

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2 BEFORE THE PATENT TRIAL AND APPEAL BOARD

3 CASE NO. PGR2023-00023

4 PATENT NO. 11,373,058

5 -----

6 PROFAC HOLDING CORPORATION AND

7 U.S. WELL SERVICES, LLC,

8 Petitioners,

9 vs.

10 HALLIBURTON ENERGY SERVICES, INC.,

11 Patent Owner.

12 -----

13

14

15 REMOTE DEPOSITION OF DR. MICHAEL NIKOLAOU

16

17 Wednesday, January 10, 2024

18 9:38 a.m. (CST)

19

20

21

22 Reported By:

23 Joan Ferrara, RMR, FCRR

24 Job No. 923744

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

January 10, 2024

9:38 a.m. (CST)

Deposition of DR. MICHAEL
NIKOLAOU, held remotely via Zoom, before
Joan Ferrara, a Registered Merit Reporter,
Federal Certified Realtime Reporter and
Notary Public.

1 REMOTE APPEARANCES:

2

3 ON BEHALF OF PATENT OWNER:

4

5 BAKER BOTTS LLP

6 2001 Ross Avenue

7 Suite 900

8 Dallas, Texas 75201

9 BY: CHAD C. WALTERS, ESQ.

10

11

12 ON BEHALF OF PETITIONERS:

13

14 WINSTON & STRAWN LLP

15 1901 L Street NW

16 Washington, DC 20036

17 BY: MATTHEW A. HOPKINS, ESQ.

18

19

20 ALSO PRESENT:

21 VALERIE BELTRAN, Lexitas Monitor

22

23

24

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

----- I N D E X -----

WITNESS	EXAMINATION BY	PAGE
DR. MICHAEL NIKOLAOU		
	MR. WALTERS	5
	MR. HOPKINS	82

1 MICHAEL NIKOLAOU,

2 called as a witness, having been duly
3 sworn by a Notary Public, was examined
4 and testified as follows:

5 EXAMINATION BY

6 MR. WALTERS:

7 Q. Good morning, Dr. Nikolaou.

8 A. Good morning.

9 Q. Have you ever been deposed
10 before?

11 A. I have. Yes, I have been deposed
12 before.

13 Q. In what context?

14 A. As an expert witness in
15 litigation between companies on technical
16 matters.

17 Q. So that was District Court
18 litigation?

19 A. I may not be familiar with the
20 exact term, "District Court litigation,"
21 but I can explain the situation in other
22 terms.

23 There were lawsuits where two
24 companies were involved. One was Magellan
25 versus Sunoco. The other one was Chem32

1 versus EuroCat. And both cases eventually
2 went to court. So I was deposed for both
3 of these cases.

4 Q. Did you testify at trial in
5 either of those cases?

6 A. I did, yes.

7 Q. Okay. Have you ever been deposed
8 in any other context?

9 A. I have been deposed also in one
10 other case that eventually didn't go to
11 court.

12 Q. Was that a lawsuit?

13 A. Yes. With Mr. Vizzaro, if I
14 remember correctly.

15 Q. Have you ever been deposed in an
16 IPR proceeding or a PGR proceeding?

17 A. An IPR proceeding or PGR
18 proceeding? Can you explain the terms to
19 make sure I don't misstate my involvement
20 in this?

21 Q. Sure.

22 By "IPR," I'm referring to an
23 inter partes review proceeding in front of
24 the U.S. Patent Office.

25 And by "PGR," I'm referring to a

1 post-grant review proceeding in front of
2 the U.S. Patent Office.

3 A. Oh, yeah, I have been deposed on
4 both of these kinds of cases, that was in
5 the previous two cases that I mentioned.
6 They involved alleged infringement and
7 alleged invalidity of patents.

8 Q. So were you deposed in both --
9 with respect to both the litigation and the
10 IPR proceedings involved with those two
11 cases?

12 A. I am not sure I can make this
13 fine distinction since I don't have legal
14 training. To me, that was one big
15 continuum.

16 But the essence of this is that I
17 offered my opinion on whether a patent was
18 valid or not and whether there was
19 infringement or not.

20 Q. Okay. Where are you located
21 right now?

22 A. I am located in the Winston &
23 Strawn offices in Washington, D.C., 11th
24 floor of their building.

25 Q. Is anyone else in the room with

1 you?

2 A. Yes. Matt Hopkins is my counsel.

3 Q. Okay. He's the only person in
4 the room?

5 A. He's the only person in the room,
6 that is correct.

7 Q. Okay. Do you have any documents
8 with you?

9 A. I do. Yes, I do.

10 Q. What documents do you have with
11 you?

12 A. I have three, four binders.
13 One -- shall I go in detail what these
14 binders contain?

15 Q. If you can tell me generally,
16 that's fine.

17 A. Generally, those are documents
18 that are directly related to the case.
19 Perhaps the most important ones are my
20 declaration, a key patent by Pankaj used in
21 the declaration, and the patent in
22 question, '058.

23 Q. Are all the documents, are they
24 clean copies or do you have any notes on
25 those documents?

1 A. They are all clean copies. I
2 don't have any notes on any of these
3 documents.

4 Q. Okay. I expect that the
5 documents include the briefing from the
6 parties in this PGR proceeding and exhibits
7 utilized in the PGR proceeding. Is that
8 fair?

9 THE WITNESS: Counsel, can you
10 help me with the terms? Is that
11 correct?

12 MR. HOPKINS: Counsel, yes. I
13 represent this is all the papers and
14 exhibits used in this proceeding.

15 THE WITNESS: Very good.

16 MR. WALTERS: Okay. And there's
17 no other documents he's got?

18 MR. HOPKINS: No other documents.

19 A. No other documents, that's
20 correct.

21 Q. What did you do to prepare for
22 today's deposition?

23 MR. HOPKINS: Objection.

24 Privilege. I just caution the witness
25 not to discuss the substance of the

1 conversations with the attorneys.

2 You may answer the question.

3 A. Okay. So I reviewed the material
4 that was in my declaration, material
5 related to references cited in the
6 declaration, and I had discussions with
7 people at Winston & Strawn for the last two
8 days.

9 Q. Who did you meet with at Winston
10 & Strawn?

11 MR. HOPKINS: Same objection.

12 You may answer the question.

13 THE WITNESS: Shall I mention
14 whom I --

15 A. I spoke with Matt Hopkins, who is
16 now in the room, in relation to this
17 deposition.

18 Q. Did you meet with anyone else to
19 prepare for the deposition?

20 A. Not to prepare for the
21 deposition.

22 Q. When did you meet with
23 Mr. Hopkins?

24 A. For the last two days, Monday and
25 Tuesday.

1 Q. And how long did those meetings
2 last?

3 A. Pretty much for the whole day,
4 each day, on and off.

5 Q. Did you review any documents in
6 connection with those meetings?

7 A. Yes. Those are the documents
8 that I mentioned, namely my declaration and
9 references cited in this declaration.

10 Q. Okay. I'd like to turn to your
11 declaration, which is Exhibit 1003.

12 Do you have your declaration in
13 front of you, Exhibit 1003?

14 A. Yes, I do.

15 Q. I'd like to turn to paragraph 2,
16 which is on exhibit page 5.

17 A. Yes.

18 Q. In this paragraph, you identify
19 documents that you reviewed in connection
20 with preparation of your declaration.

