

THE ALBERTA ENERGY REGULATOR

IN THE MATTER OF
Regulatory Appeal 1927181
to the Alberta Energy Regulator

AER PROCEEDING

VOLUME 3

VIA REMOTE VIDEO

October 15, 2020

1	TABLE OF CONTENTS		
2			
3	Description		Page
4			
5	October 15, 2020	Morning Session	332
6	Discussion		332
7	Ms. Berg Cross-examines Canadian Natural		333
8	Resources Limited		
9	Alberta Energy Regulator Staff Questions		368
10	Canadian Natural Resources Limited		
11	Alberta Energy Regulator Panel Questions		386
12	Canadian Natural Resources Limited		
13			
14	October 15, 2020	Afternoon Session	410
15	Response to Undertaking by		410
16	Canadian Natural Resources Limited		
17	Alberta Energy Regulator Panel Questions		413
18	Canadian Natural Resources Limited		
19	VERONIQUE GIRY, PETER VERMEULEN, DAVID LEECH,		419
20	EDWARD MATHISON, EARL WARD, BRETT THOMPSON,		
21	JENNIFER CLEE, Affirmed		
22	Rebuttal Evidence of ISH Energy Ltd.		419
23	Ms. Jamieson Cross-examines		445
24	Canadian Natural Resources Limited (Rebuttal)		
25	Alberta Energy Regulator Staff Questions		457
26	ISH Energy Ltd. (Rebuttal)		

1	Certificate of Transcript	466
2	<hr/>	
3	Proceedings taken Via Remote Video	
4	<hr/>	
5	October 15, 2020	Morning Session
6		
7	C. Low	The Chair
8	C. McKinnon	Hearing Commissioner
9	B. Zaitlin	Hearing Commissioner
10		
11	S. Poitras	AER Counsel
12	A. Hall	AER Counsel
13	D. Campbell	AER Staff
14	S. Botterill	AER Staff
15	L. Chen	AER Staff
16	E. Galloway	AER Staff
17	S. Harbidge	AER Staff
18	T. Rempfer	AER Staff
19	T. Turner	AER Staff
20	A. Shukalkina	AER Staff
21	T. Wheaton	AER Staff
22		
23	L. Berg	For ISH Energy Ltd.
24	S. Hryciw	
25		
26	J. Jamieson	For Canadian Natural Resources

1 Limited

2

3 A. Vidal, CSR(A) Official Court Reporter

4 S. Howden, CSR(A) Official Court Reporter

5

6 (PROCEEDINGS COMMENCED AT 9:00 AM)

7 Discussion

8 THE CHAIR: Just before we go back
9 to ISH's continued questioning of the Canadian Natural
10 panel, I just wanted to let you know we've revised, as
11 you know, the schedule, and for your planning purposes,
12 at sort of a high, high level, what it looks like is
13 finishing with the Canadian Natural witness panel this
14 morning. So ISH will finish their questioning. AER
15 staff and then the Panel, if we have questions, any
16 redirect by Canadian Natural, and then we'll take --
17 and probably fit a shorter break in there and then take
18 the longer lunch break, and then after the lunch break,
19 we would then have ISH rebuttal evidence, if any, and
20 then with the usual round of questioning.

21 So with that, I guess, Mr. Iannattone, since you
22 are the chair of the ISH -- or, sorry, the Canadian
23 Natural -- pardon me -- witness panel, have you got
24 everybody present and accounted for? It looks like it
25 to me.

26 MR. IANNATTONE: I do, Madam Chair.

1 I would like to make a request before we start
2 with the cross-examining. Yesterday, before the break,
3 there was a question that was asked to CNRL. It was
4 about Table 4-1 in 65.01, and during the break, we were
5 to come back with an answer to that question, and we --
6 we did not answer that question, so I wonder if it's
7 appropriate to answer that question now.

8 THE CHAIR: That would make sense to me,
9 but let's -- it was in response to a question from ISH,
10 I believe?

11 MS. BERG: It was. And -- and that would
12 be appreciated. Why don't we just start with that?

13 Ms. Berg Cross-examines Canadian Natural Resources
14 Limited

15 MR. IANNATONE: Okay. Mr. Lavigne, please.

16 MR. LAVIGNE: Good morning. Would we like
17 to bring that exhibit up while we discuss it?

18 MR. IANNATONE: It's page 13 of 45, 65.01.

19 MS. TURNER: One moment.

20 MR. LAVIGNE: I believe it's page 13 in that
21 document.

22 Ms. Berg, would you like to repeat the question?

23 Q MS. BERG: I believe the question -- and
24 I don't have it in front of me, but it was regarding
25 the number of wells or number of core that were pulled
26 from the KN06 box for this particular table, if

1 recollection serves.

2 A MR. LAVIGNE: Okay. Thanks.

3 For -- yeah. So for clarification, yeah, the
4 question I had is: How many cores for this table are
5 from KN06, I believe?

6 Q Okay. Yeah.

7 A Yeah. So I apologize. I was confused. I was speaking
8 to the mapping area that Canadian Natural submitted,
9 which is larger than the KN06 box, so -- but to answer
10 your question specifically, there are 12 wells in the
11 KN06 box. 8 of them have core, 11 of them have image
12 logs, and 7 wells were used to calculate the averages
13 for the values in the table.

14 Q Okay. Thank you.

15 All right. I will begin, then, my next series of
16 questions, and I -- the initial questions I'm not sure
17 who -- who will be responding from CNRL.

18 And so, Mr. Iannattone, I'll -- I'll direct them
19 to you, and -- and you can direct them to your team
20 accordingly. So I'd like --

21 A MR. IANNATTONE: Sounds good.

22 Q So I'd like to begin with some questions regarding the
23 10-01 well. If we could go to Exhibit 201, page 204,
24 please.

25 MR. IANNATTONE: Mr. Craig, please.

26 MS. BERG: And it'll be on the bottom of

1 the page for the hearing coordinator. Again, that's
2 201, PDF 204.

3 MS. TURNER: It's coming.

4 MS. BERG: Yeah. No worries. First
5 document today, so ...

6 And if we could just -- oh, sorry. If we could
7 just go to the bottom of the page, the last paragraph.

8 Q MS. BERG: So you'll see there that it
9 states: (as read)

10 Further, a well located at the 10-01 contains
11 monitoring for thermal compatibility
12 purposes. The data collected to date
13 supports no evidence that the shale barrier
14 between the McMurray reservoir and the
15 overlying gas-over-bitumen zone has been
16 impacted. Observation data has been and will
17 continue to be provided to ISH from this
18 well.

19 So my question is: What kind of data interpretation
20 was conducted in October 2019?

21 A MR. CRAIG: At that point in time, we
22 would've had the recollection. We have the pressure
23 and temperature trends that we would've started
24 collecting in about March of 2019 until that time
25 frame, and that would've been the data that was
26 supplied to ISH.

1 Q What is exactly CNRL's interpretation process when --
2 when it collects that data?

3 A So we are analyzing that data for any anomalous trends.
4 I would -- I would point us towards the submission
5 that -- it's tab -- sorry. I'll just find it here in
6 my records if we want to bring that up. There is
7 the --

8 Q I could actually just go on to my next question if --

9 A Sure, sure. I was going to try and refer to a tab that
10 CNRL had submitted that had a -- the pressure trends
11 and then a -- a table of our interpretation at the
12 time, and I believe that would answer the question.

13 At the time of --

14 Q Okay.

15 A -- August of 2019, our interpretation was that there
16 was no integrity concerns at the 10-01 wellbore.

17 Q Okay. And, sorry, that is on the record, then?

18 A It's on page 49 of 1066, so I believe that's the CNRL
19 submission, and that is exhibit number -- CNRL
20 Submission 30-02.

21 Q Sorry. Is that "30 dash" -- if it's 1066, I think that
22 might be 48 -- 48.02.

23 A Thank you for that.

24 Q Yeah. All right. Thank you.

25 How regular is your review process?

26 A We look at these wells on a monthly basis.

1 Q Okay. Thank you.

2 A So we collect the data, and it's available to us
3 daily --

4 Q Yeah.

5 A -- coming to our data-collection system. We have
6 access to the data daily. We have a formal review
7 monthly.

8 Q Okay. Thank you.

9 If you could please go to Exhibit 48.02, PDF 48.
10 And that's perfect. It's the upper one that I'll be
11 referring to.

12 So Figure 1 shows the 10-01 pressure and
13 temperature history from March 2019 to July 2020 with
14 significant events highlighted with red lines. The
15 green temperature drops significantly in November 2019;
16 correct?

17 A Yes.

18 Q Why would CNRL not flag that temperature drop as a
19 significant event?

20 A It was -- we're looking at responses that are related
21 to the SAGD operation right now, currently, in nearby
22 KN06, a couple hundred metres away, and we would see
23 anomalous issues with temperature increases. So an
24 issue with well integrity in this well may be indicated
25 by a temperature increase. A temperature decrease is
26 not a concern.

1 Q All right. One moment, please.

2 What is your explanation of that temperature drop?

3 A Well, I believe that Mr. Leech's report submitted by
4 ISH would indicate that's a Joule-Thomson effect with
5 gas flow in the wellbore.

6 Q Okay. Thank you.

7 If I could get you to go -- happily, we're in the
8 same exhibit, PDF 602. So that's just the first page
9 of the CNRL Directive 54 presentation. The annual
10 report presented to the AER was in September 2019, and
11 my understanding is there's no recent 2020 D54 report
12 available for Kirby; correct?

13 A That's correct, as I understand.

14 Q In this Directive 54 presentation, there's no mention
15 of the Kirby North 10-01 monitoring data. Can you
16 advise as to why?

17 A I would -- I believe -- I'm not exactly familiar with
18 the requirements of D54, but I believe we submitted all
19 SAGD observational data within D54. We -- I'm not sure
20 if there's a requirement within D54 to submit data from
21 noncompliant wells -- excuse me, thermally
22 noncompatible wells.

23 Q Thank you.

24 So my next line of questions are related to the
25 cement bond log report. So, again, Mr. Iannattone,
26 which member of your team would be responding to that?

- 1 A MR. IANNATTONI: Mr. Craig can respond to that.
- 2 Q Okay. Then we're going to go to Exhibit 81.01, which
3 is the cement bond log report. And just the -- a few
4 initial questions. So the cement bond logs included
5 logs from January 2015; is that correct?
- 6 A MR. CRAIG: That's correct.
- 7 Q And my understanding is the logs he was examining were
8 done during the work described in exhibit -- and I'm
9 going to lay out the exhibit and note page numbers for
10 the record. I don't need you to go there. I think you
11 can take it subject to check, but it was during work
12 described in Exhibit two oh -- 201 at pages 76
13 through 84, which was CNRL's workover of the 10-01,
14 and, again, as I understand it -- and you can take this
15 subject to check -- that work to make the 10-01
16 thermally compatible occurred between January 15th and
17 January 23rd, 2015. Both zero MPa and 7 MPa pressure
18 pass cement bond logs were run on January 20th. In the
19 subsequent days, CNRL conducted two more operations.
20 The thermal plug was run to 442 mKB, and the Wabiskaw B
21 gas zone was reperforated. So my question is: Does
22 CNRL agree that either of those operations could impact
23 the cement bond?
- 24 A No. No, we don't agree.
- 25 Q Okay. Could you elaborate on that.
- 26 A The -- I'm sure ISH has reviewed that workover report.

1 It's certainly evident that the perforation operation
2 would be on depth. So that would not impact the
3 cement, the perforations that are in the Wabiskaw. And
4 the setting of the patch is a -- it's a low-pressure
5 job execution, so there would be no reason that
6 would -- that would cause a cement integrity issue.

7 Q Does CNRL agree that the act of running a pressure pass
8 of 7 MPa could impact the cement bond?

9 A Again, no, we would not say that it's going to impact
10 the cement bond. The reason I -- I say that is that
11 when that cement was placed, if you review the drilling
12 record, the cement plug was bumped to -- I don't have
13 exactly in my -- in front of me here, but I believe it
14 was 5-and-a-half or 6 MPa, so a 7 MPa pressure pass
15 would not impact that cement.

16 Q All right. Could you please go to Exhibit 65.01 at
17 PDF 16. And it's just going to be the first -- yeah.
18 The top of the page is terrific. Thanks.

19 So here, at the top of the page, CNRL states that:
20 (as read)

21 The McMurray formation and Kirby Upper
22 Mannville, Wabiskaw B [and, obviously, there
23 was a preceding paragraph, but it indicates
24 that] 50 percent of this interval indicates a
25 good cement bond, and in the Kirby Upper
26 Mannville II pool, 80 percent of this

1 interval indicates a good cement bond.
2 Now, the summary statements there, I note, are
3 significantly different compared to the recent CBL
4 interpretation report. And, again, that is at 81.01,
5 and we don't need to jump to that, but at page 35 of
6 that report, it indicates that the cement bond log can
7 be considered in the 100 percent range.

8 So just having regard to the differences, 50,
9 80 percent, 100 percent, would you agree that
10 interpreting CBL logs is subjective?

11 A Yes, we do agree it's subjective, which is why we had
12 two independent analysis happen. The 50 and 80 percent
13 numbers you see here were conducted by our
14 well-integrity experts in-house, and the report in
15 88.01 was, of course, a third-party submission.
16 However, both reports agree that there is, without a
17 doubt, hydraulic isolation. Even with 50 or 80 percent
18 of good bond, those zones are hydraulically isolated,
19 and there is no channel that exists behind pipe.

20 Q Mr. Craig, is a 3-foot amplitude tool -- excuse me --
21 sufficient to investigate microannulus formed behind
22 cement and dry mud cake?

23 A I would say that bond logging is a standard practice.
24 I believe it is a requirement of several directives to
25 analyze bond logs and understand the cement placement
26 within the wellbores. And so the VDL tool would be a

1 standard practice to -- to evaluate cement placement.

2 Q Just one moment.

3 Did you see that the static and the 7 MPa pressure
4 amplitude curves in the recent CBL report never reach
5 zero mb?

6 A I did not notice that. I have the log in front of me,
7 and I can check, but, certainly, I know that typically
8 you only run tools up as far as possible, and you may
9 not be able to pull the tool all the way into the
10 wellhead. That may be the reason why it's not pulled
11 all the way to surface. It's a length-of-tool issue.

12 Q Sorry. Did you -- okay.

13 All right. Do you agree that if both log passes
14 for the VDL show poor formation arrivals, the cement is
15 not bonding to the formation?

16 A I would -- I believe, and certainly the interpretation
17 stands, that there is sufficient arrivals that indicate
18 bond to formation.

19 Q But just in general, would you agree that if both log
20 passes for the VDL show poor formation arrivals, the
21 cement is not bonding to the formation? And I'm asking
22 you that as a general statement.

23 A I -- I think in general, that is correct, that if you
24 have poor VDL signals, you would suspect a weak cement
25 formation bond.

26 Q Thank you.

1 A In this log, however, there are several intervals where
2 there are strong formation arrivals.

3 Q Thank you.

4 So it's fair to say that many surface casing vent
5 flow wells have excellent cement bond logs; correct?

6 A I -- it's probably a safe statement. I don't have the
7 data to follow that up, but it's probably a safe
8 statement. There is surface casing vent flow in this
9 stream, yes.

10 Q And, Mr. Craig, are you familiar with case hole density
11 neutron logs or chat logs to run on wells with gas
12 channeling mysteries where CBL logs show good bonds?

13 A Yes. I believe there is a variety of tools that can
14 also be ran if there are well-integrity concerns, yes.

15 Q And has CNRL run chat logs before?

16 A I'm sure CNRL has. I don't recall the need to run a
17 chat log in the -- the length of time that I've been
18 involved in the Kirby North project, which is now six
19 years. But has CNRL ran them? I'm sure we have.

20 Q All right. Have you considered running chat logs in
21 the 10-01?

22 A No, we have not.

23 Q All right. Thank you.

24 I'm now moving to more general questions on
25 monitoring and review. And, again, Mr. Iannattone,
26 if -- I'll -- I'll let you listen to the question

1 and -- and determine who on your team should respond.

2 So --

3 A MR. IANNATTONE: Thank you.

4 Q -- my first question involves -- if we could go to
5 Exhibit 2.01 again, page -- PDF page 58. And I
6 understand that this is the thermal wellbore compliance
7 assessment from CNRL's application, and, obviously, an
8 important part of the KN06 approval process is to
9 report on the status of wellbores within the area of
10 the drainage box.

11 So just in -- as a general question, does CNRL
12 believe that assessing wellbore compliancy is a
13 single-review process?

14 MR. CRAIG: Sorry, Gerard. You want me to
15 take this, I assume?

16 MR. IANNATTONE: Yes, I do. Thank you.

17 A MR. CRAIG: Is it a requirement obviously
18 of our application? It's a -- so this data is
19 submitted once in the application. However, any wells
20 that are identified as thermally noncompliant and then
21 work is done to make them thermally compatible,
22 Canadian Natural, as I alluded to in the 10-01 example,
23 continues to evaluate the data that is being collected
24 from those wells, and, like I say, in the 10-01
25 example, that's obtained through daily data collection
26 and a review process.

1 Q And so it's fair to say that CNRL understands that
2 wellbore integrity changes over time or could change
3 over time?

4 A That's specifically with wells that are not thermally
5 compliant, so they have casing or cement that would not
6 necessarily withstand thermal temperatures. CNRL
7 understands that we want to be monitoring those, yes,
8 that there is potential for those conditions to change
9 over time.

10 Q All right. If I could have you go to Exhibit 48.02,
11 PDF page 14. And it's just at the top of the page
12 there, yeah, so the second bullet under 'B'. So it
13 states there that: (as read)

14 There is no correlation between 10-01
15 pressure and temperature data and SAGD
16 operations of the McMurray formation,
17 therefore, confirming an effective barrier
18 between the Wabiskaw B and McMurray
19 formation.

20 So it's my understanding that the SAGD operations will
21 create conductive heating, which will increase core
22 pressure -- core pressures and temperatures above the
23 steam chamber. What are the alarm conditions set
24 for -- for pressure temperature increases at the
25 10-01 well?

26 A There is no alarm in place on the 10-01 data set. We

1 are collecting the data and analyzing for inflexions in
2 the trend, but there's no alarm set.

3 Q All right. Given the dynamic nature of the pressures
4 and temperatures reflecting the GOB zone channelling
5 gas throughout 2019, how could CNRL conclude that there
6 was not a correlation with operations in KN05?

7 A I believe that if you were to go to tab -- sorry,
8 page -- I hope I have the page number correct -- 48
9 of 106, it's Tab 008, and we have submitted --

10 Q Sorry.

11 A (INDISCERNIBLE - OVERLAPPING SPEAKERS)

12 Q That's --

13 A Okay.

14 Q Sorry. I'm just trying to get the -- the citation
15 right. So did you say -- did you mean forty --
16 Exhibit 48, page 106? Is that --

17 A Exhibit 48.02.

18 Q Yeah. Okay. And page 106?

19 A Sorry. I believe it's page -- I have page 48 here.

20 Q Oh, sorry. Page 48. Okay.

21 And, sorry, go on.

22 A So on the second plot is a comparison of the
23 10-01 pressures in the black line --

24 Q M-hm.

25 A -- at the nearby pressures from the nearest well on the
26 KN06 pad. And, clearly, there is no correlation

1 between pressures in the Kirby North KN05 pad and the
2 10-01 pressures. And I won't be able to recite the
3 paragraph, but ISH has also agreed that there is no
4 correlation between the 10-01 pressure and the nearby
5 McMurray KN05 operation.

6 Q Okay. One moment, please.

7 So, Mr. Craig, earlier you had stated that you are
8 looking for inflexions in the trend. What magnitudes
9 of inflexions are you looking for?

10 A We would be looking for anything that indicates a steam
11 chamber has impacted the 10-01 well. So we know that
12 the difference between our current steam-chamber
13 pressure in the green line is at least 2,000 kPa
14 different than what you see in the black line. So --
15 and that order of magnitude would indicate that the --
16 the barrier below the GOB or between the McMurray and
17 the GOB has been breached, and there's a -- there's an
18 issue. There needs to be a significant change to --
19 a -- a significant inflexion point to indicate an
20 issue. Pore pressure increase would be a very slow
21 response, slow pressure increase, therefore, a slow
22 response.

23 Q All right. I have some questions on start-up operating
24 procedure. Is that you, again, Mr. Craig?

25 A Yes. I'll -- I'll attempt to answer the questions and
26 rely on my panel members to assist.

1 Q Okay. So we're going to go to your opening statement
2 at 88.02, and if I could get you to go to PDF page 58.

3 So the AER, in its IRs, asked for clarifications
4 regarding details of CNRL's enhanced monitoring and
5 associated mitigation strategy. If your new enhanced
6 operating procedure, which I understand is outlined on
7 PDF page 58, had been in place for the KN02-04I, I
8 believe -- I'm not sure if it's 041 or 04I --
9 circulation start-up, would you have been able to start
10 this well below 6 MPa?

11 A So this -- page 58 is speaking to the controls that are
12 in place during circulation --

13 Q M-hm.

14 A -- but they may not speak to the revised start-up
15 procedure.

16 Q Okay.

17 A So there was a statement that you made. I just wanted
18 to clarify.

19 Q Yeah.

20 A This well, it was started up using the revised
21 procedure. It's not conclusive that we are able to
22 remain below 6 MPa, this well and any well in the
23 field. We feel there's a higher likelihood of being
24 able to stay below 6 MPa, but it's not -- it's not a
25 given.

26 Q Thank you.

1 We understand that gas lift to reduce fluid
2 density in the well prior to increasing steam rate will
3 lower the maximum circulation pressure BHP. With this
4 mitigation procedure, would you need to go to 7 MPa?

5 A Yes. So what I was attempting to articulate is that
6 the additional gas to be implemented before significant
7 steam volumes, that will reduce the hydrostatic column,
8 but the ultimate pressure that's required to lift the
9 fluid to surface is really dependent on the reservoir.
10 So we always will attempt to start up the well at the
11 lowest pressure possible. We're -- whatever that
12 pressure is that lifts fluid to surface, there's no
13 need to go beyond that pressure.

14 Q All right. Thank you.

15 If we could go to 88.02, PDF page 61. And I'm
16 just wanting to use this more for illustration
17 purposes. It's not so much a question regarding --
18 regarding this particular page.

19 So just with regard to bottomhole pressure, it's
20 measured at the heel of the wells with a bubble too;
21 correct?

22 A During circulation, gas goes down the casing, and it's
23 measured at the heel of the well; correct.

24 Q Okay. So when a restriction or a plugging happens at
25 the horizontal lateral, do you agree that pressure at
26 the toe will be undetected and higher?

1 A There is -- I don't believe our evidence indicates that
2 we have observed plugging in the lateral section of the
3 wells.

4 Q But if that was to happen, if --

5 A Yeah.

6 Q -- if there was a restriction or plugging in the
7 horizontal lateral, would you agree that pressure at
8 the toe will be undetected and higher?

9 A Is it -- am I able to communicate with my colleagues
10 on -- on this issue?

11 Q Sure.

12 A That means do I request a breakout room? I'm not sure
13 how that works.

14 Q I'm -- I am not entirely sure how that works, and so I
15 think we can ask Ms. Turner.

16 THE CHAIR: Yeah. If there's a breakout
17 room set up for them, you can send them to the breakout
18 room.

19 MS. TURNER: Anastasia, please have them
20 assigned to that breakout room.

21 So you should be getting a message soon. CNRL
22 witnesses to join the room.

23 MR. THOMSEN: And, Ms. Turner, if I could
24 have an invite to the breakout room for my second
25 log-in, please.

26 MS. TURNER: Sure. There you go.

1 You should all -- yeah. Mr. Lavigne, you should
2 have the invite to the breakout room.

3 MR. LAVIGNE: I haven't received the invite.

4 MS. TURNER: If you go to the bottom of
5 your screen, it says "breakout room."

6 MR. LAVIGNE: Yeah. I'm not seeing that.

7 MS. TURNER: If you hover your --

8 MR. LAVIGNE: Oh, I'm sorry.

9 MS. TURNER: There.

10 Madam Chair, we've sent a message to that breakout
11 room letting them know that they should join on their
12 own when they're ready.

13 THE CHAIR: I did see that. I'm wondering
14 if they're all familiar enough with Zoom to know how to
15 do that.

16 MS. TURNER: Right.

17 THE CHAIR: Maybe you could send them a
18 note with the instruction on how to do that and invite
19 them back.

20 MS. TURNER: Okay.

21 THE CHAIR: It's been over five minutes,
22 so ...

23 MS. TURNER: I can email Mr. Scrimshaw.

24 THE CHAIR: Okay.

25 THE COURT REPORTER: I'm sorry. Did you want that
26 discussion on the record?

1 THE CHAIR: That's a good question. Sure.

2 THE COURT REPORTER: Okay.

3 THE CHAIR: Did you get it? If you got
4 it, yes. If you didn't -- oh, here they are.

5 MR. CRAIG: Hello.

6 THE CHAIR: Welcome back.

7 MR. CRAIG: Okay. Thank you.

8 A MR. CRAIG: Yes. Thanks for the
9 opportunity to break out there.

10 So I think we acknowledge that in the highly
11 unlikely scenario that there is a plug in the lateral
12 section, that the toe pressure measurements could be
13 unmeasured; the toe pressure could be unmeasured.

14 We have the ability to observe -- or we -- we do
15 have the ability to detect, possibly -- or this
16 possible scenario, and that would be that our steam
17 rate -- our steam injection pressure at surface would
18 be climbing, attempting to squeeze steam into a shorter
19 section of the lateral. So that would be an indication
20 of a potential plug in the lateral.

21 In Kirby North, we have not observed this in the
22 96 wells that we started up, so I believe that the --
23 the likelihood of this happening is significantly low.

24 Q MS. BERG: Thank you.

25 So a follow-up question: How would you know,
26 then, if hydraulic fractures are propagating at the

1 toe?

2 A Well, we would need to have a significant time and
3 duration of steam injection at high rates that are
4 increasing this toe pressure above the 7 MPa and 8 MPa
5 fracture pressures. The -- the reservoir leak-off
6 would suggest that that's not going to be possible. If
7 we're going to get to that high a pressure, that plug
8 at those steam rates is going to dissolve. This
9 bitumen plug is going to become mobile when we're at
10 that significant-enough steam rate that would cause a
11 fracture.

12 Q Now, I'm going to just take one moment.

13 So, Mr. Craig, would it be fair to say that a
14 safety factor for the maximum operating pressure using
15 6 MPa would be a real mitigation measure for this?

16 A No. No, I don't. You know, I -- I think we -- I think
17 the evidence demonstrates that the 7 MPa pressure is
18 already a low risk, and reducing a pressure -- or
19 reducing the MOP from that 7 MPa pressure does not
20 significantly reduce the -- it does not significantly
21 reduce the likelihood of any fractures.

22 Q All right.

23 A I would --

24 Q Go ahead.

25 MR. IANNATONE: If I could interject here.

26 Mr. Thomsen, do you have any comments?

1 MR. THOMSEN: Yeah. Thank you,
2 Mr. Iannattone. I do.

3 A MR. THOMSEN: And so in our written
4 submission, we have had discussion about the use of
5 safety factors and also what is the -- what is the
6 intent of Directive 86 and Directive 51 and whether
7 those are appropriate to use.

8 And so, I mean, the -- the long and short of it,
9 in summary, the -- those directives have safety factors
10 that are applied for the life of -- of a well, for the
11 life of the operation, and the question with respect to
12 use of 7 MPa is for short periods of time, up to
13 14 days. And in practice, it's much shorter. We're
14 talking typically one or two hours, if it's used.

15 So the -- we have safety factors that are built
16 into the KN06 start-up plan. These safety factors are
17 incorporated in the form of short duration of use of
18 these pressures, a small injected steam volume that is
19 really -- all the steam is condensed, and it's really
20 just water, and then final -- finally, the monitoring
21 of injection rates and pressures. So Canadian Natural
22 has adequate mitigation built in with this and safety
23 factors that are incorporated with the start-up plan.

24 Q Thank you, Mr. Thomsen.

25 I now have -- and I, again, think that these are
26 questions for you.

1 Perhaps it's for you, Mr. Craig. I just -- I
2 wanted to go to the questions on maximum operating
3 pressure. And if we could first go to -- to
4 Exhibit 2 -- 2.01, page 228, and it's Table 1, the
5 Kirby North start-up data.

6 So you'll see there, sir, that there are three
7 wells with the highest-circulation start-up pressure
8 within pads KN02, KN03, and KN05; is that correct?

9 A MR. CRAIG: Yes.

10 Q Okay. So now I'd like you to go to 30.02, PDF
11 page 127. And on this page and, I believe, the next,
12 we have 96 wells listed; correct?

13 A Correct. Yes.

14 Q So I guess my question is: Why is there such a
15 discrepancy between the two tables? The -- the maximum
16 KN02 peak is 692 -- sixty-nine twenty-six from
17 KN02-09P. Data from the first table does not appear to
18 conform with the second table.

19 A Right, right. So the question is: Why is the data
20 different between Tab 37 and -- and the submission with
21 the three wells? Is that the question?

22 Q Yeah.

23 A So when the data was submitted, the -- the three-well
24 table submitted in 2019, the -- let me back up one
25 step. I think I described that our pressure and
26 temperature in our data collection system is quite

1 frequent. It can be up to one-second intervals that
2 we're collecting a data point. And so when the data
3 was pulled out of our data historian in -- the summer
4 of 2019, I believe, was the time frame of the
5 three-well table. That data was taken -- average
6 pressure over every 30 minutes. So the data that you
7 saw at the table with three is 30-minute intervals
8 taking an average pressure.

9 The data that you see on Tab 37 is taking the
10 maximum pressure that the wells saw during circulation,
11 even if that pressure was only observed for five
12 seconds. So the reason why there's significantly more
13 wells on Tab 37 in the PDF that we're seeing right now
14 is because we're taking a more conservative approach
15 around the pressures that were observed in circulation.
16 The submission prior was taking some averaging over a
17 30-minute interval, which had the effect of reducing
18 the -- the maximum pressure that would've been
19 recorded.

20 Q All right.

21 A We -- we wanted to be as transparent as we -- as
22 possible with -- with the data that was submitted. So
23 that's how we got to Tab 37.

24 Q All right. Could I have you go to Exhibit 48.02. And,
25 sorry, I don't have the -- I'll see if I can find the
26 PDF page number. It's Tab 15B, but I'm not sure that

1 they're marked that well on -- on the -- it's -- sorry.
2 I'm just going to confer. So is this Tab 15B of 48.02
3 or -- no, it's this one. And I'm -- I'm -- oh, it's
4 actually -- it's page 1066 of 1066.

5 So why are the injector depths listed on average
6 495 metres TBD and producers are 490 metres TBD?

7 MR. IANNATONE: Mr. Craig?

8 A MR. CRAIG: Yes. The -- the total depth
9 TBD, why are the injectors -- or why are the producers
10 shallower than the injectors? I may need to take this
11 on a -- on a breakout or a -- come back to you with the
12 answer. I believe it has to do with the wells being
13 potentially toe up, but I'm right now just speculating.
14 It could just be an error where we flipped injectors
15 and producers. Could I -- could I take this question
16 away?

17 MS. BERG: So I'm -- I'm wondering --
18 Madam Chair, I'm just wondering if it would make sense
19 for him to do that in a break. I -- I'm not -- I'm
20 fine if you want to confer with your colleagues
21 regarding this, but, yeah, I'm just wanting to do
22 what's most efficient.

23 THE CHAIR: Where are you in your
24 questioning, Ms. Berg?

25 MS. BERG: I -- I have just a few -- a
26 few left.

1 THE CHAIR: So you're thinking you'll be
2 wrapped up sort of by 10, ten after 10 or 10:15?

3 MS. BERG: About that, but it, of course,
4 depends on --

5 THE CHAIR: Depends on the answer.

6 MS. BERG: -- the breaks and --

7 THE CHAIR: Okay. I --

8 MS. BERG: But I do -- sorry. Go ahead.

9 THE CHAIR: Okay. So I was going to say,
10 I've had a request for a break, so we could do it one
11 of two ways. So we can break now and come back, and
12 that would give Canadian Natural an opportunity to --
13 to perhaps find the answer to this question and then
14 carry on, or we could carry on for a bit and then take
15 the break.

16 MS. BERG: Why don't we carry on for a
17 bit, take the break, and then I'll try to finish my
18 cross. And -- and -- and then do a very quick wrap-up.
19 Then -- and we can --

20 THE CHAIR: Okay.

21 MS. BERG: Does that make sense?

22 THE CHAIR: It does. I was just saying,
23 I've had a specific request for a break --

24 MS. BERG: Okay.

25 THE CHAIR: -- so for five or ten minutes,
26 and then we'll --

1 MS. BERG: Okay. And we'll see where
2 we're at.

3 A MR. CRAIG: The well did not -- sorry.
4 Just on this table, like, obviously, the wells have not
5 been drilled for KN06. These are the planned depths.

