THE ALBERTA ENERGY REGULATOR
PROCEEDING ID NO. 436

IN THE MATTER OF the Regulatory Appeal by
Obsidian Energy Ltd. of the
Alberta Energy Regulator's decision to
issue an Environmental Protection Order to
Obsidian Energy Ltd.,
pursuant to Sections 113 and 24 of the
Environmental Protection and Enhancement Act
On March 23, 2023
(Regulatory Appeal 1943624)

AER PROCEEDING
VOLUME 4

Calgary, Alberta
November 29, 2024

TABLE OF CONTENTS

EXHIBITS

Proceedings taken at the Govier Hall, Calgary, Alberta

November 29, 2024 Morning Session

A. Bolton	The Chair
B. Zaitlin	Hearing Commissioner
T. Stock	Hearing Commissioner
B. Kapel Holden	AER Counsel
O. Chijioke	AER Counsel
A. Huxley	AER Counsel
(Via Videocast)	
A. Lung	AER Staff
E. Arruda	AER Staff
M. Rahimabadi	AER Staff
P. Fitzpatrick	For Regulatory Compliance Branch
J. Allison	For Regulatory Compliance Branch
A. Hall	For Regulatory Compliance Branch
D.P. Langen	For Obsidian Energy Ltd.
A. Barrington	For Obsidian Energy Ltd.

274

K. Di Rocco, CSR(A) Official Court Reporter

(PROCEEDINGS COMMENCED AT 10:52 AM)

THE CHAIR: Thank you. Please be seated.

Okay. Just confirming that video is on again. Okay. We're good to go. Okay. Thanks.

The Panel has some questions about the non-confidential information. So we'll start with Commissioner Zaitlin.

COMMISSIONER ZAITLIN: Thank you very much.

AMY FOX, MEHRAN POOLADI-DARVISH, JAMES VERDON, STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA MARSHALL, Previously Affirmed

DEREK BOECKX, Previously Sworn

The Panel Examines the Obsidian Energy Ltd. Witnesses

Q COMMISSIONER ZAITLIN: Basically, I would like to get a slightly better understanding of the plumbing system that's occurring in the Leduc that may be allowing for migration from the high-volume Leduc disposal wells and/or the Belloy disposal wells into the Reno area. How did we get the pressure there? Once the pressure's there, then there's a different

275

question in terms of how we get down to the basement and potentially trigger any induced seismicity that's in the area.

So, firstly, what I want to try to understand is -- and this may go to Exhibit 50.05, PDF 19, which came from the Enlighten report, and it's the regional map of the Leduc and the Leduc area.

So I'm just waiting for ...

Maybe Mr. Watson can -- you brought that up the other day, the -- from the Western Canada sedimentary atlas, the -- the map that shows all of -- what was that figure?

A N. WATSON: That's Figure A6.

Q Oh. There.

A Before we dive into this, Dr. Zaitlin, may I add a comment to your question just before the break? It doesn't have to do with any of the confidential information but more to do with the development of the Leduc and how faults at the top of the Leduc might be expressed.

Q Yes. Go ahead.

A Thank you.

So there's -- as written in the report -- and there are three primary sequences within the Leduc. At the bottom -- and the Leduc over

276

the Peace River Arch reef is different from all of the other Leduc in that there doesn't have either the Cooking Lake or the Musreau Lake underlying it. It is the only Leduc reef that directly sits on top of the Peace River Arch. And -- and as there are structures there on which it builds out, and that dips -- refer to it as "basin stabilization", but essentially that -- a lot of the structures that were expressed there were then covered over by the Leduc as it developed, and then the second and third phase had less expression of that. So there are differences that you might observe for the structures at the top of the Leduc.

Q Thank you very much for that clarification.

A You're welcome. Thank you for allowing me to do that.

Q So our understanding is that the Leduc is a fringing reef complex around the Peace River Arch; correct?

A Correct.

Q And what is the range of depositional facies at the Leduc that's associated with that reef complex?

A It's a relative -- it's a -- ranges from -- boy, I wish I had a mouse. So the white area

277

in behind, which represents the exposed -- oh. Thank you.

A J. VERDON: Here's the mouse. That will control the content.

A N. WATSON: Oh, there it is. Thank you.

So where the cursor currently is is the -- as we say, it's a fringing reef. So this is the exposed Peace River Arch, so the exposed basement. As we -- and concentrically, as we go towards the outside, there would be more of what would be broadly described as lagoonal facies, so more mud-rich carbonates, fewer frame-building organisms. And then it progressively -- as we move further out towards the edge of the Leduc, there are -- it becomes more of a bank margin reef, and we have more frame-building organisms, more general porosity in that region than up closer to the -- the Peace River Arch -- the exposed Peace River Arch. Against -- since it's somewhat different than the Leduc complexes, there is -- there are influxes of clastic material into the -- that get interbedded with the carbonate material.

Q And what would the range of porosity and permeability be for the different facies that

278

are associated with that fringing reef?
A I would like to also -- I believe Ms. Marshall might be able to help with that with part of her report.
A F. MARSHALL: So for the range for the facies, we didn't separate out the facies in the model, so we can only give a general range for the entire Leduc, as opposed for individual facies. Would you like that range? I think that's something that's just not in the report.
Q Basically, what you have done is group all of the available porosity and permeability data and average that out and then gave that number to Dr. Pooladi-Darvish, who put it into his modelling?
A No. Well, partly. So I -- so I took the porosity analysis from the petrophysical data, and I populated it between the wells and the three-dimensional static model, and then I gave that three-dimensional static model that's not populated between the wells to Dr. Pooladi-Darvish.
A M. POOLADI-DARVISH: If I may.
A N. WATSON: Yes, you may.
A M. POOLADI-DARVISH: Sure. Figure R6 in

279

my direct evidence, 50.03, shows the range of the core data, porosity, and permeability that was available to the team that was imported into the geomodel, which then is -- was used to populate the rest of the model. So that would be -- it's not -- so I guess the question wasn't that averaging. The averaging was not done in that sense. But the facies -- there are no distinction between the facies.
Q So is there an available facies map that shows the distribution of the different units within the Leduc?
A N. WATSON: We -- the -- where the cores are, which would be key evidence for different facies types, there's -- as we -- the -- the people exploring along the reef did a very good job of targeting the bank margin, so where they were coring and drilling their exploration wells were focused towards the seaward side of the reef. So there's fewer wells penetrating the Leduc because there aren't expiration targets below the Leduc in the -- say, the lagoonal facies, further out towards the bank margin.
So the cores we have are more towards that particular facies.

280

So we did look at the information that was available, and it's -- most of the -- given that most of the wells are along that reef edge, there's less information to start to parse out the different facies.
Q And from a hydrodynamic point of view, to allow for the communication of the northern cluster, or Cluster 1, and Cluster 2 to migrate to the area of Cluster 3, the Reno cluster, is it the same fringing bank facies all the way around, or is there a variety of other depositional facies that may act as barriers or baffles to the movement of fluids between -- between those areas?
A Mr. -- there are -- it's -- any reef is a fairly intricate environment when considered on a very fine scale. On a larger scale, the -- it does act as a pretty consistent reservoir. That's both in the -- that's seen in both the -- the Peace River Arch reef and other Leduc reefs in Alberta.
One aspect that Mr. Boeckx was able to reference is that he saw -- he did see evidence of some reentrance, some aspects of that.
So it is -- the -- some of those aspects of the reef still did not overall impede the

281

ability to communicate pressure through the reef.
Q Okay. Sticking with the Enlighten report, if we go to PDF 44 on 50.05?
A I'm there.
Q Sorry. There is a -- there is a map that groups together all of the -- I may have the wrong thing.
In terms of structural overprinting of the Leduc paleogeography, there is a figure in the submissions that shows the distribution of different lineaments of different structures through the area in the area of interest in your report in one of the appendices. And in 81.5, which we saw this morning, we also saw that there was a number of different faults that were available to be identified.
What would be the effect of faults associated with the Peace River Arch in terms of affecting the migration pathways from the -- from the high-volume cluster wells to the south, to the 14-18 area?
A Hitchon et al., in the 1990 paper reference, does discuss the structurals of faulting within the Leduc as enhancing the ability to migrate pressures. And, also, there's a very recent

282

AGS publication on mapping the total dissolved solids through -- through the Leduc. It was Brinsky in 2023 also mapped out the continuity of the -- of the Leduc reservoir, both regionally and, if you zoom into this area, locally. And with a consistency -- in that case, he had enough information to map water driving force factors. And you can see that that's also consistent with what Hitchon had described in -- in that paper.

Q Okay. Following up on that, Dr. Verdon, how does your framework capture the complexity of the facies distribution faulting, et cetera?

A J. VERDON: So my framework -- the -- the relevant question, I think that you're talking about, I think would be the -- whether there's plausible pressure change being passed to the locations of the earthquakes, and that would very much -- well, where there's very little data, one might rely on, you know, judgement calls or past experience of similar wells and similar formations elsewhere. But ideally, the best case to answer that question would be to develop a reservoir model of the type that we've developed to actually simulate those pressure changes and incorporate those

283

effects to the best of our ability given the data available.

Q Okay. Continuing on with the Belloy fault. There's been -- there's been a discussion of that Belloy fault and where it's located and differences in positioning.

There's also a question in terms of communication along the fault, potentially, of -- of pressures. Is -- is the Belloy fault itself an open or a sealing fault?

A N. WATSON: If -- if I may, the evidence of the Belloy fault that we identified at -- at the location 1-1-82-18 W5, there's strong evidence on the logs that it penetrated a fault at the Belloy level, and that fault caused the lost circulation of drilling fluids, which they managed. But as they continued to drill the well down through to the Precambrian basement, they also had repeated lost circulation events over the course of that well. They were not able to -- they had to run two -- have two logging runs from basement up to that point, had issues logging. So they then had to do another pass over the uphole section. And then they ran -- when you look at the cement bond log -- or the cement -- pardon

284

me. Not the bond log. The cement -- the reporting of the cementing job, they had to give a -- a -- a dedicated cement operation to that part of the well because it continued to -- to even take in cement solids during the cementing of the well.

A J. VERDON: If I -- if I can then follow on from that. So that -- that's the evidence from the nearest fault for which we have direct evidence. Obviously, the -- the specific Belloy fault itself, we've observed only on seismic data, which that obviously doesn't tell you anything directly about it, so we don't have any direct observation, but you'll note that in my scheme, the question posed doesn't ask: Can you definitively prove? It asks: Is it a plausible? And I think we -- we've pretty much shown very conclusively that, given the similar experiences elsewhere where we've seen similar faults passing fluid to basement, given the observations from the nearest fault for which we have direct well intersection, that it's certainly plausible that this fault is passing pressure downwards.

A N. WATSON: Yeah. If -- and if I may add, there -- looking at the drilling

285

reviews of 11 wells in the area that went down through to the Leduc and any drilling events that occurred, there weren't similar petrophysical features or extended lost-circulation events within the Leduc. Although there was the other well that I mentioned in the reply evidence.

A D. BOECKX: Belloy or Leduc?

A N. WATSON: In the Leduc. In the -- the -- as I mentioned in the reply evidence, at the 13-18-82-19 W5 well, there was another case of this. In this case, they couldn't even log across that section because of the difficulties in drilling. The -- and the fact that you're seeing two wells and two vertical -- essentially subvertical faults and you're -- that are distributed randomly, and you're seeing two events of this nature, does speak that -- to the presence of faults that are conductive of fluids.

Q And, Mr. Boeckx, from your evaluation of the seismic, are you able to determine whether the faults are open or sealing?

A D. BOECKX: No.

Q Okay. One of the issues to try to show communication from the other clusters to the

286

Reno cluster of fluid through the Leduc may be to ask are they on the same hydrodynamic family -- on the, say, hydrodynamic gradient. Has any work been done on pressure depth or pressure elevation plots to see if we have a family or a communication across the area?

A N. WATSON: Before I answer the question, I would like to make sure that there wasn't any lack of clarity in my previous response in that when I said that the -- all of the -- the two wells that have displayed lost-circulation events were in the Belloy. When I looked at the records, I didn't see any sustained lost-circulation events of that nature in the Leduc, just to be ...

And then could you -- as far as doing pressure elevation work, pressure depth work, that was done on a regional basis in the Hitchon paper and also, to a certain extent, in the Brinsky recent mapping.

For doing the -- looking at the -- doing a gradient across the Belloy down through to the Leduc, I would recommend that that be done over the extent of pressures from the entire Rundle through Belloy. There's no Triassic left in this area. So Rundle through Belloy down into

287

the -- and then compare that to the -- the Devonian. But there isn't a significant amount of pressure data for the -- the Belloy.

Q And for the Leduc?

A So -- for the Leduc, there's significant -- there is more pressure data for that formation. And the way I would approach that problem is to look at it both regionally and then see how that fits into the regional Belloy -- Leduc picture and then look at what the local data has to tell us. The salinity of the data would be important to make sure that the gradients are consistent. There is a bit of a difference between the salinity within the Belloy versus the Devonian that would have to be considered as well when you're looking at gradients between the formations.

Q Thank you very much. That's it for me.

THE CHAIR: Thank you.

Commissioner Stock?

Q COMMISSIONER STOCK: Thank you.

I'm unclear who to direct the question to, but to Obsidian. At Exhibit 95, page 34, Obsidian stated that contributions of the 14-18 well is less than 10 percent of other wells. And -- so that's the -- page 34 is what I was

288

referring -- try 44?

A J. VERDON: I believe it's 36 that you're looking for.

Q There's 10 percent contribution.