21 Do you see that?

22 A. Yes.

23 Q. Did you -- in order to prepare
24 your declaration, did you review any other
25 documents other than those identified in

1 paragraph 2?

2 A. I don't recall reviewing any
3 other documents in any substantial manner.

4 Q. Have you reviewed the institution
5 decision from the PTAB in this PGR?

6 A. Could you help me a little bit
7 with what that document is?

8 Q. Sure.

9 You understand that petitioner
10 filed a petition for post-grant review of
11 the '058 Patent, correct?

12 A. Correct.

13 Q. And you supported that petition
14 with your expert declaration?

15 A. Correct.

16 Q. Do you understand that patent
17 owner, in response, filed a preliminary
18 response document?

19 A. Yes.

20 Q. Did you review that preliminary
21 response document?

22 A. I presume this is Document No. 2
23 in another binder.

24 THE WITNESS: Counsel, is that
25 correct?

1 A. Yes, so I have seen that.

2 Q. And in response to that, the
3 Patent Trial and Appeal Board instituted
4 this PGR by way of an institution decision.

5 Do you understand that?

6 A. Yes. That basically means in lay
7 terms that a review can proceed and we can
8 follow up with what we are doing right now.

9 Q. Did you review the institution
10 decision through which the Patent Trial and
11 Appeal Board instituted the PGR proceeding?

12 A. The institution decision --

13 THE WITNESS: Would that be a
14 document I have in my binders?

15 MR. HOPKINS: Counsel, may I just
16 show him the binder, which one you're
17 referring to, which document?

18 MR. WALTERS: Sure.

19 A. Yes. Yes, I looked into that
20 document.

21 Q. Your declaration opines that the
22 claims of the '058 Patent are invalid, is
23 that right?

24 A. Correct.

25 Q. You're not alleging that any

1 single reference discloses each limitation
2 of any particular claim, is that correct?

3 MR. HOPKINS: Objection. Form.

4 THE WITNESS: Shall I answer or
5 continue?

6 MR. HOPKINS: Yes.

7 A. Okay. My understanding is that
8 it is a combination of references in prior
9 art that render '058 invalid.

10 There is a basic patent by Pankaj
11 referred to extensively in the declaration,
12 and there are other corroborating
13 references that are used for various
14 details.

15 Q. How would you describe the
16 technology of the '058 Patent that's at
17 issue in this PGR proceeding?

18 A. The technologies are stated in
19 the summary of the patent. So I can read
20 it from there, I believe.

21 THE WITNESS: Counsel, help me
22 with, in which of these binders is the
23 '058 Patent. Number 1? This one?

24 A. '058, I'm sorry, it was the very
25 first one, yeah.

1 So it is a description of how one
2 can use stimuli produced by an electric
3 frac pump so that one can build a model
4 using measurements from sensors so that
5 this can be used to design fracturing jobs.

6 Q. What is your relevant education
7 or experience with respect to this
8 technology?

9 A. With respect to fracturing?

10 Q. With respect to the technology of
11 the '058 Patent.

12 A. With respect to the technology of
13 the '058 Patent, I'm quite familiar with
14 various aspects of it and I can elaborate a
15 little bit on that.

16 There is the general context
17 which is how you improve production in oil
18 and gas well by fracturing, by hydraulic
19 fracturing, or fracking, with which I'm
20 very familiar. We have a number of
21 publications actually on this subject.

22 And then it's an issue of how a
23 computerized system can help carry out
24 these operations in an automated or
25 semi-automated fashion, with which I'm also

1 very familiar. My main research area when
2 I finished my Ph.D. way back in '89, was
3 process control, and I have continued
4 working in that area for a number of years,
5 to this day.

6 Q. Can you explain to me how process
7 control relates to the technology, the '058
8 Patent?

9 A. I'm talking about using a
10 computer so that the computer can implement
11 various actions to the process in question.

12 Q. Can you elaborate on that with
13 respect to the '058 Patent?

14 A. Yeah. The '058 Patent involves,
15 among other things, a computer that will be
16 used to -- a computer rather or electronic
17 equipment that will be used to implement
18 things such as pump flow rate, for example.

19 Q. So you testified that this is the
20 basis of some of your research, is that
21 fair?

22 A. "This" being how to use a
23 computer to -- the various operations in
24 the oil field, yes.

25 Q. Do you have any relevant industry

1 experience other than your research?

2 A. Through consulting, yeah, through
3 consulting with various companies. A full
4 list is in my CV and I'll be happy to
5 elaborate on details, if necessary.

6 Q. Sure. Please do.

7 A. Yeah. So on consulting jobs,
8 there have been cases where computerized
9 systems would be used for various tasks,
10 either upstream or downstream. So that may
11 have been on fracturing, it may have been
12 on production, operations. It may have
13 been downstream also, like I said, which is
14 not immediately relevant to this particular
15 case.

16 Q. Have you ever been to a fracking
17 site?

18 A. Physically, no.

19 Q. Have you ever used a control
20 system for a fracturing operation?

21 A. Used, you mean physically
22 operated a control system for fracturing
23 operation? No.

24 Q. Have you ever implemented a
25 control system for a fracturing operation?

1 A. I have implemented control
2 systems for drilling operations in wells
3 that were later fractured, but my job was
4 in the drilling part and the fracturing job
5 was performed later on by other people.

6 Q. Have you ever used a
7 representative system model?

8 A. Representative system model, yes.

9 Q. When did you use a representative
10 system model?

11 A. In various systems. Mathematical
12 modeling, that I presume is what you mean.
13 It's a general concept which can be used in
14 various places. So I've used models of a
15 well, models of the earth around the well,
16 models of the equipment that goes into a
17 well or creates the well or fractures the
18 well, and so forth.

19 Q. Have you ever used a
20 representative system model with respect to
21 a fracturing operation?

22 A. Yes.

23 Q. When did you do that?

24 A. In various instances, I'll have
25 to look up my publications, but it's in

1 various cases.

2 The latest one is actually for a
3 novel application of using hydraulic
4 fracturing to generate -- to pick up heat
5 from the earth bypassing a fluid through
6 hydraulic fractures, and picking up the
7 heat at the other end of the top. It's a
8 new technology that the industry is trying
9 to explore.

10 Q. Do you consider yourself to be an
11 expert in representative system models?

12 A. Representative system models,
13 yes.

14 Q. Do you consider yourself to be an
15 expert in the use of representative system
16 models in fracturing?

17 A. Yes.

18 Q. What is a representative system
19 model?

20 MR. HOPKINS: Objection. Form.

21 THE WITNESS: Shall I answer?

22 MR. HOPKINS: You should answer
23 all the questions.

24 THE WITNESS: Oh, okay.

25 A. So a representative system

1 model -- and again, we are talking about
2 mathematical models because one could also
3 create physical models at scale or similar
4 things -- so a mathematical system model,
5 which is what I understand a representative
6 system model, is a set of equations that
7 basically describe what will happen to a
8 system if a system starts from a certain
9 point and it is left to proceeding time
10 perhaps, or if there is no time over a
11 steady state, given some possible external
12 inputs that go into the system.

