.2	0.01	None	4x4x3.75 To 4x4x18.2
9698						1	14	Bedding Joints		0.02		
9699						1	40, 6	Bedding Joints		Tight		
9700						1	7, 5	Bedding Joints		0.02		4x4x3 To 4x4x9
9701						1	2, 4	Bedding Joints		0.04		

Name: ***Smith & Naga*** 1/28 Date: July, 9-10, 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9702		Limestone	100	27	50	1	9, 2	Bedding Joints	0.25 – 18.8	Tight	None	4x4x0.6 To 4x4x7.4
9703						1	1, 7, 10	Bedding Joints		0.01		
9704		Black Shale High Carbon Content				1	3, 2, 2, 2, 1, 0, 5, 4, 1	Bedding Joints		0.01		
9705						1	2, 3, 7, 4, 3, 5, 2, 2	Bedding Joints		0.01		4x4x0.1 To 4x4x5.8
9706						1	3, 2, 5, 5, 3, 7, 8, 5, 4	Bedding Joints		0.04		
9707						1	3, 4, 7, 6, 3, 3, 8	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9708		Black Shale High Carbon Content	100	5	37	1	10, 5, 6, 4, 2, 3, 3, 6	Bedding Joints	1.1 - 10	0.02	None	4x4x0.4 To 4x4x3.8
9709						1	3, 0, 2, 7, 6, 6	Bedding Joints		0.04		
9710						1	4, 2, 0, 3, 2, 1, 2, 6, 3, 3	Bedding Joints		0.01		
9711						1	5, 5, 4, 0, 6, 4, 2, 3, 0, 4	Bedding Joints		0.04		4x4x0.5 To 4x4x3.1
9712						1	0, 5, 6, 12, 7, 10, 4, 4, 7, 1, 3	Bedding Joints		0.04		
9713						1	0, 0, 0, 2, 3, 11, 7, 3, 7	Bedding Joints		0.05		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9714		Black Shale High Carbon Content	100	11	48	1	2, 13, 0, 8, 5, 11, 7	Bedding Joints	0.8 – 10.9	0.02	None	2.3x3.5x0.8 To 4x4x4.3
9715						1	2, 9, 3, 3, 7	Bedding Joints		0.05		
9716						2	4, 85, 3, 7, 3, 8, 0, 3, 0, 4	Bedding Joints & Vertical Fractures		0.04		
9717						1	5, 5, 3, 5, 2, 2, 7, 6	Bedding Joints		0.02		4x4x0.3 To 4x4x4.3
9718						1	2, 20, 4, 12, 3, 3, 3	Bedding Joints		0.05		
9719						1	5, 5, 5, 6, 2, 4	Bedding Joints		0.05		

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9720		Black Shale High Carbon Content	98	52	75	1	2, 3, 6, 6, 2, 4, 7	Bedding Joints	1.3 – 32.3	0.05	None	4x4x0.5 To 4x4x4.4
9721						1	3, 2, 2, 7, 9, 6, 8	Bedding Joints		0.05		
9722		Limestone				1	0, 17, 12	Bedding Joints		0.01		4x4x0.6 To 4x4x12.7
9723						1	0, 8	Bedding Joints		0.01		
9724						1	6, 8, 11	Bedding Joints		Tight		

Name: ***Smith & Naga*** 5/28 Date: July, 9-10, 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9725		Limestone	98	56	69	1	0, 3, 16, 11	Bedding Joints	2.5 – 24.4	Tight	None	4x4x1 To 4x4x5.6
9726						1	18, 6, 0, 0	Bedding Joints		Tight		
9727						1	4, 0	Bedding Joints		0.02		4x4x1.4 To 4x4x9.6
9728						1	0, 9, 6	Bedding Joints		Tight		
9729						1	5	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9730		Limestone	99	82	98	1	3, 2	Bedding Joints	5.1 - 33	Tight	None	4x4x2 To 4x4x11.7
9731						1	5, 4	Bedding Joints		Tight		
9732						2	5, 27, 85	Bedding Joints & Vertical Fractures		Tight		
9733						1	13	Bedding Joints		Tight		3.5x1.5x1.1 To 4x4x13
9734						1	14	Bedding Joints		Tight		
9735						2	4, 75, 10, 85	Bedding Joints & Vertical Fractures		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9736		Limestone	93	68	94	1	3, 8	Bedding Joints	1.5 – 31.1	Tight	None	4x4x0.6 To 4x4x8.75
9737						1	2, 4	Bedding Joints		Tight		
9738						1	7, 6, 3	Bedding Joints		Tight		
9739						1	6, 2	Bedding Joints		Tight		4x4x1.6 To 4x4x12.25
9740						1	1, 3	Bedding Joints		Tight		
9741						1	7	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9742		Limestone	100	92	95	1	2, 2, 5, 2	Bedding Joints	2 – 29.2	Tight	None	4x4x1.75 To 4x4x10
9743						1	25	Bedding Joints		0.02		
9744						1	10	Bedding Joints		0.02		
9745						1	3, 8	Bedding Joints		0.01		4x4x0.8 To 4x4x11.5
9746						1	3	Bedding Joints		0.01		
9747						1	1, 3	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9748		Limestone	100	55	90	1	4, 6, 9	Bedding Joints	2.5 – 31.1	0.02	None	4x4x1 To 4x4x5
9749						1	7, 3, 2, 4, 6	Bedding Joints		0.02		
9750						1	2, 6, 7	Bedding Joints		0.04		
9751						1	8, 3, 8	Bedding Joints		Tight		4x4x1 To 4x4x12.25
9752						1	3	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9753		Limestone	100	87	96	1	4, 9	Bedding Joints	5.7 – 27.3	Tight	None	4x4x2.25 To 4x4x10.75
9754						1	5, 9	Bedding Joints		Tight		
9755						1	2, 3	Bedding Joints		Tight		
9756						1	2, 4	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9757		Limestone	97	89	100	1	5, 9	Bedding Joints	5.1 – 38.1	Tight	None	4x4x2 To 4x4x15
9758						1	6, 10	Bedding Joints		Tight		
9759						1	5	Bedding Joints		Tight		
9760						0				Tight		4x4x2.25 To 4x4x15
9761						1	2	Bedding Joints		Tight		
9762						1	2, 5, 7	Bedding Joints		Tight		

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9763		Limestone	100	99	99	1	4, 8	Bedding Joints	10.2 – 26.2	Tight	None	4x4x4 To 4x4x10.3
9764						1	5	Bedding Joints		Tight		
9765						1	12	Bedding Joints		0.01		
9766						1	7, 7, 8	Bedding Joints		Tight		

Name: ***Smith & Naga*** 13/28 Date: July, 9-10, 2008

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9767		Limestone	100	75	97	1	2, 0	Bedding Joints	2.3 – 21.6	Tight	None	4x4x2.6 To 4x4x8.5
9768						1	10, 2	Bedding Joints		0.01		
9769						1	10, 3, 7	Bedding Joints		Tight		
9770						2	80, 12, 5	Bedding Joints & Vertical Fractures		0.02		

Name: ***Smith & Naga*** 14/28 Date: July, 9-10, 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9771		Black Shale High Carbon Content	100	5	26	1	10, 11, 0, 0, 0	Bedding Joints	0.6 – 9.7	0.02	None	2.5x3.5x0.5 To 4x4x3.8
9772						2	4, 85, 5, 4, 5, 0, 2, 4	Bedding Joints & Vertical Fractures		0.05		
9773						2	0, 0, 90, 3, 6, 5, 5, 80	Bedding Joints & Vertical Fractures		0.05		
9774						2	2, 0, 4, 4, 10, 3, 5, 75, 90	Bedding Joints & Vertical Fractures		0.05		2.5x2.5x0.4 To 4x4x3.5
9775						2	76, 0, 85, 0, 2, 4, 85, 5, 0, 4, 3, 75, 3, 2, 9, 17	Bedding Joints & Vertical Fractures		0.01		
9776						2	5, 7, 70, 0, 0, 90, 2, 4, 0, 82, 3, 5, 6, 0	Bedding Joints & Vertical Fractures		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9777		Black Shale High Carbon Content	100	11	33	2	0, 90, 8, 4, 2, 11, 4, 90, 0	Bedding Joints & Vertical Fractures	0.5 – 12.1	0.05	None	2.8x0.9x0.7 To 4x4x3.9
9778						1	8, 3, 7, 2, 5, 3, 2	Bedding Joints		0.04		
9779						2	3, 4, 90, 6, 25, 0, 4, 85, 4, 8, 80, 8, 6, 85	Bedding Joints & Vertical Fractures		0.02		
9780						2	2, 90, 5, 2, 90, 3, 10, 80, 4, 1, 90, 4, 5, 7	Bedding Joints & Vertical Fractures		0.02		3.4x1.1x0.2 To 4x4x4.75
9781						2	4, 10, 0, 85, 4, 90, 5, 3, 7, 7	Bedding Joints & Vertical Fractures		0.02		
9782						2	10, 80, 2, 2, 85, 4, 3, 0, 0, 2, 5, 8, 0, 80, 15	Bedding Joints & Vertical Fractures		0.05		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9783		Black Shale High Carbon Content	100	13	61	2	3, 2, 87, 5, 2, 85, 4, 3, 82, 2, 7, 78, 4, 85	Bedding Joints & Vertical Fractures	1 - 15	Tight	None	3.1x0.75x0.4 To 4x4x3.6
9784						2	7, 0, 3, 0, 75, 6, 5, 85, 3, 8, 60, 2, 85	Bedding Joints & Vertical Fractures		Tight		
9785						2	6, 11, 6, 90, 3, 14, 85, 2, 65, 12, 7	Bedding Joints & Vertical Fractures		0.05		
9786						2	2, 8, 6, 6, 8, 2, 3, 88, 3, 90	Bedding Joints & Vertical Fractures		0.04		2.9x0.9x0.4 To 4x4x5.9
9787						2	4, 1, 5, 85, 2, 5, 2	Bedding Joints & Vertical Fractures		0.05		
9788						2	7, 0, 6, 85, 9, 4, 88, 4	Bedding Joints & Vertical Fractures		0.02		

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9789		Black Shale High Carbon Content	99	18	57	1	2, 1, 4, 2	Bedding Joints	1 -15	0.02	None	2.5x1.25x1.4 To 4x4x5.1
9790						2	3, 3, 85, 9, 3, 75, 5, 8	Bedding Joints & Vertical Fractures		0.02		
9791						1	5, 12, 7, 10, 5, 10, 2	Bedding Joints		0.04		
9792						2	6, 2, 7, 12, 80, 6	Bedding Joints & Vertical Fractures		0.02		2.75x1x1 To 4x4x5.9
9793						2	8, 85, 2, 90, 2, 14, 11, 85, 15, 25, 45	Bedding Joints & Vertical Fractures		0.05		

Name: ***Smith & Naga*** 18/28 Date: July, 9-10, 2008

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9794		Siltstone with illite	100	33	79	1	2, 1, 6, 2, 9	Bedding Joints	1.3 – 25.4	0.01	None	4x4x0.5 To 4x4x10
9795						1	6, 3, 6, 6, 4	Bedding Joints		0.02		
9796						1	2, 8	Bedding Joints		0.02		
9797						2	6, 82, 6, 2, 12, 75	Bedding Joints & Vertical Fractures		0.02		2xx3.7x0.55 To 4x4x5.1
9798						1	8, 2, 8, 3, 2	Bedding Joints		Tight		
9799						2	6, 4, 2, 85, 6, 75, 2, 7	Bedding Joints & Vertical Fractures		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9800		Siltstone with illite	100	15	71	2	26, 12, 12, 80, 6, 8, 8, 6, 4, 2, 55	Bedding Joints & Vertical Fractures	1 – 15.5	0.04	None	1.1x3.4x0.4 To 4x4x5.1
9801						1	18, 2, 2, 4, 2	Bedding Joints		0.02		
9802						1	2, 4, 6, 8	Bedding Joints		0.01		
9803						2	2, 0, 80, 5, 4, 10, 7	Bedding Joints & Vertical Fractures		0.05		0.5x4x1.75 To 4x4x6.1
9804						1	4, 4, 6, 2, 4, 8	Bedding Joints		0.04		
9805						1	3, 10, 2, 2, 2, 7	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9806		Siltstone with illite	100	49	70	2	8, 10, 6, 55, 2, 15, 15, 16, 85	Bedding Joints & Vertical Fractures	1 – 23.5	Tight	None	3.5x3.75x0.5 To 4x4x9.25
9807						1	11, 3	Bedding Joints		0.01		
9808						2	10, 2, 75, 2	Bedding Joints & Vertical Fractures		0.04		
9809						2	6, 6, 4, 0, 4, 2, 4, 75, 5	Bedding Joints & Vertical Fractures		0.04		1.2x3.5x0.4 To 4x4x4.4
9810						1	2, 5, 2, 2, 1, 2	Bedding Joints		0.02		
9811						1	6, 7, 9, 17	Bedding Joints		0.01		

Bakken Geomech. Core description File # : 16083 Well API: 33105015570000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9812		Siltstone with illite	100	37	76	2	90, 2, 11, 15, 7, 2, 85, 10, 55, 0, 1, 90	Bedding Joints & Vertical Fractures	1 – 14.2	Tight	None	3.8x0.9x2 To 4x4x5.6
9813						2	6, 3, 2, 15, 4, 6, 65	Bedding Joints & Vertical Fractures		0.02		
9814						1	8, 6, 2	Bedding Joints		Tight		
9815						1	2, 3	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9816		Siltstone with illite	100	63	91	1	6, 22, 3, 26	Bedding Joints	1.5 – 37.6	0.05	None	4x4x0.8 To 4x4x5.75
9817						1	2, 1, 3, 2	Bedding Joints		0.02		
9818						1	6, 2, 11, 3, 6, 4	Bedding Joints		0.04		
9819		Siltstone				1	3, 4, 6	Bedding Joints		0.01		4x4x0.6 To 4x4x14.8
9820						1	11	Bedding Joints		Tight		
9821						1	23	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9822		Siltstone	100	72	78	1	8	Bedding Joints	1 – 41.3	Tight	None	4x4x2.6 To 4x4x16.25
9823						1	7	Bedding Joints		Tight		
9824						1	8, 8, 13	Bedding Joints		Tight		
9825						1	7	Bedding Joints		Tight		3.5x2.6x0.8 To 4x4x9.8
9826						2	10, 8, 85, 3, 7, 6, 2, 90, 11, 4, 14	Bedding Joints & Vertical Fractures		Tight		
9827						1	6, 6, 15, 6, 5	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9828		Siltstone	100	88	91	1	4, 12, 5	Bedding Joints	2 – 24.6	0.01	None	4x4x0.7 To 4x4x9.7
9829						1	4	Bedding Joints		Tight		
9830						1	13, 6	Bedding Joints		0.01		
9831						2	15, 4, 11, 50, 80, 3, 70, 8, 2	Bedding Joints & Vertical Fractures		Tight		1.75x1.1x0.8 To 4x4x6.75
9832						2	5, 70, 6, 80	Bedding Joints & Vertical Fractures		Tight		
9833						1	11, 18, 8	Bedding Joints		0.01		

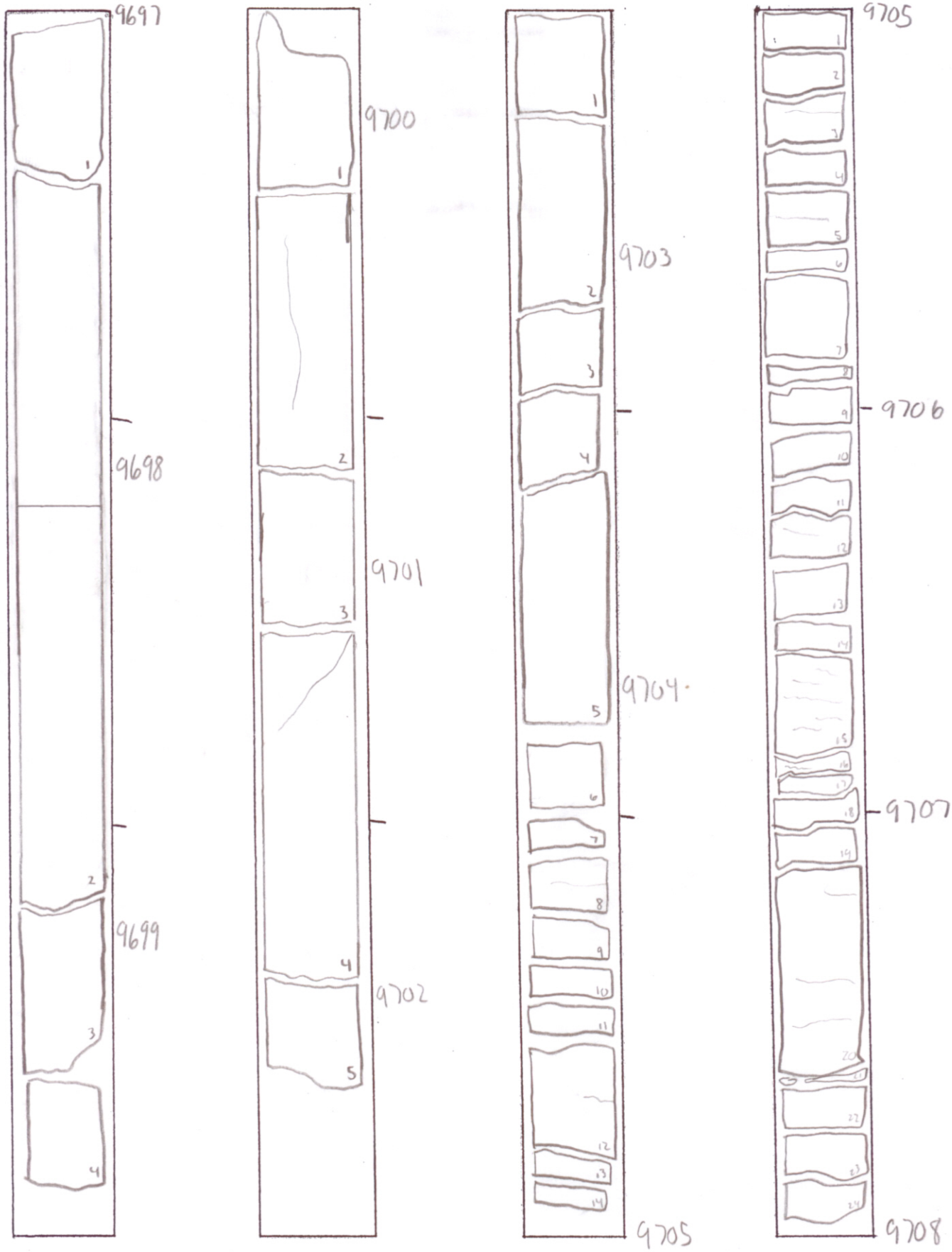
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9834		Siltstone	100	68	86	1	5, 12	Bedding Joints	0.5 – 31.2	0.04	None	4x4x0.2 To 4x4x12.3
9835						1	18, 17, 23, 25, 4, 27	Bedding Joints		0.04		
9836						1	12, 0, 36	Bedding Joints		0.05		
9837						1	47, 46, 25	Diagonal Fractures		0.04		2.8x3x0.5 To 4x4x8.2
9838						1	5	Bedding Joints		Tight		
9839						2	0, 0, 1, 0, 0, 4, 70	Bedding Joints & Vertical Fractures		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9840		Siltstone	100	43	64	1	1, 2, 5, 2, 0, 4, 1, 3, 0	Bedding Joints	1 – 15.2	Tight	None	4x4x0.5 To 4x4x6
9841						1	3, 0, 5, 8, 12	Bedding Joints		0.05		
9842						1	11, 12, 5	Bedding Joints		Tight		
9843						1	3, 1, 5	Bedding Joints		0.01		4x4x0.4 To 4x4x5.4
9844		Siltstone with illite				1	3, 4, 0, 2, 1	Bedding Joints		0.04		
9845						1	1, 2, 0, 5, 2, 9, 2, 1, 3, 2	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9846		Siltstone with illite	100	68	76	1	5, 2, 4, 2, 1, 0, 4, 1, 1, 5, 2, 2, 4	Bedding Joints	0.5 – 21.1	0.02	None	4x4x0.2 To 4x4x8.3
9847		Siltstone				1	3, 3, 4	Bedding Joints		0.01		
9848						1	2, 3, 5	Bedding Joints		Tight		
9849						1	10, 13	Bedding Joints		Tight		4x4x0.7 To 4x4x7.7
9850						1	8, 8, 4, 25, 15	Bedding Joints		0.02		

Well #16083 fracture sketch

Page: 1 of 15 BOX : 9697 - 9708 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS File no. : 16083 Operator : Hess

Drawing by : ~~Jill Herwerda~~ Daniel Smith API no. : 33105015570000

Date : 7-9-2008 Scale (ratio) : _____ Core diameter : 4"

BOX : 9708 - 9710 (in feet) (no.of slots : N/A)

Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Naga Ramesh
Date : 07/09/08

File no. : 16083
API no. : 33105015570000
Scale (ratio) : _____

Operator : Hess
Core diameter : 4"

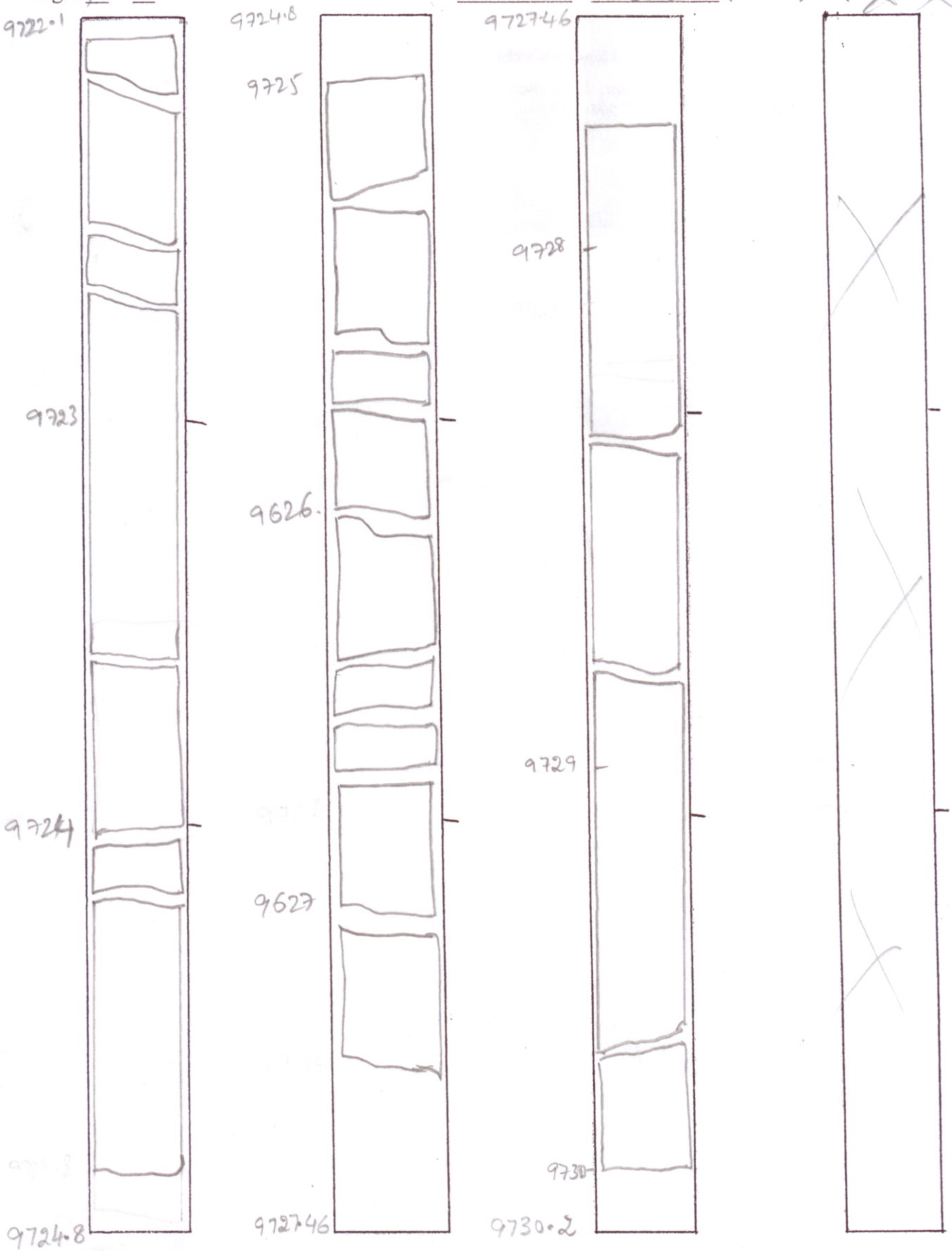
BOX : 9710.8 - 9722.1 (in feet) (no. of slots : X)

Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Naga Ramesh
Date : 07/09/08

File no. : 16083
API no. : 33105015570000
Scale (ratio) :

Operator : Hess
Core diameter : 4"

BOX : 9722.1 - 9730.2 (in feet) (no of slots : ____)



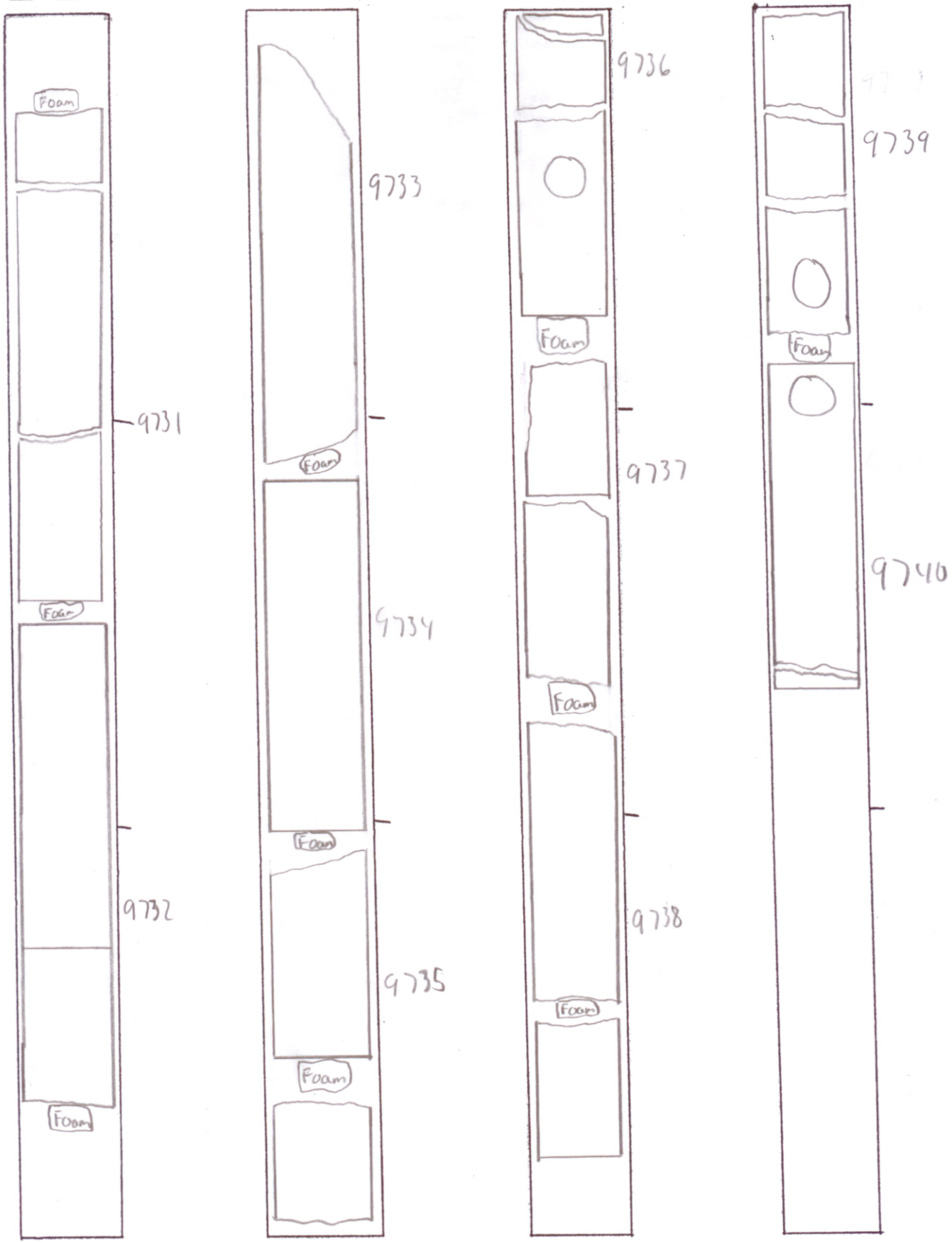
Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Sil Klotwerda~~ Naga Ramesh
Date : 07/09/08

File no. : 16083
API no. : 33105015570000
Scale (ratio) : _____

Operator : Hess
Core diameter : 4"

length: 9"/3ft , width: 0.1"/4"

BOX : 9730.2 - 9740.36 (in feet) (no.of slots : N/A)

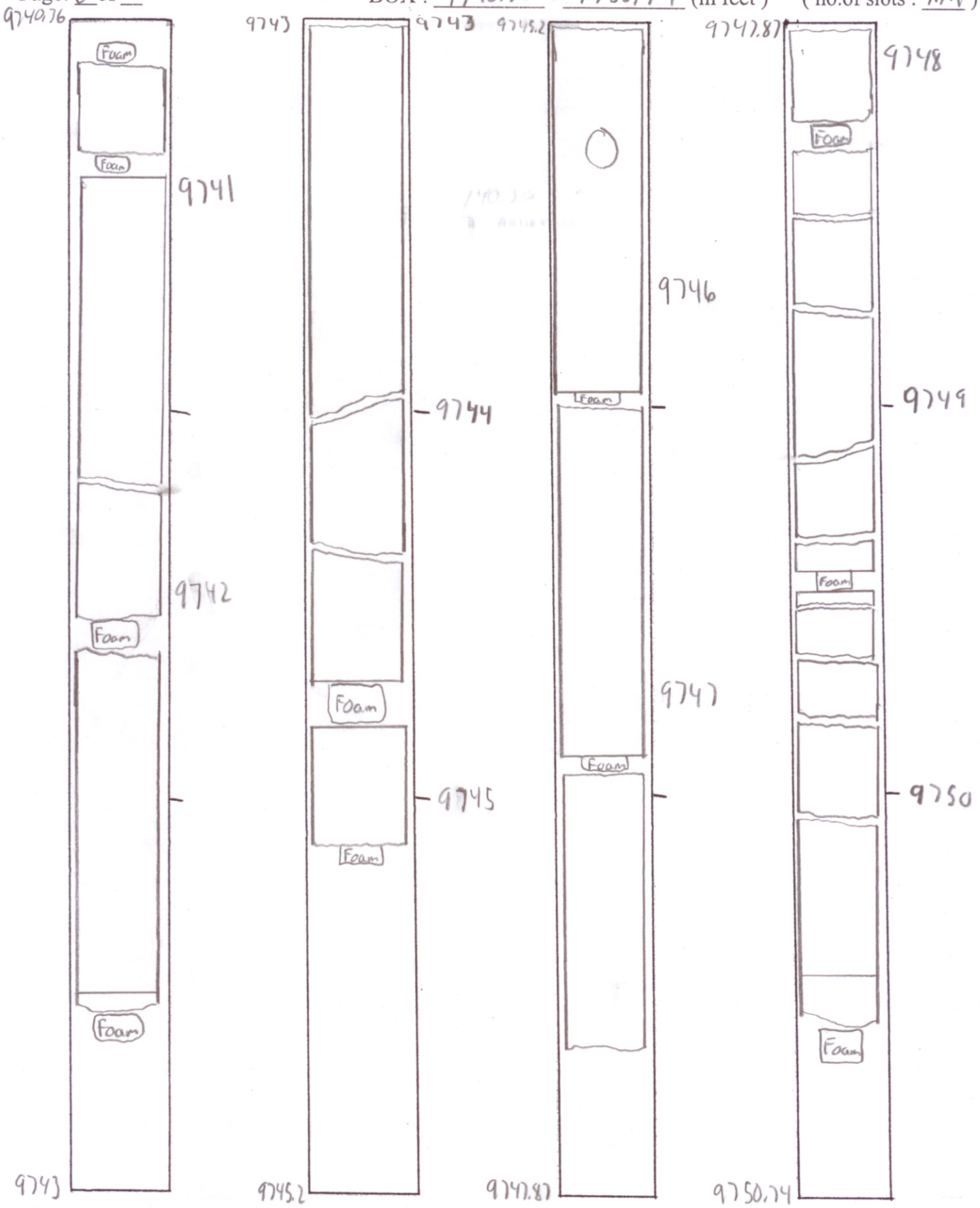


Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Helwerda~~ Daniel Smith
Date : 7-9-2008