And then in yesterday's evidence, the transcript shows at page 180, line 15, that Dr. Verdon commented that the Obsidian well was one of those that is jointly contributing to induced seismicity. These statements, among others, appear to concede that the Obsidian well is contributing, at least in part, to induced seismicity.

So my question, then, is -- or two -- what are the implications to induce seismicity if the EPO is rescinded?

A Sorry. Can you just refer me to the page again. That -- that doesn't sound like what I remember saying, but I will obviously try to find it in the transcript. Can you clarify which page. I was trying to get the transcript.

Q Page 180.

A Page 180.

Q Line 15, I believe.

A Line 15.

No. I say that if all three causes have

289

similar numbers, that would imply that they're all likely and jointly contributing; however, that's not the case. One of the causes is the Obsidian well has a significantly lower number, which would indicate that that is not contributing. I was just pointing to a hypothetical, I think, in that -- in that answer, not the actual situation.

Q Thank you.

There does seem to be some concession that there is some contribution by the Obsidian well. That's my concern, and so I'm asking if that's the case.

A No. I believe I go on to say that the -- the evidence for the Obsidian well is -- is ambiguous and that you can't conclude that it's contributing to the seismicity.

Q I see.

A M. POOLADI-DARVISH: And is it necessary about that 10 percent that I provide an explanation?

Q Go ahead.

A So that is on -- that's the -- with respect to pressure within the Leduc and the contribution of the 14-18 well to the increase in pressure. The assessment of induced seismicity, of

290

course, goes much more than that, that Dr. Verdon has conducted. This is one element in just the pressure.

Q Okay. Thank you.

Reading from the last page of Exhibit 95, I believe it is -- yes, it's the last page of the presentation in direct yesterday -- in bold, that: (as read)

> The events referenced in the EPO are likely but not definitively induced and that the evidence linking the 14-18 well to the seismic events is ambiguous and that there are other industrial activities in the area that are substantially or more likely to be the cause of the events.

And I appreciate that's not making a statement directly about the Obsidian well, but I am interested in knowing what the implications would be to induce seismicity if the EPO is rescinded.

A J. MCGILVARY: Thank you, Commissioner Stock. It's a great question.

First, I'd highlight that the EPO itself states Obsidian Energy as the sole person responsible. As such, we feel that -- in the

291

public interest, that a more accurate EPO that reflects your findings on the data provided today, be it revoking or amending, would better satisfy that mandate for public safety.

So our position is that the work done here is symbiotic with the intention of the EPO but that the EPO itself needs to be revoked or amended to meet that mandate.

Q Thank you.

Second part of my concern: How does Obsidian plan safe operation of the Obsidian well to mitigate the risk of the Obsidian well contributing to induced seismicity, if at all?

A Yes. Thank you for your question as well.

It was a quick learning curve for us in terms of how to manage induced seismicity. It's obviously an emerging part of oil and gas operations in the industry. So Obsidian Energy, as per the requirements of the EPO, instituted both the -- the short-term remediation plan but also long-term mitigation plan.

In detail, that mitigation plan essentially matches the stoplight protocol that has been implemented throughout the province. So what we now have is pending specific thresholds of

292

magnitudes of earthquakes within a reasonable proximity -- apologies -- that we will reduce the overall injection of that well for a period of time until such a time that they are reduced or time has passed and then no more earthquakes have occurred.

Q Thank you.

One final question. Could you be -- could you be specific about which parts of the existing EPO Obsidian wishes or hopes would be amended if the EPO was not rescinded?

A J. VERDON: I just want to comment on the previous question. It's worth -- oh, sorry -- worth -- worth noting that if the EPO is targeting one specific well but not -- as we've seen, there are -- there are multiple activities that are clearly -- or, in my view, clearly driving the seismicity that are not affected by the EPO. So any of the actions that Obsidian might be taking might be ineffective because there are other wells that are not currently required to take any actions in the area, and, therefore, if those other wells are driving seismicity, the EPO will have no effect on mitigating the seismicity risk as it currently stands.

293

Q Thank you.

D.P. LANGEN: Commissioner Stock, the questions you are raising are good ones with respect to what alternative relief; for example, amendment verses rescission. And I would suggest that we'll address that in argument.

COMMISSIONER STOCK: We'll appreciate having that addressed in argument. Thank you.

THE CHAIR: Okay. Thank you.

So I'm going to circle back to some of the issues we covered yesterday and -- and maybe this morning, and then I've got a few kind of new areas to probe.

Q THE CHAIR: So starting with Dr. Verdon. So in your evidence, you observed that in the reprocessed seismic nodal array data, there are no longer any events immediately adjacent to or below the Obsidian well and suggest that that supports Obsidian's view that the Obsidian well is not the cause of the seismicity events, and there was some cross-examination and direct evidence on that yesterday. So I just wanted to, again, just clarify my understanding of your evidence and test something with you.

294

A J. VERDON: Sure.
Q If the seismic events in the Reno area were triggered by pressure increases in the Leduc as a result of disposal in the northern or central wells that was then transmitted to a critically stressed fault in the Precambrian basement in the Reno area, as Obsidian is suggesting may have occurred, would this not also provide a mechanism and a possible explanation for why there are no seismic events directly below or adjacent to the Obsidian well; specifically, that the fluids and the associated pressure increase from the Obsidian 14-18 well first travelled through the Leduc to that fault or some other fault at some distance from the Obsidian well before it entered the Precambrian and was transmitted to a deeper or critically stressed fault?
A Broadly speaking, I -- I agree with the point you've made. I think the point that the reservoir modelling has shown is that where that fault might intersect, the top of where the mainshock fault is, the pressure changes caused by the Obsidian well are actually very low and a very small component of the overall pressure change, which is primarily driven by

295

those northern wells.
Q All right. Yeah. I understand that part of Obsidian's evidence about the relative contribution of pressure.
A Yeah.
Q It's more about just the mechanism that --
A Yeah. So the idea is -- if we can bring up -- again, if we can bring up -- let's go to the opening statements, the map of the events again, Slide 11. Actually, no, perhaps you want the one with the -- my apologies. I'm going to -- yeah.
We'll stick with that one, but remembering that, obviously, we're not in confidential, so it won't show the specific position of the Belloy fault really, but you know where it is --
Q Yeah.
A -- is that whether -- whether it's pressures from the Belloy well or whether it's pressures from the Leduc also encountering -- moving down that fault, that fault provides a direct connection to the top of the seismicity cloud where the bulk of the events are, and that's obviously where we think the first intersection of the fault plane was that then ruptured

296

across the entirety of it.
And as I say, that position is obviously about 3 kilometres west of the Obsidian well and directly below the Belloy well. And at that point in the Leduc, the pressure changes are being driven primarily by the wells to the north.
Q Okay.
A So -- yeah. The question is how you get pressure to that point. And then, obviously, however you were getting pressure to that point, it can go down and start reactivating that fault.
Q Okay. Thank you.
And then we also covered this issue too, and, again, I think in this morning's cross, but is it possible that fluids could have migrated vertically from the Obsidian 14-18 disposal well via faults that were not critically stressed in the lower Leduc, and potentially the upper part of the Precambrian basement and, therefore, were not susceptible to seismic slip until they reached a deeper fault in the basement that was critically stressed?
A I -- I -- if I can try and summarize your

297

question, you're -- the idea there might be some sort of pathway --
THE COURT REPORTER: I'm sorry. Can ask you to slow down. It's like you've sped right up.
A J. VERDON: Sorry. Yes, of course.
So I think the nub of your argument is the idea that, if this is the Leduc well -- the Obsidian well here, then could it be that there's pressure transfer directly down onto that fault plane.
Q THE CHAIR: Correct.
A It's not impossible. It's got a long way to go. Obviously, here we're at 1,100 metres below sea level. Where this fault plane is directly below the Obsidian well, it's at about 5,000 metres below sea level. So that's over 3 kilometres to get down there.
You know, in our view, the easier pathway would be to go laterally and reach where -- we're interested in where the top of this fault is. That's the easiest place to get to it is where this fault is shallowest.
But you'll note that in our -- in our answering of this question -- if you go to

298

Slide 24 -- thank you very much -- we -- we -- we absolutely state -- sorry. We're not there. Oh, yes. Sorry. I'm looking at the wrong -- no. There we are. Yeah, there we are.

We -- we -- we absolutely accept that there's a plausible mechanism that activities in the Leduc be passed through faults extending into the basement and that those are plausible, and we absolutely accept that and have answered that question in that way in our assessments.

But "plausible" doesn't mean did happen, and that's where all the other evidence comes in, the evidence about temporal correlation, what have you. Obviously, one part of our assessment framework is, is there a plausible mechanism. But "plausible" doesn't mean happened. What does all the other evidence tell us about the likelihood of that mechanism happening? And as I say, there are other -- the other evidence speaks to the other mechanisms being the driving force in this seismicity.

Q Okay.

A N. WATSON: I'd like to add that the 14-18 well is somewhat unique compared to other Leduc wells in the area in that it

299

doesn't penetrate -- it doesn't reach the Precambrian basement. It is in a range of 120 our so metres above the basement.

So you don't have a mechanism of it being actually at the basement. You would need that situation of a fault actually intersecting at that location rather than getting transferred down through the Leduc itself.

Q Okay. Thank you, Mr. Watson.

Did you have anything further you wanted to add?

A J. VERDON: I just wanted to briefly mention that experience in Oklahoma has actually shown the depth within -- so in Oklahoma, they inject into the Arbuckle, which is another basal aquifer. It sits right above the basement, and you have pressure transfer into the basement, and you create induced seismicity. I'm sure you guys are at least partially familiar with the issues that Oklahoma has had in that regard.

And, again, what they have seen in Oklahoma is that when they have plugged wells back to the target at the top of the Arbuckle versus the bottom of the Arbuckle, even that has a significant impact on mitigation of induced

300

seismicity.

And, in effect, the Obsidian well has already done that because it's at the top of the Leduc, not at the bottom of the Leduc, unlike the -- some of other wells in the area. So that, in itself is -- is already another factor that we didn't really factor into the framework but is relevant to induced seismicity mitigation that we've seen elsewhere, that plugging back to minimize induced seismicity.

Q Okay. Thank you. Next question is for Mr. Watson.

And we heard a little bit about this, I think, yesterday. So in the hydrodynamic section of your report -- and I can provide the specific reference if you need it -- but you state that the hydrodynamic setting indicates that both the Leduc and the Wabamun are experiencing updip flow supported by both hydraulic heat mapping and buoyancy effects.

And then you go on to say the Leduc through Wabamun section performs as a continuous and extensive hydrostatic unit. You would agree with those statements?

A N. WATSON: Yes, I would.

Q Thank you.

301

So the Leduc structure map you provide in your report -- I have a reference, but it's a confidential figure, and we don't need to get into the details, but it basically shows in a regional sense that the northern and the central wells are structurally updip from Obsidian's disposal well and the area of the Reno seismic cluster.

Given this and your statement about updip flow and the Leduc and Wabamun being a continuous hydrodynamic unit, can you just describe how fluids and the associated pressure effects are migrating from the northern and central wells to the Reno area?

A Well, the overall flow is updip, but the pressure, because of the volumes injected and the associated pressure increase over time, is working against that overall flow. The flow is occurring over -- it was established over a longer time period. Geological time it's often referred to. This is happening over the course of some decades, and that is showing the strength of the pressure pulse downdip, is that it's counteracting the established regional flow.

So what Dr. Pooladi-Darvish has observed is

302

showing that it's working counter to that flow.
Q Right. And I think we heard yesterday about it's the volume that kind of overcome -- the total volume of the fluids being injected create that pressure effect downdip; is that correct?
A M. POOLADI-DARVISH: Yes. The volume is affecting the pressure.
Q Okay. Okay. So my next question is for you, Dr. Pooladi-Darvish.
I just wanted to understand a little better about the treatment of faults in your reservoir model.
On page 15, Exhibit 50.03 of your report, you discuss the impact of faults on your reservoir modelling results. You state that a model with open faults is most representative of the reservoir behaviour.
You also go on to say that one can expect a large number of faults in the vicinity of the 14-18 well is because of the availability of 3D seismic.
And if -- you go on to say that it's plausible to think that if 3D seismic existed elsewhere, many more faults would also be detected.

303

And then the part that I wanted to explore was, you state that the model with open faults is most representative of the reservoir behaviour and suggest that if more faults were included in the rest of the model, that they would also be open and probably have little impact on the fluid flow.
So my question is really about when you model an open fault in the reservoir. What does that mean in terms of model parameters and how you treat the fault?
A Yes. Thank you very much for the question.
So faults, in two ways, are represented in a model. One is at the location of the fault. There is some displacement on the two sides of the fault, and that is included in the model.
And, however, its effect on the flow is -- I haven't dug into it, but I expect it to be quite small. The reason for it is there is still -- so from sound to sound or cabinet to cabinet, a connection. The flow as compared to thickness is quite small. And we can refer to the numbers. Maximum flows are about two -- 20 or 30 metres, whereas the thickness is about 300 metres. So there's still connection across.

