THE ALBERTA ENERGY REGULATOR

PROCEEDING ID NO. 430

IN THE MATTER OF the Responsible Energy Development Act, SA 2012, c R-17.3 and the Regulations and Rules made thereunder;

AND IN THE MATTER OF an Application to Amend Commercial Scheme Approval No. 11475 for the Kirby In Situ Oil Sands Project, KN08 and KN09 Development (Application No. 1936092)

AER PROCEEDING

VOLUME 3

Calgary, Alberta

February 8, 2024

TABLE OF CONTENTS

EXHIBITS

Proceedings taken at Govier Hall, Calgary, Alberta

February 8, 2024	Morning Session
Cindy Chiasson	Panel Chair
Brian Zaitlin	Panel Member
Meg Barker	Panel Member
William McClary	AER Legal Counsel
Shannon Peddlesden	AER Legal Counsel
Andrew Lung	AER Staff
Denise Parsons	AER Staff
Anastasia Stanislavski	AER Staff
Fahad Hamdan	AER Staff
Maryam Rahimabadi	AER Staff
Susan Harbidge	AER Staff
Maksim Xhaferllari	AER Staff
Felix Chiang	AER Staff
Scott Botterill	AER Staff
Baohong Yang	AER Staff
Elwyn Galloway	AER Staff
J.P. Jamieson	For Canadian Natural Resources Limited

M. Riley For ISH Energy Ltd.
A. McLeod For ISH Energy Ltd.

S. Murphy, CSR(A) Official Court Reporter
S. Burns, CSR(A), RPR, CRR Official Court Reporter

(PROCEEDINGS COMMENCED AT 9:10 AM)
Opening Remarks
COMMISSIONER CHIASSON: Good morning, everyone. Welcome back to Day 3 of our proceeding.

Mr. Lung, a question before we start: The room seems rather dark, but if I remember correctly, I think I was told that we need to have the shades down because it affects the quality of the video cast. Yes. Okay. No. That's fine. We will -- we will manage. I will get used to it. It just -- I think it's probably because it's foggy and that outside, but it seems a little -- a little dreary today, but welcome back. Let me just find my notes.

So the reminder, again, as every morning, is that we are video cast, and so that anyone who is in the room may be seen on the video cast. If you have concerns, please make them known to Mr. Lung.

I would just also remind, because we have a new set of witnesses here, is just the reminder about using the microphones, so -- that you can move them around, pull them closer to you, get the mic close to you. Use your best, nicely projecting voice, and it will all be good that way. We'll let you know if we're having problems hearing.

And I believe that we need -- that we have some potential new material in that we need to address? So, Ms. Riley, why don't you tell us about that, please.

Discussion

M. RILEY: Certainly. Good morning.

COMMISSIONER CHIASSON: Good morning.

M. RILEY: Give me one moment while I do this.

COMMISSIONER CHIASSON: Thank you.

M. RILEY: Does that work? It sounds like it works.

COMMISSIONER CHIASSON: That's fantastic. You're coming through beautifully.

M. RILEY: Wonderful. This morning we had sent updates or a record correction to two of the CVs that we have filed, one for Dr. Chalaturnyk and one for Mr. Barrie. I have spoken to Ms. Jamieson about it. As I understand it, they do not have any objections to this record correction being filed at this time. If that is still the case -- and she nods, so I believe that is still the case -- I would just ask that that record correction be filed.

COMMISSIONER CHIASSON: Thank you.
Thank you for the agreement on that.
So, Mr. Lung, we'll -- as it's corrections, does it just go in as the same document number or new document numbers on that?
W. MCCLARY: Yeah. We've got them as new documents. So the CV updated of Dr. Chalaturnyk is Exhibit 061.001, and the updated CV for Mr. Barrie is 061.002.
EXHIBIT 061.001 - Updated curriculum vitae for Rick Chalaturnyk
EXHIBIT 061.002 - Updated curriculum vitae for Brad Barrie
COMMISSIONER CHIASSON: Thank you, Mr. McClary.
All right. And I see that we have -- it looks like an addition to our hearing in terms of an easel flip chart here. That -- and I'm assuming that's part of what -- that ISH will be making use of that, the witnesses will be?
M. RILEY: Only in the event that it is necessary, yeah. We do hope that the Panel can see it, and we propose that after the Panel has seen it that we turn it around so that everyone else can just also have a look.
COMMISSIONER CHIASSON: Okay. And are there any thoughts, then, in relation to or suggestions with

relation to being able to capture it for the record, then?

M. RILEY: I believe we have discussed it with Mr. Lung, and he -- well, the suggestion is that we photograph it and it be uploaded as we go along.

COMMISSIONER CHIASSON: Okay. Any concerns, Ms. Jamieson?

J. JAMIESON: It's unconventional, but we're willing to give it a try.

COMMISSIONER CHIASSON: All right. Thank you. We appreciate your willingness to -- to try that.

All right. That being said, we may as well start off with ISH's direct evidence. The court reporters will deal with swearing or affirming the witnesses, and then we'll proceed from there. Right now we are looking to target around 10:45 for a break, but please let us know when it -- when it suits in the flow of your evidence. Okay. Let's proceed.

MARTIN FOWLER, BRAD BARRIE, AURELIE LAGISQUET, RICK CHALATURNYK, JOHN CHODZICKI, Sworn

KRISTOFFER VICKERMAN, Affirmed

M. RILEY: With that done, I will commence with some opening marks and then turn it over to our witness panel.

ISH Energy has been an oil and gas producer in Alberta, Saskatchewan, and British Columbia for over

30 years. ISH is proud to work in Alberta's oil and gas sector and to employ highly skilled workers in a sector that is so vital to Alberta's economy.

ISH's core values are integrity, long-term performance, humility, agility, and sharing knowledge. We believe that ISH is the last non-SAGD operator that still owns gas rights in the gas over bitumen or "GOB zone". That is, in part, what makes this SAGD development application unique. Subject to the statutory requirement not to develop and operate in a manner that will result in waste, other SAGD operators need not concern themselves with adversely impacting their vertical neighbours.

Because ISH is not a SAGD developer, ISH instructed its legal counsel to retain various external experts to speak to the questions this hearing seeks to answer. The difficulty, of course, was to provide the external experts with the data required to underline the expert opinion. Through CNRL's application and evidence, we have come across a great number of conclusions and opinions but very little actual underlying data.

CNRL made it clear that the approval they request through this application is strictly limited to the production of McMurray bitumen and does not include Wabiskaw bitumen zones. We have a record extending over thousands of pages, but every time we have received actual verifiable data, it was because either ISH or the AER requested it. As will be more fully dealt with in evidence, when data was provided -- and despite the fact that CNRL had it in a format that would allow ISH and the AER simply to verify their conclusions, CNRL in many instances provided data in the least accessible manner possible. This obstructive approach, together with a strange reluctance to agree to reasonable steps to ascertain fundamental in situ conditions and reasonable monitoring routinely undertaken by CNRL's peers throughout the lifetime of a SAGD development, has resulted in this hearing. It was only after the fourth round of SIRs by the AER and after ISH had already filed its evidence that the bulk of the information regarding static and dynamic FMI, geomechanics, and, frankly, any actionable information regarding monitoring has become available.

COMMISSIONER CHIASSON: Ms. Jamieson.

J. JAMIESON: Excuse me. I hate to interrupt, Commissioner Chiasson, but what Ms. Riley is presenting sounds a lot like final argument, and I would have thought those comments would be made tomorrow when we get there, but I leave it to you. Just the tone of it sounds like argument to me. Thank you.

M. RILEY: I will move on to what we're going to do next.

COMMISSIONER CHIASSON: Thank you.

M. RILEY: That was my next remark.

We have taken heed of the Panel's suggestion to focus our evidence on areas of disagreement, and given the time constraints, we will attempt to not repeat evidence already on the record. Instead, we will focus our evidence on the issues or part of issues not yet canvassed in full. The fact that we will not be repeating our written evidence does not mean that ISH is no longer relying on it and has not abandoned any part of it.

ISH's panel will commence its direct evidence by discussing its geologic interpretation, followed by some conclusions from its GCMS interpretation, and will very often turn to its FMI analysis.

ISH's panel will then turn to the issue that was initially described as the "coinjection issue", but there seems to be agreement between the parties that solvent "assisted start-up" is a more accurate description. We will then move on to the risk analysis and the economics underlying the risk analysis.

Finally, ISH will address the geomechanical work that was done after ISH had filed its evidence. We do not plan to present further evidence on Hearing Issue 5 because we believe that was covered sufficiently yesterday. ISH's panel is, however, available should there be any questions on that issue.

We will further introduce our Panel Members as we move through the evidence because we believe that it's more useful to have that information fresh in mind when we speak about the evidence that is being presented.

With that in mind, we will then proceed with Mr. Barrie.

COMMISSIONER CHIASSON: So, Ms. Riley, just -- and this is something I should have brought up at the start of the hearing, and I apologize for not doing it sooner, is just -- because we recognize we've got a lot of material and the rest of it here, is that just to make you and your witnesses aware, we have got all the CVs on the record, including the updated. We have looked at them, so it's not necessarily necessary to go through their backgrounds in detail. That being said, please highlight for us what you -- what you feel is important for us to know about their -- their background and experience, but just -- we don't -- we don't need a chapter and verse.

M. RILEY: Thank you. We did not plan to do that --

COMMISSIONER CHIASSON: Okay. Thanks.

M. RILEY: -- because we took heed of the

advice at the beginning of the hearing.
COMMISSIONER CHIASSON: Lovely. Thank you.
Direct Evidence of ISH Energy Ltd. Witness Panel
Q M. RILEY: Mr. Barrie, please tell the Panel what your position with ISH is?
A B. BARRIE: I am senior staff geologist.
Q Please confirm that your curriculum vitae is filed on the record in Exhibit 061.02?
A I confirm.
Q Please confirm that your CV sets out your professional qualifications accurately, was prepared under your direction and control?
A I confirm.
Q You have had the opportunity to review CNRL's responses to your geological interpretation. Please provide the Panel with your comments.
A Okay. I'd like to take this time, approximately 45 minutes, to give you a geological presentation.
Before I get started, I wonder if there's somebody with technical support that can get my monitor going for me. It seemed to have cut out. Or we can switch. Oh, okay. So that one doesn't work. Okay.
Excuse me. I will need a minute here to switch.
W. MCCLARY: Just so everyone is aware, the configuration for the witnesses, the right-hand monitor will be the screen, and the left-hand monitor is

available for other machines to be plug into, if necessary.

A B. BARRIE: So if I want to view the monitor, I'd look at this one?

W. MCCLARY: Correct. Not the right -- your right-hand side there.

A B. BARRIE: Okay. Good morning, Commissioner Chiasson, Commissioner Zaitlin, and Commissioner Barker, Mr. Lung, and other participants.

I would like to begin with a -- Exhibit 50.002, paragraph 27, PDF page 10, please. In the middle of the screen, I'm going to address paragraph 27 in which CNRL states that they: (as read)

> Consider the confinement strata to provide effective containment of Canadian Natural SAGD operation in the McMurray formation.

They go on to say that there are six correlatable units, and they describe those units as having: (as read)

> ... a high volume of shale, low vertical permeability, and being geomechanically competent.

So I would like to respond to each of those statements regarding the high volume of shale.

We estimate the volume of shale in the so-called "confining strata" to be approximately 35 percent. In other words, 65 percent of the material in the confining strata is sand, porous and permeable sand. This volume of shale, the 35 percent, is much lower than at most other SAGD developments where the volume of shale is typically 60 to 80 percent. Regarding the low vertical permeability, as I'll show in a few moments, the confinement strata consists generally of massive to bioturbated sandstones with moderate permeability with some thin bioturbated and thus permeable sandy mudstone beds.

Many of these sands also have excellent horizontal permeability that will allow SAGD reaction products to migrate freely in the reservoir and the confinement strata.

Regarding the comment about being geomechanically competent, the so-called "confinement strata" by CNRL has been fractured by a geological process called "differential compaction" that has rendered the rock weak and incompetent. Of the six so-called confining strata, it is my opinion that only two would be barriers, the marine A2 mudstone and the mid-B1 mudstone. However, the evidence shows that those two units are absent over the majority of KN08 and 09. The evidence shows that the four remaining so-called "confinement strata" have a high percentage of permeable sand that has been fractured by the process of differential compaction. I will now describe those four units in a little bit more detail.

Could you please go to Exhibit 32.02, PDF page 12, and Figure 2? Thank you.

So I'm going to start with the highest unit, which is the Wabiskaw C shown here in the middle of the screen. To orient you on the photographs -- and, by the way, is there a mouse I could use to point out things, please?

W. MCCLARY: And just as a reminder for everyone on the witness panel, if you're using a mouse to identify portions of the presentations that's on the screen, please indicate for the record -- for the transcript what you're gesturing towards as well so that we can capture that for posterity, because as we've said before, the transcript is the only record of the proceeding that we have available. Thanks.

A B. BARRIE: Okay. So --

COMMISSIONER CHIASSON: Ms. Wheaton, could we have the photo portion made a little larger, please. Thank you.

A B. BARRIE: Okay. So to orient us on this and future photographs provided by CNRL, I will point out that the bottom of this core is in the lower right side of the two photographs, which I'm using to show with my mouse, and the top of the unit is in the upper left of these two photographs. The labels that you'll see here in red are CNRL's.

So CNRL describes this unit as a argillaceous heterolithic mudstone and sandstone succession that is heavily bioturbated.

As can be seen in Figure 2 here, the image that I'm pointing to, the vertical permeability created by burrows is quite high, and I'm pointing now to this brown oil-stained sand-filled burrow extending vertically up through the rock.

So it's up this higher permeability created by these vertical burrows that we're concerned will allow reaction products from any SAGD operations to eventually breach into our Wabiskaw B gas zone.

Could I now please have Exhibit 32.02, PDF page 13, Figure 3. Thank you.

Can you scroll up just a little bit, please, so I can see the text just above Figure 3. Okay. So, yeah, if you -- sorry. You'll need to go to the preceding page just momentarily, and we'll come back to this.

So right there at 32, CNRL describes this stratum, the Basal Wabiskaw D heterolithic unit as having high mud content and wavy centimetre to decimetre thick beds containing 50 percent volume shale and a mappable calcite cemented layer. So now please if you could scroll to the next page. Thank you.

I would like to point out again the bottom right is -- of the core is on the lower right here, so depositionally this is the bottom, and then we move up. The dark brown-coloured portions of this core are the porous permeable oil-stained, bitumen-stained sandstone. So you can see immediately that there is a lot of excellent quality sandstone throughout this interval.

The calcite layer described by CNRL as "mappable", in my opinion, is a concretion essentially shaped like a ball no more than 2 to 3 metres in diameter. It is not a widespread layer across the region and is, therefore, not a barrier.

Yesterday, Mr. Lavigne describes these rocks as tidal. He said that they were deposited in an estuary affected by tides. He showed sand dunes created by tidal current and that the lows between these sand dunes contained muds which compact over time.

So if you could've looked at the sea floor at the time that this was being deposited, you would have seen a series of sand dunes punctuated by low areas containing some mud. So the muds here are not continuous. They are not a continuous barrier.

COMMISSIONER CHIASSON: Excuse me, Mr. Barrie. As I think I mentioned the other day, I'm not a geologist. Would you mind just pointing out on the photograph, for my benefit, where you're saying there's the concretion?

A B. BARRIE: Okay. You've asked a good question. It's not on this photograph, so --

COMMISSIONER CHIASSON: Okay. Thank you.

A B. BARRIE: I wasn't prepared to talk about it, but I can -- I can address --

COMMISSIONER CHIASSON: No. It's just --

A B. BARRIE: It is a diagenetic -- okay. So in sort of non-geological terms, after these rocks were deposited, there were chemical changes within the reservoir that resulted in changes to the -- essentially some of the pores were filled up with calcite that plugged the pores reducing the porosity and permeability.

COMMISSIONER CHIASSON: Oh --

A B. BARRIE: But these -- oh, sorry.

COMMISSIONER CHIASSON: Sorry. I do understand the concept. It's just I wasn't --

A B. BARRIE: Okay.

COMMISSIONER CHIASSON: I wasn't sure where it might be visible on -- on this photo.

A B. BARRIE: Right. It's not here. I'm sorry.

COMMISSIONER CHIASSON: Okay. Thank you. No. I appreciate that. Thank you.

A B. BARRIE: Okay. So we'll go to the next slide, please, which is going to be exhibit -- I think it's just Exhibit 32.02, PDF page 13, Figure 4. Right. So if we could stop a little bit above that, please, so I can see the text. There we go. Thank you.

So this is the Wabiskaw D non-reservoir unit, which CNRL describes as having bioturbation, wavy mud beds deposited also in a tidal bar setting. So the geological environment here is very similar to what I described. You can see again in the photograph the high percentage of sand and then the abundant burrowing. So a lot of this rock has been churned up and broken creating potential vertical pathways for SAGD reaction products.

Could I have, please, Exhibit 32.02, PDF page 16, and it would be Figure 8. So this is the last of the four so-called confinement strata that I wanted to describe. Based on CNRL's description, they describe this as heterolithic strata. It's mudstone proned inclined heterolithic strata. In other words, "IHS" is the acronym for that.

This unit shown here can be made of very porous permeable sand or of argillaceous muddy sandstones like shown here. Since these units were deposited in a non-marine environment, the muddy sandstones are not continuous and thus do not provide a barrier on a regional basis. In other words, the muddy sandstones have a limited extent.

In summary of this portion, there are no marine mudstone barriers over KN08 and 09 according to the evidence shown. The remaining rocks between the top of the SAGD chamber and our Wabiskaw gas are made up mostly of sand with porosity and permeability. Many of these rocks have been heavily bioturbated, which has enhanced their vertical permeability.

If I could now please have you pull up Exhibit 32.03, PDF --

Q M. RILEY: Mr. Barrie, I apologize, but can you go a little bit slower, please.

A B. BARRIE: Absolutely.

Could I have somebody please pull up Exhibit 32.03, PDF page 26, Figure 20. Thank you.

My model is that gas was generated in the McMurray as a byproduct of degradation of oil there into bitumen and has migrated up a network of open fractures created by differential compaction. The map on the left is provided by CNRL of SAGD pay in the McMurray. On the right is gas pay in the Wabiskaw B, again provided by CNRL.

So I wanted to point out here on the SAGD pay map these brown-coloured ellipses which highlight the thicker portions of the Wabiskaw -- or of the McMurray oil sand deposit -- so I'm pointing to these brown ellipses -- and I noticed early on that there's a direct correlation to the thick gas pay in the Wabiskaw B.

So I said that I felt that the direct correlation between gas and the Wabiskaw B and the McMurray proved my point. CNRL rejected the model saying that gas is where it is in the Wabiskaw B because it's on a closed structural high. So my response was to point out an area to the northeast of the two pads where there is a closed high on the Wabiskaw B seismic structure map, which I'm not showing today, and I said that there's no gas there because there's no bitumen pay there.

Could we now please pull up Exhibit 32.03, page -- PDF page 25.

So the record shows that CNRL has submitted various versions of the Wabiskaw B gas pay maps. In this submission from December of 2021, which is the same as on the previous slide, you can see I've plotted on here the area where there's no gas in the Wabiskaw B, and in the previous map, I showed there was no bitumen pay there either.

Could you please pull up Exhibit 22.02, PDF page 5. So this is another version of the same zone. They've mapped the Wabiskaw B net gas pay here from November 2023 -- so a few years later -- and what isn't shown on this map is the -- but I'll use my mouse to point out -- first of all, you can see there's a large area of gas over in this area that they've mapped, and there's a large area to the northeast of all of the pools here up in Section 9 where there is some gas pay mapped, but closer than that near to the area in Section 12 is the area that I had my black circle on showing no gas pay.

Could I now have, please, Exhibit 50.003.

W. MCCLARY: Mr. Barrie, if I could just remind you, please, to indicate for the record where you're placing your cursor on these figures and maps. It will be helpful --

A B. BARRIE: Okay.

W. MCCLARY: -- for the record here. Thanks.

A B. BARRIE: Okay. For sure. Would you prefer me to say, like, sections and townships and ranges and so on, or ...

W. MCCLARY: To the extent possible --

A B. BARRIE: Sure.

W. MCCLARY: -- if you could use a visual cue on the figure to identify -- that is easily identified on review later. We can use that in the transcript and then pinpoint what you're talking about.

A B. BARRIE: Okay.

W. MCCLARY: Because recall we'll just have a written version of this --

A B. BARRIE: Okay.
W. MCCLARY: -- if we're ever looking at it in the future. Thanks.
A B. BARRIE: Okay. I will do my best there. Thank you.
So I requested --
S. PEDDLESDEN: Dr. Fowler [sic], would you mind reviewing the previous exhibit again.
COMMISSIONER CHIASSON: Do you mean Mr. Barrie?
S. PEDDLESDEN: Oh, pardon me.
A B. BARRIE: We have to switch, yes, our name tags.
S. PEDDLESDEN: Just that previous exhibit --
A B. BARRIE: Sure.
S. PEDDLESDEN: -- if you could use the pointer --
A B. BARRIE: Sure.
S. PEDDLESDEN: -- and identify the location.
A B. BARRIE: Sure.
S. PEDDLESDEN: Appreciate it. Thanks.
A B. BARRIE: Let's go back to --
THE COURT REPORTER: Sorry. Sorry. You are interrupting, and I can't get the full sentence. It helps if I can get the full sentence and answer on the record, please.
A B. BARRIE: Okay. Okay. So I'm not sure

how much you want me to point out, but I will start with the important thing is the -- there's a large area to the southwest of the gas pool mapped in the Wabiskaw B shown in the very southwest corner of this map near the number "33" that has some gas pay mapped, and then up towards the northeast side of the map in an area where you can see the Number 9, there's some gas pay mapped. But near the number "12", much closer to the KN08 and 09 pads, is an area that I indicated had a large closed structural high with no gas.

Could we pull up now, please, Exhibit 50.003, PDF page 64. So over the two years that I've been working on this project, I've just shown you CNRL's mapping had stayed pretty much the same showing an area where there was no gas immediately to the northeast of the large gas pool mapped over the two pads, 08 and 09, and this is their most recent map after I raised these issues from January -- this map is from January 23rd of 2024, and you can see now CNRL has annotated in dashed orange the black feature that I had been referring to before, and they now have a gas pool mapped here.

When I was in the audience yesterday, I heard them say that they never mapped this area because it was isolated from the Upper II pool. However, in my opinion, it can be observed that the two could be easily connected. If you look at the area between the purple-dashed line and the orange-dashed line, there's no wells here to suggest that there should be a zero value here. These -- these could easily be mapped as one pool.

Okay. Next slide, please, which will be Exhibit 50.003, and this would be page PDF 50. Okay. So now I'm going to change to a different topic, which is the distribution of the mid-B1 mudstone.

The map in the centre of the display is an isopach map provided by CNRL of the mid-B1 mudstone. I had provided mapping earlier which showed a large area where the mid-B1 mudstone is absent, and I indicated that, and they have transposed that area onto this map. It's the area within the two blue solid lines.

So just to be clear, the white area on the north side of this map that I'm pointing to is an area that CNRL has -- and ISH agree completely that there's no bid -- no mid-B1 mudstone present here. We disagree in how far southwest of that area that the mid-B1 mudstone is absent or present. So I'm going to try to address that by talking to some of these slides that CNRL have provided.

I'd like to start by pointing out there's a few areas where we simply have no well control, and that would be where my cursor is now, which is -- I would say if the court reporter can -- it's 600 metres south of where CNRL has mapped their zero at. So there's an area here where there's absolutely no well control. So there's no way of knowing in this area if there is mid-B1 mudstone present like they've mapped.

Similarly, at the very far southwest side of this blue area that I'm pointing to -- so the very -- it looks like the toe of a boot, so to speak, there's a well here that was cored by CNRL in which they indicate that the mid-B1 mudstone was missing from core. So that's another area where there's no basis for the mapping that they provided here.