File no. : 16083
API no. : 33105 01557 0000
Scale (ratio) :

Operator : Hess
Core diameter : 4X4

BOX : 9740.36 - 9750.74 (in feet) (no.of slots : N/A)

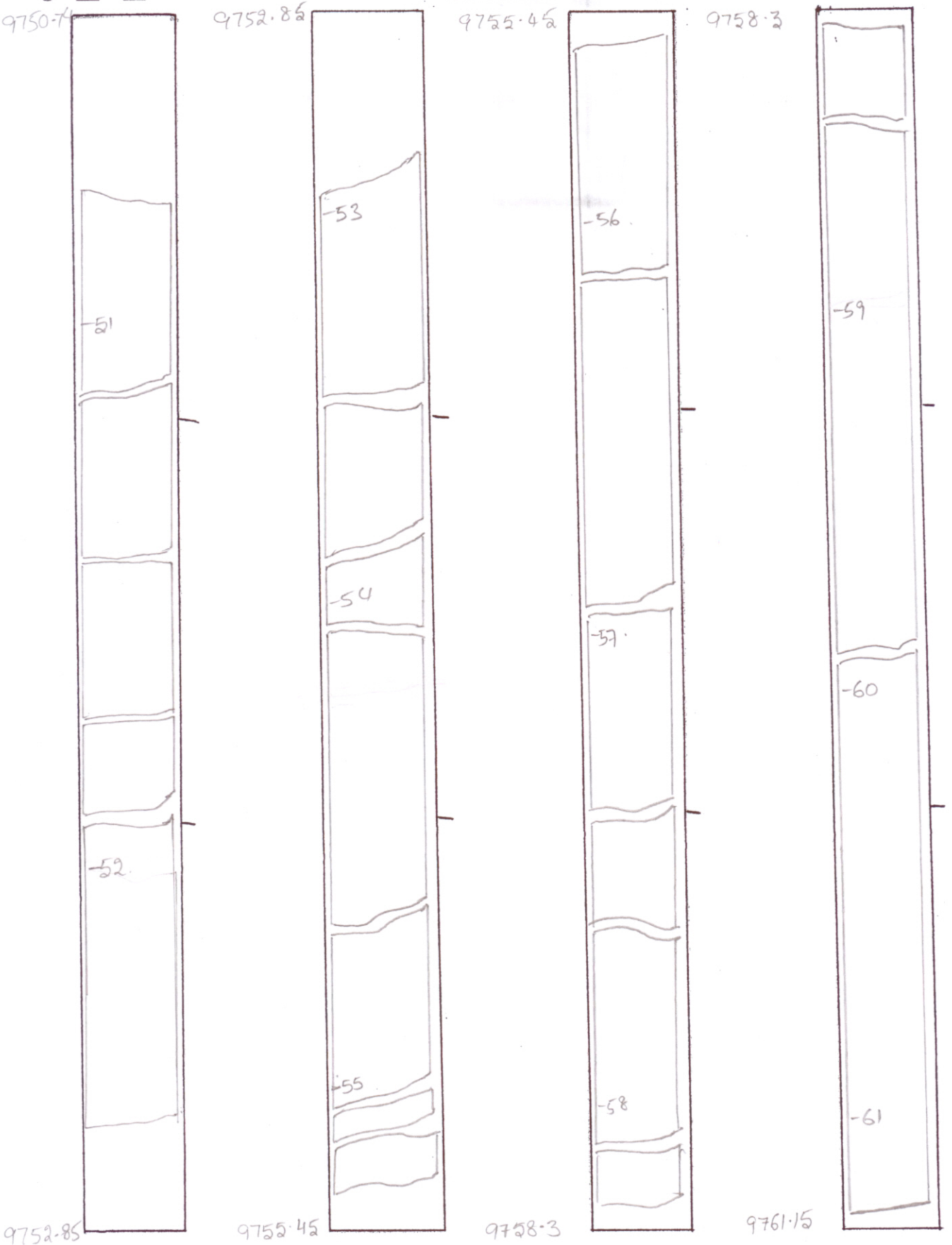


Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holwerda~~ Daniel Smith
Date : 7-9-2008

File no. : 16083
API no. : 33105015570000
Scale (ratio) :

Operator : Hess
Core diameter : 4x4

Page: 7 of 15 BOX : 9750.74 - 9761.15 (in feet) (no.of slots : 9)

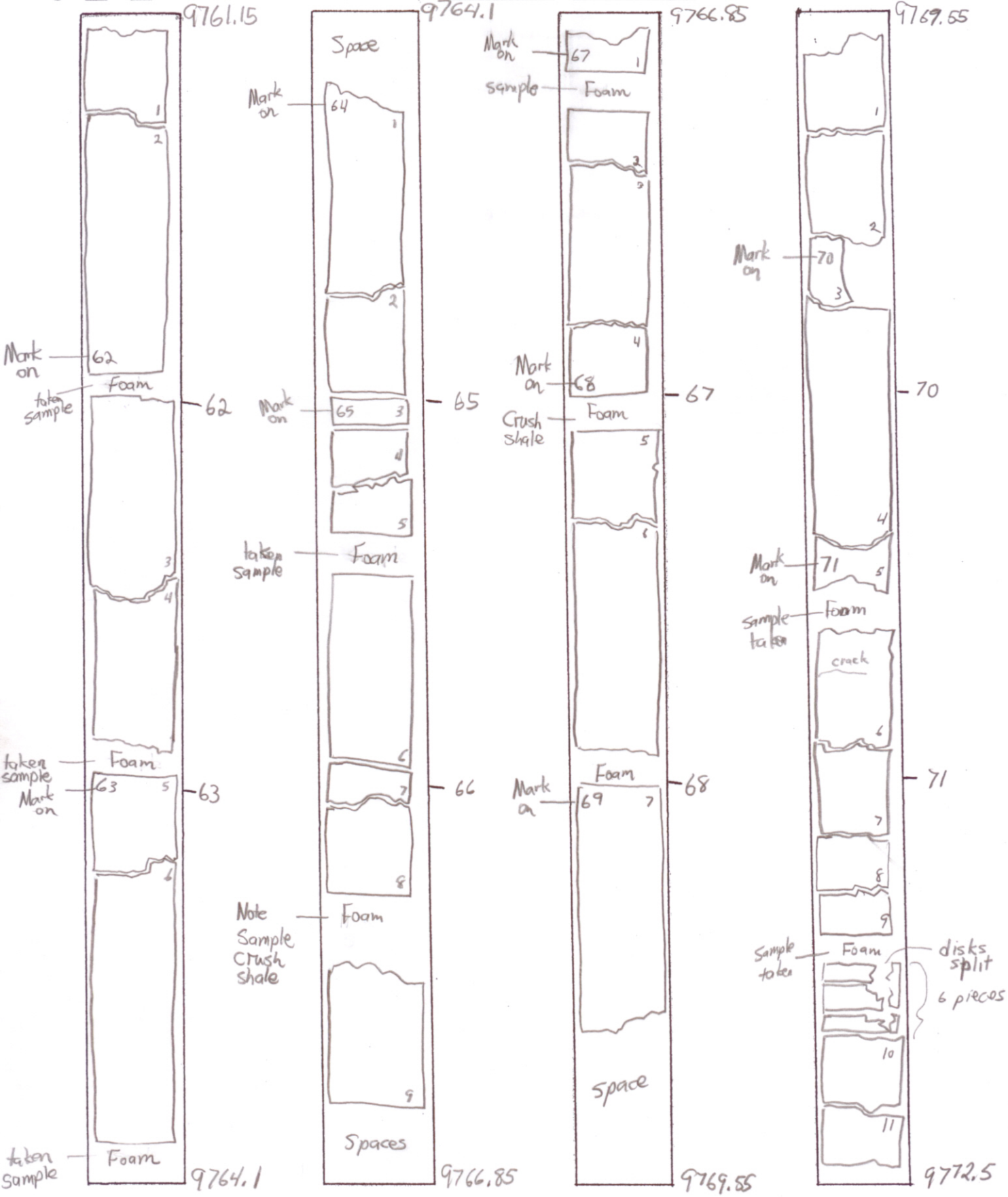


Project name : BAKKEN GEOMECHANICS File no. : 16083 Operator : Hess

Drawing by : ~~Jill Holwerda~~ Naga Ramesh API no. : 33105015570000

Date : 07/09/08 Scale (ratio) : _____ Core diameter : 4"

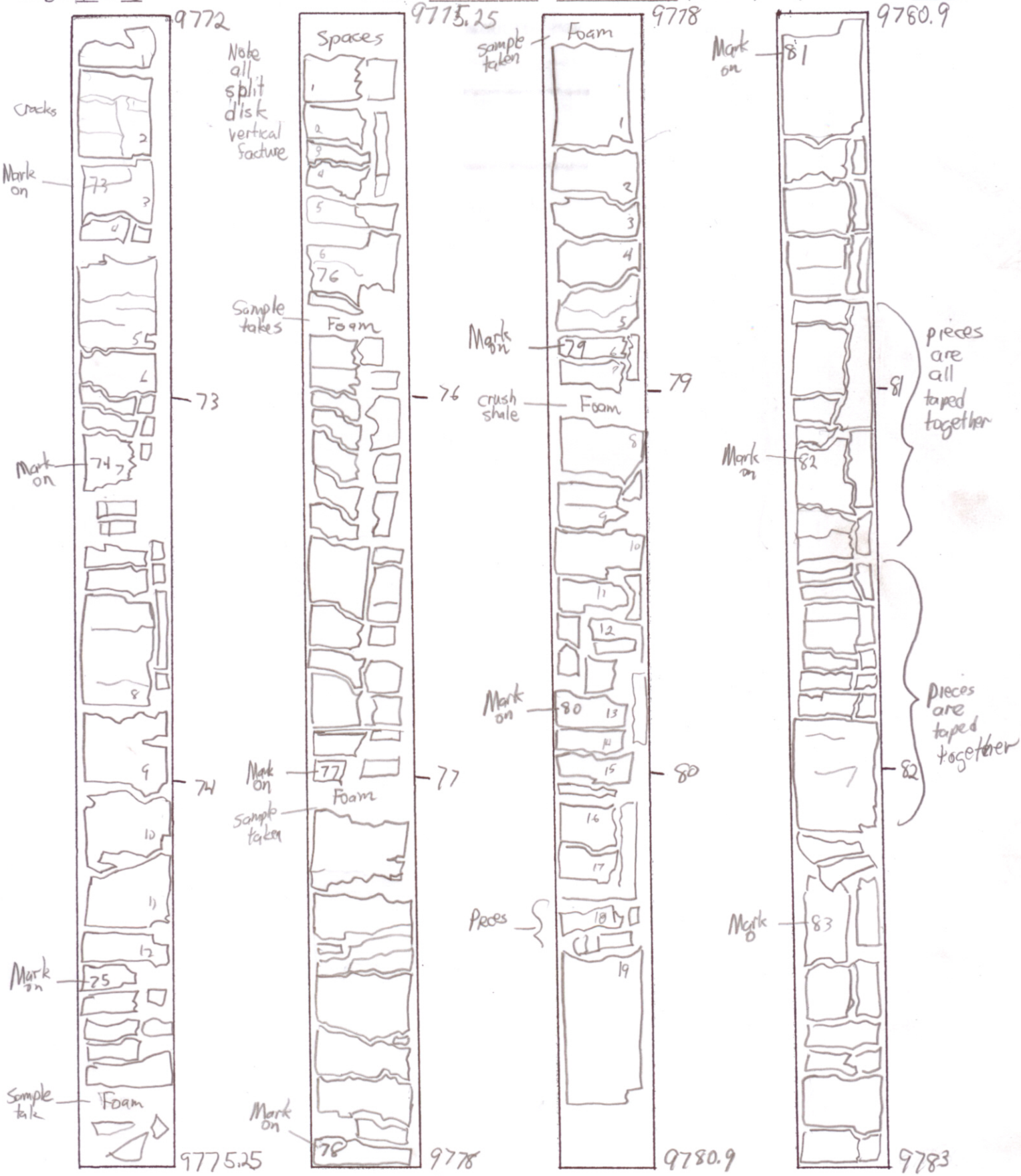
Page: 8 of 15 BOX : 9761.15 - 9772.5 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

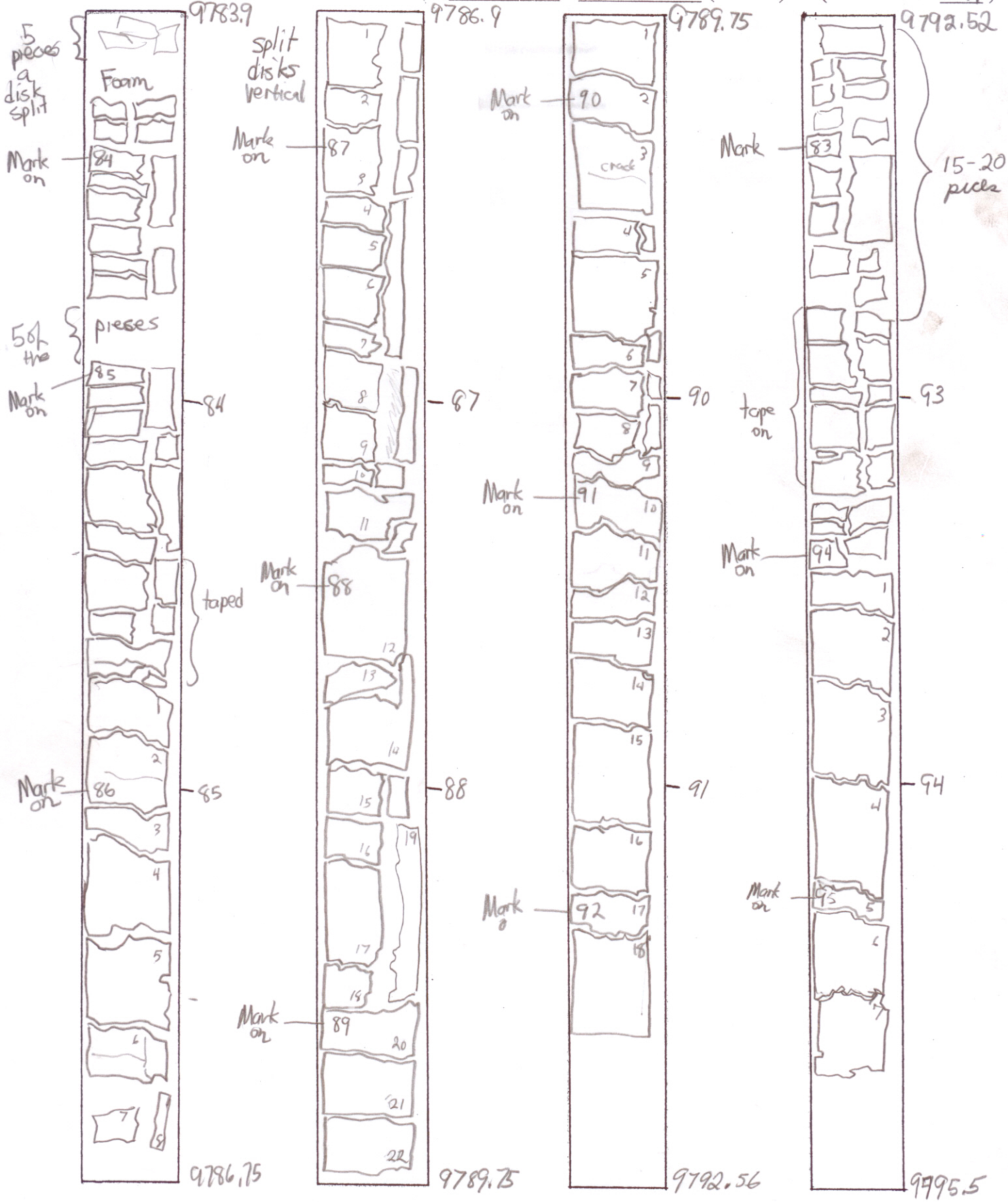
BOX : 9772 - 9783 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

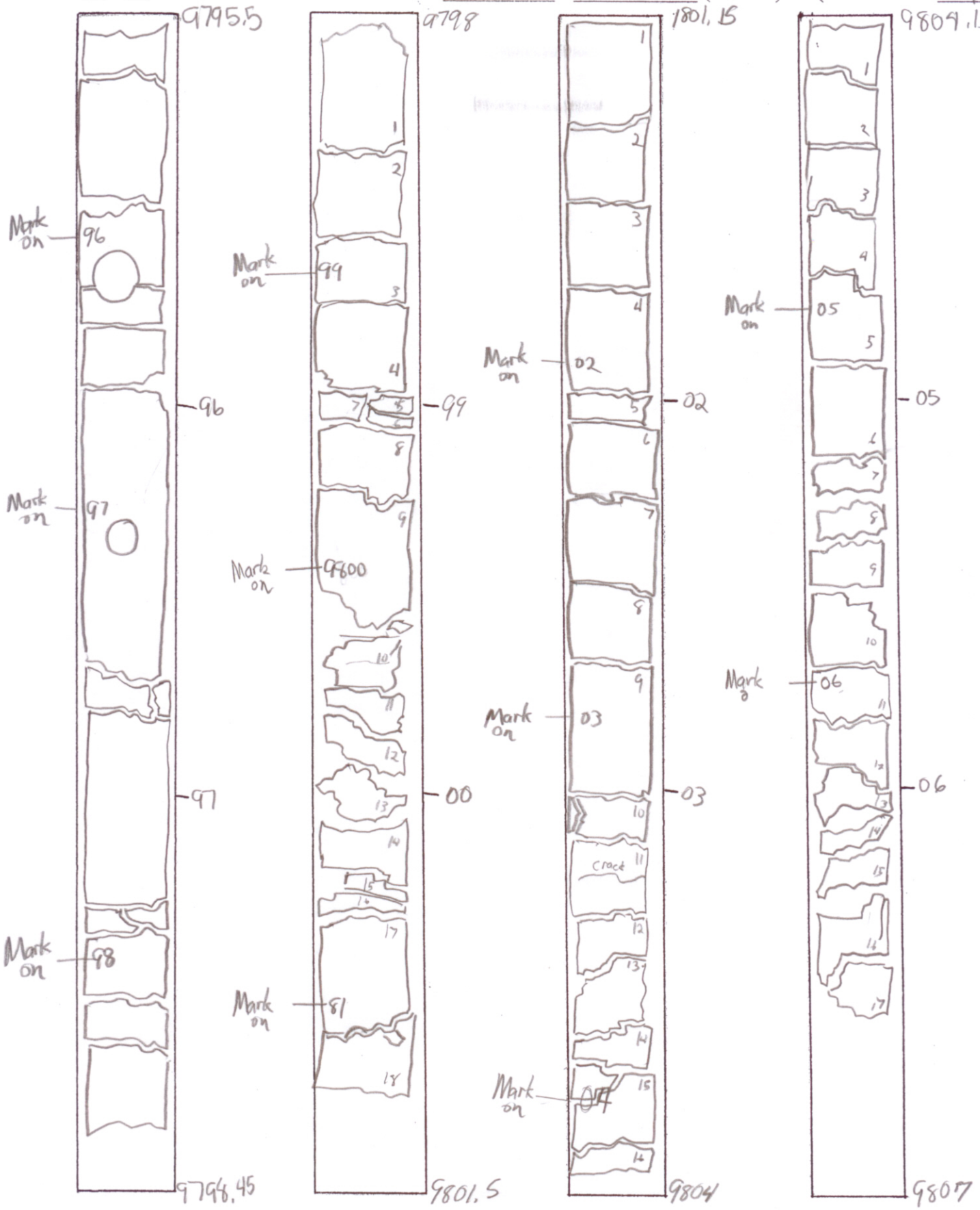
BOX : 9783.9 - 9795.5 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

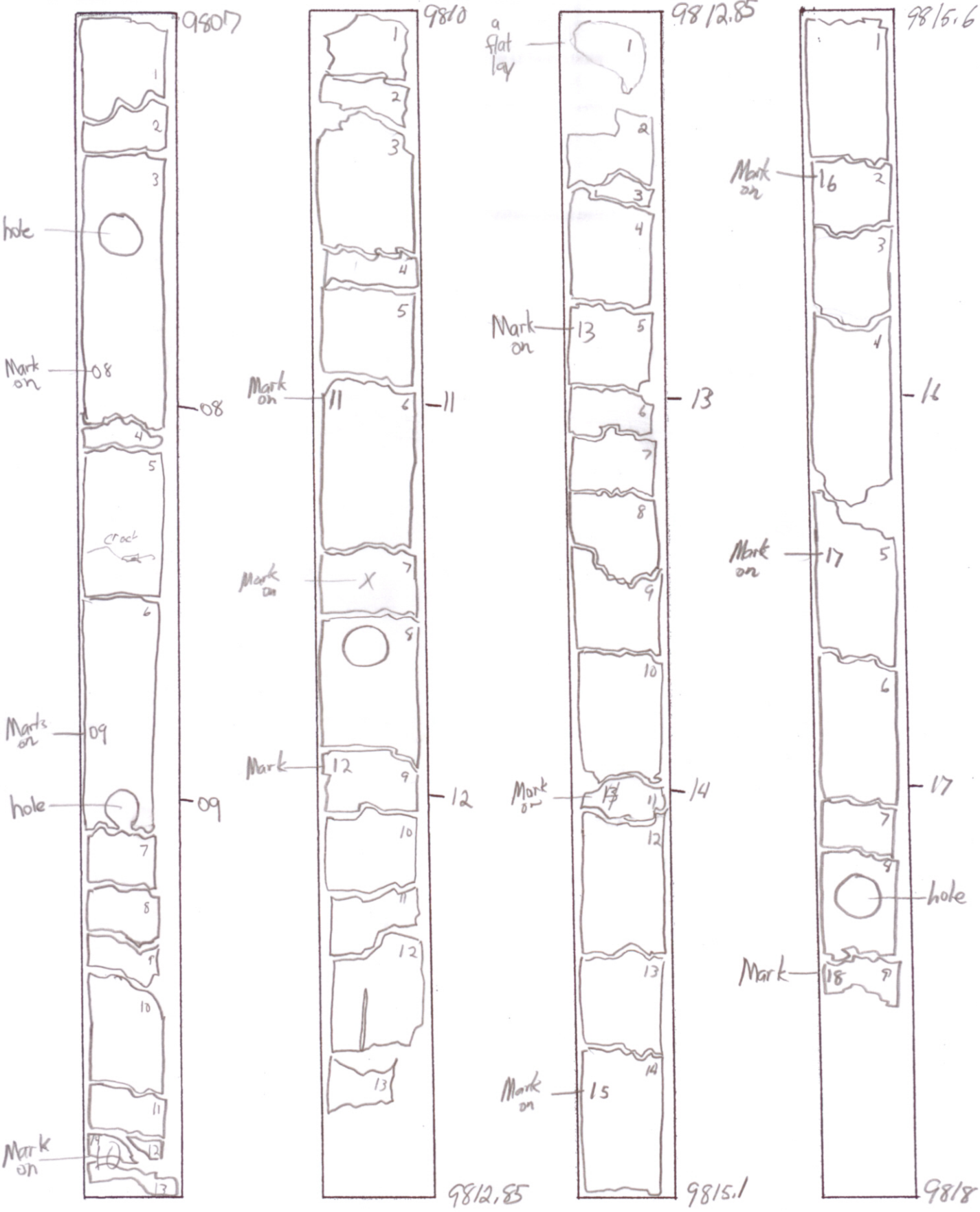
Page: 11 of 15 BOX : 9795.5 - 9807 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length width Core diameter : 4"
9"/3ft 0.33"/4"

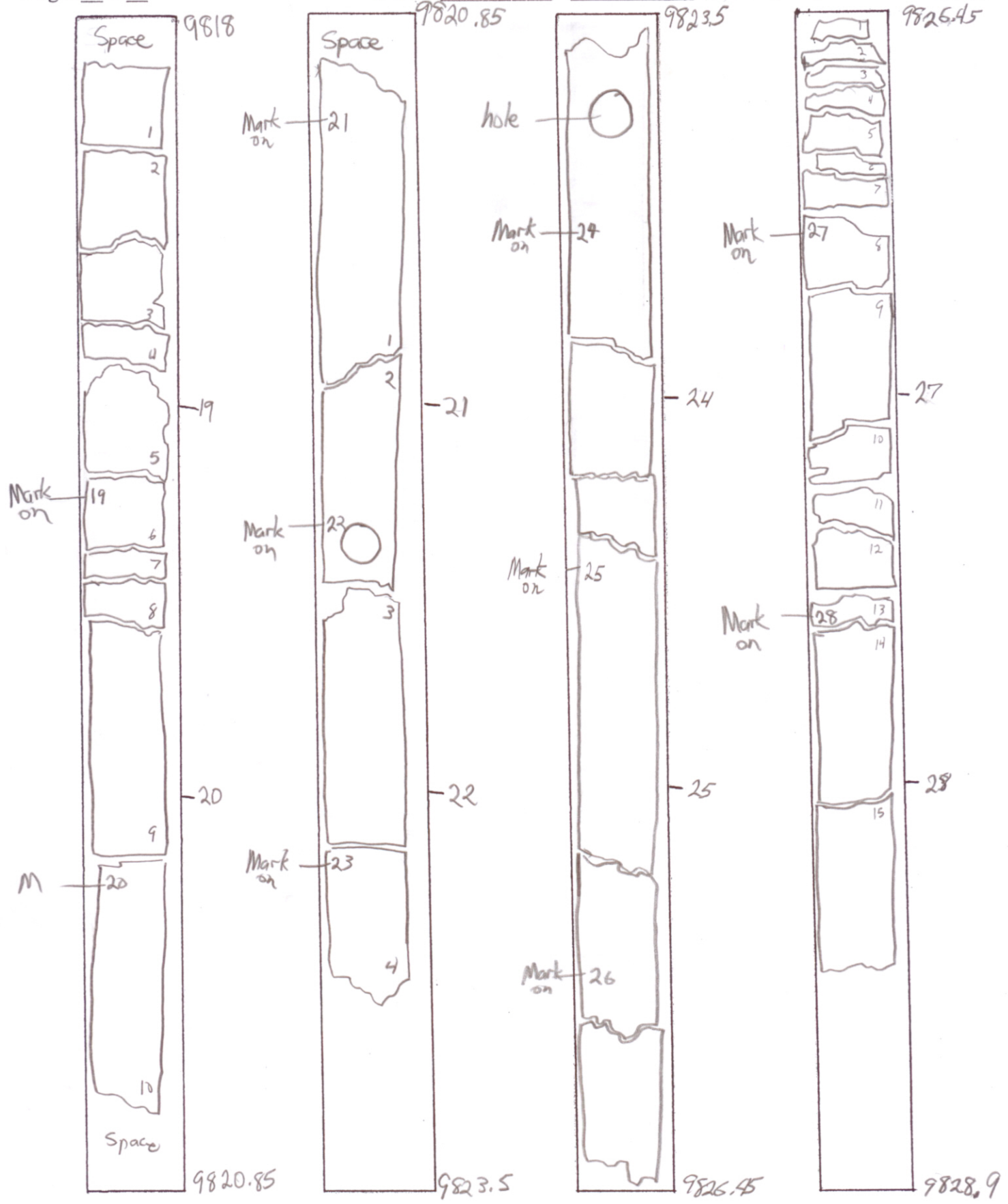
Page: 12 of 15 BOX : 9807 - 9818 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

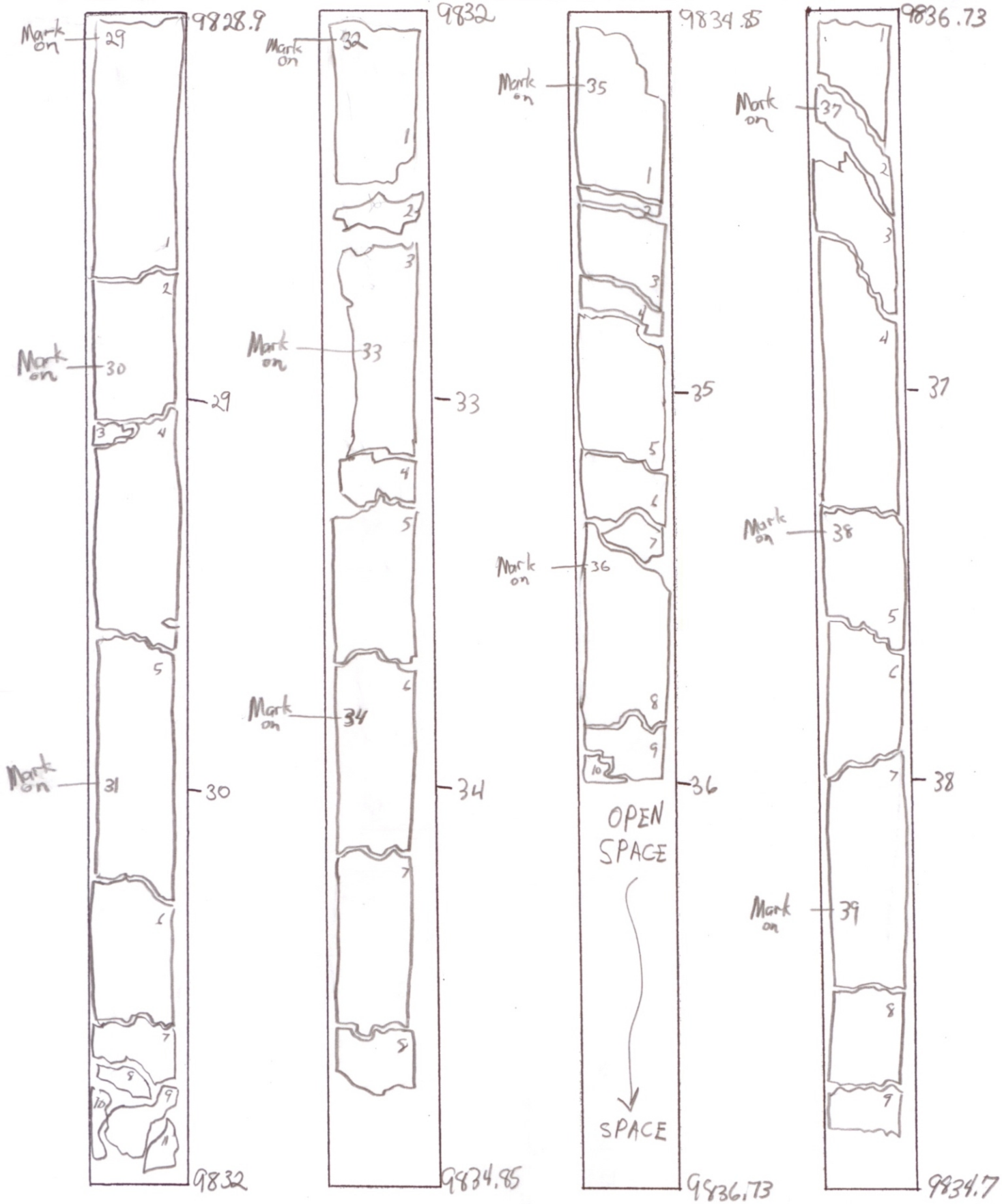
BOX : 9818 - _____ (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083 Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