304

The second way that the faults are included in the model is the so-called transmissivity multipliers across the fault. And a lot of -- a lot of times, for some faults, when you have this displacement because of the gouge or anything -- effects that are happening inside the fault, across -- if the fault's going in north-south, in an east-west direction across the fault, there would be a reduction of the permeability. And of course, that depends on whether there is compressional effects against the fault and creating that gouge or not.
So the statement where -- so these are the two ways that the faults can be -- can affect the model results. The first effect is included. The throws is in there. The second one is what we -- we adjust typically to the -- to the history matching. We don't have any way of characterizing what that number is to the so-called history matching by evidence. We say, okay, the transmissivity multiplier is 0.1 or .05 or 1.
So in here, when I say the experience of the reservoir of what -- what the statement was, the behaviour of the reservoir is most

305

representative of open. First of all, open means -- it doesn't mean more than the in situ rock. So that's transmissivity -- the maximum transmissivity multiplier that we have is as if the rock was just not fractured. We are not opening up a hose or anything in there or a big opening space. So that's the maximum that we have gone.
But when I say it's representative of is -- the base value -- this is -- this is -- so this goes to the base model that we built. In the base model, I -- I use the mid-value of transmissivity multiplier of .5. And when I -- and that model we saw that was in the node, that model was significantly overpredicting the pressure. So the models are just saying that more flowing needs to happen.
So from here, I made two -- two cases. One was, first of all, if I go from .5 to 1, does it make any difference in the results? No. .5 is effectively as communicative as 1. That's the first thing.
But more importantly, we have cases where we have taken 1.5, I think, to .1 or -- I need to see the numbers -- have reduced the transmissivity modifier. In that case, then --

306

and that is in Figure R11, the sensitivity studies -- shows that the pressures in the north would even further increase. So basically what I'm saying is the faults in the model -- if I close them further, they would be even further mismatched.

And they are -- the base value was .5. .5 is behaving as one, and I'm calling -- calling that open, open in the sense that it is -- as if the rock is.

So -- and that's based on -- and primarily it's driven by the pressures in the north as well as the south. We are -- the model would overpredict the north pressures. It shows that it has to go -- including the faults. If I close the faults, the -- in fact, they have run the case in that plot -- or let me just make sure that I refer to the plot number correctly. Yes, it's R11, which shows that if I close the faults, the pressure in the north would be 13 megapascal. Then -- then -- then the base case, that's already about 5 to 7 megapascal higher. So that's where I said the -- the -- the reservoir behaviour indicated by the pressures is behaving as if -- it's showing as if the faults are open, and then from there

307

is -- I'm saying, so ... And that's one.

And, secondly, the well both in particular and on the 14-18 well, which, in fact, the 3D seismic shows we have more faults and everything else and all of that. The well test data shows no closed boundary, shows no -- no -- no sealing fault or anything. It's -- it's open until we see constant pressure on the -- on the contrary, again, suggesting there is communication.

Q Okay. Thanks. That's helpful. A follow-up question. Something entirely different. But yesterday during cross-examination, Mr. Fitzpatrick asked Dr. Verdon about whether faults crossing an aquifer would allow pressures to dissipate into that aquifer.

So I'm interested in your thoughts on this issue, Dr. Pooladi-Darvish. What factors or mechanisms would control whether pressure from such a fault, such as an Obsidian perturbance, exists from Belloy to the basement -- what factors or mechanisms would show whether a pressure travelling along that fault would potentially dissipate into -- into an aquifer such as the Rundle or the Leduc aquifers?

A You're asking me, sir?

308

Q Yes. Yes.

A So this is more in the internal properties of the fault. So the starting point, the evidence that Mr. Watson referred to, the drilling loss and -- the drilling mud losses and everything says that the fluids are -- are being taken away by these faults.

So, then -- then, how far they go and whether they dissipate, I think that is the question. That is --

Q Yeah.

A -- more determined by the properties within -- within that fault zone and where the gouge has formed or not. It's not my area.

I have just come across a variety of faults. In some cases, they are sealing; in some cases they are not. The genesis compression against an -- I cannot comment any further.

Q Mr. Watson, do you have anything you want to add?

A N. WATSON: Oh, yes. Thank you. I was about to.

So the -- the fault that we identified in the Belloy is -- pardon me -- passing through the Rundle Permian classic aquifer on its way

309

through the Exshaw aquitard and into the Devonian aquifer.

One thing to realize about -- so let's pull apart the aquifer and actually -- if you -- in my evidence, in the hydrodynamic part -- just let me call up the right figure. I think that will be helpful. This one right here. What number is that? In 50.05, PDF page 55, please.

If you could -- thank you. You're ahead of me.

So if we take this apart by the -- on a more stratigraphic level, we can see that the -- with -- the Triassic has been eroded out. We have the Permian Belloy, say, on the left-hand side, if you look.

Oh, thank you, Mehran.

So right in this area, we have -- this is where the Belloy is. We have within the Mississippian -- because this is across the entire Peace River Arch, we also have -- the Stoddart Group has been eroded, but we do still have remnant Belloy, Shunda, Pekisko, and Banff, and then we have the extra shale below that.

So as that fault is passing through the -- through the Belloy and through the -- the

310

Debolt, Shunda, Pekisko, it's important to realize there is a -- an aquitard within the upper Pekisko, but also, although they're aquifers, the -- the Debolt itself is an interbedded carbonate, a shale carbonate with an intervening siltstone or more finer-grained carbonates and argillaceous matter, and then we get into the Shunda. We also have varying reservoir quality.

So it's -- it is an aquifer over extended periods of time for transmitting pressure, but it's not as permeable as a -- as, say, the fault that we've identified.

I can't take credit for this metaphor. Dr. Steve Rogers, a specialist in diffuse fracturing that was at a GeoConvention talk two years ago had a -- if you think of the fault itself as a -- as a garden hose and the formation of the aquifer itself as more of a sponge, you're transmitting the fluid much more quickly through the hose as opposed to through the sponge.

Q So it'd be -- to summarize, some dissipation might occur, but potentially it would be relatively smaller on the northern break, and then you have pressure in terms of coming to

311

the centre. That's what you're saying?

A I agree. That's a good summary. Thank you for --

A J. VERDON: And I think it is worth just recapping that we have seen the same phenomena through the same aquifers further west with hydraulic fracturing, induced seismicity, which we certainly see with the Montney where the interpretation is that pressures have transferred down over kilometres through these formations.

So it is -- observationally, I appreciate some of it is understanding the complex behaviour of the permeability of faults, and that -- and that obviously is a three-dimensional anisotropic problem, which is not easy to manage. But as I said, the observational evidence for that happening elsewhere in the region is there. So, again, that's the most important aspect.

Q Okay. Thank you for that.

So, Dr. Verdon, a couple of questions about the use of induced seismicity frameworks, and, again, we've talked about that today. Yesterday, Mr. Fitzpatrick was asking you about the role of judgment in applying the various

312

induced seismicity frameworks.

And I wanted to refer you to -- you may not need to look at this. You're probably pretty familiar with the paper. But Exhibit 82.4, is the Foulger et al. paper. I'll let it be pulled up.

But I'm going to point you to -- well, I'm going to read an extract from that paper. Basically, it says: (as read)

> Several questionnaires have already been published, (Davis and Frohlich 1993, Davis et al. 1995, Frohlich et al. 2016, Verdon et al. 2019) and it is clear that the approach suffers from subjectivity. Different analysts may produce different results, and where the questionnaire is complex, it may take a considerable time to apply.

So my question -- my first question is do you agree with the statement that induced seismicity framework will suffer from some subjectivity and that different expert assessors may produce different results when applying these frameworks to the same events?

A Sure. I certainly agree with the statement that the Frohlich and Davis frameworks from the

313

early '90s suffered hugely from subjectivity and didn't deal at all with the inherent uncertainties that -- that are -- that are inherent to making this kind of assessment. So I would certainly agree with the statement in regards to those papers.

The Frohlich et al. 2016 paper, I'll be honest, I'm not a fan of at all. It was developed specifically to deal with long-ago historic cases dealing with instances from Texas in the 1930s and beyond. So obviously kind of not really suited to -- to modern day given the lack of data for those kind of cases.

For our case, our -- our motivation in developing our paper was to add some quantitative analysis and rigor and to try and -- as best we can -- remove the subjectivity from this kind of assessment, and where that subjectivity remains, to quantify that subjectivity, and that's in the evidence strength ratio that forms an inherent part of our assessment.

So I -- I disagree with that characterization -- well, there is inherently some subjectivity, and I -- I agree -- I think "suffers from subjectivity" is perhaps an

314

unfair exaggeration of our approach, because the whole point of our approach is to characterize the degree of subjectivity and to introduce rigor wherever possible.

Different analysis may produce different results. As I discussed, I think, in the cross-examination, you would expect some degree of difference, but you wouldn't expect to find wildly different results so long as the analysts were following the schemes as described and the guidance within the scheme.

Within my reply evidence, I've described some instances where, in my view, it's clear that the CLM's application of my scheme didn't follow the guidance that I provided for that scheme, and that might account for -- or clearly does account for the differences in outcome that we've produced.

But where different analysts with good experience of working with induced seismicity apply the scheme as guided, I would not expect to find -- you know, there would inevitably be some difference, but not large amounts of difference.

Q And what is your opinion of the framework in the Foulger et al. 2023 paper, and what do you

315

see as the strengths and limitations of that approach, or the Foulger approach, in relation to that?

A I see it as a step backwards, in short, for reasons that I will explain to you.

Firstly, if we can go to page 25, I think -- no. Hang on. Apologies. 26 of this -- of this study -- of this exhibit. Thank you.

So this shows the scheme. You might want to kind of zoom in and expand it a bit. For most people, it's hard to see on their screen there.

They have this first step, which is an exit step for if the -- "PIE" is a potentially induced earthquake. So I do like the acronym, so I'll give them that. It is a nice acronym.

Did the PIE begin before, after, or during the onset of industrial activity? In some cases, that can be complex because in some areas, there is a lot of natural seismicity going on, and then you might have a bona fide induced event sequence start up but in an area where there's already seismicity ongoing, which in this case, you would say, well, there was already some natural seismicity there before; I

316

now exit at this step. I don't feel that's appropriate.

You can have sequences where there's some natural earthquakes that then get enhanced by the industrial activity. I've done -- I've done some work in places like Taiwan and Japan, where they're looking at doing carbon capture and storage, where they have a lot of background seismicity. So exiting the scheme just because there's natural background seismicity going on would not be an appropriate step.

And you'll also note the general -- apart from this question, the lack of any attempt to characterize and incorporate any information about the background natural earthquakes in the Foulger et al. scheme.

You'll also notice that it doesn't really deal with uncertainty. You're either required to answer the question or not. Our scheme recognizes that the strength of answer and the strength of evidence to answer these questions may vary. You may have very strong evidence to answer those questions, or you may have weak evidence. And in our scheme, you modulate the strength of your answer by the strength of the

317

evidence. There's no option to do that in the Foulger et al. scheme, which is -- obviously creates an issue.

The most important issue, however, though, is that you'll note that most of the questions -- and if you scroll down to the next page. Thank you very much. Most of those questions score 10 points.

If you scroll back up again -- sorry I'm making you jump up and down -- there are three questions that score 100 points. Essentially, those three questions dominate the Foulger et al. scheme. There's no -- the other questions, you could answer whatever you want. The answer to those three questions is going to control your answer.

And those three questions are is there spatial collocation in two dimensions; and spatial collocation in three dimensions; and then a final one, is there a temporal correlation. So, essentially, if I answer Questions 2 and 3 in the affirmative, I get 200 points there, which is going to outweigh everything else in the scheme.

Basically, any earthquake that is within the region that is perturbed -- that we think

318

is perturbed by the industrial activity, the Foulger et al. scheme will tell you it's induced. I don't think that's appropriate. I think you can have natural earthquakes occurring within that zone that you think might be perturbed, and that -- a scheme that effectively says that if it's in the perturbation scheme, it must be induced irrespective of any other evidence because the -- the strength of the other points can't outweigh that, I don't think that's appropriate. I think you should weigh the evidence in a more nuanced way, and that's what our scheme does.

Q Okay. Thank you for that.

So just returning back to the use of the Verdon 2019 framework for the 14-18 as well.

A Yes.

Q So Outer Limits provided their analysis, and they came up with an ESR score of 92 percent and an IAR of plus 31 percent.

A That's correct.

Q And then when the AER used the framework, they came up with an ESR of 80 percent and an IAR of -- I can't remember if it's 50 or 51 percent. I wrote 50, but I think it might

319

be 51.

A M-hm.

Q Recognizing that the scores are different -- and I understand your argument that, you know, the score for the Obsidian well is less than the score for the other sources.

But when I look at the numbers, and I think about subjectivity, they're not that different. Like, I understand there's a difference between, you know, 31 percent and 50 percent, but they both seem to be indicating a connection between the activity and the events. And I guess I'm just wondering about how much that 20 percent difference makes.

A As I've hopefully characterized in my evidence, I view that to be significant. As I say -- and you correctly identified it. Maybe we don't need to go into it, but the reason for the difference in the results, in my view, is the incorrect application by CLM of my scheme.

Is 20 percent a difference? So, firstly, I guess, if I only had one well, or one cause, and I was just doing an assessment on a sole cause, typically we've taken 20 to 25 percent or below being -- that's close enough to zero to say it's ambiguous. I want to see an IAR

320

above 20 to 25 percent to start thinking it's induced if I only have one cause.

However, as I've described, if an induced event is being caused by one thing, and another thing is nearby, I'll end up answering more of those questions positive. Because the events will be shallow; the events will be different in character to the regional seismicity, so it will start to pull up my induced assessment score for the thing that didn't cause it by, you know, sort of, you know 10, 15 percentage points or so.

So if we remove that pull-up effect, the induced assessment score for the Obsidian well goes below -- would go below 20 percent. If you accepted those questions are being pulled up by a false positive for the regional character question, for example, then that would be below that 20, 25 percent threshold where I say the evidence for this is ambiguous, and that's -- that's kind of the conclusion that I've made.

Q Okay. Thank you.