Now I wanted to point out a couple of things. The first one I will do is show you where we completely agree on the presence of the mid-B1 mudstone. And to do that, I might just have you zoom in on the area of -- of the 1AA/11-2, please. It's on the far right side in the middle of the screen. Yes. You're getting closer there. Thank you.

Okay. It's coming into view. If you could just scroll a bit more to the right, please. Thank you.

So in this photograph provided by CNRL at this Well 1AA/11-2, you can see the red labelling that says "mid-B1 mudstone". And ISH -- I essentially agree with this. When it's present, the mid-B1 mudstone is characterized by medium to dark grey shale. There is some -- as CNRL pointed out and we agree, there is some bioturbation in that interval as well, and it's -- it's present.

And so now if we could zoom out a little bit and -- or just go to the bottom of this page in the centre, and this is bringing me to a key and early discrepancy that I pointed out between my interpretation and that of CNRL, and that is regarding this well, which is the 100/1-3 well, which, again, is labelled here by CNRL as the mid-B1 mudstone.

I pointed out early in our -- in my submissions that this is not a mudstone. This is 60 percent porous permeable oil-stained sand and then 40 percent of fine grained argillaceous also somewhat lightly oil-stained sand. What you will see in the coming slides is how CNRL has now completely changed their interpretation. They now interpret this as a tidal channel.

So before we leave this map, I would like you to please zoom out a little bit, and I would like to talk to two more wells that are important to me, and that would be in the very upper right of the -- of the screen, please. There we go. Thank you.

If you can zoom in to the mid -- to the -- yeah, the core in the very upper right of the screen, the 11-2 well, to where you can read their label of mid-B1 mudstone, please.

So, you know -- and in the interest of time, I'm going to go quickly through this, but when you look at what they have labelled here as mid-B1 mudstone, this is clearly not a distal or an offshore marine mudstone. This looks like, to me -- like I'll show in a minute -- a continuation of the tidal flat environment which exists below and above this unit. This is not a unique unit at all. And in the interest of time, I'm going to skip the next thing I was going to talk about. It's just a similar example as that.

What I'd like to do now is to go to Exhibit 32.03, please, PDF page 7 and Figure 5. So this is a photograph, again, of a comparison between the mid-B1 mudstone, when it's present -- is shown here from the 1AA/1-1 well. It's a very -- like I said earlier, a medium grey mudstone, and then the well I mentioned earlier, the 1-3 well here, this is the interval where CNRL labelled this as mid-B1 mudstone.

And, incidentally, I should point out that all the bedding -- or the inclination that you see to the bedding here might appear sedimentary, but this is simply because the well is drilled directionally. So it's all an artifact of the way that the well was drilled and not reflecting sedimentary structures and the such.

Scroll up a little bit on that page and perhaps up a little more to the page before. Thank you very much.

So I'm now talking to this exhibit, and I'd like to start by mentioning that CNRL describes this rock here as the "lower B1", and we agree. And they describe this as a "tidal flat", not marine, and we agree with this as well. Our opinion, this is the same tidal flat sequence as below and above.

If you could please scroll down just a little bit, please.

What I've done in this photograph is I removed the red lines which CNRL had put on the photograph to help make the point that this is one, in my opinion, continuous rock type within a tidal flat sequence.

So now what I'd like to do is go into a bit more regarding CNRL's change of their description -- or their interpretation of the -- of the rock that you've just seen. So if we could go, please, to Exhibit 50.003, and this would be PDF page 52. Thank you.

If you could maybe zoom out on this one a little bit, please, so we can see more of the graph. Yeah. That's good. That's perfect right there. Thank you.

So, again, all of the annotations on this tab are CNRL's in red, and they've indicated here what they call a -- now "upper B1 tidal channel", and they've made some references that are circled in ellipses down here in the two photographs below. And it's to those two that I would like to talk in a little bit more detail. But before I do, I just wanted to remind everybody that's listening that this inclination to the bedding is not geological. It's not depositional. It's just an artifact of the fact that the well was drilled directionally.

So now, if I could please get somebody to zoom in, please, on the same page, but it's going to be the below -- if you could zoom in to the large ellipse at the bottom of the page. Thank you. Yeah. And if you can zoom in more on that ellipse, please, and maybe one more time if you wouldn't mind, please and thank you.

Okay. So, again, this is the photograph I just showed you a minute ago of what CNRL originally called the "mid-B1 mudstone". I challenge this indicating that it's a coarse grained sand, but it can be observed that these are flat line tidal deposits of the B1. There is no mid-B1 mudstone to separate here the upper B1 and the lower B1. These are not IHS beds within a channel. These are flat-lying deposits.

In my opinion, this unit has none of the features of a tidal channel deposit such as a sharp erosive base with lag. It does not contain ebb and flood tidal bundles, such as cross-bedding, ripple marks, et cetera, but it has all of the features of a tidal channel deposit -- sorry -- tidal flat deposit.

If we could now -- on the same view, there's a circle just to the left of the ellipse here that I would like you to zoom in on that one a little bit more, please. On the same -- no, just where you were, but just a left -- here, I will use my mouse, and I'll point to it. Here we go. So I'm trying to get you to zoom in on that feature there, please.

And then I'll talk to that for a second, and then a second later, I'm going to get you to zoom in a bit more, please.

But, again, CNRL has identified this in red as a "tidal channel base small breccia", but, in my opinion, this is not a clast. It is simply bioturbated sand. And if we could zoom in quite closely now to that feature that you've zoomed in on, that circle there, please zoom as -- as -- almost so that the whole circle fills the screen, please, if you could. Thank you. And maybe a couple more times right into that.

So what I wanted to point out here was that -- yeah, and maybe even one more time, if you wouldn't mind -- that when we look at this, again, the bedding here is -- it's not inclined. This, where I'm drawing my mouse at the top of the grey-coloured rock, is inclined in this photograph, but it's flat when it was deposited. And I interpret this dark brown oil sand to be a burrow of some kind, perhaps an escape burrow.

But the real reason I wanted to draw your attention to this photograph was to look at this feature, what CNRL has identified as a "clast". And you can notice that on the edges of this so-called "clast", there are quite sharp irregular, I presume, argillaceous sandy wisps, if you will, or protrusions sticking out into the -- into the homogenous sand body here, and there's another one up in this area. A very delicate lithology sticking out, and, in my opinion, there's no way this has been subject to any kind of erosion, otherwise these would have broken off. So, to me, this is an in -- in-place rock. It's not a clast, so it's not an indication of the bottom of a channel.

Now, this is where I was going to -- because I like to -- instead of talking I like to draw, but I think I'm going to try to just speak through this, but -- rather than using the flowchart -- and that is to say that my work has shown that the mid-B1 mudstone is absent over most of these two pads, and I have two potential models to account for that. One of them is that the McMurray channel underlying this area, as I mentioned earlier, has created some differential compaction that allowed for slightly more accommodation space on the flanks of the channel, and so on the flanks of the channel, we have a distinct lower B1 tidal flat deposit, which is punctuated by an incursion of the marine mid-B1 mudstone, and then normal tidal flat deposition resumed in the upper B1 tidal flat.

So on the area surrounding the underlying McMurray channel, we have a bit of a low that allowed a bit more accommodation space and little bit of room for the sea to transgress and deposit the mid-B1 mudstone.

But over the highest portion, i.e. over the top of the channel, there wasn't any accommodation space, so the mid-B1 mudstone was not deposited there, so what -- you look at cores of that area. You -- you essentially have one continuous tidal flat deposit.

Okay. The next slide will kind of try to summarize the points for this part of my talk, so that would be Exhibit 50.003 and then PDF page 50, please. Okay. Thank you. So if we could kind of zoom in on the map more, please, yeah, so it kind of fills the screen a bit. Thank you.

So CNRL indicates the mid-B1 mudstone is absent in the area shown in white, and it goes further to the northeast. Based on the evidence that -- provided, we have shown that the mud -- the mid-B1 mudstone is absent much further to the southwest inside the area of the thick blue line. A key well is the 1-3 well, which I've just shown you the photographs of, and a couple more wells that I referred to earlier, these two up here, in which, clearly, in my opinion, there's no mid-B1 mudstone present. I wanted to point out too -- and the geologists may appreciate this more, but what I see here supports my model quite nicely. If you look to the southeast side of the map, you can see that the mid-B1 mudstone is quite thick. I'm seeing values here of 79. I don't know. It's 69 there, et cetera, and then farther northwest you see it's quite thick here. As you move closer and closer to the high area here, which I map where the mid-B1 mudstone is absent, the values feather out. It progressively thins more and more as you approach this high. So it's thick here, it thins gradually, and eventually it's gone in this area.

I'm going to skip that part of -- which is to say that -- let me just say that there is an alternate interpretation here which is quite simple in that the incision that preceded the deposition of the Wabiskaw D valley fill, in my mind, simply could have continued further to the southwest. And instead of having any deposits here of the Wabiskaw D, there simply was no deposition, so the Wabiskaw -- the mid-B1 could have been removed and then just a tidal flat resumed on top of that, so ...

The key point is that the mid-B1 mudstone is absent within the area in blue, which is over large portions of the two pads.

Okay. Now we'll move on, please, to

Exhibit 32.03, PDF page 30. CNRL has written several times that the geology at the established KN01 and 04 pads is similar to geology at KN08 and 09. I'm providing the next figure to show that they're actually very different.

I want to start with the well that I've selected in the middle of this development to the east at KN01 to 04, and you can see here the top of the McMurray channel pay zone, which is just below this black double arrow, and then what I've interpreted to be IHS beds, so there's a lot of shale and a lot of sand in here and then a very thick -- an 8-metre thick mudstone bed before we get up to the base of the Wabiskaw B zone here.

So this package is 27 metres thick. When you look at my mud baseline, which I do by drawing a red line through a rock that we know to be essentially pure mud, and if you look down below that line, you can see that there's a lot of this rock in the confinement strata that is to the right of that line; in other words, it's -- it's -- it's mud and very pure mud. And down in this area there's also a lot of mud.

Now, if you look at the well that I've chosen from the centre of these KN08 and 09 pads, you can see that the geology, in my opinion, is completely different. If we look at the top of the McMurray channel pay, which I've indicated here, we're only 14 metres to the base of our Wabiskaw B gas zone. 14 metres is not very far. You can see also that there's no thick mudstone bed here like there is to the east and that the amount of shale, as indicated by the mud baseline, is quite low here. There is definitely some, but it's -- it's not as shaley as it is over to the east.

Okay. So now I'd like to please move to Exhibit 50.002 -- I'm just looking at the clock -- PDF page 61. I'm going to go through this one really quickly -- oh, sorry -- and paragraph 53.

And -- okay. So Exhibit 50.002, paragraph 53 on page PDF 61. If that -- if that's not it, then I'll just read it here. And, in essence, in that paragraph CNRL says that only one of the six potential fractures that I've identified is within the confinement strata, and my reply is that they are.

So if we can go now, please, to Exhibit 50.002, PDF page 17, Table 1. Very good. Thank you.

So CNRL provided this recently, and I've read through this, and I believe that the fractures that I've shown in photographs are naturally occurring. I believe that if these photos were shown to a panel of independent geologists, perhaps not working in the oil sands, many would reach the same conclusion. Indeed, Ogilvie report completely validates my interpretation.

I do agree that -- with CNRL's comments in some of the boxes. They said that some of my names may have been incorrectly named, and I do agree with that -- that that's possible to within 20 centimetres. I was working with core photographs, not the actual core. I wasn't able to map them in detail.

However, the key point and the focus of ISH work at the time was that these fractures incur in the interval between the top of the McMurray SAGD reservoir and the Wabiskaw B gas zone.

The next photo I would like you to pull up, please, would be Exhibit 50.003, PDF page 60. This is Tab 15. Thank you very much. And if you could zoom to the upper left portion of this, CNRL has made a schematic of the model that I did to illustrate differential compaction, and they state here that: (as read)

> The maximum amount of differential compaction in channel point bar deposits occurs above mudstone abandonment plugs. The overlying strata are not bent over the top.

So CNRL agrees that differential compaction exists at the two pads. They write that the maximum amount of compaction occurs over the mudstone abandonment plugs, and I agree with -- that there is differential compaction over the mudstone plugs, but the maximum amount of compaction is occurring by the fact that these rocks have been bent over the full width of the McMurray channel sand, not just these little mudstone plugs.

If I could go now, please, to 32.03, PDF page 33, and I'll just advise the room that I'm getting very close to the end here. Thank you.

So this model was conducted for illustrative purposes to demonstrate the effects of differential compaction. It -- differential compaction creates an extensional stress regime that results in faults and fractures.

The next slide would be to Exhibit 1.03, PDF page 17. This is a seismic section provided by CNRL early on in our exchanges -- and if you could maybe just zoom in on that a little bit, please. And I won't go into all the detail, but the point I'm trying to make I will do by pointing out what CNRL has picked as the McMurray channel -- this is the interval below the mid half of the section in orange here, and the base of that channel is the black line here. The overlying heterolithic interbedded mud deposits are this area, in flanking it in this area and then over to the right.

And what I'm trying to point out is that this whole area has been folded over the structure creating a network of open faults and fractures in addition to the fractures created by the smaller differential compaction features in these mudstone abandoned plugs.

And the final exhibit -- or second-last would be to pull up, please, 50.002, PDF page 25, and paragraph 80.

And CNRL states here that differential compaction is a common process, and essentially, if I can paraphrase, they're saying it occurs everywhere.

But I would love to now move to -- the last of my requests would be for Exhibit 20.02, and this would be PDF page 92.

So what's unique about the KN08 and 09 that makes it different from many other SAGD deposits is its narrow width. So the effects of differential compaction are more pronounced in an area where the rock has to be folded over a much more abrupt structure. If you look at the diagram labelled as "B to B Prime" by CNRL, you can see that the width of the channel here is approximately 1 mile. So the effects of differential compaction occur mostly where the rock is being folded, which is on the -- kind of towards the flanks of the channel, which is the lighter green colours. And over the top there is some fracturing occurring here, but, again, a lot of it is going to occur as you approach the edge of it where the rock is being folded the most.

If you look -- if you could imagine drawing a line north to south through the word -- or letters "KNO9", you can see that the pay body is much narrower here. It's only -- less than an LSD across. And so that rock -- all the extension has to be taken up in a very short distance. It's all occurring right over the top of the sand body in this area.

So, in summary, the evidence shows that the mid-B1 mudstone is absent over much of KN08 and 09. Since the A2 mudstone is also absent, it means that there are no barriers at KN08 and 09.

Differential compaction has created a network of open fractures and faults that we feel will be conduits for SAGD reaction products to migrate into our Wabiskaw B gas reservoir.

And, lastly, the geology at the KN08 and 09 pads is much different than that at KN01 through 04. Thank you.

Q Thank you, Mr. Barrie.

Dr. Fowler, are you well situated? Can we proceed?

A M. FOWLER: (NO VERBAL RESPONSE)

Q Excellent.

A Yes.

Q Dr. Fowler -- Dr. Fowler, please confirm that the purpose of your appearance in this proceeding is to

speak to the report that you have prepared as an independent expert in the field of GCMS data interpretation.
A That's correct.
Q Please confirm that your curriculum vitae is filed on the record as part of Exhibit 32.09 and again as Exhibit 38.01, Appendix C.
A Yes.
Q Please confirm that your CV sets out your professional qualifications accurately and was prepared under your direction and control.
A That is correct.
Q Do you acknowledge and confirm that you have a duty to provide evidence to the Regulator that is fair, objective, and non-partisan?
A Yes.
Q Please confirm that Exhibit 32.09, Tab 5 to the ISH evidence -- it is your report -- was prepared under your direction and control and that the contents thereof is accurate.
A Yes.
Q We have listened to a great deal of GCMS evidence yesterday, and I would just like -- we have one last issue that we would like to canvass with -- in front of the Panel, and it's one question. Does the fact that you observed a barrier in each well you reviewed mean

that there is nothing to be concerned about? Steam, fluid reaction products -- fluid -- steam, fluid, or reaction products will remain contained?

A While I observed different reservoir compartments and a strong barrier in each of the six wells for which geomechanical data was provided, similar to what Mr. Barland stated on Tuesday, I cannot comment on the lateral extent.

As different intervals are providing a barrier in different wells, this suggests that individual barriers are not laterally continuous over the whole area of the proposed development. That wherever this means, there are possible gaps between the different barriers that would enable steam reaction products to escape into shallow areas. From McMurray, I cannot say, as I -- as I am not an expert on the detailed geology of the area.

Q Thank you, Dr. Fowler.

I must point out that the next witness will be speaking for at least 45 minutes, so I do wonder if we should try and get through that or whether we should take the break now.

COMMISSIONER CHIASSON: That's a very good question.

Mr. Lung, do we have the same hard stop on our -- or the concern -- timing concern about our lunch space? No.

Okay. You know what? Let's -- let's go through

with -- with this material because it only takes us 15 minutes past the time we were planned, and then we will take the -- take the break after that and see -- see -- see how we move from there towards the lunch break. Thank you for checking.
M. RILEY: Very well. We'll then move on to Mr. Vickerman.
Q R. RILEY: Mr. Vickerman, please confirm that the purpose of your appearance in this proceeding is to speak to the reports that you have prepared as an independent expert in the field of BHI, which I understand you will explain, data interpretation.
A K. VICKERMAN: I confirm.
Q Please confirm that your curriculum vitae is filed on the record as part of Exhibit 49.01, Appendix A.
A I confirm that too.
Q Please confirm that your CV sets out your professional qualifications accurately and was prepared under your direction and control.
A I confirm that.
Q Do you acknowledge and confirm that you have a duty to provide evidence to the Regulator that is fair, objective, and non-partisan?
A Yeah, I do. If I may, I -- HEF, the company that I work for, has lots of different clients we work for, you know, maybe 40 different companies in any

particular year. ISH is only one of those companies. We've, in the past, worked for CNRL. We've -- we work for -- we're looking at four, I think, different oil sands operators work this -- this winter. And so we do have that duty. I -- I -- I feel that the -- the interpretations and reports that I gave to ISH is the same report that I would've given to CNRL if I had been -- been instructed to do so.

Q If you would then speak to your reports and conclusions.

A Thank you.

If we could bring up Exhibit 101, page 273, please.

So this is CNRL's slide that shows how image logs work and how the different geometries are working.

Actually, could I have the mouse, please.

W. MCCLARY: And just the requisite reminder to please identify verbally any visual cues to help us --

A K. VICKERMAN: Yeah.

W. MCCLARY: -- in the future. Thanks.

A K. VICKERMAN: So if I'm -- if I point to the coloured vertical well cartoon in the centre left, what it shows is a vertical well on the left-hand side of that diagram with -- with these horizontally oriented ellipses that are meant to show what a -- a bedding plain might look like in a vertical well, within inclined fracture cutting down through it from the top right to the bottom left.

When you -- the borehole image log is -- is a -- a measurement that reaches out to the sides of the borehole wall and is measuring -- in the case of the images that we'll be seeing today, the microresistivity or the rock, but it might be measuring something like the gamma ray or the neutron density or the sonic reflectivity. And then those measurements are then projected around the wellbore and positioned in space for an interpreter to -- to make their interpretations on.

And so when you look at an image that cuts on -- that cuts flat through a -- a borehole image -- or through the cylinder of the borehole, when that data gets unrolled and shown like on the right side of that vertical well cartoon anything that's an inclined bed that crosses all the way through the borehole now becomes this full sinusoidal shape, like the sinusoid that's labelled.

Anything that's perfectly flat relative to the borehole, basically -- planer to the borehole becomes this -- the horizontal plane. And I'd ask you to imagine -- for instance, if we had a -- a factor that was running parallel to the borehole, so an extremely steep one, this sinusoid would start to become very, very long. And from the point of -- say, if you were looking at 2 metres of data, it would -- it would appear as something that ran up the page of the screen.

And, similarly, if we were to take this -- this cylinder and imagine that we drilled a well horizontally through it, now the bedding would be the features that would be really long on the screen, and any fractures that were coming vertically into it would be horizontal across it. So there's a bit of a question of perspective. So is it a deviated well; is it a vertical well; is it a horizontal well for -- for how the features appear?

As was intimated, we've -- we've used a few different terms to talk about these kinds of tools. I prefer the more generic term of "borehole image log" because that describes the -- the -- a suite of -- a suite of -- of petrophysical measurement tools that might be run by a -- numerous different logging companies.

The more specific -- the -- the -- the term that has -- has also been used here has been "FMI". "FMI" is sort of -- it's a brand name. So it's sort of like Kleenex. We say the word "Kleenex" when we mean tissue. Kleenex is owned by a particular company. That tissue might be a -- a Scotties brand tissue or a no-name brand or -- or whatever. But "FMI" refers to an eight-pad tool that's owned by Schlumberger and is shown in the example on -- on the right here.

We'll see later on some six-pad imagers. Those are -- were star logs that were logged by Baker, and for that reason -- because there's not that much difference in terms of how you interpret them, I -- I would refer to, say, a "borehole image log" and -- and -- and avoid the -- the -- the commercial terms between them.

Can we zoom in on the -- on the right side of the image in the centre on the -- the fractures and image logs?

This is a good example. So I'm looking at the -- the top of the two coloured fracture logs, and I'm just going to trace with the mouse the -- the -- trace the upper most sinusoid going from the right of the image across to the left. And it -- it makes a -- it makes a sinusoidal trace, so there's a green line that's fit through the middle of it, and the feature is indicated as an open fracture because it has this conductive dark response. The reason that the fracture itself is conductive is because during the drilling process, regardless of what the -- the fluids that were -- happen to have resided in that fracture, those have been washed away and replaced by drilling fluid which is relatively salty. And so on these image logs, conductive things -- salty things are shown as -- as black, and resistive features are shown as white.

So this upper one is -- is an -- an end case kind of feature. I think you can -- you can see that it makes the full trace. There's evidence of it near -- near the right side of the image that -- that it makes a full sinusoid trace. So this -- this fracture has fully crossed the borehole from one side to the other.

The one that's shown below it in the same diagram, if we look over to the left side -- I'll just follow the arch of the upper part of that -- that -- that fracture that's highlighted in green, the lower of the two. I can only really see it on the -- from the -- about the one-quarter mark to about the half mark around the borehole. So this -- this is -- this fracture is basically, in my opinion, the same kind of feature as the full -- full intersection sinusoid that we see above, but this fracture terminates on a bed.

I -- I don't like to differentiate between the two of them when we do interpretations, so I -- I believe they're both fractures. Just one of them happened to end within the borehole, and the other one ends somewhere else because this fracture -- these other fractures don't extend off into -- into the infinite void. They all terminate on another bed, or they terminate on another fracture somewhere.

If we take our focus now to the -- the bottom pair of images here, this is attempting to show what a -- a closed fracture would look like in an image log. And whoever made this slide was -- was trying to show that, you know, a -- a closed fracture might be filled with a -- a resistive cement -- remember resistive features are -- are white in the borehole image log world, and -- and so they're arguing that this is a -- a healed fracture. I'm actually not really sure that these -- these features that are on here are actually healed fractures. The reason is that most of the healed fractures we see don't actually look like this. They don't look like white sinusoidal traces that cross all the way across the borehole. That's very, very uncommon. Because these measurement tools are physically measuring the return of electrical current from a source up -- uphope -- uphole on the tool through the formation and down through the buttons. And because of that, the -- the physical path of the -- that electrical current tends to find the most conductive path possible, and so features that are resistive are -- end up being hard to see, and they end up downplayed in -- in the image log. I would say maybe one in a hundred healed fractures actually looks like what's on the screen here. Very, very uncommon.

Okay. Can we move to Exhibit 32-08, PDF page 34, please. Just expand the scale a little bit so that -- yeah. There we go.

So this is from my report. This is a couple of fractures that I excerpted from the interpretation that I did. First, I'd like to note that when the -- the image that's on -- the image pair that's on the right, the upper one is showing a -- a -- a conductive open fracture that I've labelled with this pink tadpole and also with the pink sinusoid. And you can see in the image on the upper left that that pink sinusoid only extends where the feature exists and doesn't extend beyond it. And I think that's the better way to report this fracture, that it has terminated, it has a particular angular width to it, and -- and that all -- all of that information is -- is contained in an -- a file that would be given to the -- to the client that -- that asked us to do this.