BOX : 9824.9 - 9839.7 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-10-08

File no. : 16083

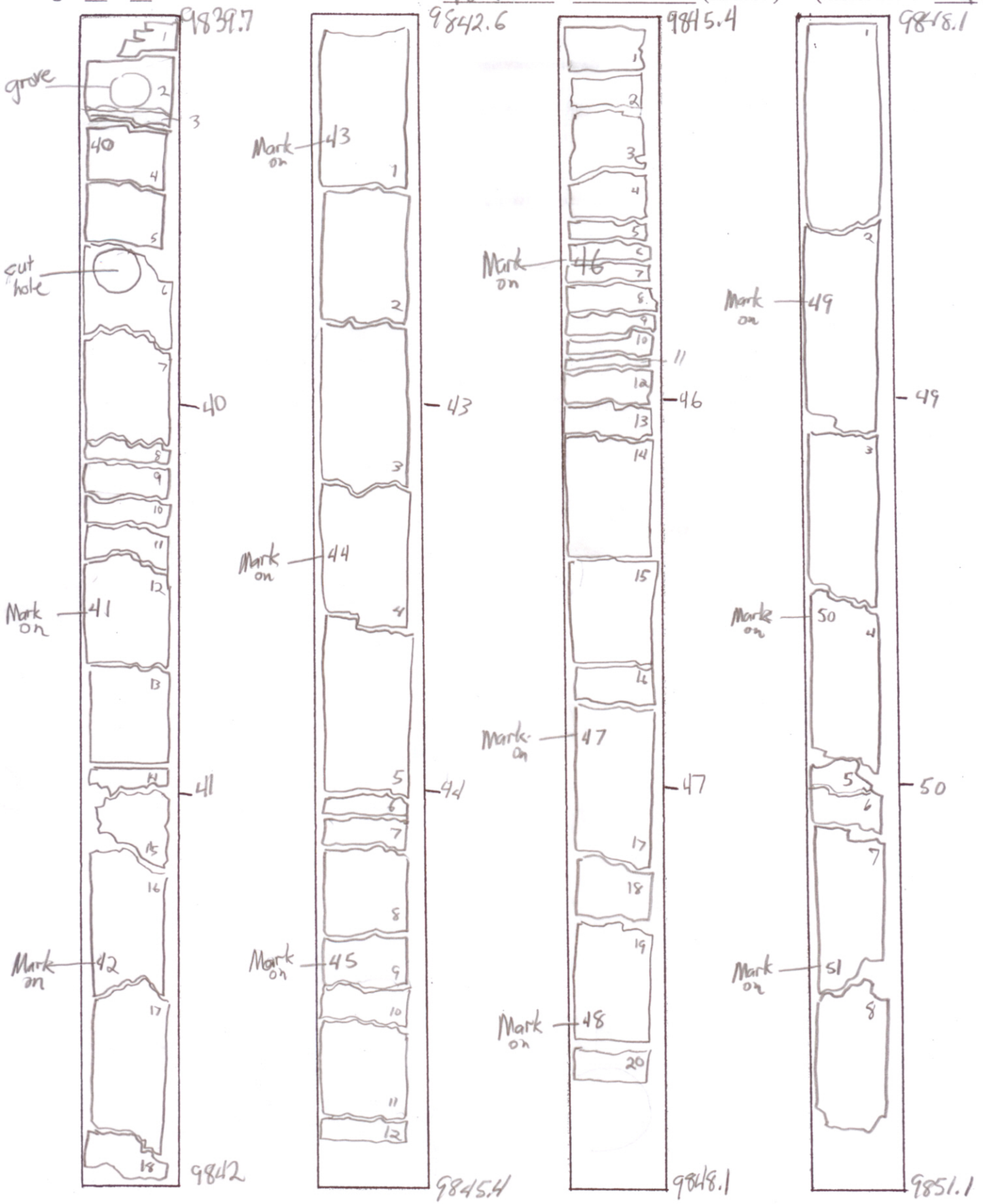
Operator : Hess

API no. : 33105015570000

Scale (ratio) : length 9"/3ft width 0.33"/4"

Core diameter : 4"

BOX : 9839.7 - 9851.1 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-10-08

File no. : 16083
Operator : Hess
API no. : 33105015570000
Scale (ratio) : length 9"/371 width 0.33"/4"
Core diameter : 4"

Well #16160 Core survey

Bakken Geomech. Core description File # : 16160 Well API: 33061004980000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9365		Limestone	100	21	62	1	15, 8, 5, 3, 5, 3	Bedding Joints	2.5 – 13.3	0.02	Calcite	4x4x1 To 4x4x5.25
9366						1	6, 6, 7	Bedding Joints		0.04		
9367						1	1, 12, 0, 6, 5, 7	Bedding Joints		0.05		
9368						2	3, 3, 10, 4, 5, 90, 6	Bedding Joints & Vertical Fractures		0.04		2.8x4x1.25 To 4x4x5.2
9369						1	4, 5, 15	Bedding Joints		0.02		
9370						1	4, 20, 1, 16	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9371		Limestone	100	24	80	1	6, 4, 22	Bedding Joints	1.8 - 14	0.04	none	4x4x0.75 To 4x4x5.5
9372						1	4, 1, 4, 6, 3	Bedding Joints		0.04		
9373						1	11, 2, 4, 17, 4, 4	Bedding Joints		0.02		
9374						1	5, 4, 5, 5, 5	Bedding Joints		0.04		4x4x0.7 To 4x4x4.5
9375						1	5, 3, 9, 2, 3, 13	Bedding Joints		0.05		
9376						1	10, 18, 8, 4	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9377		Limestone	100	42	81	1	18, 2, 32, 4, 15	Bedding Joints	1.5 – 16.5	0.05	Calcite	4x4x0.8 To 4x4x5.4
9378						1	3, 16, 16, 4	Bedding Joints		0.05		
9379						1	10, 8, 2, 3, 6, 10	Bedding Joints		0.02		
9380						1	15, 14, 7, 2	Bedding Joints		0.04		4x4x0.6 To 4x4x6.5
9381						1	12, 10, 14, 8, 3, 10	Bedding Joints		0.04		
9382						1	7, 15, 2, 1	Bedding Joints		0.05		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9383		Limestone	100	24	68	1	2, 5, 6, 3, 13, 10, 5	Bedding Joints	1 - 15	0.02	None	4x4x0.4 To 4x4x3.8
9384						1	10, 12, 8, 17, 16, 7, 10, 3, 2, 7	Bedding Joints		0.02		
9385						1	6, 7, 10, 5, 5, 4	Bedding Joints		0.04		
9386						1	3, 6, 9, 6, 18, 7, 5, 3	Bedding Joints		0.02		4x4x0.8 To 4x4x6
9387						1	10, 3, 3, 10, 5	Bedding Joints		0.04		
9388						1	1, 3, 1	Bedding Joints		0.02	Calcite	

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9389		Limestone	100	6	66	1	12, 2, 5, 10, 0	Bedding Joints	1 – 10.4	0.02	Calcite	4x4x0.4 To 4x4x3.3
9390						1	18, 5, 5, 3, 8, 17, 2	Bedding Joints		0.02	None	
9391						1	5, 10, 3, 0, 14	Bedding Joints		0.04		
9392						1	8, 2, 16, 3, 13, 8, 20, 3	Bedding Joints		0.04		4x4x0.6 To 4x4x4.1
9393						1	7, 8, 18	Bedding Joints		0.04		
9394						1	0, 4, 3, 5, 7, 4	Bedding Joints		0.02	Calcite	

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9395		Limestone	100	45	85	2	13, 11, 85, 5, 4, 5	Bedding Joints & Vertical Fractures	0.6 - 7	0.02	None	2.3x4x0.75 To 4x4x5.75
9396						1	3, 5, 7, 6, 13	Bedding Joints		0.02		
9397						1	5, 0, 0, 17, 6	Bedding Joints		0.04		
9398						1	5, 4, 7, 2, 4, 3	Bedding Joints		0.02		4x4x0.2 To 4x4x5.25
9399						1	9, 2, 0, 9, 1	Bedding Joints		0.05	Calcite	
9400						1	10, 23, 7	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9401		Limestone	100	24	65	1	4, 5, 4, 11, 4	Bedding Joints	1.9 – 18.4	0.01	Calcite	4x4x1.1 To 4x4x5.9
9402						1	2, 0, 9	Bedding Joints		0.01	None	
9403						1	7, 3, 5, 4, 1	Bedding Joints		0.02	Calcite	
9404						1	7, 10, 2	Bedding Joints		0.04	None	4x4x0.75 To 4x4x7.25
9405						1	5, 12, 7, 5, 3, 6, 7	Bedding Joints		0.05	Calcite	
9406						1	4, 4, 7, 6, 5, 8	Bedding Joints		0.01	None	

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9407		Limestone	100	55	84	1	4, 12, 2	Bedding Joints	2.5 - 33	0.02	None	1.75x1.75x 0.8 To 4x4x13
9408						2	4, 21, 90, 17, 2, 13, 8, 6, 20	Bedding Joints & Vertical Fractures		0.01		
9409						2	16, 75, 4	Bedding Joints & Vertical Fractures		0.04		
9410						1	5	Bedding Joints		0.02		4x4x2.25 To 4x4x12.6
9411						1	2, 6, 5, 2	Bedding Joints		0.02	Calcite	

Bakken Geomech. Core description File # : 16160 Well API: 33061004980000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9412		Limestone	100	85	99	1	3	Bedding Joints	5.1 – 29.8	0.01	Calcite	4x4x5.6 To 4x4x11.75
9413						1	7	Bedding Joints		Tight	None	
9414						1	10, 2	Bedding Joints		Tight		
9415						1	6, 19	Bedding Joints		0.04		4x4x2 To 4x4x11.25
9416						1	14, 17	Bedding Joints		0.02	Calcite	
9417						1	35, 2, 4	Bedding Joints		0.01	Calcite	

Bakken Geomech. Core description File # : 16160 Well API: 33061004980000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9418		Limestone	100	89	100	1	17,15	Bedding Joints	5.1-28.6	0.02	None	4x4x6 To 4x4x9
9419						1	7			0.01		
9420						1	8,26			Tight		
9421						1	9,8			Tight		2.5x1.8x1.8 To 4x4x11.25
9422						1	3			0.01		
9423						2	7,6,35,70	Bedding Joints & Vertical Fractures		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9424		Black Shale High Percentage of CARBON	100	31	71	2	2,0,90,6, 4,4,5,75	Bedding Joints & Vertical Fractures	0.5-13	0.02	None	1.75x3x0.2 To 4x4x5.1
9425						2	6,2,8,3, 55,2,9,7, 2,85			0.01		
9426						2	2,1,0,0, 90,7,8			0.04		
9427						2	0,6,85, 8,2,2,4, 88			0.02		1x1.25x0.6 To 4x4x4.75
9428						2	8,2,1,7, 75			0.01		
9429						2	14,3,6,5, 12,85			0.03		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9430		Black Shale High Percentage of CARBON	100	60	87	2	3,5,9,90, 3,7	Bedding Joints & Vertical Fractures	0.6-20.8	0.02	None	1.4x2.5x1.3 To 4x4x7.75
9431						2	7,8,5,3,	Bedding Joints & Vertical Fractures		0.01		
9432						2	15,85,3	Bedding Joints & Vertical Fractures		Tight		
9433						2	25,10,42,8	Bedding Joints & Vertical Fractures		0.04		1.8x1.8x2.1 To 4x4x8.2
9434						1	2,4,7	Bedding Joints		0.02		
9435						2	3,8,8,5, 8,6,6,5, 5,12,6	Bedding Joints & Vertical Fractures		Tight		

Bakken Geomech. Core description File # : 16160 Well API: 33061004980000 Operator: **Hess**

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9436		Black Shale High Percentage of CARBON	100	87	91	2	11,6,2,85	Bedding Joints & Vertical Fractures	4.4-26.7	0.02	None	1.6x1.8x0.6 To 4x4x10.5
9437						2	2,6,72,2	Bedding Joints & Vertical Fractures		Tight		
9438						2	6,88,3	Bedding Joints & Vertical Fractures		0.02		
9439						1	2,4,2	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9440		Dolomitic Siltstone	100	90	99	1	9	Bedding Joints	8.6 – 25.9	Tight	None	4x4x3.75 to 4x4x10.2
9441						1	15, 5, 9	Bedding Joints		0.01		
9442						1	10	Bedding Joints		Tight		
9443						1	2, 3	Bedding Joints		0.04		4x4x3.4 to 4x4x7.7
9444						1	3, 0, 4	Bedding Joints		Tight		
9445						1	8, 1	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9446		Dolomitic Siltstone	100	65	88	1	3, 6	Bedding Joints	1.8 – 23.1	0.02	None	4x4x0.7 to 4x4x9.1
9447						1	2, 6, 4, 5	Bedding Joints		0.05		
9448						1	0, 20, 0, 4, 3	Bedding Joints		0.05		
9449						1	3, 5	Bedding Joints		0.01		4x4x1.5 to 4x4x8.3
9450						1	2, 3	Bedding Joints		0.01		
9451						1	6, 2, 4	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9452		Dolomitic Siltstone	100	80	97	1	12, 4	Bedding Joints	5 – 32.5	0.01	None	4x4x2 to 4x4x12.8
9453						1	5, 2	Bedding Joints		Tight		
9454						1	6, 4, 6, 1	Bedding Joints		0.04		
9455						1	2	Bedding Joints		Tight		4x4x3.75 to 4x4x10
9456						1	2, 3	Bedding Joints		Tight		
9457						1	3, 6	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9458		Dolomitic Siltstone	100	98	100	1	7, 6	Bedding Joints	8.9 – 41.7	0.02	None	4x4x3.5 to 4x4x13.8
9459						1	16, 3	Bedding Joints		Tight		
9460						1	6	Bedding Joints		0.04		
9461						1	20	Bedding Joints		Tight		4x4x3.9 to 4x4x16.4
9462						1	3	Bedding Joints		Tight		
9463						1	2	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9464		Dolomitic Siltstone	76	79	98	2	32, 4, 90	Bedding Joints & Vertical Fractures	7.9 – 48.3	Tight	None	4x4x3.1 to 4x4x9.8
9465						1	4, 3, 12	Bedding Joints		Tight		
9466						1	2	Bedding Joints		Tight		
9467						1	9	Bedding Joints		Tight		4x4x19
9468						Core Missing						
9469						1	2	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9470		Dolomitic Siltstone	100	84	99	1	6	Bedding Joints	5.8 – 27.7	Tight	None	4x4x3.5 to 4x4x10.9
9471						1	9, 11	Bedding Joints		Tight		
9472						1	2, 12	Bedding Joints		Tight		
9473						1	8, 2, 32	Bedding Joints		Tight		4x4x2.3 to 4x4x10.3
9474						1	6	Bedding Joints		Tight		
9475						1	9	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9476		Dolomitic Siltstone	100	84	90	1	7, 14	Bedding Joints	3.8 – 39.1	Tight	None	4x4x1.5 to 4x4x7.9
9477						1	3, 2, 4	Bedding Joints		Tight		
9478						1	3, 2, 5	Bedding Joints		Tight		
9479						1	4, 2	Bedding Joints		Tight		4x4x3.6 to 4x4x15.4
9480						1	17, 3	Bedding Joints		Tight		
9481						1	2, 0	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9482		Dolomitic Siltstone	100	100	100	1	6	Bedding Joints	19.3 – 47.6	Tight	None	4x4x7.6 to 4x4x9.5
9483						1	2	Bedding Joints		Tight		
9484						1	2, 9	Bedding Joints		Tight		
9485						1	6	Bedding Joints		0.02		4x4x7.75 to 4x4x18.75
9486						1	6	Bedding Joints		0.02		
9487						1	4	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9488		Dolomitic Siltstone	100	72	89	1	2, 3	Bedding Joints	0.5 – 53.6	0.04	None	4x4x2.4 to 4x4x21.1
9489						1	4	Bedding Joints		0.01		
9490						1	4	Bedding Joints		Tight		
9491		Black Shale High Carbon Content				2	2, 88, 3, 11, 14, 7	Bedding Joints & Vertical Fractures		0.04		4x4x0.2 to 4x4x8.8
9492						1	3, 6, 22	Bedding Joints		0.02		
9493						2	2, 4, 85, 2, 14	Bedding Joints & Vertical Fractures		0.06		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9494		Black Shale High Carbon Content	100	34	74	1	4, 8, 4, 0	Bedding Joints	2 – 20.8	0.02	None	4x4x0.9 to 4x4x8.2
9495						2	3, 44, 80, 2	Bedding Joints & Vertical Fractures		0.01		
9496						1	4, 3, 2, 7	Bedding Joints		0.02		
9497						1	2, 3, 6, 6, 2, 2, 4, 1	Bedding Joints		0.02		4x4x0.8 to 4x4x5.2
9498						1	3, 2, 4, 6, 10, 11, 2	Bedding Joints		0.04		
9499						1	5, 3, 2, 7, 7	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9500		Black Shale High Carbon Content	100	26	81	1	4, 2, 6, 2, 2, 6, 4	Bedding Joints	1.5 – 14.2	0.04	None	4x4x0.6 to 4x4x5.6
9501						1	9, 7, 2, 4, 2, 0, 4	Bedding Joints		0.02		
9502						1	2, 4, 0, 3, 4, 9	Bedding Joints		0.04		
9503						1	6, 14, 2, 3	Bedding Joints		0.04		4x4x0.8 to 4x4x5.6
9504						1	2, 3, 4	Bedding Joints		0.06		
9505						1	9, 4, 12, 4, 14, 2	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9506		Black Shale High Carbon Content	100	25	67	2	1, 0, 9, 14, 85, 6, 4	Bedding Joints & Vertical Fractures	1 - 14	0.03	None	2.5x4x0.4 to 4x4x5.25
9507						1	5, 2, 1, 2, 4, 2	Bedding Joints		0.04		
9508						1	2, 3, 4, 9, 6, 2, 4	Bedding Joints		0.06		
9509						1	2, 7, 8, 6, 11, 9	Bedding Joints		0.04		4x4x0.4 to 4x4x5.5
9510						1	4, 3, 9	Bedding Joints		0.06		
9511						1	4, 12, 6, 2, 12, 6	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9512		Black Shale High Carbon Content	100	32	83	1	4, 11, 9, 4	Bedding Joints	1.5 - 15	0.04	None	4x4x1.25 to 4x4x5.9
9513						1	6, 2, 3	Bedding Joints		0.04		
9514						1	11, 2, 12, 12, 3, 6	Bedding Joints		0.02		
9515						1	6, 6, 11, 2, 3	Bedding Joints		0.04		4x4x0.6 to 4x4x5.9
9516						1	4, 2, 7, 12, 4 ,9	Bedding Joints		0.04		
9517						1	9, 2, 16, 5	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9518		Black Shale High Carbon Content	100	25	82	1	5, 15, 6, 1	Bedding Joints	2 – 13.5	0.04	None	4x4x0.8 to 4x4x3.75
9519						1	2, 0, 0, 6, 5	Bedding Joints		0.04		
9520						1	9, 10, 5, 10, 4, 3	Bedding Joints		0.06		
9521						1	6, 10, 3, 0, 20, 4, 0	Bedding Joints		0.06		4x4x1.1 to 4x4x5.3
9522						1	8, 6	Bedding Joints		0.02		
9523						1	3, 0, 30	Bedding Joints		0.06		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9524		Black Shale High Carbon Content	100	28	66	1	3, 1, 6	Bedding Joints	1.3 – 11.2	0.04	None	4x4x0.6 to 4x4x4.4
9525						1	1, 4, 2, 0, 2, 1	Bedding Joints		0.06		
9526						1	4, 5, 2, 2, 4	Bedding Joints		0.06		
9527						1	0, 3, 2, 1, 5, 5, 2	Bedding Joints		0.02		4x4x0.5 to 4x4x3.3
9528						2	17, 0, 2, 4, 90, 1, 4	Bedding Joints & Vertical Fractures		0.06		
9529						1	2, 2, 4, 2, 5, 2	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9530		Black Shale High Carbon Content	100	63	84	1	0, 1, 7, 2, 3	Bedding Joints	1.3 - 32	0.01	None	4x4x0.6 to 4x4x12.6
9531						1	5	Bedding Joints		0.02		
9532						1	20, 3	Bedding Joints		0.01		
9533						1	17, 7, 5	Bedding Joints		0.02		1.6x3.5x0.4 to 4x4x8.75
9534						2	2, 5, 4, 3, 75, 1, 10	Bedding Joints & Vertical Fractures		0.04		
9535						1	2, 5, 2, 9, 0	Bedding Joints		0.06		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9536		Black Shale High Carbon Content	100	43	71	1	8, 2, 6, 1, 2, 0, 3, 7, 15	Bedding Joints	1 – 16.5	0.02	None	4x4x0.5 to 4x4x5.5
9537						1	2, 15, 5, 20, 3	Bedding Joints		0.02		
9538						1	6, 12, 15, 7, 2	Bedding Joints		0.02		
9539		Siltstone with illite				1	7, 6, 12, 0, 6	Bedding Joints		0.01		4x4x0.4 to 4x4x5.9
9540						1	10, 3, 0	Bedding Joints		0.01		
9541						1	6, 0, 4, 4, 8, 3	Bedding Joints		0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9542		Siltstone with illite	100	69	83	1	2, 2, 3, 10	Bedding Joints	2.3 - 21	Tight	None	4x4x1.1 to 4x4x6
9543						1	11, 0, 1, 1	Bedding Joints		Tight		
9544						1	2, 6	Bedding Joints		Tight		
9545						1	4, 25, 5	Bedding Joints		Tight		4x4x0.9 to 4x4x8.25
9546						1	9, 6, 7	Bedding Joints		0.01		
9547						1	10, 11, 6, 3, 8	Bedding Joints		0.04		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9548		Siltstone with illite	100	50	78	1	6, 8	Bedding Joints	2.8 – 29.5	0.01	None	4x4x1.8 to 4x4x11.6
9549						1	5, 0, 10	Bedding Joints		Tight		
9550						1	5	Bedding Joints		Tight		
9551						2	0, 5, 80, 10	Bedding Joints & Vertical Fractures		0.01		1.4x3.5x2 to 4x4x8.1
9552						1	12, 9, 10, 15, 3, 1	Bedding Joints		0.09		
9553						1	10, 0, 4, 4, 2, 15	Bedding Joints		0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9554		Siltstone with illite	100	9	81	1	2	Bedding Joints	4.1 – 19.6	Tight	None	4x1.75x2.5 to 4x4x4.2
9555						2	5, 90	Bedding Joints & Vertical Fractures		Tight		
9556						1	6, 4, 2	Bedding Joints		0.04		
9557						1	4, 12, 9, 10, 3	Bedding Joints		0.02		1.6x3.5x1.3 to 4x4x7.7
9558						2	85, 5, 6, 11, 4, 5, 90	Bedding Joints & Vertical Fractures		Tight		
9559						1	30, 10, 14, 17	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9560		Siltstone	100	96	96	1	9, 10, 2, 4	Bedding Joints	4.3 – 38.4	Tight	None	4x4x3.8 to 4x4x15.1
9561						1	2	Bedding Joints		Tight		
9562						1	14	Bedding Joints		Tight		
9563						1	14, 8	Bedding Joints		Tight		4x4x1.7 to 4x4x9.4
9564						1	4	Bedding Joints		Tight		
9565						1	10, 8, 2	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9566		Siltstone	100	90	96	1	12	Bedding Joints	3.6 - 34	Tight	None	4x4x4 to 4x4x10.25
9567						1	6, 6	Bedding Joints		Tight		
9568						1	22, 10	Bedding Joints		Tight		
9569						1	7	Bedding Joints		Tight		4x4x1.4 to 4x4x13.4
9570						1	9, 6, 18, 4	Bedding Joints		Tight		
9571						1	15	Bedding Joints		0.04		

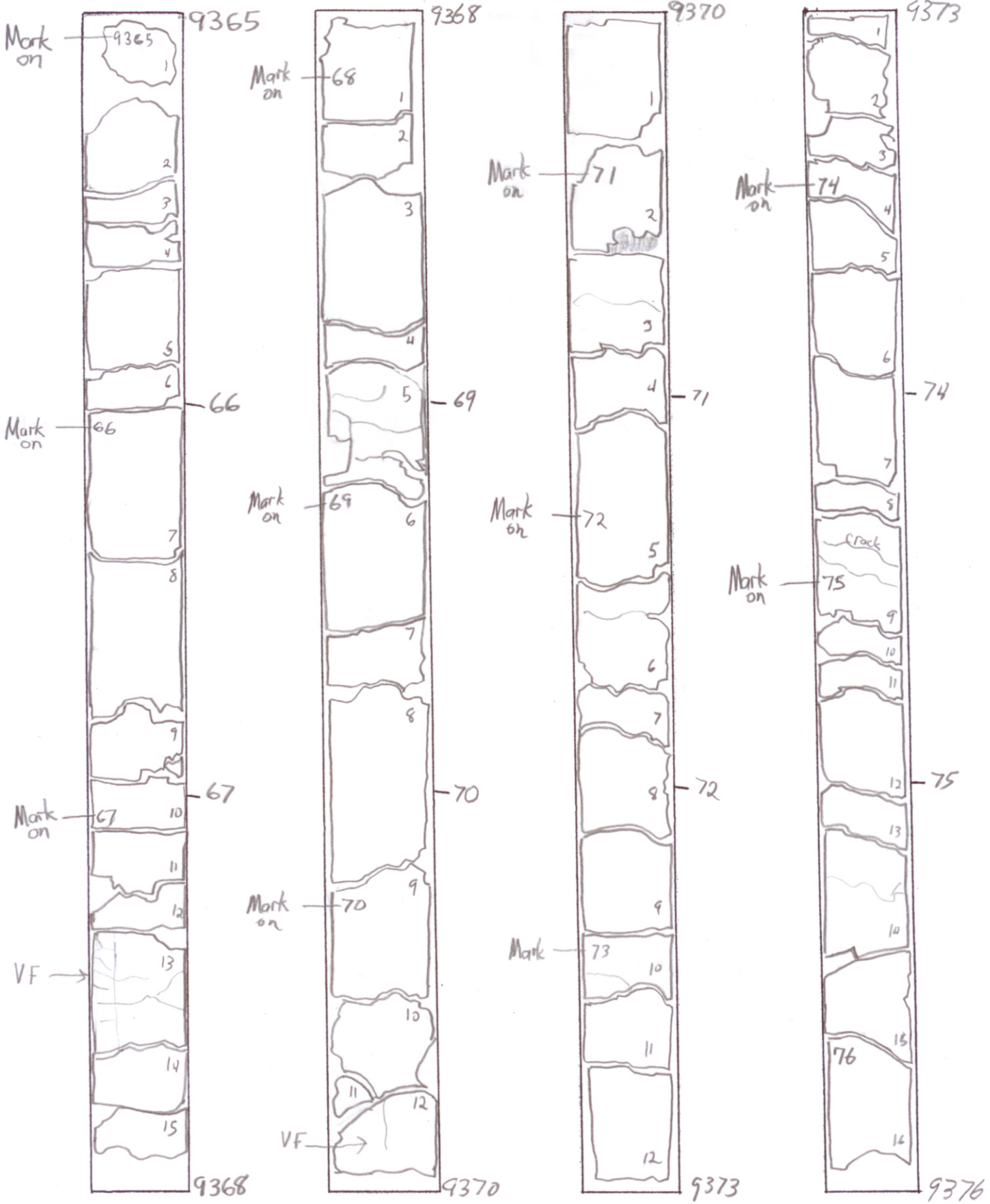
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9572		Siltstone	100	95	99	1	8, 15	Bedding Joints	7.4 – 66.7	Tight	None	4x4x4.5 to 4x4x16.5
9573						1	3, 2	Bedding Joints		Tight		
9574						0				Tight		
9575						1	36, 2, 1	Bedding Joints		Tight		4x4x2.9 to 4x4x26.25
9576						0				Tight		
9577						0				Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9578		Siltstone with clay	100	82	100	1	3, 16, 65	Bedding Joints	1.8 – 30.5	0.02	None	1.1x1.4x1 to 4x4x12
9579						2	24, 11, 36, 44, 75	Bedding Joints & Vertical Fractures		Tight		
9580						1	25, 3	Bedding Joints		Tight		
9581						1	14, 5	Bedding Joints		Tight		3x4x0.7 to 4x4x8.6
9582						2	17, 4, 2, 1, 70	Bedding Joints & Vertical Fractures		0.06		
9583						1	6, 5, 7	Bedding Joints		Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Discontinuity	Spacing. (cm)	Aperture (cm)	Filling	Block size (XYZ, inch)
9584		Siltstone with clay	100	33	72	1	9, 22, 25, 4, 0	Bedding Joints	1.5 – 23.9	Tight	None	4x4x0.6 to 4x4x3.4
9585						1	2, 7, 1, 0, 5, 6, 6	Bedding Joints		0.02		
9586						1	3, 22, 11, 7, 4, 3, 2, 6, 4	Bedding Joints		0.02		
9587						1	2, 8	Bedding Joints		0.01		4x4x1.6 to 4x4x9.4
9588						1	2, 2	Bedding Joints		Tight		
9589						1	8, 10	Bedding Joints		Tight		