Also for you, Dr. Verdon. So in your report, you state that: (as read)

Given the lateral extent of the

321

pressure faults as modelled by Pooladi-Darvish, it is reasonable to compute the correlation between injection in high-volume Leduc wells and the overall seismicity.

And I think you were asked some questions about this yesterday. And so based on this, it seems like the correlation factors you calculated for the high-volume Leduc disposal wells was with respect to all the seismicity, including the events in the north Peace and north Heart clusters, and not specifically to events in the Reno cluster. I have that right?

A Yes.

Q Okay. In its hearing submission, CLM disagrees with the assessment of the high-volume Leduc wells. Among other things, they state: (as read)

Second, the apparent correlation between the high-volume Leduc wells and the entire seismicity in the Peace River region exists but is a product of the correlation between the different clusters and the nearby associated disposal activity. In other words, this low-resolution

322

assessment hides the correlation between the seismogenic disposal wells and their nearby seismicity.
And I think you were asked some questions on this yesterday. I just want to reconfirm. Is it possible that the correlations calculated for those high-volume disposal wells are being influenced by that short-term -- sorry -- short-distance events -- seismicity events and, therefore, doesn't really see -- the correlation is being swayed by those events rather than any correlation to the actual Reno events?
A I think -- I think to answer that question, I'd like to bring up my opening statement. Slide -- Slide 20 will do -- or, actually, maybe slide -- Slide 7. So it's helpful to have a map view, right.
So these are the high-volume Leduc wells that we're talking about. There is -- there is one cluster that's in close proximity to those wells, but, actually, the bulk of the seismicity is not proximal to those wells. And, obviously, our argument is that the pressure pulse from all of these wells is spreading out and triggering all of these

323

events.
So AER's comments about that it's caused by -- looking at multiple effects of lots of wells with short-term connections, there's only one cluster that that applies to, and that's the -- the smallest cluster, as far as I'm aware, in terms of the number of earthquakes. So that effect really couldn't influence the fact that the bulk of the seismicity they're putting into that correlation, which is the north Peace River cluster, is not close to those wells either. So that short-term multiple local effects data can't apply to this because they're -- they're -- they're all so far away, the earthquakes that I've included.
Q Thank you.
I have a couple of questions that are probably for Mr. McGilvary or Mr. Charbonneau, but I may also hear from Mr. Langen that he wants to address these in argument. So I'll put the first question out there, and you can decide how you want to answer it.
But in Obsidian's initial hearing submission, you identified several alleged impacts of the order, including reputational impacts, impacts to share price, and

324

relationship with Woodland Cree.
And I guess what I'm interested in is what does Obsidian see as the relevance of these alleged impacts to the Panel's decision on whether the order should be confirmed, varied, suspended, or revoked?
D.P. LANGEN: That's a good question, Mr. Chair. Without getting into it, we don't intend to rely on any of those facts in argument, to be very clear.
THE CHAIR: Okay. Thank you.
So I did have some detailed questions, which I don't plan to ask based on that statement.
D.P. LANGEN: Thank you, sir.
THE CHAIR: Okay.
Q THE CHAIR: I guess what I am interested in -- and, again, I think this is also for Mr. McGilvary or Mr. Charbonneau -- but have there been any operational impacts on Obsidian's disposal or production operations because of the order? For instance, have you had to cease or limit disposal operations or shed any production as a result of the order, and if so, what was the extent, duration, or costs associated with those activities?

325

A J. MCGILVARY: Yes. Thank you for the question.
Since the initiation of the EPO, there are have been six seismic events -- I'm sorry. That's inclusive of the first two. So four seismic events that have been measured in our array. Those range from a magnitude of 3.4 down to a magnitude of 2.87 above the threshold that was prescribed of 2.5.
In that time, we initiated the yellow light protocol, so within the medium range, starting on April 28th, 2023, for a 15 percent reduction. That continued through the second event on May 14th, 2023, where the yellow light was maintained for another 15 days, and then again on May 19th, 2023, the yellow light protocol remained in place.
On October 3rd, 2023, there was an event of 2.87 that was not reportable. It was below the 3.8 alarm and more than 20 kilometres away, and so the stoplight protocol was not initiated.
So, in total, that's three times that we reduced the overall injectivity of that well since the EPO.
Q Okay. Thank you.
Maybe just a final question, maybe for

326

Dr. Verdon, but anybody else who would like to comment on this.

So Obsidian's evidence is that the seismic events in the Reno cluster are more likely induced than natural, and that the high-volume Leduc disposal wells and the 6-14 Belloy well are more likely to have caused the seismic events than the Obsidian 14-18 well.

Given this evidence, does Obsidian believe that the disposal wells in the area of the Peace River Arch represent a higher risk of causing induced seismicity generally, and if so, does this suggest the need for a more regional approach to assessing risk and mitigating the effects of disposal operations in the area of the Peace River Arch?

A J. VERDON: I believe so, yes. I think it's notable that seismicity has continued in the region. And we have seen -- actually, when you track on the AGS earthquake dashboard, there are -- there are indeed what appear to be new clusters starting to develop as well. So -- so I -- I do agree with that sentiment.

Q Okay. Thank you.

Mr. McGilvary or Mr. Charbonneau, do you

327

want to add anything?

A J. MCGILVARY: I think that Mr. Verdon said it fairly effectively. You know, anecdotally, it's been a steep learning curve for Obsidian. This is a topic that we did not have in-house expertise on, and as such, we've been very much learning along the lines with the conclusions of our independent experts. And as such, again, I adhere to the recommendations of the subject matter experts.

Q Okay. Thank you.

Those are all my questions. Just give me a minute.

A A. FOX: May we add a little something to that?

Q Sure.

A We have worked in the past on other areas of induced seismicity in BC and Alberta where there has been more of a cooperative approach between operators and a lot of scientific rigor applied to understand induced seismicity in those areas, Fox Creek being an excellent example where the AER and the AGS themselves did rigorous work. So just from our professional standpoint, we also believe that, like, a more cooperative approach between

328

operators is helpful.

Would you like to add anything else?

A N. WATSON: That states it well. Just looking at the -- as we've seen, there's benefits to be gained from looking at the entire sedimentary section as well the basement, and looking at it on a regional basis is helpful for understanding the problem and mitigating it. That's what we've seen both in BC and in the Fox Creek area.

THE CHAIR: Okay. Thank you Dr. Fox, Mr. Watson.

Those are all my questions. Just give me a minute to confer with my Panel mates.

Okay. Those are all the Panel's questions.

Mr. Langen, would you like to do some redirect?

D.P. LANGEN: Thank you, Mr. Chair. No, there's no redirect for the panel.

THE CHAIR: Okay. Thank you.

Then, with that, I believe the panel can be released.

We will take our lunch break now. It's 12:00. So we will reconvene at 1:00, and that will be to start direct evidence from CLM.

329

I would like to thank the Obsidian panel for responding -- first of all, for your evidence, written and oral, and for responding to all of our questions. Thank you very much.

A J. MCGILVARY: On behalf of Obsidian, we would like to thank you as well for your time. Thank you very much.

THE CHAIR: Thank you.

(WITNESSES STAND DOWN)

THE CHAIR: We are adjourned until 1:00.

PROCEEDINGS ADJOURNED UNTIL 1:00 PM

330

Proceedings taken at the Govier Hall, Calgary, Alberta

November 29, 2024 Afternoon Session

A. Bolton	The Chair
B. Zaitlin	Hearing Commissioner
T. Stock	Hearing Commissioner
B. Kapel Holden	AER Counsel
O. Chijioke	AER Counsel
A. Huxley	AER Counsel
(Via Videocast)	
A. Lung	AER Staff
A. Stanislavski	AER Staff
M. Rahimabadi	AER Staff
P. Fitzpatrick	For Regulatory Compliance Branch
J. Allison	For Regulatory Compliance Branch
A. Hall	For Regulatory Compliance Branch
D.P. Langen	For Obsidian Energy Ltd.
A. Barrington	For Obsidian Energy Ltd.

331

A. Porco, CSR(A) Official Court Reporter

(PROCEEDINGS COMMENCED AT 1:01 PM)

THE CHAIR: Thank you. Please be seated.

Mr. Allison, you're going to start?

J. ALLISON: Yes. I'm just going to introduce our witnesses and have them adopt their evidence and then my colleague Mr. Fitzpatrick will be taking over for the direct evidence.

THE CHAIR: Okay. Thank you.

J. ALLISON: Before we start, on November 27th, we filed a slide deck to accompany CLM's direct evidence. It contains only public information, and we were going to request an exhibit number for that slide deck.

B. KAPEL HOLDEN: The next exhibit number is 98.0.

J. ALLISON: Thank you very much.

EXHIBIT 98.0 - CLM PUBLIC Hearing PowerPoint Direct Opening Statement

J. ALLISON: Madam Court Reporter, I was proposing to introduce the witnesses and then we'll swear them in and then do the questioning.

332

THE COURT REPORTER: Thank you.

J. ALLISON: So beginning closest to the Commissioners is Dr. Todd Shipman. He's a senior advisor at the AER's Regulatory Compliance Branch.

Sitting next to him is Mr. Erik Kuleba of the AER Regulatory Compliance Branch. He is the statutory decision-maker who issued the EPO at issue in this hearing.

Sitting to his right is Mr. Claudio Virues. He's a senior reservoir engineer at the AER.

Sitting to his right is Dr. Mauricio Canales. He's a senior geophysicist of induced seismicity at the Alberta Geological Survey.

And, finally, we have Mr. Elwyn Galloway, who is a senior geophysicist at the Alberta Geological Survey.

Shall we proceed with swearing them in.

THE CHAIR: Yes, please do.

TODD SHIPMAN, MAURICIO CANALES, ELWYN GALLOWAY, Sworn

ERIK KULEBA, CLAUDIO VIRUES, Affirmed

THE COURT REPORTER: Thank you.

J. ALLISON: So in this proceeding CLM has filed the following evidence: Exhibit 36, which is the record of

333

the decision-maker, which consists of Exhibit 6.01 and the supplemental information, which is Exhibit 6.02.

They have also filed Exhibit Series 57, which contains the public and confidential portions of CLM's evidence-in-chief, which includes Exhibit 57.01, Exhibit 57.02, and Exhibit 57.03.

It's also filed Exhibit Series 66, which consists of Exhibit 66.1 and Confidential Exhibit 66.2, which contains the first part of CLM's public and confidential answers to Obsidian's information requests.

It has also filed Exhibit Series 71, which is Exhibit 71.1, Confidential Exhibit 71.2, and Public Exhibits 71.3 to 71.15, which contain the second part of CLM's public and confidential answers to Obsidian's information requests.

And, finally, we filed Exhibit 98, which is the slide deck filed in support of CLM's direct evidence and containing only public information.

Direct Evidence of the Regulatory Compliance Branch Witnesses

Q J. ALLISON: Dr. Shipman, I'll

334

start with you. In Exhibit Series 66, did you provide answers to Information Requests 1.10, 1.11(c), 1.22(f) and (g), 1.23(e), 1.24(c), and 1.25(c)?
A T. SHIPMAN: I believe so.
Q And do you have any changes you wish to make to that evidence?
A No.
Q And is that evidence accurate, to the best of your knowledge and belief?
A Yes.
Q Dr. Shipman, has your CV been filed as Tab 9 to Exhibit 57.01?
A Yes.
Q And does that CV accurately set out your qualifications and experience?
A Yes.
Q And do you adopt the answers you provided in Exhibit Series 66 as part of your evidence in this proceeding?
A I do.
Q Thank you.
Moving to you, Mr. Kuleba. Mr. Kuleba, is Exhibit Series 6 the record of your decision and supplemental information to that record?
A E. KULEBA: Yes.

335

Q Was Exhibit Series 57 prepared under your direction and control?
A Yes.
Q In Exhibit Series 66, did you provide answers to Information Requests 1.4(a), (b), and (d) through (e) -- (d) through (f)?
A Yes.
Q As well as 1.5, 1.7, and 1.11(a)?
A Yes.
Q And was PDF page 13 of Exhibit 98 prepared by you and under your direction and control?
A It was.
Q Do you have any changes you wish to make to that evidence?
A I do not.
Q And is that evidence accurate, to the best of your knowledge and belief?
A It is.
Q Mr. Kuleba, has your CV been filed as Tab 8 to Exhibit 57.01?
A That is correct.
Q And does that CV accurately set out your qualifications and experience?
A Yes.
Q Do you adopt Exhibit Series 6, the answers you provided in Exhibit Series 66, PDF page 13 of

336

Exhibit 98, and Exhibit Series 57 as part of your evidence in these proceedings?
A Yes.
Q Turning to you Mr. Virues.
Mr. Virues, was the report found at Tab 5 of Exhibit 57.01 and Confidential Exhibit 57.03 prepared by you or under your control?
A C. VIRUES: Yes.
Q In Exhibit Series 66 did you provide answers to Information Requests 1.12 and 1.13?
A Yes.
Q Do you have any changes you wish to make to that evidence?
A No.
Q Is that evidence accurate, to the best of your knowledge and belief?
A Yes, it is.
Q Mr. Virues, has your CV been filed as Tab 10 to Exhibit 57.01?
A Yes.
Q Does that CV accurately set out your qualifications and experience?
A Yes, it does.
Q Do you adopt Tab 5 of 57.01, Confidential Exhibit 57.03, and the answers you provided in Exhibit Series 66 as part of your evidence in

337

this proceeding?
A Yes.
Q Dr. Canales, were the reports found at Tabs 1 to 4 of Exhibit 57.01 and Confidential Exhibit 57.02 prepared by you or under your control?
A M. CANALES: Yes.
Q In Exhibit 66, did you provide answers to Information Requests 1.1, 1.2, 1.3, 1.4(c), 1.10 --
THE COURT REPORTER: Sorry. Can you slow down, please. "1.2"?
Q J. ALLISON: 1.3, 1.4(c), 1.10, 1.14, 1.15, 1.16, 1.17, 1.18, 1.19, 1.21, 1.22, 1.23, 1.24, 1.25, 1.26, 27, 28, 29, and 30?
A M. CANALES: Yes.
Q In Exhibit Series 71, did you provide answers to Information Requests 1.18, 1.9, 1.11, 1.26, and 1.27?
A Yes.
Q Were PDF pages 3 to 12 and 15 to 19 and 24 and 26 to 29 of Exhibit 98 prepared by you or under your control?
A Yes.
Q Do you have any changes you wish to make to that evidence?