13 So such a representative system
14 model can have various forms. In all
15 cases, there are some situations that are
16 used to represent the system. And one has
17 to pick up output from this calculation --
18 this is what simulation refers to, it
19 refers to actually solving -- crunching
20 numbers so that one can get the output from
21 the representative model and use it for a
22 certain purpose.

23 Q. How are representative system
24 models used in hydraulic fracturing?

25 A. A representative model in

1 hydraulic fracturing can be used in two
2 basic ways. One is if I select the inputs
3 to my model in a certain way, what will be
4 the outcome.

5 Example: If I select, say, the
6 flow rate of fluid water or slurry that
7 goes into the fracture in a certain way,
8 that would be an input to my model. What
9 would be the output, output variable could
10 be the fracture dimensions, for example,
11 how wide and how long the fracture will be.
12 Or if I use a certain proppant, that would
13 be another input to my model, what will be
14 the, again, the geometry of the fracture.

15 So that's a direct way to use the
16 model. And obviously because that
17 capability -- or rather if that capability
18 is there, one can always reverse the
19 question and say if I have a model that
20 describes how input variables affect output
21 variables, how can I get the desired output
22 variables by adjusting the input variables.

23 So that may involve trial and
24 error. It may involve more sophistication.
25 It depends on the situation.

1 Q. Is it desirable to have a
2 representative system model that accurately
3 reflects the well to which it is applied?

4 MR. HOPKINS: Objection. Form.

5 A. You're referring to -- I'm sorry
6 for not answering directly. Can you repeat
7 the question to make sure I heard you
8 correctly? So you said is it possible to
9 have a representative system model that --

10 Q. No. I said is it desirable --

11 A. Oh, desirable, okay.

12 Q. -- to have a representative
13 system model that accurately reflects the
14 well to which it is applied?

15 MR. HOPKINS: Same objection.

16 A. Yes. Yes, and let me explain
17 very briefly why.

18 A representative system model
19 will give answers to questions raised about
20 the particular task. So to the extent that
21 that model can provide answers to these
22 questions, that model would be desirable.

23 There's a famous saying, by the
24 way, to guide this process, all models are
25 wrong, but some are useful, which means

1 you'll never have perfection in your
2 predictions by the model, but you may have
3 useful outputs from the -- useful outcomes,
4 rather, from your model, which may be used
5 for a certain task, and that's what would
6 make that model desirable.

7 Q. What are the consequences of
8 using a representative system model that
9 does not accurately reflect the well to
10 which it is applied?

11 MR. HOPKINS: Objection. Form.

12 A. Accuracy is a relative term. So
13 no model will be perfect. It's a matter of
14 degree and there is always that tug of war,
15 namely, if I spend more effort on
16 developing a more detailed model, I may get
17 better predictions and there is always a
18 compromise between efforts spent to improve
19 a model and outcomes produced by a model at
20 hand.

21 As long as the outcomes from
22 using the model are useful, the model is,
23 again, a useful and desirable model to use.

24 Q. If the model is not very
25 accurate, then are there detrimental

1 consequences?

2 MR. HOPKINS: Objection. Form.

3 A. Again, "accuracy" is a relevant
4 term. So the answer to this is accuracy
5 would perhaps be best assessed by
6 anticipating what the consequences of using
7 a model of that accuracy would be.

8 Q. Okay. Does a -- I appreciate
9 that accuracy is a relative term.

10 Does a more accurate
11 representative model allow you to control a
12 fracturing pump more effectively?

13 MR. HOPKINS: Objection. Form.

14 A. In principle, any more accurate
15 model would be -- would do the same job
16 that a less accurate model would do. How
17 different the two outcomes would be depends
18 on the particular situation.

19 So you're concerned with
20 controlling an injection pump, you said?

21 Q. Controlling a fracturing pump
22 more effectively.

23 A. The control of the fracturing
24 pump is something that depends on what you
25 define as controlling. Are you referring

1 to controlling a pump to be at the flow
2 rate you desire?

3 Q. I am referring to controlling a
4 fracturing pump to achieve desired
5 fracturing results or to achieve more
6 effective fracturing results.

7 A. Very good.

8 MR. HOPKINS: Objection. Form.

9 A. So if you are to -- so
10 essentially you want to let the pump
11 deliver the flow rate that would produce
12 desired fracturing results.

13 Did I phrase your question
14 correctly?

15 Q. Yes.

16 A. In that case, in that case
17 obviously, more accuracy would be no worse
18 than less accuracy. The real question is
19 how much accuracy do you need so you can
20 get good results and can you actually
21 assess the quality of the results that you
22 would get given a certain accuracy.

23 So it's not a yes/no answer.
24 There are degradations based on cost
25 benefit essentially.

1 Q. Does a more accurate
2 representative system model allow you to
3 better enhance the productivity of a well?

4 MR. HOPKINS: Objection. Form.

5 A. In principle, if you have a more
6 accurate model, you can do anything, no
7 worse than you would do with a less
8 accurate model. And like I said, the
9 question is, is it worth the effort to get
10 the more accurate model because you'll
11 spend effort in various ways, time, money
12 and so forth. So is it worth it to go
13 through that expense in anticipation of
14 outcomes that would be potentially better.

15 Q. If expenses were the same, would
16 you desire to use a more accurate
17 representative model in order to better
18 enhance the productivity of a well?

19 MR. HOPKINS: Objection. Form.

20 A. If that is -- well, if all the
21 other factors -- expense is just one term.
22 There may be time, there may be other
23 things.

24 But overall, with a more accurate
25 model, you cannot do worse than you would

1 do with a less accurate model.

2 Q. And you could probably do better?

3 MR. HOPKINS: Objection. Form.

4 A. That depends on the situation.

5 Q. Can we turn to the '058 Patent,
6 Exhibit 1001?

7 A. Yes, sir.

8 Q. Specifically at column 3, lines
9 44 to 47.

10 A. Column 3, lines 44 to 47, yes.

11 Q. Okay. And in this text, the '058
12 Patent states: Response variables, e.g.,
13 responsive sensor values and respective
14 stimuli, e.g., experimental data, can be
15 used to select, define and/or construct a
16 representative system model.

17 Do you see that?

18 A. Yes.

19 Q. What does it mean to construct a
20 representative system model?

21 A. A representative system model, as
22 described here, is a model that would
23 connect the respective stimuli with the
24 response variables.

25 Q. And my specific question is, what

1 does it mean to construct a representative
2 system model?

3 A. To actually be able to put in
4 some form, either on paper or in the
5 computer, the mathematical model that would
6 connect the response variables to the
7 respective stimuli.