Well #16160 fracture sketch

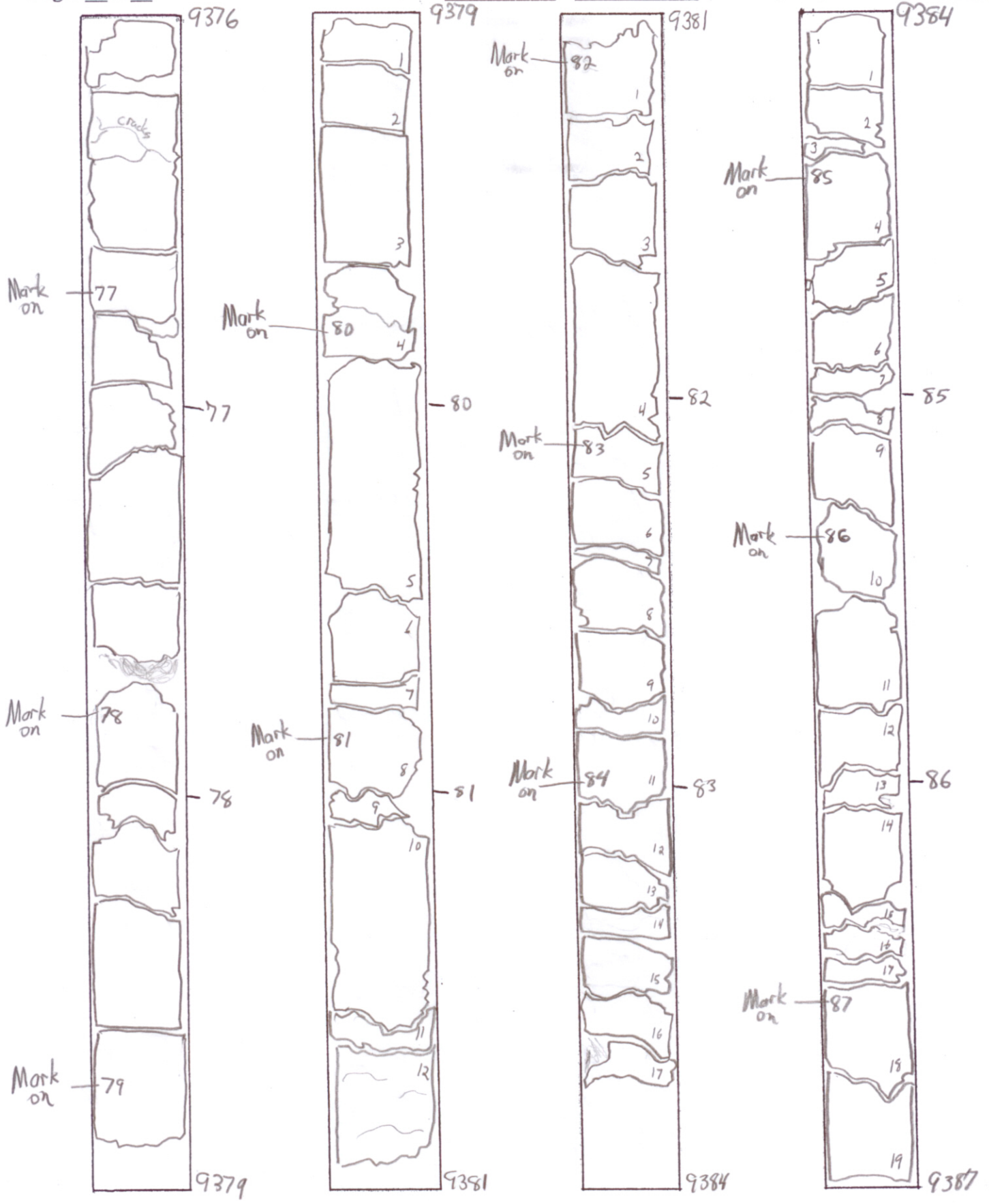
Page: 1 of __ BOX : 9365 - 9376 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-11-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

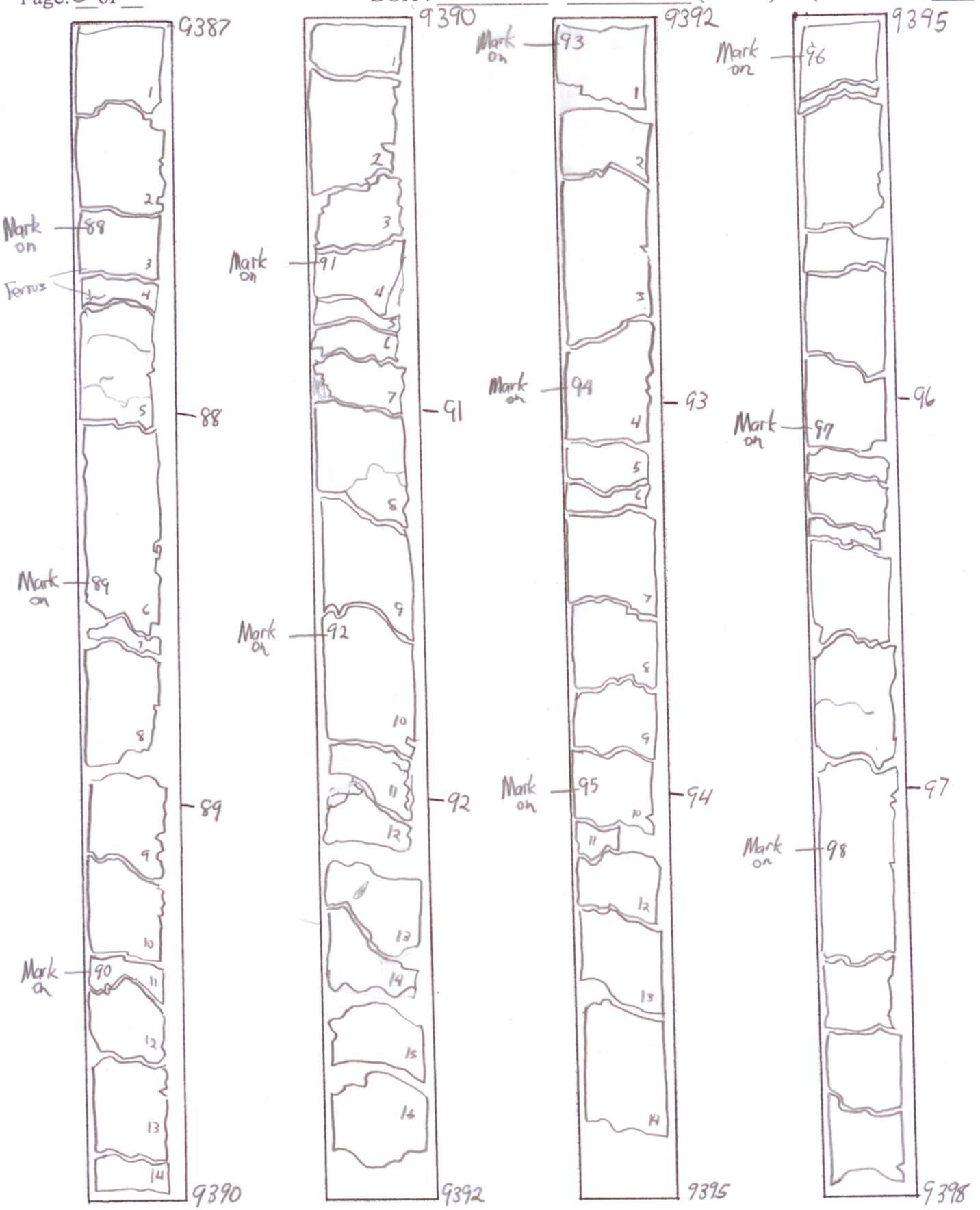
Page: 2 of __ BOX : 9376 - 9387 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-11-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) length width Core diameter : 4"
9"/3ft 0.33"/4"

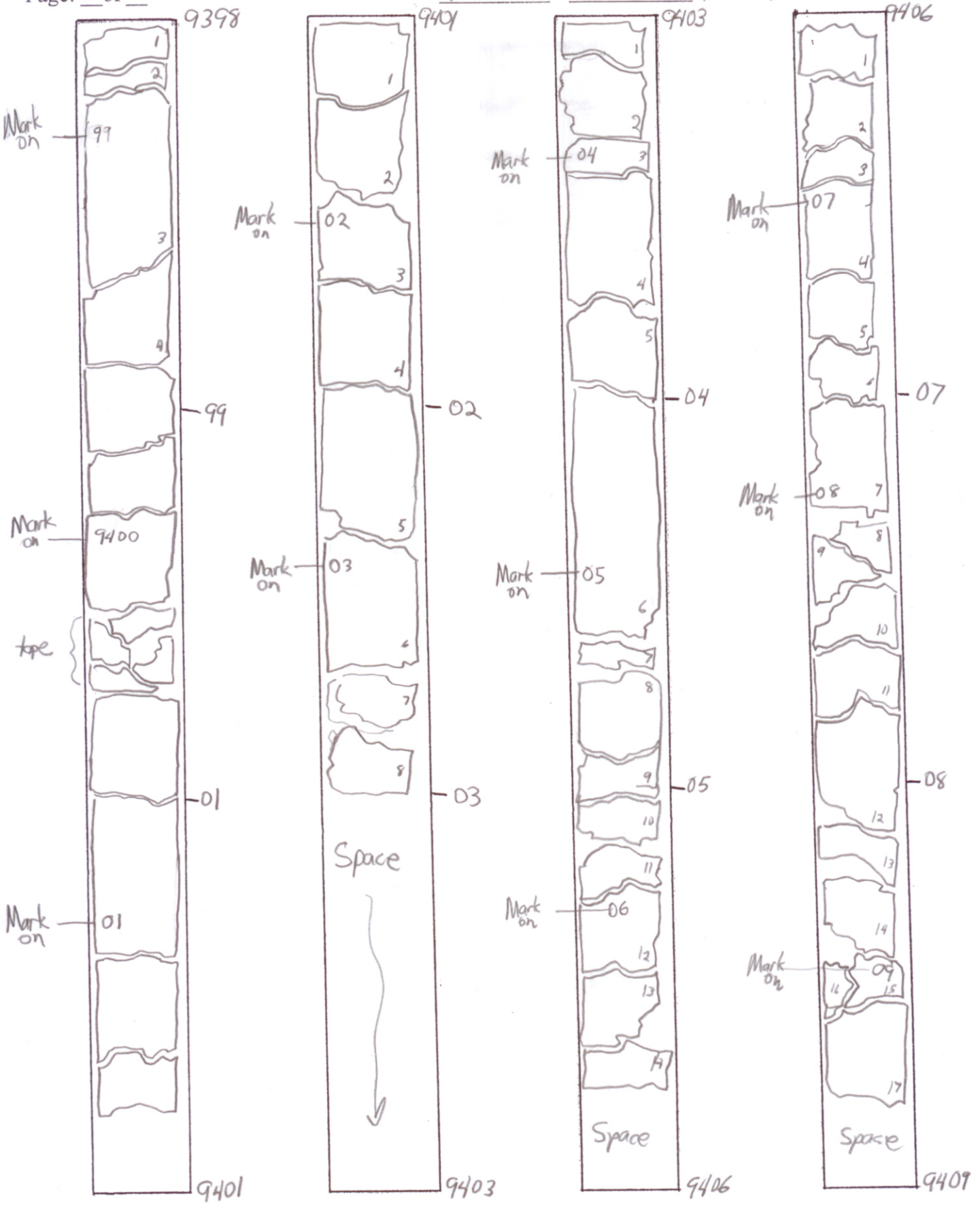
Page: 3 of __ BOX : 9387 - 9398 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-11-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width 9"/35+ 0.33"/4" Core diameter : 4"

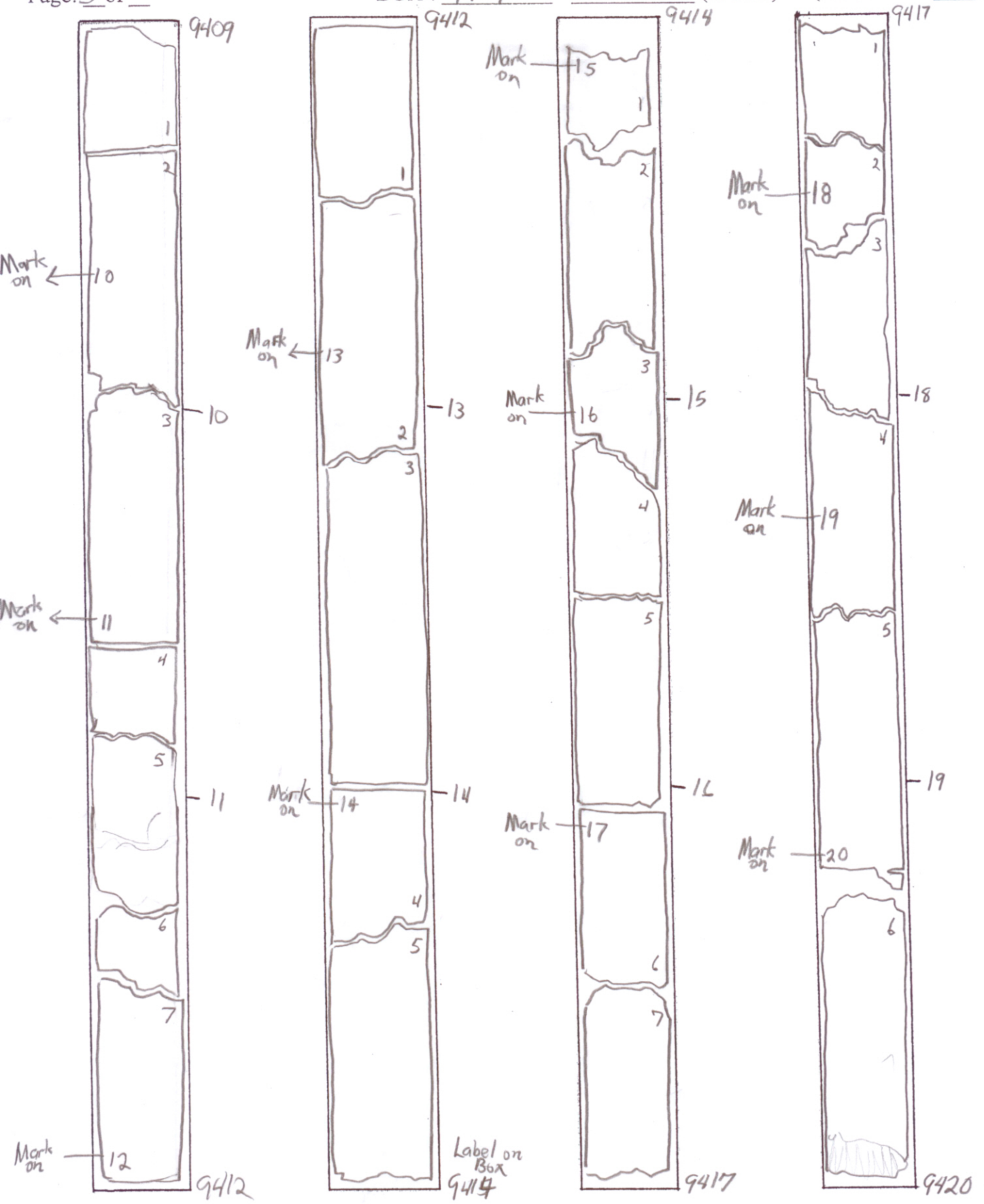
Page: 4 of __ BOX : 9398 - 9409 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-11-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width Core diameter : 4"
9"/3ft 0.33"/4"

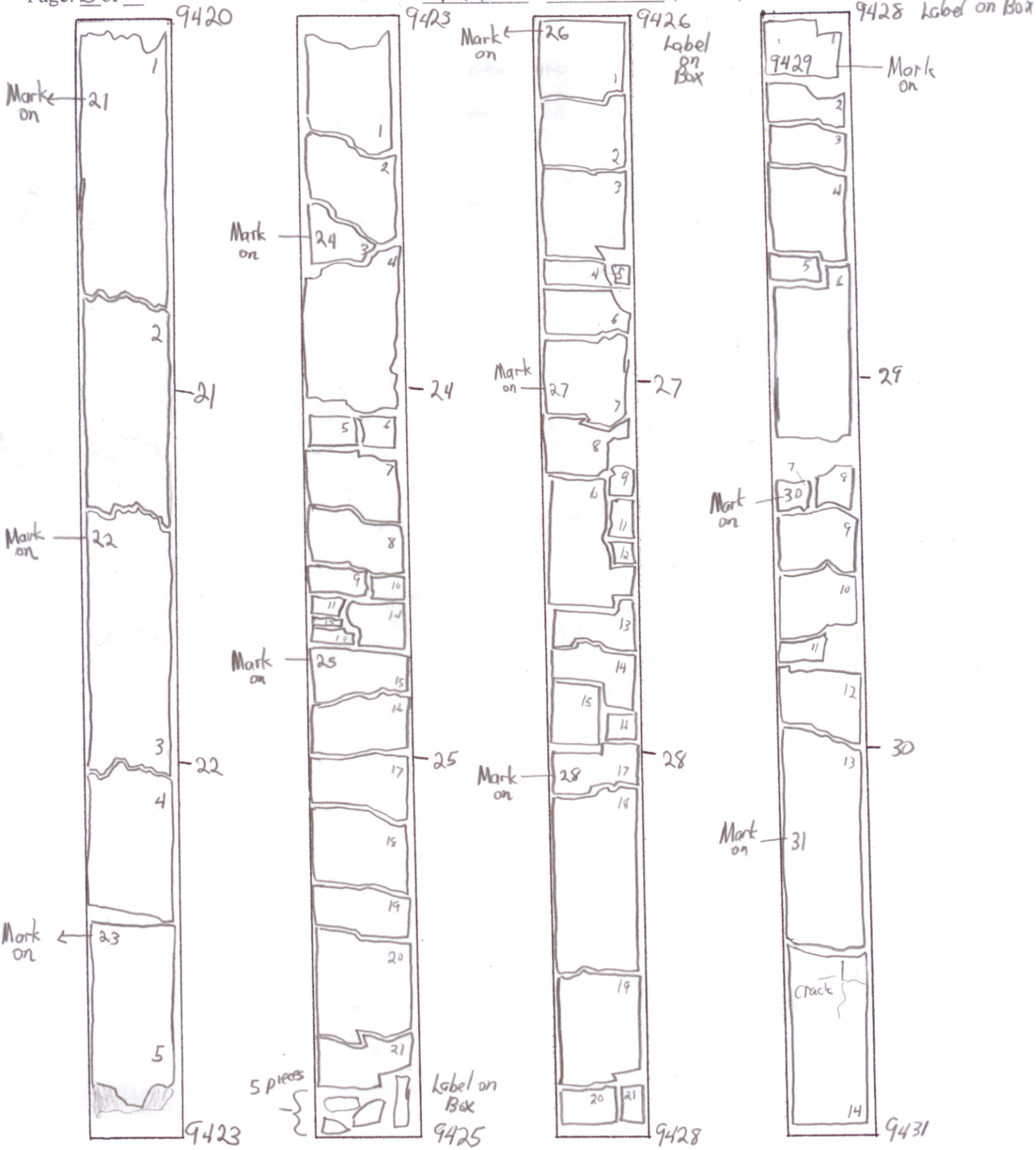
Page: 5 of __ BOX : 9409 - 9420 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

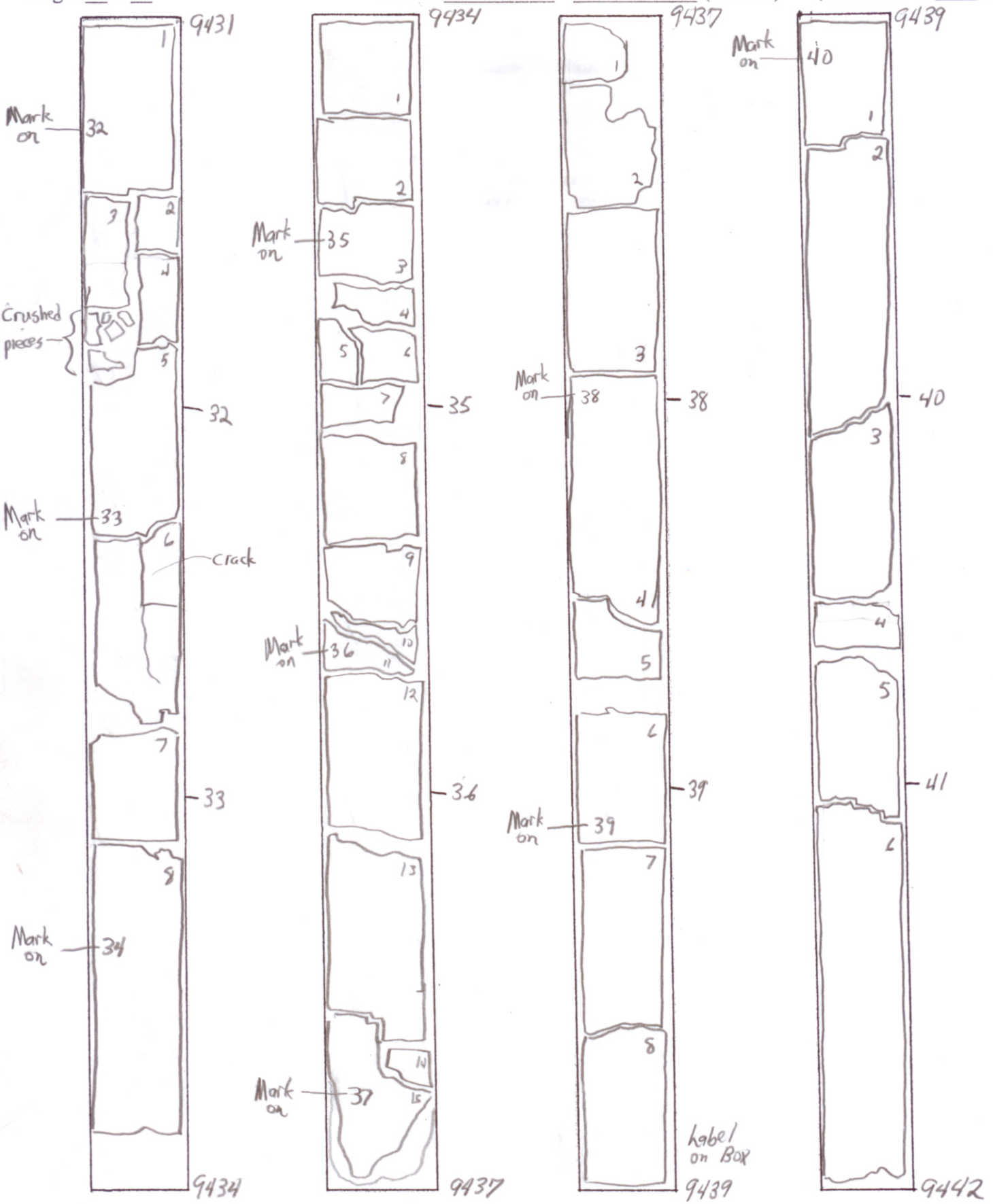
Page: 6 of __ BOX : 9420 - 9431 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

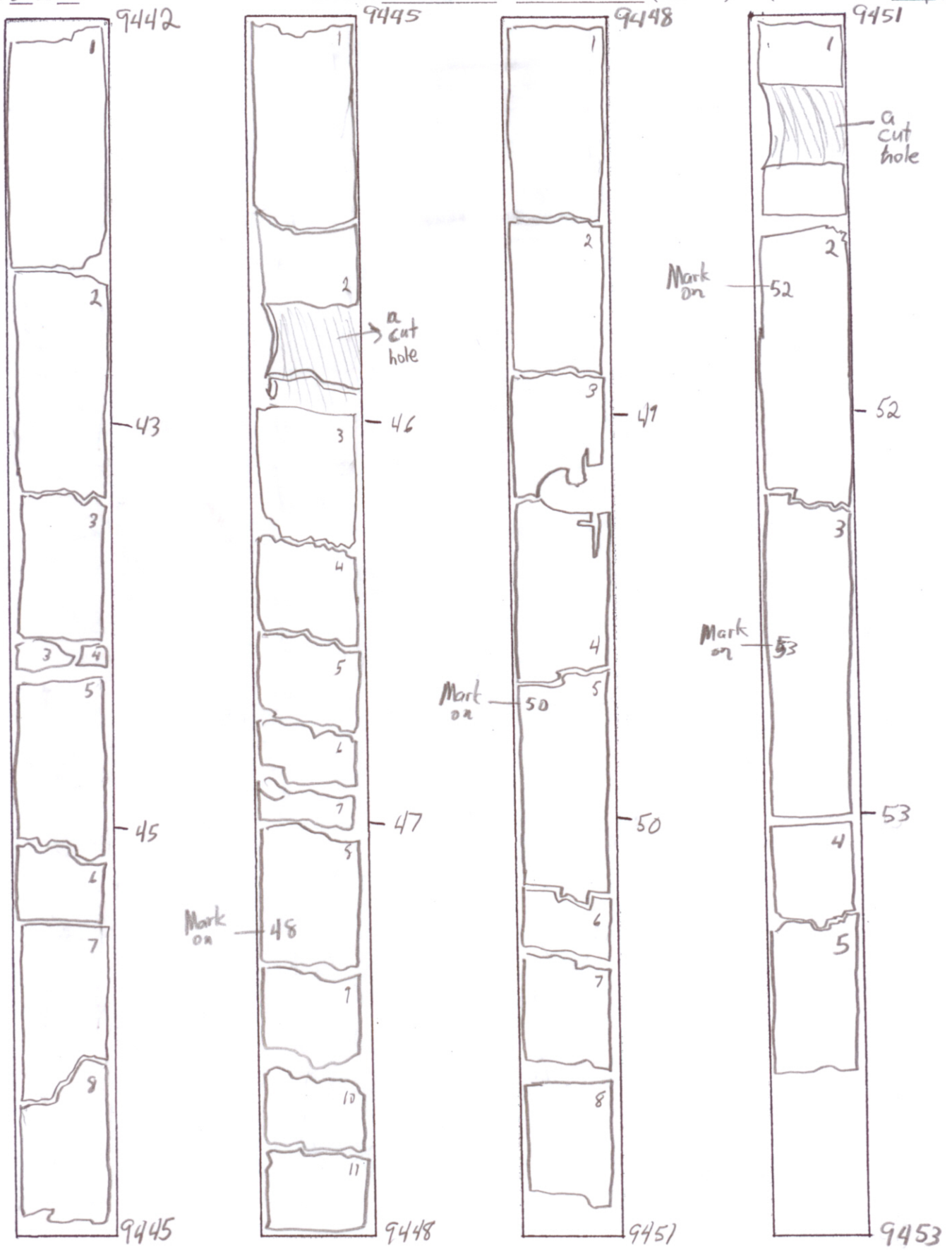
Page: 7 of __ BOX : 9431 - 9442 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

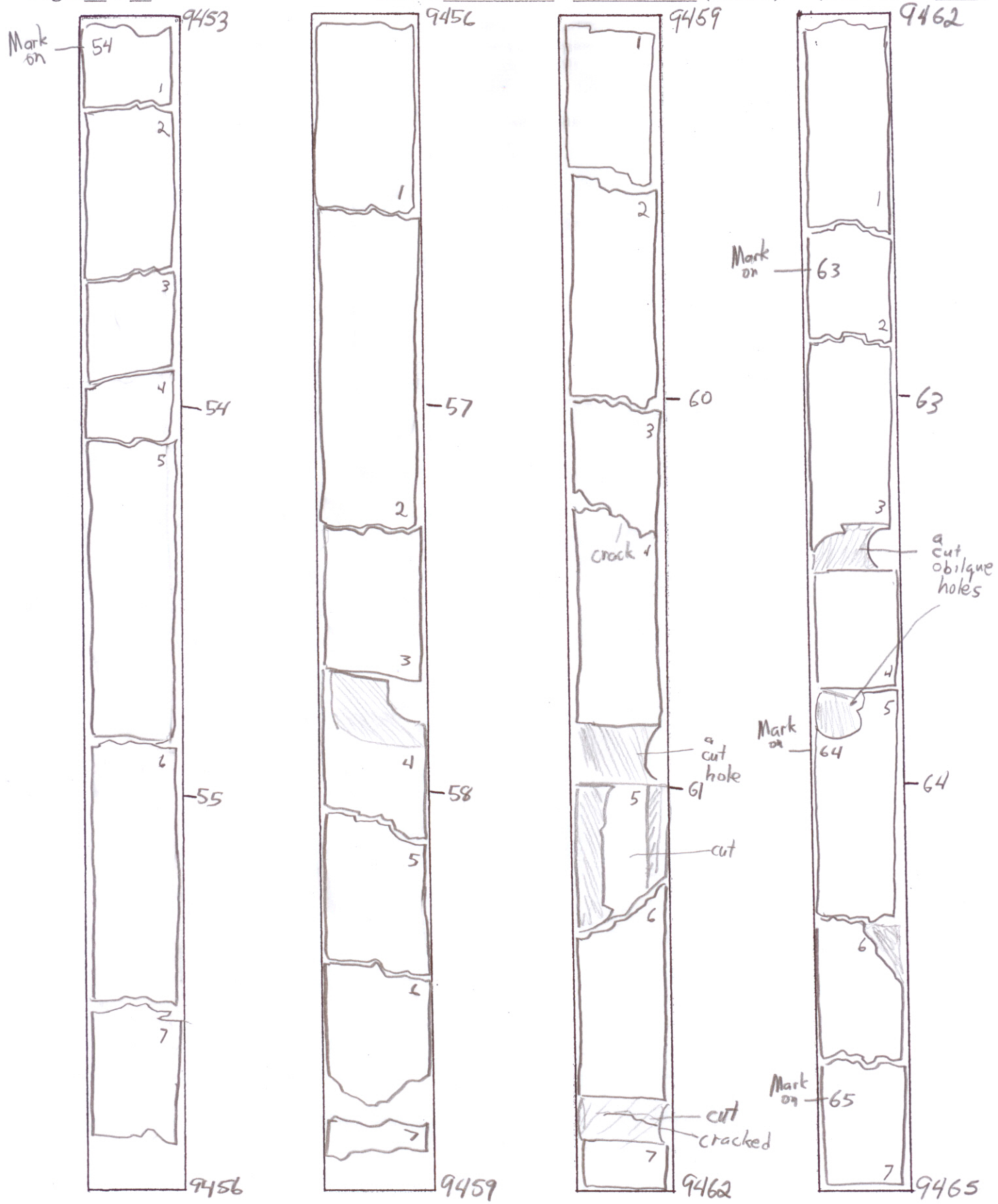
Page: 8 of __ BOX : 9442 - 9453 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