6 Q M-hm.

7 A Typically, we would expect to see injectors more
8 shallow than producers, and so, you know, they are
9 within that range that our -- our final TBD depths will
10 be in that 490 to 495 metres. So I don't know if that
11 answers any of the questions that you were going to
12 bring on, but please carry on. Sorry.

13 Q All right. Yeah. No. No problem. Thank you for
14 that.

15 And, yeah, if you want to confer with your
16 colleagues during the break and -- and add to that, I'm
17 sure that would -- we would all appreciate that. If I
18 could get you to go to Exhibit 88.02, PDF 43, please.

19 So I see here that the geo -- geomechanical model
20 runs with the assumption that the injectors are at a
21 depth of 477 metres. And so just having regard to
22 the -- the material on the last slide we looked at,
23 what will be the depth of the injectors?

24 A MR. THOMSEN: So why don't I take this
25 question here.

26 The 477 metres is a -- the shallowest point within

1 the liner as far as true vertical depth from surface.
2 As far as reconciling this with the previous figure,
3 we're going to need a break or an undertaking to -- to
4 answer that one.

5 Q Okay.

6 A But the intent with this is looking at the shallowest
7 well on the pad.

8 Q All right. I just had a follow-up question if we're in
9 88.02. So if we could go back to PDF page 58.

10 And, Mr. Craig, I believe this question will be
11 for you. So it's my understanding you said this well
12 was started with the new procedure, which means that
13 the BHP would be reduced to as low as possible with
14 lift gas; is that correct?

15 A MR. CRAIG: No. This well was not started
16 with a new procedure. Sorry to -- sorry if I wasn't
17 clear. This well was not.

18 Q Okay, okay. Just one moment, please. Okay. Just one
19 moment.

20 So, again, is it possible that this well could
21 have been started below 6 MPa with the new procedure?

22 A So I think that was the question that was asked before,
23 and --

24 Q Yes, it was.

25 A -- and I tried to articulate that it depends on a
26 number of factors, and we would not conclusively be

1 able to say that this well would've initiated
2 circulation under 6 MPa.

3 Q All right. Just some questions -- additional questions
4 regarding the 10-01. So we understand from CNRL's
5 evidence yesterday that CNRL believes the 10-01 had
6 been flowing until the hard stop on January 7th, 2020;
7 is that correct?

8 A Yes. I believe ISH and CNRL agree on that fact.

9 Q And you indicated you believe that ISH was producing
10 that gas; is that correct?

11 A ISH is the operator of the 10-01 well.

12 Q Did CNRL visit the 10-01 well site between March and
13 December 2019 to collect manual downloads of its
14 gauges?

15 A Yes. We will -- we do collect manual downloads of the
16 gauges periodically. So we would have staff on-site,
17 yes.

18 Q Okay. Just one moment, please.

19 MS. BERG: So, Madam Chair, I believe
20 that those are all my questions, subject to any
21 follow-up from the response that CNRL will be working
22 on during the break. So thank you to the CNRL panel
23 for answering my questions.

24 THE CHAIR: Okay. That's good timing.

25 So why don't we take a break now, and if we come
26 back at 10:30, Canadian Natural, will that give you the

1 time you need to sort out your response about the
2 apparent flip on that table?

3 MS. BERG: And, actually, sorry, I was
4 just advised by my client that I will have one
5 additional question, which I will ask after the break.

6 THE CHAIR: That's okay.

7 MS. BERG: Again, it -- it should be,
8 like -- yeah. It'll be minimal time, and so --

9 THE CHAIR: Okay.

10 MS. BERG: Yes.

11 THE CHAIR: So does ten -- if we go to
12 10:30, Mr. Iannattone, will that give your panel enough
13 time to -- or I guess, Mr. Craig, you're the one who's
14 got to find it.

15 MR. CRAIG: Potentially. I guess the
16 question is: Is this an undertaking and we can have
17 some other support staff dig through it, or is this
18 something that we need to do on our own? I guess
19 that's the little bit of question in the back of my
20 mind.

21 THE CHAIR: Well, Ms. Berg?

22 MS. BERG: Well, I -- I would ask that
23 you attempt to -- to address it through, you know, the
24 normal convening, but if it is something that obviously
25 cannot be -- be done with the team that you have in
26 place, then, yes, we'll take it by way of undertaking.

1 So if you could just advise after the break, that would
2 be appreciated.

3 MR. CRAIG: Sounds good

4 MR. IANNATTONE: Okay. Sounds good.

5 THE CHAIR: Okay. So we're adjourned
6 until 10:30. Thank you.

7 (ADJOURNMENT)

8 THE CHAIR: So it looks to me like we have
9 everyone present. Are we ready to proceed?

10 MS. BERG: I'm ready.

11 THE CHAIR: Okay.

12 MR. IANNATTONE: Madam Chair, we would like to
13 ask for an undertaking, but I have a question first.

14 We were considering an undertaking and bringing
15 the information in tomorrow morning, but if we do that,
16 is the panel -- will the panel remain under oath until
17 then?

18 THE CHAIR: On undertaking -- on an
19 undertaking -- so you mean under oath? Do you mean so
20 that they can't talk to anybody else, or are they still
21 sworn?

22 MR. IANNATTONE: But we can't talk with our
23 counsel?

24 THE CHAIR: No. On an undertaking, you
25 could do what you need to do to answer the question;
26 although, you shouldn't be asking for legal advice from

1 the counsel. I don't know why your legal counsel would
2 need to help you with that question.

3 MR. IANNATONE: Well, they don't. It's just
4 that if we're -- if we're going to be presenting
5 closing statements tomorrow, I need to participate in
6 that process.

7 THE CHAIR: Absolutely. You can
8 participate in that process, which then raises my
9 second concern, which is since tomorrow is our day for
10 final argument, it's entirely possible that Ms. Berg
11 wants to see the response to the undertaking before she
12 finalizes final arguments, so tomorrow morning is --
13 Oh, yes, Ms. Jamieson?

14 MS. JAMIESON: Yeah. If I could assist, I
15 actually think that the response to the undertaking
16 could be put together this afternoon and filed by the
17 end of the day and that, therefore, we would get it on
18 the record for Ms. Berg's benefit for the closing
19 argument, and it would allow us to move forward with --
20 I do need to be able to work with the Canadian Natural
21 witnesses to prepare our closing remarks.

22 THE CHAIR: Okay. So, Ms. Berg, would
23 that work for you?

24 MS. BERG: Yeah. That's -- that's fine.

25 THE CHAIR: So let's proceed on that
26 basis.

1 But also, Ms. Berg, we need, then, for the record
2 the -- the specific wording for the undertaking that
3 you want the panel to have, Ms. Berg. So can you do
4 that for us.

5 MS. BERG: I can. And so the question,
6 it related to Tab 48.02 -- sorry, not tab, but
7 Exhibit 48.02, Tab 15B. Why are the injector depths
8 listed on average 495 metres TBD and producers 490
9 metres TBD? And then, following that, there was a
10 question: The geomechanical model runs with the
11 assumption that the injectors are at a depth of 477
12 metres, based on Exhibit 88.02, PDF 43. What will be
13 the depth of the injectors? And so that, I think,
14 would cover all of the questions arising from -- from
15 that line.

16 THE CHAIR: Okay. So, Mr. Iannattone
17 or -- is that sufficiently clear for you to --

18 MR. IANNATONE: Yes, it is. Thank you.

19 THE CHAIR: Okay. Thank you.

20 Q MS. BERG: Okay.

21 And so I just had, as I noted before the break,
22 one additional question that I -- or a line of
23 questions that I wanted to ask. So if we could go to
24 Exhibit 88.02, PDF page 20.

25 Okay. So it's fair to say -- it's my
26 understanding that CNRL has confidence in RST logs

1 coupled with interpreted steam-chamber temperatures and
2 that they're indicative of steam-chamber development;
3 is that fair?

4 MR. IANNATONE: Jason Lavigne, please.

5 A MR. LAVIGNE: I'm sorry, Counsel. Could you
6 please repeat. Do we have confidence in the RST logs?
7 Was that the question?

8 Q Effectively, yes, that -- is it fair to say that CNRL
9 has confidence in RST logs coupled with interpreted
10 steam temperatures and that these are indicative of
11 steam-chamber development?

12 A I think that's fair, yes.

13 Q Okay. So my question is this: How can CNRL run RST
14 logs if CNRL does not drill an observation well in
15 KN06?

16 A The purpose of the inclusion of this RST log was to
17 demonstrate the confidence that we have and using this
18 as an analogue from a mature producing property.
19 This -- this is -- this particular example in Tab 21 is
20 from Jackfish, which occurs in the same reservoir
21 fairway with the same -- very similar reservoir and the
22 exact same confining strata. So we use this data as an
23 analogue for -- for the KN06 pad. We believe that the
24 results obtained in this RST log are representative of
25 what we would expect at KN06, and, therefore, we don't
26 feel it's necessary to do this on all of our

1 developments. We take this data where we can. It's
2 one of the benefits that Canadian Natural is able to
3 leverage its large database of SAGD projects, and so we
4 feel that this is representative, and because the
5 reservoirs are so similar, this isn't required on KN06.

6 Q All right. So given that -- I take it the answer is
7 that there won't be RST logs for KN06, and there isn't
8 an intent to drill an observation well for KN06. What
9 will be the monitoring techniques used by CNRL to
10 monitor steam-chamber vertical growth in a highly
11 heterogenous -- heterogenous -- I should know this word
12 by now -- environment such as KN06?

13 A Our intent around observation wells is they're --
14 they're drilled later on if there's a concern about
15 recovery or -- or chamber development, and -- and so
16 it's -- it's evaluated as we feel necessary.

17 Q Okay. Just one moment, please. Just one moment.

18 So, Mr. Lavigne, I just want to clarify that we
19 understood your recent response. You indicated that
20 there will be an observation well drilled later?

21 A No, I didn't. It is -- it is -- some operators have
22 used post-steam core to show that after, but I don't
23 think you can drill an obs well into an active steam
24 chamber.

25 Q Okay. All right. We just wanted to --

26 A Sure.

1 Q -- clarify that.

2 A I apologize for any confusion.

3 Q Okay. All right. I believe that those are my
4 questions, and, again, thank you to the CNRL panel for
5 responses.

6 THE CHAIR: Thank you, Ms. Berg.

7 So now I believe we have Ms. Hall up with
8 questions from AER staff.

9 MS. HALL: That is correct. Thank you,
10 Madam Chair.

11 Alberta Energy Regulator Staff Questions Canadian
12 Natural Resources Limited

13 Q MS. HALL: So my first set of questions,
14 I believe, is for Mr. Sverdahl -- I hope I'm
15 pronouncing your name correctly, sir -- on the seismic
16 evidence that you provided yesterday. So Ms. Berg had
17 asked you some questions about detailed seismic
18 analyses that might provide insight into faulting and
19 fracturing of the containment strata over KN06.

20 Specifically, for the record, this is at the top
21 of page 279 of the transcript from October 14th, 2020.
22 You were asked whether Canadian Natural made use of
23 pre-stack amplitude versus azimuth or velocity versus
24 azimuth analyses to look for subtle directional
25 amplitude and velocity variations within the confining
26 strata. You responded that Canadian Natural did not

1 perform these analyses.

2 So my question is: Do you agree that in some
3 cases, such analyses can be used to characterize fault
4 and fracture density and orientation?

5 A MR. SVERDAHL: Thanks for the question.

6 VVAz or AVAz are techniques that have been
7 potentially used to -- to understand fractures in some
8 areas. However, as recently as, I'd say, February
9 2020, there's -- there was an article in the Leading
10 Edge, which is the SEG, Society of Exploration
11 Geophysicists, journal discussing -- discussing these
12 techniques. The paper was called "A Skeptic's View of
13 the VVAz and AVAz." The point I'm making here is these
14 kind of techniques are, I'd say, at the bleeding edge,
15 if not experimental, and -- and even in the academic
16 world, there is questioning on the validity on these
17 techniques.

18 So, no, Canadian Natural has not used these
19 techniques on this project, and we don't believe
20 that -- the current state of the industry knowledge
21 that they're applicable to use here.

22 Q Okay. Thank you.

23 A You're welcome.

24 Q So my next set of questions is on -- or are on
25 geomechanical modelling, specifically, I believe,
26 Canadian Natural's internal geomechanical modelling.

1 So I think these would be for Mr. Walters.

2 A MR. WALTERS: That's correct.

3 Q Okay. Thank you, sir.

4 So Canadian Natural provides a summary of its
5 geomechanical modelling and analyses in Exhibit 30.02
6 at page -- PDF pages 36 to 38 and a report summarizing
7 the workflow and major results of its geomechanical
8 study at Tab 42 of that same exhibit, PDF pages 158 to
9 178. At PDF page 25, paragraph 106, Canadian Natural
10 states that: (as read)

11 It is Canadian Natural's view that faulting
12 is not a risk to the containment barrier at
13 the KN06 box. Furthermore, the risk to the
14 containment barrier from natural fractures is
15 negligible due to the very low natural
16 fracture density.

17 Then at PDF page 29, paragraph 133, Canadian Natural
18 states that: (as read)

19 For the KN06 containment barrier, the
20 geomechanical modelling is independent of the
21 natural fracture distribution and intensity.
22 This is because the geomechanical modelling
23 assumes the material has a low strength
24 appropriate for the presence of pre-existing
25 discontinuities.

26 So my question, sir, is whether you can clarify if

1 Canadian Natural's geomechanical modelling has
2 accounted for natural fractures or faults.

3 A Sure. Thank you for the question.

4 So the modelling that I've done from an
5 integrity-of-the-confinement-strata point of view
6 requires strength properties for that confinement
7 strata, and as is typical for caprock integrity
8 analyses, the material properties assumed for those
9 zones is assumed to be a post peak or a weakened
10 strength that accounts for the potential of having
11 natural fractures present. So it is a conservative
12 assumption from a strength point of view.

13 Now, no faults were included in the model, and
14 that was because no evidence was present to define
15 those faults, from CNRL's point of view, and the same
16 GEOSIM software and modelling approach has been used
17 for other several other SAGD operations and operators
18 that I've worked with. And in those cases, when faults
19 have been included, it's because the seismic team can
20 clearly see faults present on their seismic cross
21 sections, which, for KN06, is not the case.

22 Q Okay. Thank you.

23 My next question is with respect to Exhibit 30.02,
24 PDF page 34 at paragraph 154. Canadian Natural states
25 that: (as read)

26 It is commonly accepted that muds have higher

1 horizontal in situ stresses than sands due to
2 higher Poisson's ratios.

3 However, based on Tab 42 of Exhibit 30.02, PDF
4 page 168, Table 2, it appears Canadian Natural's
5 geomechanics modelling of start-up at KN06 used the
6 same Poisson's ratios for the mudstone layers and the
7 sandstone layers. Can you clarify Canadian Natural's
8 view on the difference, if any, between the Poisson's
9 ratio of mudstones and sandstones?

10 A Sure. So just to clarify that table presented on
11 page 168, the Poisson's ratio that was used there is
12 the same for both the sand units and the mudstone units
13 and so, really, from -- for all of the McMurray.
14 And -- however, the -- what was discussed earlier in
15 terms of the Poisson's ratio having an impact on the
16 initial stress state is a stress initialization issue.
17 So if materials have certain properties and,
18 specifically, the Poisson's ratio, and those materials
19 are laid down and a -- a load due to gravity is applied
20 to them, then shales, which typically have a higher
21 Poisson's ratio than sands in that gravity-loading
22 analysis, will generate higher horizontal stresses than
23 the sand.

24 These properties that are presented in the table
25 were more appropriate for the dynamic modelling of the
26 process, and that's why there was no variation of

1 Poisson's ratio for that table input.

2 Q Okay. Thank you.

3 A Yeah.

4 Q Sorry. Did you have something more there, sir?

5 A No. That's good. Thank you.

6 Q Okay. So just a moment, please.

7 So can you then explain how changing the Poisson's
8 ratio in the model would change the prediction
9 results -- could change the prediction results?

10 A So in the modelling here that was performed, you know,
11 all of the inputs were chosen to give a conservative
12 estimate, and the model presented in the report and our
13 submission was really focused on the problem of
14 initiating and growing a fracture during the start-up
15 period.

16 So, in general, the Poisson's ratio has a minor
17 impact on fracture growth. The stress gradient which,
18 you know, as I discussed previously, can be linked to
19 Poisson's ratio, has a larger impact on fracture growth
20 because that's one of the fracture-containment
21 mechanisms. So even though in the model here, I
22 assumed the cost-to-Poisson's ratio, the fracture --
23 the higher stress gradient in the mudstone layer was
24 used as an initial stress state and so was present and,
25 therefore, included as a stress-containment mechanism.
26 But, in general, for the fracture-growth predictions

1 and fracture initiation, the Poisson's ratio has a very
2 minor impact.

3 Q Okay. Thank you.

4 Okay. I now have a question about Exhibit 30.02,
5 PDF page 34, paragraph 155. Here, Canadian Natural
6 states that: (as read)

7 The stress contrast between the McMurray post
8 B2 reservoir and mid-B1 mudstone provides an
9 impediment as it will constrain hydraulic
10 fracture growth. The hydrostatic head of
11 water between the mid-B1 mudstone and the
12 shallowest KN06 well is 0.2 MPa.

13 Can you explain how this hydrostatic head was
14 calculated?

15 MR. THOMSEN: Yes.

16 And, Mr. Walters, if you're okay if I could jump
17 in here?

18 MR. WALTERS: Absolutely.

19 Q Thank you, Mr. Thomsen.

20 A MR. THOMSEN: So the hydrostatic head was
21 calculated based off a true vertical depth difference
22 between the shallowest wellbore and the base of the
23 mid-B1 mudstone above that point.

24 Q Okay.

25 A So, specifically -- I think it's on the next page
26 here -- we have the shallowest wellbore at 477 metres,

1 true vertical depth from ground level. And on this
2 equation up in paragraph 154, it's 455 metres. So
3 that's a difference of 22 metres, and hydrostatic head
4 of water being 10 kPa per metre, that works out to
5 0.2 MPa.

6 Q Okay. Thank you.

7 Can you clarify the -- the temperature of the --
8 the injected fluid that was assumed for this
9 calculation?

10 A Right. So steam is being injected at a low rate, and
11 between the wellbore heat losses and heat losses within
12 the liner as well as significant heat losses within
13 the -- the formation for -- I mean, if we consider a
14 hydraulic fracture having an aperture of sub
15 1 centimetre, there's a lot of surface area for heat
16 transfer within the formation. So the -- at the
17 wellhead we're injecting steam at low rates, and the --
18 any steam vapour is going to condense and cool down, so
19 we'd have warm or cold water in the reservoir.

20 Q Okay. Just a moment, sir.

21 Okay. Assuming the -- the temperature of the
22 injected fluid remained high, was still
23 high-temperature steam, would that affect the
24 calculation of hydraulic -- hydraulic head?

25 A If there was a steam chamber developed and so we had a
26 portion of the reservoir at saturated conditions with

1 steam-vapour saturation, then the hydrostatic head
2 would use a density of that steam vapour, and that
3 would be less than 10 kPa per metre. However --

4 MS. TURNER: Sorry. May I interrupt.
5 Sorry. I just have to interrupt. I just want to make
6 sure Ms. Jamieson is back in the call. Thank you.

7 A MR. THOMSEN: However, for initiating steam
8 circulation, we -- we do not have a steam chamber that
9 has developed. The purpose of the steam circulation is
10 to heat up the liquid between the injector and producer
11 such that we could start to have a fluid flow with
12 relatively small pressure differences through the
13 porous media. So there is no steam chamber developed,
14 and during circulation initiation, this is a
15 liquid-filled system.

16 Q MS. HALL: Okay. Thank you.

17 And so I believe my last question is for
18 Mr. Boone.

19 DR. BOONE: Yes. Thanks.

20 Q Hi, sir.

21 In Section 8 of your report, which is at
22 Exhibit 45, PDF page 197 through 199 -- I don't think
23 that's quite correct, but you assess the risk of
24 induced fractures during start-up breaching the
25 containment barriers at KN06. On PDF page 197, in the
26 first paragraph of that section, you state you

1 evaluated that risk using the risk matrix provided by
2 APEGA, which appears on PDF page 198 or, in larger
3 form, on PDF page 188.

4 In summarizing the results of your risk assessment
5 on PDF page 199, you state that: (as read)

6 Based on review of previous Kirby North SAGD
7 well start-ups, it is conservatively
8 estimated that there is less than a
9 10 percent likelihood that a fracture which
10 could potentially impair a Wabiskaw gas well
11 will be induced at one or more of the KN06
12 SAGD wells during start-up. [And that] After
13 consideration of the stress and leak-off
14 barriers to vertical fracture propagation
15 between the SAGD wells and the Wabiskaw gas
16 zones, it has been assessed that the
17 likelihood of a fracture which could
18 potentially impair a gas well propagating
19 into the Wabiskaw gas zone is less than
20 0.1 percent, and given the limited dimensions
21 of any single fracture, the likelihood that a
22 fracture actually does impair a gas well is
23 less than 0.01 percent.

24 My question, sir -- and I -- I know that you did go
25 through this to some extent yesterday, but could you
26 provide more detail on how these quantitative

1 probability values were calculated.

2 A Sure. So the -- the quantitative portion of it is
3 the -- or at least the initial quantitative portion is
4 that -- assume -- it was assumed -- identified one
5 fracture event out of 96 wells that previously started
6 up at KN06. So that was 1 out of 96.

7 As I read the questions put forward by the AER,
8 they wanted us to look at the KN06 pad as a whole. So
9 I -- I said, Okay. Any one out of -- any one of the
10 18 wells could fracture. And so 18 over 96 gives you
11 approximately a 20 percent chance, okay, assuming 1 out
12 of 96 times 18; right?

13 Now, however, the volume that went into that
14 fracture in the one identified case was really small.
15 It was only 1.8 cubic metres. In order for a fracture
16 to propagate up through the overburden -- or through
17 the confining strata and impact a Wabiskaw gas well, it
18 would likely have to be orders of magnitude in volume.

19 So I conservatively made the -- the assumption,
20 then, that there was a 10 percent chance of such a
21 fracture actually occurring. Okay? So -- so that's
22 somewhat less than the 20 percent but reflecting the
23 fact that it's a much larger fracture.

24 The -- the likelihood that -- that the stress
25 containment will act to impair -- impair or contain a
26 fracture, I assume that it would be 90 percent

1 effective, and that moves you down one category in
2 terms of the risk assessment.

3 And that's based on my personal experience and
4 looking at the fact that there is a significant stress
5 contrast in -- in all of the available tests in the
6 area. And so there's high confidence there is a stress
7 contrast there.

8 The leak-off, similarly, there's clearly several
9 formations there where fluid leak-off could occur. And
10 so I made the -- the conclusion, I guess, that -- that
11 that leak-off would also be 90 percent effective in
12 reducing -- or in containment of a fracture. And so
13 that moves you down one more category.

14 And then, lastly, if you're looking at geometry --
15 so -- and I think this could -- this may even be a 1 in
16 100 hundred or 99 percent chance -- is that fractures
17 really are local, and so a fracture that goes up from
18 the -- let's say, one of the injectors or producers,
19 its -- its imprint or area that it might impact above
20 the KN06 pad might be something like 10 metres wide by
21 50 metres long depending on the dimension of the
22 fracture.

23 So if you have a gas well, it would really need to
24 be in that box, that 10-metre-by-50-metre box, and then
25 you can look at that box relative to the complete size
26 of the KN06 box there or at least the KN06 pad area,

1 and -- and it's probably -- that's about 1 percent of
2 the box area -- or of the KN06 pad area. But I -- I
3 assumed that it only reduced the risk by a factor of --
4 of 10 percent.

5 So in the end, that's how I get to the -- the
6 final risk percentage.

7 Q Okay. Thank you, sir. Those are all of my questions
8 for you.

9 And now I have some questions on -- I'm not sure
10 if these will be for Mr. Thomsen or Mr. Craig, so I
11 will ask the question, and, Mr. Iannattone, you can
12 determine who is most appropriate to answer the
13 question.

14 So there was some discussion on this point earlier
15 this morning, but at Exhibit 48.02, PDF page 14,
16 just -- it's at the 'B' point there. We've seen this
17 again already this morning. Canadian Natural concludes
18 that pressure and temperature data at the 10-01 well
19 does not indicate that SAGD operations of the McMurray
20 formation are -- or does not indicate any correlation
21 between the 10-01 well and SAGD operations of the
22 MCMURRAY -- hydraulic formation, which confirms
23 effective barrier -- ineffective barrier between the
24 Wabiskaw B gas zone and the McMurray formation.

25 So my question is: If communication did exist
26 between the Kirby Upper Mannville II pool and the

1 McMurray -- understanding that Canadian Natural takes
2 the view that it is not currently in communication, but
3 if there were communication, what impact would this
4 have on SAGD operations?

5 MR. IANNATTONE: Mr. Thomsen.

6 A MR. THOMSEN: Okay. Thank you for the
7 question.

8 So what impact would it have on the SAGD
9 operation? So if there -- if there was communication
10 between the two, some of the injected fluids would be
11 flowing in some manner into that -- into the
12 gas-over-bitumen pool. So we -- we would have some
13 unexplained loss of fluids with injection. There's
14 likely some insufficiency associated with that, so that
15 could -- inefficiency would show up with a C model
16 ratio.

17 And as far as a water balance -- so I -- I was
18 talking about the unexplained losses would be -- one
19 thing that we do is we monitor differences between
20 steam injection and water production. And our goal in
21 Kirby North is a balanced operation, so we would expect
22 a water-to-steam ratio around 0.98 to 1. So it's --
23 it's fairly predictable.

24 So am I answering your question, or have I
25 answered your question?

26 Q I believe so.

1 A Sorry. One other point. Let's say there was
2 containment, and then there was a point where there no
3 longer was containment, a flow of some manner started
4 to go into the gas pool, that would also show up with
5 our bottomhole pressures. And so with relatively
6 constant steam injection, we would start to have
7 decreasing bottomhole pressures. And so either -- and
8 with the bottom water, I mean, our objective, our
9 operating philosophy, is to have a steam-chamber
10 pressure that's essentially balanced with the McMurray
11 bottom water. Any decreases in the bottomhole
12 pressure, our natural response would be to increase
13 steam rates. So we would see an inflexion with steam
14 injection into one or several wells.

15 Q Okay. Thank you.

16 So assuming Canadian Natural observed such impacts
17 to its SAGD operations, what could Canadian Natural do
18 to mitigate those impacts -- what, if anything, could
19 Canadian Natural do to mitigate those impacts that
20 would also mitigate any impacts to the GOB?

21 A Okay. So I think there's at least two parts to this
22 answer. The -- the first aspect is ISH has raised
23 concerns multiple times about operating with thermal
24 pressures above 6 MPa and up to 7 MPa, and as we've
25 outlined in our IR responses to the AER, during this
26 short period of time during initiating circulation, we

1 would simply shut down steam for the well that we're
2 trying to initiate steam circulation with.

3 So the -- the proactive approach is: If this is
4 occurring during attempting to initiate steam
5 circulation, we would shut down steam, and then we
6 would assess and -- and evaluate what's happening.

7 The -- the second issue or the potential risk that
8 ISH has raised is flowing up the 10-01 wellbore, and
9 so, again, we have -- we have downhole pressure and
10 temperature monitoring in the 10-01 well, and so if
11 this was occurring, we would be able to -- to see it
12 with the downhole measurements. And so as far as
13 mitigation, I mean, we would -- we would need to
14 assess, sort out whatever the requirements are as far
15 as a partner -- our plan with ISH and then ultimately
16 affix the wellbore conduit in the 10-01 well.

17 Q Okay. Thank you, sir.

18 So I believe I am onto my final question. In --
19 in its hearing submission at Exhibit 29.01, PDF page 8,
20 paragraph 7, ISH stated that: (as read)

21 In the event of a breach of the barrier or
22 top seal of the bitumen that results in steam
23 entering the GOB zone, the gas zone will
24 sour.

25 Yesterday Ms. Giry clarified that this would happen
26 through aquathermolysis. So my question is: If there

1 were communication between the Wabiskaw B and to the
2 McMurray formation, could repressurization of the
3 Wabiskaw B prevent souring of the GOB?

4 MR. IANNATTONE: Okay. I don't have any
5 volunteers. Yeah. Can we take a breakout room on this
6 one, please.

7 MS. HALL: Ms. Turner?

8 THE CHAIR: How long do you think you'll
9 need?

10 MR. IANNATTONE: Five minutes.

11 THE CHAIR: Yeah. Sure. Ms. Turner, can
12 you invite the Canadian Natural panel to join a
13 breakout room?

14 MS. TURNER: You should be able to join
15 now.

16 THE CHAIR: Okay. Thank you.

17 MS. TURNER: It's just the first time, I
18 think.

19 Madam Chair, they should -- the witnesses should
20 all be back in the main room now.

21 THE CHAIR: Yeah. They appear to be.

22 So, Mr. Iannattone, do you have a -- oh,
23 Mr. Thomsen is going to answer.

24 MR. THOMSEN: Yes. Thank you.

25 A MR. THOMSEN: Could the question please be
26 repeated.

1 Q MS. HALL: Sure. If there were
2 communication between the Wabiskaw B and the McMurray
3 formation, could repressurization of the Wabiskaw B
4 prevent souring of the GOB?

5 A Thank you.

6 So in order to answer this, I'm going to put
7 hydraulic fracturing in the parking lot. My
8 understanding of the question is that it's not related
9 to a question of hydraulic fracturing. Let me know if
10 I'm misunderstanding that.

11 So if there were communication, there's -- there's
12 two aspects to this answer. The -- the first one, that
13 is, as far as repressurizing the gas over bitumen, I
14 would say that's independent of -- of vertical steam
15 chamber development, and so the confinement strata is
16 an effective barrier. I think we've clearly shown
17 that. But the -- we need to have an effective barrier
18 to vertical chamber development irregardless of the
19 pressure in the gas over bitumen. So that's Part A.

20 Part B, hypothetically, if there is some open
21 conduit in between the McMurray formation, the post B2
22 reservoir and the Wabiskaw gas over bitumen, then the
23 pressure difference between the two does matter. So if
24 the GOB was repressurized -- and currently there is an
25 upward pressure gradient, but if it was repressurized,
26 theoretically, this could be a downward pressure

1 gradient on it between the gas over bitumen and the
2 McMurray formation, and this would prevent any
3 potential reservoir fluids or steam from flowing
4 upwards through some hypothetical conduit -- open
5 conduit into the GOB.

6 That being said, the -- the volume of gas to
7 repressurize the GOB is significant; it's large, to the
8 point that we'd have to re-evaluate the economic
9 viability of the KN06 development.

10 Q Okay. I think those -- that answers all my questions,
11 sir.

12 And I believe that was the last of my questions
13 for this witness panel. So thank you very much.

14 MS. HALL: Those are my questions, Madam
15 Chair.

16 THE CHAIR: Thank you, Ms. Hall.

17 So through the magic of alternate electronic
18 communications, I know that Commissioner McKinnon's
19 question or questions were answered.

20 So, Commissioner Zaitlin, do you have any
21 questions for the panel?

22 DR. ZAITLIN: Yes, I do, Madam Chair. Thank
23 you.

24 Alberta Energy Regulator Panel Questions Canadian
25 Natural Resources Limited

26 Q DR. ZAITLIN: The first question would be

1 for Mr. Sverdahl or Mr. Lavigne.

2 One of the potential risks being discussed is the
3 communication pathways of conduits for fluids via
4 faults or fracturing. Has CNRL conducted any
5 semiregional studies of faulting patterns in the Kirby
6 or the greater Kirby area utilizing other techniques?
7 Examples would be, like, high-resolution aeromagnetic
8 or HRAM to map out regional faulting geometries. And,
9 if so, what were the results?

10 MR. LAVIGNE: I was wondering if
11 Mr. Sverdahl was going to answer that.

12 A MR. SVERDAHL: We -- I think we have some
13 aeromagnetic data within the area that -- that we do
14 look at from -- from time to time here. I don't think
15 we've conducted a -- a regional fault study, per se.
16 However, we have noted faulting in -- in areas within
17 our -- our thermal assets. Primrose is an example. We
18 also have properties north -- north of Kirby North,
19 Gregoire Lake, which is adjacent to Long Lake. We note
20 that faulting is happening up there, significant
21 faulting, likely due to -- to salt collapse.