8 Q. And what does it mean to define a
9 representative system model, as that term
10 is used in the patent right there?

11 A. So to just make concrete what
12 that representative system model is.

13 Q. And what does it mean to select a
14 representative system model, as that term
15 is used there?

16 A. There may be candidates, because
17 this is not the first time -- usually
18 situations like this are not the first time
19 that anybody would try to build a model for
20 these variables, connecting stimuli to
21 response variables.

22 So there are almost certainly
23 classes of models similar, related, or of
24 the same nature that people have come up
25 with.

1 So one could select among those
2 which one would be -- or which ones rather
3 would be relevant and try to refine them
4 based on perhaps data or the particular
5 situation encountered in the particular
6 well.

7 Q. Is selecting a model different
8 than defining or constructing it?

9 A. Those are interrelated concepts.
10 Frankly, it's a matter of how one
11 understands these terms.

12 But in terms of the actual
13 process that one would follow to build a
14 model, this paragraph describes it very
15 well. It says the response variables and
16 the representative stimuli can be used for
17 that representative system model.

18 So the idea is that you have
19 response variables and you actually have --
20 gives an example, sensor data value. So
21 it's likely you'll have data for this.
22 Respective stimuli, you'll have data for
23 this. And you want to connect those.

24 So rather than give you a long
25 description of how that connection will be

1 built in a mathematical form, it says
2 select. Maybe you take something that
3 already exists and perhaps modify it a
4 little bit.

5 Define. Define means well, this
6 is the one I'm going to use here.

7 And construct. Construct, I
8 understand it to actually encompass all of
9 the above. Eventually it refers to
10 actually building that representative
11 system model.

12 Q. Do you consider yourself to be an
13 expert in electric fracturing pumps?

14 A. An expert in electric fracturing
15 pumps? Well, I understand an expert on
16 fracturing. And on electric fracturing
17 pumps, I understand what they are used for.

18 But beyond that, it's a matter of
19 mostly a mechanical engineer for the
20 internal workings and the actual details of
21 how these pumps work. But what they do,
22 yes, I understand.

23 Q. So do you not consider yourself
24 to be an expert with respect to electric
25 fracturing pumps?

1 A. Well, like I said, I understand
2 what they do and their basic principles of
3 operation. But my knowledge beyond that is
4 not as detailed.

5 Q. Okay. So how does --

6 A. I'm sorry, yeah, go ahead.

7 Q. I'm sorry. I didn't mean to
8 interrupt you.

9 A. No, I just wanted to add that I'm
10 not a mechanical engineer, but I work with
11 mechanical engineers and understand those
12 concepts in details much better.

13 Q. How does a hydraulic fracturing
14 pump work?

15 A. It has an inlet and outlet, it
16 receives a fluid, and it pumps out the
17 fluid at much higher pressures that can
18 inject it to the well.

19 Q. Hydraulic fracturing is a type of
20 stimulation treatment, is that right?

21 A. Indeed, it is. For a well, that
22 is.

23 Q. Do you consider yourself to be an
24 expert in stimulation treatments for a
25 well?

1 A. Yes.

2 Q. And stimulation treatments are
3 used to enhance the productivity of a well,
4 correct?

5 A. Correct.

6 Q. Is it desirable to enhance the
7 productivity of a well?

8 MR. HOPKINS: Objection. Form.

9 A. Overall, it is. But I would
10 qualify again my answer by saying whether
11 one will proceed with fracturing or not is
12 a cost benefit, a matter of cost benefit
13 analysis.

14 For example, the most classic
15 example, in conventional wells, fracturing
16 may or may not be necessary. Tied oil
17 wells, fracturing is a necessity.

18 Q. So I take it your answer, to
19 paraphrase -- strike that.

20 Why is it desirable to enhance
21 the productivity of a well?

22 MR. HOPKINS: Objection. Form.

23 A. Well, I'll apologize in advance
24 for this being a somewhat long answer. So
25 I'll try to make it as short as possible.

1 So when you produce oil from a
2 rock formation, you drill a well and the
3 internal pressure in the rock will push the
4 fluid, oil or gas, and/or gas, through the
5 porous of the rock to the well and then to
6 the top.

7 Now, for the fluids to traverse
8 the distance through the rock to the well,
9 there must be paths that allow those fluids
10 to go through.

11 In some rocks, these paths, the
12 porous of the rock, are nicely connected,
13 they're large enough and all that, so they
14 allow easily the fluids to travel from
15 various area of the rock to the well and
16 then to the top.

17 In these cases, fracturing may
18 not be immediately needed. It may be
19 needed later on in the life of a well when
20 you want to improve production because the
21 internal pressure is not high enough and
22 for other reasons. So that's an option.

23 Now, in other rocks, such as
24 shale, the fluids cannot travel -- cannot
25 traverse the distance from out to the well

1 very easily.

2 Think of shale as 1,000 times
3 thicker than brick. Now, if you have a
4 brick, you can pour some oil on it and it
5 will be absorbed. So brick has some
6 permeability. But if you want to push a
7 bucket, well then it's difficult for that
8 to go through.

9 Shale is 1,000 times, roughly,
10 thicker than brick. So if you drill a
11 well, the oil or gas will not flow to the
12 well on itself. In that case, you need
13 hydraulic fracturing.

14 If I may use a paradigm from
15 everyday life, think about trying to get to
16 a location by using side streets, that
17 would be traveling through shale, or by
18 driving to the nearest freeway, the freeway
19 is the fracture, and then taking the free
20 way to the location you want to reach,
21 that's the well.

22 So fracturing in this case,
23 namely building the freeway, is absolutely
24 necessary so that you can have production.

25 In fact, we may call it enhanced

1 production. But in reality, without the
2 fracture there, there is no production at
3 all, for all practical purposes.

4 Q. What equipment does one use to go
5 about stimulating a well in hydraulic
6 fracturing?

7 A. It's fracturing equipment and
8 it's a very well-described process. So I
9 can very, very briefly summarize it.

10 So after you drill the well and
11 you put whatever else you need there, you
12 need -- you initiate fractures at a certain
13 point by using literally a gun that shoots
14 goodies that impart the right properties to
15 the water, like viscosity, density and so
16 forth, proppant, of course, which is
17 something like sand.

18 You inject the water. The water,
19 because it's at high pressure, opens up,
20 namely fractures the rock. The proppant,
21 the sand that is, goes into the fractures.
22 And then when you remove the water, the
23 rock essentially chews on these sand
24 particles so it stays open. And now you
25 have your freeways that I mentioned a

1 moment ago so that the fluid's oil or gas
2 can travel to the well and then to the top.

3 Q. Do you inject --

4 A. I'm sorry, go ahead.

5 Q. Go ahead.

6 A. I just wanted to say that this is
7 very roughly the whole process in various
8 details.

9 Q. And how do you inject the water
10 and other fluids into the well?

11 A. Using a pump. There are trucks
12 at the top that prepare all these nice
13 fluids. They add additives, they add the
14 proppant and all these things. And once
15 you have your fluid, your injection fluid,
16 you put it through the pump, the pump puts
17 it to the well and initiates the process
18 that results in fracturing of the rock.

19 Q. Can you stimulate a well
20 differently depending on how the fracturing
21 pump is controlled?

22 A. Differently? In what way
23 differently? You mean are you going to
24 have a different technology or are you
25 referring to different mode? Can you help

1 me with that?