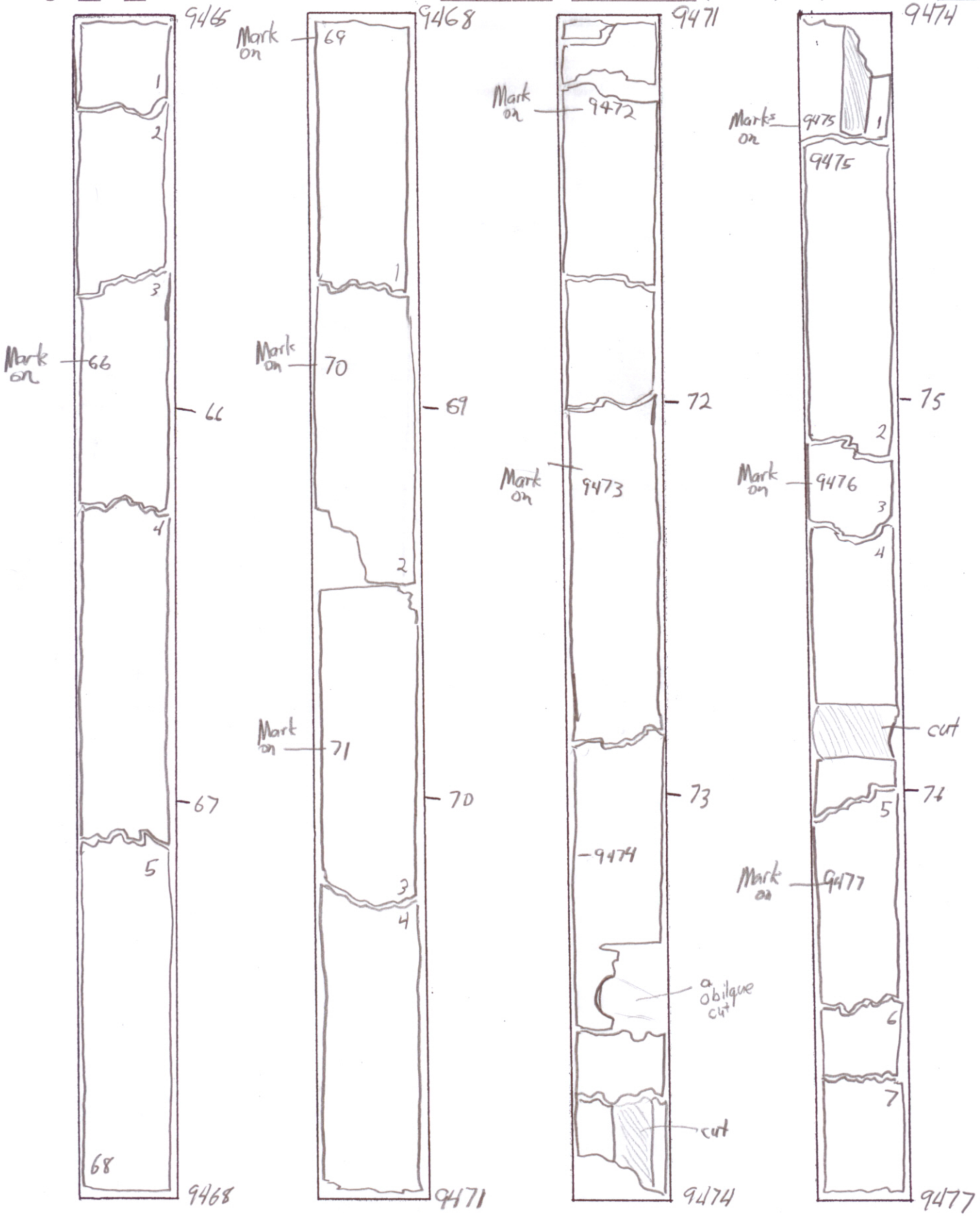
Page: 9 of __ BOX : 9453 - 9465 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width Core diameter : _____
9"/3ft 0.33"/4"

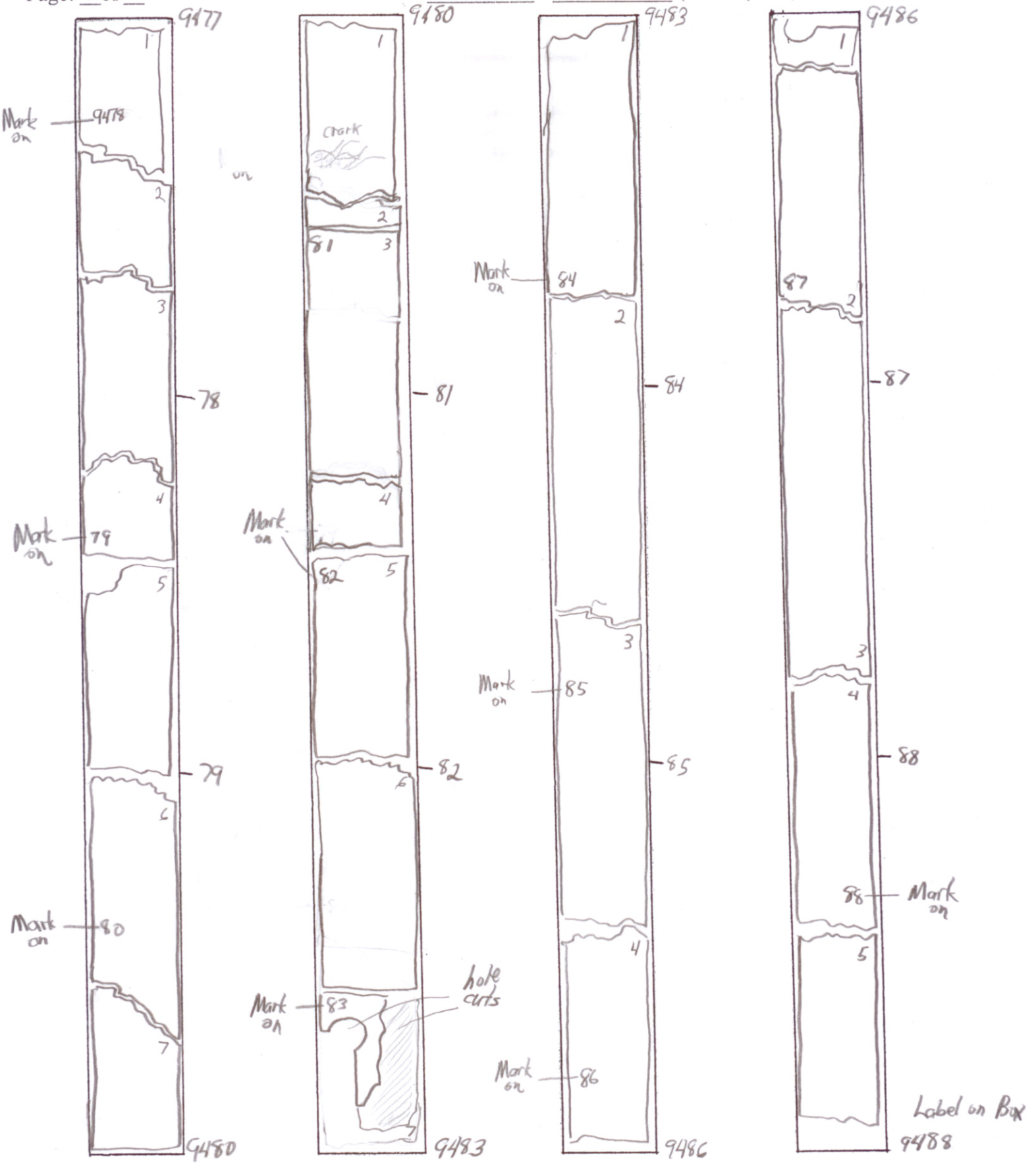
Page: 10 of __ BOX : 9465 - 9477 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

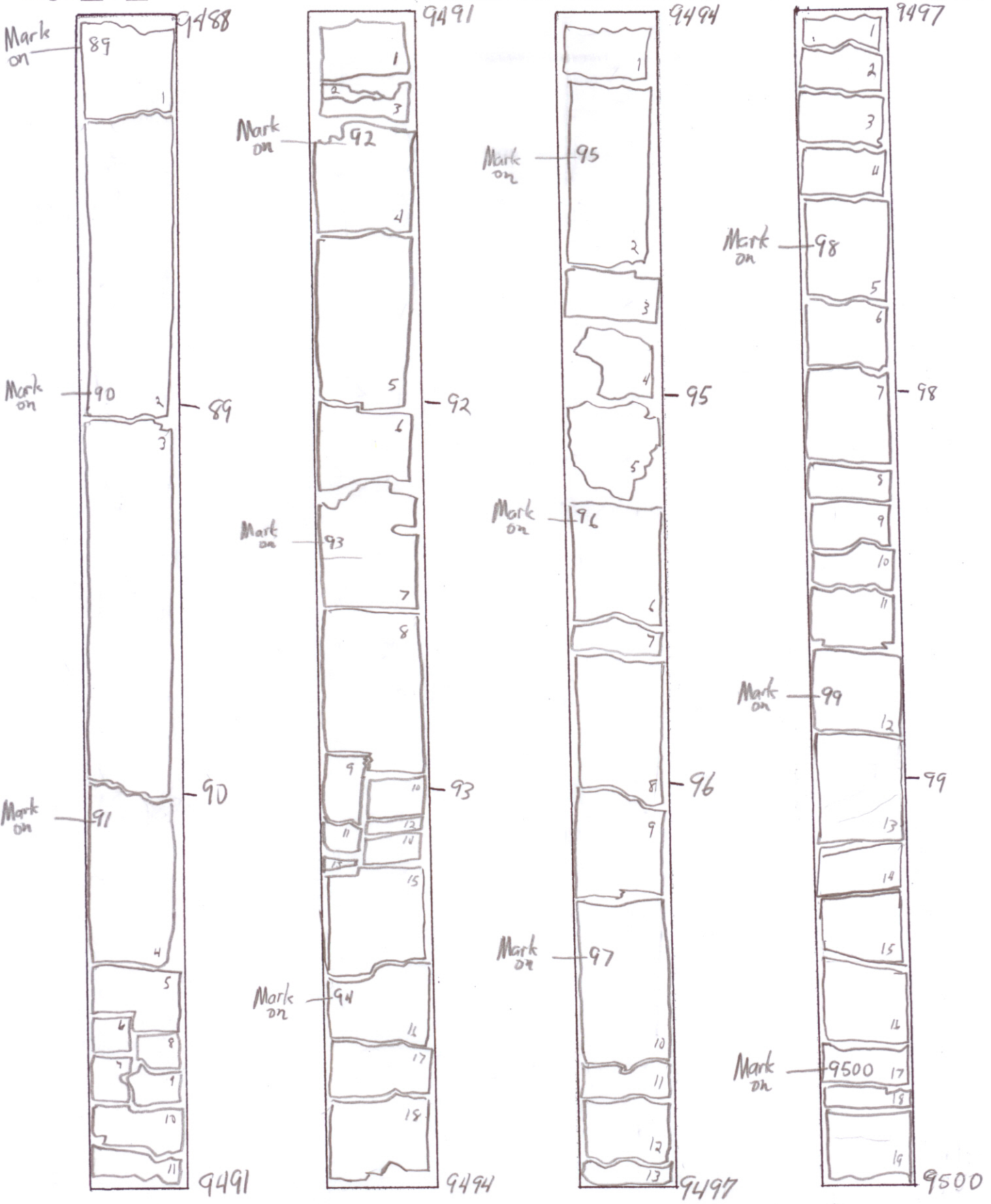
Page: 11 of __ BOX : 9477 - 9488 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width 9"/3ft 0.33"/4" Core diameter : 4"

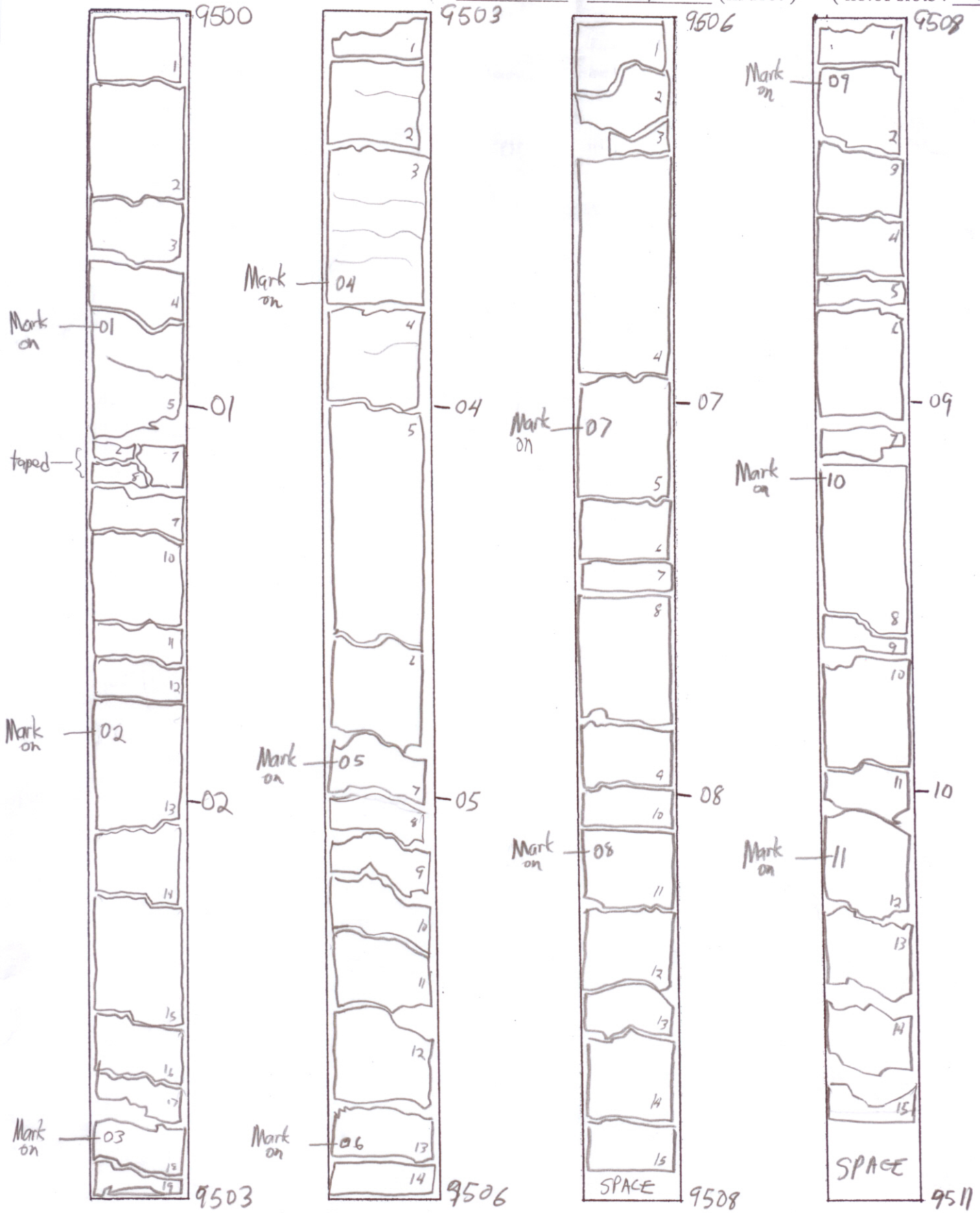
Page: 2 of __ BOX : 9488 - 9500 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width Core diameter : 4"
9"/3ft 0.33"/4"

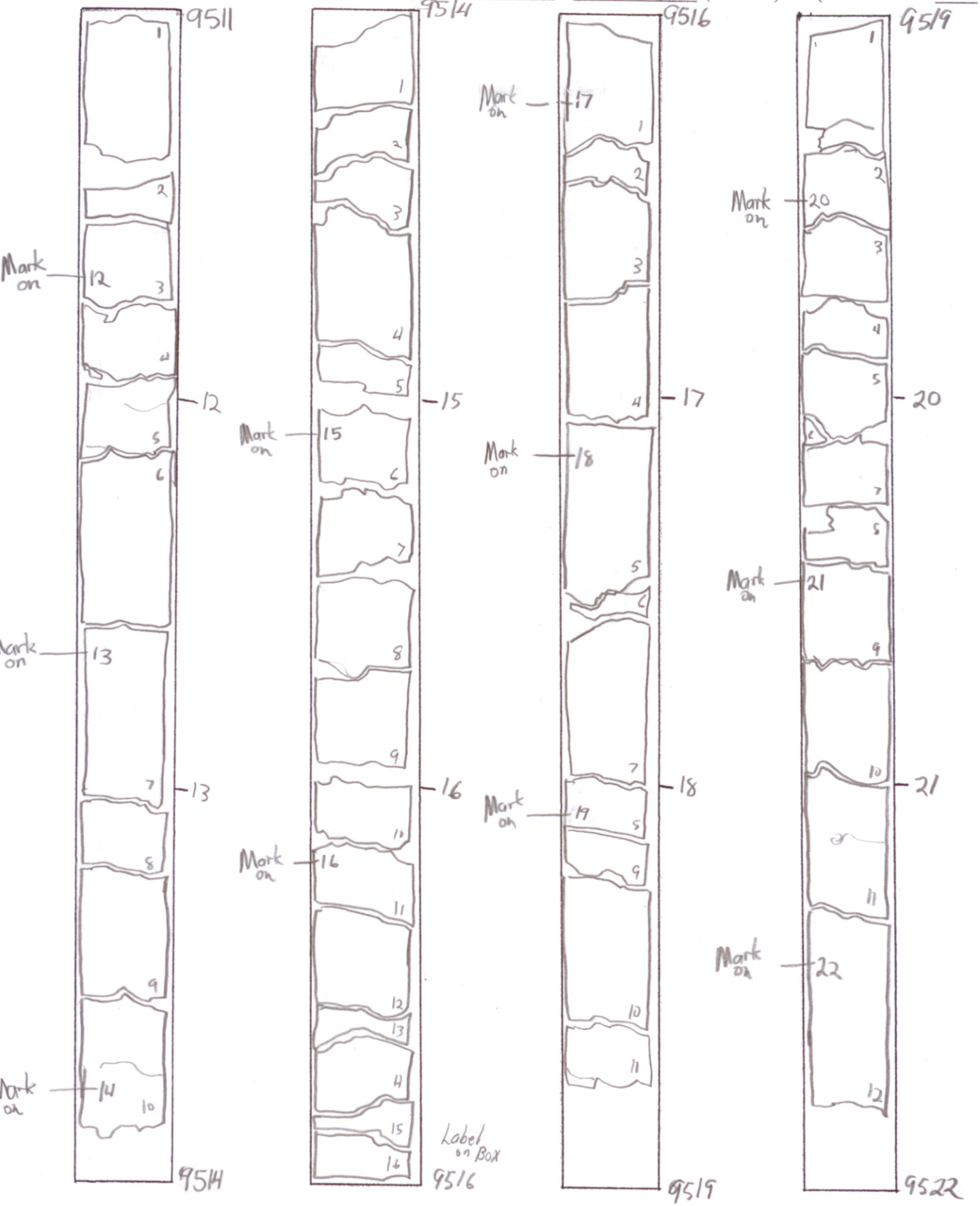
Page: 13 of __ BOX : 9500 - 9511 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width Core diameter : 4"
9"/3 ft 0.33"/4"

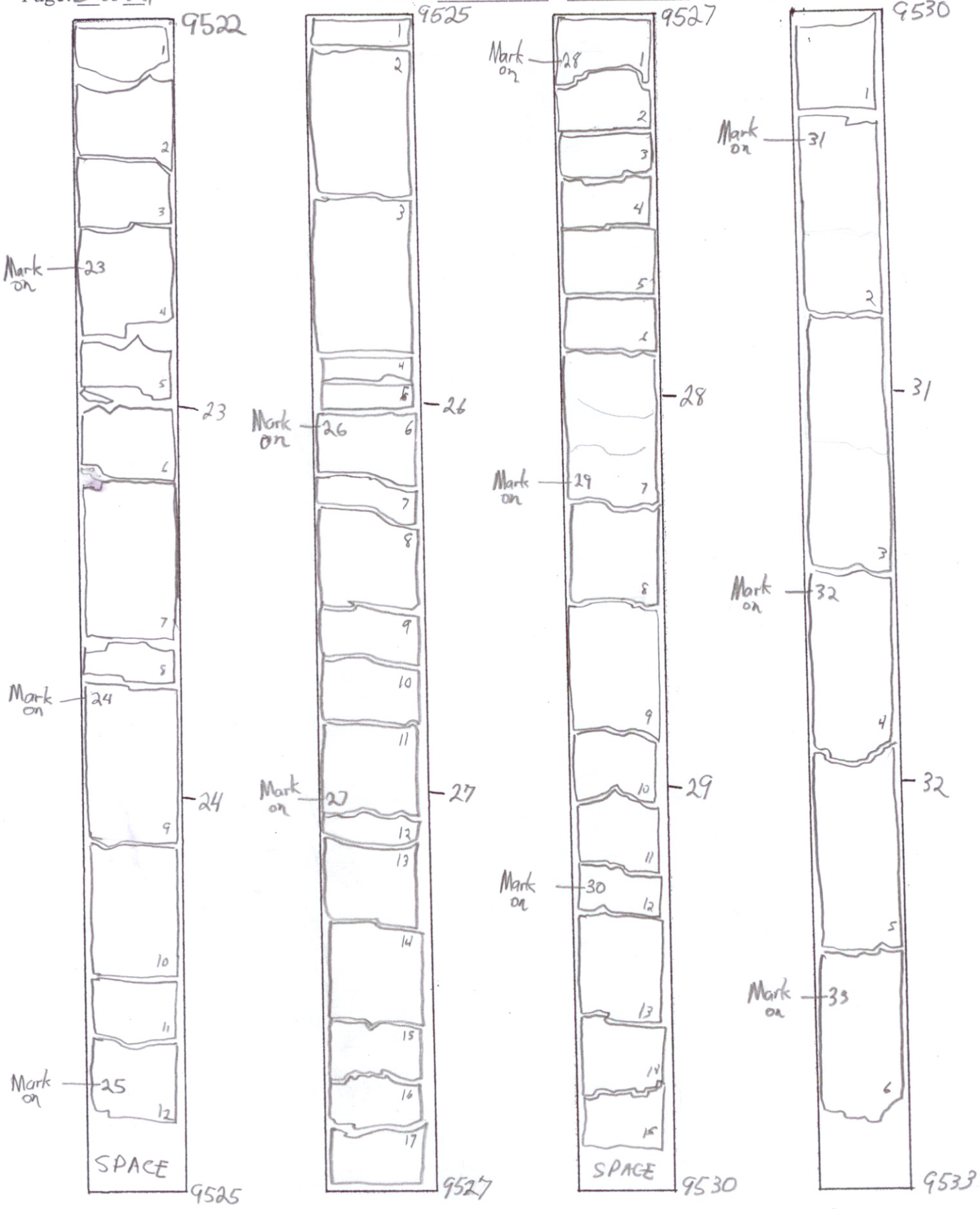
Page: 14 of __ BOX : 9511 - 9522 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-14-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3H width 0.33"/4' Core diameter : 4"

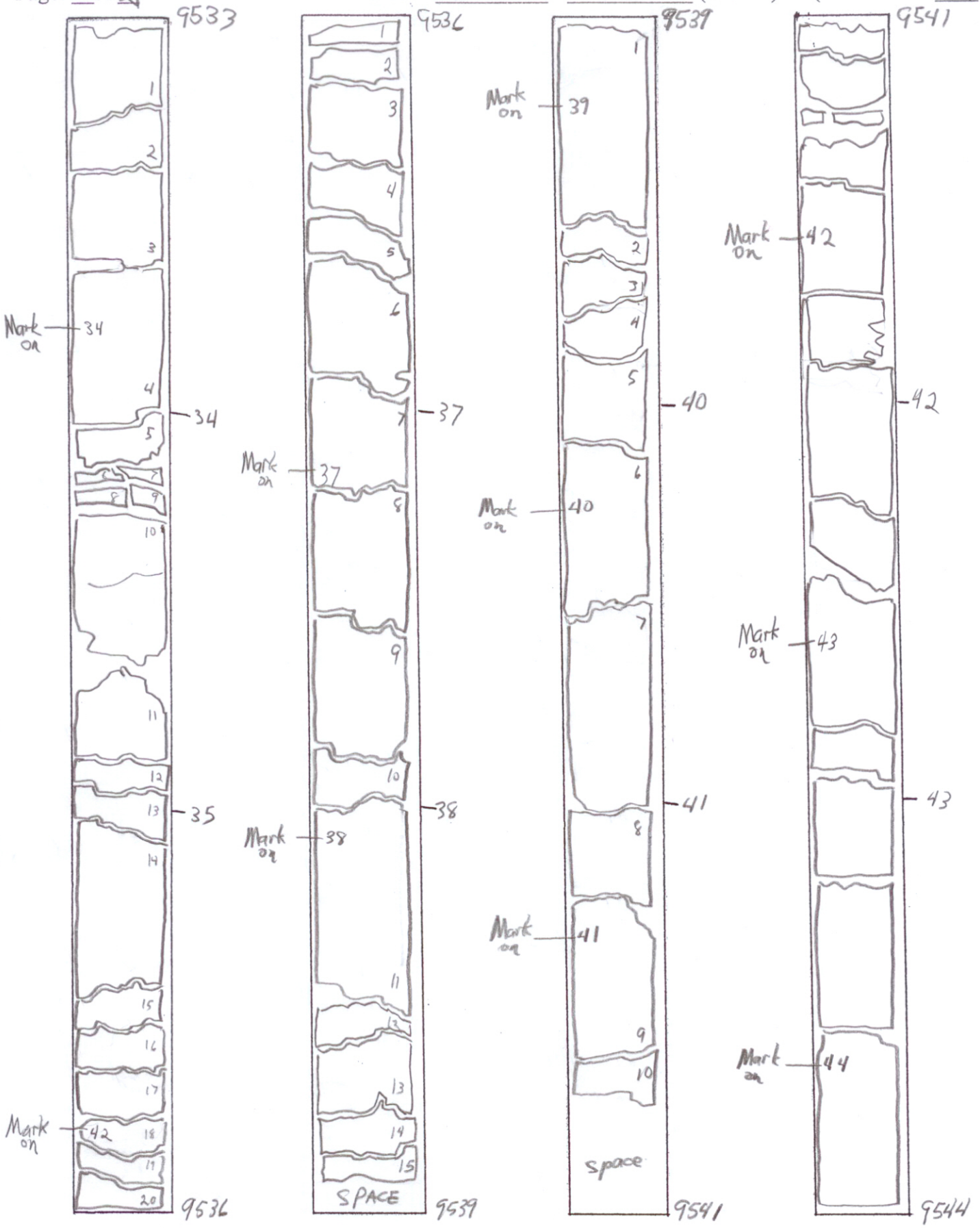
Page: 15 of 21 BOX : 9522 - 9533 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

BOX : 9533 - 9544 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-15-08

File no. : 16160

Operator : Hess

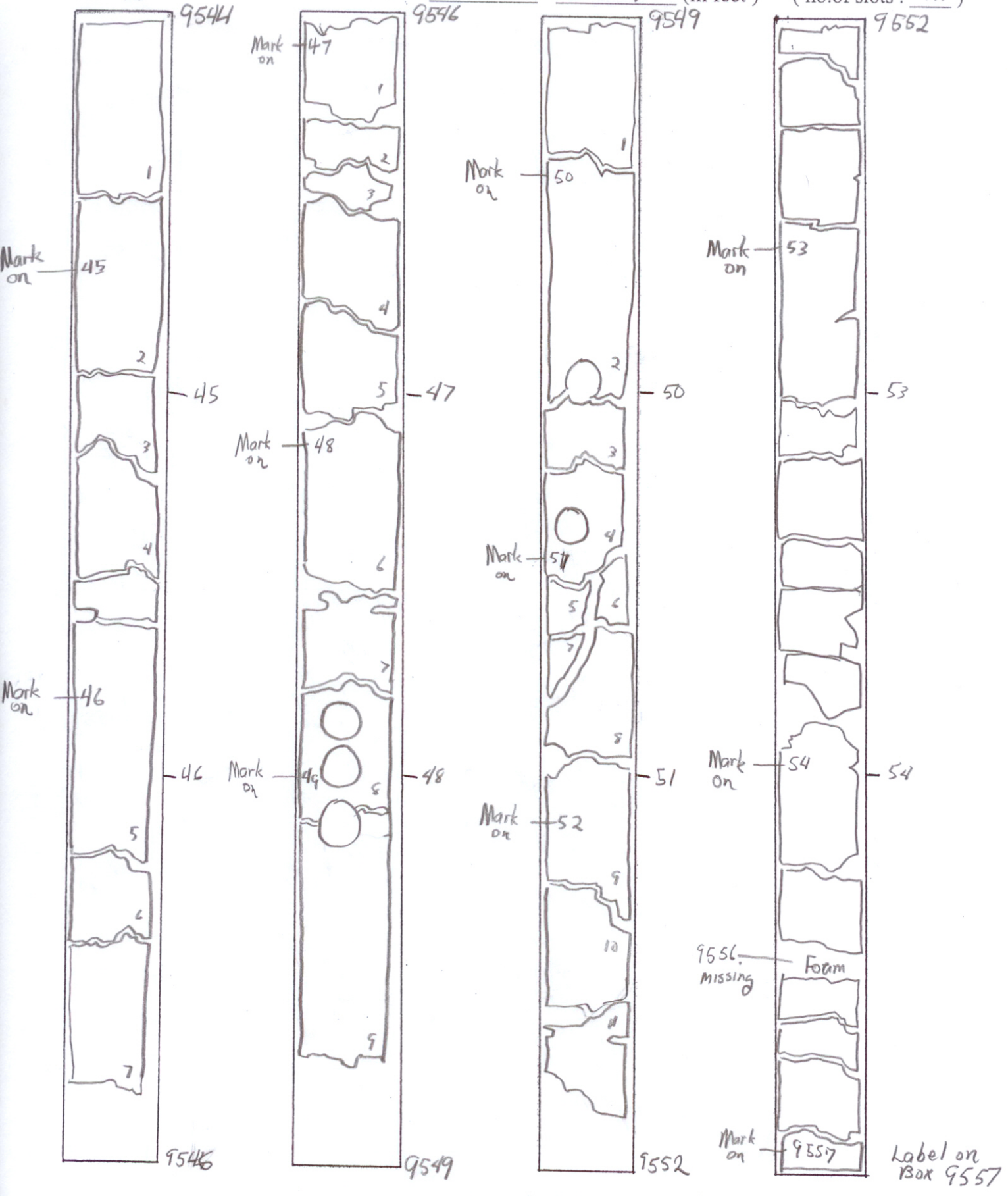
API no. : 33061004980000

Scale (ratio) : length 9"/3ft width 0.33"/4"

Core diameter : 4"

Page: 17 of 21

BOX : 9544 - 9557 (in feet) (no.of slots : N/A)