338

A No.
Q Is that evidence accurate, to the best of your knowledge and belief?
A Yes.
Q Has your CV been filed as Tab 7 of Exhibit 57.01?
A Yes.
Q Does that CV accurately set out your qualifications and experience?
A Yes.
Q Do you adopt Tab 1 to 4 of Exhibit 57.01, Confidential Exhibit 57.02, the answers you provided in Exhibit Series 66, the answers you provided in Exhibit Series 71, PDF pages 3 to 12 and 15 to 19, 24, and 26 to 29 of Exhibit 98 as part of your evidence in this proceeding?
A Yes.
Q Thank you.

And, finally, Mr. Galloway. In Exhibit Series 71, did you provide an answer to Information Request 1.20?

A E. GALLOWAY: Yes.
Q Were PDF pages 20 to 23 of Exhibit 98 prepared by you or under your control?
A Yes.
Q Do you have any changes you wish to make to

339

evidence?
A No.
Q Is that evidence accurate, to the best of your knowledge and belief?
A Yes.
Q Is your CV filed as Exhibit 84.1 in the proceeding?
A Yes.
Q Does that CV accurately set out your qualifications and experience?
A Yes.
Q Do you adopt the answers you provided in Exhibit Series 71 and PDF pages 20 to 23 of Exhibit 98 as part of your evidence in this proceeding?
A Yes.
Q Thank you very much.

I will now turn it other to my colleague Mr. Fitzpatrick for direct examination.

THE CHAIR: Thank you.

And, Mr. Fitzpatrick, just -- you know, we'll look for a break around 2:30, so just look for a natural spot. It doesn't have to be exactly at 2:30.

P. FITZPATRICK: Very good, sir. Thank you.

340

THE CHAIR: Okay.

P. FITZPATRICK: Can we call up Exhibit 98, please.

Q P. FITZPATRICK: And I would ask Mr. Kuleba if you could address the first few slides of this exhibit, please.

A E. KULEBA: Yes. Hello to everyone, and good afternoon.

To start, thank you to the Hearing Commissioners and those staff supporting the hearing.

I am Erik Kuleba. I'm the director of field operations south in the Regulatory Compliance Branch, formerly the CLM, at the AER. In my role, I have the delegated authority to make statutory decisions. I have been in a direct role making statutory decisions for more than eight years, including a number of other EPOs, one of them which was for induced seismicity.

I am the statutory decision-maker that made the decision and issued the EPO on March 23rd, 2023.

The issuance of the order was necessary to protect the public and environment, more specifically to eliminate or reduce the

341

potential adverse effects that have, are, or may occur with the increased risk of induced seismicity originating in the Reno area.

With me today are subject matter experts. Dr. Mauricio Canales, who is a senior geophysicist focused on induced seismicity in the Alberta Geological Survey, the AGS. He supports the team at the AGS that monitors for seismic activity across the province, collecting and analyzing data to study the activity where it's deemed needed.

In the study of seismic activity, he works with other AGS and AER SMEs, as required, to build a fulsome picture of the seismic activity, including the causation, mechanisms hazards, and possible mitigation. He has provided advice and support to me as a technical expert before and after issuance of the order.

To my other side here, I have Dr. Todd Shipman, senior advisor for induced seismicity and geologic hazards in the Regulatory Compliance Branch. Of note, he was in a different branch when I issued the order.

He works across the organization to provide advice on reduced seismicity in regards to

342

development of new regulatory tools and mitigation approaches, policies, senior technical support, and advice to SMEs in the field as well as others, including SDMs. He has provided advice and support to me as a technical expert before and after issuance of the order.

On the far end here, we have Mr. Elwyn Galloway, senior geophysicist in AGS mostly focusing on seismic interpretation. He is the subject matter expert for reflection seismic data at the AER. He provided the seismic interpretation to support AGS studies in the Reno seismicity, specifically focusing on describing the geological scenario where seismicity has occurred.

He often collaborates on studies with Dr. Canales and others in AGS and was brought into this proceeding to respond to information requests from Obsidian related to his area of technical expertise.

Beside me is Mr. Claudio Virues, senior reservoir engineer in the technical science and external innovation branch. He does reservoir modelling, disposal well analysis, pressure transient analysis, and participates in induced

343

seismicity reviews in his role.

Q Okay. Thank you.

And with that, if we can go into the slide deck. So the first slide, of course, is the title. The -- the next slide introduces the subject of background evidence pre March 2023.

And, Mr. Kuleba, if you could take us through Slide Number 3, please.

A Actually, Mauricio, Dr. Canales will take us through.

A M. CANALES: Hello. Well, I will explain first what is a background to seismicity in Alberta.

As well, Alberta has a long-standing record of induced earthquakes dating back to the 1970s. Some of those cases have been related to gas obstruction, like the Rocky Mountain House cluster.

However, the issue of induced seismicity became more relevant since 2011, where we note is a notable surge in earthquake frequency, largely attributed to the rise in unconventional oil and gas activities, particularly hydraulic fracturing in the Duvernay Formation.

During that decade we saw multiple cases of

344

fracking-induced seismicity, including Fox Creek, Cardston in the south, and Red Deer. Two of them related to the Duvernay.

Since 2019, however, we have been noticing an increase of seismicity but related to water disposal activities. Some of them related to the Musreau Lake induced seismicity cluster related to wastewater disposal in the Winterburn group.

THE COURT REPORTER: Sorry. Can you slow down, please.

A M. CANALES: We also note is some other cases north and south of the Musreau Lake related to water disposal into the Leduc Formation.

In this picture I show you the seismic hazard -- the annual seismic hazard map in Alberta. From 2021 we notice some clusters, including the Musreau Lake and the Rocky Mountain House. They show the annual probability to reach a given ground motion.

THE COURT REPORTER: Sorry, "a given" what?

A M. CANALES: Ground motion.

THE COURT REPORTER: Thank you.

A M. CANALES: Given ground

345

information. Then we have the seismic hazard map in -- from 2022. And as you can notice, there was a drastic increase in the seismic hazard. The probability to reach a given ground motion related to the magnitude -- in part, related to the magnitude 5.6 that happened in November of 2022.

Q P. FITZPATRICK: Next slide, please.

A Now let me describe the seismicity from November 2022.

Well, between November 2022 and March 2023, the Alberta Geological Survey recorded over 245 events associated with a Reno cluster. As you have seen through the hearing, we have three different clusters at the time. The North Peace River, which has been assumed at the time to be related to natural seismicity; the North Heart, which has been related to disposal in seismicity; and the Reno, the Reno cluster.

The one that in November 29th, 2022, registered a local magnitude of 5.59, which is depending on the -- on the measurement, could be the largest earthquake recorded in Alberta.

Then we had a second large event in March 16th, 2023, with an estimated local magnitude of 5.09.

346

Next slide, please.
Okay. So when the earthquake from November the 29th, 2022, happened, we asked the questions. This is the Davis and Frohlich, which is a standard questionnaire to determine the causation of a -- of an earthquake.
So the earthquake 5.6 happened, and at the time, because we rely only on the original array the -- the seismic original array, we determined that the depth could be between 6 and 9 kilometres, which is quite deep in comparison to the shallow activities, including the Leduc at 2 kilometres and other activities at .7 kilometres, like the Belloy disposal or even the in situ oil extraction.
So at the time we were inclined to believe that if those depths remained the same, the seismicity could be natural.
However, let's ask through these questions, given the notion that we had in November 2022, what information we had at the time.
So, first, are the events in an area where earthquakes are not typically frequent? The answer is that maybe. We have seen seismicity in other areas; however, this is a new cluster, so it was hard to determine that question at

347

the time.
The second question is: Has there been an increase in the frequency of earthquakes in this region? Well, we got a 5.6 in November. We still needed more time to see if that frequency would persist over time. So we needed -- we were not certain about Question 2 either.
So do the earthquakes coincide temporarily with an expected human activity? The answer is yes. We had disposal activity, and we had oil extraction.
Question Number 4: Are the earthquakes within a reasonable distance from the suspected human activity? The answer is yes.
Are the human cause changes in a stress on a fault large enough to explain the seismicity? And the answer is we don't know, because at the time the earthquakes were located between 6 and 9 kilometres, and the disposal activity, for instance, were at 2 kilometres. So to bridge that gap was quite hard to believe at the time. So we needed more information indeed.
As part of the due diligence and the research that we conduct at the Alberta Geological Survey, we have an instrument called

348

nodal arrays, which are essentially special seismometers that you can deploy. You can collect data. But you have to manually go there and recollect the data.
So we have used this kind of technology in the past, particularly to delineate better the depths in areas where the regional array doesn't have the capacity because it might have a low resolution.
So on the picture you see here, there is an example from the --
Q Can you describe which picture you --
A Right. Right.
THE COURT REPORTER: Sorry, I didn't hear the question. You can describe?
Q P. FITZPATRICK: Which picture you're referring to?
A M. CANALES: Well, there is a picture on the right. There is a map view of a hydraulic fracturing well, and there is seismicity showing -- the seismicity show as dots.
Then you have the grey triangles, which are the nodes that were deployed, and the idea is that after the 4.2, the earthquake 4.2 that happened in Red Deer, that was March 2019, the

349

AGS went to the area, deployed the nodes -- the grey triangles to have a better sense of the depth of the earthquakes.
There was publication afterwards, and the seismicity essentially show -- coincide in depth with the hydraulic fracturing activities in the Duvernay.
So there was a very useful tool we used at the time to better estimate the depth of the earthquakes. And at the time, they were, more or less, at the same depth of the target.
Of course, you can see in the picture that it propagates because the faults propagates upwards or downwards, depending on the -- all the geological characteristics of the area.
So shortly after the earthquake, we organized; we went to the field. It was quite challenging. It was in the middle of winter. But we were able to deploy the nodes. And the main idea was to provide further information about -- that can be useful for the research we were conducting about that large event.
So while that was in December, early December 2022, the life of the nodes usually lasts for a month and a half. So we went back to the field to recollect those nodes and

350

deploy a second round of nodes that might have been -- that was in late January 2023.

In the meanwhile, the seismicity was still persistent. We kept recording the earthquakes using the regional array, and we noticed the seismicity was actually -- was persistent, was an anomaly at the time.

Usually when you have those tectonic natural events, you have a big one, you have seismicity after, the aftershocks, but they tend to dissipate over time. This was not the case. It was still persistent. And we conducted, using the original data, a relocation that -- that was by late February 2023, and we noticed that actually the earthquakes were shallower than expected. Not from 6 to 9 kilometres, but actually reaching the 2-kilometre mark, where we had disposal activities into the Leduc. So that was a clear red flag that this cluster might have been a -- caused by a -- by disposal activities into Leduc.

However, we were still waiting for the nodal array data, and we wanted to be sure that the depths were appropriate. And because we had other activities in the area, including the

351

Belloy disposal and including the -- the oil extraction around 700, 800 metres, we wanted to be sure that those earthquakes were not also propagating into those shallower events, which is usually a strong indicator of induced seismicity.

Q And just before you go on, Dr. Canales.

A Yes.

Q Let's talk for a moment about the nodal arrays. So when the -- the nodal arrays and the locations were chosen, what was it that -- that you or whoever else was -- was selecting the locations, what were you looking for to determine where to put it?

A Right. Maybe Todd can help me to -- that part as well.

A T. SHIPMAN: Yeah. I think we reached out to operators who have wells near where we thought the epicentre was to get a -- a good circumference of measurement, and we were -- went to two -- two operators. It was Baytex and Obsidian. Got some information from the Obsidian folks, and they offered some wells. But they were all abandoned wells, and we would have had to plough to get access to and then, of course, get the hydrovac truck out

352

to place the nodal array.

And we had the same offer from Baytex, but they said we could actually go to the active wells as -- also and have access to their sites.

I did have a phone call where I spoke with Craig Dansereau -- I apologize if I'm butchering the name. And we -- I asked if we could have access to active sites, and I was told no. So ...

Q And the -- the issue as to -- as to the ploughing, did that -- I take it that related to the time of year?

A Pardon?

Q Did that relate to the time of year?

A Yes. The -- the snow was deep, and we wanted to get the array out as quick as possible, and that required the -- the fastest deployment of nodal array, which meant that we go to active sites rather than also have to pay for a service to go out and plough to access the sites.

Q And I'll ask both Dr. Canales, Dr. Shipman, in -- in your professional judgment, the actual locations of where the nodes were placed in the nodal array, did that have or not have any

353

impact on the quality of the data that was gathered?

A M. CANALES: Well, to be frank, ideally you would like a quiet place; however, because of the difficulties to reach in the middle of winter those places, we choose places that had active wells, because otherwise we wouldn't be able to bring the hydrovac. And the nodes, they have to be buried, like, a foot, but during winter it's really hard to bury it. So we needed to hydrovac, so we needed access to the places. So that was a priority. Choose the places around the -- the epicentre, the 5.6, to place the -- the nodes. So that was one main driven point.