2 Q. Electric fracturing pumps
3 create -- they can be configured or
4 controlled to create different subsurface
5 conditions. Is that fair?

6 A. Yeah, that's a fair statement,
7 yeah, yes.

8 Q. And so that process is -- the
9 stimulation process includes controlling a
10 fracturing pump to generate specific
11 subsurface conditions, correct?

12 A. Yeah, there is an entire schedule
13 of operations of how you actually go about
14 doing this fracturing operation.

15 So the pump will have to adhere
16 to that schedule in terms of when, what is
17 injected at what flow rate, pressure and so
18 forth.

19 Q. And so my other question, earlier
20 question was can you stimulate a well
21 differently depending on how the fracturing
22 pump is controlled?

23 MR. HOPKINS: Objection. Form.

24 A. So differently, again, are you
25 saying if I use a different, let's say,

1 profile of how I use the pump, will I end
2 up with a different fracturing pattern? Is
3 that what you're asking?

4 Q. Yes. Will you end up with
5 different subsurface conditions?

6 A. You'll -- yeah, if you -- that's
7 why people want to design the fracturing
8 operation in a way that makes sense because
9 depending on how you use the pump, you will
10 get different outcomes downhole.

11 For example, if you pump for
12 let's say longer or at higher pressure, you
13 may end up having longer or wider
14 fractures -- depending on wider if you have
15 different proppant, or longer if you pump
16 longer at higher pressures, and so forth.

17 So, to summarize, if you use a
18 different schedule for how you do the
19 fracturing operation, you will end up with
20 different fracturing outcomes, yes.

21 Q. And electrical fracturing pumps
22 can be controlled via control algorithms,
23 correct?

24 A. Yeah, this is -- yeah, that's
25 right.

1 Q. And those control algorithms can
2 be used to achieve certain formation
3 responses?

4 MR. HOPKINS: Objection. Form.

5 A. Well, the typical thing is that
6 the pump will -- the pump doesn't know
7 anything about what is happening downhole.
8 You communicate with the pump by asking it
9 to deliver a certain pressure or flow rate
10 basically.

11 But what is that pressure or flow
12 rate is something an engineer will have to
13 figure out using whatever tools the
14 engineer has, because the engineer
15 understands what the pump does to the
16 formation and how the fracture will be
17 created and what is the pump operation that
18 will deliver a desirable outcome in forming
19 a fracture or multiple fractures.

20 Q. So I think you testified that,
21 correct me if I'm wrong, but controlling a
22 fracturing pump in different ways -- by
23 controlling a fracturing pump in different
24 ways you can generate different subsurface
25 conditions?

1 MR. HOPKINS: Objection. Form.

2 A. So, yeah, if a pump is operated
3 differently, the outcome's subsurface,
4 downhole, will be different, which is why
5 people want to design that operation
6 sensibly from the get-go and perhaps adjust
7 it as they go along to get the desirable
8 outcomes.

9 Q. And the different subsurface
10 conditions will impact the effectiveness of
11 the treatment?

12 MR. HOPKINS: Objection. Form.

13 BY MR. WALTERS:

14 Q. Is that fair?

15 A. Effectiveness? Can you help me
16 understand what do you mean by the term
17 "effectiveness"?

18 Q. You can -- is it fair to say you
19 can enhance the productivity of a well
20 through the creation or generation of
21 different subsurface conditions?

22 MR. HOPKINS: Objection. Form.

23 A. You can enhance the productivity
24 of a well by putting the right fractures in
25 place. So will the operation of the pump

1 have an effect on whether desirable
2 fractures will be formed in place? The
3 answer is yes.

4 Q. Is it fair to say that one set of
5 subsurface conditions created through the
6 fracturing pump will enhance or may enhance
7 productivity of a well over another set of
8 subsurface conditions that are generated
9 through the pump?

10 MR. HOPKINS: Objection. Form.

11 A. So you're asking whether
12 different operations of the pump will
13 result in different fractures, which in
14 turn will result in different productivity?
15 That depends. In general, yes. But the
16 difference, the quantitative differences
17 will be a matter of actually figuring out
18 how different the fractures will be for
19 different operations of the pump and how
20 there's different fractures of
21 productivity, of course.

22 Q. And a POSITA would appreciate or
23 understand that it's desirable to achieve
24 subsurface conditions that enhance
25 productivity of a well?

1 MR. HOPKINS: Objection. Form.

2 BY MR. WALTERS:

3 Q. Correct?

4 A. I'm sorry, your first word was?

5 Q. A POSITA, a person of skill in
6 the art.

7 A. Oh, a POSITA, okay, I'm sorry.

8 Q. Let me rephrase the question.

9 A. Yeah, yeah, yeah, sure.

10 Q. A person of skill in the art
11 would understand that it's desirable to
12 achieve subsurface conditions that enhance
13 the productivity of a well?

14 MR. HOPKINS: Objection. Form.

15 BY MR. WALTERS:

16 Q. Correct?

17 A. This is fair, yes, indeed.

18 Q. And is it fair to say this method
19 would make it easier to achieve subsurface
20 conditions that enhance the productivity of
21 a well would be considered an improvement
22 to fracturing operations?

23 MR. HOPKINS: Objection. Form.

24 A. Such a method would be desirable.

25 How much of an improvement it would be

1 depends on comparing it to prior methods
2 already known, what a new or a particular
3 method contributes that is different, and
4 so forth.

5 Q. A few minutes ago you were
6 talking about tools that an engineer might
7 use when creating desirable subsurface
8 conditions to enhance productivity of a
9 well.

10 A. Yes.

11 Q. Is one of those tools a
12 representative system model?

13 A. A representative system model is
14 definitely one of the tools that an
15 engineer can use to create subsurface
16 conditions for good fracturing, yes.

17 Q. Is it fair to say that different
18 wells respond differently to fracturing
19 operations?

20 MR. HOPKINS: Objection. Form.

21 A. In general, there is variability
22 from well to well. It's whatever mother
23 earth put down there. So how large this
24 variability depends on each situation. But
25 would one expect variability, yes,

1 absolutely.

2 Q. As an example of that, if you
3 applied the same control algorithm to
4 fracturing pumps at two different wells,
5 you may achieve different subsurface
6 conditions at each of those wells?

7 MR. HOPKINS: Objection. Form.

8 A. So let me try to answer as
9 accurately as possible.

10 So I presume you're referring to
11 using the pump to implement the same, let's
12 say, flow rates, pressures, everything that
13 comes from the pump is the same.

14 Q. Correct.

15 A. Yeah, good. Yeah, that's a fair
16 statement.

17 So if everything that comes out
18 from the pump is exactly the same, then for
19 wells that have some variability and some
20 differences between them you may not get
21 exactly the same outcomes. This is
22 absolutely correct.

23 Q. And one of those wells you may
24 enhance the productivity of the well more
25 than the other well?

1 MR. HOPKINS: Objection. Form.

2 A. There may be differences in
3 productivity depending on how different the
4 wells are, how sensitive the fracture
5 formation -- fracture building that is --
6 is to having different or the same
7 parameters for the outputs of the pump and
8 so forth.