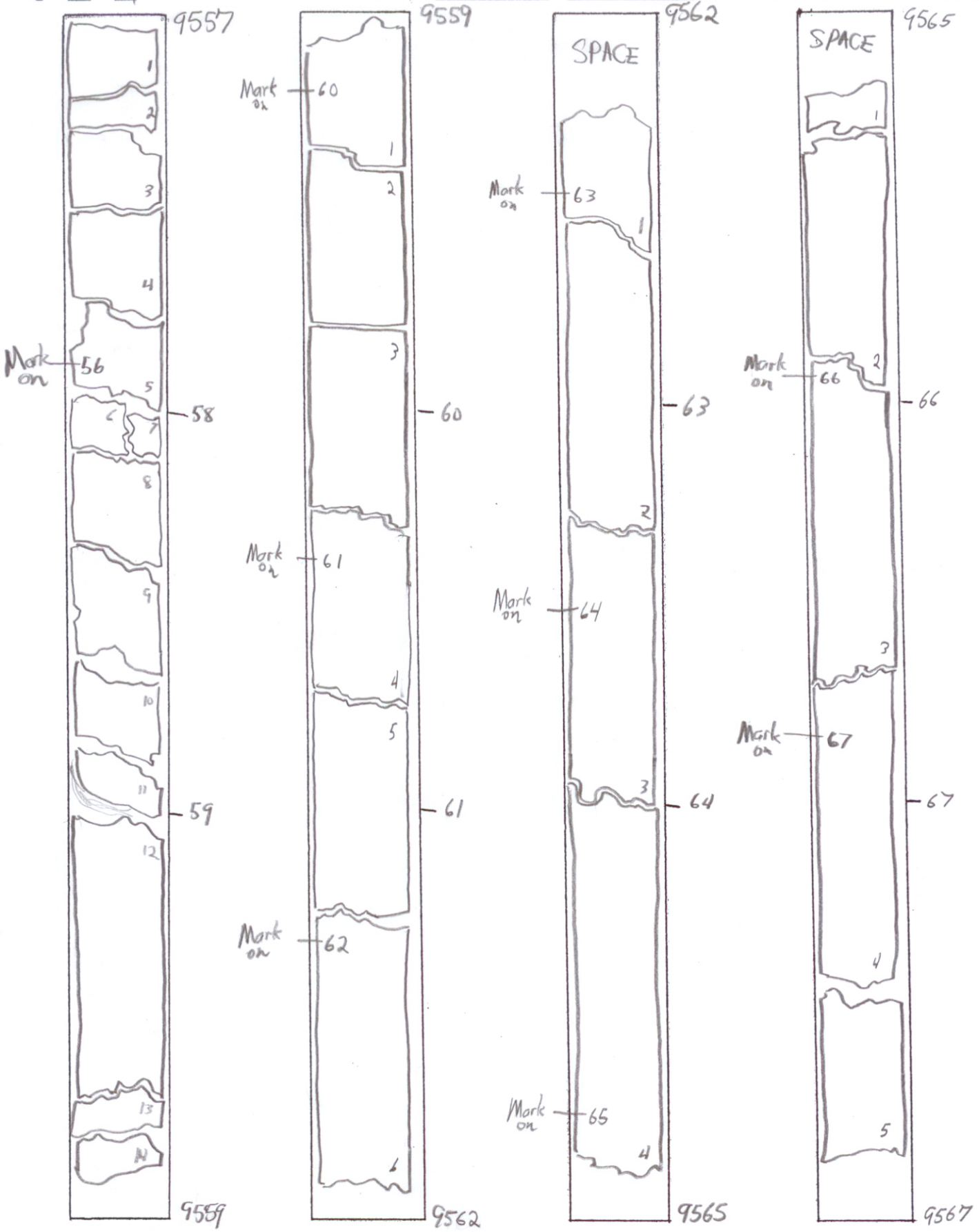
roject name : BAKKEN GEOMECHANICS
rawing by : Jill Holwerda
ate : 7-15-08

File no. : 16160
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4"

Operator : Ross

Core diameter : 4"

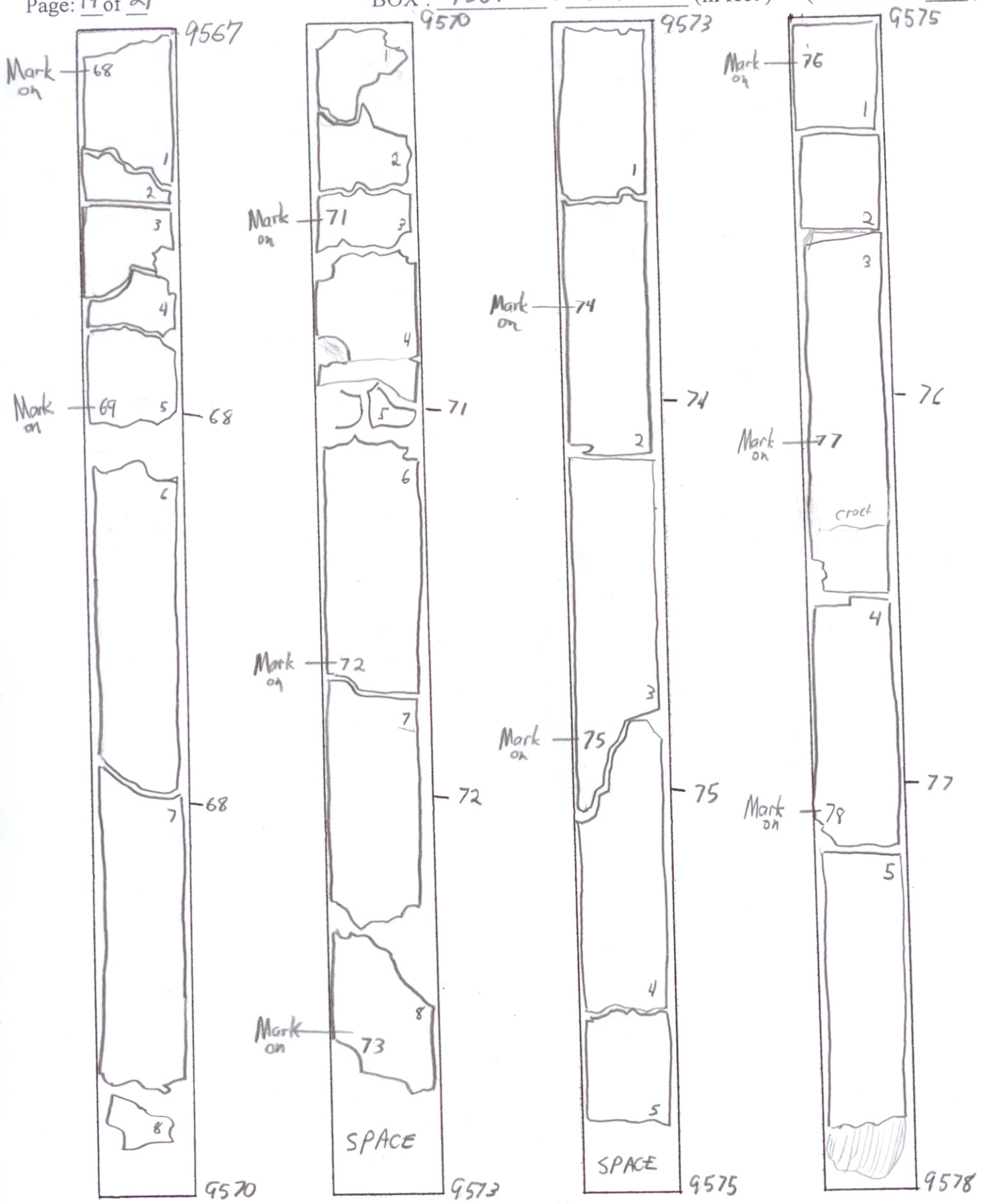
BOX : 9557 - 9567 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 16160
Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 5"/3ft width 0.33"/4"
Core diameter : 4"

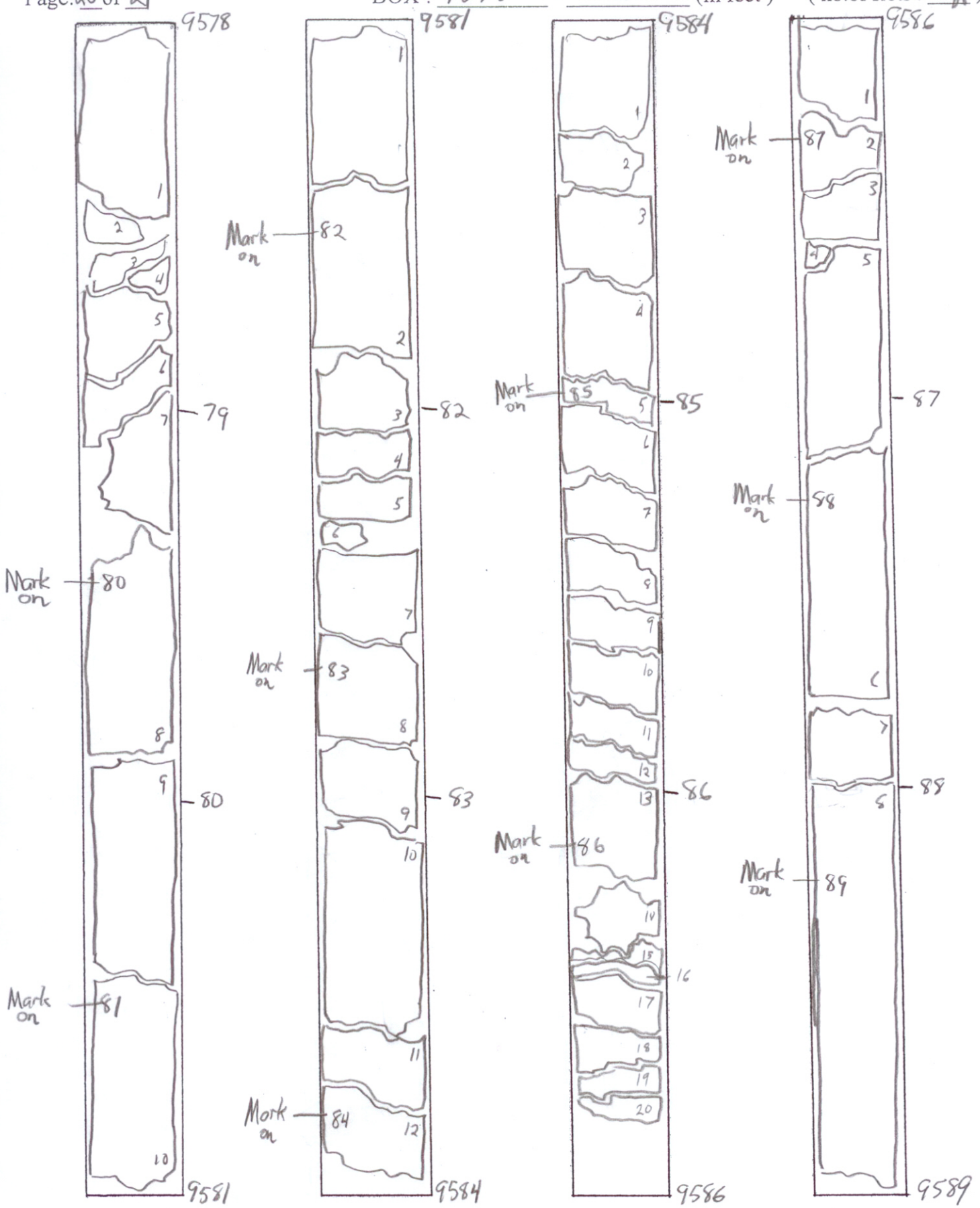
BOX : 9567 - 9578 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length width Core diameter : 4"
9"/3ft 0.33"/4"

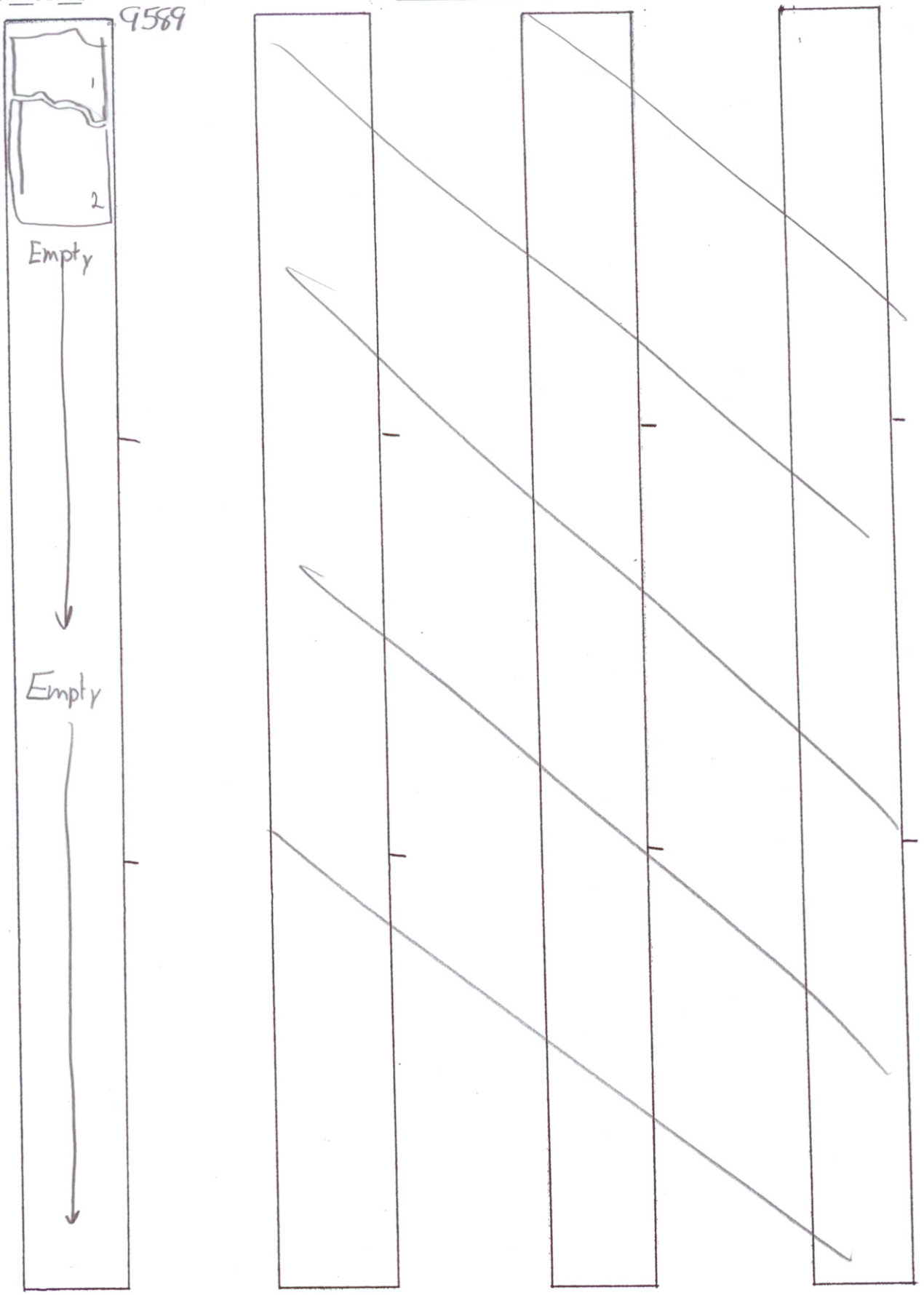
BOX : 9578 - 9589 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-15-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

BOX : 9589 - — (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 1-15-08

File no. : 16160 Operator : Hess
API no. : 33061004980000
Scale (ratio) : length 9"/3ft width 0.33"/4" Core diameter : 4"

Well #16333 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10840		Lime stone no OIL	100	58	80	1	3,0,0,5,8	0.8-23.8	Bedding joints	Tight	No	0.5x2.5x3.2 to 4x4x11.5
10842						1	7,0			0.01		
						2	4,90		Bedding joints & Vertical fractures	tight		
10844						2	3,82					
						1	5,0,7,3, 0,3		Bedding joints			
10846						1	8,0,0,0,13 0					
		Black shale								0.02		
10848		High carbon content				1	0,0,5,5,2, 4,8,2,4,3,3, 10,6,3,5,0, 0,2,7					
10850												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10850		Black shale High carbon content	100	4	33	1	0,8,7,3,4, 5,12,11,0, 5,8,0,2,6, 0,4,3,0,0,2, 0,5	0.3-11.8	Bedding joints	0.02 tight	no	2.5x3x0.2 to 4x4x4.6
10852							0,5,0,15,8, 5,5,6,10,9, 3,4,5,2,10, 5,3,5,6,5,4, 7					
10854							8,12,10,6,6, 3,6,7,12,13, 2,2,0,0,5,6, 7					
10856							2,0,3,4,5,4, 5,4,0,3,5,5, 8,3,2,3,3,3					
10858							3,3,3,6,7,2, 5,0,5,3,0,0, 5,3,7,3,5					
10860												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10860		Black shale High carbon content	100	24	56	1	5,2,7,5,4, 7,2,7,0,4, 8,6,0,0,3, 2,3	1-20	Bedding joints	tight	No	1.9x3.5x0.3 to 4x4x6.25
10862							3,2,3,0,3, 4,6,10,6,8, 5,20,5,5,0					
		Sandy Silt stone										
10864							5,8,7,7,10, 3,9,10,12, 8,15,5			0.01		
10866							10,0,12,8, 10,8,5					
10868							9,10,10,8, 10,6,7,7, 9,6			0.02		
10870												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10870		Sandy Silt stone	100	78	90	1	7,7,4,5,0, 0,5,0,10	0.76-43.8	Bedding joints	0.01 tight	No	4x4x0.3 to 4x4x17.25
10872							15,0,12,2					
10874							8,3,9,3, 7					
10876							0,0,5,2,5					
10878							2,4,3,3,0					
10880												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10880		Sandy Silt stone Calcite cement	100	47	82	1	2, 11, 8, 6, 5, 4, 9, 6, 8, 10, 10	0.5 – 34.3	Bedding joints	0.01	No	4x4x0.2 to 4x4x13.5
10882							8, 5, 7, 6, 2, 0, 5, 6, 12, 12, 17			0.01		
10884							7, 13, 9, 7, 4, 3, 3, 3, 2, 0, 0			0.02		
10886							6, 5, 5, 5, 3, 0, 4			0.01		
10888							4, 3, 15, 5, 0			tight		
10890												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10890		Sandy Silt stone Calcite cement	100	85	96	1	8, 8, 10, 6	2.5 – 38.75	Bedding joints	Tight	No	2.25x4x0.5 to 4x4x15.25
10892							7, 3, 3, 0			Tight		
10894							7, 2, 0, 5			0.01		
10896							4, 5, 11, 5, 11, 2, 4			0.01		
10898							5, 4			Tight		
10900												

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10900		Sandy Silt stone Calcite cement	100	100	100	1	3, 4, 0, 6	10.9-20.8	Bedding joints	0.01 tight	No	4x4x4.3 to 4x4x8.2
10901.4												

Well #16333 fracture sketch

Note: Shapes misproportion / actually wider than illustrated in drawing.

Page: 1 of 7 BOX : 10840 - 10850 (in feet) (no.of slots : 5)

Project name : BAKKEN GEOMECHANICS File no. : 16333 Operator : Marathon Oil Corp.

Drawing by : Jill Holwerda API no. : 33025005970000

Date : 6-26-08 Scale (ratio) : length 9.0"/2ft width 0.33"/4" Core diameter : 4"

Note: Shapes misproportion/actually wider than illustrated in drawing.

BOX : 10850 - 10860 (in feet) (no.of slots : 5)

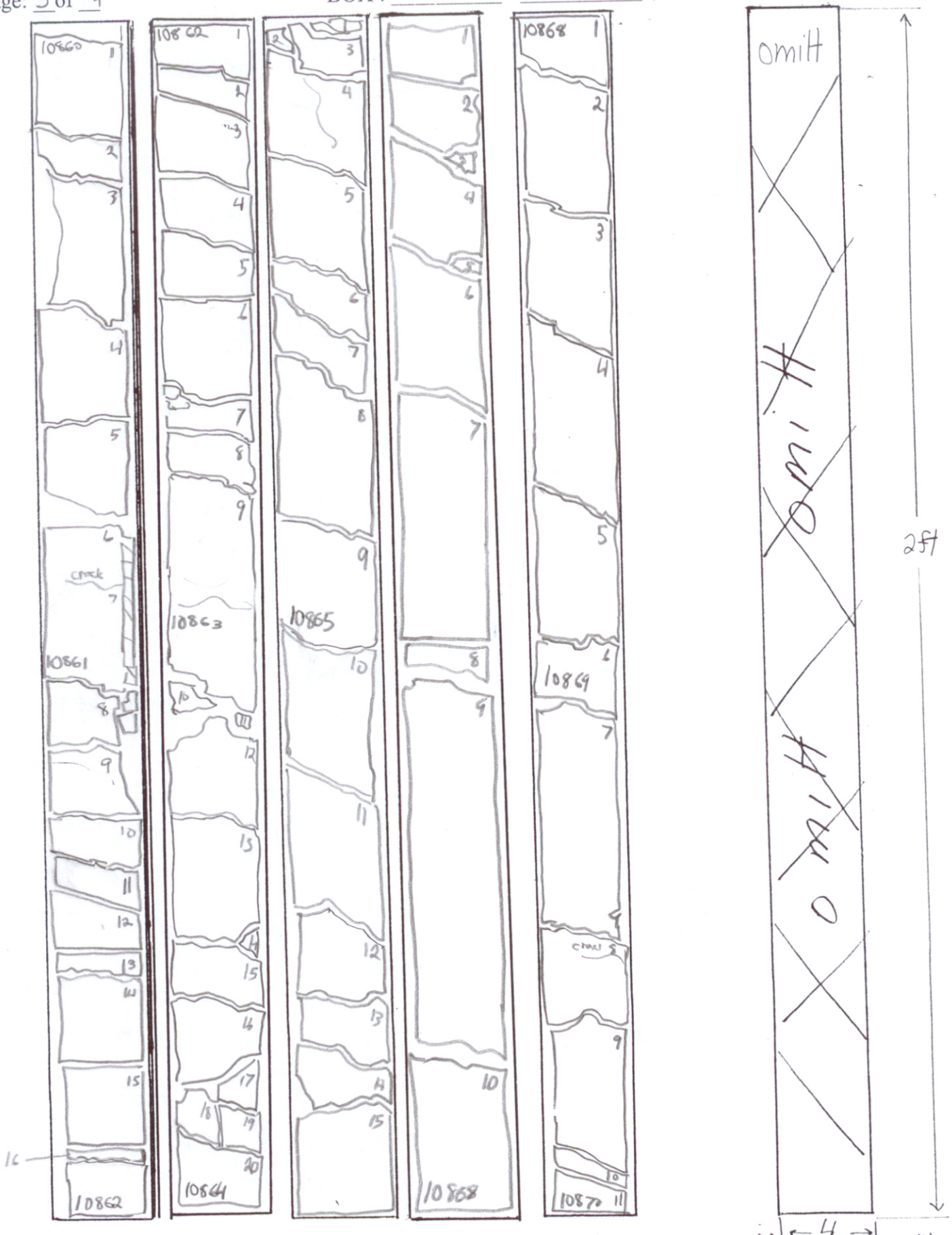
Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 06-30-08

File no. : 16333
API no. : 33025005970000
Scale (ratio) : length 9.0"/2ft width 0.33"/4"

Operator : Marathon Oil Corp.
Core diameter : 4"

Note: Shapes misproportion / actually wider than illustrated in drawing.

BOX : _____ - _____ (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 6-30-08

File no. : 16333

API no. : 33025005970000

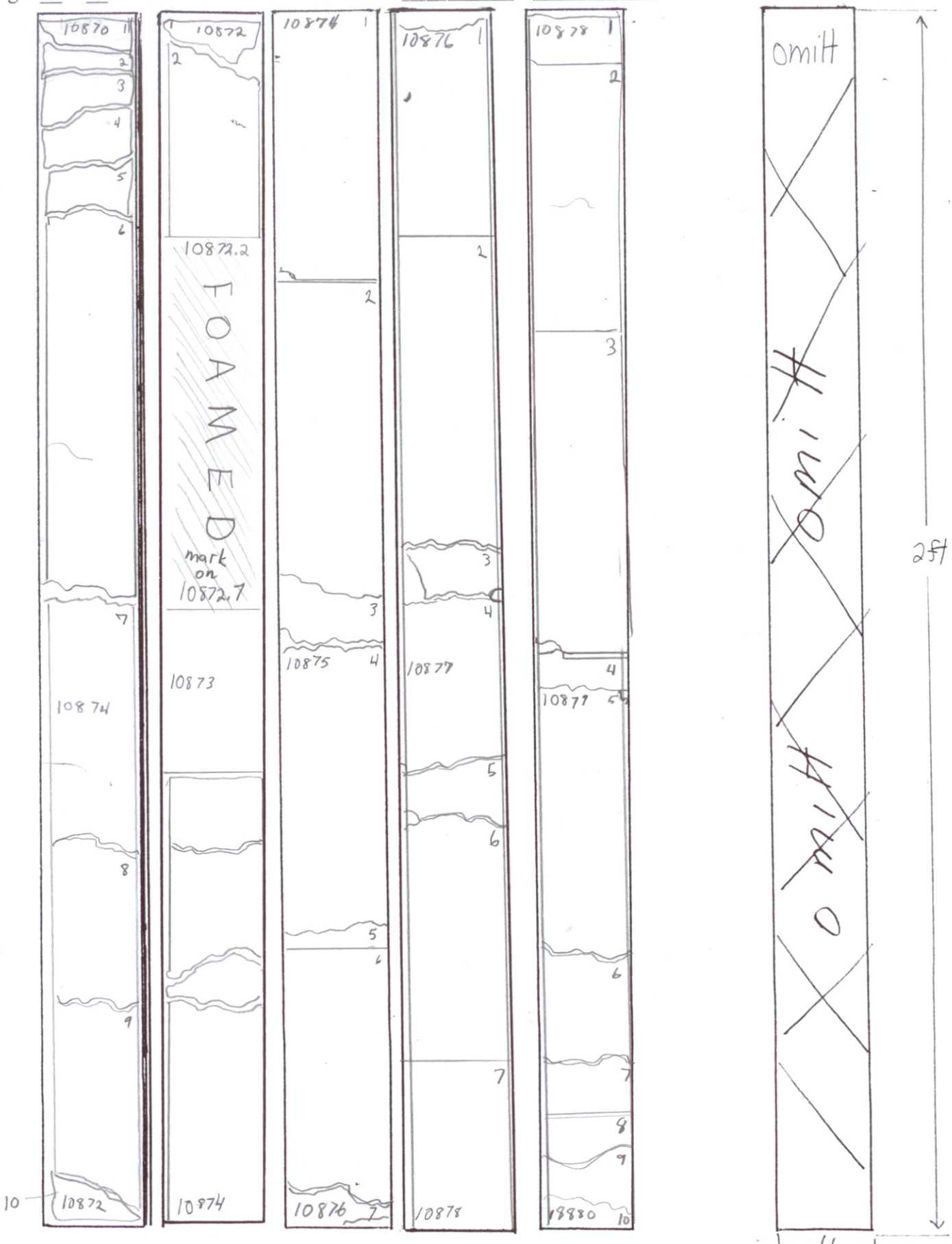
Scale (ratio) : length 9.0"/2ft width 0.33"/4"

Operator : Marathon Oil Corp.

Core diameter : 4"

Note: Shapes mispropportion / actually wider than illustrated in drawing.

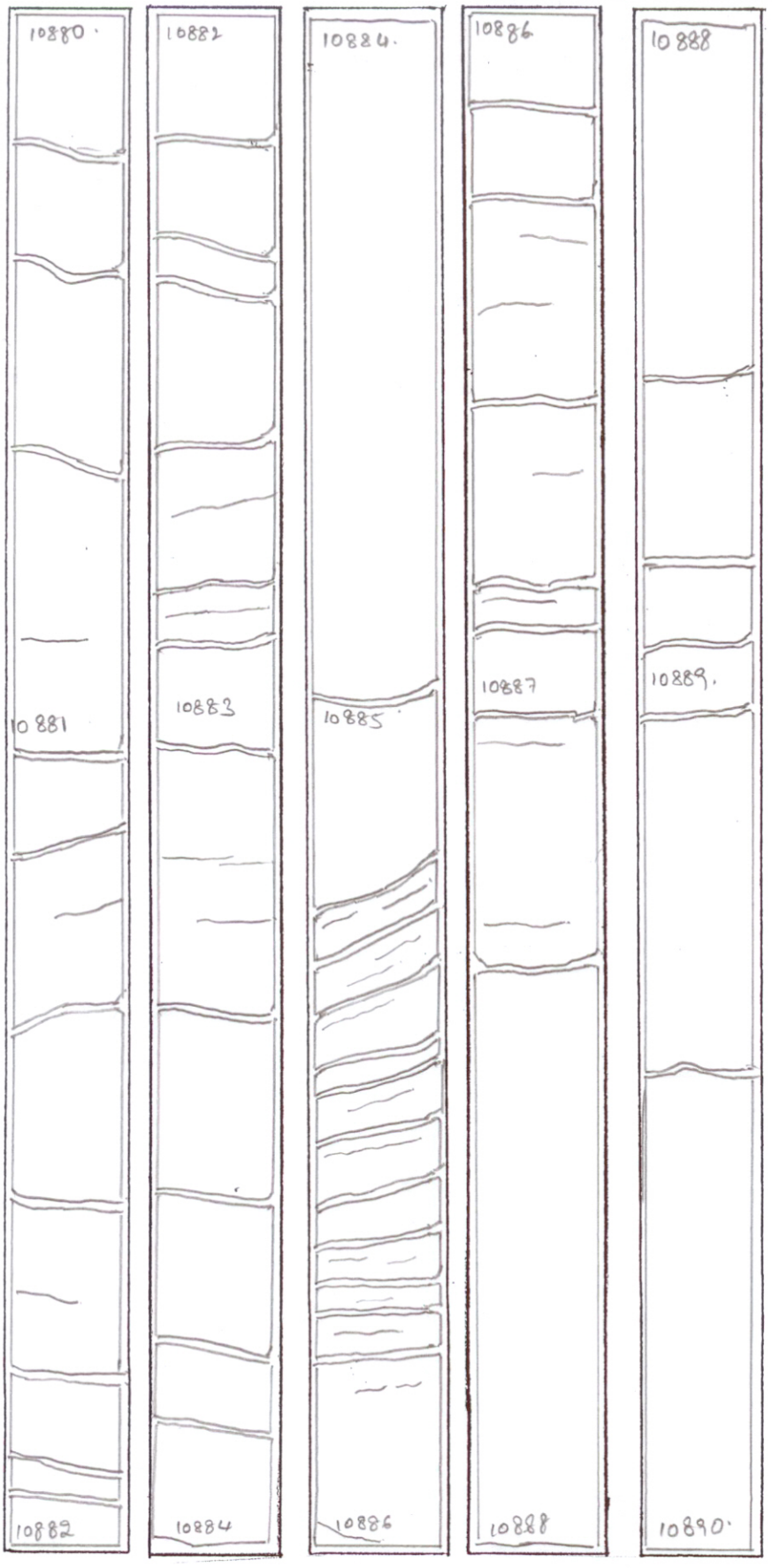
Page: 4 of 7 BOX: 10870 - 10880 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 6-27-08

File no. : 16333 Operator : Marathon Oil Corp.
API no. : 33025005970000
Scale (ratio) : length 9.0"/2ft width 0.33"/4" Core diameter : 4"

BOX : 10880 - 10890 (in feet) (no.of slots : 5)