Q The second and the -- the third placements, were there any similar issues or considerations that came into play?

A Can you repeat?

Q The second and third placements of nodal arrays?

A Oh, they were the same places, yes, the same. We just took out the node, and we replaced it. So the same locations.

Q All right. Please continue.

A Well, this is the relocation by February 2023.

354

And next slide. I cannot move it. Oh. Yeah. Next slide. Thank you.

So -- well, the other component we were considering -- and we were aware by March 2023 -- is that the seismicity did not stop. So we got the event 5.09 in March 2023, which, again, was a clear indicator that the seismicity persists. This is an anomaly in terms of what we expect for the background seismicity in the area; therefore, this was a case of induced seismicity.

The question that we were having was which operation was responsible? As I mentioned before, we had an immediate area. And you can see in the picture, these are the -- the blue dots are the earthquakes recorded up to March 2023.

The grey lines are the in situ oil extraction, and the two blue triangles are the disposal wells, the WD1, the Obsidian well, or the Leduc well; and the WD2 is the Baytex well injection into the -- the Belloy.

Next slide. Yes.

So here I show an improvement, essentially, that you get from the nodal array data.

The -- on the left side, we have the

355

regional data between November 2022 to March 2023, and on the left side you have a comparison with the first round of nodal array data. And you can see a big improvement.

The earthquakes shift closer to the disposal activity, and as you can -- as you will see on the next slides, they also will move shallower, and you have a better sense of the depth of the seismicity and the location of the fault, right, which was a main feature that you can get out of the nodal array data. You can image the activated fault, more properly placed.

So the earthquake from March 2023 happened. At the time, that was January 2023, we get the first round of data. We sent that data to Nanometrics to process it as fast as they could. We can process that data as well, but it would take us a long time, given that we're dealing with thousands of earthquakes. So we needed the data as fast as we could. We send that to Nanometrics, and shortly after the earthquake from March the 16th, 2023, we got the results.

So as soon as we got the results, we plot and we analyze the location of the earthquakes,

356

and we found that, yes, the earthquakes were shallower than previously thought, and they were -- they -- they were two planes. We call those planes later the eastern and the western cluster, you -- as you can see in the picture.

And we see that those two planes go from the depths of the basement, and they tend to reach the Leduc Formation.

What we saw from that picture is that we don't see any full propagation beyond the Leduc, at least for this particular fault that got activated, and -- and particularly to the other shallower formations, including the Belloy, where we have disposal activity. And further up we have the Bluesky, where there is oil extraction, which we know that oil extraction in certain conditions can cause induced seismicity.

But given this information was clear to us and also given the other considerations I previously mentioned, the seismicity was persistent. The depths are closer to the Leduc Formation. They tend to reach the Leduc Formation, and -- and then we reached the conclusion that this is a case of water disposal induced seismicity related to the

357

Leduc.

On top of that, I should add that at the time, by March 2023, we already had other cases of Leduc disposal induced seismicity, including the Gold Creek and the -- and Kakwa -- that's south of Grande Prairie -- and also nearby in the -- in the Peace River region. So that's how we reached the conclusion. This is another picture also.

Q This is on Slide 11 now?

A Yes. We moved the slide. This is another picture from Slide 11. This is a 3D view of -- of the cloud of seismicity. We were aware that they were some planar features, those artifacts.

We -- at the time, we were aware that those artifacts were a consequence of issues with the velocity model, that at the time the velocity model was a bit crude, but over time and with reprocessing, we prove it, and we solved those planar features.

So even if those planar features did not -- they were -- again, artifacts were not real. It was clear that we had two subclusters reaching the depths of the interface between the Leduc Formation and the basement.

358

And, again, as I mention in the previous slide on the right-hand, you have two figures. The orange line shows the volumes of the -- of both the Leduc and the Belloy well. And we saw a continuous volume, right, injected into -- into both disposal activities, together with seismicity that was still happening. So ...

Now, let's -- let me review the questions that I formulate earlier and we answered based on information from November 2022, which the results were ambiguous. And we were inclined that could actually be a natural earthquake by November 2022.

So let's ask the question: Are the events in an area where earthquakes are not typically frequent? The answer is yes. It's an anomaly.

Has there been an increase in the frequency of earthquakes in this region? The answer is yes. We saw the earthquake 5.6, and since then, we have had seismicity, including a 5.1 in March 2023.

Do the earthquakes coincide temporally with the suspected human activity? The answer is yes.

Are the earthquakes within a reasonable

359

distance from the suspected human activity? Now we can answer that, yes, because the seismicity is reaching the depths of the Leduc Formation where we have disposal activity related to -- particularly in that region, to the Leduc disposal well, the 14-18.

Are the human-cause changes in stress on a fault large enough to explain the seismicity? The answer is yes. We know that disposal activity after a long period of time can pressurize the reservoir to a point that the fault -- the basement would default, which is the typical pattern of induced seismicity in Alberta. We are dealing with faults that propagate down to the basement, and they reach the sedimentary strata. We know that's a typical pattern, and we know that by changing the pressure, you can activate those faults.

So I also want to bring my attention -- or your attention on the picture on the right. You can see this is a sketch, of course, of what would be the geology, the latest stratigraphic column in that region. As you can see, we have the Leduc disposal activity. One important piece of information is that the Leduc, it's in direct contact with the

360

basement. And this was a critical aspect that we consider when understanding the causation of the seismicity.

What does it mean if the Leduc has direct contact with the basement? It means that -- it has to mean that the possibility of the fluid to interact with the Precambrian basement and the basement, with it fault, which are the host of the large earthquakes.

However, the Belloy, which, again, we didn't see propagation of that activated fault up to the -- to the other levels of the strata, has multiple formations. Actually, 1.2 kilometres from the Belloy target to the basement.

And in those formations, we have shales, carbonates, a wide range of different -- different stratigraphic composition.

So the conclusion was that the Leduc well, the 14-18, had all of the conditions to be considered the seismogenic well, the causation of this earthquake -- this earthquake sequence.

Q And now once you -- you've done that analysis -- excuse me -- Dr. Canales, I understand that you then had some communication with Mr. Kuleba?

361

A Yes.

Q And what can you tell us about that?

A Well, we informed about your discoveries with Dr. -- sorry -- with Mr. Kuleba, showing him all the work we did with the nodal array data, understanding the geology of that particular region, and essentially showing that our conclusions on the time -- well, at that time show that the disposal activity from the 14-18 well were the culprit of that -- of that seismicity.

Q And, Mr. Kuleba, maybe you could take it from there and -- and tell us -- tell the Panel your perspective of the information that was conveyed to you and -- and what you did as a result of that?

A E. KULEBA: Yes, of course. I'll start actually a few days before that.

So on March 16th, when the 5.09 seismic event occurred, there was initial correspondence from AGS that they suspected it was induced.

So with that potential, I started just looking into what regulatory tools could be considered if an action need be taken to protect the public and the environment.

362

We had used orders before for induced seismicity as there is another legislation to fall back on, up until recently, when we got updated Directive 65 in the organization to -- to better deal with seismogenic wells.

And it wasn't till the start of the next week, the Monday, the 20th, where I attended a meeting set up by my leader where it was shared by Todd and a peer of mine, a director peer of mine in AGS, that analysis done by AGS showed that the seismic events could be attributed to a disposal operation.

Q And the Todd you're referring to is Dr. Shipman?

A Dr. Shipman. Sorry.

Q Thank you. Please go on.

A Yeah. I also understand from that meeting that there had been a meeting where information was shared with some subject -- other staff across the organization, one of which was a manager that reported to me. So I reached out to them to get some information, and they shared their notes with me for that, which was helpful context as I was able to secure a meeting with Mauricio the next day as well.

A PowerPoint was shared with me. And in

363

that meeting with Mauricio, he ran me through it and talked through the evidence to support the 14 -- that the 14-18 disposal operation induced the seismic events.

In that meeting, I also asked about two nearby wells specifically and if there was any reason why it wouldn't be them that induced the -- the seismicity and was given answers that were simplified to my technical understanding, which is certainly not the level of the subject matter experts in the area.

I also asked about the risk and if there was a timeline on when the seismicity of considering magnitudes could happen again. And I was told that that really couldn't be predicted, but it had occurred twice within three-and-a-half months, and so there was certainly an increased risk that it could happen at any time.

Through that technical advice of the concern of the risk and that it may present itself again uncertainties with, and the advice shared with me by SMEs on their conclusion of the responsible party, I was able to start forming the opinion that there could be adverse effects if the seismicity remained unaddressed.

364

So with that -- and, again, going back to that an order was the most appropriate means at that time to address the seismicity, we started developing an order with the -- the support of a compliance advisor, who just helps draft the order, as well as SMEs, the two most important being Todd and Mauricio, so that we could proceed potentially and I could consider it.

The SMEs, in developing the order, they support me to ensure that the -- the facts and evidence and the terminology used and the timeline is correct as well as to ensure that the terms that could be used would be appropriate to mitigate the risk.

While we were drafting the order, there was a meeting with our technical staff, so our subject matter exerts, one of which was Dr. Shipman, and Dr. Canales with Obsidian's technical experts, where they shared our evidence. In that meeting, I also had asked if we could get the contact information for an executive at Obsidian so I could reach out and notify them that an order was under consideration and schedule a due process.

I got that information on the Thursday morning. Reached out to -- and I'm sorry if I

365

say his name wrong. And he's not in the room. Apologies for that. Mr. Cliff Swadling. And notified him that I was considering an order due to the induced seismicity. And we scheduled a due process for later that day.

So Thursday, March 23rd, we had that due process meeting where I -- at the beginning, I opened it up with preamble that I would run through the order, and Obsidian would certainly have the opportunity if they had anything they would like me to consider, that they could share it then for myself to -- before I made a decision.

I ran through the whereas clauses, again, noting that technical evidence was shared by our SMEs the day before, and then ran through the terms of the order, to which there were some questions, very technical questions, about what was meant by the mitigation plan or towards the nodal array that we need to be deployed or the IRIS system, which is how they capture the data. Those were answered by Mr. Shipman.

There was one question and -- asked about the timing of one of the clauses to extend it an additional few days, which I agreed to.

366

At the conclusion of running through the terms of the order, I again asked if Obsidian had anything they'd like me to consider. They did not. And so at that point, I noted that once the agreed-upon changes were made in the terms that I would go ahead and issue the order.

Q Now, in respect of the -- the order itself -- and there's -- there's the operative provisions that are -- that are on Slide Number 13 that's on the screen in front of you -- could you perhaps explain to the -- the Panel what thought process you had in terms of -- of the terms that were drafted as well as any alternatives you considered to -- to the terms that were actually put into the order?

A Yes. So the -- the terms of the order, they -- they were meant to, again, address the potential for adverse effects of the seismicity occurring, so primarily to reduce the frequency and -- and survey the magnitudes of -- as -- of those occurrences.

So, with that, Obsidian would need to set up an array to do monitoring around their well and then submit a mitigation plan, which

367

commonly ends up being -- and in this case it did as well, including the traffic light protocol which was spoke to by Mr. McGilvary earlier where it's got the yellow light threshold where they must take an action, and then a red light threshold where there would be other actions as well if -- if those magnitudes were hit or identified in and around the well.

Other options, obviously, would have been to just suspend the well, ask them to cease operations. But this was the most appropriate means, and it's been used elsewhere to mitigate the risk, and so it seemed like the most appropriate place to start. And -- and I came to that conclusion in consultation and through the advice of the subject matter experts as we built the order.

Q And you've mentioned that during the due process meeting with Obsidian's representatives that there was some discussion about specific terms, and there were some requests that were made to adjust some of the terms?

A Yes. I believe it was on Clause 1. I think I had it as five calendar days to submit the immediate action plan, and they requested seven, which I agreed to.

368

So, generally, if there's a request, I consider it, and if it's reasonable, obviously I can apply it. So ...

Q And, Mr. Kuleba, who ultimately made the decision to issue the order?

A I did.

Q Okay. Could you go on to the next slide, please. So Slide 14. We're going on to further evidence post-March 2023. Go on to Slide 15.

And that would mean Dr. Canales is going to pick it up from here?

A M. CANALES: Yes. Yes. Thank you.

Q Please.

A So in this slide on the left-hand, you see the seismicity from the original array post March 2023. As you can see, the seismicity is still persistent.

On the right-hand, we have the -- the disposal activity, which is still happening. So that was, again, a reiteration of the anomalous behaviour that this sequence had. So was a reformation. There was an induced case.

So we were aware that the -- the nodal array data processed by Nanometrics had some

369

issues. Minor issues. But we wanted to correct them and improve particularly the velocity model, which is a key component.

The velocity model is built using well load data from that area of the Peace River region. We used the sonic logs to extract information about the VS and the VP, which, again, are used for -- for the velocity model to have an estimation of the velocity of the P&S waves originated from -- in this case from the earthquakes.

So we would process the data. On the left-hand -- of -- on the left-hand, you see the total number of earthquakes we obtained by processing the data. Again, this was internal by the AGS. You see similar features, the eastern and the western cluster. We proceed to do further analysis to prove the location of those earthquakes. Since many of these earthquakes are actually mislocated or wrongly interpret, we want to refine them.

And on the right-hand, we have the location of the most certain earthquakes from the first round of data. And, again, we have a similar picture without the artifacts.

So we solved the issue. We address the

370

issue related to the -- to the artifacts, the linear artifacts. But, again, we still see those events which are interpret as faults, right, as the activated fault reaching the depths of the Leduc Formation that interface between Leduc and the basement.

Q Can you just maybe describe.

A Right.

Q If you go back one slide, please.