And so this upper feature, I think, is very clearly an open fracture. It's more typical of the kinds of fractures that we see. And, again, this is a very, very bright example. This is what a strong open fracture example would look like.

In our experience in oil sands fracture imaging is that the fractures in the caprock tend to be fairly subtle features, and the reason that we come to that conclusion is based on the -- you know, the wealth of having looked at perhaps somewhere around 3,000 borehole image hogs in the oil sands with several hundreds of those having had core comparisons to them where we were asked to shift the core so that it was alongside the image and see them side by side. Plus occasional times when we're asked to review a specific spot and say, you know, is there a fracture here? We say -- we see something in the core. Is there something in the -- in the -- in the image log? And what we find is generally that we tend to undercount them in -- in the image log. And so for that reason, we try to be a little more aggressive in picking fractures in borehole image logs in the oil sands because they're such a -- an -- important. So they're important for this kind of hearing.

So we would like to identify -- you know, instead of a feature that we would be normally looking for a 70 or 80 percent confidence, maybe we would look for a 60 percent confidence in the -- in the fracture.

If we can look at the -- the second -- the second pair of images in the -- in the bottom, this is my example of a healed fracture. So the healed fractures are identified with -- with yellow sinusoids and yellow tadpoles. And the feature at the top of the image on the right is a very clear, in my mind, example of what a healed fracture looks like in a borehole image log. You can't really see a -- a white sinusoidal trace going through it. What you see from the static log is the presence of an -- an overly dark zone in the inside of the trough of the feature and perhaps an overly dark zone on the inside of the cusp of the feature.

So I was pointing -- the trough being the -- the low part of the sinusoid on the upper half of the right image and the peak being the edge of the image.

To my mind, I -- this is a very high confidence healed fracture. I would say hundred percent that I would -- any of -- any of my colleagues would pick this as a healed fracture every single time.

Looking below this, there are other features that come in that make this -- that are basically parallel to that and have a similar -- a similar geometry and a similar presence of -- of the -- of the overly dark on the inside of the cusp. And you don't actually see the plane of the feature itself, but you just see the presence of that darkness.

When -- this might be a good time to talk about the difference between the images on the -- on the right side versus the left side. So the images on the right side are -- this is what was supplied by CNRL. This was the bitmap that was in their -- in their exhibits. And as was discussed yesterday, this is a statically normalized image log.

So to generate this kind of log, the -- the -- the data is loaded into your software, and your software then separates the -- the image resistivities and -- and bins them into particular -- particular bins, so maybe the -- the top -- the most resistive 10 percent would be then shown as the white colour on the log, the most conductive 10 percent might be the black colour on the log, and all of the different shadings that you see in the -- in the image log, then, are -- are -- are assigned based on how much of that is present in -- in the well in question.

The problem is -- that was discussed yesterday is that there are some zones that might be all resistive or all conductive. And so you might have a zone, you know, perhaps like the top one on top -- pointing at the top right, where it's all kind of the same orange colour, and it's -- it's harder to see the features that are coming through on the log here.

And so from that, then, we generate a -- a dynamically normalized image log. There are a few examples later on in -- in CNRL's rebuttal submissions that came where they -- where they showed the static image and the dynamic image. That's my preferred way of showing all of these logs.

Now, on my dynamic image, because I was working with the bitmap, there's a lot of streaking between the pads. So I'm looking at the -- the two images on the left side of the screen. There's the -- the -- the -- the pink sinusoidal trace that shows where the fracture is, and then there's a bit of noise in between each pad. That is because I -- I've taken a -- a log that was a bitmap. I've now applied that vertical dynamic normalization to change the colour pallet to enhance the contrast. So to generate this image, for each pixel, it looks at the metre of data above and below it and says -- and analyzes, Is that most the resistive or the most conductive in that metre, and reassigns the colours. And so we can see more contrast because of that.

COMMISSIONER ZAITLIN: Can you also explain the central column, please?

A K. VICKERMAN: Oh, sure. Yeah. So the -- the central column shows a standard dip meter-type interpretation -- or tadpole log. And so what we have is the -- there's no legend on here, but the -- the left edge of that gridded central track is where zero degrees of -- of bedding dip would be or zero degrees of -- of feature dip. And the right side would be where it's 90 degrees of dip, so it's a vertical -- vertically oriented feature.

So if you look at the -- at the -- or the pink tadpole at the top, it -- because it's positioned between the 80 degree and the 90 degree range -- you can see at a glance that it's, you know, some -- it's somewhere in the high 80 degrees in terms of -- of dip, and then the tail of the tadpole points in a -- in a 360 degree, you know, looking down grid towards where the down dip direction of that feature is. So this feature -- it may be hard to see at this scale, but it says it's 87 point something at 257. So that means it's 87 degrees of dip and that the dip direction is towards 257, so west/southwest.

I guess it's worth -- worth talking when -- when we're saying about how images might look different if we're looking at the -- if it's a borehole that's cutting in a different orientation. So the -- the features on the -- on the bottom right -- and I'm just -- I'm just sweeping from the bottom edge maybe a -- a -- a quarter of the way across up to the middle, there's a -- there's a -- there's a dark hump that's shown there. Because there's lots of these general tracks of similar colour that are cutting across, I -- I would say that all of these features that I can see going in this orientation are beds. So I'm making a -- a -- a sweep where there's an upward -- there's a peak in the -- in the centre of the image and a trough on the edge of the image. And then anything that's cutting across that feature is not a bed. It's -- it could be a -- a fracture, or it could be, you know, something else.

So with that -- with that introduction out of the way, I thought I would go through the -- the -- the various image logs that were submitted to this -- this hearing process. So if we go first to 15.01, page 195, please. So this is fine at this scale.

So this image was submitted statically normalized with no dynamic images supplied. So at this scale, it's very hard for an interpreter to make any judgments about whether there is a -- a fracture or not present in this -- in this interval. And so from my point of view, there's -- you cannot justify any conclusions about the presence or absence of fractures based on this image alone.

Further, this image is presented without any orientation. I can tell from the header at the very top of it -- if you look at the top of the column, there's a 'U' on the left, then an 'R', then a 'D', then an 'L, then a 'U', as you go from left to right across the top of the image, and that tells me that this -- this is plotted on the high -- with the high side of the hole as the orientation of that sinusoidal presentation. So the 'U' is up; 'R' is right; 'D' is down; 'L' is left; 'U' is up again. But I cannot tell from this what the magnitude of the deviation is, what the whole azimuth is, what the calipers are reading. I can't verify that the -- the processing is correct. And so, in my mind, this is a -- an incomplete image.

Further, there's no interpretation shown on this. So there's no sinusoids, there's no tadpoles, and it would -- it's impossible for me as a skilled interpreter to know for sure -- to -- to tell whether this interpretation was done well or not, and it's definitely impossible for the Panel to do that because I -- I imagine that in this field you're lay people.

In -- in -- in my opinion, anytime borehole image data is shown, it's -- it's incomplete to show it in this format, that it should be shown -- it should be supplied as a raw and DLIS -- a -- a -- a -- raw DLIS file which contains, in a digital format, all of the measurements of all of the -- the buttons for each pad, as well as the information about the orientation of the -- those pads, the orientation of the tool, the orientation of the hole, the caliper measurements of the -- of the features.

From that kind of data, then, anybody with proper processing software could load the data in and do an -- do a full interpretation and be able to verify, you know, whether -- whether the data is -- was correctly interpreted.

I would like to see -- if you're just going to show a plot of the data like this, I would like to see the static image plus the dynamic image plus an interpretation all in the same presentation. If -- if that had been done, it would've been possible for somebody to take a look through those logs and -- and make an assessment without going through great expense of hiring somebody like me to interpret the fractures in the bedding and just verify, Do you agree with how it was done or not?

And then further you should be supplying that answer as a table, What -- what's the magnitude of the bedding, dip, the dip direction, what's the dip type, those kind of -- those kind of things, usually in an LAS file.

THE COURT REPORTER: "LAS file"?

A K. VICKERMAN: L-A-S. A -- it's a log ASCII standard.

Oh, before we leave this -- so this is -- this is one of those six-pad tools that has been misnamed as an "FMI" in the discussions here today. This is a star image log but, more generally, a borehole image log.

If we can go to 32.07, Tab 3, please.

So after ISH received these static image logs, they, like many in this room, are not borehole image log interpretation experts, and so they weren't able to do a proper assessment of whether there were fractures or not based on the evidence that was there. And so they then went to the -- a public -- a third-party log vendor and acquired this image which was entered into evidence. We would note at the top here that this is a -- a Schlumberger processed and interpreted log. There's a -- a name of the interpreter log analyst maybe halfway down on the -- on the screen in the -- in the header part of the -- of the image.

If we can scroll down a little bit on this image, please.

So this image is shown with a static image on the left, a dynamic image on the right. It's -- it's really unfortunate, and this is typical of the quality of the images that is in the public domain. It's shown in the very least contrast possible. There's really only four colours that you can see in this image log, which is a travesty because it's -- it's logged with -- with hundreds or maybe a thousand significant digits of -- of possible different resistivity measurements, and it -- and it's been boiled down to four. It's either white, it's black, or two shades of grey.

In the -- in the centre of this plot is a -- a depth track where it starts at 430.

Can we scroll down to 436, please.

So we can see on the -- on the right track here some of the tadpoles coming in. And so there are -- if -- comparing the -- the shape of the -- this tadpole to what's shown in the header, the interpreter has -- has identified a number of beds. And then right near the bottom -- I don't know if we want to bring that to the centre of the screen, but the -- the Schlumberger interpreter at the time called this feature a -- a "partially open fracture". And I -- I don't like that terminology. I think if you're going to say it's a -- an open fracture, call it an "open fracture" because what I -- I know that Schlumberger means by this is that it's open for part of the borehole and not open for others rather than meaning that it's partially healed or partially not.

Now, I might disagree with this interpreter, and I'll talk about that later when I get here, but this data that's in the public domain was enough to get ISH suspecting that there may be fractures present, and so that's why it was submitted.

At that point, I was brought in. If we can bring up 15.01, page 195 again.

So I was asked by ISH to look at these -- at the image logs that were in both the confidential and non-confidential submissions and help them to pick a couple of them to do a bit of further work to see if we could -- whether there was fractures or not in the --

present in the well.

Can we scroll down to the depth of 313.

So looking at this, this was the very clear healed fracture feature that I talked about -- showed in my report before. So at a glance, I -- I told them, Yeah, no, this is a good well. I can see some -- I can see some features between 314 and 315 that -- that look like some amount of fracturing.

If we scroll further down to -- to 323.

THE COURT REPORTER: Sorry. I can't quite see. Is it 5-23 like a well?

K. VICKERMAN: Or five -- sorry. 523. So that's the -- the depth track that's on -- on the -- on the right side. So if we stop here.

When I -- when I look at the -- at the feature that's just above 523, I -- my eye sees, looking through the centre -- maybe the centre half of the image, an -- an -- an upward curving cusp of -- of dark conductive features that could possibly be a -- an open fracture that crosses through this bed.

Like was said yesterday, I -- I -- I would not want to make an interpretation based on this static image alone. I would want to have, you know, first off, the -- the raw digital data and -- and do a proper processing interpretation myself. But I would look at this -- and we'll do that dynamic normalization that I showed elsewhere.

Can we go to page -- or to Exhibit 15.01, page 201, and scroll down to 499.

So in the -- in the top of this resistive zone, so where the -- in the centre between 499 and -- and 501, the -- these beds are -- are resistive, and so they have that light colour. And at -- at the upper part of it maybe in the 499.3 or so, I can see a -- a dark partial sinusoidal trace coming through and crossing the -- the middle four paths where the -- the curvature is -- is down towards the centre of the image. And so I would suspect from this that there might be some kind of fracture at this depth.

So I -- I then suggested to ISH, you know, these -- these are a couple of good wells to look at. These are the ones that we chose, and this is what HEF processed and -- and interpreted and submitted in our report.

If we go to page -- Exhibit 32-08, page 48. And just zoom back a little bit.

So this is the -- this is what I produced for ISH. There -- there's quite a lot of noise in the -- in the image on the left here, and so it's this kind of streaky non-response to the dynamic normalization. And that's because the image that's on the right is showing all black, all one colour, and there was nothing to expand out into a -- a properly dynamically normalized image. So even though I've done what I can, you still can't know whether there's a bed or a fracture in this zone.

If we can scroll down to a depth of 514. So this is that -- that healed fracture that's -- that I have shown a few times. If we go through the tracks from the -- from the left to the right, so the left-most track is -- the deviation is shown as this tadpole that's in the centre. It -- the scale -- its scale is between 0 degrees and 100 degrees, I think, of -- of deviation. So this is quite a deviated well, being at -- at -- at 50 degrees or something like that and -- and trending towards the southeast, just where the tip of this deviation tadpole points.

I have a -- a green indication of the gamma ray and then the -- the -- the dotted curves on the left edge of the calipers. So those are -- those are measuring the -- the diameter of the borehole in the various image pad directions.

I have interpreted four different healed fractures in this zone. You know, looking at it today and in preparation, I might have drawn another fracture below here because you see that overconductive cusp. So that's in a similar orientation to the yellow ones outlined above but just below 515, maybe 515.1.

And this is probably a good time to mention that, you know, these are all interpretations. When I look at an image log, I might be making 300 really small decisions. So, Is this feature bad or not? Is it a lateral cretion or not? Is it a scour surface or not? Is this thing that's crossing it, is it a fracture, is it a bit mark, or is it something else? So there's lots of decisions, and any one interpreter, if I come -- came back and interpreted this again, I might come up with -- I would come up with something that is 90 percent the same as what's been shown here, but probably not 100 percent the same. And it's okay to have some variation between interpreters.

If we scroll down to depth 523.

So just above -- just above 523, there's that partial -- partial sinusoid that I had -- that I had indicated that I saw before. I -- I think I have good evidence that there is a -- a dark feature that is crossing through the bed -- through the bedding. It looks like a fairly low-angle feature on the screen, but it calculates out to a dip of 71 degrees. So this is a very steep feature that is -- is -- is crossing the bedding at a -- at a high angle. It's conductive. So my determination is it's an open fracture.

COMMISSIONER ZAITLIN: Excuse me. When you point out these features, do you also know the stratigraphic horizon which is being shown.

A K. VICKERMAN: That's a -- that's a great question. So I -- when I was tasked -- when we were tasked with doing any -- any image interpretation, we're agnostic to what -- the situation of the -- of the oil companies or the gas companies' situation. I just go through and identify all of the features in the zone that I see and that I believe in, and so I -- the -- if we maybe jump to the bottom of this image -- I don't know if -- that's probably not easy to do without scrolling. If you could maybe zoom way out and then ...

Yeah. So at this scale near the bottom of the image -- yeah, this -- this scale is fine -- is that fracture that I identified before. It didn't matter to me that this fracture is in the -- is in the Paleozoic basement at the bottom. I'm just identifying the fracture in the beds that I see. I didn't know where the -- where the confinement strata was or any of the other high-level discussions. I only identify the features that I could see and put them in my reports.

COMMISSIONER CHIASSON: Just a question: In your middle gridding here between the two, I'm going to say, photos, because I don't know the right term. Yes. That -- that there. Is that -- what is that?

A K. VICKERMAN: So can we just scroll up to see the next one above it. I think that might be a little bit easier. Oh, no it's not great.

So this is a Stereonet presentation of the dip direction. Maybe if we can jump to page 42 in my report. So just remember the shape of that. It's a round thing with bars going out from the side of it.

So this is a Stereonet plot of the fracture data. I don't know if everybody is used to seeing these, but this is shown, you know, with "north" on the top of the plot, "east", "south" "west", and then the magnitude of the dip goes from zero at the middle of the plot out to 90 degrees of dip at the edge of the plot, and then any of these dots that are shown on here would be a particular feature that's plotted. So this one that I'm highlighting right in the -- near the edge of the diagram in the top left -- there's a -- there's a magenta dot there -- so this fracture that's here is near vertical because it's near the edge of the -- of the feature, and it dips towards the northwest.

Now, that it dips towards the northwest and is almost vertical, it's not different, actually, from this feature in the bottom right of the -- of the diagram which is near vertical and dips to the southeast. So for that reason, we then show on this same plot a summary of the azimuth, but we don't show the -- the dip direction azimuth; we show the strike azimuth, which is 90 degrees towards -- from the down-dip direction, and that's what creates these -- these triangles here, so this -- this is a histogram of the azimuths of the features of the dip direction of the feature.

So this could be shown as an unwrapped histogram plot where you had zero degrees, you know, 30 degrees of azimuth, and so it would look like a normal bar plot with -- with a peak at a particular direction.

In this case, the peak is over here in the northeast -- northeast corner, and there's a peak in the southwest corner.

COMMISSIONER CHIASSON: Thank you.

A K. VICKERMAN: Yeah. No problem.

If we can go down to page 46. So after we did our interpretations, we generated this kind of summary fracture density plot. Again, I have no idea where -- what -- what the zone of interest is or anything like that. I have just observed, yes, there are a certain number of these pink open fractures at particular depths and that I've observed these yellow healed fractures at different depths and then supplied a fracture density curve on the right side of these tracks. And so the fracture density is a calculation with a sliding window saying how many fractures are present in a metre.

And what we can see from this is while there are some fractures present, it's not a continuous presence of fracturing through the whole image log.

Maybe jump to page 43, please. So this is -- oh, there we go. So this is that -- that same Stereonet plot of the healed fractures. So we've counted 14 healed fractures in the well. They have a similar orientation in that they're oriented northeast to southwest maybe a little bit more northerly if we go up one page to the open fractures. Sorry. I rolled them out. I'm usually used to doing these.

So this one is more -- is more northeast/southwest, and the healed fractures was a little more northerly. That's not uncommon to have a bit of variation between the heal fractures and the open fractures because heal -- heal fractures can be -- can be older in that they could be fractures that are -- have been present longer, have been exposed to more groundwater, had more chance for mineral cements to be deposited in the -- in the open aperture, or they could have been created with a different process.

If we could jump to page 26 -- oh, sorry -- 27. I can't read my own handwriting. Thank you.

So I -- I made the comment in my executive summary that it has a low to locally moderate intensity of open fracturing. So if you remember back to that fracture density plot, there were gaps between where there were fractures present and that at some points the fracture density approached maybe five fractures per metre in a confined layer. So I'm saying it's low -- low overall to locally moderate -- in some places it's moderate density -- and with a similar orientation and intensity of healed fractures. There were -- there were similar number counted.

It said many of them are bed terminating, and they appear to be fine in aperture. So the fractures weren't, in my view, extremely large-looking, and that's what that comment is meant to say. They had a particular orientation, and there were no observed shears or interpretable large fractures in the image, so I can't see a fault. I can't see anything that looks like a major fracture.

Maybe in the interest of time -- so we looked at the -- we looked at two wells. The second well would be Exhibit 32.08, page 22. And I'll just jump to -- yeah, page 22 is good. So this is the fracture density plot for the second well that we -- that we looked at. Zoom out a little bit, please, so we can see a bit more context. What I can see here is that while there are some fractures present, there are less than the previous well. And that's what I reported to ISH. There's fewer fractures present in this well, and this is where they're located; this is where they're oriented.

And if we can jump to page 3 of this report. In my executive summary, I say the fractures are sparse, and there's not enough of them to comment on the orientation trends. The reason -- there may be three or four features. It's -- it's hard to say that there's an average based on three points. I don't like to do that. So if there's -- if it's not a statistically significant number of features, I -- I wouldn't show a -- a comment on the orientation.

I don't see any drilling-induced fractures; I don't see any faulting or any of those kinds of features in this log.

Now, all of this is -- is couched a little bit because I'm working with a flawed image log. I took their -- the static image. I dynamically normalized it as well as I could, but there are zones that are in this interval that I can't necessarily tell whether it's fractured or not.

Move to 44.10, page 10. Oh, can we not show that one?

So subsequent to doing my report, I -- I was asked with a few emails to look at and comment on some of the image excerpts that have also been shown. So we go to page 10 in this file. And can we zoom in so that the image log, you know, makes at least the half the screen? Yeah. Scroll down to it.

When I was looking at this image log -- again, I'm looking at a static log and not the dynamic -- I can see a discontinuity that crosses here. I said, Okay. There's one over here, and I thought there might be something on this edge over here. There's a bit of interpreter's liberty in there, and there's definitely a lot of uncertainty. So when I advised ISH that there's a feature at this depth, that's a possible but not definitive healed fracture based on this evidence.

So if -- if this and this and this all linked up when you looked at it with a dynamically normalized image, I would say it's probably a healed fracture. You know, again, it's more 60, 70 percent confidence. Just based on this alone, I would say it may be 40 percent confidence that there's a healed fracture.

The other possible description for this is that these two things on the -- on the right and the centre that are pointed out by the arrows make a line that is inclined up to the right -- up to the left on the image. And the typical kind of feature that would look like that in a image log is a bit mark, what I would call a "bit mark", so that is either from the bit itself as it's corkscrewing down. It would scratch -- scratch a line that's rotating down through the image, and it makes something that is a line on the borehole image log. And if you remember back, anything that's a plane makes a sinusoid, so anything that's a line can't be a sinusoid. It has -- it can't -- anything that's a line on the image log can't be a plane in 3D space, so that line makes a helix. And when describing, I like to talk with my hands. I'm kind of showing a corkscrew-shape thing, and that would be the scratch of the bit as it's -- it's coiling down through or coiling up through or any part of the drill stem assembly that has either scratched the surface of the -- of the borehole or somehow impacted the mud or scratched in the mud cake that might be present there.

We can jump to Exhibit 50.03, page 56. So this was CNRL's rebuttal. And you'll note that when they want to actually show and make their point, they show the image in the format that I would have requested. So they have a static image on the left here of the -- of the images that are on the left-hand side and a dynamically normalized image on the right. We can see many more features. I'm just pointing at a depth of 453.5. There's a resistive band that's maybe 20 centimetres thick in there. It's hard to see any contrasted features that are in that 20-centimetre interval, but if we look at the dynamic image on the right, there's many more little fine beds that appear in the dynamic image log. And they've shown some kind of interpretation; in this case, they have shown these little arrows that are present, and if I had been provided this image log, I don't think I would have said that there was a healed fracture at that depth. I would have said, Yeah this looks like a bit mark. This is a properly statically normalized image. They may have had a chance to adjust -- adjust the colour scheme that's on the screen, and I would have agreed with the interpreter in this case.

I'm not sure that all of the features that have arrows on here are tool marks. I think in their terminology they're using "tool mark" to mean "bit mark" like I would. But I think two people can disagree, and that's fine. I think there's a fair amount of this helical scratch that -- that stands out a bit more on this log compared to the log we saw before.

If we can go to page 55. So remember this plot that's on the right side. This is that black-and-white or near black-and-white image plot that -- that ISH provided that had a Schlumberger-interpreted pick on it, and we can see the legend here. I don't know if we want to zoom in close or not, but this -- this tadpole has a square head on it, and comparing to the header, it's a square filled-in head which is that partially opened fracture. That was the interpretation of the Schlumberger interpreter.

If we look at the CNRL log interpretation on the left, there are numerous arrows showing tool marks, and I would disagree with this interpretation. I don't think these look like those -- that helical scratch that was present in the previous log. I think this is something different, and I also don't agree with the Schlumberger interpreter either. The Schlumberger interpreter has picked -- and I'm pointing with my -- my feature on the image on the right at the dark blob that's about halfway up the right-most image near the edge of the track and about halfway across the -- that same track is the similar -- a similar feature on the opposite side of the borehole.

If we look to the CNRL image, that -- that same feature is rotated a little bit because the Schlumberger image is shown oriented to north, and there's a -- presumably a -- oriented to the high side of the hole. And so that -- that feature that was near the edge of the Schlumberger plot is now a third of the way in from the right side of the -- of the CNRL plot.