9 Q. Would you agree that the more
10 information you have about the well that
11 you are treating, then the more effective
12 the fracturing operation may be?

13 MR. HOPKINS: Objection. Form.

14 A. That's an overall valid statement
15 for anything in the sense that the more
16 information you have about something, the
17 more informed an exercise you can take to
18 accomplish the task at hand.

19 Q. And one way of obtaining
20 information about a well is through sensor
21 data, is that right?

22 A. One way of doing that is -- well,
23 sensors -- I presume sensors related to
24 well, right? Yes.

25 Q. And sensor data can tell you how

1 a well responds to a given stimulus, is
2 that right?

3 A. Sensor data, yeah, can give you
4 various pieces of information depending on
5 what each sensor measures.

6 Q. And sensor data can tell you how
7 a well responds to a given sequence of
8 stimuli, is that right?

9 A. Sensor data can give you values
10 for parameters that each sensor measures in
11 response to stimuli, yes.

12 Q. Is it fair to say that knowing
13 how a given well responds to stimuli allows
14 you to better understand how to generate
15 desirable subsurface conditions during
16 fracturing?

17 MR. HOPKINS: Objection. Form.

18 A. It's fair to say that having data
19 from the response of a well to stimuli can
20 help you build a better model that captures
21 the effect of these stimuli on the things
22 that are measured. A model in the sense
23 that we discussed a few minutes ago of
24 making a mathematical connection between
25 the data.

1 Q. And building a better model may
2 allow you to generate more desirable
3 subsurface conditions during fracturing?

4 MR. HOPKINS: Objection. Form.

5 A. The conditions you build with a
6 better model are not going to be worse than
7 the conditions you would build with a worse
8 model, that's absolutely correct. How
9 different they would be depends.

10 Q. They may be better?

11 A. They may be better.

12 MR. HOPKINS: Objection. Form.

13 A. They may be better.

14 MR. WALTERS: We've been going
15 about an hour. Would you like to take
16 a break? I didn't mention this
17 earlier, but if you ever need to take
18 a break, feel free to let me know and
19 we'll do so as long as it's not when a
20 question is pending.

21 THE WITNESS: Thank you. I
22 appreciate it.

23 MR. WALTERS: Would you like to
24 take a break now?

25 THE WITNESS: Sure, that's a good

1 time.

2 MR. WALTERS: And you said you've
3 been deposed in IPR proceedings
4 before, but I just want to make sure
5 that you understand that the PTAB
6 rules prohibit your discussing the
7 substance of your testimony with
8 counsel during breaks.

9 Do you understand that?

10 THE WITNESS: Absolutely.

11 MR. WALTERS: Okay.

12 (Recess taken from 10:25 a.m. to
13 10:36 a.m. CST)

14 BY MR. WALTERS:

15 Q. Welcome back, Dr. Nikolaou.

16 A. Thank you.

17 Q. I'd like to turn to the '058
18 Patent.

19 A. Yes.

20 Q. And specifically Claim 1.

21 A. Yes.

22 Q. So Limitation 1C of Claim 1
23 recites selecting a representative system
24 model based on the received formation
25 response data and sequence of stimuli.

1 A. Yes.

2 Q. Correct?

3 A. Correct.

4 Q. So I'd also like to discuss the
5 Pankaj reference, Exhibit 1005, with
6 respect to this limitation.

7 A. Yes.

8 Q. And my question is how does
9 Pankaj disclose selecting a representative
10 system model?

11 A. Pankaj talks -- first of all,
12 Pankaj is a wider, has a wider scope. It
13 looks at the entire operations for a well
14 from the beginning all the way to drilling
15 the well, completing the well, starting
16 production and producing from that well.

17 So Pankaj talks about using a
18 model for the well in various places.

19 In particular, for the fracturing
20 exercise he refers to specific software
21 such as UFM, which takes inputs and certain
22 variables and produces outputs that can be
23 used in the fracturing operation.

24 Q. What is a UFM?

25 A. UFM is a software. UFM stands

1 for unconventional fracturing model. So
2 it's a piece of software to which you
3 provide the schedule of input variables,
4 such as pumping rates or treatment
5 pressure, or kind and concentration of
6 proppant, things like that.

7 So you provide these inputs to
8 the software and the software tells you
9 this is the kind of fracture you are going
10 to get, it's going to have this geometry,
11 this opening, and so forth.

12 Q. Okay. And so going back to my
13 other question, you gave me a general
14 answer. My question is specifically, you
15 opine that Pankaj discloses selecting a
16 representative system model, correct?

17 A. Correct, yes.

18 Q. So how does Pankaj disclose that?
19 What specific portions of Pankaj disclosed
20 that?

21 A. So in various places -- I'll
22 just -- let me see what I can mention here
23 because it's a long patent.

24 For example, he talks about, in
25 paragraph 74, page 6 -- are you there yet?

1 Q. Yes.

2 A. It says: The design of the
3 hydraulic fracture and workflow involves
4 creating treatment designs in areas with
5 fractural treatment fluid and proppant
6 schedule. The simulation models may then
7 run on these schedules to predict the
8 fracture propagation, fluid and proppant
9 placement in the ultimate fracture geometry
10 achieved.

11 So it's a pretty good summary of
12 what they refer to when they mean -- when
13 they refer to, rather, fracture design.

14 Q. So what do you contend is the
15 representative system model that's selected
16 in Pankaj?

17 A. It says the top of the right
18 column on page 6, the simulation models.
19 These are models.

20 This is at the beginning, and
21 then they continue further down on how
22 these models can be refined and so forth.

23 Q. Is it your opinion that the
24 representative system model that's selected
25 in Pankaj to read on Limitation 1C is an

1 existing model?

2 A. It may start -- existing, you
3 mean preexisting, something like that,
4 right?

5 Q. Yes.

6 A. It may start like this, but it is
7 stated further down in paragraph 76: Once
8 the treatment is executed on the well side,
9 the treatment data, e.g., treatment
10 pressure, proppant concentration, proppant
11 rate, the microseismic hydraulic fracturing
12 monitoring data can be used to recalibrate
13 the stimulation design model by matching
14 the observed parameters against the
15 predicted parameters from the simulation
16 run.

17 So, clearly, Pankaj says that you
18 can -- you start with something, you don't
19 start with a blank slate, but you expect
20 that if data become available or when data
21 become available you may recalibrate the
22 stimulation design model so you can have
23 better outcomes. If you believe that the
24 exercise is worth it, of course.

25 Q. The last limitation of Claim 1

1 requires controlling a fracturing pump
2 based on the representative system model.

3 A. In '058, right?

4 Q. Yes.

5 A. Correct, yes.

6 Q. Okay. And I believe that in your
7 opinion Pankaj, Figure 11, at steps 1180
8 and 1182, describe controlling the
9 fracturing pump based on the representative
10 system model. Is that fair?