A Yes, this here. Yes.

Q And on -- let's go with Figure F. It has the -- the 'F' at the top left-hand corner. And could you describe the -- the locations of -- of the faults that you were just telling us about.

A Right. Right. So on Figure F, you can see two subclusters. We call them, based on their location, the western subcluster and the eastern subcluster. Those can be interpret as two faults or as part of the same fault plane.

Independently, those earthquakes are reaching the depths of the basement and Leduc Formation, that interface. And that's critical because in cases of induced seismicity, one of the main points is having earthquakes -- one of the main points -- I should correct -- to

371

identify seismicity and identify the proper activity, it's having seismicity at a target location of the injection. So here we're -- we're having a -- earthquakes reaching that interface between Leduc and basement, and we were having disposal into the Leduc.

And, again, these two clouds can be interpret as part of a fault plane that got activated by the -- by the disposal activity.

Q Thank you.

Please go on to Slide Number 17.

A Thank you.

So you might be asking, well, what happened with the other rounds of data? Once we went to the field in December, we came back in January, we replace the nodes, we collect data from January to March of 2023, we replace again the nodes, and we got a final round of data between March 2023 up to April 2023.

This is the processing of the second round of data. That period was -- was relatively quiet; therefore, there is a sparse seismicity. You can still -- in Figure F you can still see a resemblance of the two clusters we identify in the previous round of data; however, it's not strong. There's not a large number of

372

earthquakes to -- to elucidate out of it. It was a period of -- of quiet activity.

However, we were lucky enough that in March 2023, we were able to not only collect -- record the 5.1 that happened in March the 16th but also the aftershocks of that sequence.

So on the left side, on Figures B and C, those are all of the earthquakes we detect. But as I mentioned in the previous slides, we wanted to refine and be sure of the location of the earthquakes. So we performed HypoDD, double difference, relocation to have a better sense of where are the most certain earthquakes located. And we got a similar pattern. We got a -- an eastern cluster, as you can see on the F figure, and a western cluster again.

So we have a -- still an activation of a fault plane that -- that is happening in that area. And, again, particularly when we see the full catalogue, they seem to be reaching that interface between Leduc and basement and not going beyond the -- the Leduc and basement interface. And this is the last round of nodal array data.

Q That's Slide 18 that we're on.

373

Could you go on to Slide 19.

A Right. So one way to be -- or to assure that we had a reliable location of earthquakes from the nodal array data was to compare it with other -- with independent processing -- well, in this case was -- was with Nanometrics. We process, again, the first round of data and rounds 2 and 3 with Nanometrics. And we compare their processing with our processing, and those are the figures I'm showing on Slide 19.

So the Figures A and B refers to the first round of data. As you can see, the orange are the -- the orange dots are the events from Nanometrics; the blue dots are the events from AGS; and, again, we don't have a hundred percent match, but there is a very good -- a very strong correlation between the events processed by Nanometrics and the events processed by AGS.

Are we having some small differences? Yes. And even minor changes in the peak of the P&S wave can change the location; however, there is consistency. A pretty good consistency, I would say.

So on Figures E and F, it is a similar

374

story. The orange dots are the events detected and located by Nanometrics for the third round of data, and the blue dots are the earthquakes located and detected by the AGS using the third round of data. And, again, there is a very strong correlation of the -- there's a very good match.

So that give us confidence that the initial location of earthquakes from the nodal array data given by the AGS it's quite certain, and all of the conclusions we -- we arrive from them can have some rigorosity. So I will ...

Q Go on to Slide 20. And you're passing the microphone to Mr. Galloway.

A E. GALLOWAY: Thank you.

So this slide -- to speak to the 2D seismic data that we had available for studying, we have to go backwards in time a little bit to when the -- the 5.59 magnitude earthquake occurred in November 2022.

At that time, as my colleagues have conveyed, our initial assessment was that it was a natural earthquake. This presented an interesting opportunity to study the geological scenarios where -- where natural earthquakes occur in Alberta.

375

So to support that -- that type of study, we ventured to gain access to seismic data located near to the -- the epicentre.

Going into that study, we understood that the Peace River Arch in general was an area of relatively significant structure relative to other areas of the Western Canadian Sedimentary Basin. And so we suspected that seismic could offer some indication of faults that were involved in the -- in the earthquake.

Now, accessing -- getting access to -- to seismic data -- needed to seek out what seismic data was available, identified some 2D seismic lines in the area, and engaged a data owner, Pulse Seismic, to inquire about gaining access to that data.

The conversations for that began in February 2023, and by the end of February, Pulse had granted us access to the 2D seismic data.

Immediately after gaining access to the data, I began efforts to evaluate the quality of the data and to -- to load the data into our software system so that we could begin interpretation of the data.

An important step in that process is to

376

load the data in, verify its -- its location is sound, which was -- which was performed, and then begin to what we call balance the 2D seismic grid, which means that -- ensure that the -- the 2D seismic data, the lines where they intersect, they agree in -- in both time shift but also phase rotation to -- to ensure that the -- ensure that the interpretation is sound.

The -- the objective of the study was, as I mentioned, to understand the location of faults in the region, and given that it was a region of considerable -- or relatively considerable structure, I understood that the objective of the study was to, first of all, have a broad sense of a stratigraphic interpretation, meaning -- what I mean by that is that the -- in general, the -- the stratigraphy would be understood, meaning separation between Cretaceous from Paleozoic, for instance, and have an understanding of the depths of some of the key recognizable horizons. So it's a -- a broad stratigraphic interpretation and not a specific interpretation of a -- a particular stratigraphic unit.

The other objective was to identify and map

377

out faults that might appear in the -- in the area as identified by 2D seismic data. And so -- right. So balancing -- the process of balancing was, yeah, to ensure that reflections were aligned from one line to the next and that the phase was consistent from line to -- line to line.

Now, I understand that phase rotation, when it comes to seismic data, is not an intuitive thing. The phase rotation affects the shape of the wave form of a reflection, and so, for example, it can take a peak in the seismic records and turn it into a -- a trough, or it could turn it into a peak and a trough or a trough and a peak. It's -- it varies the -- the appearance of the energy that is recorded in the seismic trace.

Now, when phase rotation is applied, it's applied on a trace-by-trace basis and applied in general the same phase rotation to the entire 2D seismic line in -- in the balancing process.

Now, when balancing these 2D seismic lines, we are comparing the -- the appearance of the seismic, specifically the phase, comparing it to each other, but also comparing it to

378

synthetic seismograms that are generated from well log data. The map on the right side of this slide is a map that shows a number of wells that were used for -- well, in the figures -- in this Figure 4, velocity modelling, a subset out of these, 10 out of the, I believe, 22 on the slide -- 10 of these were -- or synthetic seismograms were generated for 10 of these wells and used to also check the phase of the -- the 2D seismic lines in the balancing process.

So when determining the -- the correct phase for each line, I need to -- to consider both the -- the tie-in phase to the synthetic seismograms and also the tie to intersecting 2D seismic lines to try out a -- sort of a best-fit solution when it comes to -- to balancing.

Now, I recognize that there is uncertainty in tying the line phases from -- to both the wells and to the other seismic lines. And, in this case, given the objective of the work, which, to reiterate, was to understand the broad stratigraphic interpretation of the -- the stratigraphic column and the fact that I'm looking at identifying large through-going

379

faults through a -- through the stratigraphic column, I made the decision to -- not to spend time refining the -- the accuracy of the phase rotation for each individual line to an unreasonable degree.

Okay. So I think that's it for this slide.

Q Okay. Slide 21, then.

A Okay. So Slide 21, we're -- we're looking at some of the outcomes from the 2D seismic interpretation. This -- there's a lot going on in this figure, and so I'll walk the Panel through it.

Well, by now, we have seen the clusters of earthquakes many times, but, in this case, what's being shown in Figure -- I guess this would be Figure C on this -- on this slide is the topdown view of those seismic earthquakes -- or the earthquakes that were recorded by the nodal data. To be more specific, it's the AGS -- AGS relocated data, the -- the best -- best version of those earthquake locations that we have, the ones with the most confident location.

And on -- in all of these figures, the colours of the earthquake locations correspond to the date. So the earliest earthquakes are

380

the -- the dark-blue colour, and the -- the latest earthquakes would be the yellow and green colours.

Okay. So this -- to be clear, this includes the Rounds 1, 2, and 3 data in all of these figures.

I've provided a -- oh, in Figure C, we have identified the locations from which the other figures, Figures A and B, are generated from, so the -- the perspective for the following -- the other figures is indicated on the slide, so indicated in Figure C.

So the prospective location for -- for the Figure A is immediately north of the cluster of -- of seismic events. The location from which the Figure B was -- was generated is indicated by this location labelled "B" within Figure C. And so when we look at those -- oh, the other thing to point out on this Figure C is the location of the injector wells. The injection into Leduc is occurring at the dark-blue-coloured well indicator, and the -- the injection into the Belloy is occurring at the light-blue well indicator.

The other thing in this -- in these figures is the portion of the 2D seismic line that was

381

interpreted. It runs roughly northeast to southwest, nearly through the Belloy injector -- well -- sorry -- nearly through the Leduc injector well.

If we move now to Figure A, we have in depth the view of the seismic data -- the seismic cross-section. We have a view to the -- included in this view also the injector wells, the Leduc injection here and Belloy injection here where the light-blue well indicator is. And we can see again the cluster of earthquakes shown below the -- or in -- into the Precambrian basement.

One thing that you'll notice is distinct in this -- in these clusters of earthquakes is that we see, over time, a difference in depth for the earthquakes, and we take this to indicate that there is a second fault plane that's been activated as time has evolved. It's probably most evident in Figure B, which this is a -- looking at the cluster from a perspective west-northwest of -- of the activity. We can see two different planes that have been activated, one which I -- I believe would agree with the fault plane that we've seen from -- in -- in other evidence and the

382

other being a deeper fault plane, which is only activated at later times.

Of interest in this -- when -- when thinking about the cluster of earthquakes, something of interest is that from a topdown view, there is coincidence with the later earthquakes and earlier earthquakes in this western portion of the cluster, yet when we look at it in depth, the -- there is a distinct -- or when we look at the depth section, there's a distinct change in depth.

This is of interest because these -- the early and late portions of this western cluster are aligned on a single plane, and that single plane intersects both of these other planes, the activated fault planes, and the intersection of those planes is marked by a cluster of earthquakes.

Moving to the 2D seismic that's evident in the Figure B and also Figure A. I recognize that it's -- it's shown in this -- in these figures to indicate that the -- or to demonstrate that the -- the earthquakes that we have observed and are illustrated in this cluster follows in the Precambrian basement, which is not labelled on -- on -- in Figure B;

383

but in Figure D, we see now that once some vertical exaggeration is applied, we can now make out some of the particulars about the seismic interpretation in this case.

So moving to Figure D, we have a portion of the 2D seismic line. We have some -- two wells indicated. One's the 14-18 well, which is injecting into the Leduc. We have the light-blue well that's injecting into the Belloy. We have a number of reflectors indicated. And, again, in this -- in this broad stratigraphic interpretation, we have a pre -- Precretaceous nonconformity interpreted on the 2D section, we have interpretation of the Shunda reflector, Banff reflector, Wabamun, Leduc, and then, finally, the Precambrian basement reflector.

On this cross-section, we can see that there is a -- some variability in the elevation along that Precambrian reflector. There are some areas, such as sort of the, I guess, southern portion of this 2D seismic line, where there -- the elevation of the Precambrian reflector is quite consistent, very smooth.

As you go toward the north end of this 2D seismic reflect -- 2D seismic cross-section, we

384

see some relatively dramatic changes in elevation to the Precambrian reflector. These changes in -- in elevation are attributed to faulting in the area. We interpret it from just 2D seismic line, but there are Precambrian faults that exist that have changed the elevation of the Precambrian reflector.

Importantly, these dramatic changes in pre -- or, importantly, these faults seen in the Precambrian reflector are located very near to the Obsidian injection well, which is -- which is injecting into the Leduc.

Recognizing that the -- the variability of -- recognizing that the -- that the variability of the Precambrian reflector and the associated fault interpretation could be quite relevant to our study of induced seismicity or, at this time, study of -- yeah, study of seismicity in this area, we sought to understand, well, first, details about the orientation of these faults and understand in which areas similar variations in Precambrian reflector elevation might be present.

Now, I've shown on the previous -- or -- previous slide the -- the grid of 2D data that we had access to for this study.

385

Unfortunately, the -- the complexity and the density of faults that were evident on -- in this area near the 14-18 well were such that the efforts to correlate any kind of interpretation from one -- from a 2D seismic line to others was extremely uncertain. The ability to correlate a particular fault interpreted on one line with a particular fault interpreted on another line was very -- yes, very uncertain.

So instead of trying to identify and map out individual faults, the -- I decided to identify areas of -- identify areas that were more faulted than others, looking for areas with, as -- or distinguish areas such as this relatively complex Precambrian faulting area near the Obsidian well compared to areas where we see little to no variation in the Precambrian elevation.

So to do so, I calculated a seismic attribute, which we can speak to on the next slide.

Q Slide 22.

A I can change it. Very good.

Okay. So to describe the variations along the Precambrian reflector, I calculated a

386

variability attribute. I can describe the details of that variability attribute calculation. We -- in this plot, we have, to start, the solid red line, which is the -- the -- the time of that Precambrian reflector as interpreted by me.

So you can see that along the distance of a 2D seismic line, the variations in that reflector are shown to range from, in this case, 1,775 milliseconds to 6 -- 1,660 milliseconds.