This looks to me -- it's dark and conductive. I can't see any features within it. And so, in my mind, this is a -- a -- a spot where a bit of the borehole has broken in. So the -- it's a borehole failure feature.

And what I see, looking at this log, is that there are many of those. There's lots of irregular dark conductive non- -- they're -- they're not -- they're not part of a continuous bed that crosses across a -- discontinuous spots where the -- in my view, the -- the borehole wall has fallen in.

And that's supported a little bit with the caliper log that CNRL posted on the side here. So the calipers are -- and I'm now looking at the -- the -- the third track from the left on the left-most image. There are dotted lines coming down that -- from the header here, it says that these are the -- the caliper. And the caliper enlarges at this -- at this depth, and so the -- the hole has -- has -- has become larger, at least in the direction that the caliper was oriented.

You may note that only one of the caliper swings out, and the other remains static and stationary. What I believe is that this -- this feature is a borehole breakout feature. So because of its orientation -- it's -- it's oriented on the -- on the -- the southeast and the northwest sides of the borehole. Because it's a paired feature that is present on -- on -- on one -- on -- on one side of the borehole and 180 degrees apart on the opposite side of the borehole, because it has this irregular edge and no internal bedding or anything else, this looks to me like a borehole breakout feature, which is a -- a stress-induced well failure feature that -- where the -- the borehole tends to fall in -- in the minimum horizontal stress direction. These are commonly seen in borehole image logs generally and also specifically in the oil sands.

The other artifacts that I can see on the screen is this -- this dotted spotty bits that are present near the top of especially the dynamic image of CNRL. There's sort of clouds that look black and white spotted. There's several of them at various depths, including in the middle of the log and including near the -- the bottom of the log in -- in the centre of the CNRL static image -- or dynamic image -- normalized image on the right.

My interpretation is this is also a common feature especially seen in the oil sands. This is a -- a -- oil smearing, mud smearing kind of an artifact. And so perhaps bitumen or some mobile oil from somewhere else in the -- in -- in the drilling process that's been brought to this particular depth and smushed onto the side of the -- of the borehole wall, and it -- you end up with those resistive speckles of -- of bitumen that are making it so that the electrical current return can't come back to the pads. And so any time it comes to the -- one of those bits of bitumen, it -- it can't read the -- the bed beneath. And so I -- I don't think you can see any of the features behind any of these images -- any of these artifacts. And that's just a fact of life when -- when dealing with image logs, especially in the oil sands. These are -- this kind of artifact is present. But I also don't think that this is a tool mark as indicated on the plot here.

So this is not a bad spot to make that comment again. I agreed with the CNRL interpreter that the previous thing on -- that I had called a "healed fracture" is a tool mark or bit mark as I recall it. I don't think that anything that's on this screen is necessarily a -- a tool mark. I think it's a -- a borehole failure feature and some of these speckles from that -- that mud smearing.

If we can go to 15.01, Tab 25. I think that's page 339. Can we zoom way in on the -- just the image logs first. So I -- I would like it so that the two image logs face -- fill the screen or got as close to it as we can. Maybe one more. If we can go one more in. Thank you.

Now, I'm going point to some features -- this image was discussed yesterday, so I thought I'd offer an opinion on it. I'm going to point to some features at the bottom of the image below the black rectangle that are especially visible on the -- on the image on the -- on the right, so the dynamically normalized image.

If I look at -- from looking at the full pad that's first visible on the right side of the image that's touching the bottom of that black rectangle and then skip two pads over, there's a similar-appearing kind of feature, and then two pads over there's another similar kind of appearing -- appearing feature where the -- it looks like it's smeared out or something has been stretched. So if you were to have taken a picture and then pulled it apart 10 centimetres, it -- it might look like this.

If you look at the other pads and not the -- the first and third and fifth from the right-hand edge but the -- maybe the first and third and fifth from the left-hand edge, we can see a similar smear that is or -- that is offset a little bit in depth. So it's a little bit below that black rectangle. This -- this feature that we're seeing here is a -- is what we call a "pull". This is a spot where the -- the logging tool got stuck in the hole. And when it's stuck, it -- depth is still being accumulated. So at -- at the surface, the -- the -- the logging cable that's above this tool is building up tension, it's stretching, and it's recording depth measurements, but the tool itself isn't moving. So the -- what you end up with is a repeated measurement until the tool can jerk forward, it gets enough tension, it gets unstuck, and then jerks forward. So this feature is -- is a pull. It's an artifact of -- of -- of the logging process and -- and not anything else.

The -- if we look above -- within this black rectangle, maybe a third of the way up from the bottom, there were several sigmoidal features identified in the -- in the -- in the static image, so the right-most image and the first pad near the centre. There's this S-shaped feature and fourth pads, and then in the third pad in the middle, a bit of a stretch. So it's a -- in my mind, this is exactly the same kind of feature as the stretch below. It's -- what you're seeing is the -- the tool slowing down as before it got stuck, being stuck, and then jerking forward. And so this feature that is an S shape in the image log properly should be shown as a -- as a plane. This is a processing artifact that should have been corrected before interpretation, and, in a way, it gets in the way of the -- of the interpretation.

At -- at this scale, looking at the dynamic image log, I can see a number of discontinuities that cross vertically along a couple of the pads. So I'm going to -- looking again at the dynamic image on the right, inside of the black rectangle, maybe a quarter of the way down is a -- is a bright feature that comes -- and maybe this bed actually looks like it might offset a little bit. So the bed in the third pad seems to have a bit of a step up, and then there's a bit of a white feature above it.

We continue that trace down. Oh, what's this thing? There's another thing that is vertically oriented that is running parallel to the pad and maybe -- you know, whether it terminates or crosses that bed, I don't know.

And then down sitting in that third pad, there's another feature that is inclined down to the right, a series of -- of blobs that, you know, could be an open -- an open fracture of some kind.

If we jump over to the bottom right of the image that is shown within the black rectangle, there is again another feature that runs parallel to the pad and up through the centre of it. It's dark and conductive.

I -- there's a question of what this is. This is possibly a fracture that is running parallel to the borehole at this depth. There are other explanations. This could be a drilling-induced fracture which might have a similar appearance. It could be a burrow. But one possibility is that this is a -- a fracture that is present at this depth.

If we look at the scale that's shown on the right-hand -- or left-hand side of this log, this is from 529 to 530, so any one of these features might be, say, 20, 30 centimetres long.

Can we zoom out a little bit so that we can see the core as well as the image. Maybe just, yeah, scroll it down at this zoom level. Yeah. This is good.

Now, the features that were identified in the core, I can't -- I -- I don't really comment. I -- I didn't look at the -- the core myself. But I would note that the scale of these features are similar to those that we saw in the image log. So this feature is maybe 30, maybe slightly larger than 30 centimetres long. It is very much parallel to the core. And so it doesn't -- like in the -- in the example that I talked about at the beginning of the sinusoidal thing crossing the borehole, making a sweep, and crossing all the way out the side of the borehole, that would -- that would make a sinusoidal shape. But if you had a feature that was parallel to the borehole, parallel to the core, it could exist as this feature that's parallel to the pad. So I -- I don't know that you can say that this image disproves that there is a fracture here. I think it's a -- from this image, there's a possibility that this feature that's on the -- on the right side that I showed that's kind of below the continuous bedding arrow and then three pads over to the left extending upwards from that, that that could also be a feature that would be parallel to the borehole, a non-sinusoidal feature, and it -- I would say it's definitely a possibility that there's a fracture here given the evidence from the image log.

So my conclusions would be that the -- the image logs were submitted without dynamic normalization and -- or -- or interpretation and that this is incomplete and not sufficient to justify any conclusions. There's no way that I could -- I could justify the conclusions based on what was submitted. I don't know that the -- the AER could do likewise.

Given this, ISH sought out the third-party images that indicated some possible fracturing in the area. That was that Schlumberger interpretation and image that I disagree with. But that was enough for them to say that there -- maybe there's some fracturing here.

We were brought in to look at that -- at the -- the CNRL-submitted and the third-party images, and selected a couple that looked like they had some -- some fracturing in them. We then digitized the orientation because we weren't supplied it and the image data from CNRL and -- and did the interpretations. I produced reports on the two wells, and I found evidence of fracturing in both. Thank you.

COMMISSIONER CHIASSON: Thank you.

So I would suggest at this stage we take a break. Our court reporters have been going hard for a couple of hours. So we will break now. We will return back at 11:35, and we'll test things then in terms of what sort of time span we're looking at till a lunch break. Thank you.

(ADJOURNMENT)

COMMISSIONER CHIASSON: Thank you, everyone.

Ms. Riley, can you give me an idea of what might be a reasonable chunk of time -- if we were to look to go roughly an hour, will that suit for your timing? I know that the parties have breakout rooms and that type of thing. If you would like to go shorter, that's fine. I'm just thinking in terms of the people will need to be fed at some point.

M. RILEY: Yes. We are also part of those people that would like to be fed.

I've discussed it with my co-counsel, and we agree that the topic that we want to canvass next can be canvassed in half an hour, so --

COMMISSIONER CHIASSON: Okay.

M. RILEY: -- so we hope that we'll be done with that topic at noon, and then --

COMMISSIONER CHIASSON: Okay.

M. RILEY: -- that might be a good time

for a break.
COMMISSIONER CHIASSON: And then suggest that we break for lunch then?
M. RILEY: Yes.
COMMISSIONER CHIASSON: Okay. Thank you very much.
A. MCLEOD: Good morning, Commissioners. Andrew McLeod, for the record again.
This morning I'm going to be canvassing some evidence with Ms. Lagisquet.
Q A. MCLEOD: Now, Ms. Lagisquet, would you please confirm that the purpose of your appearance in this proceeding is to speak to the report you prepared as an independent expert witness in the field of in situ project development and risk assessment?
A A. LAGISQUET: That's correct.
Q And would you please confirm that your CV is filed on the record as part of Exhibit 32.11, which is Tab 7 of your report and again in Exhibit 38.01, Attachment A?
A That's correct.
Q And would you please confirm that your CV sets out your professional qualifications accurately and was prepared under your direction and control?
A Yes.
Q And do you acknowledge and confirm that you have a duty to provide evidence to the Regulator that is fair, objective, and non-partisan?

A Yes.
Q And please confirm that Exhibit 32.11, Tab 7 to ISH's submission, which is your report, was prepared under your direction and control and that the contents thereof are accurate.
A That's correct.
Q Are there any additions that you have to your report?
A Yes, Mr. McLeod. I would like to make two additions to my report.
Q Could you just speak closer to your mic?
A Yes.
Q Thanks.
A So they would be -- they would be in Exhibit 32.11, page 18, paragraph 1313.
Q Would you like that brought up on the screen?
A If it's necessary.
Q Sure.
A Otherwise I can just state the changes or the modifications.
A. MCLEOD: Would you please bring up Exhibit 32.11.
A A. LAGISQUET: Page 18, please. So I would like to add risk of direct communication between the McMurray and Wabiskaw D formations at Cenovus Christina Lake.
Q A. MCLEOD: Okay. And so that is at

line 312 there? Is that where you wanted to make that addition?
A No. In the title of the section.
Q Oh, I understand. Okay.
A Yes.
Q And so would you just read into the record again what you intended that to say?
A Yes. So the title of that section needs to read "Subsurface Steam Loss of Containment -- Containment: Direct -- Risk of Direct Communication Between the McMurray and Wabiskaw D Formations at Cenovus Christina -- Christina Lake".
Q Very good. And I think that you mentioned that you had a second addition?
A Yeah. Again, on page 33 now, please.
Sorry. It's in the references. So it would be page 40. Sorry. Line 731. The paragraph needs to read "Risk of steam breach in Wabiskaw zone at Christina Lake".
Q Okay.
A That's all.
Q Very good. Thank you.
Now, Ms. Lagisquet, what experience do you have with SAGD solvent injection?
A I'm a technology development specialist. I've been working for the last 20 years in the oil sands industry

both at Statoil and Suncor. And during the span of my career, I've been leading multiple analysis [sic] on solvent -- solvent-assisted and various other variation on the steam-solvent processes. I prepared reservoir simulation studies in that space. I led teams of development specialists in the commercialization of various solvent processes. And I led two field pilots; one at Statoil and one at Suncor.

Q Thank you.

Now, in relation to the solvent-assist start-up that you discussed in your report, I believe that Dr. Boone took exception with some of the example projects you used in your report to show that solvent-assist start-up is an experimental process. Can you comment on the literature view that Dr. Boone provided in response?

A Yes. If we can look at Exhibit 15.01, page 48. And if we scroll down, I believe, there is the beginning of a literature review that was provided by Canadian Natural. Yeah.

So Canadian Natural provided a list of field pilots associated with solvent-assisted start-up, and they have listed six -- six of them and provided some details of when they were tested, where they were tested, and a qualitative analysis of their success. So if you scroll a little bit more because it's over two pages -- yeah.

So what we can see from that literature review is that there is limited information about solvent-assisted start-up in the industry. A total of four -- five operators tested it. Usually they are tested -- they have been tested in the past on one to two well pairs. There might be an inference that Cenovus has tested it on more well pairs. But there is relatively little information available to actually make a determination as to whether or not solvent-assisted start-up is a mature technology at this point in time. And that's the reason why I mentioned that, in my opinion, it's still highly experimental.

I'm also saying that because the range of outcomes that have been observed vary quite a bit, and usually what that means is that there is residual risk associated with the technology, and it could be in many different areas, right. When you de-risk a new technology, there are various aspects that you are looking at de-risking. You are looking at de-risking the technical aspects, you know, how it's going to behave subsurface. You're also looking at de-risking the surface technical aspects, how the facilities are going to behave with the introduction of a product that is not standard to SAGD operations. And you are also

looking at de-risking the economics of the technology.
We know that pilots are seldom economic. If you want to de-risk aspect of the projects, you also need to de-risk the economics such that at scale it still makes sense to deploy the opportunity.
Q Thank you.
Now, you just mentioned that you see CNRL's approach here as experimental. But CNRL tells us that they've used solvent-assisted start-up on other projects in the past and without lost monitoring.
So can you tell us what is different about the proposal that CNRL has before the -- the Tribunal today?
A Yeah. Absolutely. We can go to Exhibit 32.11, page 32. Sorry. I meant 20.02. Page 141. Yes.
So this is a summary that CNRL has provided on their test to KN01 Well Pair Number 8 and -- but the only cords they concluded on the last bullet point: (as read)
More piloting is required to commercialize the hydrocarbon agent enhanced start-up technology.
Now, if you zoom out a little bit, just to orientate ourself as to where KN01 is located. So we've seen maps of the Kirby north project development area. KN01 is on the eastern part of the project development area;

KN08, KN09 on the western part of the development area. I think we have already highlighted that there are some geological differences between the two areas, so going from the results of one well pair to the commercialization to -- up to 33 well pairs, you know, increasing the rates potentially from a hundred cubes as tested at KN01, 08 to potentially 350 cubes per well pair, is, you know, a leap in terms of how the technology is being -- at this point, I would say on two pads -- being commercialized.

Q Okay. And -- and so you pointed out there that CNRL has come to the conclusion that more piloting is required to commercialize their hydrocarbon agent enhanced start-up technology. What -- what would that involve, in your view?

A On the subsurface, if I started with that, as you can see on this test, they had one well pair that was used as the pilot well. And I can only guess that the reason why they selected that well pair is because it has, you know, similar geology. If you look at the isopach, they look similar. So that would be used to compare the performance on the well, what you tested, the technology versus the performance of the -- of the well that doesn't have the technology.

I haven't seen the plan to have any control wells at KN08 and KN09. I believe it was mentioned yesterday that an option would be putting it on every other well pair. Also appreciate that those wells are not drilled yet, so making a determination today as to how many control wells you're going to have versus the number of wells where you're going to test the technology is difficult. But I think it's -- it's important to remind ourselves that, yes, those wells are not drilled yet. So we don't know what we're going to find out as we drill them; right? And there may be a determination that either is not necessary to test the technology there, or there is no value in testing the technology there because of reservoir considerations, whatever the case may be.

Q Okay. Now, I'll turn to page 20 of Exhibit 50.03. And if you can just scroll down a little bit there. I believe it's the third heading. Actually, let me -- let me walk back just a little bit of that page. Okay.

Okay. So Dr. Boone responded to your definition of "discontinuities", and -- and he indicates that none of these examples are discontinuities that would alone allow fluid migrations from the McMurray to the Wabiskaw B zone.

Was it your intention in providing those definitions to suggest that one of those mechanisms would allow for fluid migration?

A It is possible. I think we've seen through -- or we've

heard over the last couple days and we've seen on the maps that, you know, those confinement interval do not -- to a large extent, none of them covers the entire project development area; right? My fellow panel member this morning also reiterated that. And so as a result, you know, it is entirely possible that there are pathways already established that would allow the migration of either steam or reaction product. I can bring a map if that's helpful to kind of contextualize what I'm saying.
Q Sure. Yeah.
A Can you please bring Exhibit 44.10. Page 15 would be the last page. Yeah.
Okay. And can you please try to centre the image so that I can see the bottom two. Perfect. Yeah. A little bit more -- little bit down so that I can see the header where it starts with "Local Versus Regional", please. There you go. Perfect. Thank you.
And so what we've seen or what we heard yesterday -- what we've heard with Dr. Fowler this -- this morning is that, you know, at the local scale -- so when you look at it at the core level and you have your GCMS data, there may be one -- at least one barrier that you can say is -- is there. And the challenge is that, you know, life is not 1D; life is not 2D. We've seen a lot of cores; we've seen a lot of

maps. What we're trying to resolve here is the continuity, like the 3D behaviour of SAGD on this proposed project development area.

So if you go from the local scale to the regional scale and you put together the information from the geology, you put together the information from the GCMS data, what you can conclude is that there are holes here and there. And what those holes provide for the steam chamber that I have illustrated at the bottom of -- of those schematics is the fact that through those purple lines that are little squiggles, you have pathways from the McMurray up into the Wabiskaw B for either steam or reaction products, and that would be exsolved gas from bitumen or H2S due to a aquathermolysis that could end up contaminating the Wabiskaw B.

Q Understood.

Now, I apologize. I kind of got us a little bit off track of the solvent assist. So we'll turn back to that. But from what you've been telling us, I mean, it sounds like there's quite a bit of uncertainty in what CNRL's plans to do with its solvent assist start-up commercial test. What additional information or analysis would you recommend that CNRL do before proceeding with this -- this commercial scale test?

A Well, the -- the whole point of doing a field test is to collect data such that you can calibrate your simulation models, history match them, and predict future behaviour.

So, you know, one of the first, you know, steps that we take is actually building a reservoir model. I don't know if it's available as of yet, but if it isn't, it's probably something that I would endeavour to do. Then, you know, once you complete -- once you do your test, you know, collect data that -- you know, that can be available -- and in that case, that would require some monitoring to understand, you know, the behaviour that is being observed.

What -- from what I understand from the way the test is planned on being conducted is that it's very temporary. They're going to steam their -- circulate -- circulate their well pairs, inject solvent, let it soak, produce back, move on to the next well pairs. So very temporary surface facilities. So I don't know if there is much to de-risk there, but there is always an aspect of -- you bring a new product to your pad. That introduces a risk; right?

So ensuring that the surface facility is compatible with the technology that you want to test, I think, is an important aspect, especially in terms of scaleup. I don't know if they would necessarily follow the same implementation. Like, it sounds like they might be trucking the -- the solvent. It's not entirely sure to me if it's going to be a -- a solvent bullet or if it's going to be a number of trucks that you're going to bring back and forth until you're done that stimulation. But no matter what you do, as I said, the whole point of doing a test, it's to collect data; and to get data, you need to have some form of monitoring. Without more information about how the test is going to be conducted, how many well pairs, what are going to be the ultimate volumes injected in the ground, it's -- it's challenging for me to -- to establish how they could, you know, further de-risk their -- their activities and as a result comment on any more tests, but I'll leave it at that.

Q Okay. Thank you.

Now, one other question I've got for you -- and I don't know much about these -- these chemicals, but I understand that ISH already uses xylene in its gas-recovery operations. So how does that differ from what CNRL is proposing?

A Yeah. I think if you could go to my report. It would be -- let me check -- Exhibit 32.11, page 26, Table 4. Yes. So the bottom part would be the table. Yeah.

So, you know, to -- to get a sense of the scale of hydrocarbon solvent that might be injected during the solvent-assisted start-up, I was, you know, looking at ranges. So it is mentioned that KN08 could have, you know, a minimum of 20 -- 18 well pairs, maximum of 24. KN09 might -- might have 7 to 9 well pairs. So, you know, the range is 25 to 33 well pairs. So at a -- at a max rate as is currently proposed up to 350 cubes per well pair, it would be, you know, 9,000 to 12,000 cubes that would be injected, roughly, and I'm rounding up here. If you want an order of magnitude, it's, you know, pretty visual. It's like, you know, three to five Olympic pool size. So that would give you an idea of the volume.

What ISH uses for their wells is .5 litres. So, like, in terms of scale, it's -- it's absolutely not comparable.

Q So, like, quarter of a pop bottle versus --
A Yeah, pretty much.
Q -- three to five swimming pools?
A Yes.
Q Okay.
A Yeah.
Q I understand.

Now, the last question that I have for you -- if we can turn to Exhibit 50.002 at page 44.

All right. So one of the -- the issues that CNRL has raised with the solvent loss monitoring that you've recommended is the -- the cost. And -- and they've suggested that it would be about $2-and-a-half million to do this monitoring for 90 days.

Now, in your experience as an in situ project development expert, how do the figures in this table, and specifically the figures associated with -- with solvent loss monitoring, compare with the expected total installed cost for a well pad of this nature?

A It's minimal. I would say the infrastructure for a well pad would be upwards of 200 million, so --

Q Okay. So --

A -- this would be minimal.

Q Talking about a drop in the bucket then?

A Yes, pretty much.

Q Okay. Thank you.

Do you have any other comments about the solvent-assist start-up that is being proposed? And it's okay if you don't have any.

A No. I would say -- we looked yesterday briefly at the plot plan. I didn't review the plot plan in -- in much details because I think there was only limited information. I would say as you introduce -- as -- as I mentioned before, as you introduced a new product to your facility, there is a certain amount of usually surface modification that is required.

So, again, everything is a risk-based decision; right? When you -- when you develop a project, you

start your project development, and you initiate a risk matrix; right? And so as you do that, you identify the areas that are, you know, risky or maybe things you don't know about that introduce uncertainty. As a result, it creates a risk. I would say it's the only area that I haven't looked into much detail that I would say could introduce a risk relative to the other pads where that technology hasn't been tested.
Q Okay. Well, we can talk a little bit more about risk after lunch, but it sounded like you're saying that there's a specific risk with xylene that you didn't consider?
A Xylene or any kind of solvent. You know, there is -- like, every product has an auto ignition temperature as well as flash point. And so, you know, again, as you introduce a new product to a facility, depending on how they are designed, they may or may not be able to handle that new product, and that's why you would do surface facilities. I haven't looked at this in much detail because there is not much information about it in this material, but I would say that's an area that, yeah, I would have liked to look more into the details.
Q Very good. Well, those are all my questions about solvent-assist start-up.
A. MCLEOD: So, Commissioner Chiasson, I'm ready to go for lunch.

COMMISSIONER CHIASSON: As I suspect are most of the people in the room. So thank you very much. We will break now for lunch and return at ten past 1.