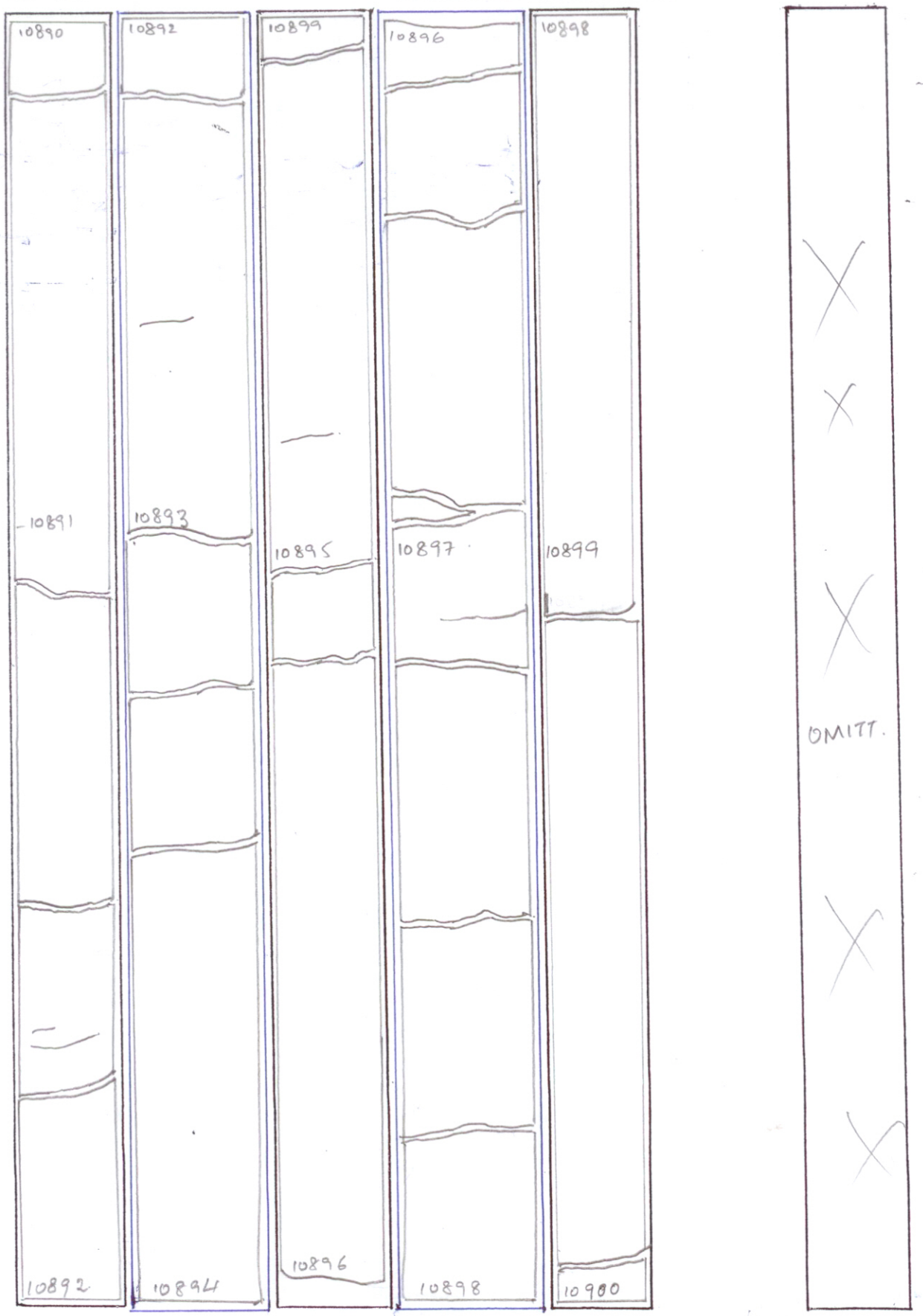


Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Bill Holwerda~~ Naga
Date : 06/30/08

File no. : 16333
API no. : 33025005970000
Scale (ratio) : length 9.0"/2ft, 0.33"/4"

Operator : Marathon
Core diameter : 4"

Page: 6 of 7 BOX : 10890 - 10900 (in feet) (no.of slots : 5)



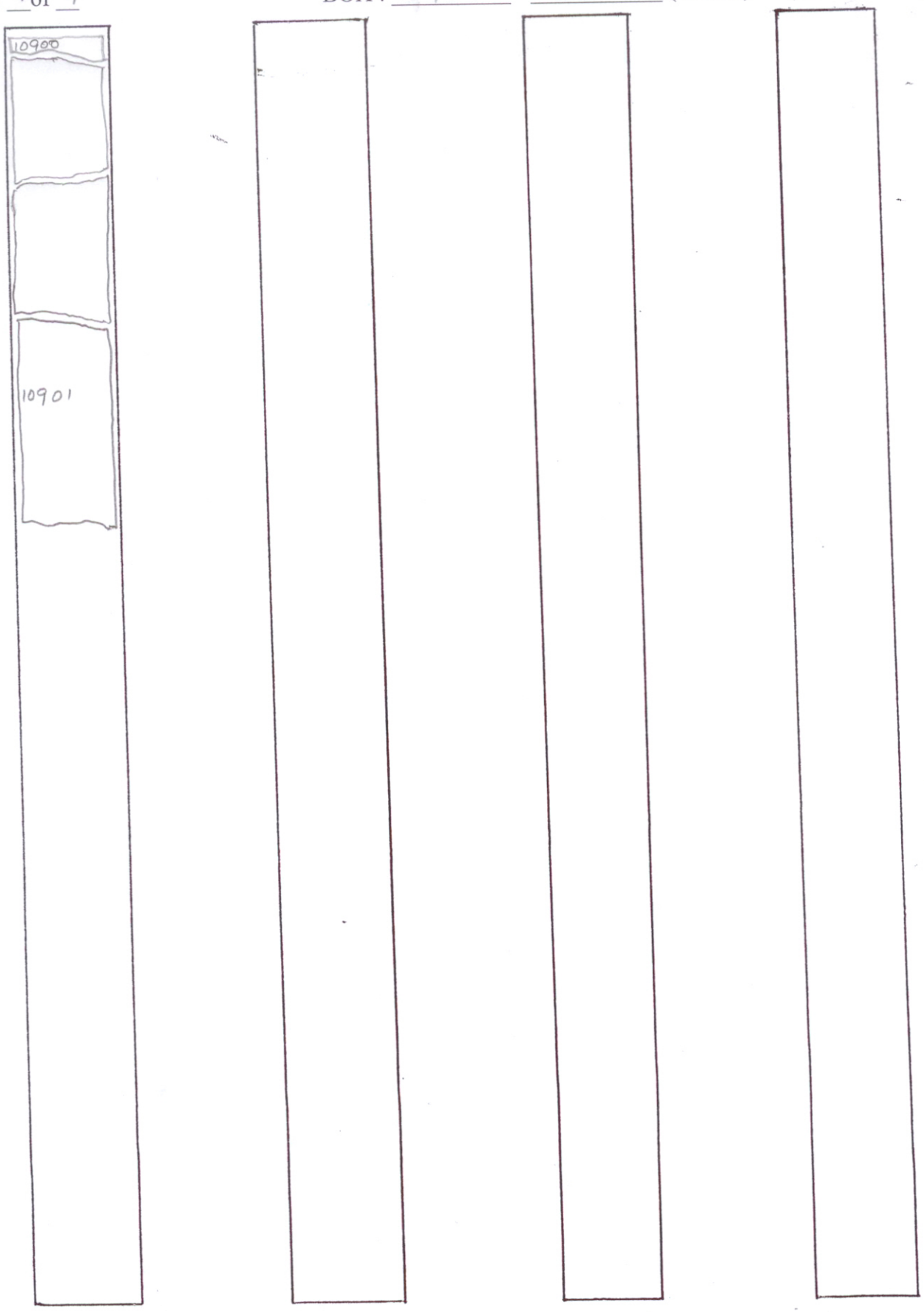
Project name : BAKKEN GEOMECHANICS File no. : 16333 Operator : Marathon

Drawing by : ~~Jill Holweda~~ Naga API no. : 33025005970000.

Date : 06/30/08 Scale (ratio) : length Core diameter : 4"

9.0"/2ft , 0.33"/4"

BOX : 10900 - 1091.4 (in feet) (no.of slots : 5)



Project name : BAKKEN GEOMECHANICS
Drawing by : ~~Jill Holderda~~ Naga
Date : 06/30/08

File no. : 16333
Operator : Marathon
API no. : 33025005970000
Scale (ratio) : length
9.0"/2ft , 0.33"/4"
Core diameter : 4"

Well #16433 Core survey

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10591		Limestone	100	77	92	1	0	1.3 – 26.4	Bedding Joints	Tight	None	4x4x6.7 to 4x4x10.4
10592						1	5		Bedding Joints	0.02		
10593						1	9, 4, 5		Bedding Joints	0.02		
10594						1	5, 5, 0, 0, 3, 3		Bedding Joints	Tight		4x4x0.5 to 4x4x5.25
		Black Shale										
10595		High Carbon Content				1	0, 0, 4		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10596		Black Shale High Carbon Content	100	62	83	1	3, 3	1.3 – 17.8	Bedding Joints	Tight	None	4x4x4.2 to 4x4x7
10597						1	0, 6, 25		Bedding Joints	Tight		
10598						1	10, 2		Bedding Joints	0.04		
10599						1	0, 3, 0, 3, 3,		Bedding Joints	0.02		2x2.5x1.25 to 4x4x5.8
10600						1	0, 0, 0		Bedding Joints	0.02		
10601						2	0, 5, 5, 80, 0, 0, 3, 85, 0, 2		Bedding Joints & Vertical Fractures	0.05		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10602		Black Shale High Carbon Content	99	17	68	2	0, 10, 60, 4, 5, 0, 70, 75, 2, 4, 3, 6	1.5 – 16.4	Bedding Joints & Vertical Fractures	0.01	None	2.5x2.5x1.3 to 4x4x3.75
10603						2	5, 0, 78, 3, 5		Bedding Joints & Vertical Fractures	0.01		
10604						2	6, 4, 0, 80, 5, 0, 0, 2		Bedding Joints & Vertical Fractures	0.05		
10605						2	0, 0, 0, 50, 4, 5, 3, 0		Bedding Joints & Vertical Fractures	0.04		2.75x2.5x1.2 to 4x4x6.6
10606						1	2, 3, 2, 0, 2, 5, 4, 2		Bedding Joints	0.01		
10607						1	3, 5		Bedding Joints	0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10608		Black Shale High Carbon Content	100	52	77	1	5, 4, 5, 3, 0, 0, 2, 15, 4	1.3 – 20.8	Bedding Joints	0.02	None	1.75x2.5x0.5 to 4x4x5.7
10609						1	5, 0, 4, 5		Bedding Joints	0.01		
10610						1	0, 5, 10, 7		Bedding Joints	0.01		
10611						1	0, 6, 10, 7, 0		Bedding Joints	Tight		3.5x2x0.5 to 4x4x8.25
		Siltstone										
10612						1	9, 5, 8		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10613		Siltstone	100	81	97	1	8, 8, 4	3.4 – 23.8	Bedding Joints	Tight	None	4x4x1.75 to 4x4x8.25
10614						1	4		Bedding Joints	Tight		
10615						1	3, 0, 4		Bedding Joints	Tight		
10616						1	0, 5, 2		Bedding Joints	0.01		4x4x1.4 to 4x4x12.6
10617						1	3, 8		Bedding Joints	Tight		
10618						1	2, 3		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10619		Siltstone	100	72	91	1	0, 2, 1, 2	3.1 – 23.8	Bedding Joints	Tight	None	4x4x2.7 to 4x4x7.1
10620						1	4, 0		Bedding Joints	Tight		
10621						1	3, 3		Bedding Joints	Tight		
10622						1	3,2		Bedding Joints	Tight		4x4x1.25 to 4x4x9.4
10623						1	8, 4, 2, 12		Bedding Joints	Tight		
10624						1	6, 14		Bedding Joints	0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10625		Siltstone	100	60	86	1	11, 3, 0, 4, 0, 0, 0	0.8 – 43.2	Bedding Joints	Tight	None	4x4x0.25 to 4x4x17
10626						1	2, 7, 10		Bedding Joints	0.01		
10627						0			Bedding Joints	Tight		
10628						1	4		Bedding Joints	Tight		
10629						1	0, 2, 0, 1, 0		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10630		Siltstone	97	75	96	1	2	2.4 -30.2	Bedding Joints	0.01	None	4x4x1 to 4x4x11.9
10631						1	4		Bedding Joints	0.02		
10632						1	2, 10, 5, 7		Bedding Joints	0.02		
10633						1	2, 3, 3		Bedding Joints	0.01		4x4x1.4 to 4x4x6.8
10634						1	7		Bedding Joints	0.04		
10635						1	4, 3, 0, 3		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10636		Limestone	100	91	97	1	2, 0, 0	2.5 – 29.8	Bedding Joints	Tight	None	4x4x3.6 to 4x4x8.8
10637						1	5		Bedding Joints	Tight		
10638						1	2, 2, 4, 2		Bedding Joints	Tight		
10639						0			Bedding Joints	Tight		4x4x1 to 4x4x11.75
10640						1	0, 5		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10641		Limestone	100	96	96	1	2, 2	2.5 – 26.7	Bedding Joints	Tight	None	4x4x1 to 4x4x9.7
10642						1	4, 1		Bedding Joints	Tight		
10643						1	8, 6		Bedding Joints	Tight		
10644						1	0, 7		Bedding Joints	Tight		4x4x4.4 to 4x4x10.5
10645						1	0		Bedding Joints	Tight		
10646						1	1		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10647		Limestone	100	90	95	1	6, 13, 3	1.5 – 33.0	Bedding Joints	Tight	None	4x4x1.25 to 4x4x7.75
10648						1	2, 0, 0,		Bedding Joints	Tight		
10649						1	0, 14		Bedding Joints	Tight		
10650						1	0		Bedding Joints	Tight		4x4x0.6 to 4x4x13
10651						1	3, 6, 2		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10652		Limestone Black Shale High Carbon Content	100	38	94	1	10, 5, 5	4.4 – 16.5	Bedding Joints	Tight	None	4x4x1.75 to 4x4x6.5
10653						1	0, 0, 0, 0		Bedding Joints	0.02		
10654						1	0, 0, 0, 3		Bedding Joints	Tight		
10655						1	0, 2, 5, 0		Bedding Joints	0.01		4x4x2 to 4x4x6.25
10656						1	4, 0, 4		Bedding Joints	0.02		
10657						1	0, 4, 0, 1		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10658		Black Shale High Carbon Content	100	26	92	1	5, 0, 3	2.3 – 11.4	Bedding Joints	Tight	None	4x4x2 to 4x4x4.5
10659						1	0, 2, 6, 0, 3		Bedding Joints	Tight		
10660						1	1, 1, 1		Bedding Joints	Tight		
10661						1	5, 2, 2, 5, 7, 4, 5		Bedding Joints	Tight		4x4x0.9 to 4x4x4
10662						1	0, 6, 5, 4		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10663		Black Shale High Carbon Content	100	66	82	1	3, 3	2.5 – 19.3	Bedding Joints	Tight	None	4x4x1.0 to 4x4x6.7
10664						1	7, 6, 4, 0, 3, 1		Bedding Joints	Tight		
10665						1	3, 0, 2		Bedding Joints	0.04		
10666						1	0, 2		Bedding Joints	Tight		4x4x1.25 to 4x4x7.6
10667						1	0, 1, 0		Bedding Joints	Tight		
10668						1	2, 2, 0		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10669		Black Shale High Carbon Content	100	74	79	1	1, 0, 4	1.25 – 21.4	Bedding Joints	0.01	None	4x4x1.25 to 4x4x8.4
10670						1	2, 2		Bedding Joints	Tight		
10671						1	3, 1, 0		Bedding Joints	Tight		
10672						1	2, 3		Bedding Joints	Tight		1.7x4x0.6 to 4x4x4.9
10673						1	7, 3, 2, 12, 15		Bedding Joints	Tight		
10674						2	5, 2, 4, 90, 4, 1, 2, 8, 90, 90, 2, 0, 90		Bedding Joints & Vertical Fractures	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10675		Black Shale	100	80	83	2	0, 0, 90, 6, 4, 80	2.5 -19.6	Bedding Joints & Vertical Fractures	0.02	None	2.2x4x1 to 4x4x7.7
		Siltstone with illite										
10676						1	3, 10		Bedding Joints	Tight		
10677						1	8, 0		Bedding Joints	0.01		4x4x1.8 to 4x4x6
10678						1	5, 0, 2		Bedding Joints	0.01		
10679						1	7, 17		Bedding Joints	Tight		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10680		Siltstone with illite	100	56	80	1	10, 2, 6	1.9 – 23.5	Bedding Joints	0.02	None	4x4x2.25 to 4x4x9.25
10681						1	2, 3, 11		Bedding Joints	Tight		
10682						1	2, 3, 4		Bedding Joints	0.04		
10683						1	5, 2, 7		Bedding Joints	0.04		4x4x0.8 to 4x4x8.7
10684						1	0, 0, 5, 0, 3		Bedding Joints	0.02		
10685						1	0, 4		Bedding Joints	0.01		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10686		Siltstone with illite	100	64	80	1	2, 3, 0, 0, 3	0.8 - 26	Bedding Joints	0.01	None	4x4x0.25 to 4x4x10.25
10687						1	7		Bedding Joints	0.02		
10688						1	5, 5, 5, 10, 4		Bedding Joints	Tight		4x4x1 to 4x4x7.25
10689						1	0, 12		Bedding Joints	0.01		
10690						1	5, 5, 0, 4		Bedding Joints	0.05		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10691		Siltstone with illite	100	51	79	1	5, 2, 5, 3, 2, 2, 5, 0, 1, 0	0.6 – 22.4	Bedding Joints	0.02	None	4x4x0.25 to 4x4x8.8
10692						1	3, 15, 0, 0		Bedding Joints	0.01		
10693						1	3, 5		Bedding Joints	0.02		
10694						1	2, 0, 3		Bedding Joints	0,01		4x4x1.1 to 4x4x6.5
10695						1	1, 12, 15		Bedding Joints	Tight		
10696						1	4, 0, 0		Bedding Joints	0.01		

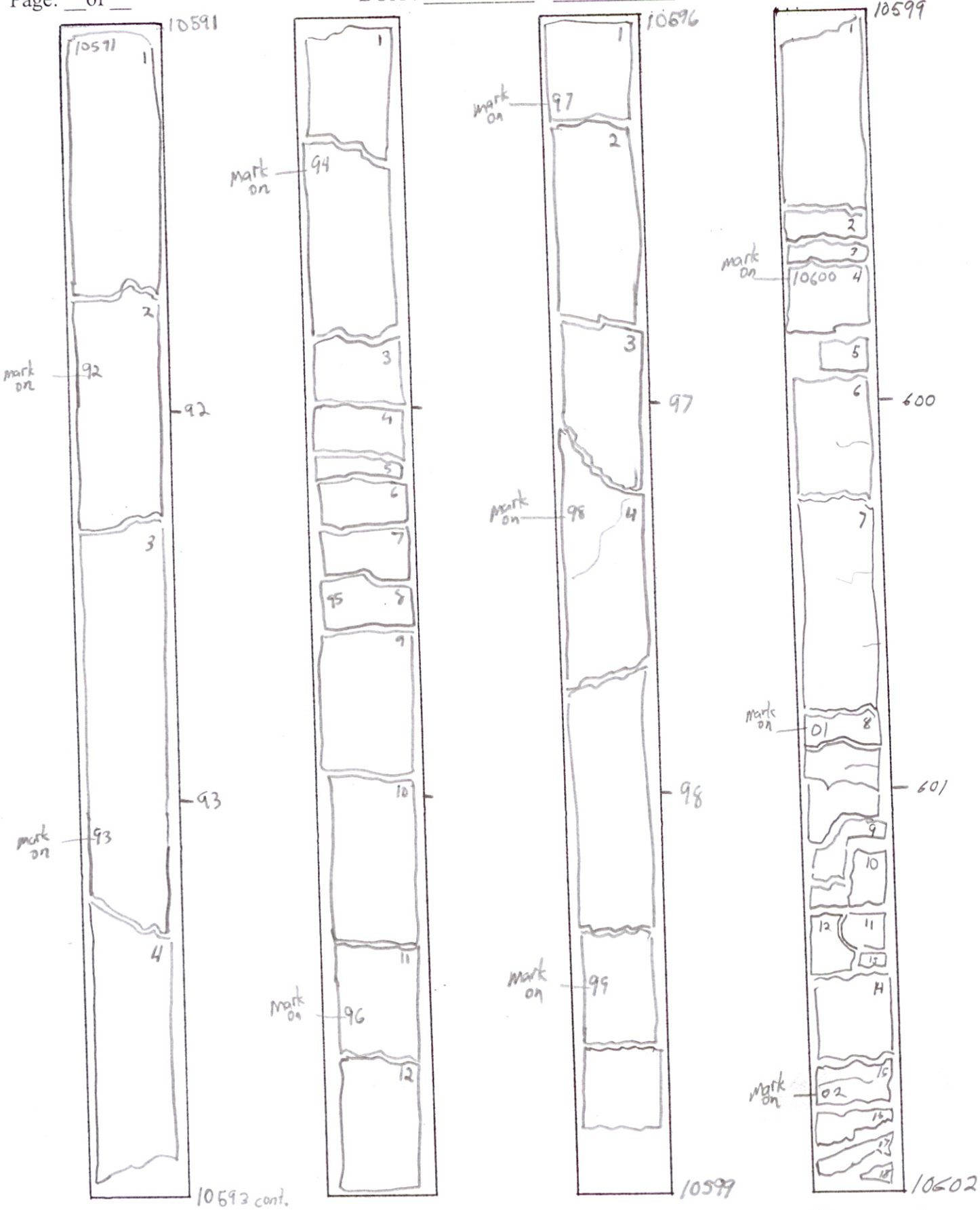
Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10697		Siltstone with illite	100	56	83	1	5, 3, 10, 2, 2	1.3 – 15.9	Bedding Joints	0.01	None	1.5x2x0.5 to 4x4x6.25
10698						2	2, 7, 40, 70, 30, 3		Bedding Joints & Vertical Fractures	Tight		
10699						2	8, 60, 5		Bedding Joints & Vertical Fractures	Tight		
10700						1	2, 3, 3, 8, 0		Bedding Joints	0.02		4x4x0.5 to 4x4x6.7
10701						1	6, 8, 3		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10702		Siltstone with illite	100	57	75	1	5, 7	1.4 -27.2	Bedding Joints	Tight	None	4x4x0.9 to 4x4x10.7
10703						1	8, 2, 4, 10, 4, 5, 4, 1		Bedding Joints	0.01		
10704						1	7, 1, 4, 0		Bedding Joints	0.04		
10705						1	3, 3, 5, 3		Bedding Joints	Tight		4x4x0.6 to 4x4x9.3
10706						1	0, 28		Bedding Joints	Tight		
10707						1	15, 15		Bedding Joints	0.02		

Depth (ft)	Profile (1:12)	Rock & Seepage	Total recovery (%)	RQD (>10cm) (%)	RQD (>5 cm) (%)	Sets	Dip (degree)	Spacing. (cm)	Discontinuity	Aperture (cm)	Filling	Block size (XYZ, inch)
10708		Siltstone with illite	100	65	83	1	7, 6, 8	2.54 – 22.7	Bedding Joints	0.01	None	4x4x1.5 to 4x4x6.6
10709						1	0, 6, 10		Bedding Joints	0.01		
10710						1	13, 12		Bedding Joints	Tight		
10711						1	7, 10		Bedding Joints	0.01		4x4x1 to 4x4x9
10712						1	14, 18, 9, 7, 2, 10, 19, 7		Bedding Joints	0.02		
10713												

Well #16433 fracture sketch

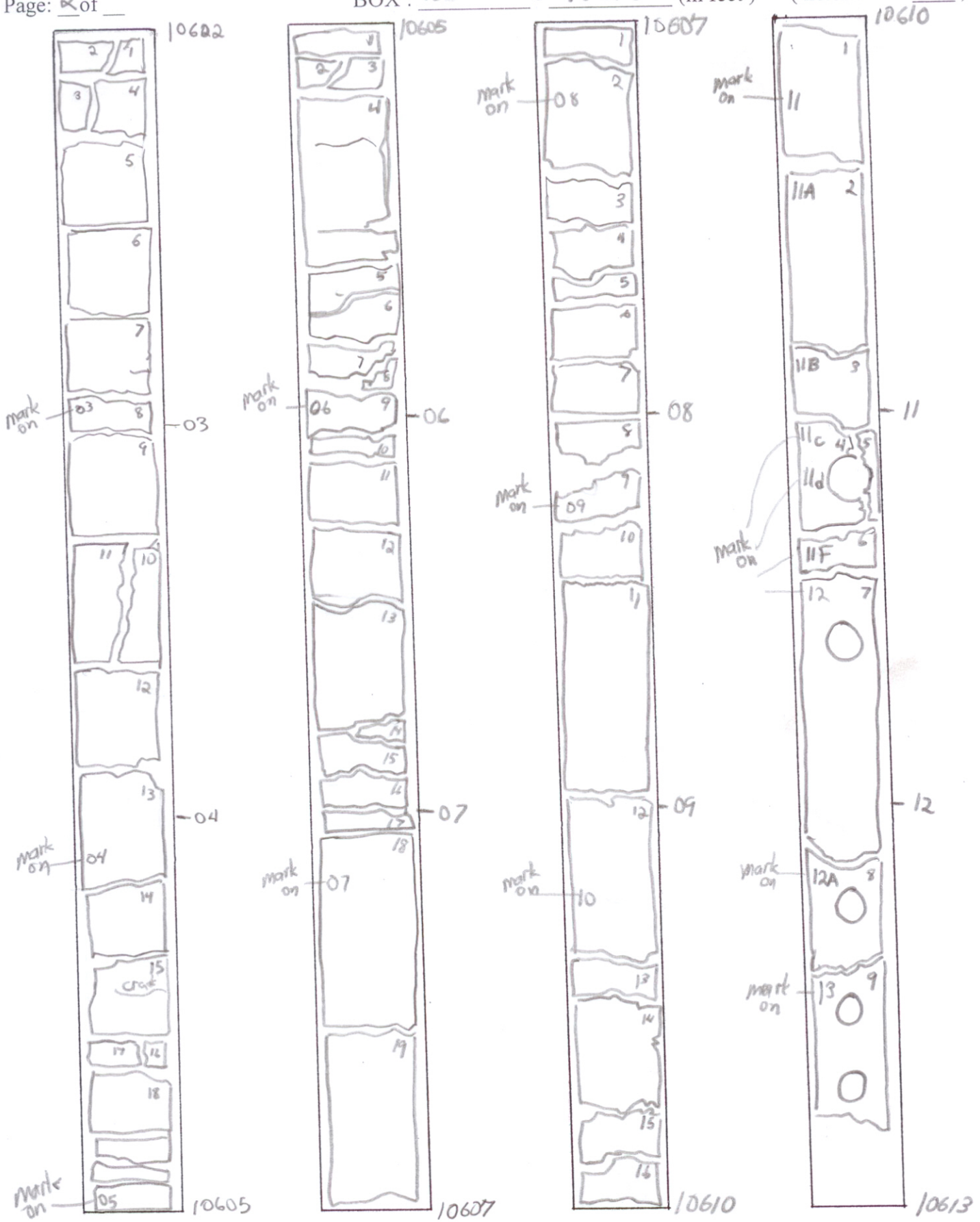
Page: 1 of __ BOX : 10591 - 10602 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp.
API no. : 33053027690000
Scale (ratio) : length width Core diameter : 4"
9in /3ft 0.33"/4"

Page: 2 of __ BOX : 10602 - 10613 (in feet) (no.of slots : ____)

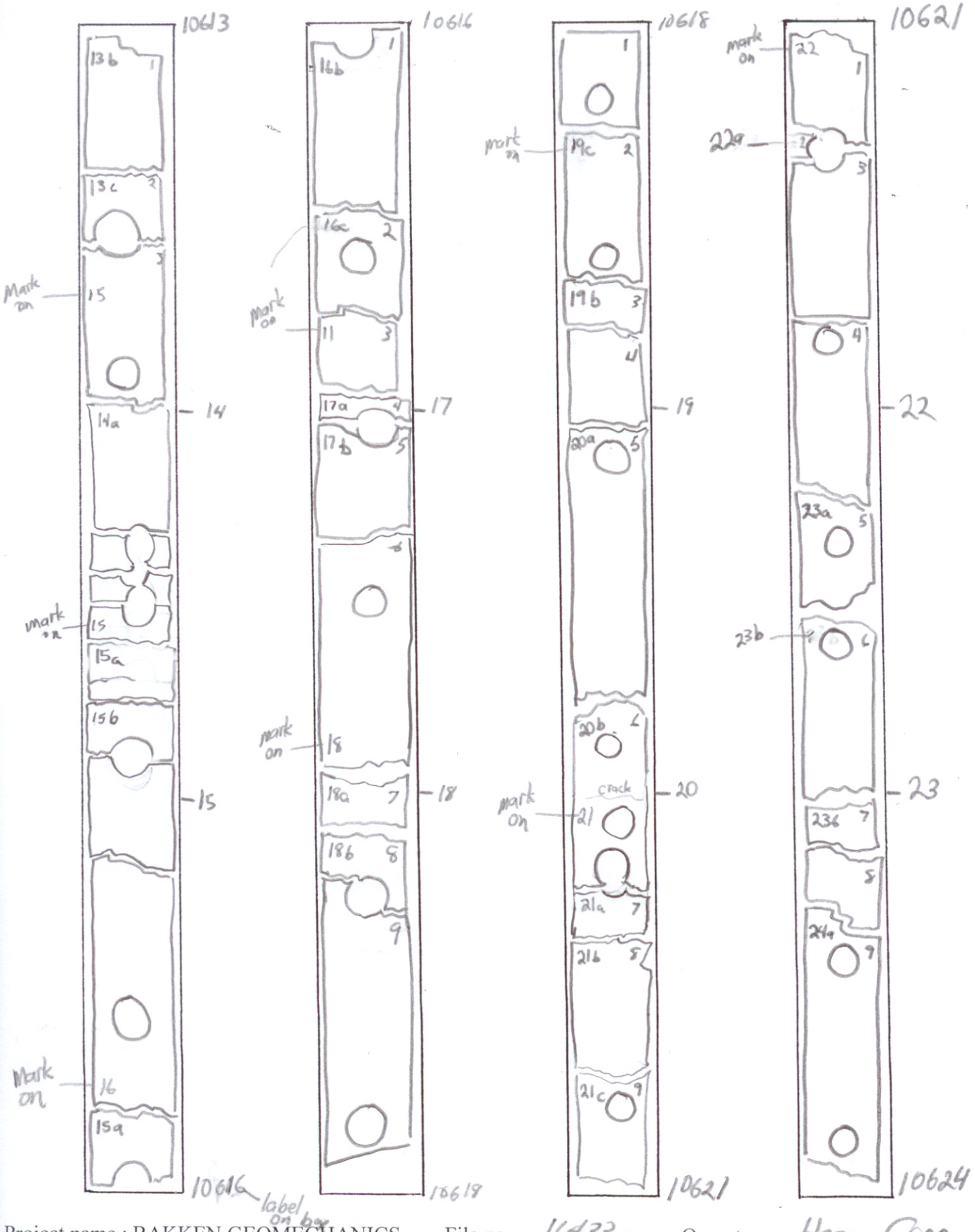


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433
API no. : 33053027690000
Scale (ratio) : length width
9in/3ft 0.33"/1"

Operator : Hess Corp.
Core diameter : 4"