22 We do use regional publications. We included a
23 figure from the AER/AGS Study 95 on -- on salt
24 collapse. So we do incorporate that kind of work into
25 our interpretations. However, we just -- we haven't
26 seen any -- any issues of faulting over our operating

1 assets.

2 Q And so nothing in the immediate KN06 drainage box area?

3 A Nothing in the immediate area. I think we do notice on
4 aeromag that there is some deep-seated anomalies to the
5 north potentially, Snowbird -- Snowbird Tectonic Zone,
6 but it does not appear to be at all an impact on -- on
7 our -- our operating asset at KN06.

8 Q Thank you very much.

9 A Thank you.

10 Q My second question would be directed to Dr. Boone.

11 Does the orientation of the SAGD well pairs -- are
12 they dependent on the regional stress regime, or is it
13 solely a spacing issue associated with the bitumen
14 distribution?

15 A DR. BOONE: Sorry. Can you repeat that
16 question, please.

17 Q Sure.

18 The orientation of the SAGD well pairs, are
19 they -- have any dependency on the regional stress
20 regime in the area, or is it because of other factors
21 like spacing issues?

22 A I'm maybe not the best person --

23 Q Okay.

24 A -- because I wasn't involved in the KN06 orientation.
25 But just in general, I'm going to say geology rules,
26 and you put your wells in the best reservoir at the

1 orientation that allows you to recover the most
2 resource, and -- and stress generally is not a
3 consideration --

4 Q Is --

5 A -- but it --

6 Q Sorry. Go ahead.

7 A But if one of the other CNRL folks wants to add to
8 that, they can.

9 A MR. IANNATTONI: Yeah. I -- I would just say
10 that that answer is correct. We're orienting the
11 wellbores to maximize the recovery, and we're not
12 considering stress.

13 Q Is stress a consideration on the fracability of the
14 sealing units?

15 A DR. BOONE: I can answer that.
16 Definitely. Yes. Stress -- I think, as Mr. Thomsen
17 said previously, stress really is the control on the
18 fractures. The -- the material strength in resistance
19 to fracturing is called "fracture toughness," but for
20 rock, you can basically assume it's close to zero.

21 Q Is there anything unique about what's happening in the
22 KN06 area?

23 A Not that I have seen.

24 Q Okay. And the last few questions will have to do with
25 Exhibit 88.02, if we can bring that up, please. And
26 it'll be PDF page 10. So I think it would be for

1 Mr. Lavigne.

2 So we've -- we've had a look at this schematic a
3 couple of times, both from CNRL and by ISH, and one of
4 the observations would be, in the formation and timing
5 of the post B2 reservoir and the non-reservoir IHS, is
6 the bounding basal surface, which I'm going to call the
7 "sequence boundary" going forward.

8 So to Mr. Lavigne, is it possible for the sequence
9 boundaries to have a sufficient reservoir quality to be
10 a potential pathway for the migration of fluids away
11 from the steam chamber in the KN06 box?

12 A MR. LAVIGNE: Just for clarification, you
13 mean laterally into what's depicted as the McMurray C
14 in those diagrams?

15 Q The sequence boundary would be from the base, along the
16 side, and up into the interfluve. And can the
17 interfluve then be intersected with another pathway
18 that may cause a torturous path of migration?

19 A Okay. I'll take a -- take a stab at this. The --
20 first of all, the -- the -- the basal unconformity cuts
21 into the McMurray C. There are sands in the McMurray C
22 that are lateral to that, but outside of the basal
23 unconformity in the interfluve regions, the B2 mud is
24 preserved, and so it -- it provides sealing capacity
25 outside of the -- of the unconformity.

26 The -- there are also -- there are also within the

1 post B2 valley -- as I alluded to under
2 cross-examination yesterday afternoon, this cartoon is
3 a -- is a very simple depiction of the internal
4 architecture of the post B2 fill, and based on 3D
5 seismic analysis of nearby reservoirs in the same
6 valley fill, we do observe that there are multiple
7 terraces within the post B2 fill, and when you examine
8 the KN06 drainage box, it -- it does not occupy the
9 entire incised valley fill of the -- of what's depicted
10 here as the post B2 reservoir. And so there are
11 non-reservoir older terraces that are -- that are
12 preserved within the valley fill, and they would
13 provide lateral containment of the reservoir.

14 Now, when we -- when we look at the plan
15 development, our well spacing is -- is 60 metres
16 between -- between wells, and what we -- what we see
17 over the -- when the -- when the pad reaches its -- its
18 economic limit, the steam chambers have coalesced, and
19 so what we look -- and that's within good reservoir,
20 high-permeability reservoir. When we consider the
21 effect of the lateral migration of steam outside of the
22 main reservoir fairway, which the KN06 box is placed
23 in, we would expect much slower lateral development of
24 the -- of the reservoirs.

25 And so even if we allowed for -- a triple the well
26 spacing, say 180 metres, that's one of the reasons why

1 when we -- when we showed our mapping area, the mapping
2 extent is much bigger than the box, and in the -- in
3 the north-south direction, we -- we mapped 380 metres.

4 So we think that it's -- it's -- that's a very
5 conservative -- you know, it's -- we've -- we've looked
6 well beyond reasonable reservoir. We've looked well
7 beyond the lateral extent of reservoirs, and the -- and
8 the KN06 box is placed in such a way that it's bounded
9 laterally by non-reservoir facies, and so we think
10 that -- we think that the -- the mapping extent
11 laterally is -- is very conservative and -- and much
12 larger than, say, three times the well spacing. So
13 we -- we think that the steam chamber does not have any
14 lateral ability to -- to leave the post B2 valley and
15 pass through the unconformity.

16 Overtop of the box, the -- the post
17 B2 non-reservoir facies, although there are thickness
18 variations within it and, as we discussed at length
19 yesterday, there are variations in the sand content of
20 the IHS units that cap the valley fill; however -- and
21 I -- I would add that on 3D seismic, we actually see
22 the abandonment plug of the -- of the upper tier, which
23 is off into the north of the KN06 pad. And so we -- we
24 have an idea about the size of the potential point bar
25 deposits that -- that are on top and cap the reservoir,
26 and we've mapped a continuous muddy to mixed IHS facies

1 across the entire post B2 valley fill. And so the
2 upper tier also appears to be sealed.

3 And so I'm not sure if I've gotten exactly to your
4 question, Dr. Zaitlin, but I -- I believe that we've
5 tried to demonstrate that laterally, away from the
6 unconformity, there is a seal. Where the post B2
7 reservoir unit may come into contact with the hummocky
8 cross-stratified sands of the upper B2 regional
9 sequence, the permeability differences are -- are --
10 are quite profound, and we don't feel that there's the
11 potential for lateral leakage of the steam chamber that
12 way.

13 Q Thank you. Thank you very much for that.

14 Can we just turn to PDF page 14 now. So if I
15 understand you correctly, you have the valley and
16 terrace geometries laterally to the main system, and
17 then within the system, within your post B2 reservoir,
18 like in your type well here at 11-01, you have a
19 15-metre-thick sand package broken up to three 5-metre,
20 roughly, thick sands, and on the GC-MS plot that you've
21 showed us, that you've circled, there is a potential
22 barrier between the top and the middle of those two
23 sands; correct?

24 A Yes.

25 Q That's right.

26 So each one of those are individual channels or

1 point-bar-type sequences within the greater post B2
2 reservoir. Did you just mention that you were able to
3 map those out by utilizing 3D so that you have their
4 distribution?

5 A I would say not in KN06 but within -- within the -- the
6 same valley system. So one of -- and I believe you
7 touched on this yesterday in your questioning. Are
8 these interpreted to be single 40-metre-thick incised
9 valley fills, or is there more stratigraphy? And that
10 would -- that would speak to potential barriers within
11 the system, as you mentioned, you know, perhaps a
12 series of, say, 5-metre-thick channel deposits.

13 When -- when Canadian Natural first evaluated its
14 Kirby South development in -- in the same architecture
15 valley fill, it was assumed that all of the sand within
16 the valley fill was -- was part of that. And it was
17 difficult, perhaps, to pit the base of the incision to
18 actually identify the unconformity -- the basal
19 unconformity, and often at Kirby South, for example, it
20 was a sand-on-sand contact, maybe with a breccia, maybe
21 not. So there was a little bit of uncertainty picking
22 that.

23 However -- and so we -- we learned by examining
24 the 3D seismic the -- the sort potential for terrace
25 architecture within the valley fill, and so then we
26 take it to north to Kirby North and specifically KN06,

1 there similarly is the potential to misidentify the
2 unconformity if it happens to sit on McMurray C sands.

3 But in the case of Kirby North in KN06, the bottom
4 water is higher in this area compared to Kirby South,
5 and that effectively pushes you up out of the
6 complicated architecture at the bottom.

7 In -- one -- one comment that was raised yesterday
8 is that these are -- these are fairly narrow incised
9 valleys on the order of, you know, maybe maximum
10 2 miles wide, and yet they're 40 metres deep, and --
11 and so the -- the proportion of, say, channelized
12 thalweg facies to point bars is out of scale. And so
13 I -- I think in -- in the Kirby North, Pads 1 to 4, I
14 think we actually can sort of see the base of that
15 meander belt, and it's about 15 metres. So the
16 40-metre-deep incised valley is actually subdivided
17 into 25 metres of clean sand, and then the point bar
18 sequence on the top. When we look at the -- the
19 abandonment plugs that we see at the top of the
20 reservoir unit and we do the math on the width-to-depth
21 ratios, we come out with the meander-belt thickness of
22 around 12 metres or so.

23 And so it appears like there's potentially another
24 unconformity within the valley fill sequence, and I
25 believe that that explains some of the GC-MS results
26 where we seem to have multiple barriers even within the

1 post B2 fill. So I think that there's the potential
2 for complexities that we may not be able to resolve
3 in -- in particularly sandy sequences where discrete
4 mud breaks are not -- are not present. And so we
5 really do the GC-MS to evaluate the potential for
6 the -- the compartmentalization of the reservoir.

7 Q Thank you very much.

8 One last question. When you're talking about
9 you're his or your inclined heterolithic stratification
10 associated with the point bars, are we talking about
11 fluvial point bars, estuarine point bars, or, if we
12 have more than one age, both?

13 A Well, that is certainly a hot topic amongst academic
14 circles these days. And, you know, I -- I was a part
15 of the Ichnology Research Group at the University of
16 Alberta, which, you know, initially had interpreted the
17 presence of the brackish-water trace-fossil suite to
18 indicate estuarine conditions.

19 However, many years on with the incorporation of
20 3D seismic from wide areas over the base and in
21 specific areas, I think that we have seen that these
22 incised valley fills, which occur at several different
23 stratigraphic horizons in the upper McMurray, seem to
24 show in the upper portions thalwegs that bounced from
25 wall to wall within the valleys, and I think people
26 like Professor Blum in Kansas would argue that that's a

1 completely fluvial morphology. And I think that we
2 feel -- I tend -- I tend to agree with that, and I
3 think that the most parsimonious interpretation is that
4 these are completely fluvial systems, and in the Lower
5 Cretaceous, the largely cylindrical-dominated suite is
6 happening in purely fluvial settings. Because I don't
7 think the 3D -- or, sorry, the planform morphology of
8 the channels is consistent with any sort of estuarine
9 conditions.

10 Q Thank you very much.

11 DR. ZAITLIN: Madam Chair, that's it for me.

12 THE CHAIR: Thank you.

13 I do have a few questions.

14 Q THE CHAIR: So sticking with the theme of
15 the GC-MS data, if we could pull up Exhibit 30.02,
16 PDF page 18. Okay. Maybe not. Let's try that again.
17 Oh, sorry. Page 109. There was the reference, and
18 then there's the chart.

19 So what I'm looking at -- I'm wanting to
20 understand if I'm reading this correctly, and on the
21 chart, it appears to me that there are no samples taken
22 between the post B2 incision top and the red dashed
23 line immediately below it that falls between 470 and
24 465. Am I reading that correctly? Were there no
25 samples there?

26 A MR. LAVIGNE: Yes. It's a -- it's a

1 mudstone-rich portion, and -- and I don't believe
2 there's significant volume of hydrocarbons able to be
3 recovered from that to do the testing.

4 Q Okay. Thank you. I don't like to assume anything.

5 On the same exhibit, PDF page 31 -- I don't think
6 we need to turn to it, but we can if the person that
7 Mr. Iannattone thinks should answer the question wants
8 to -- there's a reference in paragraph 143 to:
9 (as read)

10 Circulation start-ups with bottomhole
11 pressures between 6 to 7 megapascals allowing
12 for operational efficiencies and smoother
13 central processing facility conditions.

14 And I would just like someone to elaborate on that for
15 me.

16 MR. IANNATONE: Mr. Craig, please.

17 Q THE CHAIR: You're muted, Mr. Craig. We
18 can't hear you.

19 A MR. CRAIG: Sorry about that.

20 What we're -- what happens -- so when we're
21 unloading wells -- when there's lower pressures being
22 used, there are slugs that -- wells will slugs. So
23 they'll have kicks of fluid to surface, kicks of fluid
24 to surface, and then they will not circulate.

25 So as we're unloading those wells, those slugs at
26 surface cause pressure impacts at the plant, the

1 facility, and they have been known to not -- you know,
2 we high-level vessels. Will -- will cause CPF upsets.
3 So that's -- that's what we're discussing there.

4 Q And then I'm -- so -- and I'm thinking back to some
5 questioning earlier this morning. It's possible to
6 start up at 6 megapascals, although in some cases
7 perhaps not easily, but, operationally, it's -- it's
8 preferable to start up at a higher pressure, if that's
9 possible or appropriate in the circumstances?

10 A So I would say we want to efficiently unload the wells
11 as quickly as possible using the lowest pressure
12 possible, and 7 MPa allows us to do that. That gives
13 us the operational flexibility to have the wells unload
14 in one or two or three or less -- or, you know, those
15 amount of, you know, fluid slugs to surface, and if we
16 are forced to limit ourselves to a lower pressure,
17 we'll have these operational inflexibility, or we'll --
18 we'll be assuming those -- that slugging period for a
19 longer time.

20 Q Okay. Thank you.

21 So then in Exhibit 63.01, or -- sorry. It appears
22 in both places, so I've got two different references.
23 The easier one to go to is actually probably
24 Exhibit 2.01 and PDF page 139, and I think it's
25 paragraph 12, although since I don't see paragraph
26 numbers, I don't know how I came up -- came up with a

1 number. Maybe I'll just read what I'm talking about,
2 and if you are concerned about the accuracy of my note,
3 then we can -- I can get us to the right reference.

4 But there was a comment: (as read)
5 To the effect that although the lateral
6 extent of IHS units had been estimated and
7 modelled, operational issues will arise due
8 to the uncertainty with the effective
9 vertical and horizontal permeability
10 encountered.

11 And then there was a suggestion that some further
12 modelling might be necessary or appropriate.

13 So, again, Mr. Iannattone, I'll let you tell me
14 who is the appropriate person to respond, but can you
15 just elaborate on that for me in the context of whether
16 that's simply related to steam-chamber development or
17 something more. Again, I don't want to assume.

18 MR. IANNATTONE: I think this is going quite a
19 ways back here. I think we'd like to have a breakout
20 on this one. Is that possible?

21 THE CHAIR: Okay. Well, let's set that
22 one aside. Rather than taking the break now, 'cause
23 I'm looking at the time, let's set that aside for a
24 minute. I'll go through my other questions, and then
25 maybe what we'll do is take the midday break then
26 before any redirect so that you can -- and then you can

1 come back after the midday break and give me the answer
2 if --

3 Ms. Jamieson, will that work for you? Okay. I'm
4 getting a nod.

5 MS. JAMIESON: Yes.

6 THE CHAIR: Okay. Thank you.

7 So, yes, you can --

8 MR. IANNATONE: And so --

9 THE CHAIR: -- come back to me with that
10 one after the break.

11 MR. IANNATONE: Just before we move on, can
12 you repeat the question one more time, please.

13 THE CHAIR: Okay. So there is a reference
14 in my note. Obviously, I have to go back and
15 double-check. It was that in Exhibit 2.01 at PDF
16 page 139: (as read)

17 To the effect that although the lateral
18 extent of the IHS units have been estimated
19 and modelled, operational issues will arise
20 due to the uncertainty with the effective
21 vertical and horizontal permeability
22 encountered.

23 And then I think there was a suggestion that further
24 pad modelling needed to be undertaken, and my concern
25 was -- I look at that and think, Well, that's got to do
26 with steam-chamber development, but I don't want to

1 assume that's the case.

2 Oh, Ms. Jamieson is waving at me. Yes.

3 MS. JAMIESON: I just want to -- if they're
4 going to work on this on the break, what I'm noticing
5 about the reference you did give, assuming it's
6 correct, is it's page 139 of 243. At the bottom
7 right-hand corner, it says "ISH Markit", which -- so I
8 believe it -- this -- if it is this reference, that
9 would've been a report filed by ISH in the early days
10 of this proceeding. And so -- so I just want Canadian
11 Natural's witnesses to be aware of that when they go to
12 look for the reference.

13 THE CHAIR: Thank you, Ms. Jamieson.

14 MR. IANNATONE: If that's the case, is the
15 question still valid to CNRL, if it's an ISH document,
16 which it appears to be?

17 THE CHAIR: Well, let's hear -- so we can
18 do it this way. So let's --

19 MS. BERG: Sorry. I might be able to
20 help.

21 THE CHAIR: Okay.

22 MS. BERG: It's my understanding that
23 this -- and I don't have the document in front of me,
24 but it's my understanding that this quote from IHS
25 Markit is in turn a quote from the original
26 application, but that is subject to check. So that

1 might be helpful to you and the CNRL witness.

2 THE CHAIR: Okay. Thank you.

3 So when you said the "original application",
4 you're talking about the original application for KN06?

5 MS. BERG: I believe so, yes.

6 THE CHAIR: Okay. Thank you.

7 So another question arising out of my review of
8 Exhibit 63.01, which, Mr. Iannattone, is, in fact,
9 ISH's reply submission, but it raises the question
10 that, I think, only Canadian Natural can answer. It's
11 ISH's evidence that on May 22nd, 2014, Canadian Natural
12 requested ISH's agreement to abandon the 10-01 well.
13 So, again, I don't want to make any assumptions about
14 why that might've been the case. So I'm wondering if
15 that's correct from Canadian Natural's point of view
16 and, if so, why that request was made.

17 A MR. CRAIG: Yeah. So I can -- I can
18 answer that one. So as part of the KN06 application,
19 we, of course, did the thermal compatibility review.
20 The 10-01 well was flagged, obviously, as being not
21 compliant with the thermal operation, and -- sorry, and
22 this was not necessarily specific to KN06. This well
23 is within 300 metres of our KN05 pad. So it was
24 flagged back in 2014.

25 The requirement at the time was to mitigate those
26 wells, repair them, or abandon them prior to the

1 drilling of Kirby North, and so we engaged in
2 discussions with ISH at that time around potential
3 abandonment and remediation options available.

4 Q Okay. Thank you. That's helpful.

5 I'm just crossing off questions that I came to
6 that were answered.

7 So, Dr. Boone, I have a couple of questions that,
8 I think, are for you.

9 At one point in your report that's included in
10 Exhibit 30.02, I think you say that the barrier does
11 not need to be continuous over even the KN06 box to be
12 effective. Can you help me better understand what you
13 mean by that.

14 A DR. BOONE: Sure.

15 I -- I -- I don't recall exactly where I say that,
16 but, again, it relates back to if fractures are being
17 generated, they're -- they're local events. And so,
18 you know, as they rise up from -- from the wellbore,
19 they spread out, but they're going to spread out to
20 typically widths that might be 40, 50 metres, and --
21 but they're very thin too; right? They're only, you
22 know, typically millimetres opening on these fractures.

23 So in order to be contained, there really only has
24 to be a local seal or a local barrier there, and, you
25 know, they -- it doesn't have to be a continuous
26 barrier over the pad like we would normally want if --

1 for pressure containment because fractures, you know,
2 really can't find tortuous pathways around the
3 barriers.

4 Q But to be -- for the barrier then to impede the course
5 of the fracture, I mean, the geometry would be such
6 then, if I understand you correctly, that the fracture
7 actually has to meet the barrier. So if you have a
8 barrier that's not continuous and a fracture that
9 somehow misses the barrier -- I guess that's where I
10 was a little confused.

11 A No. I mean, that's correct. Now, if you're looking at
12 a stress barrier, though, you know, what happens is
13 in -- in -- in the -- in -- at least this is what
14 people understand about stresses and having measured
15 them -- is that they're sort of continuous through a
16 given layer.

17 So if you look at in particular -- like, that B1,
18 which is a very muddy, sandy layer, within that, say,
19 5 or 10 metres, you're going to have relatively uniform
20 stresses, and because it's a relatively muddy zone,
21 it's typically going to have a significantly higher
22 stress than the sands below.

23 And so you're not relying on the continuity of any
24 single mudstone in there but more on the fact that it's
25 a muddy sequence.

26 Q Okay.

1 A And that whole sequence will have a higher stress.

2 Q Okay. That's helpful, and that might actually be a
3 good segue, then, to my next question, which is at
4 page 191. I'm referring to page 191 of Exhibit 30.02,
5 and I think it's Figure 3. It's the stress gradients.

6 So --

7 A Yes.

8 Q -- my question is: When I look at this, it appears to
9 me that in some -- let me phrase it this way. What is
10 a -- what magnitude of difference in stress gradients
11 is required or do you look for to then be able to say
12 you've got an effective barrier to fracture
13 propagation?

14 A I would say -- and I don't think there's any magic
15 number here, but I would say at least half a megapascal
16 or -- and so -- or half a kPa per metre, sorry -- would
17 be a barrier.

18 And so -- and what happens is -- and -- and the
19 fracture will rise. It'll encounter that barrier, and
20 then it'll start to -- to spread laterally. And in
21 particular with these fractures, which are -- they're
22 water-driven fractures. They're steam-driven
23 infrastructures. There's this trade-off between how
24 far they can grow, and yet they're limited by the
25 leak-off into the formation.

26 So the amount of fluid injected into the fracture

1 all ends up leaking off into the formation, and the
2 fracture can only grow large enough to accommodate that
3 leak-off. Okay? And so -- so when you hit a barrier,
4 even a small barrier that -- in a reservoir like the
5 McMurray sands causes the fracture to -- prefer to move
6 sideways rather than upwards, then that really has an
7 effect on limiting the fracture because of the combined
8 leak-off and stress mechanism.

9 Q Okay. Thank you.

10 THE CHAIR: I'm crossing off all of the
11 rest of my questions. Those are all my questions. And
12 so now I have a couple of questions not for the -- for
13 the Canadian Natural witness panel. So we have the one
14 undertaking.

15 You were asked to have time over break,
16 Mr. Iannattone, to deal with one of my questions.

17 And then I have a question -- Ms. Berg, are you
18 going to be putting up a rebuttal witness panel?

19 MS. BERG: Yes. We do have some rebuttal
20 evidence for after lunch, so the witnesses will be
21 ready to go.

22 Madam Chair, I also wanted to note. You had
23 earlier been looking at Exhibit 2.01, the -- and it was
24 PDF 139, an excerpt from the IHS Markit report.

25 THE CHAIR: Yes.

26 MS. BERG: And so if we -- we did scroll

1 up, we -- I have the page in front of me now -- that
2 material was from AER Application 1712215 Kirby
3 expansion project application December 2011
4 supplemental information request to March 2013
5 response.

6 So I just wanted to clarify that for the record.
7 It is CNRL material, but it's drawn from the -- the
8 Kirby expansion project application.

9 THE CHAIR: Okay. Thank you very much.
10 That's helpful to myself and to Canadian Natural. I
11 appreciate that.

12 So we'll take a break for lunch, and then when we
13 come back, Canadian Natural, do you have a response to
14 that question? We can hear it, and then, Ms. Jamieson,
15 you have an opportunity for any redirect, and then we
16 will go to rebuttal evidence, if that works for
17 everyone. Is that -- yeah? Are you nodding?

18 MS. JAMIESON: Yes, it does. Thank you.

19 THE CHAIR: Okay. So if we break till
20 1:15, will that give everybody enough time? Okay. So
21 we are adjourned until 1:15. Thank you.

22

23 PROCEEDINGS ADJOURNED UNTIL 1:15 PM

24

25

26

1 Proceedings taken Via Remote Video

2

3 October 15, 2020 Afternoon Session

4

5 C. Low The Chair

6 C. McKinnon Hearing Commissioner

7 B. Zaitlin Hearing Commissioner

8

9

10 S. Poitras AER Counsel

11 A. Hall AER Counsel

12 D. Campbell AER Staff

13 S. Botterill AER Staff

14 L. Chen AER Staff

15 E. Galloway AER Staff

16 S. Harbidge AER Staff

17 T. Rempfer AER Staff

18 T. Turner AER Staff

19 A. Shukalkina AER Staff

20 T. Wheaton AER Staff

21

22 L. Berg For ISH Energy Ltd.

23 S. Hryciw

24

25 J. Jamieson For Canadian Natural Resources

26 Limited

1 A. Vidal, CSR(A) Official Court Reporter

2 S. Howden, CSR(A) Official Court Reporter

3

4 (PROCEEDINGS COMMENCED AT 1:17 PM)

5 THE CHAIR: Good afternoon, everyone.

6 Again, I'm scanning my screen. So I see we've got both
7 counsel.

8 Mr. Iannattone, your panel -- for some reason, I
9 have this feeling that we might be missing someone, but
10 maybe it's just the different -- there we go. I was
11 right. Whenever you're ready.

12 Response to Undertaking by Canadian Natural Resources
13 Limited

14 MR. IANNATTONE: Okay. Madam Chair, I have a
15 question for you regarding the undertaking. We have a
16 verbal answer that we could provide now, or if you'd
17 prefer, we could actually update -- we made a
18 mathematical error in Tab 15B, the depth summary, so we
19 can give a verbal answer now, or we can update that
20 table and submit it later this afternoon.

21 THE CHAIR: So I think the Tab 15B
22 would've related to Ms. Berg's question; is that right?

23 MR. IANNATTONE: That's correct.

24 THE CHAIR: What would your preference be,
25 Ms. Berg?

26 MR. IANNATTONE: I would prefer to do it

1 verbally now.

2 THE CHAIR: Sorry. I was asking Ms. Berg
3 what her preference would be.

4 MR. IANNATTONE: Oh, I'm sorry.

5 MS. BERG: Yes. And I have -- I have no
6 issue with Mr. Iannattone providing a response right
7 now. I think it would be helpful as well just for the
8 record if the correction could also -- a written
9 correction could also be submitted, but, yes, no issue
10 with having the provision of that answer now.

11 MR. IANNATTONE: Okay. So we'll start with
12 that with Mr. Thomsen.

13 THE CHAIR: Okay.

14 A MR. THOMSEN: Okay. So we'll start with
15 Exhibit 48.02 and page 1066, so the tab is 15B. And
16 there -- my understanding is there's two questions
17 here. The first one is: Why are the injectors shown
18 with a -- at a lower depth than producers? So as
19 Mr. Iannattone mentioned, there was -- there was a
20 simple calculation miss between the injectors and
21 producers. For SAGD trajectory planning, the producer
22 trajectories are planned out carefully, and we don't --
23 so we don't create injector trajectories because when
24 they're drilled, they're arranged off of the producer.

25 So the -- the shallowest well on KN06 would be
26 KN06 1 injector, and so the trajectory that's planned

1 for the KN06 1 producer -- I have it in front of me --
2 this -- this trajectory from November 2019, the true
3 vertical depth at the total of this well. So the total
4 depth is 489 metres TBD from the kelly bushing, and so
5 that is consistent with Tab 15B.

6 And so the -- the simple calculation miss was
7 5 metres was added for the injector, and, instead,
8 5 metres should be subtracted. So the correct total
9 depth for the KN06 1 injector or 1I is 489 metres
10 minus 5, so 484 metres is the -- is the correct value.
11 And so this would carry forward for all of the
12 injectors on the pad, just -- they should be 5 metres
13 above the producer. So that is Part 1, as far as
14 what's going on with this seeming backwards depth here,
15 is the producers do have the correct depths listed, and
16 it was just the injector true vertical depths; that
17 simple mistake was made.

18 So I believe the second part of the question is:
19 Reconcile the difference between Tab 15B and -- and
20 then the CNRL opening statement. There is a slide that
21 shows the 477-metre depth for the stress profile. I
22 don't have the exhibit number handy, off the top of my
23 head, or the tab number, but --

24 MS. BERG: I believe it's 80.02.

25 THE CHAIR: The opening statement? It's
26 88.02, I think, for --

1 MS. BERG: Sorry. Sorry. Thank you.

2 MR. THOMSEN: Okay. So, then, as far as the
3 stress profile, there is a calculation using a depth of
4 477 metres, so it fits the units. If we look, Tab 15B
5 has units of metres true vertical depth from the kelly
6 bushing. And for the geomechanics evaluation, we want
7 to be accurate; we want a tight evaluation. So we used
8 a depth from ground level, so metres from ground level,
9 and that is included in our July 3rd, 2020, Canadian
10 Natural written submission where we outline that.

11 And so Tab 15B, KN06 1I, the shallowest point of
12 all KN06 wells is 484 metres from the kelly bushing.
13 We have a kelly bushing to ground level difference of
14 7 metres. So if we take that 484 metres minus 7, we
15 end up with 477 metres TBD from ground level.

16 So I believe that answers both those questions,
17 but was that clear?

18 MS. BERG: Yes. Thank you very much,
19 Mr. Thomsen.

20 And I don't have any follow-up questions, Madam
21 Chair.

22 Alberta Energy Regulator Panel Questions Canadian
23 Natural Resources Limited

24 MR. IANNATTONE: Okay, then. I'd like to ask
25 Mr. Lavigne to answer the Panel Chair 's final
26 question.

1 MR. LAVIGNE: Thank you, Mr. Iannattone.

2 A MR. LAVIGNE: Madam Chair, could -- could I
3 get you to just sort of reframe the question just a
4 little bit for clarity. I just want to make sure that
5 I'm -- I'm speaking to the issues that -- that you
6 raised. I was a little bit confused when I saw the
7 passage.

8 Q THE CHAIR: So my question was -- so it
9 was the -- the passage that talks about: (as read)

10 The lateral extent of the IHS units has been
11 estimated and modelled, and operational
12 issues will arise due to the uncertainty with
13 the effective vertical and horizontal
14 permeability encountered.

15 So -- and then it's -- I believe it went on to talk
16 about the potential for -- potentially a requirement of
17 further modelling. So my -- when I read that, what
18 I was wondering is: Are the operational issues and the
19 modelling relating solely to the reservoir development
20 and steam chamber, or is that -- are there broader, I
21 guess, implications for that in respect of containment
22 of the steam?

23 A Okay. Thank you for the clarification.

24 So to -- to address that -- and perhaps you've
25 given me a little bit of latitude to provide some
26 context to the question -- when the -- the -- the --

1 when the SIR was submitted, Canadian Natural had
2 started up the development at Kirby South, but it was
3 still early days, and we didn't have a lot of
4 operational data back from that time.

5 And one of the things that we learned -- and in
6 the -- in the paragraphs that you mentioned in that
7 Markit citation, they -- they talked initially about
8 breccia, and -- and then they moved to IHS.

9 So one of the things we learned really early on
10 in -- in the development at Kirby South was that
11 breccias can -- can be a problem, and they can become
12 barriers to steam. And breccias were a factor in the
13 AB/12-04 well that was referenced in the -- in the
14 passage, and we learned -- we learned from operational
15 data in Kirby South that we experienced nonconformance
16 issues and poor start-up due to the fact that there
17 were breccias in and around the injector producer
18 level. And that necessitated redrilling some well
19 pairs to -- to get the steam chamber to get growing
20 effectively.

21 And as the economics of a SAGD project require,
22 you know, fairly quick start-up, we -- we learned -- we
23 learned some important lessons about geological
24 heterogeneities. So after that, in the spirit of
25 continuous improvement that -- that is an important
26 core value to us, we substantially modified the Kirby

1 North IDA. And because of the heterogeneities that are
2 described, we actually modified the drainage boxes, and
3 there's no well pair in the -- in the region tested by
4 the AB/12-04 well. So in -- in that well, probably a
5 bigger problem was not the 1-metre mud bed that was
6 referenced in that passage, but it turned out that
7 overlying that area, there was about 18 metres' worth
8 of mixed to muddy IHS, and we realized that that was
9 not a reservoir. That is now -- and in the context of
10 this hearing, that's what we classify as "post B2
11 non-reservoir," and we -- we know from -- now from more
12 recent operational experience that we can't get steam
13 rising into that unit, and so the drainage box
14 boundaries in KN02 were modified to avoid encountering
15 that -- that particular feature.