PROCEEDINGS ADJOURNED UNTIL 1:10 PM

Proceedings taken at Govier Hall, Calgary, Alberta

February 8, 2024 Afternoon Session

Cindy Chiasson	Panel Chair
Brian Zaitlin	Panel Member
Meg Barker	Panel Member
William McClary	AER Legal Counsel
Shannon Peddlesden	AER Legal Counsel
Andrew Lung	AER Staff
Denise Parsons	AER Staff
Anastasia Stanislavski	AER Staff
Fahad Hamdan	AER Staff
Maryam Rahimabadi	AER Staff
Susan Harbidge	AER Staff
Maksim Xhaferllari	AER Staff
Felix Chiang	AER Staff
Scott Botterill	AER Staff
Baohong Yang	AER Staff
Elwyn Galloway	AER Staff
J.P. Jamieson	For Canadian Natural Resources Limited

M. Riley For ISH Energy Ltd.
A. McLeod For ISH Energy Ltd.

S. Murphy, CSR(A) Official Court Reporter
S. Burns, CSR(A), RPR, CRR Official Court Reporter

(PROCEEDINGS COMMENCED AT 1:13 PM)

COMMISSIONER CHIASSON: Okay. It looks like we have everyone we're expecting to see here. So welcome back.

So, Ms. Riley, Mr. McLeod -- and this is not to pressure you in any way -- I just ask in terms of if you can give me an idea of what you anticipate for your timing on your direct, and it's more so I ask because we need to make sure, depending on our timing, that our court reporters get the opportunity to have the break and switch over their pieces of -- their bits of what they're doing, and that, so ...

M. RILEY: We discussed that during the lunch adjournment, Mr. McLeod and I, and he will be done with what he needs to do by about half past 1. Then I intend to move over to Dr. Chalaturnyk, and he should be done by 2, perhaps shortly after 2, because I see it's now almost quarter past. So five or ten minutes after 2 at the most.

COMMISSIONER CHIASSON: And -- and that takes you to the end of your direct, then?

M. RILEY: Correct.
COMMISSIONER CHIASSON: All right. Thank you. So you said about quarter past 2 or so?
M. RILEY: At the very latest.
COMMISSIONER CHIASSON: All right. So then, Ms. Jamieson, would you be looking to have a break before -- before you start your cross-examination, then?
J. JAMIESON: That would definitely be appreciated.
COMMISSIONER CHIASSON: All right.
J. JAMIESON: 15 or 20 minutes is all we need.
COMMISSIONER CHIASSON: All right. Let's -- let's plan, then, that we will go -- go 'til ISH is done with their direct, and then we will -- we'll take a break, and we'll check in with you then on the -- on the optimum time, if that time window still -- still works for you, and we will plan to take a break then.
J. JAMIESON: Thank you.
COMMISSIONER CHIASSON: Super. Thank you all thank you so much.
So, Mr. McLeod, I think we're back to you then.
A. MCLEOD: Thank you, Commissioner Chiasson, and good afternoon.
MARTIN FOWLER, BRAD BARRIE, AURELIE LAGISQUET, RICK

CHALATURNYK, JOHN CHODZICKI, Previously Sworn
KRISTOFFER VICKERMAN, Previously Affirmed
Direct Evidence of ISH Energy Ltd. Witness Panel
Q A. MCLEOD: I'm going to proceed now to discuss the evidence surrounding the risk assessments, and in -- in that respect, Ms. Lagisquet, would you be able to -- actually, let's bring up an exhibit first.
A. MCLEOD: Shall we bring up Exhibit 50.003 at page 20?
Q A. MCLEOD: All right. So, Ms. Lagisquet, I apologize. I've been just waiting to mess that up all morning.
So as I understand it, Dr. Boone, in his -- in his first report, conducted an informal risk assessment. You conducted a formal risk assessment under the APEGA guideline, at least with respect to some of the risks on this project, and Dr. Boone responded with this revised risk assessment that I've brought up on the screen here. So I'm wondering if you can comment on Dr. Boone's risk assessments.
A A. LAGISQUET: Yeah. I can to some extent, but I would say that we probably focused on different areas of the risk. If I understand it well, what Dr. Boone was focusing on is -- was whether or not there were -- there were faults or fractures present, and I don't take that into account in my -- in my risk

assessment. I do highlight the presence of discontinuities, and those could be many different things, right. We've seen it over the last couple of days, and as I said earlier this morning, we've seen that from the map.

We -- we don't see a continuous layer over the project development area. The GCMS data validates that. We don't have an idea of the lateral continuity of barriers when they exist. You know, they could be a risk of, you know, induced fractures during start-up, depending on the MOP. So I -- I took a broader approach to risk assessment rather than focus on the very -- on a narrower kind of assumption that there would or wouldn't be fractures or faults.

Q Okay. Now, if we turn to page 22 of this same exhibit. I believe here Dr. Boone has mentioned that he's taken, I think, three likelihood credits on -- on this risk, and I'm wondering if you can comment on the appropriateness or -- or the -- whether -- whether you too would have taken those three likelihood credits?

A Yes. So I think you are pointing to Risk Number 2, Bullet Point 4 --

Q Yeah.

A -- and three likelihood credits are taken for the presence of leak of barriers, stress barriers in proximity to gas well. I would say that the first two would be subsurface considerations, and I think there is still quite a lot of uncertainty around the subsurface to kind of be able to assert that there would be leak of barriers or stress barriers.

Proximity of a gas well, I think Dr. Boone and I had a bit of back-and-forth around, you know, whether monitoring wells are a way to prevent the risk, and I think he made it clear in his report answering my risk assessment that it's not a good way to prevent the risk, which I agree with, and I haven't taken any likelihood credit for, you know, the addition of an observation one or gas monitoring well.

So I think it's extreme in this case to take three likelihood credits.

Q Okay. Now, if we just turn to the next page, page 23. So I see here under the -- the second risk that Dr. Boone initially graded this as a likelihood of 4, and -- and after taking the likelihood credits, the -- the likelihood is reduced to 1?

A M-hm.

Q And so I guess out of these three risks -- sorry. Let me approach that in a slightly different way. The -- the most likely risk that Dr. Boone identified was Risk Number 2. You'll agree with me?

A Correct.

Q And -- and if he hadn't applied these three likelihood

credits, ultimately the -- the likelihood of this risk would not have been reduced to a white risk?
A Yeah. That's correct.
Q All right. Thank you.
Now, what were the risks you identified and -- and assessed for this proposal?
A Yeah. So I took a broad approach to -- to risk assessment, and I considered various variable, including the uniqueness of the geology, namely, the presence or absence of discontinuities providing a pathway to steam or a reaction product migration upwards.
I looked also at the uniqueness of the situation. We're looking at GOB shut-in wells above the proposed development area. There's a presence of thick bitumen pay in the Wabiskaw D directly adjacent to the McMurray bitumen in the proposed development area. The lack of control wells in -- in KN09 and also in KN08 was taken into account. I looked at the fact that, you know, there isn't a clear strategy on the MOP, and through the various submissions, there was clarification that was attempted to be provided, but I don't know if we -- we have a better understanding of what the MOP is going to be, how the temporary MOP is going to be used.
I also took into account the scale-up of the start-up technology that is not commercially proven --

proven, and also looking at the risk assessment holistically, right. I think in Dr. Boone's report there was an attempt to look at what happens around the start-up, and that is relevant, but I looked at the start-up as well as what could happen over the 20-plus years of SAGD operations, and that's what drove, you know, how I developed the -- my risk assessment.

And so from that, I identified three main risks, and you may want to bring up my table.

Q Sure. Yeah. We'll bring up Exhibit 32.11.

A And as we do so, I can -- I can go through the risk. So the first risk that I identified was the risk to ISH's gas shut-in assets over the lifetime of SAGD operations at KN08 and KN09. I looked at the risk to ISH's assets due to long-term consequences of high-pressure SAGD start-up at KN08 and KN09. And the third one that I looked at was the risk to ISH's shut-in assets due to xylene losses in the reservoir due to high-pressure hydrocarbon-assisted SAGD start-up at KN08 and KN09. And so what's important to -- to highlight here --

Q Sorry. Let me -- I'll just interrupt you for a moment --

A Yes.

Q -- so that I can get Tab 7 brought up, which is PDF page 33. Is that the -- the table --

A Yeah, that's right.
Q -- you wanted to discuss?
A Yeah. Or if you want to go to the table above, that is, you know, the summary, basically, of the risk assessment, so the one with the -- the dots.
Q Sure.
A Yeah. Right. So when you evaluate the risk, you look at the likelihood of that risk; you look at the consequence of that risk, and you determine based on your inherent risk if you need to mitigate it, and if you do, what are relevant mitigating strategies to prevent or reduce the risk, and depending on what you identify, you can lower the likelihood of that risk happening, and that moves you from the left to the right in -- in your risk map.
So after I took some -- identified some mitigation strategies, which were primarily acquiring additional strat wells to delineate, you know, the areas where there is little well control in the KN09 area in particular because there is uncertainty around where the mid-B1 mudstone is actually deposited, and also by lowering the MOP during start-up and throughout the life of the SAGD operations, I was able to take either one or two likelihood credits to lower my -- my risk profile.
Q Perfect. And it sounded like from what we heard

yesterday from CNRL that you and they agree that
reducing the MOP will have an effect on the risk?
A Yes. Correct. That's what I heard too, but I don't --
I don't think I heard the technical justification for
lowering the risk from 6,000 kPa to 55 [sic] kPa. So,
yes, lowering their MOP, generally speaking, might
lower your risk, but what I'm most interested in is
understanding the technical justification to propose to
lower the MOP.
Q Okay. Now, if we just turn to Exhibit 50.03 at
page 21, so I think that you've already told us that --
that you and Dr. Boone evaluated different risks. Now,
for -- for Risk Number 1 that Dr. Boone identified, I
see that under the "Consequence", he notes that the
consequence is somewhere -- is a financial consequence
somewhere between 274,000 and $711,000.
Can you comment on -- on the -- whether -- whether
that value is -- is a realistic one to use for this
risk?
A I mean, he -- Dr. Boone justified his -- his numbers,
but I would disagree with those numbers, given the
valuation that ISH provided on their shut-in gas
assets. I would also highlight the fact that when you
conduct a risk assessment, you're trying to understand
the inherent risk, you know, based on, you know, the
controls you have, and there is no control here.

That's what we are talking about. You know, there is no control.

So it's fair to assume that without any control over the life cycle of the -- those two drainage boxes, it is fair to assume that the entire value of those asset would be lost if they were contaminated because you have no way to know what's happening.

Q And -- and is it reasonable to have first discounted the value of those assets for 20 years, or ...

A My understanding is that the valuation, as ISH provided it, is consistent with the way you value reserves.

Q Okay. So, in other words, once you know that a reserve exists, you've produced some of it, and then it's been shut in, you don't apply a discount to the -- the remaining value?

A Correct.

Q Okay. Now, the one last thing that I wanted to ask you about is -- and I think that you briefly covered this before, but Dr. Boone asserts that monitoring itself is not a mitigation. What are your thoughts on that?

A Yeah. I tend to agree with that statement. However, if you do have monitoring and you get data that indicates that something is happening, then you can take actions -- potentially modify your operating strategy to lower the risk -- and as a result you don't prevent the risk, but you lower the financial

consequence associated with the risk.
Q Right. So producing information isn't useful, but reviewing that information and doing something with it is?
A Yes.
Q Thank you.
Now, those are all my questions on the risk assessment unless you had anything that you wanted to add.
A Yeah. Maybe something that I would like to add is, like, even though Dr. Boone and I potentially disagree on how we conducted the risk assessment, what I did notice through the submissions is that CNRL actually -- Canadian Natural -- sorry -- actually leveraged some of the mitigations that I had identified; namely, you know, drilling additional strat wells to, you know, lower the subsurface uncertainty as well as lowering the -- the MOP. So that tells me that -- somehow that my assessment is -- is validated by Canadian Natural.
Q Very good. Thank you.
Now I'm -- I have very few questions for Mr. Chodzicki.
Mr. Chodzicki, will you please confirm that the purpose of your appearance in this proceeding is to opine or speak to the thermal compatibility issues as well as the 10-1 well?

A J. CHODZICKI: That is correct.
Q Okay. And my friend Ms. Riley indicated this morning that we have covered the thermal compatibility issues, so I'm not going to ask you a bunch of questions about that nor about the 10-1 well.
A Okay.
Q But can you please confirm that your CV is filed on the record as part of Exhibit 38.01, Appendix E?
A Yes, it is.
Q And would you please confirm that your CV sets out your professional qualifications accurately and was prepared under your direction and control?
A Yes, that is correct.
Q And, Mr. Chodzicki, you're available to speak to the concerns with the 10-1 well and Hearing Issue 5, if needed?
A That is correct.
Q Very good. Those are all my questions.
Q M. RILEY: Dr. Chalaturnyk, we now turn to you last but not least. Sorry. I'll just bring this closer.
Please confirm that the purpose of your appearance in this proceeding is to speak to the report you prepared as an independent expert witness as well as the other evidence filed on the record in the field of geomechanics.

A R. CHALATURNYK: I -- I confirm.
Q Please confirm that your updated curriculum vitae as filed on the record is part of Exhibit 61.001?
A That's correct.
Q Please confirm that your updated CV sets out your professional qualifications accurately and was prepared under your direction and control.
A It was.
Q Do you acknowledge and confirm that you have a duty to provide evidence to the Regulator that is fair, objective, and non-partisan?
A I can confirm that.
Q Please confirm that Exhibit 32.10, Tab 6 to the ISH evidence, your report, was prepared under your direction and control and that the contents thereof is accurate?
A It is, subject to a few corrections that are provided in the Exhibit 47.002, which was ISH's reply to CNRL's geomechanics IRs. Other than that, it's correct.
Q CNRL filed geomechanical modelling in response to information requests by the AER. CNRL has also indicated that, in its view, the material above KN08 and KN09 is in a stress state and will not exhibit brittle behaviour. Please provide the Panel with your comments on these issues.
A Thank you. Thank you, Ms. Riley.

Good afternoon, Commissioners Chiasson, Barker, and Zaitlin. I -- I do know the schedules have been adjusted slightly to provide an opportunity for cross-examination for me, so I do very much appreciate that, and I will try and be as -- as -- as quick as I can.

If I can -- if I can bring up Exhibit 46.002, page 38. And -- and just as it's coming up, let me provide a little bit of context. In the first initial review of the evidence provided by CNRL, there was a -- a great deal of effort and -- and I think, quite appropriately, a great deal of effort -- and we heard a great deal of that evidence yesterday -- on conclusions and evidence provided around fracture containment behaviour of the McMurray formation under short-term conditions, 48 hours, days, 6.6 MPa, and also a conversation around work that was done for caprock integrity, which in general is the Clearwater clay shale, Wabiskaw shale caprocks overlying the entire --

THE COURT REPORTER: Can you slow down a bit, please.

A R. CHALATURNYK: I'm going too fast? Okay. Yeah.

The Clearwater and Wabiskaw shale formal caprocks. In reviewing the information, in fact, I -- I didn't see any issues with that. What I did find, given the condition -- the questions for the hearing which had to do with whether there was the potential for fluid migration from the SAGD chambers through the confinement strata into the Wab B gas pool is that what I found absent in that original information was a conversation or evidence that talked about how those zones would behave under the change in pore pressures and deformations that would occur from SAGD over the lifetime of the SAGD project.

So it -- it was with some of the geo -- geomechanical modelling that was -- was put forward that attempted to speak to that issue, but the geomechanical modelling as well was presented to support the issue around fracture containment and caprock integrity.

And so what I'd like to do as a part of this direct evidence is offer some observations on that modelling and some observations on brittle ductile behaviour, which -- it was noted by Dr. Boone, and I agree that it -- it's an important subject at the moment given the paucity of -- of direct evidence over KN08 and KN09 and -- and some general observations around in situ stress.

And so for this figure that's up on the screen for geomechanical modelling, this does represent a -- a standard accepted workflow for caprock integrity.

You -- you look at the three-dimensional geology of the condition here and you extract a 2D cross-section, which you can see in the dotted line and -- and clearly labelled in the -- in the image, and you build an -- an assessment, and you run simulations to look at -- at -- at how stresses change in the caprock, and you ensure that those are meeting the requirements of your project.

One of the issues with extracting a 2D section like that when you turn your attention to the detailed mechanics of the confinement strata is that you're left with some generalizations that make it very difficult to try and interpret how those geomechanical responses affect the behaviour of the confinement strata.

And -- and to just touch on that, if I could bring up 46.002, page 42. And -- and the top image is fine; it's permeability.

But what that image does show was the lithological distributions that were assumed for that 2D model. And what you can notice in the model, the -- the dark red, is -- is the McMurray. It -- it -- it pretty much assumes that the McMurray properties and the -- and the lithological heterogeneity within the McMurray is -- is homogeneous. But you can see in the upper zones, the lower B1, the -- the interpretation of the mid-B1 mudstones, the upper B1s, those are assumed to be continuous all the way across the model, and we'll -- we'll see in a minute the table of properties that each of those lithological units have been assumed to have constant properties.

And so what -- what I wanted -- what I want to draw your attention to and why I think this is a particular issue when it comes to looking at the details of fluid movement through the confinement strata is that where I have the mouse -- if you look at this elevation about two -- minus 220 -- I think it's about 224, and if we look just at the -- for instance, just as an example, the lower B1, and you look at the grid blocks that were used there, the vertical resolution of that grid block is on -- on average -- others change, but let's say 2 metres. So this is that very first interval when the rising steam chambers, rising pore pressures from the SAGD process, you know, will contact these zones. And that's -- that's roughly in that -- in that 2-metre zone.

So -- so beyond the issues of treating the properties, if we just go back again to the -- page 38.

So if you just keep in mind that image that just disappeared and you look at the 2D cross-section, that dotted line that was chosen, when -- when we do modelling in that 2D cross-section, what that does or what that means is that for the interpretation on that section -- many more sections could be chosen, but for this particular instance, it assumes that the properties in that section are equal in all directions. They're equal all the way to the bottom left, and they're equal all the way to the bottom -- upper right. So that cross-section is assumed -- if I look at the results of that cross-section, the behaviour that I'm going to get from it, I'm going to -- at this particular point, I would make the -- the assumption that I'm -- I'm thinking that the behaviour is equal all the way across this site. And that clearly is not going to represent the three-dimensional heterogeneity and the geology of the confinement strata that has been given in a range of evidence by CNRL and evidence this morning by my colleague Brad this morning. So that degree of heterogeneity isn't reflected in -- in the model.

So if we could go back again to that page 42 since it's in the same section. And I just draw your attention again to this 2 metres-ish roughly here in terms of the height, and if I could bring up Exhibit 50.003, page 50.

W. MCCLARY: Dr. Chalaturnyk, if I could please just remind you when indicating on slides to use a visual cue on the slide. Thank you.

A R. CHALATURNYK: Thank you. Thank you.

So we've seen this in the evidence provided for geological interpretations across the site, but what I'd like to do is point out, and I'm -- I'm pointing to the well 1 of AC/07-03. If you could scroll down just a little bit. And -- and if you like, for -- for visual reference -- I can't see the number down below. The one in the bottom right-hand corner I am pointing at, which is 1AD/04-02. And these wells are more or less in the -- in the location where the 2D cross-section was chosen for the modelling study.

And so in looking at -- and -- and I'm just pointing at the 07-03. You can look at the variability in the sand and the shale distributions. If you look at the well in the lower right, the 04-02, which I'm pointing at, you can also see a difference in -- in the lithological distribution of the shale and the sand lithologies.

And the -- so the challenge becomes that when you take the 2-metre element that I had chosen before that says the -- the -- the upper B1 and I look at this kind of heterogeneity, I have to upscale those characteristics. I need to -- I need to make some decision about -- if -- if I say 07-03, which I'm pointing at, if I stack those core, that's roughly a 1.75-metre height. So from a variability point of view, you could think that this variability has to sit within that one grid block.

And when you upscale the properties, you basically have to homogenize that heterogeneous behaviour. So I assume average properties; I assume a Young's modulus; I assume -- but what happens is for the -- for the determination of potential leakage pathways through these systems is that by homogenizing that layer, I can't extract the detailed failure mechanisms that happen in this heterogeneous material with an upscaled homogeneous-type element.

So when I'm looking at the test -- or the simulation results, it's very difficult to try and understand how pore pressures and deformations affect a homogeneous upscaled element and -- and try and understand the detailed mechanisms that might lead to migration pathways through this heterogeneous interval. And now this becomes true for the complete confinement strata. Each of the elements in each of the major lithological zones all had to be upscaled.

So, for instance, if we -- if you could go back to Exhibit 46.002, page 43, which is Table 1. And I -- and I will apologize that this is not the updated table, but that -- that -- that's okay. There was a submitted updated table that primarily adjusted the maximum horizontal stress. But really what I wanted to -- to -- to point your attention to was the --

the -- the last -- the second column, if you like, which is the Young's modulus.

So this is what happens in -- in upscaling is I -- I need to make a determination of the upscaled modulus. And in this particular case, these zones have all been upscaled to an average Young's modulus of 500 MPa. We know there's variability in the geology. We know there's variability in the shale sand divisions, yet the stiffness, which controls issues around deformation and how the -- how the behaviour stress changes that are going to occur towards failure have just been all upscaled to a single value, which hides what the influence would be of that heterogeneity.

And to give you a sense of what that means relative to this SAGD process, if I could bring up -- go back to Exhibit 46.002 on page 51, PDF page 51.

So -- so this is a -- I think if you scroll down to time period 6.8 years, yes, which is two thousand -- yeah, just the lower one. And that's okay. That's -- that's good enough.

So I'm just pointing to the time scale here. We could -- you know, you could look at the just over three-year time scale or -- or if we just do look at the -- the bottom one, which is 6.8 years, which is, you know, roughly in that half of the -- half of the SAGD pilot phase, what you see in the results that come out of the modelling is the predicted distribution of the steam chamber, which is primarily the red zone, and the -- and the heating that is occurring around the boundaries and up into the confinement strata.

And so now what you see is a very uniform steam chamber development because of the assumed homogeneous properties of the McMurray, which is typically for caprock integrity studies, is the kind of thing you would do, but the question here is: What are the detailed mechanisms -- potential mechanisms for fluid migration through the confinement strata.

So these uniform steam chamber developments don't reflect the kind of complex steam chamber development that will happen when you include the heterogeneity in the McMurray. And -- and people see it -- see it in a whole range of SAGD projects, even in -- as they do 3D and 4D time-lapse seismic data.

But the other thing you can see is that because of this uniform distribution, these homogeneous properties that are assumed in this confinement strata then don't reflect the complexities of both this Delta T, which will affect deformations, thermal-induced stresses. And if you just flip to page -- same -- same document but page 49, so it's just back two. Yes. So -- yeah, flip down to the -- thank you very much.

So if we look at the same time frame, 6 point --

6.8 years, this is the assumed or -- or computed pore pressure distribution up into the confinement strata. And I'm pointing my mouse now at -- at this -- this -- this one -- lower B1 that I was pointing to in terms of the heterogeneity and the upscaling. And you can see that there's an upward migration of pore pressure, and the pore pressure rises.

Well, those pore pressures, in a -- in a homogeneous element, hides the complexity in which pore pressure changes in the heterogeneous elements of sand and shale units, how those would migrate under the loading conditions.

And so it makes it difficult in -- in this particular modelling and the results that were presented to try and decipher detailed mechanisms and how migration pathways may evolve over the lifetime of -- of the SAGD project.

The -- the other thing -- and this is less of an -- an issue with -- with the modelling, per se, but these results were presented for an operating condition of 4,000 kPa -- I'm not worrying about the short-term 6.6 -- 6,000 -- I don't have an issue with the fracture containment -- is that these were -- these were conducted for the long-term SAGD project of 4,000 kPa, 4 MPa, but there's been lots of discussion around the approval for a temporary MOP of 5,500 kPa. 5,500 kPa brings with it a higher steam temperature, a higher pore pressure gradient up and into these confinement strata, and so, yes, there are the operational challenges that were discussed by CNRL, which are real, having to balance against bottom water, absolutely.

But there is the potential, given the approval of 5,500 kPa that if, for some reason, in that heterogeneous geology over KN08 and KN09 that, in fact, the communication with the bottom water is not as actually prolific as it's expected to be, there may be instances where you may want to actually operate at a higher pressure, maybe up to the 5,500, but it might be some modest number above 4.