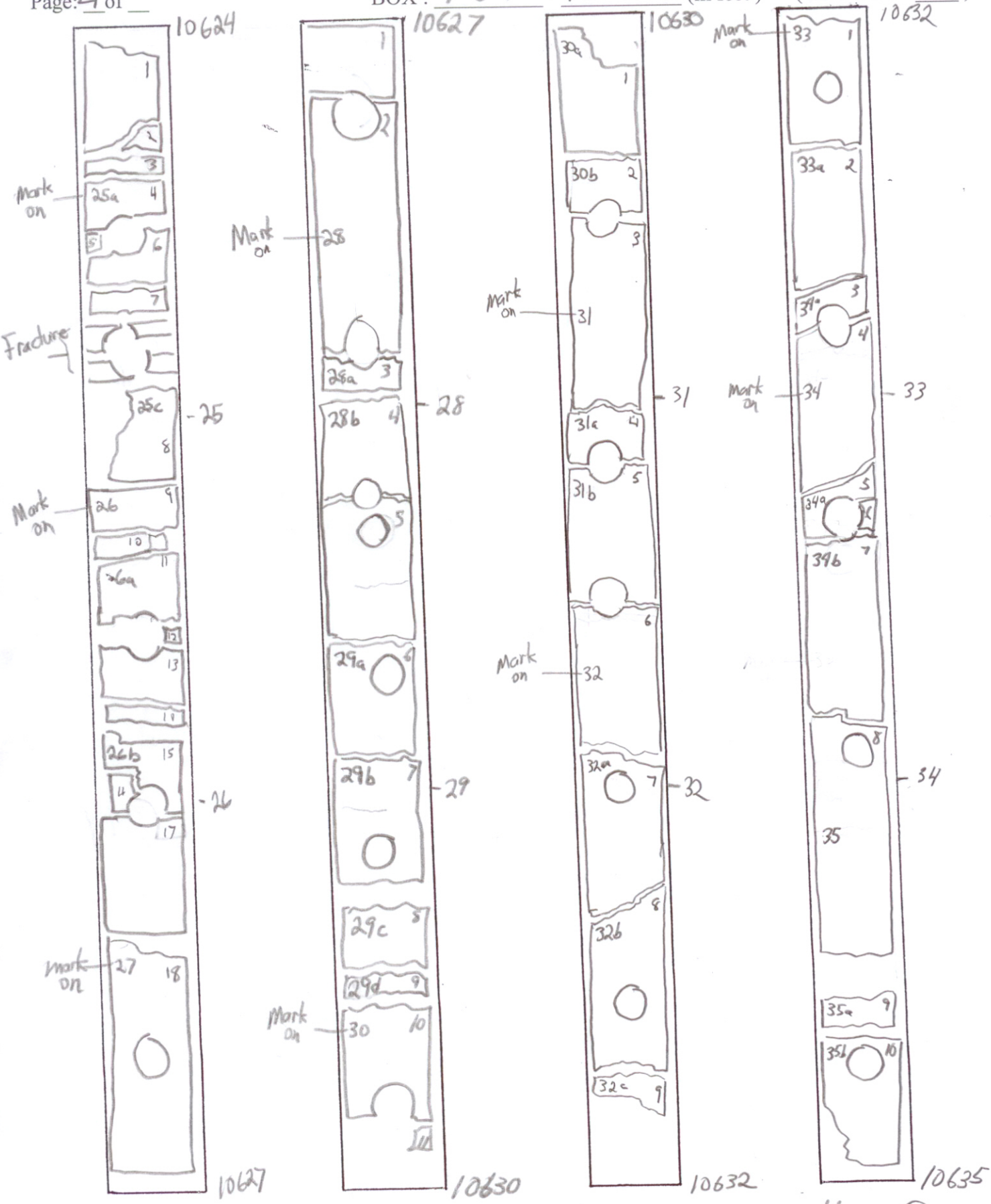
Page: 3 of _ BOX : 10613 - 10624 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no : 16433 Operator : Hess Corp
API no : 33053027690000
Scale (ratio) : length width Core diameter : 4"
9in/3ft 0.33"/4"

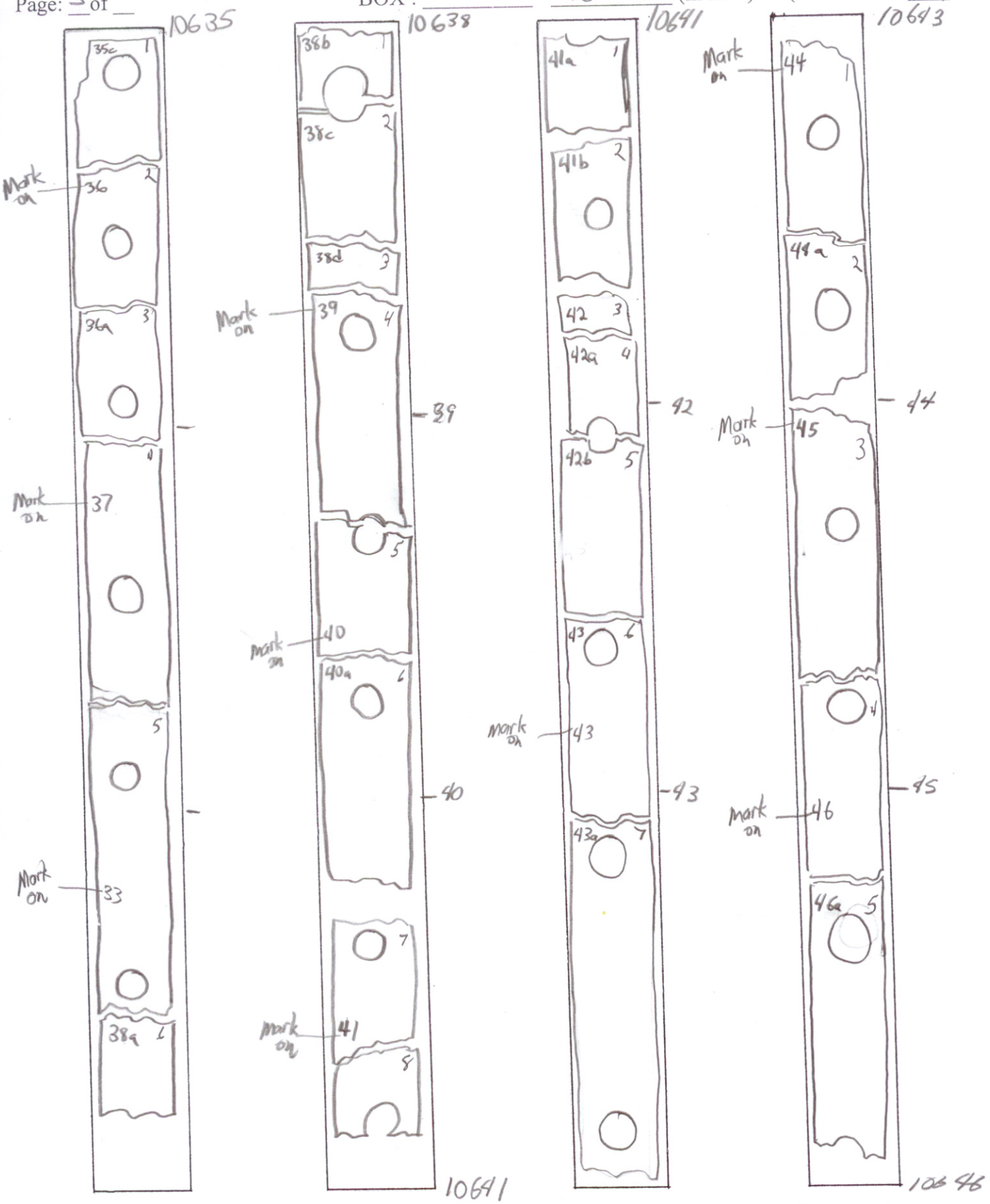
Page: 4 of __ BOX : 10624 - 10635 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp
API no. : 33053027690000
Scale (ratio) : length width Core diameter : 4"
9in/3ft 0.33"/4"

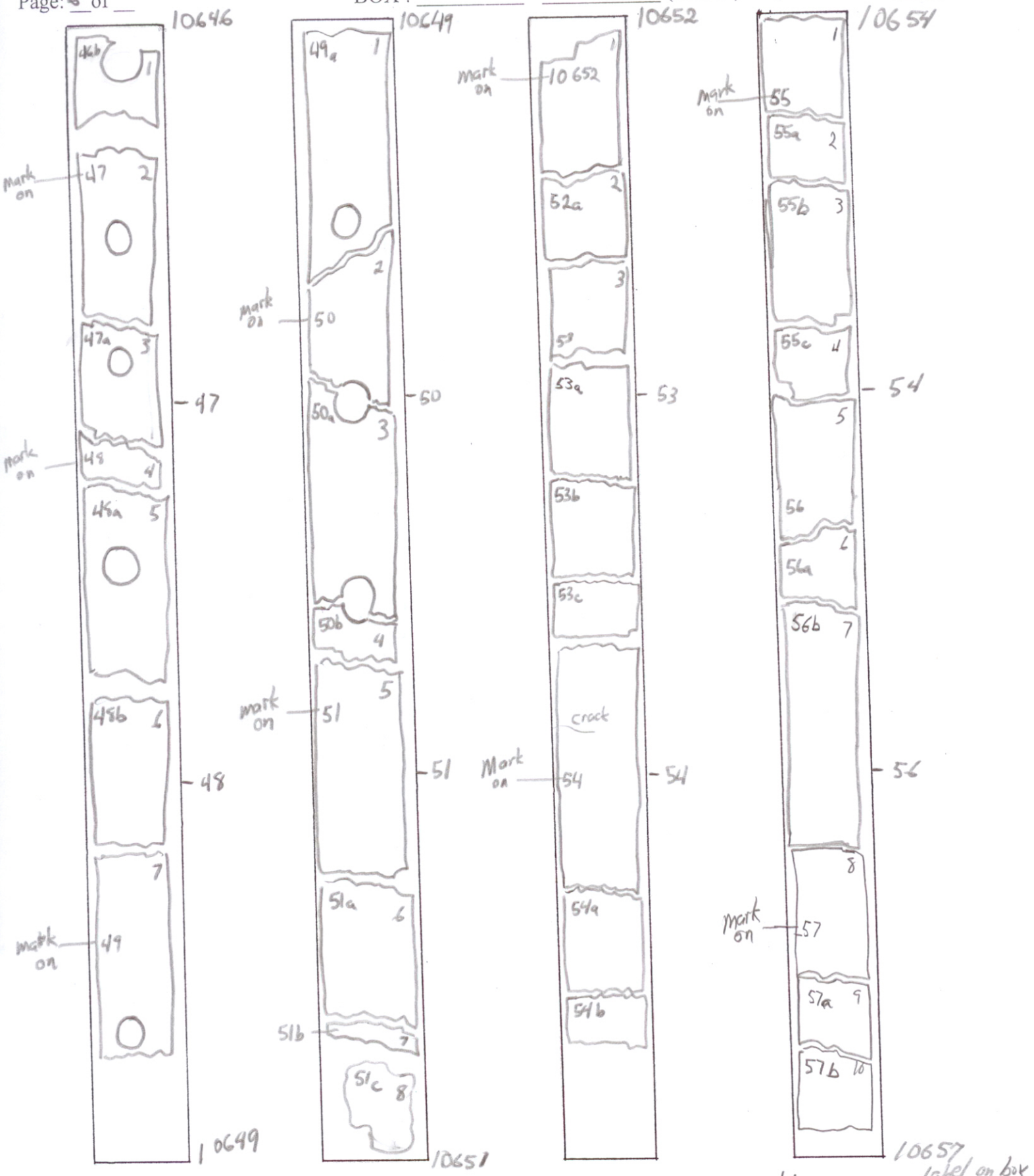
Page: 5 of __ BOX : 10635 - 10646 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp
API no. : 33053027690000
Scale (ratio) : length 9in/3ft width 0.33"/4" Core diameter : 4"

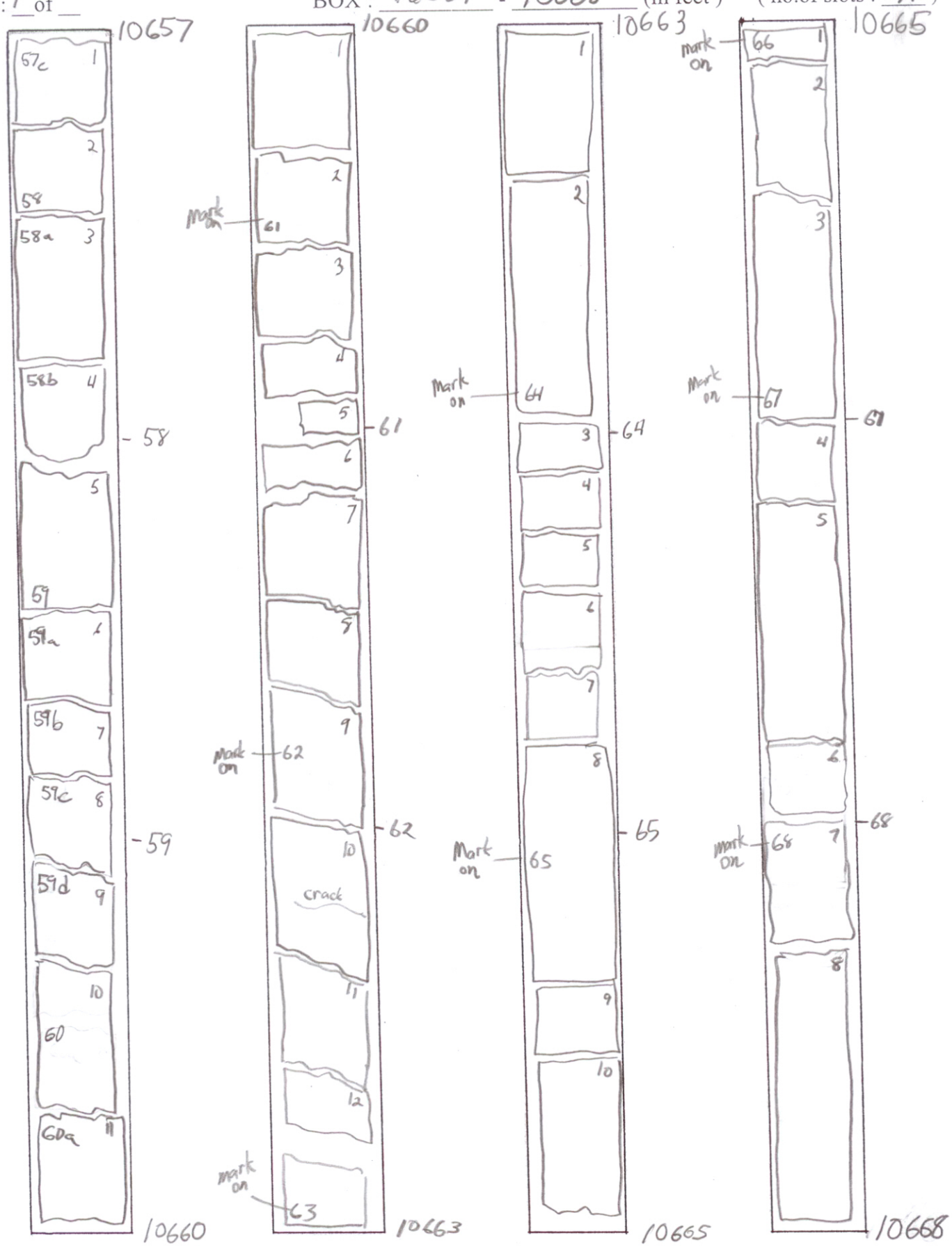
Page: 6 of __ BOX : 10646 - 10657 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp
API no. : 33053027690000
Scale (ratio) : length 9in/3f width 0.33"/4" Core diameter : 4"

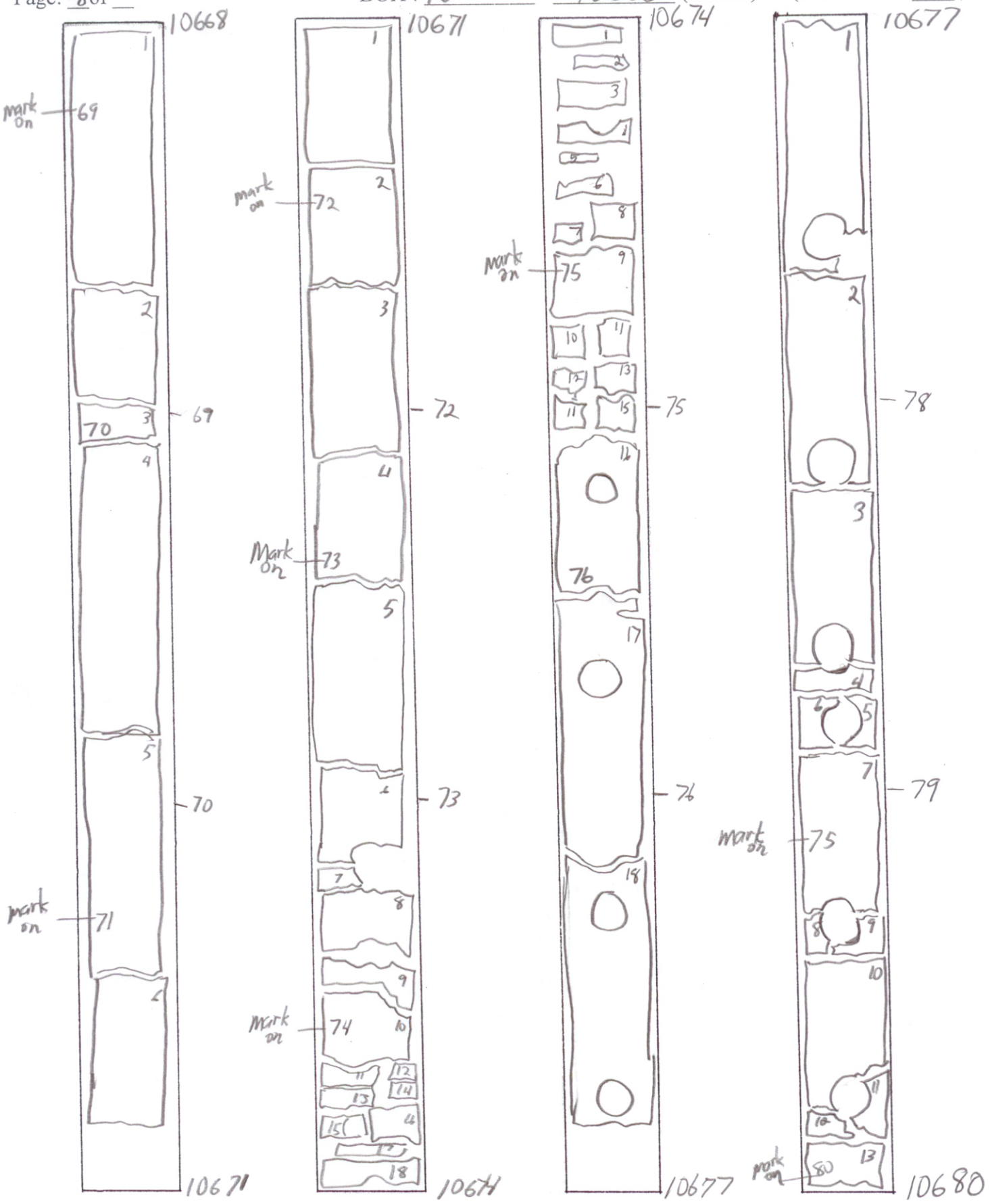
Page: 7 of __ BOX : 10657 - 10668 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp
API no. : 33053027690000
Scale (ratio) : length width Core diameter : 4"
9in/3ft 0.33"/4"

Page: 8 of __ BOX : 10668 - 10680 (in feet) (no.of slots : N/A)

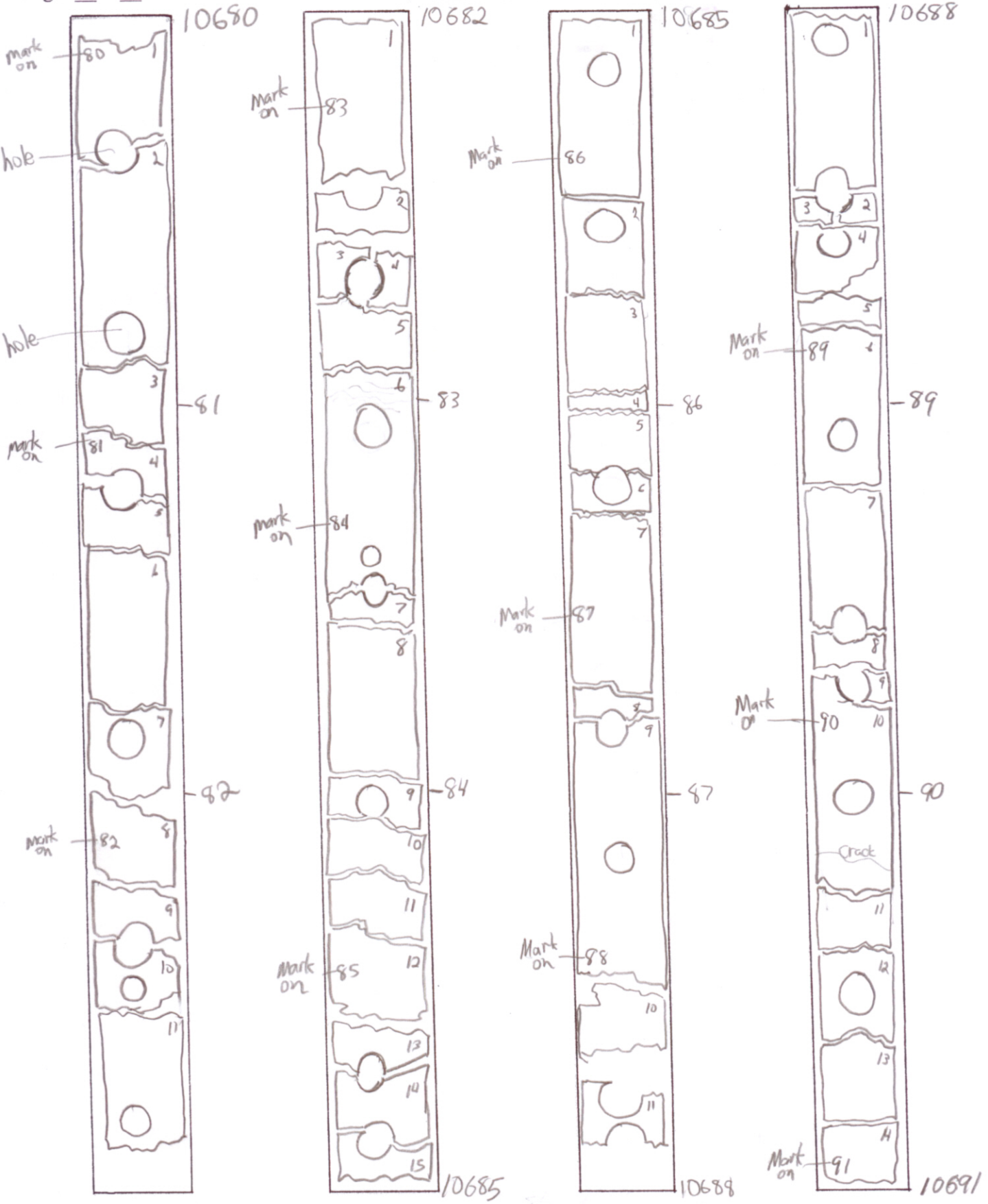


Project name : BAKKEN GEOMECHANICS File no. : 16433 Operator : Hess Corp.

Drawing by : Jill Holwerda API no. : 33053027690000

Date : 7-1-08 Scale (ratio) : length 9in/3ft width 0.33"/4" Core diameter : 4"

Page: 9 of 11 BOX : 10680 - 10691 (in feet) (no.of slots : N/A)

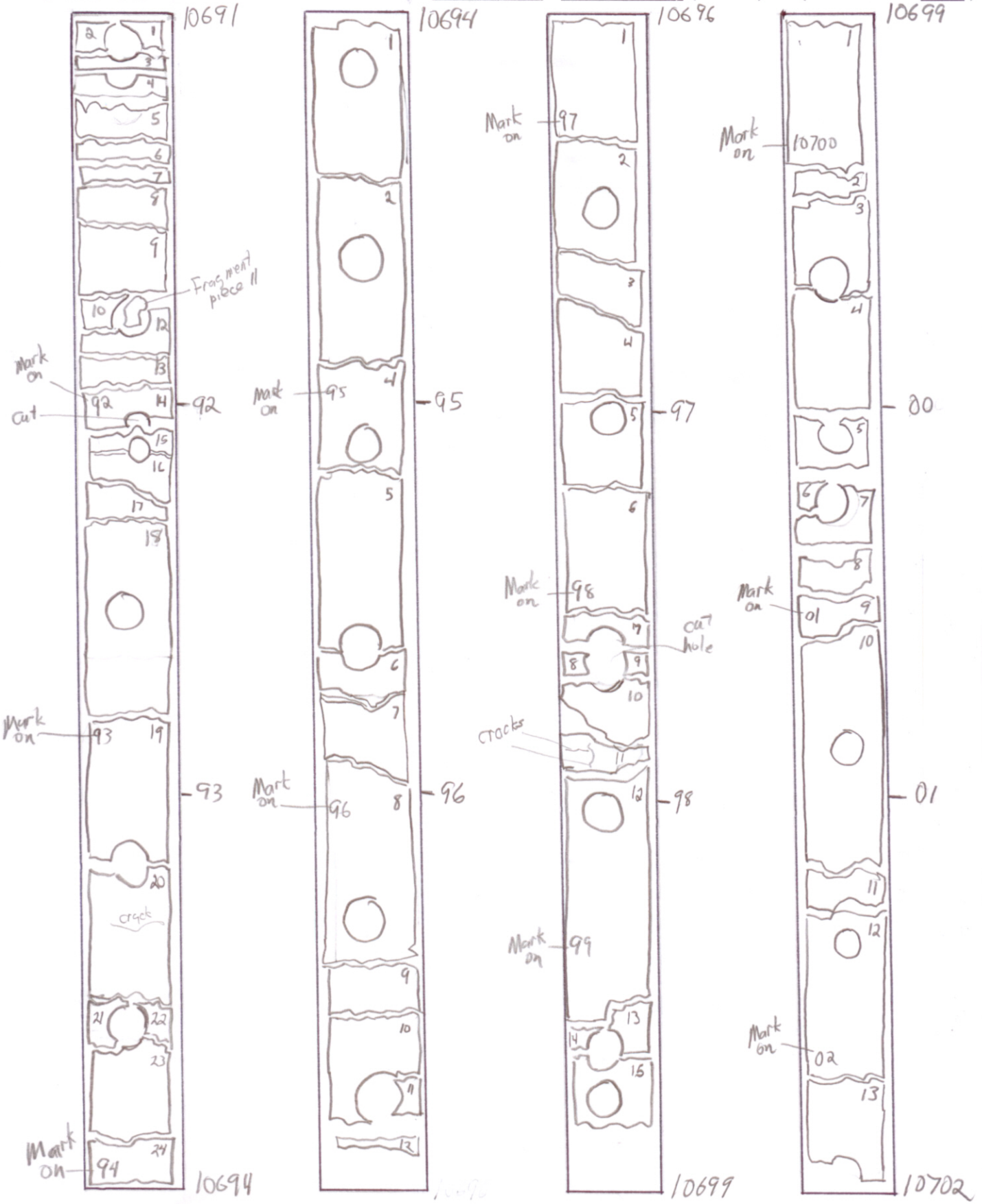


Project name : BAKKEN GEOMECHANICS
Drawing by : Jill Holwerda
Date : 7-1-08

File no. : 16433 Operator : Hess Corp.
API no. : 33053027690000
Scale (ratio) : length 9in/3ft width 0.33"/4" Core diameter : 4"

Page: 10 of 11

BOX : 10691 - 10702 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 16433

Operator : Hess

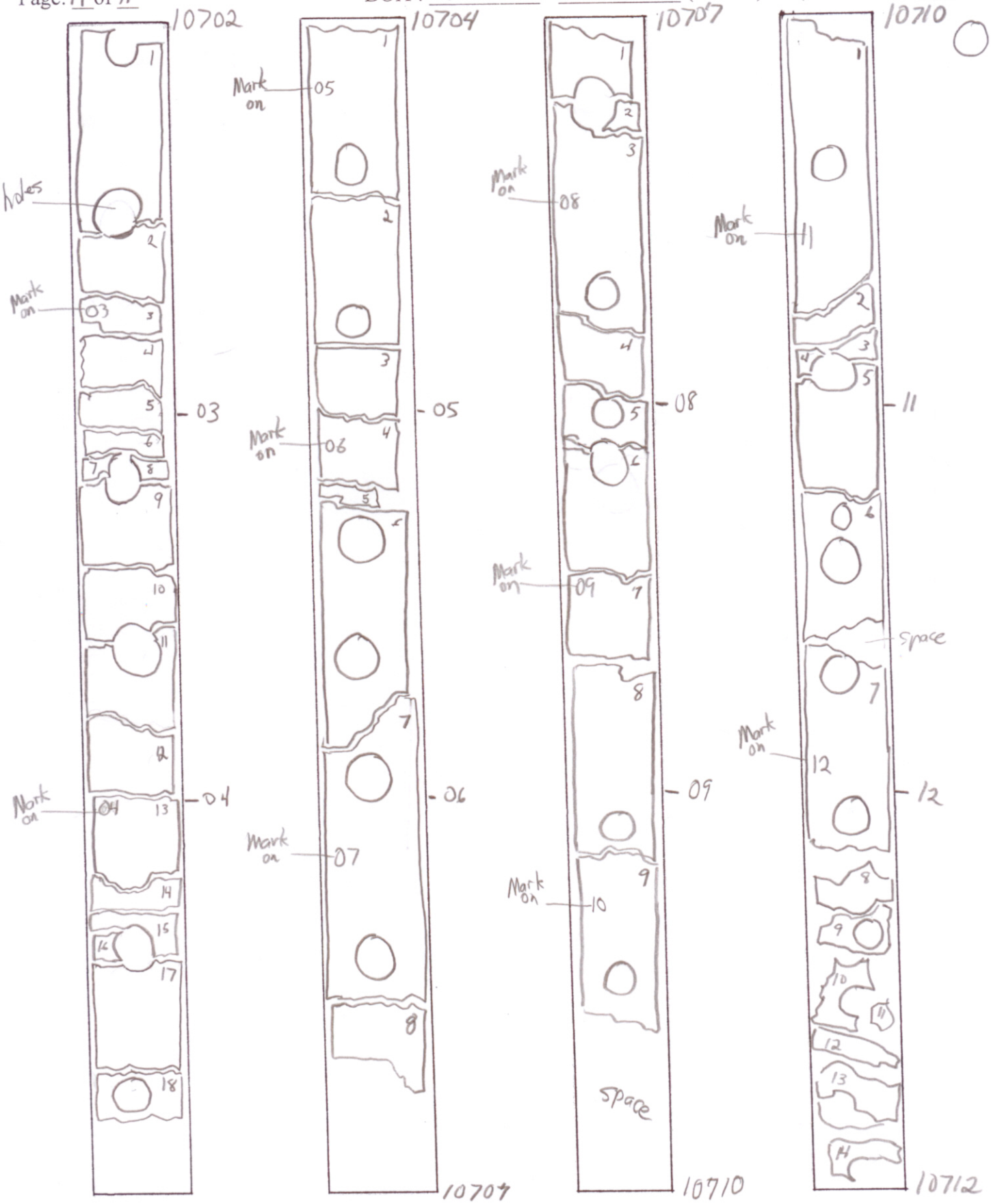
API no. :

Scale (ratio) :

Core diameter : 4"

Page: 11 of 11

BOX : 10702 - 10712 (in feet) (no.of slots : N/A)



Project name : BAKKEN GEOMECHANICS

Drawing by : Jill Holwerda

Date : 7-2-08

File no. : 16433

API no. :

Scale (ratio) :

Operator : Hess

Core diameter :