16 Speaking specifically to IHS beds referenced later
17 in the passage, we -- we realized that lower down in
18 the reservoir, down near injector producer level, the
19 higher energy, sandier deposits that we discussed
20 earlier in the hearing, they do not have the same
21 lateral extent. It's once we get higher up into the
22 reservoir and we start encountering the thicker,
23 muddier beds that -- that we -- there -- the issues
24 about -- from an economic point of view, that's why the
25 steam -- the steam chamber stops there, and we no
26 longer consider that reservoir.

1 So after starting up the Kirby South, we learned a
2 lot about -- about what constitutes reservoir and what
3 will hold back steam chambers. So the modelling, I
4 believe, referenced in that passage refers to the --
5 the geostatistical model, and we use that to help
6 forecast tight curves and things like that. So I don't
7 think that we -- I don't think that we would rerun that
8 model in the absence of new data, but it's made us much
9 more aware of where potential boundary conditions exist
10 for reservoirs.

11 I'm not sure if that fully answers your question,
12 Madam Chair.

13 Q It does. Thank you.

14 A Okay.

15 THE CHAIR: So, Ms. Jamieson, the panel is
16 yours for any redirect.

17 MS. JAMIESON: Thank you, Madam Chair. We
18 actually -- I did have a number of questions for the
19 Canadian Natural witness panel, but the AER staff and
20 the Panel has actually covered all of the same ground.
21 So I have no further questions for our Panel. Thank
22 you.

23 THE COURT REPORTER: You're muted, Madam Chair, by
24 the way.

25 THE CHAIR: My lips are moving, but nobody
26 can hear anything.

1 Thank you, Mr. Vidal.

2 So let me try that again. So I think with that, I
3 can thank the Canadian Natural witness panel for your
4 attendance and for your answers yesterday and today,
5 and you are now -- here's that phrase again that I
6 don't like so much, but it is what it is. You're
7 dismissed and free to -- to confer with -- with
8 colleagues, counsel, et cetera.

9 And, Ms. Berg, you're going to proceed with some
10 rebuttal evidence; is that the plan?

11 MS. BERG: We do have some rebuttal
12 evidence, Madam Chair, yes.

13 So I would --

14 THE CHAIR: Sorry. Just --

15 MS. BERG: Oh, sorry. Go ahead.

16 THE CHAIR: So I was going to ask our --
17 in terms of logistics, so that means we need all the
18 Canadian Natural witnesses to go off camera and yours
19 to come on.

20 MS. BERG: So I would ask all of the ISH
21 witnesses to -- to put their cameras on, please, and
22 I -- if someone could let me know when that happens
23 because I'm not seeing everyone on my particular
24 screen. Everybody's on?

25 All right. Madam Chair, I would ask -- I believe
26 that the -- the entire panel has opted to be affirmed,

1 so if we could proceed with that.

2 VERONIQUE GIRY, PETER VERMEULEN, DAVID LEECH, EDWARD

3 MATHISON, EARL WARD, BRETT THOMPSON, JENNIFER CLEE,

4 Affirmed

5 Rebuttal Evidence of ISH Energy Ltd.

6 MS. BERG: Thank you.

7 I'd like to start with Mr. Vermeulen.

8 Mr. Vermeulen, I understand you would like to
9 respond to some new evidence provided by Mr. Sverdahl
10 yesterday.

11 MR. VERMEULEN: Yes. I would like to respond
12 to some of the evidence from yesterday regarding
13 seismic interpretation.

14 So by way of background, in CNRL's hearing
15 submission, a semblance slice was presented in time and
16 created from a post-stack migrated seismic volume at an
17 approximate mid-B1 mudstone level and was used by ISH
18 to point out several dissimilarity anomalies on this
19 slice. This is Exhibit 30.02, PDF 120. If it's
20 possible to bring that up, it would be appreciated.

21 Thank you.

22 In CNRL's opening statement, they presented a
23 different semblance slice to represent the same mid-B1
24 mudstone level.

25 Is it possible to bring up the unmarked version,
26 which is Exhibit 49.02, PDF 1113?

1 THE CHAIR: Do we need the page number
2 again?

3 MS. TURNER: Can you repeat the exhibit and
4 page number.

5 MR. VERMEULEN: It's Exhibit 49.02.

6 MS. TURNER: Yes.

7 MR. VERMEULEN: PDF 1113. And if we could
8 just keep both those tabs close together so that we can
9 toggle back and forth. Great. Thank you.

10 So noted as the preference of the Kirby project
11 geophysicist, this semblance slice was created from a
12 pre-stack migrated SAP seismic volume that had been
13 stretched to depth. This process, as CNRL noted, could
14 cause variations due to the velocity process of
15 converting the time-migrated version to depth.

16 So could we just toggle back and forth between
17 those two just so that the Panel can see the -- the
18 differences or the variations. Great.

19 So the time to depth stretch semblance slice was
20 mostly absent of the original dissimilarity anomalies
21 pointed to by ISH in their opening statement and
22 instead contained noticeable smearing in a
23 predominantly east-to-west direction.

24 If we could just go to the other exhibit.

25 CNRL went on to explain the absence of
26 dissimilarity anomalies, and enhancement of acquisition

1 footprint was the result of the pre-stack time
2 migration's ability to be more focused. Focusing in
3 seismic processing indicates that images become more
4 clear and edges become sharper. Also, the modern
5 processing that CNRL indicated the 2008 Kirby North 3D
6 seismic volume had undergone is designed to maximize
7 the seismic signal and minimize or remove noise.

8 CNRL's semblance slice created from the pre-stack
9 migration that was stretched to depth saw the
10 dissimilarity anomalies become less sharp and, by
11 amplifying the acquisition footprint noise, made the
12 image less clear. CNRL's argument that the pre-stack
13 time migration tends to focus reflection events is
14 poorly demonstrated in their depth converted pre-stack
15 time migration semblance slice.

16 Without CNRL submitting more semblance slices
17 above and below the approximated mid-B1 mudstone level
18 created from the less noisy and arguably more focused
19 post-stack time-migrated volume, CNRL has not clearly
20 demonstrated that their seismic does not show subtle
21 faults and fractures.

22 When asked what further interpretation steps would
23 be taken after suspecting a fault on a semblance
24 volume, CNRL did not suggest a simple review of more
25 semblance slices, nor did they suggest to toggle their
26 time horizons to display amplitude, nor would they make

1 use of the pre-stack time-migrated gathers to look at
2 how amplitude and velocity varies with azimuth.
3 Instead, CNRL has noted they would turn back to the
4 stacked seismic sections from which the semblance was
5 created to highlight faults for visual verification.

6 CNRL states in their geophysical cross-response
7 that they would easily recognize a 7-metre displacement
8 on seismic markers at the Wabiskaw B Paleozoic or
9 within the reservoir itself.

10 I find this an extraordinary accomplishment. With
11 100 hertz of dominant frequency at the McMurray level
12 in the 2008 Kirby North 3D seismic and using a velocity
13 range from 2,500 to 2,750 metres per second, which was
14 taken from the velocity model CNRL provided in
15 Exhibit 49.02, PDF 1116, geophysicists can calculate
16 the seismic wave to have a 25-to-28-metre wavelength.

17 With small velocity and density changes expected
18 across a 7-metre displacement in the Wabiskaw and
19 McMurray formations, the perturbation on this seismic
20 wave forming would certainly be extremely small.
21 Coupled with the expected vertical or subvertical
22 orientation of a fault and the 2008 Kirby North 3D
23 lateral trace spacing of 12.5 metres, the time
24 difference between adjacent traces would be less than
25 3 milliseconds on a stacked seismic section.

26 Add to this any random or known acquisition

1 footprint noise that was insufficiently removed in
2 processing and that the 2008 Kirby North 3D seismic
3 acquisition geometry only produces 15 old data at the
4 Wabiskaw McMurray level makes CNRL's claim of
5 identifying faults with 7 metres of displacement on a
6 stacked seismic section truly remarkable.

7 The geophysical tools CNRL chooses to interpret
8 subtle faulting and fractures in the combining strata
9 forego significant geophysical and data analysis
10 advancements the industry had made in the last
11 20 years. Modern geophysical interpretation tools have
12 allowed for multiple attributes to be used in
13 combination to highlight features not visible by mere
14 visual -- visual inspection.

15 That's all I have to comment on the seismic
16 interpretation. Thank you.

17 MS. BERG: Thank you, Mr. Vermeulen.

18 Mr. Mathison, I understand that you would like to
19 respond to some of the new evidence provided by
20 Mr. Lavigne yesterday.

21 THE CHAIR: You're on mute, Mr. Mathison.

22 MR. MATHISON: Thank you, Ms. Berg.

23 I would like to respond to statements made by
24 Mr. Lavigne yesterday in the course of evidence in
25 cross-examination.

26 Would you please refer to 88.02, PDF 17. I think

1 we may be out. Try 16. I think we may have the wrong
2 number here. There it is.

3 There's a core photograph on the right and a well
4 log on the left of the 1AA/11-01 well. You'll notice
5 that there is a red line in the core photograph at the
6 bottom, lower left-hand corner labelled "non-reservoir
7 base."

8 That's not the one. I think we're going to have
9 to get -- figure out where we are in this. I think we
10 may be -- go up one more, please. Yes. This is --
11 this is the correct one. Sorry. My apologies.

12 You'll notice that the -- on the lower left-hand
13 corner, we have a red line marking "non-reservoir
14 base."

15 And now if we'll go to PDF 18. I'm hoping this is
16 correct. Yes, this is correct. What we're seeing,
17 really, is just an expanded view of the core, adding
18 core both below and above. The interval showed is
19 illustrated on the overlying well log. CNRL neglected
20 to mark the top of the reservoir which occurs at the
21 base of the core that is just above the 'R' in
22 "hearing." So in the caption below, if you'll go to
23 "Canadian Natural hearing," it's right above the 'R'.
24 So that's where that red line, the base of -- of
25 non-core or non -- non-oil -- or non-reservoir is in
26 that well.

1 Without knowing this -- that this -- without
2 knowing this, it would be difficult to state precisely
3 where the top of this thick, sandy IH -- without --
4 pardon me. Without knowing this, it would be difficult
5 to state precisely where the top is, where the top of
6 the reservoir is, as there are thick, sandy IHS above
7 the boundary, and we can see just above in -- just
8 above the 'R' and just above the 'G', we have some beds
9 that are in several decimeters thick whereas we see
10 below the boundary -- let's say just above the 'T' --
11 we have some thin beds in there and certainly thinner
12 than what we're seeing above the boundary.

13 In -- in the Fustic, et al. -- and this is 30.02,
14 PDF 95, and this is -- this was information that was
15 presented by CNRL, and looking at the second paragraph,
16 the first sentence -- I don't believe this is it. Oh,
17 sorry.

18 THE CHAIR: Can you repeat the exhibit
19 number and the page.

20 MR. MATHISON: Oh, yes. It's 30.02, and it's
21 95.

22 MS. TURNER: Yes. Thank you. We just have
23 a computer-frozen issue.

24 MR. MATHISON: That's -- that's fine. Thank
25 you.

26 And you'll notice in the second paragraph on the

1 right-hand side -- so it starts with "visual," and I'll
2 just read it out for you: (as read)

3 Visual core investigation and log analysis
4 cannot accurately predict the lateral extent
5 and permeability of fluid migration and
6 molecular diffusion through the reservoir.

7 And to go on, so in response to this, the picking --
8 the difficult of picking a precise top of reservoir, in
9 particular where there's sandy IHS, is illustrated in
10 their Exhibit 02.01, PDF 29. If we refer to that,
11 please.

12 Yes. Thank you.

13 And this is what they used in the modelling.
14 Where the sandy IHS, according to their modelling
15 input, it clearly goes up to just below the lower B1
16 boundary, we can see that in the 05 -- 1A -- is it
17 "1A"? I can't read it off the screen. It's the -- the
18 well at the far left-hand side and, to the certain
19 extent, the next well over also.

20 This is much higher than the previous well, so the
21 11 -- the AA/11-01 well that we just looked at
22 previously. Therefore, the pick of the top of the
23 reservoir is inconsistent and cannot be considered as a
24 continuous unit.

25 Since the -- and this is moving on. Could I get
26 you to bring up Adams. And this is a part of the CNRL

1 submission, 88.02, PDF 19, and this is in gas
2 chromatography-mass spectroscopy. That's correct.
3 That's it. You'll notice that the chart in the
4 left-hand corner is from Adams 2008.

5 And with regards to this, CNRL has chosen to
6 interpret the GC-MS -- oh. They have chosen -- oh,
7 sorry. Pardon my -- okay. They have chosen to use --
8 they have interpreted their GS -- GC-MS data in a
9 manner consistent with Adam -- Adams 2008. In fact,
10 you would see that it's very similar to the chart of --
11 the four charts at the bottom of Adams. It's very
12 similar to the chart that's farthest to the right,
13 which is Image D.

14 Now -- and moving on, they have chosen to ignore
15 revisions made by Fustic, et al. -- and, of course,
16 Adams was one of the authors in this -- which are --
17 and this is based on data from the joint venture
18 Athabasca sands project. It's a joint venture between
19 Nexen and -- I forget now. Sorry. My apologies.

20 Anyways -- so could we go to the Fustic, et al.
21 30.02, PDF 92. Perhaps it's -- I'll get the correct --
22 I have a page number 92. For some reason, ours -- so
23 this is the 30 -- 30.02. Where is it? Oh, could you
24 scroll down, please. Sorry. My apologies.

25 Now, you'll notice -- you'll notice that in this
26 diagram, they only have three diagrams, and the one

1 diagram that is missing is the one that most closely
2 approximates what we see or what the -- the
3 compositional gradients indicate in the AA/11-01 well,
4 and I'll show you. The one that -- one that Fustic,
5 et al. believe is -- is the valid evidence of the
6 barrier is the -- the -- what their chart on -- on the
7 right, "Chart C," and you'll notice what they see is
8 a -- the trending up to the right of the gas -- of
9 the -- the compositional gradient, and then a kickback
10 over top where there is a barrier so that it doesn't go
11 straight up. It comes back.

12 And I'll show you an example. If you would please
13 go to page 92. And this is right out of their work.
14 Pardon me. Sorry. Wrong page number. Page 96,
15 please. So it's just in this document but just down
16 four pages.

17 And could you bring up -- there. And you'll
18 notice this is based on real-world data, and you'll
19 notice that on the left-hand side, they are
20 interpreting barriers between the various channel
21 units, and you'll see that the -- you can see the two
22 gradients going over from the same position; whereas,
23 in the Well 2, you'll see the compositional gradient
24 goes continuously up and bends off to the right, and
25 this is going through two channels.

26 And what may be of interest is that the channel on

1 the right has 17 metres of IHS; whereas, the channel on
2 the left has 12 metres, yet the channel on the right is
3 the stacked channels. On the right -- pardon me,
4 are -- they -- they are interpreting it that there's no
5 barrier between them. So even where you have very
6 thick IHS, you can still get communication and -- and
7 movement of fluids through those IHS.

8 So to move on -- that's it for that. Now, please
9 turn to CNRL 88.02, page 23. That's great. And could
10 we zoom in on it a little bit. What I'm interested
11 in -- I'll show you -- is this interval here that
12 Mr. Lavigne looked at, and he -- yeah. He interpreted
13 it as coring-induced fractures, saying it -- it looked
14 like petal centre -- centreline fracture. Now, the
15 problem that I have with this interpretation is that
16 because the stratigraphy within this interval is
17 virtually completely destroyed -- it -- you can't --
18 you know, the typical stratigraphy is what we see on
19 either side of -- of this core interval, and so,
20 therefore, the -- the destruction of that -- that
21 layering had to have occurred prior to the cementation.

22 And -- and I think that in -- in all probability,
23 although you can't say for certain because we do not
24 have any geochemistry from this -- this -- this layer
25 because the cores are gone, that I believe a more
26 reasonable interpretation -- he -- Mr. Lavigne

1 interprets this as a concretion. I think it's much
2 more likely that this is strata that has been totally
3 destroyed by fluids that have accessed that zone along
4 the fracture system. And, in fact, they probably had
5 brought in the cementing medium with them, which is
6 carbonate cement.

7 And the only way we can resolve this completely is
8 to have oxygen isotope and carbon isotope data, which,
9 of course, are not available anymore. And you'll --
10 if -- if this was coring-induced fracturing, we would
11 expect to see these petal-centerline fractures to be
12 open, and I -- I do not see -- other than maybe the
13 centre, but I'm not even sure that's coring-induced.
14 Perhaps it is, but -- but certainly in the overlying
15 stuff, we do not see any -- any petal-like
16 structures -- petal fractures coming off there, which
17 we would expect to see.

18 Could I turn your attention to PDF 24,
19 Exhibit 82 -- 88.02, please. And this is a
20 continuation of that -- we're just down below that --
21 that core interval. We're down in what CNRL has
22 interpreted as the "B2," and you'll notice the -- the
23 base of the B2 occurs at -- right there, just to the
24 top of the second column on the -- on the -- at the
25 top. And the top of the B2 appears at the top of --
26 top of the first column.

1 So that entire interval between those is
2 considered to be part of the -- pardon me, the B1
3 mudstone, what they referred to as the "mid-B1
4 mudstone," you can see there; they have labelled it as
5 such. But the interesting thing about this is that at
6 the bottom of this, you'll notice the black zone, the
7 dark zone, dark grey to black, and this is a
8 carbonaceous mudstone. Even with just core
9 photographs, it's evident that this is a carbonaceous
10 mudstone. This cannot be part of the B1.

11 You know, it -- it's -- yeah. I don't know how
12 they can consider it that, but, anyways, we won't get
13 into that, but certainly not. So if there's any
14 B1 present in this well, it has to be much thinner,
15 and, in fact, I don't -- and granted we are looking at
16 core photographs, I don't see anything in here that --
17 in -- in the overlying strata, it's looking to be a
18 mid -- medium grey mudstone, but -- but I do not see
19 any evidence of silty bioturbated zone. So, in fact,
20 this -- the B1 may actually -- or the B1 mudstone may
21 actually be absent in this well, which raises serious
22 concerns about what is happening to cause that.

23 May I address your attention to PDF 25, the next
24 page, please.

25 Now, this is, again, one that Mr. Lavigne chose to
26 look at. And could I direct your attention to -- to

1 the Number 2, the -- the close-up of Number 2, which he
2 interprets as coring-induced fractures.

3 And you'll notice that at the base of this is a
4 unit that he considers to be drilling mud. Now, it's
5 ironic -- or it's unusual -- I have never seen it, and
6 I've looked at hundreds of core in the Mannville and in
7 the McMurray formation, and I have never seen drilling
8 mud that looks like this. Drilling mud is generally
9 the same colour as the mudstones above. It's brown --
10 it's a grey. This looks a lot more like the -- the
11 sand -- and you can see at the top of one, that sand.
12 And I think the best interpretation -- and because we
13 have -- we don't have the core, we have to make an
14 interpretation -- is that this is actually a sand and
15 that perhaps even that it's -- it's competent because
16 it's stuck together, and there may even be a fracture,
17 and I'll give him that. This could be a
18 drilling-induced fracture in the sand. So to go on,
19 you know, I don't -- don't believe his interpretation
20 of that is correct.

21 And, again, going to the -- can we zoom in just to
22 the interval above the Box Number 2. So I -- I've
23 pointed to it. We'll see if we can -- how well we can
24 see that. We may have to bring up the -- the actual
25 core photograph, which is -- and I don't know if I've
26 got it. It's in the 02-01 well.

1 Excuse me for just one second as I look that up.
2 My apologies. It's a -- page 39 of the annotated
3 cores, which is 65.02. Is that correct? It's ISH's --
4 or CNRL's submission. 53.02, is that correct? Yeah,
5 53.02 -- pardon me -- and page 39, please. It's the
6 same core. So we're in the right thing. Now we need
7 page thirty -- 39, please. There we are. And could we
8 zoom in on the -- I'll move the -- the -- yeah. So
9 just this upper portion of the core, this is the --
10 yeah. That's good. That's probably good enough.
11 We'll probably lose resolution here.

12 So this is the top of the box that Mr. Lavigne
13 chose us -- chose for us to look at, and so we're --
14 what I want to point to is that this interval above
15 hardly looks like drilling-induced fracturing. You can
16 see in this one you do have a nice orthogonal pattern.
17 Well, it could be drilling-induced. This one doesn't.
18 What this one looks like is -- is more of a -- just a
19 broken-up piece of core, and you'll notice that there
20 is a little bit of sands in interstices between these
21 highly broken, fragmented core mudstone fragments. And
22 I think that -- I think that a more reasonable
23 interpretation is that -- of this is that what we are
24 looking at is -- in the lower part, that these are
25 probably natural fractures and that, as we move up,
26 the -- the intensity of fracturing has increased to the

1 point of complete brecciation.

2 Let's move on to -- okay. I would like to point
3 out also that this is the same well that ISH presented
4 the intense fracturing faulting, which I interpret,
5 actually, as faulting, in the Paleozoic, and I'll give
6 the reference -- I don't think we need to look at it --
7 65.02, page 41, but you needn't go there, as well as
8 the distorted strata in the McMurray A that Mr. Poitras
9 referred to. And as well as that, Mr. Lavigne
10 considered a large -- what I would -- he considered a
11 large outsized clast. I would consider it just highly
12 distorted mudstone beds in 88.03, page 33.

13 So this was all in one well. It's -- to me,
14 that's highly unlikely that you're going to get that
15 degree of drilling-induced fracturing in one well;
16 whereas, you don't see that intensity, for the most
17 part, in other wells. We do see lots of evidence of
18 fracturing, but this intensity is really anomalous.

19 So moving on. And I'd like to refer to the
20 hearing transcripts October the 14th, Volume 2,
21 page 312.

22 MS. TURNER: Mr. Mathison --

23 MR. MATHISON: Did you get that?

24 MS. TURNER: You would like us to share
25 our --

26 MR. MATHISON: Yes, please.

1 MS. TURNER: Just one moment. You said
2 from October 14th?

3 MR. MATHISON: Yes. October 14th, Volume 2,
4 page 312.

5 MS. TURNER: Okay. There's only 224 pages
6 in Volume 2.

7 MR. MATHISON: I must have the --

8 MS. TURNER: You mean October 13?

9 MR. MATHISON: It was the cross of -- of CNRL
10 yesterday.

11 MS. TURNER: Okay. So to -- from
12 October -- sorry. From October 14th has 224 pages.

13 MR. MATHISON: We must have a -- I'm not
14 sure. It is a cross on the oil water contact between
15 the two wells, 'K' to K Prime. I'll just refer to what
16 I have here, and we'll -- we'll sort that out. Is that
17 okay with you?

18 MS. TURNER: Sure.

19 MR. MATHISON: Madam Chair, we'll get the
20 exact reference there.

21 Let's -- could we go to Exhibit 29.02. And it's
22 the 'K' to K Prime cross-section. It's part of ISH's
23 submission.

24 MS. TURNER: Do you have a page number for
25 Exhibit 29.02?

26 MR. MATHISON: There -- there's no page

1 number. There's only four --

2 MS. TURNER: Okay.

3 MR. MATHISON: -- four in there. Is that the
4 'K' to 'K'? No. That's 'A' to 'A'. I think it's the
5 last -- I believe it's the last one in the series.
6 And -- oh, that is 'K' to K Prime. Yes, yes. We'll
7 look at that. And could I get you to zoom in on the
8 far right-hand side. I know we don't -- you don't need
9 the -- no, no. Left. Do I have the wrong reference
10 here? Ah, yes. There we are. There's the AA/06-01
11 and the AA/07-01. We asked Mr. Lavigne to give us the
12 oil water contacts in two wells, and he graciously
13 complied.

14 And I would like to, first of all, take a look at
15 the 06-01. So could we do a close-up at the bottom of
16 the well, just the very -- very -- we don't need to see
17 what the well is. We know what they are. So just
18 do -- and now scroll down, please. Yeah. There we go.
19 A little bit more, please. Thank you.

20 And so he -- he gave us -- he said that -- he gave
21 us a depth of -- and this is directly from the
22 transcript of "492 metres at a resistivity of 10 ohms."
23 And when -- now, could we scroll over to the next well
24 to the right, and this is the 7 -- the AA/07-01 well.
25 When we asked Mr. Lavigne to give us an oil water
26 depth, he responded by giving us two depths, at 498

1 and -- you can see that at 500 is the -- 500 is just
2 almost right at the bottom of the well. I'll show you
3 that. This is 500. And what Mr. Lavigne gave us was
4 498, which is just 2 metres above this, and he said
5 that it could be at 498 and that -- he said that there
6 was a saturation gradient, and he responded that it
7 could also be as high as 493.

8 My pointer -- there it goes. So somewhere in
9 there is -- is where he thinks that the oil water
10 contact -- and I -- I would argue that -- that I think
11 Mr. Lavigne has -- has made an error here, and if you
12 look at this right here -- if you look right there and
13 you go over and you read the ohms, this is -- this is
14 our 10-ohm cutoff that he used on the 06-01 well. So
15 that's 10 ohms, and you can see that, clearly, our oil
16 water contact is below 500. In fact, it's closer to
17 501.

18 So if we take that information and we calculate
19 that depth, we have KBs for both of these wells, and if
20 you -- I don't think we need to go up and check that,
21 but, you know, for people who would like to, they can
22 see it on the -- on the well log. The depth for the --
23 the 06-01 well is -- has a KB of 681.3, and the
24 AA/07-01 well has a KB of -- of -- oh, where is it --
25 six -- no. Pardon me. The AA well has a KB of
26 679.1 -- excuse me -- and the -- the AA/07-01 well has

1 a KB of 681.3.

2 So if you calculate out the water contacts, given
3 the KB, it would -- the oil waters come out at -- in
4 the AA/06 well is 187.1. So it's this well.

5 Now, I must -- I must, first of all, explain that
6 this cross-section is hung stratigraphically so that
7 it's hung as close as we can be to what it was at the
8 time of deposition.

9 And so what we see in the oil water contacts is,
10 shall we say, a fossil contact. Anyways, I'll go --
11 and then I'll go over to the 07-01 well, and that works
12 out to 180.4. So we simply subtract the two, and it
13 indicates that there is a 6.6-metre difference in the
14 oil water contacts between these two wells.

15 And so from my experience on the western plains
16 working all the way -- you know -- that's a significant
17 offset, and although I'm not going to demonstrate it
18 here, on other cross-sections in this area, we see
19 those offsets not just at the Paleozoic, but we see
20 them all the way up through the column getting up to
21 the top of the Mannville -- close to the top of the
22 Mannville. And in some instances, we see them at the
23 base of fish scales. So those -- those are significant
24 offsets.

25 And I'd like to quote Mr. Lavigne from the record.
26 Now, I'll say Hearing Transcript Volume 2, PDF 172,

1 line 24 to 26.

2 And we asked if he agreed that the oil water
3 contact will represent a near horizontal surface at the
4 time that the reservoir was filled, to which he
5 replied -- and this is PDF 172, lines 4 to 10 -- it
6 must have been PDF 71, the previous one, because it was
7 just above this. Sorry. My -- again, my apologies.
8 To which he replied: (as read)

9 I think that this is a dangerous practice,
10 especially since in -- in an -- oil sand
11 reservoirs, after the charge, the degradation
12 of the oil to bitumen happens very quickly.
13 And so, essentially, that oil contact freezes
14 in place. Any structural movement or changes
15 to that after the fact has the effect of
16 bending the oil water contact.

17 So we're seeing what he calls a "bending" of the oil
18 water contact, and this is a significant thing, and he
19 also -- he mentions that structural movement can be --
20 and, I would argue, is the most likely cause of this.

21 The other thing that's of interest is this offset
22 in elevation of oil water contact occurs at a steep
23 gradient in the Paleozoic unconformity derived from
24 seismic.

25 Now, this is -- this is their seismic,
26 Exhibit 29.02, PDF 11. Could I see that, please.

1 Could we have that brought up, please.

2 MS. TURNER: Did you say Exhibit 29.02?

3 MR. MATHISON: Oh, it must be -- sorry. My
4 mistake. 30.02, and it's PDF 11.

5 MS. TURNER: Thanks.

6 MR. MATHISON: I'm sorry. I must have the
7 wrong number there. I'll get it for you. It's
8 actually page one -- 118. My -- my mistake.

9 MS. TURNER: Of Exhibit 30.02 for the --

10 MR. MATHISON: That's correct. This is the
11 one.

12 And I'll just point to where those wells occur.
13 So 06-01 -- AA/06-01 and AA/07-01. There's AA/07-01,
14 and I think this is AA/06-01 back here, one of those.
15 Do we have a map (INDISCERNIBLE - BACKGROUND NOISE)?
16 There. That's what I need.

17 It's actually between these two wells, AA/06-01
18 and AA/07-01. Now, this is based on seismic and, I
19 would argue, is far less precise than -- than using
20 well logs and -- and actually see it, and we also have
21 the core evidence. We can tell that.

22 So between those two wells, we're looking at
23 6 metres of offset, and I've shown you another
24 cross-section, 'W' to 'W', that we have an 11-metre
25 offset at Paleo and 7.5 metres up here.

26 So, you know, clearly, their seismic is seeing

1 something coming through there, a linear feature, with
2 a significant amount of offset, and that is reflected
3 not only in the Paleozoic and overlying strata but also
4 reflected in the oil water contacts.

5 So this is -- this means that this feature,
6 whatever you want to call it, whether we call it a
7 "flexure" or whether we call it a "fault," is a late
8 feature in that it's later than oil migration, which is
9 considerably later than the deposition of the Mannville
10 group and also after biodegradation. So the oil has to
11 be frozen in place, and this is -- Mr. Lavigne has made
12 that point already, and thank you very much.

13 And in -- now, this is -- I think we'll just leave
14 it at that. Well, I'll make one comment more, and this
15 refers back to their submission earlier, but they have
16 tried to dismiss this as differential compaction, but
17 the difficulty that I have with that is there are
18 actually thicker sands in some of these wells or
19 equivalent sands in these wells, and so I -- I don't
20 understand where you're getting this compaction from.
21 If you're looking at sands in the -- the -- their
22 post B2 valley fill that are equivalent in thickness or
23 certainly in -- and, in fact, somewhat in part thicker,
24 I don't understand how you can expect to get that
25 differential compaction. Anyways, that's -- that's all
26 I have to say.

1 And thank you very much, Madam Chair.

2 MS. BERG: Thank you, Mr. Mathison.

3 And then, finally, Ms. Giry, I understand that you
4 would like to respond to some of the new evidence
5 provided by Mr. Craig and Mr. Iannattone yesterday.

6 MS. GIRY: Yes. Thank you.

7 I would like to address allegations that we have
8 heard in this proceeding regarding ISH and the
9 deliberate production of GOB gas.

10 Specifically, I want to address Mr. Craig's clear
11 allegation yesterday and today that ISH, as the
12 operator, shut in the 10-01 well on January 7, 2020,
13 after having produced GOB gas. This is not the first
14 such allegation against ISH. In its evidence filed in
15 this proceeding in Exhibit 48.02, PDF 48, CNRL wrote
16 about the voluntary self-report that ISH made regarding
17 the 10-34 gas well. CNRL said -- and I quote -- "the
18 data also provides evidence" -- that's the next page:
19 (as read)

20 The data also provides evidence that gas
21 production from the Upper Mannville II pool
22 may have been initiated prior to April 2019,
23 and that production was shut in in January
24 2020 as disclosed in ISH's notice of
25 noncompliance dated January 15, 2020.

26 For the record, ISH's voluntary self-report is on the

1 record of this proceeding, and I also made a correction
2 to that self-report in my opening statement.

3 It seems that following the receipt of Mr. David
4 Leech's report in this proceeding, that CNRL has now
5 abandoned the allegation regarding the 10-34. Given
6 that the evidence indicates that the gas had been
7 flowing from 10-01, CNRL has changed its story. It is
8 now accusing ISH on turning on the 10-01 well and
9 producing GOB gas for a period of many months. The
10 10-01 well is monitored by CNRL and located 700 metres
11 from CNRL's plant. It is also our understanding that
12 the 10-01 well was manually checked by CNRL during the
13 period when gas was flowing from the GOB zone.

14 These accusations are not true. ISH has not
15 turned on production in any GOB well, including the
16 10-01, the 10-34, and the 16-35. We are an ethical
17 operator. I am the COO of ISH, and I would not
18 compromise my integrity or my long career as an
19 engineer in the oil and gas sector by allowing my
20 company to engage in such profoundly unethical conduct.

21 ISH continues to believe that there is a serious
22 issue with the 10-01 well. That is the most reasonable
23 explanation that fits the evidence regarding flow of
24 the 10-01. ISH did not produce that gas.