11 A. Let me go to Figure 11 to refresh
12 my memory.

13 I'm sorry, could you repeat? I'm
14 on Figure 11. Could you repeat your
15 question?

16 Q. I believe it's your opinion in
17 your declaration that Pankaj discloses
18 controlling the fracturing pump based on
19 the representative system model through
20 steps 1180 and 1182 of Figure 11?

21 A. Regarding the pump control -- let
22 me see the corresponding steps in that
23 figure -- let me start by saying that
24 controlling the pump is also stated in
25 paragraph 74 and 76. So 74 says that

1 treatment design scenarios with actual
2 treatment, fluid and proppant schedules.

3 And 76 explains that this means
4 treatment pressure, proppant concentration,
5 pump rates -- it's the third line of
6 paragraph 76.

7 But let me turn to Figure 11
8 again to find the corresponding places --
9 oh, yeah.

10 So item 1176 refers to UFM, the
11 unconventional fracture modeling software,
12 which does generate pumping rates, among
13 other things. And this is part of the
14 exercise where the model is updated based
15 on data.

16 Q. And Pankaj describes that, in
17 Figure 11, that the production operations
18 at a wellbore are based on well --
19 integrated well site parameters, correct,
20 specifically at step 1182?

21 A. 11 --

22 MR. HOPKINS: Objection. Form.

23 A. 1182? In Figure 11, it says
24 actually 182. Is that what you're
25 referring to?

1 Q. I think that's a typo. In
2 Pankaj, it describes it as 1182.

3 A. It's certainly a typo.

4 I'm sorry, your question again on
5 1182 is what?

6 Q. Pankaj describes that production
7 operations at each wellbore are based on
8 integrated well site parameters, correct?

9 A. She does, yes.

10 Q. And those integrated well site
11 parameters are based on the updated
12 mechanical earth model for all wellbores,
13 correct?

14 A. Correct, yes. But this is about
15 production. This is not about the
16 stimulation part, right. Remember, Pankaj
17 is integrated. It's the whole way from
18 starting the well all the way to -- after
19 drilling, completing, putting the
20 production in place, you start producing.

21 So this very last one 1182 refers
22 to production operations, right.

23 Q. What does 1180 refer to?

24 A. It's an update of parameters
25 based on data in the mechanical earth

1 model.

2 Q. So the last limitation of Claim 1
3 of the '058 Patent requires controlling a
4 fracturing pump based on the representative
5 system model.

6 MR. HOPKINS: Counsel, may we go
7 off the record real quick?

8 MR. WALTERS: Sure.

9 (Recess taken from 10:49 a.m. to
10 10:54 a.m. CST)

11 BY MR. WALTERS:

12 Q. Dr. Nikolaou, I believe you
13 testified earlier that step 1182 --

14 A. Could you start from --

15 Q. I will start over.

16 A. Okay.

17 Q. Dr. Nikolaou, I believe you
18 testified earlier that step 1182 of Figure
19 11 of Pankaj related to production
20 operations as opposed to controlling a
21 fracturing pump, is that right?

22 A. That is correct, yes.

23 Q. Does step 1180 also relate to
24 production operations?

25 A. This is for -- yeah, for the

1 entire well site.

2 Q. And does step 1176 -- strike
3 that.

4 Does step 1178 also relate to
5 production operations as opposed to
6 controlling a fracturing pump?

7 A. 11 -- sorry, 1178, that's the one
8 you asked about, correct?

9 Q. Correct.

10 A. 1178 integrates the mechanical
11 earth model. So it's things related to the
12 reservoir, the rock itself, with things
13 related to the fracture, things we learned
14 from the fracture.

15 So the quick summary. There is
16 an earth model and how the rock behaves.
17 And to that rock, we just put some
18 fractures. So now we have more information
19 so it can update everything based on what
20 we learned from the fracturing exercise.

21 So the previous two steps, 1176
22 and 1177, used these two simulators, UFM
23 and eclipse, which are products, so that
24 you can combine the two, the fracture and
25 the rock, and create an integrated model.

1 And the two combined will give us the
2 integrated mechanical earth model based on
3 which we're going to predict production and
4 then we'll proceed with production further
5 down in 1182.

6 Q. Pankaj discloses fracture
7 parameters with respect to Figure 11 in
8 step 1176, correct?

9 A. Yes.

10 Q. And Pankaj's fracture parameters
11 are generated based on collected well site
12 data, is that right?

13 A. Well, this is part of the whole
14 exercise of predicting things and then
15 actually measuring.

16 So the simulator UFM that is
17 mentioned there can generate predictions
18 for these. And then there are data on
19 which these can be updated.

20 Q. So is it fair to say that
21 Pankaj's fracture parameters are generated
22 based on collected well site data?

23 A. Well, it's the whole exercise,
24 like I said. You have a model that says if
25 you do this, if you take these actions,

1 you're going to create this fracture.

2 That's the model. That's UFM, to be
3 specific, for one particular simulator.

4 So UFM says do these with your
5 pumps and proppants and everything, the
6 inputs that go to UFM, you will get this.

7 Then you get data and you may
8 update all this using the data that you're
9 collecting.

10 This is what's described in
11 paragraphs 74 and 76 basically.

12 Q. Can we turn to Pankaj at
13 paragraph 100?

14 A. Paragraph 100, Pankaj, yes. Yes,
15 I'm there.

16 Q. Pankaj here states that for each
17 wellbore, fracture parameters are generated
18 based on well site data, is that right?

19 A. This is correct for that step,
20 yes.

21 Q. And that's discussing Figure 11?

22 A. The 1176 -- yes, Figure 11.

23 Q. Can we turn to paragraph 119?

24 A. 119, yes.

25 Q. And this paragraph discusses step

1 1177 of Figure 11?

2 A. 1177, correct.

3 Q. And do you see where it states
4 that Pankaj's reservoir parameters are
5 generated based on collected well site data
6 and on the generated fracture parameters,
7 correct?

8 A. Well, what line are you reading,
9 in particular?

10 Q. The second sentence.

11 A. That says the reservoir
12 parameters 1177 may be generated using
13 reservoir simulation, eclipse, or
14 intersect, is that correct?

15 Q. No, I'm at paragraph 119.

16 A. Oh, 119, right above it then.

17 The second sentence says: The
18 reservoir parameters, e.g., pressure flow
19 rate, permeability, viscosity, et cetera,
20 may be determined based on the well site
21 data and the generated fracture parameters
22 1176.

23 Correct, is that what you're
24 referring to?

25 Q. Yes, yes.

1 A. Okay. And the question is again?

2 Q. Well, my question was Pankaj's
3 reservoir parameters are determined based
4 on well site data and generated fracture
5 parameters, correct?

6 A. And simulation.

7 Q. Pankaj's reservoir parameters are
8 also determined based on simulation
9 techniques?

10 A. No, on both. Let me explain the
11 whole process.

12 So you have your well. You use
13 your fracturing simulator to design
14 fracturing treatment. You're start
15 implementing that. Once you get data, you
16 may update it. Eventually you finish the
17 fracturing job.

18 Now, once you finish the
19 fracturing job, you have already collected
20 data and you want to update the reservoir
21 model.