Shown by the dashed line is a smoothed trend of that horizon interpretation. The trend line was calculated at a given point as the mean of the values of the horizon within 500 metres.

The other line on this plot is the variability calculation. The -- the variability curve across the line is the measure of standard deviation of the difference between the horizon line, the solid line, and the trend line, which is the dashed line.

So what we can see is that areas where -- so along the 2D seismic line, areas where the elevation is smoothly varying, we have -- so along the red line here, the dashed

387

line, and the solid red line are in very close agreement. So in those areas, we could -- we can see that the variation -- the variability of that solid red line relative to the dashed line is low. And what we see on the variability curve is, yes, we see low variability.

Contrast that with an area like this area shown at 4,000 metres distance along the line, the -- a marked departure of the solid horizon line from the dashed trend line.

In these regions, there is a lot of variability from between the horizon and the trend line, and, thus, the standard deviation and the variability -- the variability curve increases dramatically, showing that this area of the 2D seismic line would have a large variability in Precambrian elevation, and from that, we would -- which we're using a proxy for areas where there is dramatic Precambrian faulting.

Okay. So from -- right. So this attribute was calculated along each of the 2D seismic lines that we had access to, and the values along those 2D seismic lines, the -- the variability values were gridded to cover the

388

area and create a -- an attribute map, which is shown on Slide 23.

So on this map, we have -- the variability attribute is coloured according to the scale that's shown in the bottom right part of the figure ranging from dark colours, being less variable, and the more variable areas being coloured in the -- the light yellows into orange colours. To help understand the -- the range of variability that this scale bar is -- is meant to display, I've provided example of figures or examples of the Precambrian variation that corresponds to levels of variability. So areas where we see very consistent elevations from the Precambrian reflector are shown by the -- the, yes, blue to purple colours, and areas such as -- or for areas where we see high variability in the Precambrian basement elevation, we can expect to see trends in the -- the Precambrian basement top, such as shown here, where we believe there are a number of faults that are present.

So on the figure, we have indicated two wells, the first being the Obsidian well, which is injecting into the Leduc, which sits

389

directly on the Precambrian basement; and for context, we've also included the Belloy injector. The black lines on this map are indicating the -- the control points, the areas -- the 2D seismic lines that were used in -- in calculating this 2D seismic map. For context, we've included the Leduc reef edge indicated as a -- as a band in this case. The precise interpretation of the Precambrian reflector is -- is made more difficult by the presence of the Leduc reef edge and so have, in part, obscured the -- the appearance of the map in that -- that range or that area. And, for context, I've indicated which part of the map is -- is on reef and which would represent off-reef areas.

So the -- sorry. Okay. So what do we observe on the attribute map? What we can see is that the area where the -- the Leduc injector is located has an obviously high levels of Precambrian elevation variability, which we're using as a proxy for degree of faulting in the area.

This attribute does not seem to show any strong trends across the area, however, does -- from the Obsidian injector, does suggest that

390

the area of enhanced variability extends some distance to the south and east.

It may be of interest to -- to point out that in the area of the Belloy injector, we do -- we see low -- very low levels of elevation variability. So one would expect that in that area we might see varying flat Precambrian basement.

It also might be of interest to -- to mention that in the case of a strike-slip fault where we don't see any vertical displacement, the variability of the elevation of the Precambrian would not be expected to be -- sorry. The variability of the Precambrian basement would not be expected to be high. In fact, there are many -- in most cases, what we -- we observe -- most cases where we suspect strike-slip faulting, we have little to no evidence from seismic data that the -- there -- there is any offset on those strike-slip faults.

P. FITZPATRICK: Okay. So I think we're going to get back to Dr. Canales at this point. I see it's 2:25. I wonder, Mr. Chair, if this might be an appropriate time to take the afternoon break.

391

THE CHAIR: Yeah. I think that's probably a good option. So let's take a break and come back at 2:40.

P. FITZPATRICK: Thank you.

(ADJOURNMENT)

THE CHAIR: Thank you. Please be seated.

Please carry on, Mr. Fitzpatrick.

P. FITZPATRICK: Thank you, Mr. Chairman.

Q P. FITZPATRICK: If we could continue with Slide Number 24. And, Dr. Canales, if you could pick it up from there, please?

A M. CANALES: Can you put it on presentation mode, please.

A. STANISLAVSKI: You can do it too.

A M. CANALES: Pardon?

A. STANISLAVSKI: You can do that too.

A M. CANALES: It doesn't move, I believe. Oh, it moves. Now I see. Thank you.

Okay. So as I was explaining earlier, after March 2023, when the order was issued, we kept studying the area. As I show you -- showed earlier, we processed -- we processed the first round of nodal array data. Then we processed the other two rounds of nodal

392

array data, and we found similar results. The earthquakes were -- were in the basement, and we found a connection between the -- the Leduc Formation and the basement.

As my -- my colleague Elwyn -- Dr. -- I'm sorry -- Mr. Elwyn shown, we also found compelling evidence of a fault in the basement close to the Obsidian well.

So we were getting further evidence that we affirm the involvement of this disposal activity regarding the -- the Reno cluster, right, that hosted these two large events.

On top of that, we evaluate other methods to assess the -- to determine the ordering of the sequence.

I should mention that these questionnaires that I'm going to show you now, the Foulger 2022 and the Verdon 2019, are useful for rapid assessment of the -- of a sequence, if it was induced or if it was natural. However, if we want to rely on the true origin of the sequence, we need to study the geology, the physics, and understand the mechanisms. These are guidance. They help us -- they're suggestions that help us particularly to rapidly determine if a sequence is natural or

393

induced, but, again, it's the door that will help us for further investigation.

So on the right-hand -- and I describe these in more detail, what are the kind of questions, but they are mostly related with temporal correlation, spatial correlation, depth of the earthquakes, understanding of the mechanisms, focal mechanisms. There's a number of questions that I describe in the report.

And in this slide, I show what would be the results of the Foulger and the Verdon questionnaire for the Obsidian well, the Leduc disposal in that area.

From the Foulger questionnaire, we got that 61 percent of the points goes towards induced; 33 percent equivocal that hasn't been determined; 6 percent, not enough data; and zero percent natural. That's my answer to the questions for the Leduc well.

On the other hand, you might notice that in the Foulger there is a large equivocal component, and this is because they put a heavy weight on that temporal correlation.

And then it's an issue of both -- both questionnaires. We know that for disposal activities, it can take a long time for the

394

activity to appear. So you can have years of -- of volumes, and then only at the end of it you have the activation. So that correlation is hard to attain. And one of the issues with these kind of questionnaires is that sometimes they put too much weight on it.

On the right side -- sorry. On the right-hand, I want to show you the results of the Verdon questionnaire. Again, I answer all the questions. The ESR, which refers to the evidence strength ratio or how confident are we with the current amount of data, it's 80 percent, which is robust; and for the IAR, it's 50 percent. You still have a sense of the -- that scale, a hundred, it means -- a hundred percent for the IAR means very strong or certainly gives seismicity; zero, it's uncertain; and then negative minus a hundred, it's natural. So just to have a sense of it.

So now let's start with the responses to the Obsidian report. May I?

Q P. FITZPATRICK: Yes, please. Go ahead. So you're going on to Slide Number 26?

A Right. So I will just mention some of the -- of the main findings we got out of these reports. One of those, I think, has been

395

mentioned already. It's that the recomputed catalogues, both our own and that produced by the AGS, do not show any seismicity in proximity to the Obsidian well, and I think that's -- that's evidently not true. We have plenty of seismicity around the Obsidian well -- the Obsidian well. And moreover we have seismicity reaching the depths of the Leduc Formation, which, again, for an induced seismicity perspective, that's a very strong indicator.

For most cases, I would say -- I'm not -- I'm unaware -- let's say Alberta. For most cases, you have seismicity at the depth of the injection activity, and that propagates down to the basement and upwards, depending on the nature of the fault. So this is a typical case for that matter.

Again, this is a repetition of -- that there is no seismicity in the proximity of the Obsidian well, which, again, that's not true. There is plenty of seismicity around that well, and this is the third round of data where we observe the same pattern.

We -- we believe that there was another fault plane that was activated later in time,

396

by March 2023. But, again, it's a similar pattern, so it might be a parallel fault to the original fault that got activated. Again, it's a similar -- nothing else that would change our conclusions.

Now, as you are aware, Verdon, Dr. Verdon, they -- they made an assessment and given percentage of weight to the different activities in that area, to the Obsidian well, to the Belloy well, and to the other northern Leduc wells, right.

So, as I mentioned earlier, those questions are based on multiple characteristics, including original seismicity, temporal occurrence, temporal correlation, depth of the events, spatial correlation, earthquake mechanism, and source mechanism.

So for the Obsidian well, we actually did the reassessment, and as I showed you earlier, we got a very strong ESR: The evidence of strength ratio, a hundred percent; and the IAR, 51 percent.

For the Belloy well -- and I should clarify the point here. We consider that many of the assumptions of the Verdon work are based on evidence that are not quite strong. So what we

397

consider is, well, what would happen if -- for the Belloy well -- that Belloy fault is not actually a conduit? What would happen if there is a sealing component, if there is the viscidity of the pressure? What if that fault that would have to cross 1.2 -- 1.2 kilometres of sedimentary strata plus more kilometres into the basement -- what would happen if actually it did not transmit pressure?

So we create a range for both the ESR and the IAR. For the ESR, again, it seems to be strong, 91 percent, 100 percent. Again, I think that's an issue for the questionnaire. And the IAR moves between 21 percent to 48 percent. The lowest value indicates what would happen if these fault -- these fault that would actually allow for a mechanism, it's -- it's not relevant for the pore pressure communication, so I provide a range.

For the high-volume Leduc wells, the evidence of strength ratio ranges between 85 percent to 100 percent, and the induced assessment ratio ranges between minus 12, which would indicate natural seismicity or towards natural seismicity, to 35 percent.

And, again, for the particular high-volume

398

Leduc wells, I put the proper -- or I would consider the reservoir model, and what would happen if those values of pore pressure increase are actually not as high coming from the north as they are suggesting, or what would happen if that communication has actually been truncated.

If the reservoir model, which is the main component to indicate that the high-volume Leduc wells are part of the story, if that reservoir model -- it's not accurate, then that pressure might be completely different. And that's something we know from reservoir models. By changing the input parameters, you can drastically increase the outcome of the pore pressure increase.

So what we did here was what if the reservoir model is not as reliable? Then you have those negative values as shown at the IAR.

But, again, as I mentioned earlier, these assessments are -- are guidance. We need to really understand the geology and the physics to come up with an understanding of the induced seismicity.

So I also implemented the Foulger et al. 2023 questionnaire. On the right, we have the

399

Obsidian well. 64 percent -- percent of the points go towards induced, 31 percent equivocal, 5 percent not enough data, zero percent natural. The values are slightly different to agree with some of the elements presented by the reports from Obsidian, so this is a reassessment.

Then for the Belloy well, which it's in the middle, the equivocal components is 58 percent, which, again, indicates a heavy reliance of a fault that might or might not be a conduit. Then we have 36 percent for induced and 6 percent for not enough data.

And for the distant Leduc wells, something similar happens. How much reliable are the reservoir models? How reliable are the values of pore pressure increase at the -- at the -- at the Reno cluster? We put that into the model -- sorry -- into the -- the questionnaire, and we get this information, which essentially tells, well, could be either induced; it's equivocal; it's natural; it's really inconclusive, for that -- for that matter. But, again, and I repeat -- this is the third time I repeat it -- these are guidelines for a rapid assessment. We need to

400

rely on the geology and the physics to properly understand the induced seismicity causation.

I think that's it.

Q That's it.

All right. So I do now want to ask Mr. Kuleba about a bit of a different subject matter. Mr. Kuleba, you heard testimony from Obsidian's witnesses in reference to a request for mediation, and I wonder if you could tell the Panel briefly your recollection as to that request, whether it was declined; if so, why it was declined.

A MR. KULEBA: Yes. I can -- I can share why we disagreed with the request for ADR. For one, we felt that the interest of this proceeding would be in the public interest, and so we thought transparency would be quite important.

But, primarily, because there is no information, documents, or submissions provided to us before the request or along with it to go along with it so we'd know what we're actually going to ADR for. So, with that, we disagreed with that. I -- I found Exhibit 29.01; those reasons are there as well.

Q That's 29.01 of this proceeding?

401

A Yes. Yeah.

P. FITZPATRICK: Mr. Chairman, the next area that I intend to go into is going into confidential material. I don't expect to be very long. Probably be just a few minutes, and then I expect to conclude and to turn over the podium to my friend.

THE CHAIR: Okay. Thank you.

So we'll make the change to go in camera, which means we'll have to cease the video, and we will also have to clear the room of anybody who's not signed the undertaking. So if, again, Counsel can just confirm whether there's anybody there that has not signed the undertaking.

P. FITZPATRICK: I believe everyone that's here has signed an undertaking, sir.

THE CHAIR: Okay. If staff can just let us know when the video has ceased, then we will proceed.

D. LANGEN: Mr. Chair, I can -- I'll take my friend's word for it. Thank you.

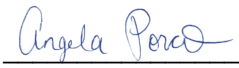
THE CHAIR: Thank you.

(PUBLIC PROCEEDINGS ADJOURNED)

CERTIFICATE OF TRANSCRIPT:

We, A. Porco and K. Di Rocco, 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 30th day of November 2024.



A. Porco, CSR(A)
Official Court Reporter
Commissioner for Oaths Appointee No. 0734405
ASRA Membership No. 185

K. Di Rocco, CSR(A)
Official Court Reporter
Commissioner for Oaths Appointee No. 0728318
ASRA Membership No. 57