25 Yesterday, Mr. Iannattone referred to the
26 confidential and without-prejudice meetings held since

1 February 2020 and mentioned ISH Kirby
2 asset/liabilities. I want to note that the licencing
3 liability rating, the LLR, as defined by the AER, for
4 ISH Kirby asset is around 1.7.

5 We understood that when we began this appeal that
6 this would be a hard fight with an entity like CNRL on
7 the other side. However, I never imagined that CNRL
8 would hurl out completely unfounded, very serious
9 accusations that are clearly aimed at ending ISH as a
10 company as well as ending the careers of senior
11 personnel at ISH, including me. Thank you.

12 MS. BERG: Madam Chair, that concludes
13 the rebuttal evidence. The ISH panel is now open for
14 questions.

15 THE CHAIR: Thank you.

16 Ms. Jamieson.

17 MS. JAMIESON: Madam Chair, may I have five
18 to ten minutes to confer with my clients?

19 THE CHAIR: Sure. Let's take a ten-minute
20 break. Well, let's take a break and reconvene at 2:45.

21 MS. JAMIESON: Thank you very much.

22 (ADJOURNMENT)

23 THE CHAIR: We must be getting closer to
24 the end of the day. The message we got from Ms. Turner
25 at this time was simply "come back," not "we're ready
26 for you," not "come back when you're ready," just "come

1 back." So here we are. So, Ms. Jamieson, over to you.

2 MS. JAMIESON: Good. Thank you very much.

3 Ms. Jamieson Cross-examines Canadian Natural Resources
4 Limited (Rebuttal)

5 Q MS. JAMIESON: So I do have a set of
6 questions, and they're really just for Mr. Vermeulen.
7 Yes. Thanks for unmasking.

8 So, Mr. Vermeulen, in your rebuttal evidence just
9 now, you made a series of comments regarding Canadian
10 Natural's seismic methodology, and I just have a set of
11 questions to try to derive some clarity around that
12 issue, if we could.

13 So the first one -- I'd like to just bring up
14 Exhibit 89.01 from yesterday. It was ISH's Aid to
15 Cross-Examination Number 3. Thank you.

16 So -- and this is not a field I'm very
17 knowledgeable about, Mr. Vermeulen, so bear with me if
18 I could, but I understood one of your --

19 MS. BERG: Sorry. One moment. Oh,
20 there. I was just wanting the exhibit to come up.
21 Sorry, JoAnn.

22 MS. JAMIESON: Thanks.

23 Q MS. JAMIESON: I just understood some of your
24 comments related to some of your earlier -- some of the
25 earlier questions that Ms. Berg had about this
26 document. So let's just give this a try.

1 So, first of all, the questions that Ms. Berg were
2 asking related to this document, I understood as
3 relating to workflow; is that correct?

4 A MR. VERMEULEN: Yeah. Yeah, that's correct.

5 Q I think I -- my recollection is the suggestion was that
6 Canadian Natural, you know, wasn't following the
7 recommended workflow that came from this Attribute
8 Studio software. Is that -- am I on the right line
9 there?

10 A Well, it was just that -- the point, I guess, that ISH
11 was trying to put across was that the Attribute Studio
12 contains the entire workflow for advanced quantitative
13 interpretation, and if CNRL made use of that -- that
14 workflow was -- was really the -- the question.

15 Q So you weren't suggesting the actual workflow is --
16 this is a sales brochure. You weren't suggesting the
17 actual workflow was in this document, were you?

18 A No, no, no.

19 Q And you could have, perhaps, provided a peer-reviewed
20 workflow published in one of the journals that would've
21 described the workflow?

22 A I suppose I could've, yeah.

23 Q Mr. Vermeulen, now, I appreciate just some of the
24 confidential information requests, but I -- I don't
25 think it's going to be a problem, but the request from
26 the IR -- and I don't think we need to bring it up, but

1 we could, but our recollection was that you requested
2 the pre-stack migrated volume. Can you confirm that?

3 A I did, yeah. That --

4 Q Right.

5 A The SEG-Y volume?

6 Q The actual data, the actual pre-stack migrated volume.

7 A Yeah.

8 Q Yes. So you requested that.

9 And then would you agree that, in general, that
10 pre-stack migration data is superior to post-stack for
11 image faulting?

12 A You know, in -- in general, I would agree with that
13 statement, but after reviewing the semblance depth
14 slice, I guess, that was created from the -- the
15 pre-stack time migration, I would be concerned that the
16 acquisition footprint wasn't sufficiently (AUDIO FEED
17 LOST) in the processing, and so then I would -- I would
18 say --

19 THE COURT REPORTER: Sorry, Mr. Vermeulen. Your
20 mic cut out a bit there.

21 MR. VERMEULEN: Sorry.

22 THE COURT REPORTER: If you could --

23 A MR. VERMEULEN: I'll just repeat myself.

24 The pre-stack time migration that was used to
25 create the semblance depth slice, which demonstrated
26 that there was still quite a bit or even an enhancement

1 of the acquisition footprint, would be of concern
2 and -- and so that's what I would say about that.

3 Q MS. JAMIESON: You're saying that that would
4 be a concern, but you don't actually have any evidence;
5 there's no evidence on the record that you could point
6 to that in some way Canadian Natural's acquisition
7 footprint was sufficient, can you? Is there evidence
8 you can point to that would support that concern?

9 A Well, the smearing on the -- the semblance depth slice
10 would be, I guess, the evidence that would show that
11 there is -- you know, compared to the post-stack
12 migrated semblance time slice, you know, the -- the
13 acquisition footprint was -- was quite a bit more
14 pronounced on the pre-stack time migration.

15 Q Okay. And then can -- I'd like to just ask you about
16 resolution limits. How did you calculate your
17 resolution limits?

18 A Well, I -- I was basing this just on a simple
19 back-of-the-envelope calculation based on the
20 frequency, the velocity, and the depth of -- of
21 displacement.

22 Q Back-of-envelope frequency and -- sorry, what was the
23 other part of your answer?

24 A So the hundred-hertz dominant frequency within the --
25 the Wabiskaw McMurray zone that was given yesterday,
26 and then the velocity from 49.02, figure -- or Tab 4F,

1 I believe. CNRL had provided the velocity model that
2 they -- they had used for the depth conversion. Yeah.

3 Q So I believe Canadian Natural actually said that the
4 frequency for the Wab and the McMurray was 105 to 110.

5 A Okay.

6 Q Do you recall that, sir?

7 A Yeah. I -- I do recall that, actually, yes. Five --
8 like, 5 hertz would make a very minimal impact on -- on
9 my back-of-the-envelope calculation.

10 Q Now, can -- are you aware of the Rayleigh -- sorry,
11 excuse me -- the Rayleigh criterion, which I understand
12 is a quarter wavelength?

13 A Yeah, yeah. Tuning effect. I am -- I am aware of
14 that, yeah. And if you -- if you take the wavelength
15 that I provided and you divide it by four, then that's
16 sort of the -- the vertical resolution of the -- the
17 seismic. This is what would be considered the absolute
18 best-case scenario for -- for seismic or almost, like,
19 the theoretical. Once you throw in things like
20 acquisition footprint or -- or random noise and -- and
21 other things that are going to disturb your signal,
22 that changes.

23 Q Okay. And what about the Widess criterion resolution,
24 the detection limit; are you aware of what that is?

25 A Could you clarify for me.

26 Q Well, my understanding --

1 A Is that the lateral -- like, are you --

2 Q Yeah.

3 A -- referring to lateral resolution? Yeah, yeah. Okay.

4 Q Yes. And what would it be? What's the limit of
5 detection?

6 A You know, in -- in this case, I -- I would say that the
7 limit of detection is your bin size.

8 Q The limit of detection is your bin size.

9 What about one eighth, the wavelength?

10 A Again, that would be a more theoretical and not
11 practical calculation.

12 Q Have you calculated it here, the Widess criterion of
13 the one-eighth wavelength for seismic detection limit?
14 I need some sense, sir, of what detection limits you're
15 applying to the seismic.

16 A I'm -- I'm really just considering the -- the fact that
17 your stack trace -- your stack traces are
18 12-and-a-half metres apart and if you had a -- the
19 point that I was trying to -- to put across, though, is
20 that if you had a vertical or subvertical fault, that
21 you would -- you would really have only, you know,
22 one -- one CDP or maybe two CDPs of -- of imaging
23 capabilities on those faults. And so it would be
24 really hard to detect a -- a perturbation caused by a
25 fault on the seismic stack section, which -- in my
26 experience, I -- you know, working in -- in the

1 Fort McMurray area where, you know, even with very
2 large faulting and extreme salt dissolution and
3 collapse, with seismic of the similar acquisition
4 parameters and -- and almost similar depths, you know,
5 I -- I was not able to see faults that were offset by
6 7 metres just by going to the stack section. I was
7 using enhanced interpretation tools, you know, such as
8 the semblance and such as, you know, like, this fault
9 attribute that Attribute Studio has by a -- a different
10 software provider.

11 Q Okay. So some of that's theoretical, and some of it,
12 it sounds like you actually applied this -- this
13 seismic data set. Would you agree with me that,
14 generally speaking, you need a detection limit of 2
15 to 3 -- at least something needs to -- you have to have
16 a detection limit above 3 metres to actually see
17 anything on seismic? Do you agree with that? Like,
18 I'm not hearing any hard numbers from you, so I'm
19 trying to find out what detection limits you were
20 applying.

21 A Well, I -- I'm not certain of the -- the question,
22 actually.

23 Q In ISH's evidence, we understood that you were
24 asserting that there was a 7- to 7-and-a-half-metre
25 fault of some sort and --

26 A Yeah.

1 Q -- the question, really, to you is -- sorry. Let me
2 just finish. The question is: Shouldn't that be
3 showing up on the seismic lines that you were provided,
4 if it was, in fact, there?

5 A No. I -- and this is what I'm -- I'm challenging, is
6 that with -- you know, when you're only sampling that
7 fault with a fold of 15 and with the velocities and the
8 frequencies that -- that CNRL had given and from my
9 personal past experience interpreting faults within the
10 Fort McMurray area, I find it extremely difficult
11 to detect a fault with 7 metres of -- or -- or of
12 displacement.

13 Q Back to the Widess detection limit, shouldn't a 7-metre
14 fault be imaged?

15 A Well, again, I -- I would go back to the fold of your
16 Kirby North 2008 3D data set and -- and the frequency
17 and -- and in my past experience. I -- I -- with a
18 data set that was, like, extremely similar to the
19 parameters with, you know, line intervals in the 100-
20 to 125-metre range and -- and source and receiver
21 intervals in the 25-metre range. I -- I disagree
22 with --

23 Q Okay. I'll just --

24 A -- with the -- well, the statement that you guys
25 could -- could image faults of 7 metres' displacement.

26 Q Just one moment.

1 A Sure.

2 Q Sir, just for clarity, you're saying that based on the
3 information you received, the seismic semblances, you
4 were -- to you, you're inferring that the work perhaps
5 wasn't done, but that's -- that's not your -- is it
6 possible that Canadian Natural did the work. We know
7 this is confidential 3D seismic. They said in their
8 submission -- they explained what the 3D seismic was
9 all about, and they shared with you their conclusions?

10 A Yes.

11 Q So your view is not -- I just want it clear for the
12 record. Is it possible that all that work was actually
13 done but didn't show up in the semblance slices you
14 requested?

15 MS. BERG: Sorry.

16 Q MS. JAMIESON: Is that a possibility?

17 MS. BERG: Sorry. I'm going to
18 interject. That's a hypothetical, and -- and all
19 Mr. Vermeulen can speak to is the evidence that's on
20 this proceeding and what CNRL did or did not do,
21 really. I -- I -- I don't see how having Mr. Vermeulen
22 respond to that question gets us anywhere on such a
23 hypothetical. If CNRL wanted to put that evidence on
24 the proceeding, it could have.

25 MS. JAMIESON: Thank you.

26 Madam Chair, if I could try the question another

1 way.

2 Q MS. JAMIESON: Mr. Vermeulen, is it possible
3 that the work was done but that you have not observed
4 it?

5 MS. BERG: And I'm going to raise the
6 same --

7 A MR. VERMEULEN: Okay.

8 MS. BERG: -- issue. All that
9 Mr. Vermeulen can speak to -- and -- and -- is the
10 evidence that he saw in this proceeding. Maybe we need
11 a ruling on this issue.

12 MS. JAMIESON: No, that's fine. I'll move
13 on. Thank you.

14 Q MS. JAMIESON: Mr. Vermeulen, do you agree
15 that significant erosion at the Paleozoic unconformity
16 has taken place at the KN06 box?

17 A MR. VERMEULEN: Do I agree with that?

18 Q Yes. Based on the evidence that you have reviewed.

19 A Based on the evidence that I've reviewed -- and -- and
20 really I've -- I've only looked at the seismic data
21 in -- in great detail -- I would say that it's
22 plausible, yeah.

23 Q And do you agree that there's structural variations at
24 that unconformity as a result of this erosion?

25 A I would say that that's a plausible interpretation too,
26 yes.

1 Q Do you agree that erosion is a more likely explanation
2 for the structures that are observed rather than the
3 faulting?

4 A Well, I think that in order to comment on that, I would
5 go back to what ISH had requested or even suggested in
6 their response to CNRL's submission. It was that, you
7 know, the semblance slice does show discontinuities on
8 it, and, you know, semblance is -- is calculated to
9 show subtle structural and stratigraphic features that,
10 you know, maybe the interpreter can't readily pick up
11 visually.

12 And so ISH had suggested that CNRL provide slices
13 above and below the mid-B1 mudstone level and -- and
14 instead CNRL had decided to switch the domain to a
15 depth domain and use a different volume, and -- and it
16 just kind of -- to me, it -- it was a simple request,
17 and -- and it -- it -- so without that evidence, I
18 don't think I could -- I could concretely confirm that
19 it isn't structured.

20 Q Okay. Thank you.

21 So a couple last questions. It sounded like you
22 did agree or confirm that you were able to see erosion,
23 but you were unable to see faulting. It's just
24 confusing that --

25 A I didn't give confirmation of faulting; right? So
26 the -- the -- the semblance slices, if they were to

1 have been provided above and below, those
2 discontinuities that we saw within the KN06 drainage
3 box and outside would've had a lateral and a vertical
4 extent, and if they terminated quickly, then -- then we
5 could conclude that -- that the -- the faulting or
6 fracturing was -- was unlikely. If -- if we did see
7 these discontinuities continue with some extent,
8 then -- then I would lean to a more structural
9 interpretation.

10 Q I -- I may have a -- what about on the seismic line?
11 If I asked you that question again, were you able to
12 see erosion but you did not see any faulting on the
13 seismic line, for one?

14 A Well, here, again, is -- is -- you know, I would say
15 that the -- the person with the most information has --
16 has the ability to make the correct interpretation, and
17 having just two single cross-sections going north-south
18 and east-west probably isn't enough to -- to make a
19 correct interpretation.

20 Q Okay. Thank you, Mr. Vermeulen. One last question.

21 Do you agree that this VVAz and then VAVz [sic]
22 seismic interpretation techniques are really
23 controversial at best in the geophysical industry right
24 now?

25 A You know what? I -- I didn't actually read the paper
26 that was -- that was mentioned today, but, of course,

1 you know, I'd say most new-ish seismic interpretation
2 techniques are -- are, you know, start off as
3 controversial and -- and because they haven't been
4 tested thoroughly enough, and -- and that's just the
5 nature of, you know, professionals. Some like to use
6 tools that they are familiar with and -- and some like
7 to play with their data set with new tools.

8 Q Okay. Okay. Sir, thank you very much, and I
9 appreciate your patience with my questions.

10 MS. JAMIESON: Madam Chair, I think that's
11 all we have for the ISH panel.

12 THE CHAIR: Thank you, Ms. Jamieson.

13 Ms. Hall or Mr. Poitras, do AER staff have any
14 questions for the ISH rebuttal panel?

15 MS. HALL: Thank you, Madam Chair.

16 Yes. I have just a few questions. The first
17 would be for Mr. Mathison.

18 Alberta Energy Regulator Staff Questions ISH Energy
19 Ltd. (Rebuttal)

20 Q MS. HALL: Mr. Mathison, with the
21 exception of the B1 and A2 mudstone intervals, both ISH
22 and Canadian Natural interpret heterolithic and
23 mudstone units compromising the B2 valley fill or post
24 B2 valley fill and heterolithic and mudstone units
25 within the B1 sequence to be deposited in relatively
26 shallow point bar and tidal flat settings respectively.

1 Can -- my question for you is: Can mudstone
2 facies in these depositional settings become fractured
3 and/or brecciated by processes other than faulting such
4 as pedogenic alteration?

5 A MR. MATHISON: Yes. Yes, they can. And I --
6 I don't deny that. What my issue is, that the
7 pervasiveness of these fracturing and not just in the
8 units that are close to this -- you know, close to
9 subaerial are -- are also fractured and often in the
10 same wells. So I think based on that, the -- the --
11 the weight of the evidence is that -- that these things
12 have probably -- probably represent fractures.

13 And, you know, I -- I'm certainly willing to admit
14 in a few cases they -- you know, they may be related to
15 that, and I have considered that.

16 Now, the one thing I do -- I disagree. I don't
17 agree with CNRL in their interpretation of the -- the
18 upper B1, what they consider upper B1. I suspect it's
19 more likely a bay fill -- bay-fill succession that --
20 in that it overlies -- it overlies a flooding surface
21 which has created -- and there is the creation of
22 accommodation space which gets taken up.

23 So it's a very brackish -- brackish deltaic units,
24 bay-filled deltas. So -- and -- and you can get
25 things -- you can get slump and rotation of stuff, and
26 I agree that -- with that.

1 But some of the other stuff, the -- that -- what I
2 would interpret to be shattering -- almost a shattering
3 of -- of some of these intervals, I don't think so.

4 And the other thing that -- that's of interest is
5 if you look at -- there's a whole number of things that
6 would indicate that we've had fluid flow going through
7 those what I have interpreted to be faults or
8 whatever -- fracture systems, and that -- that this has
9 led to cementation in the basement in -- in the
10 McMurray formation just overlying the -- the Paleozoic
11 but has also led to cementation up as high as -- I
12 have -- I have witnessed it in actually the 15-02 well.

13 It's incredibly compelling evidence that there's
14 fracturing all the way up to the Wabiskaw and that
15 we've had fluid flow that has -- has resulted in -- in
16 cementation up there in -- in highly disruptive strata.

17 So I -- you know, to go back to that, I -- I --
18 yes, I would admit, and the problem -- part of the
19 problem is we're -- we're dealing with -- with
20 pictures. Had we had the core, some of these things
21 could easily be resolved. But I -- I think that the
22 vast majority of them do represent fractures.

23 Q Okay. Thank you.

24 A Thanks.

25 Q And just a quick follow-up question. Is it possible --
26 would you say that it's possible that any of the

1 cementation could result from migration along permeable
2 pathways?

3 A Well, yes, certainly, it -- it would be. I think that
4 the question that I -- I tried to raise was that
5 without the geochemistry, the oxygen isotope or the
6 carbon isotope, we can't say for certain, you know,
7 where this -- where these fluids are coming from. I
8 mean, it -- it -- to me, it would -- would appear to be
9 not obvious but -- but a reasonable interpretation that
10 they are coming out of -- out of the Paleozoic given
11 that it's a carbonate unit and -- and the McMurray
12 formation.

13 The only other thing that I can think of in the
14 McMurray formation is -- I don't know. You know -- you
15 know, so there doesn't seem to be a source -- a local
16 source for -- for -- for carbonate within the actual
17 strata of the McMurray formation.

18 Now, I want to -- I have actually worked with this
19 data, and I've -- I've actually been a co-author on the
20 Wabiskaw B, and it was very useful. We were able to
21 determine that the -- what some people consider to be
22 concretions, and -- and we could, in some instances,
23 demonstrate that these were actually layers -- were
24 marine-sourced. The carbonate was marine-sourced, and
25 the temperature would indicate that it was subaerial
26 exposed.

1 So -- so you have to think of the source. Where
2 is your source of the elements? And then what are the
3 pathways that these -- these elements can move into
4 that formation? And I think the most recently --
5 reasonable interpretation is they probably come from
6 the Paleozoic going up into the overlying strata,
7 probably coming in along the fracture systems as we see
8 in the 02-01 well.

9 And -- and -- and -- and so I -- you know, I -- I
10 do believe that is it, but I can't prove that because
11 we do -- do not have the core evidence and the
12 geochemistry to -- to demonstrate that with -- with
13 certainty.

14 I think -- I believe -- have we frozen?

15 THE CHAIR: Ms. Hall, are you --

16 MS. HALL: I'm having some definite
17 connection issues.

18 THE CHAIR: Okay.

19 MS. HALL: I -- I --

20 MR. MATHISON: Did -- did you hear that?

21 MS. HALL: I -- some of, I think. I
22 think the people who needed to hear have -- our staff
23 has heard.

24 MR. MATHISON: Yeah. Okay. Thank you.

25 MS. HALL: Thank you for that.

26 MR. MATHISON: Yeah. Thank you.

1 MS. HALL: Okay. So those are my
2 questions for you, Mr. Mathison. Thank you very much.

3 MR. MATHISON: Yes. Thank you.

4 MS. HALL: And then I do have some
5 questions for Mr. Vermeulen, please.

6 Q MS. HALL: Mr. Vermeulen, you mentioned
7 some differences -- or you had spoken about some
8 differences between the two semblance maps provided by
9 Canadian Natural, and I believe those are at
10 Exhibit 30.02 at PDF page 120.

11 MS. HALL: And, Ms. Turner, no need to
12 bring these up. I think we were just -- just looking
13 at them recently so -- but this is just for the record.

14 Q MS. HALL: And also at Exhibit 49.02, PDF
15 page 24.

16 And we note that the colour scales used to
17 demonstrate semblance in these two maps are not
18 consistent between the post-stack time migration
19 semblance and the pre-stack time migration semblance
20 maps.

21 So if -- my question is: If both maps were
22 presented using a consistent colour scale, say, the
23 colour scale used for the post-stack migrated version,
24 how would the two maps compare?

25 A MR. VERMEULEN: Well, I -- I did notice the
26 same discrepancy in the colour scales, as you had --

1 had noticed as well, and I believe that the depth
2 converted semblance slice is actually a shift to the --
3 to the whiter side, and so that it maybe that the
4 features would have been diminished just because you
5 would expect those dissimilarity features to come out
6 the same. But because the pre-stack migrated volume
7 has such a strong or dominant footprint, that kind of
8 overrides it.

9 But the other thing that is of a concern and I
10 need to point out is that one's in depth and one's in
11 time. And so the -- I guess the processes is what you
12 stretch your -- your -- your seismic traces from the
13 time domain to the depth domain. It can also cause
14 distortions in your volume. In this case, it would be
15 a semblance volume.

16 So I'm -- I -- I almost have to say that I -- I
17 can't answer your question, is what it would look like,
18 because they're apples compared to oranges,
19 essentially, is -- is what it is.

20 Q Thank you, sir. And just one moment, please.

21 MS. HALL: Those are my questions. Thank
22 you, Madam Chair.

23 And thank you, Mr. Vermeulen.

24 THE CHAIR: Thank you, Ms. Hall.

25 Commissioner McKinnon or Commissioner Zaitlin, any
26 questions for you?

1 MS. MCKINNON: None from me.

2 DR. ZAITLIN: None from me. Thank you.

3 THE CHAIR: And none here either.

4 So I think that means that I can thank the ISH
5 rebuttal evidence panel for their time this afternoon
6 and let you know that you are now dismissed.

7 And that brings us to the end of the day today.
8 Tomorrow we are scheduled for closing argument starting
9 at 9. I think we are expecting one written filing
10 later today to complement information that we had
11 orally on the record this afternoon. And, otherwise,
12 as far as I'm aware, that's it.

13 Ms. Berg or Ms. Jamieson, is there anything that
14 I'm missing or anything we need to deal with before
15 tomorrow?

16 MS. JAMIESON: No further comments from us,
17 and we will -- I assume we can just file that updated
18 table as part of our undertaking response through
19 Ms. Turner. Would that be --

20 THE CHAIR: Yes.

21 MS. JAMIESON: -- appropriate?

22 THE CHAIR: -- please. Yeah.

23 MS. JAMIESON: Okay.

24 THE CHAIR: That would be appropriate,
25 yeah.

26 MS. JAMIESON: We'll do that.

1 MS. BERG: And -- and nothing from us
2 either. Thank you.

3 THE CHAIR: Okay. Thank you.

4 Thank you. Well, then, we are adjourned until 9
5 tomorrow morning. Thank you.

6

7 PROCEEDINGS ADJOURNED UNTIL 9:00 AM, OCTOBER 16, 2020

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

1 CERTIFICATE OF TRANSCRIPT:

2

3 We, Andres Vidal and Sarah Howden, certify that
4 the foregoing pages are a complete and accurate
5 transcript of the proceedings taken down by us in
6 shorthand and transcribed from our shorthand notes to
7 the best of our skill and ability.

8 Dated at the City of Calgary, Province of Alberta,
9 this 15th day of October 2020.

10

11

12

13



14

Andres Vidal, CSR(A)

15

Official Court Reporter

16

17

18

19



20

Sarah Howden, CSR(A)

21

Official Court Reporter

22

23

24

25

26

0	10,16 403:12,20 442:12 443:7,8, 10,12,16,22,24	139 399:24 401:16 402:6 407:24	1927181 329:8	361:6 368:21 369:9 409:3 413:9 442:12,24, 25 444:1 465:7 466:9
0.01 377:23	10-34 442:17 443:5,16	14 345:11 354:13 380:15 393:14	197 376:22,25	204 334:23 335:2
0.1 377:20	10-metre-by-50- metre 379:24	143 398:8	198 377:2	20th 339:18
0.2 374:12 375:5	10-ohm 437:14	14th 368:21 434:20 435:2,3, 12	199 376:22 377:5	21 366:19
0.98 381:22	100 341:7,9 379:16 422:11	15 329:26 330:5, 14 331:5 395:15 409:3 423:3 442:25 452:7	1:15 408:20,21,23	22 375:3
008 346:9	100- 452:19	15-02 459:12	1:17 410:4	224 435:5,12
02-01 432:26 461:8	105 449:4	15-metre-thick 393:19	1A 426:16,17	228 355:4
02.01 426:10	106 346:9,16,18 370:9	154 371:24 375:2	1AA/11-01 424:4	2I 412:9 413:11
041 348:8	1066 336:18,21 357:4 411:15	155 374:5	2	2nd 403:11
04I 348:8	109 397:17	158 370:8	2 355:4 372:4 395:10 428:23 432:1,22 434:20 435:3,6 437:4 438:26 451:14	23 429:9
05 426:16	10:15 358:2	15B 356:26 357:2 365:7 410:18,21 411:15 412:5,19 413:4,11	2,000 347:13	23rd 339:17
06-01 436:15 437:14,23 440:13	10:30 361:26 362:12 363:6	15th 339:16 466:9	2,500 422:13	24 430:18 439:1 462:15
07-01 438:11	11 334:11 426:21 439:26 440:4	16 340:17 424:1 465:7	2,750 422:13	243 402:6
1	11-01 393:18	16-35 443:16	2.01 344:5 355:4 399:24 401:15 407:23	25 370:9 395:17 431:23
1 337:12 355:4 375:15 378:6,11 379:15 380:1 381:22 395:13 411:26 412:1,9, 13	11-metre 440:24	168 372:4,11	25-metre 452:21	25-to-28-metre 422:16
1-metre 416:5	110 449:4	17 423:26 429:1	26 439:1	279 368:21
1.7 444:4	1113 419:26 420:7	1712215 408:2	29 370:17 426:10	29.01 383:19
1.8 378:15	1116 422:15	172 438:26 439:5	29.02 435:21,25 439:26 440:2	2:45 444:20
10 358:2 375:4 376:3 377:9 378:20 379:20 380:4 389:26 405:19 436:22 437:15 439:5	118 440:8	178 370:9	3	3 329:15 406:5 422:25 445:15 451:15,16
10-01 334:23 335:10 336:16 337:12 338:15 339:13,15 343:21 344:22,24 345:14,25,26 346:23 347:2,4, 11 361:4,5,11,12 380:18,21 383:8,	12 334:10 395:22 399:25 429:2	18 378:10,12 397:16 416:7 424:15	2008 421:5 422:12,22 423:2 427:4,9 452:16	3-foot 341:20
	12-and-a-half 450:18	180 391:26	201 334:23 335:2 339:12	30 336:21 356:6 427:23
	12.5 422:23	187.1 438:4	2011 408:3	30-02 336:20
	120 419:19 462:10	188 377:3	2013 408:4	30-minute 356:17
	125-metre 452:20	19 427:1	2014 403:11,24	30-minutes 356:7
	127 355:11	191 406:4	2015 339:5,17	
	13 333:18,20 435:8		2019 335:20,24 336:15 337:13,15 338:10 346:5 355:24 356:4 361:13 412:2 442:22	
	133 370:17		2020 329:26 330:5,14 331:5 337:13 338:11	