And so what happens is at this point, this modelling, again, doesn't help us inform what might happen in these scenarios with the confinement strata that would speak to this issue of fluid migration up and into the Wab B gas pools.

So if I could -- and I'll just make a transition to the second topic, but if you could bring up Exhibit 47.002, pages 20 and 21. And the reason for -- for bringing this up is to make the transition to the conversation around brittle and ductile behaviour.

So in response to some IRs, information requests, from CNRL, there was -- there was a conversation around, you know, what was -- what evidence did I have that suggested that the behaviour for this class of materials, the mud-dominated or fine-grained horizons within the confinement strata, exhibited a brittle response? And by "brittle" in this context, it was interpreted to mean what we refer to as a "strained softening response", and just by pointing to the stress strain curve, which is the upper curve, this post-peak strain softening response, which was also spoken to in the -- in the modelling report, is that underloading the material will reach a peak strength and under continued loading and straining, the strength will drop off. It will decrease to some post-peak value that is lower. That's typically what we refer to as a "brittle response".

And in the testing as a part of the IR, information request, I gave full stress strain and volumetric strain data. The volumetric strain data is in the bottom that talks to how the volume change of the material will change as these materials are stressed and strained under a triaxial test.

And so -- so -- so the issue is that there was an argument or a discussion now around what these tests meant relative to KN -- KN08 and KN09, and if we -- if we flip to Exhibit 50.003, page 26. In an effort to sort of look at this relative to KN08 and KN09, Dr. Boone adopted a -- a particular technique to look at what the transition might be between brittle behaviour and ductile behaviour and had presented this figure in his report and -- and primarily utilized a reference that was provided -- I think it might actually be on the next -- next page or upper portion, the Ingram Urai 1999 approach to look at issues around brittle/ductile transitions.

And primarily if you look in this upper figure, what happened was, is that the -- the approach looks at the triaxial data and takes the volumetric strain component of that triaxial data and plots that versus the effective stress, so the effective stress I'm pointing to is the 'X' axis, so it's a range of effective stresses that the testing was conducted at, and the vertical axis is the volumetric strain that occurred during the lab tests.

And so he plots using a series of data that we had provided, a public triaxial test data that would exist inside the AER databases, and based on a position here where it shows -- where it hits zero, if it -- if the material shows a behaviour that is contractant, in other words, under shear, it will actually reduce in volume, and where it will change to being dilatant or where it will increase in volume during shear and defines a -- a transition.

The interesting thing is -- about this particular definition from the reference from Ingram is that even by -- by -- by the author's own admission, that's referred to as an unconventional definition.

So before I -- before I talk to this a little bit because I want to talk to this lab data issue, is that these are -- well, actually let me talk to the lab data first, actually.

So -- so in -- in this, I think you will see somewhere in here that -- yes, down at the very bottom, you will see that: (as read)

> The data provided by Dr. Chalaturnyk in response to the information request is very useful in assessing this transition for -- for Wabiskaw shales.

And I -- while I really -- I do appreciate the acknowledgement of it being valuable, I would -- I would suggest that for the question of the hearing and the question of actually looking at how fluids may potentially migrate through the confinement strata, that these may not have been the right kind of tests to be using. And let me explain that for a second, and I'll just leave it on this page.

So we -- actually, no. Actually for the sake of that discussion, maybe if we go back to Exhibit 47.002 on page 20. So these are the data, in particular CST3, CST4, CST5, and so on that was used in that figure for the transition. The reason why these may not be the most appropriate tests for what is happening potentially over KN08 and KN09 is that these are what are referred to as "compression loading tests". These are triaxial tests in which the samples are loaded vertically under shear, and the mean effect of stress in the specimens increases as I shear the specimens.

In general, in caprocks immediately above expanding steam chambers in this sort of lower B1 zones, upper B1s and -- and so on, the stress path is a compression unloading stress path, and the compression unloading stress path -- the effect of stress decreases during shear. So the volumetric response of those materials is quite different.

So now instead of -- instead of increasing effective stresses during shear that cause the volumetric behaviour you see in the lower portion of this program, the stress path that would have come from the modelling, it would exist somewhere in the modelling, I haven't seen it, but from experiences with other projects where we have looked at these issues around caprock integrity and the behaviour of these intervals, in general, you will find that stress path is a compression unloading stress path. So that draws a little bit into doubt about where that transition boundary sits.

The other thing is, is that in the literature, recent publications have come out that have shown, you know, upwards of 35, if not more, ways or descriptions for calculating the brittle index of these materials. A substantial number, all the way from strength based to mineralogically based, includes -- includes the approach that was used by Dr. Boone, although used a slightly different part of the reference, and so one of the other things for -- that I think is relevant to this confinement strata over KN08 and KN09, is one of the approaches that was inside the reference that was used by Dr. Boone but has been used by others, including -- including ourselves, on a review of Alberta basin-specific materials, not -- not in other settings, but specific to Alberta, extremely large review of the datasets for testing that exist within the Alberta Energy Regulator database and that review included Clearwater, Lea Park, unconventional shales, Wabiskaw, McMurray, with a systematic review of those test results and the stress states and using an approach based on where this sits relative to something called the "Mogi line", which is a -- a well-accepted technique for looking at brittle and ductile behaviour in rock mechanics. And in that large review while many of the formations in Alberta exhibit ductile response, the Wabiskaw and the McMurray and the Clearwater all resulted in a classification of brittle behaviour.

The other part of this -- and it is important, so I apologize. I'm going to take a couple minutes still because I do agree with Dr. Boone on this, is something related -- the brittleness index is related to something that is referred to as the "overconsolidation ratio". And the overconsolidation ratio provides a measure of the maximum -- the ratio of the maximum stress that a particular horizon has ever seen in its geological life divided by the current effect of stress. So in general, in the McMurray region -- the Athabasca McMurray region, there are estimates of sediments of -- a thousand metres of sediment overlying these particular areas that has been eroded.

And because the -- the expanse is quite large, the stress change that will have occurred at depth from a thousand metres of sediment and you take the unit weight of that material, you get -- and it -- it -- it can -- you know, you -- depends on what number you use, but even if you use 21 kPa per metre, which is the vertical stress gradient that in general CNRL has used and other -- other people use, it would suggest that in the confinement strata the maximum vertical stress that this material has ever seen is 21 MPa-ish, plus/minus.

The current effective stress that's calculated from the stress distributions adopted by CNRL show that the in situ vertical stress -- current in situ vertical stress is roughly in the 7 to 7-and-a-half -- let's say -- yeah, 7 -- maybe it's easier to do the calculation -- 7 MPa in the middle of the confinement strata, which means the overconsolidation ratio, which is 21 divided by 7, is 3. And in a wide body of literature, including -- including the -- the reference utilized by Dr. Boone but many other that we can point to, show that if that overconsolidation ratio is above 2 to 2-and-a-half, then that -- that will be an indicator of brittle behaviour.

So using, you know, several lines of evidence would suggest that -- that -- that in the -- in the absence of direct physical measurements in the confinement strata over KN08 and KN09, that it is -- it would be likely that the kind of behaviour that would be seen under the loading of SAGD would exhibit a -- a brittle response.

To -- to turn our attention just a -- at the end here just to the in situ stress values, if you can turn to Exhibit 46.002, Tab 5, Figure 7, page 46 of 72.

So there was some discussion in the evidence I provided in trying to sort of look at issues around what the in situ stresses might be. There was establishment of -- of appropriate stress gradients, fracture grade -- minimum stress gradients from DFITS.

There were no -- no issues with DFITs. These -- you know, the kind of analysis conducted by -- by CNRL on -- on due diligence for DFITs, I think, was -- was -- was quite good. But that wasn't the issue here. The issue is the confinement strata; it's not the Clearwater caprocks. There are some issues with having a stress -- a variation in the McMurray and how you would model that, but in the confinement strata, this is the -- this is the data that was interpreted by CNRL and utilized for their simulation work, and I -- I'm using the arrow to point to the left-hand plot, and there are multiple lines in here. The left-hand line is the yellow line, which is the assumed pore pressure through the column, including through the confinement strata and into the McMurray. The pink line is the interpreted variation in the minimum horizontal stress. The blue line is the interpretation of the maximum horizontal stress, and the black line is the interpretation of the vertical stress distribution.

This uses a technique -- and -- and -- and it was talked about in CNRL reports about 1D mechanical earth modelling, and you -- you -- you calculate this variation. And you will see -- and I'm pointing my mouse to these open circles that lie in the plot that respond to the locations where DFITs were conducted to interpret the in situ stress, and these are calibrated -- they're shifted to match those physical measurements in the field. But what you will see is that in the McMurray -- the variation in the minimal horizontal stress is actually reasonably constant. It -- it doesn't vary a great deal.

But if you look up inside the confinement strata, you can see that because of the variability -- we chatted before about upscaling, sand shale sequences; there were comments yesterday about a higher mud content, Poisson's ratio, vertical stress attracting and transferring more stress to the horizontal direction -- that the pink line shows quite a bit of variability inside the confinement strata.

And -- and so if you take a calculation of that pink line, not a -- not an average gradient -- if you -- maybe just for the sake of the -- the discussion, if you blow up right here on the -- where it shows the legend but just to the right of the pink line, anywhere in there, if you blow that right up enough for us to see dotted lines drawn in there. So -- yeah. It might -- it's -- it's -- maybe -- yeah. Thank you. Thank you. That'll work.

So you can see where average dotted lines are chosen for each of these sort of lithologies within the confinement strata that match to the stress gradient distribution that we're given in Table 1 that we had shown previously from the modelling study. But what's important to note when the question is about fluid migration and potential mechanisms in which those confinement strata are going to deform under stress change and pore pressure change is that the variability in that minimum in situ stress is quite substantial, and it reflects the heterogeneity. And if you calculate here in some of these locations where this minimum horizontal stress minus the yellow line, which is the pore pressure, these become the -- this -- this K_not that was talked about in the direct evidence, that this now starts to be in this range of .4 to .6 as a -- as a way of describing this initial in situ stress.

And -- and in the geomechanical modelling report, it was stated that -- and there wasn't much data given, but it was -- there was shear strength data that was discussed -- said, Well we chose 'C' prime equal to zero, and -- and the friction angle was 30 degrees. And so for something like a 30-degrees friction angle and you calculate this equivalent K_not, that comes to .33. So at -- at -- at a K_not of .33, the stress conditions would be touching the failure envelope. And in these instances here, there are cases where that initial stress state is at .4, which is -- which is now saying that the starting stress state is actually almost nearing what you would consider to be the failure stress state for these materials.

The other -- the other part about this -- now, I know -- I think I had asked that in cross-examination. I'll leave that.

Maybe perhaps if you can switch to my last -- last comments on in situ stress, which is related to this -- this plot, but Figure 233 --

W. MCCLARY: Just --

A R. CHALATURNYK: Sorry.

W. MCCLARY: Just before we do that, Dr. Chalaturnyk, I wanted to clarify that the comments that you were just making in relation to the log are in relation to the depths of 440 to 460 on that log?

A R. CHALATURNYK: Oh, yeah. Sorry. So --

W. MCCLARY: For the record.

A R. CHALATURNYK: Yeah. For the record. Sorry. So we can -- if you look -- yes. So it's over the -- for this calculation of the K_not, which is -- is basically from about 458 -- 458 sort of up through the sort of entire confinement strata package up -- up through to the sort of base of the Wab B. And I'm -- I'm using my mouse. So that's about 440, I guess. 440 to 458. It's the variation in stress over what we would consider to be the confinement strata.

W. MCCLARY: Thank you.

A R. CHALATURNYK: Yeah.

And -- and so Exhibit 01.01, PDF page 67, Figure 233.

So I think this has been shown before, and what I've -- if you just can scroll down just a little bit. And this is in reference to just the -- the assumed in situ stress values, particularly in the confinement strata, is that there have been conversations put forward that stresses are -- are regionally consistent. And so, you know, "regionally consistent" would mean that the geological framework for these regionally consistent estimates of in situ stress would -- would predicate that the geological framework is -- is similar across those regional distances, and -- and I think there has been arguments made, even this morning, in the geological framework that once you are to the east of KN08 and KN09, that geological lithology is not the same as it is at KN08 and KN09, yet all of the in situ stress data that was generated for -- for, in essence, calibrating the pink line that we saw on the previous plot come from a -- a -- a region well west -- or east of -- of KN08 and KN09.

And if you -- if you can turn -- and sort of the final slide -- to page 55. And if you just, yeah, can kind of scroll out so it's the whole thing.

So if you -- so in KN08 and KN09, there have been many arguments to this. There will clearly be discussions and -- and debate about what this variability looks like. There's been evidence provided on both sides. But relative to in situ stress, if you look at the mid-B1 stone -- mudstone isopach -- and if you switch now to page 56 -- these ranges of isopachs, erosional surfaces now downcutting and changes to sort of a channel erosion in the middle of KN08. And if you switch to the next one, page -- page 57, you know, these -- this variability, which differentiates itself from what the interpretation of the geological framework would have been east of KN06 or -- or where the DFITs were calculated, I would suggest would -- would suggest the potential that in -- within the confinement strata there may have been reasons, given these depositional environments, for changes in that minimum horizontal stress.

So perhaps in summary of time -- if I can find my little tiny summary page. Hang on a sec. Just to make sure I get that correct. So while modelling studies were appropriate for fracture containment and overall caprock -- overall caprock, the Clearwater formation upper caprocks were -- were quite sufficient and, in my opinion, were sufficient, it would be my position that at the moment the information or the evidence provided is not sufficiently refined to inform detailed assessments of the behaviour of the heterogenous confinement strata and the development of potential fluid migration pathways over the life of the SAGD project.

I think in the absence of KN08- and KN09-specific core testing, I think uncertainty remains concerning the potential quantification of brittle/ductile transition behaviour for the fine-grained zones within the confinement strata, even though I have even postulated other methods to define that brittle behaviour and the variability in the geological interpretations for the confinement strata above KN08 and KN09 produces, I think, sufficient uncertainty in the applicability of a regional interpretation of in situ stress magnitudes, and for the KN08 and KN09 drainage areas, given the importance of understanding this mechanism of fluid migration, potential development of fluid migration pathways through this confinement strata, in particular dominated by the calculation or determination of the minimum horizontal in situ stress, I think it's warranted, given the importance of these conditions, that -- that additional in situ stress interpretations are established, both for geomechanical modelling studies that would be relevant to the behaviour of the confinement strata and -- and defining the limits for containment.

And I should say that at a broad context and final summary, the -- the part that I think is important in this discussion or important in the debate around these mechanisms is that while we -- we can make the point that the caprock, the proper caprock that really will hold the SAGD chambers within the subsurface, the mechanisms that lead to movement of fluids from the SAGD chambers up through this confinement strata to immediately below that proper caprock is an important component of all the SAGD projects in Alberta. Understanding what those look -- what those mechanisms are will help inform shallow projects; it will help inform what factors of safety do mean when it comes to understanding those mechanisms. And that's why I think in this context it's important for understanding this in KN08 and KN09. Thank you.

M. RILEY: That is then the end of ISH's direct evidence.

COMMISSIONER CHIASSON: Thank you, Ms. Riley.

Thank you to the witnesses.

So, Ms. Jamieson, refresh me, then, on how much of a break you think you might need.

J. JAMIESON: I'm just looking at the clock. If we could have 30 minutes, that would be fabulous. Could we do that?

COMMISSIONER CHIASSON: 30 minutes?

W. MCCLARY: I think that would -- that would work for us as well, then, to confer for questions from the --

COMMISSIONER CHIASSON: All right. We will take 30 minutes. We will return back at 2:45, then. Thank you.

Just a reminder to the witness panel that you are all sworn and/or affirmed, so please do not, during the break, discuss with your counsel in relation to the evidence or what you're anticipating in cross-examination. Thank you.

(ADJOURNMENT)

COMMISSIONER CHIASSON: You're prepared to proceed, Ms. Jamieson?

J. JAMIESON: I am. Thank you.

COMMISSIONER CHIASSON: All right. Go ahead, then, please.

J. Jamieson Cross-examines the ISH Energy Ltd. Witness Panel

Q J. JAMIESON: Good afternoon, Dr. Chalaturnyk. My set of questions is for you just to expedite our schedule --

A I appreciate. Thank you.

Q -- so if you'll humour me. And, of course, I am not a geomechanical engineer. I have been spending a lot of time with them lately.

A My apologies.
Q Yeah. So just bear with me, please. I'll need some patience.
So I'd like to start, if I could, by bringing up Exhibit 32.10, and this is Tab 6 from Dr. Chalaturnyk's report, page 13. Yeah -- sorry -- 32.10, yeah.
J. JAMIESON: Maybe if you could just expand it out a bit. I'd just like to -- lines 29 to 33.
Q J. JAMIESON: It's just a statement that you've made, Dr. Chalaturnyk, that we want to follow up on.
So you stated: (as read)
While hearing discussions are likely to resolve geological setting issues, the presence or non-presence of the mid-B1 mudstone, existing fractures, et cetera, even the potential that the DFIT in the 9-6 well was indicative of a westward trend of a reducing minimal horizontal in situ stress seems to me to provide sufficient uncertainty that would warrant "a modern DFIT test" be conducted in the KN08 and KN09 drainage area.
Do you see that quote?
A I do, yes. Yeah. Thanks.
Q Would you just generally agree that Canadian Natural has significant experience with DFIT interpretations

based on their work?
A Absolutely. Yes. I can confirm that. I agree.
Q Thank you. Do you think Canadian Natural also has the technical capability to identify initiation and propagation of hydraulic fracturing --
A Yes.
Q -- generally?
A Yes.
Q Thank you.
Okay. If we could please go to Exhibit 15.01, page 41, paragraph 173. Is it up there? Yeah. Good stuff. Yeah, as long as that's readable. I'm not sure how much time you've spent with all the submission materials, Dr. Chalaturnyk, so in fairness, they are extensive, so we'll just go through this.
A I'll try.
Q Are you aware that Canadian Natural's evidence in the proceeding is that it has started up 146 Kirby north wells on steam circulation as stated in this paragraph?
A Actually, I am, and I heard it in evidence yesterday as well.
Q Thank you.
A Yeah.
Q Yeah. And if we could, please, same exhibit, go to Tab 34, which is at page 494, the same document. So if we can just bear with me. This is a table of the Kirby

north maximum bottom-hole pressures applied during start-up. And would you, please, if you could, state the maximum start-up bottom-hole pressure gradient for Well Count Number 2. So we're looking for well name, Kirby north, KN02-41.

A And you just want me to read what the maximum start-up bottom-hole pressure gradient is?

Q Yes.

A It says in the table it's 13.7 kPa per metre.

Q 13.7. Thank you.

And then scrolling down one page, would you please state the maximum start-up bottom-hole pressure gradient for Well Number 40, and this would be Kirby north 03-3I?

A I should have opened the file on my laptop. I -- 40 -- sorry.

Q Yeah. It's -- no problem. Count 40, Well Name KN03-3I.

A 11.9 kPa per metre.

Q 11.9. Thank you.

Okay. I can bring this one up, but this is really from an early report. Maybe we should go there anyway in the completion. Exhibit 15.01, page 96, Figure 7. So this would -- I believe is an appendix to the hearing submission, and it would be Figure 7. Is that what we have? I should look on here. Okay.

So this is an appendix to Dr. Boone's 2020 report. It's an example of potential hydraulic fracturing during circulation start-ups. If you can scroll up to page 87, this is the summary of key findings and what we find under the first bullet is that out of all of those start-ups -- and I believe there were 96 at the time -- but in any event, one of his key findings was that they found only one well with characteristics that are indicative of possible fracturing. Do you see that?
A Yeah. Yes. And I think I recall reading it, so I'm looking pretty quickly, but I do recall that conclusion, yes.
Q Sure. So --
A M-hm.
Q And just in the interest of time, that was at the time of the KN06 proceeding, Canadian Natural had this experience of 96 --
A Oh, 96.
Q -- wells, and since then we're at 146; right?
A Indeed, yes.
Q Okay. You're with me?
A Yeah, yeah.
Q Now if we could, same exhibit, please move to PDF page 69, and there should be a Figure 5 there. Yeah. Scroll down, please, Point i, and there Dr. Boone

writes: (as read)

Previously 1 in 96 wells are identified to have likely fractured -- sorry. 1 in 96 wells was identified to have likely fractured during start-up. With the additional wells that have since started up, it is now 1 in 146 wells.

Do you see that text?

A I do, yes.

Q Thank you.

So do you agree now that there is data other than DFIT data that can be used to understand stress variations in the Kirby north area?

A No.

Q No?

A No.

Q You disagree completely?

A Well -- and I should clarify that because it's a fairly hard answer.

Q It was a hard no?

A I apologize. Yes, indeed.

Q Please do.

A I think in the evidence it provided, although I did go by it very fast, I think in the evidence that CNRL has provided around fracture containment within the McMurray during the start-up of the SAGD process is convincing. I don't -- I didn't have an issue with that and I -- and I don't even after recalling this evidence, which I think, to your point of reviewing it all, is -- is -- is compelling. And -- and the reason that I'm -- I answered very quickly, which I apologize -- I shouldn't be quite so blunt -- is that that -- I didn't see that as being the component of the in situ stress distribution that was of key interest in the confinement strata.

So, yes -- no, I -- I thought that -- that in terms of the work, the operational experience across sort of all of the asset areas when in the McMurray, in terms of that process and the convincing numerical modelling studies that were done by CNRL, you know, even up at the --

Q M-hm.

A -- temporary MOPs was convincing, so, no, I don't have a problem.

Q Okay. And I appreciate, you know, given credit for the work. I actually don't think it's credit for the work or the diligence that Canadian Natural is looking for. It's some recognition that there might be some deep knowledge on stress variations in the Kirby north area. From all the start-ups from --

A Oh, I see.

Q -- to develop an understanding of stress

characterization in the area, that this actual
operational start-up data --
A M-hm.
Q -- is data that can be counted towards understanding
stress variations.
A Yeah, I would agree within the McMurray, yes.
Q Within the McMurray?
A Within the McMurray, yes. Yeah.
Q All right. If you'll just give me a moment, please.
Okay. Thank you. I'm going to -- we're going to
switch out geomechanical engineers just for fun.
A Okay. Yeah.
Q All right. All good. Thank you very much. Okay.
So I'm not sure which exhibit we have. Yes, if
you could please go to Exhibit 32.10 now. It's Tab 6,
and this is Dr. Chalaturnyk's report, and if we could
look at page 13 of 31. It's the same quote. Yay. I
recognized it. So -- I'm a little slow, but I
recognized it.
Let's start -- I'm not sure where the words -- it
starts: (as read)
While hearing discussions are likely to
resolve geological setting issues, presence
or non-presence of the mid-B1 mudstone,
existing fractures, et cetera, even the
potential that the DFIT in the 9-6 well was

indicative of a westward trend of a reducing minimal horizontal in situ stress.

So that's the sentence we want to focus on.

Dr. Chalaturnyk, do you agree that typically shaley or muddy materials have a higher Poisson's ratio than sandy materials?

A I think in this class of materials, the answer would be yes.

Q Yes? Thank you.

And do you agree that this difference in elastic properties typically results in a stress contrast between a sandy zone and an overlying shady zone? Sorry. Yeah, shaley zone. That's the word.

A Yeah, and I think we heard that yesterday in some evidence that Poisson's ratio underloading will result in differential stress that will be exhibited in a -- in a difference in the stress contrast, yes.

Q Just a moment.

A Yeah. It's okay.

Q Okay. If we could please go back to Exhibit 15.01. And this would be page 92.

Okay. So the figure that you have in front of you shows DFIT data for multiple wells throughout the region, so this would be Kirby/Jackfish/Pike, and I just want to point out before I ask my question, if we go back -- just scroll one page to page 91. I believe there's a map there. Yes. So that would indicate where the DFIT data is derived from.

Do you agree that this data represents multiple wells throughout the region and that these wells have tested multiple zones at times, both McMurray and overlying muddy or shaley layers?

A Yes.

Q All right. And if you could scroll back to the figure. So one more. Thank you.