<p>30.02 355:10 370:5 371:23 372:3 374:4 397:15 404:10 406:4 419:19 425:13,20 427:21,23 440:4, 9 462:10</p> <p>300 403:23</p> <p>31 398:5</p> <p>312 434:21 435:4</p> <p>33 434:12</p> <p>332 330:5,6</p> <p>333 330:7</p> <p>34 371:24 374:5</p> <p>35 341:5</p> <p>36 370:6</p> <p>368 330:9</p> <p>37 355:20 356:9, 13,23</p> <p>38 370:6</p> <p>380 392:3</p> <p>386 330:11</p> <p>39 433:2,5,7</p> <p>3D 391:4 392:21 394:3,24 396:20 397:7 421:5 422:12,22 423:2 452:16 453:7,8</p> <p>3rd 413:9</p> <hr/> <p style="text-align: center;">4</p> <hr/> <p>4 395:13 439:5</p> <p>4-1 333:4</p> <p>40 395:10 404:20</p> <p>40-metre-deep 395:16</p> <p>40-metre-thick 394:8</p> <p>41 434:7</p> <p>410 330:14,15</p>	<p>413 330:17</p> <p>419 330:19,22</p> <p>42 370:8 372:3</p> <p>43 359:18 365:12</p> <p>442 339:20</p> <p>445 330:23</p> <p>45 333:18 376:22</p> <p>455 375:2</p> <p>457 330:25</p> <p>465 397:24</p> <p>466 331:1</p> <p>470 397:23</p> <p>477 359:21,26 365:11 374:26 413:4,15</p> <p>477-metre 412:21</p> <p>48 336:22 337:9 346:8,16,19,20 442:15</p> <p>48.02 336:22 337:9 345:10 346:17 356:24 357:2 365:6,7 380:15 411:15 442:15</p> <p>484 412:10 413:12,14</p> <p>489 412:4,9</p> <p>49 336:18</p> <p>49.02 419:26 420:5 422:15 448:26 462:14</p> <p>490 357:6 359:10 365:8</p> <p>492 436:22</p> <p>493 437:7</p> <p>495 357:6 359:10 365:8</p> <p>498 436:26 437:4, 5</p> <p>4F 448:26</p>	<hr/> <p style="text-align: center;">5</p> <hr/> <p>5 405:19 412:7,8, 10,12 449:8</p> <p>5-and-a-half 340:14</p> <p>5-metre 393:19</p> <p>5-metre-thick 394:12</p> <p>50 340:24 341:8, 12,17 379:21 404:20</p> <p>500 437:1,3,16</p> <p>501 437:17</p> <p>51 354:6</p> <p>53.02 433:4,5</p> <p>54 338:9,14</p> <p>58 344:5 348:2,7, 11 360:9</p> <hr/> <p style="text-align: center;">6</p> <hr/> <p>6 340:14 348:10, 22,24 353:15 360:21 361:2 382:24 398:11 399:6 440:23</p> <p>6.6-metre 438:13</p> <p>60 391:15</p> <p>602 338:8</p> <p>61 349:15</p> <p>63.01 399:21 403:8</p> <p>65.01 333:4,18 340:16</p> <p>65.02 433:3 434:7</p> <p>679.1 437:26</p> <p>681.3 437:23 438:1</p> <p>692 355:16</p>	<hr/> <p style="text-align: center;">7</p> <hr/> <p>7 334:12 339:17 340:8,14 342:3 349:4 353:4,17, 19 354:12 382:24 383:20 398:11 399:12 413:14 423:5 436:24 442:12 451:6 452:11,25</p> <p>7- 451:24</p> <p>7-and-a-half- metre 451:24</p> <p>7-metre 422:7,18 452:13</p> <p>7.5 440:25</p> <p>700 443:10</p> <p>71 439:6</p> <p>76 339:12</p> <p>7th 361:6</p> <hr/> <p style="text-align: center;">8</p> <hr/> <p>8 334:11 353:4 376:21 383:19</p> <p>80 340:26 341:9, 12,17</p> <p>80.02 412:24</p> <p>81.01 339:2 341:4</p> <p>82 430:19</p> <p>84 339:13</p> <p>86 354:6</p> <p>88.01 341:15</p> <p>88.02 348:2 349:15 359:18 360:9 365:12,24 389:25 412:26 423:26 427:1 429:9 430:19</p> <p>88.03 434:12</p> <p>89.01 445:14</p>	<hr/> <p style="text-align: center;">9</p> <hr/> <p>9 464:9 465:4</p> <p>90 378:26 379:11</p> <p>92 427:21,22 428:13</p> <p>95 387:23 425:14, 21</p> <p>96 352:22 355:12 378:5,6,10,12 428:14</p> <p>99 379:16</p> <p>9:00 332:6 465:7</p> <hr/> <p style="text-align: center;">A</p> <hr/> <p>A' 436:4</p> <p>A2 457:21</p> <p>AA 437:25</p> <p>AA/06 438:4</p> <p>AA/06-01 436:10 440:13,14,17</p> <p>AA/07-01 436:11,24 437:24,26 440:13,18</p> <p>AA/11-01 426:21 428:3</p> <p>AB/12-04 415:13 416:4</p> <p>abandon 403:12, 26</p> <p>abandoned 443:5</p> <p>abandonment 392:22 395:19 404:3</p> <p>ability 352:14,15 392:14 421:2 456:16 466:7</p> <p>absence 417:8 420:25</p>
---	---	---	---	---

absent 420:20
431:21
absolute 449:17
Absolutely 364:7
374:18
academic 369:15
396:13
accepted 371:26
access 337:6
accessed 430:3
accommodate
407:2
accommodation
458:22
accomplishment
422:10
accounted
332:24 371:2
accounts 371:10
accuracy 400:2
accurate 413:7
466:4
accurately 426:4
accusations
443:14 444:9
accusing 443:8
acknowledge
352:10
acquisition
420:26 421:11
422:26 423:3
447:16 448:1,6,
13 449:20 451:3
act 340:7 378:25
active 367:23
actual 432:24
446:15,17 447:6
460:16
Adam 427:9
Adams 426:26
427:4,9,11,16
add 359:16 389:7
392:21 422:26

added 412:7
adding 424:17
additional 349:6
361:3 362:5
365:22
address 362:23
414:24 431:23
442:7,10
adequate 354:22
adjacent 387:19
422:24
adjourned 363:5
408:21,23 465:4,
7
**ADJOURNME
NT** 363:7 444:22
admit 458:13
459:18
advanced 446:12
advancements
423:10
advice 363:26
advise 338:16
363:1
advised 362:4
AER 329:14
331:11,12,13,14,
15,16,17,18,19,
20,21 332:14
338:10 348:3
368:8 378:7
382:25 408:2
409:10,11,12,13,
14,15,16,17,18,
19,20 417:19
444:3 457:13
AER/AGS
387:23
aeromag 388:4
aeromagnetic
387:7,13
affect 375:23
affirmed 330:21
418:26 419:4

affix 383:16
afternoon 330:14
364:16 391:2
409:3 410:5,20
464:5,11
age 396:12
agree 339:22,24
340:7 341:9,11,
16 342:13,19
349:25 350:7
361:8 369:2
397:2 447:9,12
451:13,17
454:14,17,23
455:1,22 456:21
458:17,26
agreed 347:3
439:2
agreement
403:12
ahead 353:24
358:8 389:6
418:15
Aid 445:14
aimed 444:9
alarm 345:23,26
346:2
Alberta 329:2,9
330:9,11,17,25
368:11 386:24
396:16 413:22
457:18 466:8
allegation
442:11,14 443:5
allegations 442:7
allowed 391:25
423:12
allowing 398:11
443:19
alluded 344:22
391:1
alteration 458:4
alternate 386:17

amount 399:15
406:26 441:2
amplifying
421:11
amplitude
341:20 342:4
368:23,25 421:26
422:2
analogue 366:18,
23
analyses 368:18,
24 369:1,3 370:5
371:8
analysis 341:12
372:22 391:5
423:9 426:3
analyze 341:25
analyzing 336:3
346:1
Anastasia 350:19
and/or 458:3
Andres 466:3,14
annotated 433:2
annual 338:9
anomalies 388:4
419:18 420:20,26
421:10
anomalous 336:3
337:23 434:18
answering
361:23 381:24
answers 359:11
386:10 413:16
417:11 418:4
anymore 430:9
APEGA 377:2
aperture 375:14
apologies 424:11
427:19,24 433:2
439:7
apologize 334:7
368:2
apparent 362:2

appeal 329:8
444:5
appears 372:4
377:2 393:2
395:23 397:21
399:21 402:16
406:8 430:25
apples 463:18
applicable
369:21
application
344:7,18,19
402:26 403:3,4,
18 408:2,3,8
applied 354:10
372:19 451:12
applying 450:15
451:20
appreciated
333:12 363:2
419:20
approach 356:14
371:16 383:3
approval 344:8
approximate
419:17
approximated
421:17
approximately
378:11
approximates
428:2
April 442:22
aquathermolysis
383:26
architecture
391:4 394:14,25
395:6
area 334:8 344:9
375:15 379:6,19,
26 380:2 387:6,
13 388:2,3,20
389:22 392:1
395:4 416:7

438:18 451:1
452:10
areas 369:8
387:16 396:20,21
arguably 421:18
argue 396:26
437:10 439:20
440:19
argument
364:10,19 421:12
464:8
arguments
364:12
arise 400:7
401:19 414:12
arising 365:14
403:7
arranged 411:24
arrivals 342:14,
17,20 343:2
article 369:9
articulate 349:5
360:25
aspect 382:22
aspects 385:12
asserting 451:24
assess 376:23
383:6,14
assessed 377:16
assessing 344:12
assessment
344:7 377:4
379:2
asset 388:7 444:4
asset/liabilities
444:2
assets 387:17
388:1
assigned 350:20
assist 347:26
364:14
assume 344:15
378:4,26 389:20

398:4 400:17
402:1 464:17
assumed 371:8,9
373:22 375:8
378:4 380:3
394:15
assumes 370:23
assuming 375:21
378:11 382:16
399:18 402:5
assumption
359:20 365:11
371:12 378:19
assumptions
403:13
Athabasca
427:18
attempt 347:25
349:10 362:23
attempting
349:5 352:18
383:4
attendance
418:4
attention 430:18
431:23,26
attribute 446:7,
11 451:9
attributes 423:12
AUDIO 447:16
August 336:15
authors 427:16
AVAZ 369:6,13
average 356:5,8
357:5 365:8
averages 334:12
averaging
356:16
avoid 416:14
aware 402:11
417:9 449:10,13,
24 464:12
azimuth 368:23,
24 422:2

B

B' 345:12
B1 405:17 426:15
431:2,10,14,20
457:21,25 458:18
B2 374:8 385:21
390:5,23 391:1,4,
7,10 392:14,17
393:1,6,8,17
394:1 396:1
397:22 416:10
430:22,23,25
441:22 457:23,24
back 332:8 333:5
351:19 352:6
355:24 357:11
358:11 360:9
361:26 362:19
376:6 384:20
399:4 400:19
401:1,9,14
403:24 404:16
408:13 415:4
417:3 420:9,16
422:3 428:11
440:14 441:15
444:25,26 445:1
452:13,15 455:5
459:17
Back-of-
envelope 448:22
back-of-the-
envelope 448:19
449:9
background
419:14 440:15
backwards
412:14
balance 381:17
balanced 381:21
382:10
bar 392:24
395:17 457:26

barrier 335:13
345:17 347:16
370:12,14,19
380:23 383:21
385:16,17 393:22
404:10,24,26
405:4,7,8,9,12
406:12,17,19
407:3,4 428:6,10
429:5
barriers 376:25
377:14 394:10
395:26 405:3
415:12 428:20
bars 395:12
396:10,11
basal 390:6,20,22
394:18
base 374:22
390:15 394:17
395:14 396:20
424:7,14,21,24
430:23 432:3
438:23
based 365:12
372:3 374:21
377:6 379:3
391:4 427:17
428:18 440:18
448:19 453:2
454:18,19 458:10
basement 459:9
basically 389:20
basing 448:18
basis 336:26
364:26
bay 458:19
bay-fill 458:19
bay-filled 458:24
bear 445:17
bed 416:5
beds 416:16,23
425:8,11 434:12
began 444:5

begin 334:15,22
believes 361:5
belt 395:15
bending 439:16,
17
bends 428:24
benefit 364:18
benefits 367:2
Berg 330:7
331:23 333:11,
13,22,23 334:26
335:4,8 352:24
357:17,24,25
358:3,6,8,16,21,
24 359:1 361:19
362:3,7,10,21,22
363:10 364:10,
22,24 365:1,3,5,
20 368:6,16
402:19,22 403:5
407:17,19,26
409:22 410:25
411:2,5 412:24
413:1,18 418:9,
11,15,20 419:6
423:17,22 442:2
444:12 445:19,25
446:1 453:15,17
454:5,8 464:13
465:1
Berg's 364:18
410:22
best-case 449:18
BHP 349:3
360:13
bigger 392:2
416:5
bin 450:7,8
biodegradation
441:10
bioturbated
431:19
bit 358:14,17
362:19 394:21
414:4,6,25

429:10 433:20 436:19 447:20,26 448:13 bitumen 353:9 383:22 385:13, 19,22 386:1 388:13 439:12 black 346:23 347:14 431:6,7 bleeding 369:14 Blum 396:26 bond 338:25 339:3,4,18,23 340:8,10,25 341:1,6,18,23,25 342:18,25 343:5 bonding 342:15, 21 bonds 343:12 Boone 376:18,19 388:10,15 389:15 404:7,14 Botterill 331:14 409:13 bottom 334:26 335:7 351:4 382:8,11 395:3,6 402:6 424:6 427:11 431:6 436:15 437:2 bottomhole 349:19 382:5,7, 11 398:10 bounced 396:24 boundaries 390:9 416:14 boundary 390:7, 15 417:9 425:7, 10,12 426:16 bounded 392:8 bounding 390:6 box 333:26 334:9, 11 344:10 370:13 379:24,25,26	380:2 388:2 390:11 391:8,22 392:2,8,16 404:11 416:13 432:22 433:12 454:16 456:3 boxes 416:2 brackish 458:23 brackish-water 396:17 breach 383:21 breached 347:17 breaching 376:24 break 332:17,18 333:2,4 352:9 357:19 358:10, 11,15,17,23 359:16 360:3 361:22,25 362:5 363:1 365:21 400:22,25 401:1, 10 402:4 407:15 408:12,19 444:20 breakout 350:12, 16,17,20,24 351:2,5,10 357:11 384:5,13 400:19 breaks 358:6 396:4 breccia 394:20 415:8 breccias 415:11, 12,17 brecciated 458:3 brecciation 434:1 BRETT 330:20 419:3 bring 333:17 336:6 359:12 389:25 419:20,25 426:26 428:17 432:24 445:13	446:26 462:12 bringing 363:14 brings 464:7 broader 414:20 brochure 446:16 broken 393:19 433:21 broken-up 433:19 brought 430:5 440:1 brown 432:9 bubble 349:20 built 354:15,22 bullet 345:12 bumped 340:12 bushing 412:4 413:6,12,13 <hr/> C <hr/> cake 341:22 calculate 334:12 422:15 437:18 438:2 448:16 calculated 374:14,21 378:1 450:12 455:8 calculation 375:9,24 411:20 412:6 413:3 448:19 449:9 450:11 Calgary 466:8 call 376:6 390:6 441:6,7 called 369:12 389:19 calls 439:17 camera 418:18 cameras 418:21 Campbell 331:13 409:12	Canadian 330:7, 10,12,16,18,24 331:26 332:9,13, 16,22 333:13 334:8 344:22 354:21 358:12 361:26 364:20 367:2 368:11,22, 26 369:18,26 370:4,9,11,17 371:1,24 372:4,7 374:5 380:17 381:1 382:16,17, 19 384:12 386:24 394:13 402:10 403:10,11,15 407:13 408:10,13 409:25 410:12 413:9,22 415:1 417:19 418:3,18 424:23 445:3,9 446:6 448:6 449:3 453:6 457:22 462:9 cap 392:20,25 capabilities 450:23 capacity 390:24 caprock 371:7 caption 424:22 carbon 430:8 460:6 carbonaceous 431:8,9 carbonate 430:6 460:11,16,24 career 443:18 careers 444:10 carefully 411:22 carry 358:14,16 359:12 412:11 cartoon 391:2 case 343:10 371:21 378:14 395:3 402:1,14	403:14 450:6 463:14 cases 369:3 371:18 399:6 458:14 casing 343:4,8 345:5 349:22 category 379:1, 13 caused 450:24 CBL 341:3,10 342:4 343:12 CDP 450:22 CDPS 450:22 cement 338:25 339:3,4,18,23 340:3,6,8,10,11, 12,15,25 341:1,6, 22,25 342:1,14, 21,24 343:5 345:5 430:6 cementation 429:21 459:9,11, 16 460:1 cementing 430:5 centimetre 375:15 central 398:13 centre 429:14 430:13 centreline 429:14 certainty 461:13 Certificate 331:1 466:1 certify 466:3 cetera 418:8 chair 331:7 332:8,22,26 333:8 350:16 351:10,13,17,21, 24 352:1,3,6 357:18,23 358:1, 5,7,9,20,22,25
--	---	--	--	---

361:19,24 362:6, 9,11,21 363:5,8, 11,12,18,24 364:7,22,25 365:16,19 368:6, 10 384:8,11,16, 19,21 386:15,16, 22 397:11,12,14 398:17 400:21 401:6,9,13 402:13,17,21 403:2,6 407:10, 22,25 408:9,19 409:5 410:5,14, 21,24 411:2,13 412:25 413:21,25 414:2,8 417:12, 15,17,23,25 418:12,14,16,25 420:1 423:21 425:18 435:19 442:1 444:12,15, 17,19,23 453:26 457:10,12,15 461:15,18 463:22,24 464:3, 20,22,24 465:3	429:1,2 channeling 343:12 channelized 395:11 channelling 346:4 channels 393:26 397:8 428:25 429:3 characterize 369:3 charge 439:11 chart 397:18,21 427:3,10,12 428:6,7 charts 427:11 chat 343:11,15, 17,20 check 339:11,15 342:7 402:26 437:20 checked 443:12 Chen 331:15 409:14 chooses 423:7 chose 431:25 433:13 chosen 373:11 427:5,6,7,14 chromatography -mass 427:2 circled 393:21 circles 396:14 circulate 398:24 circulation 348:9,12 349:3, 22 356:10,15 361:2 376:8,9,14 382:26 383:2,5 398:10 circumstances 399:9	citation 346:14 415:7 City 466:8 claim 423:4 clarification 334:3 390:12 414:23 clarifications 348:3 clarified 383:25 clarify 348:18 367:18 368:1 370:26 372:7,10 375:7 408:6 449:25 clarity 414:4 445:11 453:2 classify 416:10 clast 434:11 clean 395:17 clear 360:17 365:17 413:17 421:4,12 442:10 453:11 CLEE 330:21 419:3 client 362:4 clients 444:18 climbing 352:18 close 389:20 420:8 438:7,21 458:8 close-up 432:1 436:15 closely 428:1 closer 437:16 444:23 closing 364:5,18, 21 464:8 CNRL 333:3 334:17 336:10, 18,19 337:18 338:9 339:19,22 340:7,19 343:15,	16,19 344:11 345:1,6 346:5 350:21 361:5,8, 12,21,22 365:26 366:8,13,14 367:9 368:4 387:4 389:7 390:3 402:15 403:1 408:7 412:20 420:13,25 421:5,16,19,24 422:3,6,14 423:7 424:19 425:15 426:26 427:5 429:9 430:21 435:9 442:15,17 443:4,7,10,12 444:6,7 446:13 449:1 452:8 453:20,23 455:12,14 458:17 CNRL's 336:1 339:13 344:7 348:4 361:4 371:15 419:14,22 421:8,12 423:4 433:4 443:11 455:6 co-author 460:19 coalesced 391:18 cold 375:19 collapse 387:21, 24 451:3 colleagues 350:9 357:20 359:16 418:8 collect 337:2 361:13,15 collected 335:12 344:23 collecting 335:24 346:1 356:2 collection 344:25 355:26 collects 336:2	colour 432:9 462:16,22,23,26 column 349:7 430:24,26 438:20 combination 423:13 combined 407:7 combining 423:8 COMMENCED 332:6 410:4 comment 395:7 400:4 423:15 441:14 455:4 comments 353:26 445:9,24 464:16 Commissioner 331:8,9 386:18, 20 409:6,7 463:25 commonly 371:26 communicate 350:9 communication 380:25 381:2,3,9 384:1 385:2,11 387:3 429:6 communications 386:18 compaction 441:16,20,25 company 443:20 444:10 compare 462:24 compared 341:3 395:4 448:11 463:18 comparison 346:22 compartmentali zation 396:6 compatibility 335:11 403:19
---	---	---	---	---

compatible 339:16 344:21	concludes 380:17 444:12	confirm 447:2 455:18,22	containment 368:19 370:12, 14,19 376:25 378:25 379:12 382:2,3 391:13 405:1 414:21	core 333:25 334:11 345:21,22 367:22 415:26 424:3,5,17,18,21 426:3 429:19 430:21 431:8,16 432:6,13,25 433:6,9,19,21 440:21 459:20 461:11
compelling 459:13	conclusion 379:10	confirmation 455:25	content 392:19	cores 334:4 429:25 433:3
competent 432:15	conclusions 453:9	confirming 345:17	CONTENT 330:1	coring-induced 429:13 430:10,13 432:2
complement 464:10	conclusive 348:21	confirms 380:22	CONTEXT 400:15 414:26 416:9	corner 402:7 424:6,13 427:4
complete 379:25 434:1 466:4	conclusively 360:26	conform 355:18	continuation 430:20	correct 337:16 338:12,13 339:5, 6 342:23 343:5 346:8 349:21,23 355:8,12,13 360:14 361:7,10 368:9 370:2 376:23 389:10 393:23 402:6 403:15 405:11 410:23 412:8,10, 15 424:11,16 427:2,21 432:20 433:3,4 440:10 446:3,4 456:16, 19
completely 397:1,4 429:17 430:7 444:8	concretely 455:18	confused 334:7 405:10 414:6	continue 335:17 456:7	correction 411:8, 9 443:1
complexities 396:2	concretion 430:1	confusing 455:24	continued 332:9	correctly 368:15 393:15 397:20,24 405:6
compliance 344:6	concretions 460:22	confusion 368:2	continues 344:23 443:21	correlation 345:14 346:6,26 347:4 380:20
compliance 344:12	condense 375:18	connection 461:17	continuity 405:23	cost-to-poisson's 373:22
compliant 345:5 403:21	condensed 354:19	conservative 356:14 371:11 373:11 392:5,11	continuous 392:26 404:11,25 405:8,15 415:25 426:24	could've 446:22
complicated 395:6	conditions 345:8, 23 375:26 396:18 397:9 398:13 417:9	conservatively 377:7 378:19	continuously 428:24	counsel 331:11, 12 363:23 364:1
complicated 395:6	conduct 443:20	considerably 441:9	contrast 374:7 379:5,7	
complied 436:13	conducted 335:20 339:19 341:13 387:4,15	consideration 377:13 389:3,13	control 389:17	
compositional 428:3,9,23	conductive 345:21	considered 341:7 343:20 426:23 431:2 434:10 449:17 458:15	controls 348:11	
compromise 443:18	conduit 383:16 385:21 386:4,5	considering 441:9	controversial 456:23 457:3	
compromising 457:23	conduits 387:3	constant 382:6	convening 362:24	
computer-frozen 425:23	confer 357:2,20 359:15 418:7 444:18	constitutes 417:2	conversion 449:2	
concern 337:26 364:9 367:14 401:24 448:1,4,8 463:9	confidence 365:26 366:6,9, 17 379:6	constrain 374:9	converted 421:14 463:2	
concerned 400:2 447:15	confidential 443:26 446:24 453:7	contact 393:7 394:20 435:14 437:10,16 438:10 439:3,13,16,18, 22	converting 420:15	
concerns 336:16 343:14 382:23 431:22	confinement 371:6 385:15	contacts 436:12 438:2,9,14 441:4	COO 443:17	
conclude 346:5 456:5	confining 366:22 368:25 378:17	contained 404:23 420:22	cool 375:18	
			coordinator 335:1	

366:5 409:10,11
410:7 418:8
couple 337:22
390:3 404:7
407:12 455:21
coupled 366:1,9
422:21
Court 332:3,4
351:25 352:2
410:1,2 417:23
447:19,22
466:15,21
cover 365:14
covered 417:20
CPF 399:2
Craig 334:25
335:21 339:1,6
341:20 343:10
344:14,17 347:7,
24 352:5,7,8
353:13 355:1,9
357:7,8 359:3
360:10,15
362:13,15 363:3
380:10 398:16,
17,19 403:17
442:5
Craig's 442:10
create 345:21
411:23 447:25
created 419:16
420:11 421:8,18
422:5 447:14
458:21
creation 458:21
Cretaceous
397:5
criterion 449:11,
23 450:12
cross 358:18
371:20 435:9,14
cross-
examination
391:2 423:25
445:15

Cross-examines
330:7,23 333:13
445:3
cross-examining
333:2
cross-response
422:6
cross-section
435:22 438:6
440:24
cross-sections
438:18 456:17
cross-stratified
393:8
crossing 404:5
407:10
CSR(A) 332:3,4
410:1,2 466:14,
20
cubic 378:15
current 347:12
369:20
curves 342:4
417:6
cut 447:20
cutoff 437:14
cuts 390:20
cylindricus-
dominated 397:5

D

D54 338:11,18,
19,20
daily 337:3,6
344:25
dangerous 439:9
dark 431:7
dash 336:21
dashed 397:22
data 335:12,16,
19,25 336:2,3
337:2,6 338:15,
19,20 343:7
344:18,23,25
345:15,26 346:1
355:5,17,19,23,
26 356:2,3,5,6,9,
22 366:22 367:1
380:18 387:13
397:15 415:4,15
417:8 423:3,9
427:8,17 428:18
430:8 442:18,20
447:6,10 451:13
452:16,18 454:20
457:7 460:19
data-collection
337:5
database 367:3
date 335:12
dated 442:25
466:8
David 330:19
419:2 443:3
day 364:9,17
444:24 464:7
466:9
days 339:19
354:13 396:14
402:9 415:3
deal 407:16
464:14
dealing 459:19
December
361:13 408:3
decided 455:14
decimeters 425:9
decrease 337:25
decreases 382:11
decreasing 382:7
deep 395:10
deep-seated
388:4
define 371:14
defined 444:3
definite 461:16

degradation
439:11
degree 434:15
deliberate 442:9
deltaic 458:23
deltas 458:24
demonstrate
366:17 393:5
438:17 460:23
461:12 462:17
demonstrated
421:14,20 447:25
demonstrates
353:17
density 343:10
349:2 369:4
370:16 376:2
422:17
deny 458:6
dependency
388:19
dependent 349:9
388:12
depending
379:21
depends 358:4,5
360:25
depicted 390:13
391:9
depiction 391:3
deposited 457:25
deposition 438:8
441:9
depositional
458:2
deposits 392:25
394:12 416:19
depth 340:2
357:8 359:21,23
360:1 365:11,13
374:21 375:1
410:18 411:18
412:3,4,9,14,21
413:3,5,8 420:13,

15,19 421:9,14
436:21,26
437:19,22
447:13,25 448:9,
20 449:2 455:15
463:1,10,13
depths 357:5
359:5,9 365:7
412:15,16 436:26
451:4
derive 445:11
derived 439:23
Description
330:3
designed 421:6
destroyed 429:17
430:3
destruction
429:20
detail 377:26
454:21
detailed 368:17
details 348:4
detect 352:15
450:24 452:11
detection 449:24
450:5,7,8,13,14
451:14,16,19
452:13
determine 344:1
380:12 460:21
developed
375:25 376:9,13
development
366:2,11 367:15
385:15,18 386:9
391:15,23 394:14
400:16 401:26
414:19 415:2,10
developments
367:1
diagram 427:26
428:1

diagrams 390:14
427:26

difference
347:12 372:8
374:21 375:3
385:23 406:10
412:19 413:13
422:24 438:13

differences
341:8 376:12
381:19 393:9
420:18 462:7,8

differential
441:16,25

difficult 394:17
425:2,4 426:8
452:10

difficulty 441:17

diffusion 426:6

dig 362:17

dimension
379:21

dimensions
377:20

diminished
463:4

direct 334:18,19
431:26

directed 388:10

direction 392:3
420:23

directional
368:24

Directive 338:9,
14 354:6

directives 341:24
354:9

directly 436:21

disagree 452:21
458:16

disclosed 442:24

discontinuities
370:25 455:7
456:2,7

discrepancy
355:15 462:26

discrete 396:3

discuss 333:17

discussed 372:14
373:18 387:2
392:18 416:19

discussing
369:11 399:3

discussion 330:6
332:7 351:26
354:4 380:14

discussions
404:2

dismiss 441:16

dismissed 418:7
464:6

displacement
422:7,18 423:5
448:21 452:12,25

display 421:26

disruptive
459:16

dissimilarity
419:18 420:20,26
421:10 463:5

dissolution 451:2

dissolve 353:8

distorted 434:8,
12

distortions
463:14

distribution
370:21 388:14
394:4

disturb 449:21

divide 449:15

document
333:21 335:5
402:15,23 428:15
445:26 446:2,17

domain 455:14,
15 463:13

dominant 422:11
448:24 463:7

double-check
401:15

doubt 341:17

downhole 383:9,
12

downloads
361:13,15

downward
385:26

drainage 344:10
388:2 391:8
416:2,13 456:2

drawn 408:7

drill 366:14
367:8,23

drilled 359:5
367:14,20 411:24

drilling 340:11
404:1 432:4,7,8

drilling-induced
432:18 433:15,17
434:15

drop 337:18
338:2

drops 337:15

dry 341:22

due 370:15 372:1,
19 387:21 400:7
401:20 414:12
415:16 420:14

duration 353:3
354:17

dynamic 346:3
372:25

E

EARL 330:20
419:3

earlier 347:7
372:14 380:14
399:5 407:23

416:20 441:15
445:24,25

early 402:9
415:3,9

easier 399:23

easily 399:7
422:7 459:21

east-to-west
420:23

east-west 456:18

economic 386:8
391:18 416:24

economics
415:21

edge 369:10,14

edges 421:4

EDWARD
330:20 419:2

effect 338:4
356:17 391:21
400:5 401:17
407:7 439:15
449:13

effective 345:17
379:1,11 380:23
385:16,17 400:8
401:20 404:12
406:12 414:13

effectively 366:8
395:5 415:20

efficiencies
398:12

efficient 357:22

efficiently
399:10

eighth 450:9

elaborate 339:25
398:14 400:15

electronic 386:17

elements 461:2,3

elevation 439:22

email 351:23

encounter

406:19

encountered
400:10 401:22
414:14

encountering
416:14,22

end 364:17 380:5
413:15 444:24
464:7

ending 444:9,10

ends 407:1

energy 329:2,9
330:9,11,17,22,
25,26 331:23
368:11 386:24
409:22 413:22
416:19 419:5
457:18

engage 443:20

engaged 404:1

engineer 443:19

enhanced 348:4,
5 451:7

enhancement
420:26 447:26

entering 383:23

entire 391:9
393:1 418:26
431:1 446:12

entity 444:6

environment
367:12

equation 375:2

equivalent
441:19,22

erosion 454:15,
24 455:1,22
456:12

error 357:14
410:18 437:11

essentially
382:10 439:13
463:19

estimate 373:12
estimated 377:8
 400:6 401:18
 414:11
estuarine 396:11,
 18 397:8
et al 425:13
 427:15,20 428:5
ethical 443:16
evaluate 342:1
 344:23 383:6
 396:5
evaluated 367:16
 377:1 394:13
evaluation
 413:6,7
event 337:19
 378:5 383:21
events 337:14
 404:17 421:13
Everybody's
 418:24
evidence 330:22
 332:19 335:13
 350:1 353:17
 361:5 368:16
 371:14 403:11
 407:20 408:16
 418:10,12 419:5,
 9,12 423:19,24
 428:5 431:19
 434:17 440:21
 442:4,14,18,20
 443:6,23 444:13
 445:8 448:4,5,7,
 10 451:23
 453:19,23
 454:10,18,19
 455:17 458:11
 459:13 461:11
 464:5
evident 340:1
 431:9
exact 366:22
 435:20

examine 391:7
examining 339:7
 394:23
Examples 387:7
excellent 343:5
exception 457:21
excerpt 407:24
excuse 338:21
 341:20 433:1
 437:26 449:11
execution 340:5
exhibit 333:17
 334:23 336:19
 337:9 338:8
 339:2,8,9,12
 340:16 344:5
 345:10 346:16,17
 355:4 356:24
 359:18 365:7,12,
 24 370:5,8
 371:23 372:3
 374:4 376:22
 380:15 383:19
 389:25 397:15
 398:5 399:21,24
 401:15 403:8
 404:10 406:4
 407:23 411:15
 412:22 419:19,26
 420:3,5,24
 422:15 425:18
 426:10 430:19
 435:21,25 439:26
 440:2,9 442:15
 445:14,20
 462:10,14
exist 380:25
 417:9
exists 341:19
expanded 424:17
expansion 408:3,
 8
expect 359:7
 366:25 381:21
 391:23 430:11,17

441:24 463:5
expected 422:17,
 21
expecting 464:9
experience 379:3
 416:12 438:15
 450:26 452:9,17
experienced
 415:15
experimental
 369:15
experts 341:14
explain 373:7
 374:13 420:25
 438:5
explained 453:8
explains 395:25
explanation
 338:2 443:23
 455:1
Exploration
 369:10
exposed 460:26
extent 377:25
 392:2,7,10 400:6
 401:18 414:10
 416:21 426:4,19
 456:4,7
extraordinary
 422:10
extreme 451:2
extremely
 422:20 452:10,18

F

facies 392:9,17,
 26 395:12 458:2
facility 398:13
 399:1
fact 361:8 378:23
 379:4 403:8
 405:24 415:16
 427:9 430:4

431:15,19 437:16
 439:15 441:23
 450:16 452:4
factor 353:14
 380:3 415:12
factors 354:5,9,
 15,16,23 360:26
 388:20
fair 343:4 345:1
 353:13 365:25
 366:3,8,12
fairly 381:23
 395:8 415:22
fairway 366:21
 391:22
falls 397:23
familiar 338:17
 343:10 351:14
 457:6
farthest 427:12
fault 369:3
 387:15 421:23
 422:22 441:7
 450:20,25 451:8,
 25 452:7,11,14
faulting 368:18
 370:11 387:5,8,
 16,20,21,26
 423:8 434:4,5
 447:11 451:2
 455:3,23,25
 456:5,12 458:3
faults 371:2,13,
 15,18,20 387:4
 421:21 422:5
 423:5 450:23
 451:5 452:9,25
 459:7
feature 416:15
 441:1,5,8
features 423:13
 455:9 463:4,5
February 369:8
 444:1

FEED 447:16
feel 348:23
 366:26 367:4,16
 393:10 397:2
feeling 410:9
field 348:23
 445:16
fight 444:6
figure 337:12
 360:2 387:23
 406:5 424:9
 448:26
file 464:17
filed 364:16
 402:9 442:14
filing 464:9
fill 391:4,6,7,9,12
 392:20 393:1
 394:15,16,25
 395:24 396:1
 441:22 457:23,24
 458:19
filled 439:4
fills 394:9 396:22
final 354:20
 359:9 364:10,12
 380:6 383:18
 413:25
finalizes 364:12
finally 354:20
 442:3
find 336:5 356:25
 358:13 362:14
 405:2 422:10
 451:19 452:10
fine 357:20
 364:24 425:24
 454:12
finish 332:14
 358:17 452:2
finishing 332:13
fish 438:23
fit 332:17

fits 413:4 443:23
flag 337:18
flagged 403:20, 24
flat 457:26
flexibility 399:13
flexure 441:7
flip 362:2
flipped 357:14
flooding 458:20
flow 338:5 343:5, 8 376:11 382:3 443:23 459:6,15
flowing 361:6 381:11 383:8 386:3 443:7,13
fluid 349:1,9,12 375:8,22 376:11 379:9 398:23 399:15 406:26 426:5 459:6,15
fluids 381:10,13 386:3 387:3 390:10 429:7 430:3 460:7
fluvial 396:11 397:1,4,6
focus 421:13
focused 373:13 421:2,18
Focusing 421:2
fold 452:7,15
folks 389:7
follow 343:7
follow-up 352:25 360:8 361:21 413:20 459:25
footprint 421:1, 11 423:1 447:16 448:1,7,13 449:20 463:7
forced 399:16
forecast 417:6

forego 423:9
foregoing 466:4
forget 427:19
form 354:17 377:3
formal 337:6
formation 340:21 342:14, 15,18,20,21,25 343:2 345:16,19 375:13,16 380:20,22,24 384:2 385:3,21 386:2 390:4 406:25 407:1 432:7 459:10 460:12,14,17 461:4
formations 379:9 422:19
formed 341:21
forming 422:20
Fort 451:1 452:10
forty 346:15
forward 364:19 378:7 390:7 412:11
fossil 438:10
fracability 389:13
fracture 353:5, 11 369:4 370:16, 21 373:14,17,19, 22 374:1,10 375:14 377:9,14, 17,21,22 378:5, 10,14,15,21,23,26 379:12,17,22 389:19 405:5,6,8 406:12,19,26 407:2,5,7 429:14 430:4 432:16,18 459:8 461:7

fracture-
containment 373:20
fracture-growth 373:26
fractured 458:2, 9
fractures 352:26 353:21 369:7 370:14 371:2,11 376:24 379:16 389:18 404:16,22 405:1 406:21,22 421:21 423:8 429:13 430:11,16 432:2 433:25 458:12 459:22
fracturing 368:19 385:7,9 387:4 389:19 430:10 433:15,26 434:4,15,18 456:6 458:7 459:14
fragmented 433:21
fragments 433:21
frame 335:25 356:4
free 418:7
freezes 439:13
frequencies 452:8
frequency 422:11 448:20, 22,24 449:4 452:16
frequent 356:1
front 333:24 340:13 342:6 402:23 408:1 412:1
frozen 441:11 461:14

fully 417:11
Fustic 425:13 427:15,20 428:4

G

G' 425:8
Galloway 331:16 409:15
gas 338:5 339:21 343:11 346:5 349:1,6,22 360:14 361:10 377:10,15,18,19, 22 378:17 379:23 380:24 382:4 383:23 385:13, 19,22 386:1,6 427:1 428:8 442:9,13,17,20 443:6,9,13,19,24
gas-over-
bitumen 335:15 381:12
gathers 422:1
gauges 361:14,16
gave 436:20 437:3
GC-MS 393:20 395:25 396:5 397:15 427:6,8
general 342:19, 22,23 343:24 344:11 373:16,26 388:25 447:9,12
generally 389:2 432:8 451:14
generate 372:22
generated 404:17
geo 359:19
geochemistry 429:24 460:5 461:12

geological 415:23
geology 388:25
geomechanical 359:19 365:10 369:25,26 370:5, 7,20,22 371:1
geomechanics 372:5 413:6
geometries 387:8 393:16
geometry 379:14 405:5 423:3
geophysical 422:6 423:7,9,11 456:23
geophysicist 420:11
geophysicists 369:11 422:15
GEOSIM 371:16
geostatistical 417:5
Gerard 344:14
Giry 330:19 383:25 419:2 442:3,6
give 358:12 361:26 362:12 373:11 401:1 402:5 408:20 410:19 432:17 434:5 436:11,25 445:26 455:25
giving 436:26
goal 381:20
GOB 346:4 347:16,17 382:20 383:23 384:3 385:4,24 386:5,7 442:9,13 443:9, 13,15
good 333:16 334:21 340:25

341:1,18 343:12
352:1 361:24
363:3,4 373:5
391:19 406:3
410:5 433:10
445:2

graciously
436:12

gradient 373:17,
23 385:25 386:1
428:9,23 437:6
439:23

gradients 406:5,
10 428:3,22

granted 431:15

gravity 372:19

gravity-loading
372:21

great 420:9,18
429:9 454:21

greater 387:6
394:1

green 337:15
347:13

Gregoire 387:19

grey 431:7,18
432:10

ground 375:1
413:8,13,15
417:20

group 396:15
441:10

grow 406:24
407:2

growing 373:14
415:19

growth 367:10
373:17,19 374:10

GS 427:8

guess 332:21
355:14 362:13,
15,18 379:10
405:9 414:21
446:10 447:14

448:10 463:11

guys 452:24

H

half 406:15,16

Hall 331:12
368:7,9,13
376:16 384:7
385:1 386:14,16
409:11 457:13,
15,20 461:15,16,
19,21,25 462:1,4,
6,11,14 463:21,
24

handy 412:22

happen 341:12
350:4 383:25

happening
352:23 383:6
387:20 389:21
397:6 431:22

happily 338:7

Harbidge 331:17
409:16

hard 361:6 444:6
450:24 451:18

head 374:10,13,
20 375:3,24
376:1 412:23

hear 398:18
402:17 408:14
417:26 461:20,22

heard 442:8
461:23

hearing 331:8,9
335:1 383:19
409:6,7 416:10,
20 419:14
424:22,23 434:20
438:26 451:18

heat 375:11,12,15
376:10

heating 345:21

heel 349:20,23

held 443:26

helpful 403:1
404:4 406:2
408:10 411:7

hertz 422:11
449:8

heterogeneities
415:24 416:1

heterogenous
367:11

heterolithic
396:9 457:22,24

high 332:12
353:3,7 375:22
379:6 437:7
459:11

high-level 399:2

**high-
permeability**
391:20

high-resolution
387:7

**high-
temperature**
375:23

higher 348:23
349:26 350:8
371:26 372:2,20,
22 373:23 395:4
399:8 405:21
406:1 416:19,21
426:20

**highest-
circulation** 355:7

highlight 422:5
423:13

highlighted
337:14

highly 352:10
367:10 433:21
434:11,14 459:16

historian 356:3

history 337:13

hit 407:3

hold 417:3

hole 343:10

hope 346:8
368:14

hoping 424:15

horizons 396:23
421:26

horizontal
349:25 350:7
372:1,22 400:9
401:21 414:13
439:3

hot 396:13

hours 354:14

hover 351:7

Howden 332:4
410:2 466:3,20

HRAM 387:8

Hryciw 331:24
409:23

hummocky
393:7

hundred 337:22
379:16

hundred-hertz
448:24

hundreds 432:6

hung 438:6,7

hurl 444:8

hydraulic 341:17
352:26 374:9
375:14,24 380:22
385:7,9

hydraulically
341:18

hydrocarbons
398:2

hydrostatic
349:7 374:10,13,
20 375:3 376:1

hypothetical
386:4 453:18,23
hypothetically
385:20

I

Iannattone
332:21,26
333:15,18
334:18,21,25
338:25 339:1
343:25 344:3,16
353:25 354:2
357:7 362:12
363:4,12,22
364:3 365:16,18
366:4 380:11
381:5 384:4,10,
22 389:9 398:7,
16 400:13,18
401:8,11 402:14
403:8 407:16
410:8,14,23,26
411:4,6,11,19
413:24 414:1
442:5 443:25

Ichnology
396:15

IDA 416:1

idea 392:24

identified 344:20
378:4,14

identify 394:18

identifying 423:5

ignore 427:14

IH 425:3

IHS 390:5
392:20,26 400:6
401:18 402:24
407:24 414:10
415:8 416:8,16
425:6 426:9,14
429:1,6,7

II 340:26 380:26 442:21	incision 394:17 397:22	ineffective 380:23	416:18	interpret 423:7 427:6 434:4 457:22 459:2
illustrated 424:19 426:9	inclined 396:9	inefficiency 381:15	injectors 357:9, 10,14 359:7,20, 23 365:11,13	interpretation 335:19 336:1,11, 15 341:4 342:16
illustration 349:16	included 339:4 371:13,19 373:25 387:22 404:9 413:9	inferring 453:4	379:18 411:17,20 412:12	397:3 419:13 421:22 423:11,16 429:15,26
image 334:11 421:12 427:13 447:11 452:25	including 443:15 444:11	inflexion 347:19 382:13	input 373:1 426:15	432:12,14,19 433:23 446:13 451:7 454:25 456:9,16,19,22 457:1 458:17 460:9 461:5
imaged 452:14	inclusion 366:16	inflexions 346:1 347:8,9	inputs 373:11	insight 368:18
images 421:3	inconsistent 426:23	information 363:15 408:4 425:14 437:18 446:24 453:3 456:15 464:10	inspection 423:14	inspection 423:14
imagined 444:7	incorporate 387:24	infrastructures 406:23	instances 438:22 460:22	instances 438:22 460:22
imaging 450:22	incorporated 354:17,23	initial 334:16 339:4 372:16 373:24 378:3	instruction 351:18	instruction 351:18
immediately 397:23	incorporation 396:19	initialization 372:16	insufficiency 381:14	insufficiency 381:14
impact 339:22 340:2,8,9,15 372:15 373:17,19 374:2 378:17 379:19 381:3,8 388:6 449:8	increase 337:25 345:21 347:20,21 382:12	initially 396:16 415:7	insufficiently 423:1	insufficiently 423:1
impacted 335:16 347:11	increased 433:26	initiate 383:2,4	integrity 336:16 337:24 340:6 345:2 371:7 443:18	integrity 336:16 337:24 340:6 345:2 371:7 443:18
impacts 382:16, 18,19,20 398:26	increases 337:23 345:24	initiated 361:1 442:22	integrity-of-the- confinement- strata 371:5	integrity-of-the- confinement- strata 371:5
impair 377:10, 18,22 378:25	increasing 349:2 353:4	initiating 373:14 376:7 382:26	intense 434:4	intense 434:4
impede 405:4	incredibly 459:13	initiation 374:1 376:14	intensity 370:21 433:26 434:16,18	intensity 370:21 433:26 434:16,18
impediment 374:9	independent 341:12 370:20 385:14	injected 354:18 375:8,10,22 381:10 406:26	intent 354:6 360:6 367:8,13	intent 354:6 360:6 367:8,13
implemented 349:6	indication 352:19	injecting 375:17	interest 428:26 439:21 459:4	interest 428:26 439:21 459:4
implications 414:21	indicative 366:2, 10	injection 352:17 353:3 354:21 381:13,20 382:6, 14	interested 429:10	interested 429:10
important 344:8 415:23,25	INDISCERNIB LE 346:11 440:15	injector 357:5 365:7 376:10 411:23,26 412:7, 9,16 415:17	interesting 431:5	interesting 431:5
imprint 379:19	individual 393:26		interfluve 390:16,17,23	interfluve 390:16,17,23
improvement 415:25	induced 376:24 377:11		interject 353:25 453:18	interject 353:25 453:18
in-house 341:14	industry 369:20 423:10 456:23		internal 369:26 391:3	internal 369:26 391:3
incised 391:9 394:8 395:8,16 396:22				intervals 343:1 356:1,7 452:19, 21 457:21 459:3

investigation

426:3

invite 350:24

351:2,3,18

384:12

involved 343:18

388:24

involves 344:4**IR** 382:25 446:26**ironic** 432:5**irregardless**

385:18

IRS 348:3**ISH** 330:22,26

331:23 332:14,

19,22 333:9

335:17,26 338:4

339:26 347:3

361:8,9,11

382:22 383:8,15,

20 390:3 402:7,9,

15 404:2 409:22

418:20 419:5,17

420:21 434:3

442:8,11,14,16

443:8,14,17,21,

24 444:1,4,9,11,

13 446:10 455:5,

12 457:11,14,18,

21 464:4

ISH's 332:9

403:9,11,12

433:3 435:22

442:24,26 445:14

451:23

isolated 341:18**isolation** 341:17**isotope** 430:8

460:5,6

issue 337:24

340:6 342:11

347:18,20 350:10

372:16 383:7

388:13 411:6,9

425:23 443:22

445:12 454:8,11

458:6

issues 337:23

387:26 388:21

400:7 401:19

414:5,12,18

415:16 416:23

461:17

J**Jackfish** 366:20**Jamieson** 330:23

331:26 364:13,14

376:6 401:3,5

402:2,3,13

408:14,18 409:25

417:15,17

444:16,17,21

445:1,2,3,5,22,23

448:3 453:16,25

454:2,12,14

457:10,12

464:13,16,21,23,

26

January 339:5,

16,17,18 361:6

442:12,23,25

Jason 366:4**JENNIFER**

330:21 419:3

Joann 445:21**job** 340:5**join** 350:22

351:11 384:12,14

joint 427:17,18**Joule-thomson**

338:4

journal 369:11**journals** 446:20**July** 337:13 413:9**jump** 341:5

374:16

K**K'** 436:4**Kansas** 396:26**KB** 437:23,24,25

438:1,3

KBS 437:19**kelly** 412:4 413:5,

12,13

kickback 428:9**kicks** 398:23**kind** 335:19

369:14 387:24

455:16 463:7

Kirby 338:12,15

340:21,25 343:18

347:1 352:21

355:5 377:6

380:26 381:21

387:5,6,18

394:14,19,26

395:3,4,13 404:1

408:2,8 415:2,10,

15,26 417:1

420:10 421:5

422:12,22 423:2

444:1,4 452:16

KN02 355:8,16

416:14

KN02-04I 348:7**KN02-O9P**

355:17

KN03 355:8**KN05** 346:6

347:1,5 355:8

403:23

KN06 333:26

334:5,9,11

337:22 344:8

346:26 354:16

359:5 366:15,23,

25 367:5,7,8,12

368:19 370:13,19

371:21 372:5

374:12 376:25

377:11 378:6,8

379:20,26 380:2

386:9 388:2,7,24

389:22 390:11

391:8,22 392:8,

23 394:5,26

395:3 403:4,18,

22 404:11

411:25,26 412:1,

9 413:11,12

454:16 456:2

knowing 425:1,2,

4

knowledge

369:20

knowledgeable

445:17

kpa 347:13 375:4

376:3 406:16

L**labelled** 424:6

431:4

laid 372:19**Lake** 387:19**large** 367:3 386:7

407:2 434:10,11

451:2

largely 397:5**larger** 334:9

373:19 377:2

378:23 392:12

lastly 379:14**late** 441:7**lateral** 349:25

350:2,7 352:11,

19,20 390:22

391:13,21,23

392:7,14 393:11

400:5 401:17

414:10 416:21

422:23 426:4

450:1,3 456:3

laterally 390:13

392:9,11 393:5,

16 406:20

latitude 414:25**Lavigne** 333:15,

16,20 334:2

351:1,3,6,8

366:4,5 367:18

387:1,10 390:1,8,

12 397:26 413:25

414:1,2 423:20,

24 429:12,26

431:25 433:12

434:9 436:11,25

437:3,11 438:25

441:11

lay 339:9**layer** 373:23

405:16,18 429:24

layering 429:21**layers** 372:6,7

460:23

Leading 369:9**leak-off** 353:5

377:13 379:8,9,

11 406:25 407:3,

8

leakage 393:11**leaking** 407:1**lean** 456:8**learned** 394:23

415:5,9,14,22,23

417:1

leave 392:14

441:13

led 459:9,11**LEECH** 330:19

419:2

Leech's 338:3

443:4

left 357:26 424:4

429:2 436:9

left-hand 424:6,

12 426:18 427:4

428:19
legal 363:26
 364:1
length 343:17
 392:18
length-of-tool
 342:11
lessons 415:23
letting 351:11
level 332:12
 375:1 413:8,13,
 15 415:18 416:18
 419:17,24 421:17
 422:11 423:4
 455:13
leverage 367:3
liability 444:3
licencing 444:2
life 354:10,11
lift 349:1,8
 360:14
lifts 349:12
likelihood
 348:23 352:23
 353:21 377:9,17,
 21 378:24
limit 391:18
 399:16 449:24
 450:4,7,8,13
 451:14,16 452:13
limited 330:8,10,
 12,16,18,24
 332:1 333:14
 368:12 377:20
 386:25 406:24
 409:26 410:13
 413:23 445:4
limiting 407:7
limits 448:16,17
 450:14 451:19
linear 441:1
liner 360:1
 375:12

lines 337:14
 439:5 452:3
linked 373:18
lips 417:25
liquid 376:10
liquid-filled
 376:15
listed 355:12
 357:5 365:8
 412:15
listen 343:26
LLR 444:3
load 372:19
local 379:17
 404:17,24 460:15
located 335:10
 443:10
log 338:25 339:3
 341:6 342:6,13,
 19 343:1,17
 366:16,24 424:4,
 19 426:3 437:22
log-in 350:25
logging 341:23
logistics 418:17
logs 334:12
 339:4,5,7,18
 341:10,25 343:5,
 11,12,15,20
 365:26 366:6,9,
 14 367:7 440:20
long 354:8 379:21
 384:8 387:19
 443:18
longer 332:18
 382:3 399:19
 416:26
looked 359:22
 392:5,6 426:21
 429:12,13 432:6
 454:20
lose 433:11
loss 381:13

losses 375:11,12
 381:18
LOST 447:17
lot 375:15 385:7
 415:3 417:2
 432:10
lots 434:17
low 331:7 352:23
 353:18 360:13
 370:15,23
 375:10,17 409:5
low-pressure
 340:4
lower 349:3
 397:4 398:21
 399:16 411:18
 416:17 424:6,12
 426:15 433:24
lowest 349:11
 399:11
lunch 332:18
 407:20 408:12

M

M-HM 346:24
 348:13 359:6
Madam 332:26
 351:10 357:18
 361:19 363:12
 368:10 384:19
 386:14,22 397:11
 407:22 410:14
 413:20 414:2
 417:12,17,23
 418:12,25 435:19
 442:1 444:12,17
 453:26 457:10,15
 463:22
made 348:17
 368:22 378:19
 379:10 403:16
 410:17 412:17
 417:8 421:11
 423:10,23 427:15
 437:11 441:11
 442:16 443:1
 445:9 446:13
magic 386:17
 406:14
magnitude
 347:15 378:18
 406:10
magnitudes
 347:8
main 384:20
 391:22 393:16
major 370:7
majority 459:22
make 333:1,8
 339:15 344:21
 357:18 358:21
 376:5 403:13
 414:4 421:26
 432:13 441:14
 449:8 456:16,18
makes 423:4
making 369:13
manner 381:11
 382:3 427:9
Mannville
 340:22,26 380:26
 432:6 438:21,22
 441:9 442:21
manual 361:13,
 15
manually 443:12
map 387:8 394:3
 440:15
mapped 392:3,26
mapping 334:8
 392:1,10
maps 462:8,17,
 20,21,24
March 335:24
 337:13 361:12
 408:4
marine-sourced
 460:24

mark 424:20
marked 357:1
markers 422:8
marking 424:13
Markit 402:7,25
 407:24 415:7
material 359:22
 370:23 371:8
 389:18 408:2,7
materials
 372:17,18
math 395:20
mathematical
 410:18
Mathison 330:20
 419:3 423:18,21,
 22 425:20,24
 434:22,23,26
 435:3,7,9,13,19,
 26 436:3 440:3,6,
 10 442:2 457:17,
 20 458:5 461:20,
 24,26 462:2,3
matrix 377:1
matter 329:7
 385:23
mature 366:18
maximize 389:11
 421:6
maximum 349:3
 353:14 355:2,15
 356:10,18 395:9
mb 342:5
Mckinnon 331:8
 409:6 463:25
 464:1
Mckinnon's
 386:18
McMurray
 335:14 340:21
 345:16,18 347:5,
 16 372:13 374:7
 380:19,22,24
 381:1 382:10

384:2 385:2,21
 386:2 390:13,21
 395:2 396:23
 407:5 422:11,19
 423:4 432:7
 434:8 448:25
 449:4 451:1
 452:10 459:10
 460:11,14,17
meander 395:15
meander-belt
 395:21
means 350:12
 360:12 418:17
 441:5 464:4
measure 353:15
measured
 349:20,23 405:14
measurements
 352:12 383:12
mechanism
 373:25 407:8
mechanisms
 373:21
media 376:13
medium 430:5
 431:18
meet 405:7
meetings 443:26
megapascal
 406:15
megapascals
 398:11 399:6
member 338:26
members 347:26
mention 338:14
 394:2
mentioned
 394:11 411:19
 415:6 444:1
 456:26 462:6
mentions 439:19
mere 423:13

message 350:21
 351:10 444:24
methodology
 445:10
metre 375:4
 376:3 406:16
metres 337:22
 357:6 359:10,21,
 26 365:8,9,12
 374:26 375:2,3
 378:15 379:20,21
 391:15,26 392:3
 395:10,15,17,22
 403:23 404:20
 405:19 412:4,7,8,
 9,10,12 413:4,5,
 8,12,14,15
 422:13,23 423:5
 429:1,2 436:22
 437:4 440:23,25
 443:10 450:18
 451:6,16 452:11
metres' 416:7
 452:25
mic 447:20
microannulus
 341:21
mid 431:18
mid-b1 374:8,11,
 23 419:17,23
 421:17 431:3
 455:13
midday 400:25
 401:1
middle 393:22
might've 403:14
migrated 419:16
 420:12 447:2,6
 448:12 462:23
 463:6
migration
 390:10,18 391:21
 421:9,13,15
 426:5 441:8
 447:10,15,24

448:14 460:1
 462:18,19
migration's
 421:2
miles 395:10
millimetres
 404:22
milliseconds
 422:25
mind 362:20
minimal 362:8
 449:8
minimize 421:7
minor 373:16
 374:2
minus 412:10
 413:14
minute 400:24
minutes 351:21
 356:6 358:25
 384:10 444:18
misidentify
 395:1
misses 405:9
missing 410:9
 428:1 464:14
mistake 412:17
 440:4,8
**misunderstandi
 ng** 385:10
mitigate 382:18,
 19,20 403:25
mitigation 348:5
 349:4 353:15
 354:22 383:13
mixed 392:26
 416:8
mkb 339:20
mobile 353:9
model 359:19
 365:10 371:13
 373:8,12,21
 381:15 417:5,8
 422:14 449:1

modelled 400:7
 401:19 414:11
modelling
 369:25,26 370:5,
 20,22 371:1,4,16
 372:5,25 373:10
 400:12 401:24
 414:17,19 417:3
 426:13,14
modern 421:4
 423:11
modified 415:26
 416:2,14
molecular 426:6
moment 333:19
 338:1 342:2
 347:6 353:12
 360:18,19 361:18
 367:17 373:6
 375:20 435:1
 445:19 452:26
 463:20
monitor 367:10
 381:19
monitored
 443:10
monitoring
 335:11 338:15
 343:25 345:7
 348:4 354:20
 367:9 383:10
monthly 336:26
 337:7
months 443:9
MOP 353:19
morning 330:5
 331:5 332:14
 333:16 363:15
 364:12 380:15,17
 399:5 465:5
morphology
 397:1,7
move 364:19
 401:11 407:5
 429:8 433:8,25

434:2 454:12
 461:3
moved 415:8
movement 429:7
 439:14,19
moves 379:1,13
moving 343:24
 417:25 426:25
 427:14 434:19
MPA 339:17
 340:8,14 342:3
 348:10,22,24
 349:4 353:4,15,
 17,19 354:12
 360:21 361:2
 374:12 375:5
 382:24 399:12
mud 341:22
 390:23 396:4
 416:5 432:4,8
muddier 416:23
muddy 392:26
 405:18,20,25
 416:8
muds 371:26
mudstone 372:6,
 12 373:23 374:8,
 11,23 405:24
 419:17,24 421:17
 431:3,4,8,10,18,
 20 433:21 434:12
 455:13 457:21,
 23,24 458:1
mudstone-rich
 398:1
mudstones 372:9
 432:9
multiple 382:23
 391:6 395:26
 423:12
mute 423:21
muted 398:17
 417:23
mysteries 343:12

N	<p>needn't 434:7</p> <p>neglected 424:19</p> <p>negligible 370:15</p> <p>neutron 343:11</p> <p>new-ish 457:1</p> <p>Nexen 427:19</p> <p>nice 433:16</p> <p>nod 401:4</p> <p>nodding 408:17</p> <p>noise 421:7,11 423:1 440:15 449:20</p> <p>noisy 421:18</p> <p>non-core 424:25</p> <p>non-oil 424:25</p> <p>non-reservoir 390:5 391:11 392:9,17 416:11 424:6,13,25</p> <p>noncompatible 338:22</p> <p>noncompliance 442:25</p> <p>noncompliant 338:21 344:20</p> <p>nonconformance 415:15</p> <p>normal 362:24</p> <p>north 338:15 343:18 347:1 352:21 355:5 377:6 381:21 387:18 388:5 392:23 394:26 395:3,13 404:1 416:1 421:5 422:12,22 423:2 452:16</p> <p>north-south 392:3 456:17</p> <p>note 339:9 341:2 351:18 387:19 400:2 401:14 407:22 444:2</p>	<p>462:16</p> <p>noted 365:21 387:16 420:10,13 422:3</p> <p>notes 466:6</p> <p>notice 342:6 388:3 424:4,12 425:26 427:3,25 428:7,18,19 430:22 431:6 432:3 433:19 442:24 462:25</p> <p>noticeable 420:22</p> <p>noticed 463:1</p> <p>noticing 402:4</p> <p>November 337:15 412:2</p> <p>number 333:25 336:19 346:8 356:26 360:26 400:1 406:15 412:22,23 417:18 420:1,4 424:2 425:19 427:22 428:14 432:1,22 435:24 436:1 440:7 445:15 459:5</p> <p>numbers 339:9 341:13 399:26 451:18</p>	<p>observe 352:14 391:6</p> <p>observed 350:2 352:21 356:11,15 382:16 454:3 455:2</p> <p>obtained 344:25 366:24</p> <p>obvious 460:9</p> <p>occupy 391:8</p> <p>occur 379:9 396:22 440:12</p> <p>occurred 339:16 429:21</p> <p>occurring 378:21 383:4,11</p> <p>occurs 366:20 424:20 430:23 439:22</p> <p>October 329:26 330:5,14 331:5 335:20 368:21 409:3 434:20 435:2,3,8,12 465:7 466:9</p> <p>Official 332:3,4 410:1,2 466:15, 21</p> <p>offset 438:17 439:21 440:23,25 441:2 451:5</p> <p>offsets 438:19,24</p> <p>ohms 436:22 437:13,15</p> <p>oil 435:14 436:12, 25 437:9,15 438:3,9,14 439:2, 10,12,13,16,17,22 441:4,8,10 443:19</p> <p>older 391:11</p> <p>on-site 361:16</p> <p>one's 463:10</p>	<p>one-eight 450:13</p> <p>one-second 356:1</p> <p>open 385:20 386:4 430:12 444:13</p> <p>opening 348:1 404:22 412:20,25 419:22 420:21 443:2</p> <p>operating 347:23 348:6 353:14 355:2 382:9,23 387:26 388:7</p> <p>operation 337:21 340:1 347:5 354:11 381:9,21 403:21</p> <p>operational 398:12 399:13,17 400:7 401:19 414:11,18 415:4, 14 416:12</p> <p>operationally 399:7</p> <p>operations 339:19,22 345:16,20 346:6 371:17 380:19,21 381:4 382:17</p> <p>operator 361:11 442:12 443:17</p> <p>operators 367:21 371:17</p> <p>opportunity 352:9 358:12 408:15</p> <p>opted 418:26</p> <p>options 404:3</p> <p>orally 464:11</p> <p>oranges 463:18</p> <p>order 347:15 378:15 385:6 395:9 404:23 455:4</p>
		O		
	<p>oath 363:16,19</p> <p>objective 382:8</p> <p>obs 367:23</p> <p>observation 335:16 366:14 367:8,13,20</p> <p>observational 338:19</p> <p>observations 390:4</p>			

orders 378:18
orientation
 369:4 388:11,18,
 24 389:1 422:22
orienting 389:10
original 402:25
 403:3,4 420:20
orthogonal
 433:16
outline 413:10
outlined 348:6
 382:25
outsized 434:11
overburden
 378:16
OVERLAPPIN
G 346:11
overlies 458:20
overlying 335:15
 416:7 424:19
 430:14 431:17
 441:3 459:10
 461:6
overrides 463:8
Overtop 392:16
oxygen 430:8
 460:5

P

package 393:19
pad 346:26 347:1
 360:7 366:23
 378:8 379:20,26
 380:2 391:17
 392:23 401:24
 403:23 404:26
 412:12
pads 355:8
 395:13
pages 339:12
 370:6,8 428:16
 435:5,12 466:4

pair 416:3
pairs 388:11,18
 415:19
Paleo 440:25
Paleozoic 422:8
 434:5 438:19
 439:23 441:3
 454:15 459:10
 460:10 461:6
panel 330:11,17
 332:10,13,15,23
 347:26 361:22
 362:12 363:16
 365:3 368:4
 384:12 386:13,
 21,24 407:13,18
 410:8 413:22,25
 417:15,19,20,21
 418:3,26 420:17
 444:13 457:11,14
 464:5
paper 369:12
 456:25
paragraph 335:7
 340:23 347:3
 370:9,17 371:24
 374:5 375:2
 376:26 383:20
 398:8 399:25
 425:15,26
paragraphs
 415:6
parameters
 451:4 452:19
pardon 332:23
 425:4 427:7
 428:14 429:3
 431:2 433:5
 437:25
parking 385:7
parsimonious
 397:3
part 344:8
 385:19,20 394:16
 396:14 403:18

412:13,18 426:26
 431:2,10 433:24
 434:17 435:22
 441:23 448:23
 459:18 464:18
participate
 364:5,8
partner 383:15
parts 382:21
pass 339:18
 340:7,14 392:15
passage 414:7,9
 415:14 416:6,17
 417:4
passes 342:13,20
past 452:9,17
patch 340:4
path 390:18
pathway 390:10,
 17
pathways 387:3
 405:2 460:2
 461:3
patience 457:9
pattern 433:16
patterns 387:5
PDF 335:2 337:9
 338:8 340:17
 344:5 345:11
 348:2,7 349:15
 355:10 356:13,26
 359:18 360:9
 365:12,24 370:6,
 8,9,17 371:24
 372:3 374:5
 376:22,25 377:2,
 3,5 380:15
 383:19 389:26
 393:14 397:16
 398:5 399:24
 401:15 407:24
 419:19,26 420:7
 422:15 423:26
 424:15 425:14
 426:10 427:1,21

430:18 431:23
 438:26 439:5,6,
 26 440:4 442:15
 462:10,14
peak 355:16
 371:9
pedogenic 458:4
peer-reviewed
 446:19
people 396:25
 405:14 437:21
 460:21 461:22
percent 340:24,
 26 341:7,9,12,17
 377:9,20,23
 378:11,20,22,26
 379:11,16 380:1,
 4
percentage
 380:6
perfect 337:10
perforation
 340:1
perforations
 340:3
perform 369:1
performed
 373:10
period 373:15
 382:26 399:18
 443:9,13
periodically
 361:16
periods 354:12
permeability
 393:9 400:9
 401:21 414:14
 426:5
permeable 460:1
person 388:22
 398:6 400:14
 456:15
personal 379:3
 452:9

personnel 444:11
perturbation
 422:19 450:24
pervasiveness
 458:7
petal 429:14
 430:16
petal-centerline
 430:11
petal-like 430:15
PETER 330:19
 419:2
philosophy
 382:9
photograph
 424:3,5 432:25
photographs
 431:9,16
phrase 406:9
 418:5
pick 426:22
 455:10
picking 394:21
 426:7,8
pictures 459:20
piece 433:19
pipe 341:19
pit 394:17
place 345:26
 348:7,12 362:26
 439:14 441:11
 454:16
placement
 341:25 342:1
places 399:22
plains 438:15
plan 354:16,23
 383:15 391:14
 418:10
planform 397:7
planned 359:5
 411:22,26

planning 332:11
411:21
plant 398:26
443:11
plausible 454:22,
25
play 457:7
plot 346:22
393:20
plug 339:20
340:12 352:11,20
353:7,9 392:22
plugging 349:24
350:2,6
plugs 395:19
PM 408:23 410:4
point 335:21
336:4 347:19
356:2 359:26
369:13 371:5,12,
15 374:23
380:14,16 382:1,
2 386:8 392:24
395:12,17
396:10,11 403:15
404:9 413:11
416:24 419:18
433:14 434:1,2
440:12 441:12
446:10 448:5,8
450:19 457:26
463:10
point-bar-type
394:1
pointed 420:21
432:23
pointer 437:8
Poisson's 372:2,
6,8,11,15,18,21
373:1,7,16,19
374:1
Poitras 331:11
409:10 434:8
457:13

pool 340:26
380:26 381:12
382:4 442:21
poor 342:14,20,
24 415:16
poorly 421:14
Pore 347:20
porous 376:13
portion 375:26
378:2,3 398:1
433:9
portions 396:24
position 428:22
possibility
453:16
possibly 352:15
post 371:9 374:7
385:21 390:5
391:1,4,7,10
392:14,16 393:1,
6,17 394:1 396:1
397:22 416:10
441:22 457:23
post-stack
419:16 421:19
447:10 448:11
462:18,23
post-steam
367:22
potential 345:8
352:20 371:10
383:7 386:3
387:2 390:10
392:24 393:11,21
394:10,24 395:1
396:1,5 404:2
414:16 417:9
potentially
357:13 362:15
369:7 377:10,18
388:5 395:23
414:16
practical 450:11
practice 341:23
342:1 354:13