So now we're back looking at the stress gradients by formation from different service providers, and we've established that's throughout the area. Do you agree that in the KN08 and KN09 drainage areas we should also expect a stress contrast between the McMurray sand and the muddy confinement strata consistent with this regional data?

A I'm going to have to apologize that I don't know the details of each of those particular wells. Perhaps if I could ask a clarification before answering your question. Is the Wabiskaw that is identified in that particular horizon in -- in lower B1, upper B1, like, is it in the middle -- our conversation, I guess, in this hearing is this confinement strata package, and is that Wabiskaw, which we're shown sort of -- sort of uniformly within --

Q M-hm.

A -- is it within that confinement strata, or is it -- is it something else?
Q I'll find out --
A Could you --
Q -- if I can.
A -- yeah, if you please.
Q These particular geomechanical engineers are quite certain this is the Wabiskaw A shale, so -- so I think --
A Yeah.
Q Yeah.
A Okay. No. That's great. No. Thank you. So --
Q Okay.
A -- the Wabiskaw A shale is the shale that sits just below the Clearwater and represents what would be classically defined as the "caprock" --
Q M-hm. Correct.
A -- for a SAGD project. And I think I also said that I was convinced by the discussions with CNRL and the technical events they provided around caprock integrity, we had -- we had -- there were two parts that I -- I thought were -- were -- were compelling in the -- in the -- sort of in the world of SAG -- SAGD that was -- it was compelling in terms of fracture containment in the McMurray during start-up, which we just chatted about, and it was compelling for caprock

integrity as overall containment of the SAGD chambers.

What -- what -- what I was referring to, I guess, in the -- in the conversation was -- is the variability in the in situ stresses interpreted within the confinement strata, which was indicated by the variation in the purple line in the interpreted log response of the variability in the stress which reflected this in situ stress stiffness contrast that you asked about previously.

So -- so I -- I think from a -- in the regional interpretation, east of KN08 and KN09 --

Q M-hm.

A -- absence, I think -- and, again, the hearing -- I guess in the -- in the body of evidence, geological structures -- or geological environment will -- will debate those. In -- in -- in the absence of the geological heterogeneity that I think exists differently in KN08 and KN09, to answer your question -- it's a long answer, I suppose; I apologize, but -- is that this is -- this would be a regional interpretation east of KN08 and KN09 for the caprock --

Q M-hm.

A -- and for McMurray sands and the McMurray shale, which is the upper -- I'm assuming the upper portion and IHS of the McMurray, but that's an assumption.

Q So let me make sure -- and I do recall your comments earlier about the -- your concerns about the heterogeneity of the confinement strata.

If we can go back to the map. It's one page up. So I think the point of this map, if you look at the red star, is they sort of cover the region; right? We've got some way over to the east, the Jackfish. We've got the one at KN06. We've got one further south at 13-20. So -- and then if you'll humour me, please, if we can scroll back to the other figure. We're not offering this up to get your opinion on the caprock. I thought that was quite clear that you made. I appreciate that. But just the -- the concept, if you will, that the stress contrast between these general layers are fairly consistent throughout the region, that that's what this -- this figure represents.

A For the -- for the general region, yes. The confinement strata lies in the white space between the McMurray shale and the Wabiskaw, and so there would need to be a discussion about whether I think the depositional environment and the geological settings of KN08 and 0K9 [sic] represent some variability in that white space that exists between those two. And -- and -- and -- and that is seen in other places. You can have that kind of stress variability, given the variation of properties in that --

Q Right. Understood.

A So --
Q And your --
A So these are -- I think these are valid for -- for east of that region, yes. Yeah. Or for those horizons, yes.
Q For those horizons. Okay.
And just where we started, if you recall, I asked you if you agree that typically shaley or muddy materials have a higher Poisson's ratio than sandy materials. You agreed. And then we talked about how that difference in elastic properties typically results in a stress contrast between a sandy zone and overlying shaley zone. So we're providing this stress gradient by formation map to show there's actually pretty solid consistency through the region. And if I understand your answer, you're -- you're agreeing with that conceptually, but you're saying you would limit this to the east. Is that what your evidence is?
A I -- it was -- the observation I had provided was that in what I had reviewed -- I mean, it wasn't my remit to interpret the geological information. Evidence was provided yesterday; evidence was provided this morning that spoke to what I think were cogent arguments around the uniqueness of the geology in KN08 and KN09 relative to the east.
Q M-hm.

A I think evidence was provided this morning of KN01 and 02 and a -- a position of a thick mudstone that was -- was a regional deposition of a thick mudstone that was absent in -- in KN08 and KN09, amongst all of the other things, erosional surfaces, erosional channels, and other things. So -- so long answer is that -- that -- that for these stress distributions for the purposes of the behaviour in the McMurray and the behaviour for caprock integrity assessments, absolutely.

I'm suggesting that for the -- the question that I was asked to review the evidence for, which was the behaviour of the confining strata in particular of the movement of fluid migration from the SAGD up through that package to the Wab B gas pools, that -- that was less certain about what that stress value should be. Although it was interpreted in the evidence of being -- and I apologize if I get this wrong, but, like, 14.6 I think was the number or 13.1 in the McMurray stress contrast --
Q That's right.
A -- of 1.5. There was some numbers like that.
Q Right.
A Yes. And so I'm suggesting that given -- given the -- the un -- the absence of specific data in that -- geological differences that exist in KN08 and KN09, that there was a potential that that horizontal

stress -- that minimum horizontal stress could drop to something less than 14.6.
Q Understood.
A That was all.
Q Thank you.
A That was all.
Q I think we have one follow-up here.
A Sure.
Q Yeah. So let's just look here at the stress gradients, and I want to point out second from the bottom of that list of wells. It's sort of a turquoise colour, I believe, but it's the well -- the 2-26 --
A Yeah.
Q -- -75. So that particular measurement, do you agree that that -- you might not know this, but that it represents the mid-B1 mudstone, the regional mudstone?
A Oh. Is -- is that what --
Q Are you able to --
A Is that what's --
Q -- tell that from this?
A Well, I -- I -- I can see where it sits on there. Is that -- is that -- does the mid-B1 mud one -- mudstone --
Q Or it might be the B1 regional sequence, but it's in there.
A Yes. So that's classified as McMurray shale?

Q Yes. Within the McMurray shale.
A Yeah. I -- I -- I don't know the details --
Q You don't know --
A -- of 227, but I'll -- no, I'll --
Q That's fair.
A No, it's fair. Yeah. Sure. I -- I don't know --
Q Like, generally speaking --
A -- subject to the --
Q -- it would fall in that. We -- we know it's not the McMurray sands. We know it's not the Wabiskaw. So --
A Yes.
Q -- that likely represents a mid-B1 or a regional B1 sequence measurement. Would you agree, just notionally, that that would make sense?
A It was -- I think CNRL has already presented evidence that that was -- on average, was assumed to be 14.6, which is --
Q Yeah.
A -- plus/minus --
Q I think we're --
A -- 15.2. I mean, it --
Q Yeah.
A Yeah. So 14.6 is what was already submitted.
Q Right. And I don't think, again, we're offering it up for the specific numbers, but just to --
A Oh.

Q -- illustrate the stress gradient between a
McMurray shale, you know --
A Yeah.
Q -- mid-B1 pic --
A And the --
Q -- versus McMurray sands?
A Sands. Yeah.
Q That's clearly --
A Oh, fair.
Q -- clearly a stress -- okay.
A Absolutely. I think that's -- I -- I think there was evidence provided by CNRL for, you know, a range of SAGD projects in the province, and that tends to be, on average, the kind of trend directions that you see, yes.
Q All right. Thank you very much, sir.
A Yes.
Q Okay. We have one more line.
A Oh, okay.
Q And I have some hesitation in wading into the area of brittle versus ductile rock --
A Oh, no. It's good to --
Q -- behaviour.
A No. Happy to have the discussion.
Q I'm sure it'll be fun. Okay. Here we go.
So Exhibit 32.10. Is that where we are? Okay.

And then page 8, and this is lines 34 to 36.

And this, of course, is your report. I believe it's the front of your report, the kind of general summary that you provide. But we have this paragraph right at the end, and I'm going to draw your attention to two sentences. The very first one, it reads: (as read)

> This class of materials that make up the confining strata will generally exhibit a brittle or post-peak strength softening behaviour with shear deformation, which would create transmissible pathways for fluid to migrate between the higher pressure SAGD chamber with respect to the pressure in the Wab B gas sands and -- and the gas sands.

That's what the sentence says. And then the sentence at the end of the paragraph reads: (as read)

> But the implication is that if the confining strata material above and laterally adjacent to the growing steam chambers is subjected to deformations resulting from thermal expansion of the McMurray reservoir, the brittle failure will create additional discontinuities within these materials, impacting their ability to seal against the upward flow of fluids.

And would this remain your evidence, or would you have any modifications to those two sentences based on what you've heard or what Dr. Boone has put in his report?

A No. And -- well, I -- I think the -- the -- the general nature of those statements was that if -- and that's why it's important. If the failure conditions in these materials demonstrated a brittle response, then there was the chance that those failure mechanisms may create discontinuities that would remain open, hence the importance of the conversation which -- and I think was the evidence that Dr. Boone presented in this discussion between brittle and ductile behaviour.

So I think -- I -- I'm not sure I would change it generically. I'm just saying that this would be the impact if there was brittle failure, yes.

Q Thank you.

So I need to go now to Exhibit 50.003, page 29, and this is Dr. Boone's report. He provided a figure and -- there it is there. And if we can expand it maybe just so that the figure showed really well. Thank you very much. Okay.

So this is where Dr. Boone plotted the approximately -- he approximately plotted the confinement strata for the KN08/KN09 on this plot. And I believe you commented on this, and I -- and I missed this, but it sounded like you referred to Mogi, some

type of --
A Oh, and -- and -- no, and actually I referred to what's in the caption of the text, actually. I didn't reference this in my direct evidence, which I apologize -- at the time.
Q Okay.
A But I think what I had referenced is, in fact, a line that is in Dr. Boone's caption, which -- which brittleness index, the BRI, is equal to, like, a -- an unconfined compressive strength of an overconsolidated material compared to an unconfined compressive strength of a normally consolidated material.
Q Right. Okay.
A So we had -- I -- I kind of probably -- I said it in words, but I didn't actually point to this plot, which is --
Q Oh. I -- I -- okay. But can you just confirm that -- can we use this and what you recognize in Dr. Boone's report as sort of a generally accepted procedure for assessing brittleness? Do you concur with that?
A It's -- it's one of 35 methods to establish what a brittleness index is, yes.
Q Okay. Well, let's --
A Then it is the reference -- Ingram's reference. This is the technique. There is a --
Q You're saying the reference is correct --

A Correct.
Q -- but you're not -- maybe it's my term "generally accepted procedure". You're not quite -- you're saying this is 1 of 35. So you're not really sure that it's "generally accepted". Is that what you're saying?
A There's a -- there's a line about the -- determining -- again, and I apologize if this is -- it tends to become difficult in this class of materials under sampling and sampling in an undisturbed form that you can get an incompliant compressive strength that is -- is not without its uncertainties.
And so the part that I -- I -- in this particular curve, and I had seen it. There's the blue dot. The blue dot shows an estimate or an interpretation of unconfined compressive strength based on an estimation of the cohesive strength, and an estimate of the depth and an estimate of what the in situ effect of pressure is.
But I think what -- what I would point out in the data is that there are two open circles at the bottom where it says: (as read)
The dilatancy transition is unknown.
And I would suggest that trying to use the data anywhere above the 1,000-metre mark, that line represents a lot of uncertainty. Those open circles define an unknown dilatancy transition, and the class

of materials that are represented by the Wabiskaw are all in that upper horizon.

So -- so, yes, the blue -- the blue dot plots there, but there's a -- there's a curve fit plotted by -- by the author, so, yeah.

Q If you'll humour me, let's use this plot and see where it takes us.

Do you agree that generally, as this plot shows, that for a given material with specified unconfined compressive strength that it will behave brittle at shallow depths and ductile at deeper depths?

A With -- with the caveat --

Q M-hm.

A -- and we have to define "shallow" and "deep" relative to the stress history of the material, I -- I had mentioned that one of the other very significant ways of defining "brittleness" is -- is related to the stress history of that material, which is the overconsolidated versus normally consolidated behaviour.

And so just by even a quick calculation of -- of the stress history for these materials would suggest that you were -- we're in a range of brittleness index that's -- would suggest a risk of dilatancy.

Q Thank you. That's fair enough. But I think within your answer, I actually -- oh my goodness. Okay.

So let's try this question: Can you just please explain for the Panel how the overburdened compression ratio is determined or calculated?

A So the overconsolidation ratio that I referenced is a standard term in geotechnical engineering that relates the preconsolidation stress, which is the maximum effect of stress that a deposit has ever seen in its geological history, divided by the current effect -- vertical effect of stress.

Q Okay. Thank you. Just give me a moment, please.

All right. So if you have laboratory data for the strength of the shales, could you -- could you still rely on the OCR to assess brittleness?

A In fact, it is -- it is a standard lab test that is generally required to make this measurement. You need to do a odometer or a one-dimensional compression test over a range of stresses that moves the material from its overconsolidated state to its -- okay. Okay. Sorry. I know you -- the geotechnical engineer. So I bring a sample to surface, it's unloaded, and when I take that sample, I put it back in a cell, and I -- what I do is I keep increasing the loads until the material moves from an overconsolidated behaviour to what's referred to as a "normally consolidated behaviour", and the rate at which those deformations occur change and where that inflection point occurs

defines the pre-consolidation stress.
Q Okay.
A And so now you can determine from that test, generally as a lab test, once you have that pre-consolidation stress, it's a measure of what the maximum effect of stress generally -- I mean, there are nuances to it, but generally defines that maximum effect of stress. You can do the calculations that exist in evidence today for the intervals in the confinement -- to define the current effective stress, if you divide them, they will define the overconsolidation ratio.
Q Okay.
A And I should say there are no lab tests. I didn't see any lab tests. I -- I don't know if lab tests have been done in KN08 and KN09, if subsampling of the lower B1, upper B1 -- I mean, if there is those kinds of tests have actually been conducted for those particular materials, I -- I'm willing to stand corrected.
Q Yeah. Fair enough. And we did see that in your report. I think our question is at a higher conceptual level than that.
A M-hm.
Q Taking you back to your general statement that you made: (as read)

This class of materials that make up the

confining strata will generally exhibit a
brittle or post-peak strength softening
behaviour with shear deformation which would
create transmissible pathways for fluid.

And I think the question that just follows is that -- that "generally exhibit" should have been qualified by the information that you had stated previously, which would be depth, the effect of stress rate or state, that type of thing. That -- that was a blanket statement that needed some qualification.

A Agreed.

Q Agreed. Okay.

A Agreed.

Q All right. So let's try this one. This is going back -- same chart; we've got it up here -- and if my understanding is correct, you mentioned the blue dot, and the blue dot is about 1 MPa -- is that correct -- or just past?

A Of unconfined compressive strength, yes.

Q Unconfined, yeah.

A Yeah.

Q So do you agree that given the depth of the confinement strata at KN08 and KN09 of about 450 metres and typical unconfined compressive strength of McMurray and Wabiskaw shales, about 1 MPa, that the confinement strata at KN08 and KN09, as plotted, they should fall in the category of "ductile"?

So I can repeat that if you need to, but we want you to now apply this theory to the depth of KN08 and KN09 and tell us your conclusion.

A So UCS data --

Q M-hm.

A -- I'm not sure. In fact, I can't recall from Dr. Boone's report where exactly that came from. If it came from a correlation with sonic velocities and mineralogy, I don't know. I didn't see any test results. I don't know if I've seen unconfined compressive strength tests, so to go and -- you know, to go to other Wabiskaw shale A, Clearwater formation shales and -- and speculate what unconfined compressive strengths would be at those depths is probably a little -- would be premature for me. So if we --

Q Okay.

A But even -- even if we go with that -- I mean, even if -- let's say there is an -- a difference of an opinion and it's -- it's not one, but it's one and a half or it's two, what I'm suggesting is that -- that for the importance of understanding the migration of fluids in the confinement strata and making an assessment a priority at the moment without any evidence of any material behaviour at KN08 and KN09, I would suggest that relying on a curve fit to the left of the data where open circles within the depth of uncertainty for the -- this dilatancy transition thing is unknown and using that as an explicit definition for actually becoming an -- all behaviour being non-dilatant would probably not be the -- the -- the best way to go.

Q Fair enough. So is your evidence you just can't get there based on the 450-metre depth?

A And -- and site-specific information about how those units would behave within the confinement strata, yes.

Q I don't mean to be provocative about this --

A That's okay.

Q -- and it's -- probably will reflect my lack of understanding, but --

A It's okay.

Q -- isn't that what you're doing when you just say, This is brittle, when -- you know, like, we're -- we're pointing -- we've got some general principles here in the sense that "shallow" is generally brittle, "deeper" is generally ductile, and you're saying even at a depth of 450 you can't get to the general principle of ductile that -- but I -- I'm just saying aren't you doing the opposite by labelling it all "brittle" without further information?

A Oh. Oh, I see where you're getting -- okay. Yeah. No, no. I should be clear about this. No, no. I --

I'm not saying that -- that if -- if I go from 450 to 480 to 490 and go to 500 or 600 or whatever the depth might be that you're not going to go through a brittle/ductile transition. I -- I didn't say that.
Q No, I understand.
A I -- I --
Q I'm just --
A Yeah. So -- so I'm --
Q Help me.
A -- I'm -- I'm suggesting that there are multiple ways --
Q M-hm.
A -- to define brittleness, that in the absence of specific information at KN08/0K9 makes it a very -- it makes it a difficult situation to land on a definitive answer.
Q Okay.
A That's all. That -- that's all I'm saying, yes.
Q I understand that, and I understand that you're pointing to the complexity. But what you are agreeing to is the general concept, that, generally speaking, rocks behave more ductile at depth than shallow?
A Well, and I think more important -- and -- and to -- to -- to points that Dr. Boone made in his report, that if shear occurs in materials that are ductile, then those -- those discontinuities that are created are

likely going to remain closed. If the material is brittle and it shears and is dilatant, then those discontinuities are likely to remain open.
Q Okay.
A And so that -- that is a -- as -- as a concept, absolutely.
Q Okay. Thank you.
A Yes.
Q Appreciate that.
A Absolutely.
Q Let's try this one.
If you could please bring up Exhibit 47.002, page 20.
And this is, I believe, a response to one of the Canadian Natural IRs that --
A IRs, yes.
Q You provided this plot, yeah. You probably recognize that.
A Yeah.
Q And are these lab tests that you -- that were performed by you or in your lab?
A Yes.
Q And are the samples taken from the Wab D mudstones from the Suncor MacKay project?
A Correct.
Q In your report, did you provide the labels "dilation"

and "contraction"?
A Yes.
Q In this context, is "contraction" synonymous with non-dilatant --
A Non-dilatant?
Q Dilatant?
A Yeah.
Q Sorry -- as previously shown; is that correct?
A It refers to a -- a reduction in volume as shearing is occurring in the tests, yes.
Q Reduction in volume as shearing is occurring.
A Yeah.
Q Thank you.
A Yeah.
Q Okay. So let's look at CST4, which has a confining stress of 690 kPa?
A Yeah.
Q And that behaves in a dilatant manner, so it indicates a risk of open fractures. Would you agree?
A In -- within the theory that we had just chatted about, it -- in the stress-strain curve, it exhibits a brittle strength softening response, and it's followed by a -- a dilatent volumetric response, yes.
Q Okay. Thank you.
And what about CST3? You'd agree that that's at the transition between dilation and non-dilation?

A From -- yeah. From a -- from stress-strain point of view, it -- it displays strain-softening behaviour, but the volumetric behaviour is -- I mean, yeah, marginally if not just zero; right? It -- it --
Q Okay.
A -- it contracts initially and then barely dilates, yeah.
Q Would you agree that the CTS -- CST5 sample is exhibiting non-dilatant behaviour, which, according to the previous model, means that the fractures are likely sealed? So sealed fractures?
A Yeah. Probably very likely in -- in CST3 -- or -- sorry -- CCS5, if-- if -- if we looked at the samples -- and I think I did show all of the images of the post-failure condition of the tests likely suggest that -- yeah, that it would -- it would have been closed.
Q Okay.
A Yeah.
Q Thank you.
A Yeah.
Q CST4, which has a confining stress of 690 kPa; CST3, 1,470 kPa; CST5 has a 1,970 kPa; correct?
A Correct.
Q So at the effective -- so at effective stresses above 1,470 kPa, the behaviour is not indicative of open

fractures; correct?
A Yeah. That's -- yes.
Q You agree?
A It's -- well, it's -- yeah.
Q Thank you.
A M-hm.
Q If we could please bring up Exhibit 50.003. Is that what we're in? No. 50.003, page 26, please.
Oh, do I have the right -- there's no page numbers. Okay. So page 26. Yeah.
So Dr. Boone provided this chart, and -- which plots the test versus confining stress at the top and then illustrates the transition versus depth showing the stresses at KN08/KN09. You see that?
A I do.
Q And the initial minimum effective stress in the confining strata at KN08/KN09 exceeds 4,000 kPa. So it's clearly in the ductile regime, which one would expect closed fractures. Do you agree with that?
A In the assumed position of the transition that was interpreted by Dr. Boone, yes.
Q Right. You'd agree this isn't even close, meaning it's -- it's way past the transition at 4,000 kPa?
A Indeed. But the stress state within the confinement strata is actually not represented by the dots shown by Dr. Boone, as evidenced by the in situ stress estimates

provided in the direct evidence I provided.
Q Are you able to give us a reference for that, or you're just saying --
A Well, if I would --
Q -- generally?
A If we would have been able to use slides, I would -- I would have shown you those calculations, and I'm -- I'm -- I'm happy to -- I don't know -- what is it called -- no.
I'm looking at Ms. Riley. I've been instructed not to offer undertakings.
Q Fair --
A I will leave it to Ms. Riley, but, yes, I have the data, and I have the slides to show the calculations of what the variation in that minimum effective stress is, given the stress profile data supplied by CNRL.
Q Okay. Fair enough. I think we'll leave it there since --
A Okay.
Q -- obviously that information's not on the record.
A Yeah.
Q And --
A Fair enough. Yes.
Q -- none of us want to go there, so ...
Can you please turn up Exhibit 47.002, page 20, if you could. And -- page 20, yeah. So -- no. That

doesn't look right.
So I think this is coming from your report?
A Yeah.
Q It's Figure 15. You call it "Figure 2", "Changes in Hydraulic Conductivity and Volumetric Strain with Axle Strain Number 5". Does that ring a bell in your report?
A Yeah. I'm trying to find --
Q It's two graphs, Figure 2.
A Oh, Figure -- Figure --
Q Just need a page number --
A Figure 2?
Q Yes.
A Figure 2. Figure 2. So -- oh, it was -- well, Figure 2 in the original report was the centrifuge testing. Are we getting after the centrifuge testing?
Q Let's see -- this might be Figure -- I think I'm quoting the reference. So --
A Oh, okay.
Q It's Figure 15. This is 11. Maybe keep going down.
A Oh, Figure 15.
Q I think I was --
A Oh, it must be --
Q -- referring you to a reference, and that's not right.
A Oh. Yeah. I don't think that --
Q Right here. We've got it here. Thank you very much.

A Oh, yes. Yes.
Q Good job.
A Yeah.
Q Okay. Yeah. So can you -- you provided this as an example of brittle dilatant behaviour; correct?
A Yeah, just as a -- an example from a public -- or from a publication. Yes.
Q Right. And can you just confirm that this test in particular describes a volcanic pumice tuff --
A Oh.
Q -- is that correct?
A Oh. Oh, yeah. No. It's -- yeah. No.
Q So it's not a shale?
A Completely inappropriate for our conversations about shale, yes. No. This was -- this was supplied to a response that said, Do you have anything that shows that there's an increase in permeability with shear? Yeah. No, no. It's -- this -- this is not for a -- not for a shale and definitely not for the shales represented by --
Q Okay.
A -- our confining strata. Sure. Yes. Absolutely.
Q I think actually that's part of the question, that we were looking for you to provide an appropriate example. Are you --
A Yeah.