439:9
pre-existing
370:24
pre-stack 368:23
420:12 421:1,8,
12,14 422:1
447:2,6,10,15,24
448:14 462:19
463:6
preceding
340:23
precise 426:8
440:19
precisely 425:2,5
predict 426:4
predictable
381:23
prediction 373:8,
9
predictions
373:26
predominantly
420:23
prefer 407:5
410:17,26
preferable 399:8
preference
410:24 411:3
420:10
prepare 364:21
presence 370:24
396:17
present 332:24
363:9 371:11,14,
20 373:24 396:4
431:14
presentation
338:9,14
presented 338:10
372:10,24 373:12
419:15,22 425:15
434:3 462:22
presenting 364:4

preserved
390:24 391:12
pressure 335:22
336:10 337:12
339:17 340:7,14
342:3 345:15,22,
24 347:4,13,20,
21 349:3,8,11,12,
13,19,25 350:7
352:12,13,17
353:4,7,14,17,18,
19 355:3,7,25
356:6,8,10,11,18
376:12 380:18
382:10,12 383:9
385:19,23,25,26
398:26 399:8,11,
16 405:1
pressures 345:22
346:3,23,25
347:1,2 353:5
354:18,21 356:15
382:5,7,24
398:11,21
prevent 384:3
385:4 386:2
previous 360:2
377:6 426:20
439:6
previously
373:18 378:5
389:17 426:22
Prime 435:15,22
436:6
Primrose 387:17
prior 349:2
356:16 403:26
429:21 442:22
proactive 383:3
probability
378:1 429:22
problem 359:13
373:13 415:11
416:5 429:15
446:25 459:18,19

procedure
347:24 348:6,15,
21 349:4 360:12,
16,21
proceed 363:9
364:25 418:9
419:1
proceeding
329:14 402:10
442:8,15 443:1,4
453:20,24 454:10
proceedings
331:3 332:6
408:23 409:1
410:4 465:7
466:5
process 336:1,25
344:8,13,26
364:6,8 372:26
420:13,14
processes 458:3
463:11
processing
398:13 421:3,5
423:2 447:17
produce 443:24
produced 442:13
producer 376:10
411:21,24 412:1,
13 415:17 416:18
producers 357:6,
9,15 359:8 365:8
379:18 411:18,21
412:15
produces 423:3
producing 361:9
366:18 443:9
production
381:20 442:9,21,
23 443:15
professionals
457:5
Professor 396:26
profile 412:21
413:3

profound 393:10
profoundly
 443:20
project 343:18
 369:19 408:3,8
 415:21 420:10
 427:18
projects 367:3
pronounced
 448:14
pronouncing
 368:15
propagate
 378:16
propagating
 352:26 377:18
propagation
 377:14 406:13
properties 371:6,
 8 372:17,24
 387:18
property 366:18
proportion
 395:11
prove 461:10
provide 368:18
 377:26 391:13
 410:16 414:25
 455:12
provided 335:17
 368:16 377:1
 419:9 422:14
 423:19 442:5
 446:19 449:1,15
 452:3 456:1
 462:8
provider 451:10
providing 411:6
Province 466:8
provision 411:10
publications
 387:22
published 446:20

pull 342:9 397:15
pulled 333:25
 342:10 356:3
purely 397:6
purpose 366:16
 376:9
purposes 332:11
 335:12 349:17
pushes 395:5
put 364:16 378:7
 385:6 388:26
 418:21 446:11
 450:19 453:23
putting 407:18

Q

quality 390:9
quantitative
 377:26 378:2,3
 446:12
quarter 449:12
question 333:3,5,
 6,7,9,22,23
 334:4,10 335:19
 336:8,12 339:21
 343:26 344:4,11
 349:17 352:1,25
 354:11 355:14,
 19,21 357:15
 358:13 359:25
 360:8,10,22
 362:5,16,19
 363:13,25 364:2
 365:5,10,22
 366:7,13 369:2,5
 370:26 371:3,23
 374:4 376:17
 377:24 380:11,
 13,25 381:7,24,
 25 383:18,26
 384:25 385:8,9
 386:19,26
 388:10,16 393:4
 396:8 398:7

401:12 402:15
 403:7,9 406:3,8
 407:17 408:14
 410:15,22 412:18
 413:26 414:3,8,
 26 417:11 446:14
 451:21 452:1,2
 453:22,26
 456:11,20 458:1
 459:25 460:4
 462:21 463:17
questioning
 332:9,14,20
 357:24 369:16
 394:7 399:5
questions 330:9,
 11,17,25 332:15
 334:16,22 338:24
 339:4 343:24
 347:23,25 354:26
 355:2 359:11
 361:3,20,23
 365:14,23 368:4,
 8,11,13,17
 369:24 378:7
 380:7,9 386:10,
 12,14,19,21,24
 389:24 397:13
 400:24 404:5,7
 407:11,12,16
 411:16 413:16,
 20,22 417:18,21
 444:14 445:6,11,
 25 446:1 455:21
 457:9,14,16,18
 462:2,5 463:21,
 26
quick 358:18
 415:22 459:25
quickly 399:11
 439:12 456:4
quote 402:24,25
 438:25 442:17

R

R' 424:23
raise 454:5 460:4
raised 382:22
 383:8 395:7
 414:6
raises 364:8
 403:9 431:21
ran 343:14,19
random 422:26
 449:20
range 341:7
 359:9 422:13
 452:20,21
rate 349:2 352:17
 353:10 375:10
rates 353:3,8
 354:21 375:17
 382:13
rating 444:3
ratio 372:9,11,15,
 18,21 373:1,8,16,
 19,22 374:1
 381:16,22
ratios 372:2,6
 395:21
Rayleigh 449:10,
 11
re-evaluate
 386:8
reach 342:4
reaches 391:17
read 335:9
 340:20 345:13
 370:10,18 371:25
 374:6 377:5
 378:7 383:20
 398:9 400:1,4
 401:16 414:9,17
 426:2,17 437:13
 439:8 442:19
 456:25
readily 455:10
reading 397:20,
 24
ready 351:12
 363:9,10 407:21
 410:11 444:25,26
real 353:15
real-world
 428:18
realized 416:8,17
reason 340:5,10
 342:10 356:12
 410:8 427:22
reasonable 392:6
 429:26 433:22
 443:22 460:9
 461:5
reasons 391:26
rebuttal 330:22,
 24,26 332:19
 407:18,19 408:16
 418:10,11 419:5
 444:13 445:4,8
 457:14,19 464:5
recall 343:16
 404:15 449:6,7
receipt 443:3
received 351:3
 453:3
receiver 452:20
recent 338:11
 341:3 342:4
 367:19 416:12
recently 369:8
 461:4 462:13
recite 347:2
recognize 422:7
recollection
 334:1 335:22
 446:5 447:1
recommended
 446:7
Reconcile 412:19

reconciling 360:2	399:22	remarks 364:21	repressurizing 385:13	449:16,23 450:3
reconvene 444:20	referred 431:3 434:9 443:25	remediation 404:3	request 333:1 350:12 358:10,23 403:16 408:4 446:25 455:16	resolve 396:2 430:7
record 336:17 339:10 340:12 351:26 364:18 365:1 368:20 408:6 411:8 438:25 442:26 443:1 448:5 453:12 462:13 464:11	referring 337:11 406:4 450:3	Remote 329:16 331:3 409:1	requested 403:12 447:1,8 453:14 455:5	resolved 459:21
recorded 356:19	refers 417:4 441:15	remove 421:7	requests 446:24	resource 389:2
records 336:6	reflected 441:2,4	removed 423:1	require 415:21	Resources 330:8, 10,12,16,18,24 331:26 333:13 368:12 386:25 409:25 410:12 413:23 445:3
recover 389:1	reflecting 346:4 378:22	Rempfer 331:18 409:17	required 349:8 367:5 406:11	respect 354:11 371:23 414:21
recovered 398:3	reflection 421:13	repair 403:26	requirement 338:20 341:24 344:17 403:25 414:16	respond 339:1 344:1 400:14 419:9,11 423:19, 23 442:4 453:22
recovery 367:15 389:11	reframe 414:3	repeat 333:22 366:6 388:15 401:12 420:3 425:18 447:23	requirements 338:18 383:14	responded 368:26 436:26 437:6
red 337:14 397:22 424:5,13, 24	regard 341:8 349:19 359:21	repeated 384:26	requires 371:6	responding 334:17 338:26
redirect 332:16 400:26 408:15 417:16	regime 388:12,20	reperforated 339:21	rerun 417:7	response 330:15 333:9 347:21,22 361:21 362:1 364:11,15 367:19 382:12 408:5,13 410:12 411:6 426:7 455:6 464:18
redrilling 415:18	region 416:3	replied 439:5,8	Research 396:15	responses 337:20 368:5 382:25
reduce 349:1,7 353:20,21	regional 387:8, 15,22 388:12,19 393:8	reply 403:9	reservoir 335:14 349:9 353:5 366:20,21 374:8 375:19,26 385:22 386:3 388:26 390:5,9 391:10, 13,19,20,22 392:6,25 393:7, 17 394:2 395:20 396:6 407:4 414:19 416:9,18, 22,26 417:2 422:9 424:20 425:6 426:6,8,23 439:4	rest 407:11
reduced 360:13 380:3	regions 390:23	report 338:3,10, 11,25 339:3,26 341:4,6,14 342:4 344:9 370:6 373:12 376:21 402:9 404:9 407:24 443:4	reservoirs 367:5 391:5,24 392:7 417:10 439:11	restriction 349:24 350:6
reducing 353:18, 19 356:17 379:12	regular 336:25	Reporter 332:3,4 351:25 352:2 410:1,2 417:23 447:19,22 466:15,21	resistance 389:18	result 421:1 454:24 460:1
refer 336:9 423:26 426:10 434:19 435:15	Regulator 329:2, 9 330:9,11,17,25 368:11 386:24 413:22 457:18	reports 341:16	resistivity 436:22	resulted 459:15
reference 397:17 398:8 400:3 401:13 402:5,8, 12 434:6 435:20 436:9	Regulatory 329:8	represent 419:23 439:3 458:12 459:22	resolution 433:11 448:16,17	results 366:24 370:7 373:9 377:4 383:22 387:9 395:25
referenced 415:13 416:6,16 417:4	related 337:20 338:24 365:6 385:8 400:16 410:22 445:24 446:2 458:14	representative 366:24 367:4		review 336:25 337:6 340:11 343:25 344:26
references	relates 404:16	repressurize 386:7		
	relating 414:19 446:3	repressurized 385:24,25		
	relative 379:25			
	rely 347:26			
	relying 405:23			
	remain 348:22 363:16			
	remained 375:22			
	remarkable 423:6			

377:6 403:7,19 421:24	354:5,9,15,16,22	scenario 352:11, 16 449:18	13,22 457:1 463:12	setting 340:4
reviewed 339:26 454:18,19	SAGD 337:21 338:19 345:15,20 367:3 371:17 377:6,12,15 380:19,21 381:4, 8 382:17 388:11, 18 411:21 415:21	schedule 332:11	self-report 442:16,26 443:2	settings 397:6 457:26 458:2
reviewing 447:13	sales 446:16	scheduled 464:8	semblance 419:15,23 420:11,19 421:8, 15,16,23,25 422:4 447:13,25 448:9,12 451:8 453:13 455:7,8, 26 462:8,17,19 463:2,15	shale 335:13
revised 332:10 348:14,20	salt 387:21,23 451:2	schematic 390:2	semblances 453:3	shales 372:20
revisions 427:15	samples 397:21, 25	screen 351:5 410:6 418:24 426:17	semiregional 387:5	shallow 359:8 457:26
right-hand 402:7 426:1 436:8	sampling 452:6	Scrimshaw 351:23	send 350:17 351:17	shallower 357:10
rise 404:18 406:19	sand 372:12,23 392:19 393:19 394:15 395:17 432:11,14,18 439:10	scroll 407:26 427:24 436:18,23	senior 444:10	shallowest 359:26 360:6 374:12,22,26 411:25 413:11
rising 416:13	sand-on-sand 394:20	seal 383:22 393:6 404:24	sense 333:8 357:18 358:21 450:14	share 434:24
risk 353:18 370:12,13 376:23 377:1,4 379:2 380:3,6 383:7	sandier 416:19	sealed 393:2	sentence 425:16	shared 453:9
risks 387:2	sands 372:1,21 390:21 393:8,20, 23 395:2 405:22 407:5 427:18 433:20 441:18, 19,21	sealing 389:14 390:24	September 338:10	sharp 421:10
rock 389:20	sandstone 372:7	seconds 356:12	sequence 390:7, 8,15 393:9 395:18,24 405:25 406:1 457:25	sharper 421:4
room 350:12,17, 18,20,22,24 351:2,5,11 384:5, 13,20	sandstones 372:9	section 350:2 352:12,19 376:21,26 422:25 423:6 450:25 451:6	sentences 394:1 396:3	shattering 459:2
rotation 458:25	sandy 396:3 405:18 425:3,6 426:9,14	sections 371:21 422:4	series 334:15 394:12 436:5 445:9	shift 463:2
roughly 393:20	SAP 420:12	sector 443:19	serves 334:1	short 354:8,12,17 382:26
round 332:20	Sarah 466:3,20	SEG 369:10	Session 330:5,14 331:5 409:3	shorter 332:17 352:18 354:13
RST 365:26 366:6,9,13,16,24 367:7	saturated 375:26	SEG-Y 447:5	set 345:23,26 346:2 350:17 368:13 369:24 400:21,23 445:5, 10 451:13 452:16,18 457:7	shorthand 466:6
rules 388:25	saturation 376:1 437:6	segue 406:3	show 342:14,20 343:12 367:22 381:15 382:4 396:24 421:20 428:4,12 429:11 437:2 448:10 453:13 455:7,9	showed 392:1 393:21 424:18
ruling 454:11	scale 395:12 462:22,23	seismic 368:15, 17 371:19,20 391:5 392:21 394:24 396:20 419:13,16 420:12 421:3,6,7,20 422:4,8,12,16,19, 25 423:2,6,15 439:24,25 440:18,26 445:10 449:17,18 450:13,15,25 451:3,13,17 452:3 453:3,7,8 454:20 456:10,	showing 452:3	shown 385:16 411:17 440:23
run 339:18,20 342:8 343:11,15, 16 366:13	scales 438:23 462:16,26	sections 371:21 422:4	shows 337:12 412:21	showing 452:3
running 340:7 343:20	scanning 410:6	sector 443:19	Shukalkina 331:20 409:19	shut 383:1,5 442:12,23
runs 359:20 365:10		SEG 369:10	sic 456:21	
		seismic 368:15, 17 371:19,20 391:5 392:21 394:24 396:20 419:13,16 420:12 421:3,6,7,20 422:4,8,12,16,19, 25 423:2,6,15 439:24,25 440:18,26 445:10 449:17,18 450:13,15,25 451:3,13,17 452:3 453:3,7,8 454:20 456:10,		
<hr/> S <hr/>				
safe 343:6,7				
safety 353:14				

side 390:16 426:1,18 428:19 429:19 436:8 444:7 463:3	383:17 386:11 415:1 449:6 450:14 453:2 457:8 463:20	414:3 435:16 449:16 451:25	squeeze 352:18	statement 342:22 343:6,8 348:1,17 412:20,25 419:22 420:21 443:2 447:13 452:24
sideways 407:6	sit 395:2	sounded 455:21	stab 390:19	statements 341:2 364:5 423:23
signal 421:7 449:21	site 361:12	sounds 334:21 363:3,4 451:12	stack 450:17,25 451:6	states 335:9 340:19 345:13 370:10,18 371:24 374:6 422:6
signals 342:24	situ 372:1	sour 383:24	stacked 422:4,25 423:6 429:3	static 342:3
significant 337:14,19 347:18,19 349:6 353:2 375:12 379:4 386:7 387:20 398:2 423:9 438:16,23 439:18 441:2 454:15	sixty-nine 355:16	source 452:20 460:15,16 461:1, 2	staff 330:9,25 331:13,14,15,16, 17,18,19,20,21 332:15 361:16 362:17 368:8,11 409:12,13,14,15, 16,17,18,19,20 417:19 457:13,18 461:22	status 344:9
significant- enough 353:10	size 379:25 392:24 450:7,8	souring 384:3 385:4	standard 341:23 342:1	stay 348:24
significantly 337:15 341:3 352:23 353:20 356:12 405:21	Skeptic's 369:12	South 394:14,19 395:4 415:2,10, 15 417:1	stands 342:17	steam 345:23 347:10 349:2,7 352:16,17,18 353:3,8,10 354:18,19 366:10 367:23 375:10, 17,18,23,25 376:2,7,8,9,13 381:20 382:6,13 383:1,2,4,5,22 385:14 386:3 390:11 391:18,21 392:13 393:11 414:20,22 415:12,19 416:12,25 417:3
similar 366:21 367:5 427:10,12 451:3,4 452:18	skill 466:7	space 458:22	start 333:1,12 348:9 349:10 376:11 382:6 399:6,8 406:20 411:11,14 416:22 419:7 457:2	steam-chamber 347:12 366:1,2, 11 367:10 382:9 400:16 401:26
similarly 379:8 395:1	slice 419:15,19,23 420:11,19 421:8, 15 447:14,25 448:9,12 455:7 463:2	spacing 388:13, 21 391:15,26 392:12 422:23	start-up 347:23 348:9,14 354:16, 23 355:5,7 372:5 373:14 376:24 377:12 415:16,22	steam-driven 406:22
silty 431:19	slides 421:16,25 453:13 455:12,26	speak 348:14 394:10 453:19 454:9	start-ups 377:7 398:10	steam-vapour 376:1
similar 366:21 367:5 427:10,12 451:3,4 452:18	slide 359:22 412:20	SPEAKERS 346:11	started 335:23 348:20 352:22 360:12,15,21 378:5 382:3 415:2	steep 439:22
similarly 379:8 395:1	slow 347:20,21	speaking 334:7 348:11 414:5 416:16 451:14	state 369:20 372:16 373:24 376:26 377:5 425:2,5	step 355:25
simple 391:3 411:20 412:6,17 421:24 448:18 455:16	slower 391:23	specific 358:23 365:2 396:21 403:22	stated 347:7 383:20	steps 421:22
simply 383:1 400:16 438:12 444:25	slugging 399:18	specifically 334:10 345:4 368:20 369:25 372:18 374:25 394:26 416:16 442:10		sticking 397:14
single 377:21 394:8 405:24 456:17	slugs 398:22,25 399:15	spectroscopy 427:2		stop 361:6
single-review 344:13	slump 458:25	speculating 357:13		stops 416:25
sir 355:6 368:15 370:3,26 373:4 375:20 376:20 377:24 380:7	small 354:18 376:12 378:14 407:4 422:17,20	spirit 415:24		
	smearing 420:22 448:9	spoken 462:7		
	smoother 398:12	spread 404:19 406:20		
	Snowbird 388:5			
	Society 369:10			
	software 371:16 446:8 451:10			
	solely 388:13 414:19			
	sort 332:12 358:2 362:1 383:14 394:24 395:14 397:8 405:15			

story 443:7	structured 455:19	421:20 423:8 455:9	458:20	400:1 403:4
straight 428:11	structures 430:16 455:2	subtract 438:12	suspect 342:24 458:18	talks 414:9
strata 366:22 368:19,26 371:7 378:17 385:15 423:8 430:2 431:17 434:8 441:3 459:16 460:17 461:6	stuck 432:16	subtracted 412:8	suspecting 421:23	TBD 357:6,9 359:9 365:8,9 412:4 413:15
strategy 348:5	studies 387:5	subvertical 422:21 450:20	Sverdahl 368:14 369:5 387:1,11, 12 419:9	te 460:5
stratification 396:9	Studio 446:8,11 451:9	succession 458:19	switch 455:14	team 334:19 338:26 344:1 362:25 371:19
stratigraphic 396:23 455:9	study 370:8 387:15,23	sufficient 341:21 342:17 390:9 448:7	sworn 363:21	techniques 367:9 369:6,12,14,17, 19 387:6 456:22 457:2
stratigraphically 438:6	stuff 430:15 458:25 459:1	sufficiently 365:17 447:16	system 337:5 355:26 376:15 393:16,17 394:6, 11 430:4	Tectonic 388:5
stratigraphy 394:9 429:16,18	subaerial 458:9 460:25	suggest 353:6 421:24,25	systems 397:4 459:8 461:7	temperature 335:23 337:13, 15,18,23,25 338:2 345:15,24 355:26 375:7,21 380:18 383:10 460:25
stream 343:9	subdivided 395:16	suggested 455:5, 12	T	temperatures 345:6,22 346:4 366:1,10
strength 370:23 371:6,10,12 389:18	subject 339:11, 15 361:20 402:26	suggesting 446:15,16	tab 336:5,9 346:7, 9 355:20 356:9, 13,23,26 357:2 365:6,7 366:19 370:8 372:3 410:18,21 411:15 412:5,19,23 413:4,11 448:26	ten 358:2,25 362:11 444:18
stress 372:16 373:17,23,24 374:7 377:13 378:24 379:4,6 388:12,19 389:2, 12,13,16,17 405:12,22 406:1, 5,10 407:8 412:21 413:3	subjective 341:10,11	suggestion 400:11 401:23 446:5	table 330:1 333:4,26 334:4, 13 336:11 355:4, 17,18,24 356:5,7 359:4 362:2 372:4,10,24 373:1 410:20 464:18	ten-minute 444:19
stress- containment 373:25	submission 336:4,19,20 341:15 354:4 355:20 356:16 373:13 383:19 403:9 413:10 419:15 427:1 433:4 435:23 441:15 453:8 455:6	suite 396:17 397:5	tables 355:15	tend 397:2
stresses 372:1,22 405:14,20	submit 338:20 410:20	summarizing 370:6 377:4	tabs 420:8	terminated 456:4
stretch 420:19 463:12	submitted 334:8 336:10 338:3,18 344:19 346:9 355:23,24 356:22 411:9 415:1	summary 341:2 354:9 370:4 410:18	takes 381:1	terms 372:15 379:2 418:17
stretched 420:13 421:9	submitting 421:16	summer 356:3	taking 356:8,9, 14,16 400:22	terrace 393:16 394:24
strong 343:2 463:7	subsequent 339:19	superior 447:10	talk 363:20,22 414:15	terraces 391:7,11
structural 439:14,19 454:23 455:9 456:8	substantially 415:26	supplemental 408:4	talked 415:7	terrific 340:18
	subtle 368:24	supplied 335:26	talking 354:14 381:18 396:8,10	tested 416:3 457:4
		support 362:17 448:8		testing 398:3
		supports 335:13		tests 379:5
		suppose 446:22		thalweg 395:12
		surface 342:11 343:4,8 349:9,12 352:17 360:1 375:15 390:6 398:23,24,26 399:15 439:3		thalwegs 396:24

theme 397:14	374:15,19,20	toggle 420:9,16 421:25	transcript 331:1 368:21 436:22 438:26 466:1,5	372:20 404:20,22 405:21
theoretical 449:19 450:10 451:11	376:7 380:10 381:5,6 384:23, 24,25 389:16 411:12,14 413:2, 19	tomorrow 363:15 364:5,9, 12 464:8,15 465:5	transcripts 434:20	<hr/> U <hr/>
theoretically 385:26	three-well 355:23 356:5	tool 341:20,26 342:9	transfer 375:16	ultimate 349:8
thermal 335:11 339:20 344:6 345:6 382:23 387:17 403:19,21	throw 449:19	tools 342:8 343:13 423:7,11 451:7 457:6,7	transparent 356:21	ultimately 383:15
thermally 338:21 339:16 344:20,21 345:4	tidal 457:26	top 340:18,19 345:11 368:20 383:22 392:25 393:22 395:18,19 397:22 412:22 424:20 425:3,5 426:8,22 428:10 430:24,25,26 432:11 433:12 438:21	trend 346:2 347:8	unable 455:23
thick 393:20 425:3,6,9 429:6	tier 392:22 393:2	topic 396:13	trending 428:8	uncertainty 394:21 400:8 401:20 414:12
thicker 416:22 441:18,23	tight 413:7 417:6	tortuous 405:2	trends 335:23 336:3,10	unconformity 390:20,23,25 392:15 393:6 394:18,19 395:2, 24 439:23 454:15,24
thickness 392:17 395:21 441:22	till 408:19	torturous 390:18	triple 391:25	undergone 421:6
thin 404:21 425:11	time 335:21,24 336:12,13 343:17 345:2,3,9 353:2 354:12 356:4 362:1,8,13 382:26 384:17 387:14 399:19 400:23 401:12 403:25 404:2 407:15 408:20 415:4 419:15 420:19 421:1,13, 15,26 422:23 438:8 439:4 444:25 447:15,24 448:12,14 462:18,19 463:11,13 464:5	total 357:8 412:3, 8	true 360:1 374:21 375:1 412:2,16 413:5 443:14	understand 338:13 339:14 341:25 344:6 348:6 349:1 361:4 369:7 393:15 397:20 404:12 405:6,14 419:8 423:18 441:20,24 442:3 449:11
thing 381:19 431:5 433:6 439:18,21 458:16 459:4 460:13 463:9	time-migrated 420:15 421:19 422:1	totally 430:2	Tuning 449:13	understanding 338:11 339:7 345:20 360:11 365:26 381:1 385:8 402:22,24 411:16 443:11 449:26
things 415:5,9 417:6 449:19,21 458:11,25 459:5, 20	times 378:12 382:23 390:3 392:12	touched 394:7	turn 393:14 398:6 402:25 422:3 429:9 430:18	understands 345:1,7
thinking 358:1 399:4	timing 361:24 390:4	toughness 389:19	turned 416:6 443:15	understood 367:19 444:5 445:18,23 446:2 451:23
thinks 398:7 437:9	today 335:5 418:4 442:11 456:26 464:7,10	trace 422:23 450:17	Turner 331:19 333:19 335:3 350:15,19,23,26 351:4,7,9,16,20, 23 376:4 384:7, 11,14,17 409:18 420:3,6 425:22 434:22,24 435:1, 5,8,11,18,24 436:2 440:2,5,9 444:24 462:11 464:19	undertaken 401:24
thinner 425:11 431:14	toe 349:26 350:8 352:12,13 353:1, 4 357:13	trace-fossil 396:17	turning 443:8	
third-party 341:15		traces 422:24 450:17 463:12	twenty-six 355:16	
thirty 433:7		trade-off 406:23	type 393:18	
THOMPSON 330:20 419:3		trajectories 411:22,23	typical 371:7 429:18	
Thomsen 350:23 353:26 354:1,3, 24 359:24		trajectory 411:21,26 412:2	typically 342:7 354:14 359:7	
		transcribed 466:6		

undertaking
330:15 360:3
362:16,26
363:13,14,18,19,
24 364:11,15
365:2 407:14
410:12,15 464:18

undetected
349:26 350:8

unethical 443:20

unexplained
381:13,18

unfounded 444:8

uniform 405:19

unique 389:21

unit 393:7 395:20
416:13 426:24
432:4 460:11

units 372:12
389:14 392:20
400:6 401:18
413:4,5 414:10
428:21 457:23,24
458:8,23

University
396:15

unload 399:10,13

unloading
398:21,25

unmarked
419:25

unmasking
445:7

unmeasured
352:13

unusual 432:5

update 410:17,19

updated 464:17

upper 337:10
340:21,25 380:26
392:22 393:2,8
396:23,24 433:9
442:21 458:18

upsets 399:2

upward 385:25

upwards 386:4
407:6

usual 332:20

utilizing 387:6
394:3

V

valid 402:15
428:5

validity 369:16

valley 391:1,6,9,
12 392:14,20
393:1,15 394:6,9,
15,16,25 395:16,
24 396:22 441:22
457:23,24

valleys 395:9
396:25

values 334:13
378:1

vapour 375:18
376:2

variation 372:26

variations
368:25 392:18,19
420:14,18 454:23

varies 422:2

variety 343:13

vast 459:22

VAVZ 456:21

VDL 341:26
342:14,20,24

velocities 452:7

velocity 368:23,
25 420:14 422:2,
12,14,17 448:20,
26 449:1

vent 343:4,8

venture 427:17,
18

verbal 410:16,19

verbally 411:1

verification
422:5

Vermeulen
330:19 419:2,7,8,
11 420:5,7
423:17 445:6,8,
17 446:4,23
447:19,21,23
453:19,21 454:2,
7,9,14,17 456:20
462:5,6,25
463:23

VERONIQUE
330:19 419:2

version 419:25
420:15 462:23

versus 368:23

vertical 360:1
367:10 374:21
375:1 377:14
385:14,18 400:9
401:21 412:3,16
413:5 414:13
422:21 449:16
450:20 456:3

vessels 399:2

viability 386:9

Vidal 332:3
410:1 418:1
466:3,14

Video 329:16
331:3 409:1

view 369:12
370:11 371:5,12,
15 372:8 381:2
403:15 416:24
424:17 453:11

virtually 429:17

visible 423:13

visit 361:12

visual 422:5
423:14 426:1,3

visually 455:11

volume 329:15
354:18 378:13,18
386:6 398:2
419:16 420:12
421:6,19,24
434:20 435:3,6
438:26 447:2,5,6
455:15 463:6,14,
15

volumes 349:7

voluntary
442:16,26

volunteers 384:5

VVAZ 369:6,13
456:21

W

W' 440:24

Wab 449:4

Wabiskaw
339:20 340:3,22
345:18 377:10,
15,19 378:17
380:24 384:1,3
385:2,3,22 422:8,
18 423:4 448:25
459:14 460:20

wall 396:25

Walters 370:1,2
374:16,18

wanted 332:10
348:17 355:2
356:21 365:23
367:25 378:8
407:22 408:6
453:23

wanting 349:16
357:21 397:19
445:20

WARD 330:20
419:3

warm 375:19

water 354:20
374:11 375:4,19
381:17,20 382:8,
11 395:4 435:14
436:12,25 437:9,
16 438:2,9,14
439:2,16,18,22
441:4

water-driven
406:22

water-to-steam
381:22

waters 438:3

wave 422:16,20

wavelength
422:16 449:12,14
450:9,13

waving 402:2

ways 358:11
400:19

weak 342:24

weakened 371:9

weight 458:11

well-integrity
341:14 343:14

wellbore 336:16
338:5 344:6,12
345:2 374:22,26
375:11 383:8,16
404:18

wellbores 341:26
344:9 389:11

wellhead 342:10
375:17

wells 333:25
334:10,12 336:26
338:21,22 343:5,
11 344:19,24
345:4 349:20
350:3 352:22
355:7,12,21
356:10,13 357:12
359:4 367:13
377:12,15 378:5,
10 382:14 388:26

391:16 398:21,
22,25 399:10,13
403:26 413:12
434:17 435:15
436:12 437:19
438:14 440:12,
17,22 441:18,19
458:10

western 438:15

Wheaton 331:21
409:20

whiter 463:3

wide 379:20
395:10 396:20

Widess 449:23
450:12 452:13

width-to-depth
395:20

widths 404:20

**without-
prejudice** 443:26

withstand 345:6

witnessed 459:12

witnesses 350:22
364:21 384:19
402:11 407:20
418:18,21

wondering
351:13 357:17,18
387:10 403:14
414:18

word 367:11

wording 365:2

work 339:8,11,15
344:21 364:20,23
387:24 401:3
402:4 428:13
453:4,6,12 454:3

worked 371:18
460:18

workflow 370:7
446:3,7,12,14,15,
17,20,21

working 361:21
438:16 450:26

workover
339:13,26

works 350:13,14
375:4 408:16
438:11

world 369:16

worries 335:4

worth 416:7

would've 335:22,
23,25 356:18
361:1 402:9
410:22 446:20
456:3

wrap-up 358:18

wrapped 358:2

written 354:3
411:8 413:10
464:9

wrong 424:1
428:14 436:9
440:7

wrote 442:15

Y

years 343:19
396:19 423:11

yesterday 333:2
361:5 368:16
377:25 383:25
391:2 392:19
394:7 395:7
418:4 419:10,12
423:20,24 435:10
442:5,11 443:25
445:14 448:25

Z

Zaitlin 331:9
386:20,22,26
393:4 397:11
409:7 463:25

464:2

zone 335:15
339:21 346:4
377:19 380:24
383:23 388:5
405:20 430:3
431:6,7,19
443:13 448:25

zones 341:18
371:9 377:16

zoom 351:14
429:10 432:21
433:8 436:7