Q -- aware of a good example that would show in this area?
A So, again, if -- if -- if we would've been able to use the slides --
Q Oh, okay.
A -- I would have shown you a reference of an individual who did testing on shales utilizing the definitions for brittle index that we have been establishing and showing that if the brittle index is above 2 and a half, the behaviour of those materials will be brittle, dilatant, and will show permeability increases by orders of magnitude.
Q Okay. Understood. And those ones unfortunately are not on the record.
A They are not.
Q Is there any way -- any reason why you didn't provide it in response to Canadian Natural's information request specifically requesting pertinent examples?
A Oversight and a rookie move on my part. My apologies to CNRL.
Q Okay. So then --
A But I can provide it.
Q All right. Thank you. Appreciate that.
We have reviewed your original report. I don't think this is on the record either, but it does -- it does provide the backup or the lab results -- is it

specific to this ...
Okay. So this is -- maybe I better get this back up just so you can stay with me. So in your report, page 20, let's see if we get --
A Page 20.
Q Oh, this is -- this the reference that's not correct.
A Oh. Sorry.
Q We want this one, but that's not the page number.
A I can ...
Q Let's see if this is fair game --
A Sure.
Q -- Dr. Chalaturnyk, so you have a report. It's called "Petro-Canada Limited MacKay River Thermal Project Geomechanics Laboratory Program Clearwater and Wabiskaw Formations December 7, 2009", and that is the report, we understand, to have backed up the example that you did provide in response to the information requests.
A Yeah. Just -- I was just going to go to where I think I listed those -- those references. Hang on. Sorry. Yeah. Yeah, yeah. Okay.
Q So this would be -- I'm going to -- this might be helpful.
A Those -- those reference or my reference to them is kind of page 12 -- page 12 -- 11, 12 of -- of my IR response.
Q Let's try this and just see if it takes us there.

Exhibit -- Exhibit 44.002 --
A Okay.
Q -- page 74. Yeah. And if you could scroll --
A Oh, here we are. Okay. Thank you.
Q That's not the response. Hmm ... Let's see if we can do this.
But you had -- you agree with me that you did talk about the MacKay thermal project results in your -- in your --
A Yeah.
Q -- IR response? You recall that, sir?
A Yeah, I think I provide basically three -- three sets of results to demonstrate the brittle response and the stress strain behaviour that was -- yeah, I think. But there were two conducted in my lab: one conducted by Tetra Tech in Edmonton for Wabiskaw A and Wabiskaw D intervals, yes.
Q Exactly. That's what I'm trying to refer to.
A Yes. Yes.
Q And then you found that that report was assessing or conducting before and after permeability tests on Wab D specimens; correct?
A They -- they did include -- yes, I think -- I think in the full reports --
Q Yes.
A -- there is some permeability testing data, yes.

Q Okay. Thank you.
And would you agree that that report shows that there was no permeability increase associated with the induced shear fractures in either the Wabiskaw or the Clearwater shales?
A It did.
Q Yes?
A Yes.
Q Thank you.
You're aware that the Wabiskaw D shale that you tested and provided evidence of "brittleness" is the primary caprock for the Suncor MacKay River SAGD project; correct?
A Correct.
Q And you're aware that that project has been operating for more than 20 years?
A Correct.
Q At the MacKay site, the confining shales would have been subjected to the thermal expansion of sands that you express concern about above, correct, in that report or -- sorry -- that you were suggesting earlier?
A So are -- are we moving towards details of these projects as analogs for KN08 and KN09? Is that -- is that where we're headed because that might be a little difficult for me to speak on in detail. I've had, you know, some passing involvement in those projects. I

have not been professionally engaged in analyzing those projects, so I'm -- it would be a little difficult for me. Generically, if we want to talk generically.

Q I think we are talking generic, and just the concept that you've held out an example where you're suggesting that you could get to induced shear fracture of those shales, and yet we actually have an operating SAGD project for 20 years --

A M-hm.

Q -- that -- that just isn't the case?

A Yeah.

Q That has not occurred?

A Yeah. And I think if you read the details of the IR response, the IR response from CNRL asked, You made a claim about brittle behaviour, what -- what evidence or experience have you had in your -- in your life that shows that, in fact, you could get this kind of stress strain response that is -- is strain softening or demonstrates a brittle response?

I -- I -- I didn't supply the data for a wide-reaching conclusion of KN08 and KN09. They -- it was -- it was meant specifically to CNRL's direct question that says, You said "brittle": What evidence do you have in your experience that shows that it's brittle for this class of materials? That's all I have.

I -- again, I will say that if -- if -- if there is data of core testing specifically from KN08 and KN09 in this confinement strata under this condition, I -- I'll sit corrected.

Q For sure.

A Fair enough.

Q Understood. Yeah.

A Yeah.

Q I think what we were just trying to get at is you're sort of claiming brittleness over here in an established caprock that has clearly been containing steam for the past 20 years, so just -- it would suggest that you're -- you know, that you're applying a theory that's just not being proven in practice.

A The reason I'm hesitating is that your question stated specifically "held steam", and it is difficult for me to comment on direct experience in those field projects that demonstrates the movement of pressure beyond that horizon. And I don't think I'm in a position to be able to talk about that in detail, but your comment or your question specifically was steam containment, which is by definition a vapour phase and high temperature and so on, as everybody knows. But -- but that's not necessarily a germane conversation around how the confinement strata at KN08 and KN09 are going to behave over the lifetime of the project. It's -- I -- I had thought about this when thinking about CNRL and the evidence that was provided that if steam as a vapour phase arrived in the Wabiskee -- Wabiskaw B pool, we would have other serious issues to be talking about.

But that's not -- in my mind, when I reviewed the evidence was not what the germane question was about. The -- the question was fluid migration and in the range of descriptions that have been provided: steam, condensed steam, reaction products, and so on, but the fluid migration from the SAGD up through the confinement strata to the Wab B. So, yes, I know you're asking me to -- to speak to the issue of steam containment in a shallow SAGD project like the MacKay River, but there -- it would be difficult at the moment for us to get into the conversation about what that means relative to how fluid pressures and other such processes would occur in the -- in the -- in the overlying zones.

Q Yeah. Understood.

A That's a long answer. I apologize.

Q That's okay.

A I guess I find it very difficult to be able to give you the answer that I think you're looking for because it's a very complex situation involving monitoring data, surveillance data, and -- and other things that have happened that -- that make it difficult for me to, I

think, give you the answer you're looking for.
Q I think -- I'll just boil it right down. My last two simple questions. We know -- you don't have any evidence to suggest that at Fort McKay after 20 years that that caprock, which you have characterized as "brittle", is not containing the steam. And I'm specifically using the "steam".
A Steam. Yeah. No, I --
Q You agree. You have no evidence?
A I do not.
Q And are you aware, sir, that the wording of Hearing Issue 1 actually is "steam"? I understand your client is concerned about other --
A No, I --
Q -- issues, but the wording of Hearing Issue 1 is "steam"; correct?
A Yeah, sorry. And I apologize because I had migrated to the language that was used by the AER in their IRs to CNRL which spoke specifically to fluid migration from the SAGD chambers up through the confinement strata, so I apologize.
Q Fair enough.
A But I did use --
Q That's a good point.
A I did use AER language.
Q Fair enough.

If you'll just give me one moment, we'll just confer and see if we're finished.

Thank you very much. I think we're done with that -- that line of questioning, and we'll just hold on and wait for our turn for the rest of you tomorrow.

A Thank you.

Q Thank you very much.

COMMISSIONER CHIASSON: Thank you. All right. So we do have some questions from the AER. So please proceed, Ms. Peddlesden.

The Alberta Energy Regulator Counsel Questions the ISH Energy Ltd. Witness Panel

Q S. PEDDLESDEN: Good afternoon. So I am Ms. Peddlesden, and I'm here with the Alberta Energy Regulator, and I just had a few follow-up questions.

I'm looking at the practical value of a DFIT. Is the critique ISH provides of Canadian Natural's geomechanical model still as relevant if the KN08 and KN09 steam chambers are contained as Canadian Natural claims, the steam chamber will be based upon what has been defined in the submissions as the confinement strata made up of the six co-relatable units in varying thicknesses?

A R. CHALATURNYK: I think the component of the discussion that's happened relative to your question is a conclusion based on stress contrasts and the submission of geomechanical modelling that is based on the initial assumptions of what those in situ stress states are, and the repercussions, I guess, or if the consequences, I suppose is maybe a better way, is that if the horizontal stresses that are -- have been regionally estimated are transferred to the confinement strata and given the geological heterogeneities that exist in KN08 and KN09 result in a lower horizontal stress, you know, I -- I can't -- I argue there were some interpretations of some other values, but if it's lower, then -- then I think the consequences for the question change.

It -- it -- it -- lower stresses will result in deformations having a larger impact on the -- on the integrity of those zones and will have a larger impact on the ability to contain the fluid movement and to be able to lower stresses will change the outcomes of the geomechanical modelling.

So, yes, I would say that if there is the potential, given the geological environment, that there is an uncertainty or a lower horizontal minimum stress that, yes, it may change the outcome.

Q Okay. And now I'll ask for Exhibit 46.002 at PDF page 70 to 71. Great. Figures 30 to 31.

I just wanted you to identify which variables of Canadian Natural's geomechanical model ISH expects

would change with the data of a more proximal DFIT to the KN08 and KN09.
A So relative to Figure 30 and Figure 31. Is -- is that -- is that correct?
Q Not necessarily.
A Oh.
Q Just if we had a more proximal diagnostic fracture injection test.
A Oh, I see. Okay. So --
Q As suggested.
A So -- so clearly in the -- in the evidence I had provided, you know, I had recognized the expertise and experience of Mr. Walters in conducting these kinds of simulations. That -- that's -- that wasn't at all in question. When it comes to results like this, there has been the interpretation that based on regional -- regional characterization or regional interpretation of the stress distributions, that the stress contrast in the -- specifically shown in this one -- let's pick the lower -- the lower B1 is 13.7 kPa per metre. Mid-B1 -- I will leave it to the geologists to have the discussion around the heterogeneity of the presence or non-presence of mid-B1.
But if you pick 13.7, it is -- it is correct in -- in the position by CNRL that that stress contrast under the short-term conditions, 24 hours of injection, is

sufficient to contain the fracture -- vertically growing fracture within the McMurray; correct? If you look at this data.

So the question becomes if the regional interpretation doesn't reflect the geological heterogeneities that exist within KN08 and KN09, which have been spoken at -- at length in the hearing, result in the stress contrast from 13.7 going to 13.1, not even as low as -- as what was interpreted in another place but drops to 13.1 or -- or even lower locally, then there's a potential for that fracture -- vertical fracture growth to propagate well into the confinement strata.

I am -- and I think I -- in -- in questioning with CNRL, I -- I -- I -- I -- I didn't see any evidence to suggest that that becomes a risk for caprock integrity, and there's a difference. It's not a risk for caprock integrity. This is about the behaviour of the confinement strata in sealing against the migration of fluids out of the SAGD chamber into the Wab B gas pool over the life of SAGD.

So, yeah, if -- if -- if -- if -- if those horizontal stress estimates drops, then -- then you will have the potential for the fracture to grow vertically up into the confinement strata.

Q And what I'm trying to explore with you is what value

or certainty would the Regulator gain from a DFIT test more proximal? Which parameters can you identify? Obviously you identified --
A Yeah. Yeah.
Q -- that 13.1 might be more --
A Okay. And -- and -- so you --
Q -- conservative --
A So I -- so you would like me to kind of speak --
Q The value.
A -- a value statement on --
Q Is it going --
A -- on behalf of AER or -- or -- or just --
Q No. Just --
A -- my opinion --
Q -- like, why -- why would it guide --
A Oh, okay.
Q -- our approval MOP? Which parameters do you anticipate would change with a more proximal DFIT test? Can it identify the brittle or ductile behaviour of the confinement strata? I'm not concerned about the caprock as you had said.
A Oh, okay.
Q That's fair.
A No. I -- well, there are a few of the issues we chatted about in terms of the behaviour of the -- you know, the mud zones and the sand zones within the

confinement strata. Understanding what that initial stress state is, if it varies, helps better understand how the confinement strata is going to respond to SAGD pore pressures and temperatures. So the value of the DFIT locally or proximally to KN08 and KN09 from -- from the point of view of -- of the confinement strata would provide confidence that if you confirmed that the horizontal -- minimum horizontal stress was in line with -- with these regional estimates, then that would confirm that -- that -- that, in fact, the confinement strata will behave as proposed.

If the value is lower, then you -- you stand the chance that the predicted behaviour will result in fluid migration through the confinement strata into the overlying zones such as the Wab B gas pools.

And so that's -- that's -- that's a -- that's a particular end result that's a part of the discussions at the hearing, but I would suggest in the -- in my final statement that -- regarding SAGD projects, per se, that it -- that it -- that understanding what those mechanisms are and ensuring that we understand better what those mechanisms are moving through the confinement strata helps us better understand what our caprock integrity risks are. I mean, so -- so minimum horizontal stress is inherent in any of those discussions.

Q Are you referring to in situ stress or --
A Yeah.
Q -- is it --
A The -- the -- in the -- in the language or the terms and stuff, Sh min, the -- the minimum stress -- in this particular case, the minimum stress happens to be the horizontal, but -- and in -- and most of this has been determined by the DFIT. So it's the minimum horizontal stress.
Q Thank you.
A Yes.
Q And is it ISH's position that a DFIT would reveal further information on the ductility of the confinement strata?
A No, not necessarily. No.
Q Now, if I could get Exhibit 32.02.
Hold on. I'm just going to confer.
As far as the range of values you may anticipate for -- from the DFIT model, what is your position on the sensitivity analysis that's already been applied in the Canadian Natural geomechanical model?
A Can -- I've -- don't have the exhibit number.
Q 32.02.
A No, no.
Q No?
A Well, actually, let me see if it's -- it's the --

the -- you might -- you might have it in my slide deck. It's the second-last one that showed the stress profile, and I apologize that I don't -- to -- to answer your question -- sorry. This might help with it.

Q This is helpful.

A Yeah. Just to help with that question.

Q Yeah. I appreciate it.

A Yeah. Yeah, yeah. It's -- we'll see how fast -- see who can -- who can win the race faster. It's the in situ stress, and it is -- oh, no, that's the DFITs. No. No, no, no. I mixed up all of these documents, and I apologize. Oh, for God's sake. Ah, Exhibit 46 -- 46.002, Tab 5, Figure 7, page 46 -- PDF page 46 of 72.

So I think this might -- this -- this uncertainty level -- so I had -- I had indirect -- I had pointed out that in the confinement strata there have been estimates of the -- of variation in the minimum stress gradient indicated by the dotted lines. So we had blown in -- we had -- we had -- yeah. We had gone in. And so -- so in the kind of numbers that we've been talking about that we see in the tables, those gradient values are the values interpreted by fitting those pink straight lines in there that are not representative of the variability in the horizontal stress that's been interpreted from continuous logs as a part of CNRL's interpretation of their mechanical earth model.

So when you -- when you say about -- so I guess the impact, I guess if you like, is that that variability, theoretically, would still exist. And there were sensitivity studies that I -- I think Mr. Walters might have shown -- and, again, I'm going to apologize if I've get the -- the numbers wrong. He took the stress gradient in the lower B1 and the stress gradient in the McMurray and shifted them down -- and shifted them both down by equal amount. I'll have to find the things, but that was a part of the sensitivity. He said, Well, listen, we'll test it, and we'll shift the things down. But -- but it's the dotted lines that shifted, not the solid pink variation in the interpreted variation in the minimum horizontal stress.

So the implications are that if that variation still remains within the confinement strata, that that variation may push the actual local minimum stress to a point that actually will not resist fracture propagation. That's the implication.

Does that -- does that help? Sorry. I didn't know if that would help --

Q It does help.

A -- in terms of your question.

Q But the DFIT would not identify the brittleness?
A Ah, okay. You're getting at the value of the DFIT. So the DFIT value --
Q Yes.
A -- in this piece of work, which is a key, standard workflow -- I mean, Mr. Walters is an expert at this. This has not been in question. Those interpretations of the variations in Sh min, the minimum horizontal stress, have to be calibrated or typically calibrated to the DFIT number, which is the open circles in this plot.
Q So that brings me to: Would the new DFIT --
A Yes.
Q -- in a proximal location to the proposed drainage boxes significantly change the Sh min curve, in your opinion?
A Yeah. So if the DFIT results in a reinterpretation of what that minimum stress is at any particular depth and it's lower than that open circle that exists within the confinement strata, the whole curve shifts to the left.
Q Right.
A And that has impacts on -- on the -- on the containment characteristics of the confinement strata. So the value is that in order to calibrate this data, if the new DFIT shifts that number to the left, the whole curve shifts to the left.

Q And how much variation are you anticipating?
A Oh.
Q What's your position?
A I -- I -- I don't know. I -- I think there was pushback -- again, I think in my report there was some conversation around the low confidence of the interpretation of the confinement strata DFIT in the 9-6 well, which is the closest. I think, you know, it's off to the east of -- of -- of KN06. And, you know, there were experts in -- in CNRL that analyzed the data. There are -- there are ways to do it, the -- the response of the pressures, the volume injected, and so on, and there was a low confidence limit given to that estimate, and so it was disregarded.
The -- the -- in the same well, there were other DFITs conducted in the Clearwater for caprock integrity assessment, and in the -- I don't know if it was in the -- but there were other -- yeah -- in the McMurray, which are the open circles that you see here -- and even though it was the same operation, those were deemed to be valid.
So all I had pointed out at the time is that the -- the interpreted much lower Sh min in that test in the confinement strata may have suggested some uncertainty in what those estimates are for the minimum stress.

But I think, you know, that -- it wasn't based on my interpretation. It was just looking at the behaviour and looking at the consequences for the confinement strata in KN08 that I -- I'd -- I'd made that observation.

So the uncertainty part, I -- I -- I probably haven't looked at the data enough to be able to offer a -- a -- a solid conclusion to you. Sorry.

Q And now we'll turn to Exhibit 32.02, page 10 at paragraph 22. I'll just read it out loud so -- (as read)

> ISH has not and does not seek an order preventing CNRL from developing the bitumen resources. ISH is asking that the conditions of approval recognize the unique geology underlying KN08 and KN09 and include appropriate measures to mitigate the concomitant risk.

Speak to that. What conditions are you looking for specifically within your expertise? Oh, I didn't mean to scare you.

A I think this is at the point when I do not have the -- can't speak on behalf of ISH.

Q It's only because you're leaving early --

A Yeah, I know.

Q -- that I put it to you.

A So maybe that -- perhaps I don't know -- I think I can turn it over to the chair.
Q No, you don't have to.
A Oh, okay.
Q It's not our issue yet.
A Oh, okay.
Q Yeah. No.
A I -- I'd be --
Q I just wanted to ask you before you departed.
A Yeah. That would be a little probably beyond my remit.
Q That's fair.
A Sorry.
Q That's fair.
So in a similar vein, before I let -- let this drop, if the Sh min is indeed lowered, what mitigation strategy would you propose? It's kind of the same question. Like, what condition would help mitigate risk of breakthrough of the confinement strata?
A Good question. That's a -- that's a great question, actually. I think in my mind -- and -- and I spoke to it generically about even the importance for us in -- in the -- in the -- in the SAGD projects and the -- and the technical people involved in SAGD projects is about better understanding what the potential is for these fluid migration pathways, if or if they do not occur, you know, what happens to pore pressures and -- and so

on.

So in some ways I'm not -- it really is in constraining those values helps us better understand how that confinement strata would behave, and from a -- I suppose from an ISH perspective, it helps them better understand what that potential risk profile looks like for the -- over the life of the SAGD project for -- for fluids migrating to the Wab B gas pool. But I would suggest in -- in -- in terms of even your earlier question sort of on the -- from a perspective of, say, if you like, an AER in ensuring subsurface containment and subsurface assurance issues is that, you know, even if you look to projects that have -- have -- have failed, Jocelyn, others, whatever, it has to have started with fluid migration from the SAGD chamber moving through these intervening layers to some upper interval that has now failed and moved and -- and -- and moved to the surface. So a better understanding of how that interval behaves provides knowledge, if you -- like, for a whole range of SAGD projects who are -- who are actually dealing with the containment side even as you move shallower in the column. If we better understand that, we better understand where we sit relative to factors of safety.

So I would say that that's the reason why refinement of that kind of information at KN08 and KN09 beyond the potential risk of -- of contamination in the Wab B gas pool also has much larger value-added contributions to the industry.

Q Thank you for that. My questions are concluded.

A Thank you.

COMMISSIONER CHIASSON: So thank you for that. The Hearing Panel has no questions --

A Oh, okay.

COMMISSIONER CHIASSON: -- for you, Dr. Chalaturnyk.

A Thank you.

COMMISSIONER CHIASSON: So I think Ms. Peddlesden probably covered off what we may have been wondering about, as well as the cross-examination. So thank you very much.

At this point, Ms. Jamieson, we do have time in the day if you are inclined to continue your cross-examination; however, if you would prefer -- if you would prefer to leave it till tomorrow morning, then we can close off for the day as well.

J. JAMIESON: If I could just have a moment to confer.

COMMISSIONER CHIASSON: Absolutely.

J. JAMIESON: I'll see what that might look like. Thank you.

COMMISSIONER CHIASSON: Actually, Ms. Jamieson, because this may be relevant in your conferring, I should mention that if we were to continue, we do need to take at least a break to allow our court reporters to switch over.

J. JAMIESON: Yeah. Thank you. I appreciate that. I'm going to try to get a sense of it and to see where that would take us.

COMMISSIONER CHIASSON: Okay. Yeah.

J. JAMIESON: Just so we're not staying late.

COMMISSIONER CHIASSON: Okay. Thank you.

J. JAMIESON: Okay. Thank you.

Commissioner Chiasson, we think if it works for the Panel, that we would like to stop here. We'd be prepared to come back, finish off in the morning. But just because of how this has unfolded we're just not quite ready to go right now, and I couldn't give you a sense of how much time we're going to need.

COMMISSIONER CHIASSON: No. Thank you. We appreciate that. And I don't think that's a problem otherwise.

Any concerns, Ms. Riley, in terms of that?

M. RILEY: I certainly don't have a concern with stopping today. I would just like to confirm that Dr. Chalaturnyk is then no longer under oath and released --

COMMISSIONER CHIASSON: Yes.

M. RILEY: -- and excused.

COMMISSIONER CHIASSON: No. No. That was -- that was going to be my -- that was going to be my next job.

So let's do that, then. We will close for today. The usual reminders to remember to take all your belongings.

So, Dr. Chalaturnyk, thank you very much. You are released, which is, like, not parole. You're free and clear. The rest of the witness panel, we would remind you that you are still under oath and affirmed, so please do not discuss with your counsel overnight or that -- and we will see you back tomorrow.

(WITNESSES STANDS DOWN)

COMMISSIONER CHIASSON: And, to confirm, we will restart again tomorrow at 9:00 and anticipate running through the rest of the hearing, including final argument. So thank you all. I hope everyone enjoys having a little bit of earlier time today. I suspect we will. And that -- And thank you, all. We will see you tomorrow morning.

PROCEEDINGS ADJOURNED UNTIL 9:00 AM, FEBRUARY 9, 2024

CERTIFICATE OF TRANSCRIPT:

We, Sandie Murphy and Sandra Burns, certify that the foregoing pages are a complete and accurate transcript of the proceedings, taken down by us in shorthand and transcribed from our shorthand notes to the best of our skill and ability.

Dated at the City of Calgary, Province of Alberta, this 8th day of February 2024.

Sandie Murphy, CSR(A)
Official Court Reporter

Sandra Burns, CSR(A), RPR, CRR
Official Court Reporter

F

J

K

U