22 The eclipse that is mentioned in
23 line 6 of paragraph 119, the eclipse
24 simulator is a simulator for the reservoir.
25 So that simulator needs to have a

1 description of the rock and what you did to
2 that rock.

3 So what you did to that rock is
4 the outcome of that previous process I
5 already mentioned, namely doing the
6 simulation for fracturing, actually
7 implementing the fracturing, finishing up
8 with the fracturing, collecting throughout
9 the whole process and data, use these data
10 to update the model -- that's what you have
11 in that step.

12 Q. Can we turn to Pankaj at
13 paragraph 61?

14 A. 61, yes.

15 Q. The second sentence there states:
16 In particular, injection may be manipulated
17 by adjusting the material being injected
18 and/or the way it is injected to achieve
19 the fractures which draws fluid from
20 formations into the wellbore and up to the
21 surface.

22 Do you see that?

23 A. Precisely, yes.

24 Q. Does this mean that an operator
25 would start the injection process and

1 adjust the material being injected or the
2 way it is injected based on how the
3 fracture process is proceeding?

4 A. That might be one option. But as
5 far as this sentence is concerned, the
6 statement says that the injection may be
7 manipulated. So you would manipulate the
8 injection by making the corresponding
9 adjustments to the material being injected
10 or the way it is injected.

11 Q. And those --

12 A. Yeah.

13 Q. Go ahead.

14 A. I want to say, details on that
15 are given a little further down.

16 Q. Okay. But those adjustments,
17 such as the way the material is being
18 injected or the way it is injected, are
19 based on how the fracture process is
20 proceeding?

21 A. That may be done in a number of
22 ways. There is not specific reference
23 here. But further down in paragraphs 74
24 and 76, there is one scenario that may be
25 used using a simulator to make predictions

1 given some input schedules and then how to
2 update these schedules once data becomes
3 available.

4 Q. And the data that becomes
5 available is the data based on how the
6 fracture process is proceeding?

7 A. Yes.

8 Q. Can we turn back to your
9 declaration, paragraph 81?

10 A. Certainly. Paragraph 81 that
11 says: For these reasons it is my opinion
12 that a POSITA, et cetera, right?

13 Q. You beat me to it.

14 A. Just pure luck.

15 Q. Yes.

16 A. Uh-huh.

17 Q. And starting at paragraph 81,
18 you're discussing Limitation 1A of the '058
19 Patent, which requires generating a
20 sequence of stimuli for application to a
21 well environment, correct?

22 A. Correct.

23 Q. What definition of sequence did
24 you use?

25 MR. HOPKINS: Object to form.

1 BY MR. WALTERS:

2 Q. -- in applying that -- strike
3 that.

4 What definition of sequence did
5 you use in applying Pankaj to that claim
6 limitation?

7 A. Standard understanding of the
8 term. Sequence one after another, for
9 example.

10 Q. Okay. Do you have Exhibit 2011
11 in front of you?

12 A. Exhibit 2011? I have all
13 exhibits, so I'm sure I can pull it out.

14 THE WITNESS: Counsel, can you
15 help me find it?

16 A. You said Exhibit 2011?

17 Q. Yes.

18 MR. HOPKINS: Counsel, may we go
19 off the record?

20 MR. WALTERS: I can share it if
21 you want me to.

22 MR. HOPKINS: That's actually --

23 MR. WALTERS: It's a dictionary
24 definition.

25 THE WITNESS: Okay. That's going

1 to be the easiest.

2 MR. WALTERS: Let me figure out

3 how to do that. Okay.

4 A. Okay, 2011 PDF, right?

5 Q. Yes.

6 A. It's downloading. Save it.

7 Q. I also shared 2012.

8 A. Okay, let me find where it saved

9 it. And let me open 2012 in documents.

10 Good. 2012. Okay, I opened both, 2011,

11 2012, yes.

12 Q. Okay. Exhibit 2011 is the New

13 Oxford American Dictionary definition of

14 sequence -- strike that.

15 Exhibit 2011 includes the New

16 Oxford American Dictionary definition of

17 sequence.

18 Do you see that?

19 A. Yeah, I see the cover page. Yes,

20 it's on page 3, yes.

21 Q. And the first definition there is

22 a particular order in which related events,

23 movements, or things follow each other.

24 Do you see that?

25 A. Yes.

1 Q. Do you agree with that definition
2 as the term "sequence" is used in the '058
3 Patent?

4 MR. HOPKINS: Object to form.

5 A. I have no reason to disagree.

6 Q. And turning to Exhibit 2012.

7 A. 2012, yes, the American Heritage
8 Dictionary, yes.

9 Q. And the definition of "sequence"
10 that's identified on 2012 includes a
11 following of one thing after another,
12 succession.

13 Do you see that?

14 A. Yes, a following of one thing
15 after another, succession -- yes, uh-huh.

16 Q. Do you also agree with that
17 definition of the term "sequence" as it's
18 used in the '058 Patent?

19 A. Yes.

20 MR. HOPKINS: Objection. Form.

21 BY MR. WALTERS:

22 Q. And you're not suggesting that
23 the term "sequence" as it's used in the
24 '058 Patent is used in a manner that it
25 contradicts either of these definitions?

1 MR. HOPKINS: Objection. Form.

2 A. Not really.

3 Q. The claims of the '058 Patent
4 recite method, systems and computer
5 readable medium for controlling electric
6 fracturing equipment for fracturing a well.

7 A. Yes.

8 Q. Is that right?

9 A. Yes.

10 Q. Are you familiar with allergy
11 skin tests?

12 A. With allergy skin tests?
13 Encyclopedically, you have an allergy and
14 the doctor tries to find out what causes it
15 basically? That's what you mean, right?

16 Q. However you think -- whatever you
17 think it means.

18 MR. HOPKINS: Objection. Form.

19 BY MR. WALTERS:

20 Q. Is it fair to say that an allergy
21 skin test would not fall within the scope
22 of Claim 1?

23 MR. HOPKINS: Objection. Form.

24 A. An allergy skin test would not
25 fall within the scope of Claim 1 -- '058,

1 on '058, right?

2 Q. Correct.

3 A. So an allergy skin test is not in
4 the scope of Claim 1 -- no, I don't think
5 it's in the scope of it.

6 Q. Are you familiar with how probe
7 messages are sent in a wireless messaging
8 communication system?

9 A. Probe messaging?

10 MR. HOPKINS: Objection. Form.

11 A. I'm not quite familiar with that
12 technology.

13 Q. Is it fair to say that sending
14 message, any type of message in a wireless
15 communication network, would not fall
16 within the scope of Claim 1?

17 A. I cannot see the immediate
18 relevance, what you just said about
19 messaging, wireless messaging, within the
20 scope of Claim 1.

21 Q. Okay. I'd like to turn to
22 Exhibit 1014, which is the Gottumukkala
23 reference.

24 Do you have it in front of you?

25 A. Yes, right here.

1 Q. Okay, great.

2 You've reviewed this reference,
3 correct?

4 A. Yes. It's one of the
5 corroborating references we cite at the
6 end, I cite at the end of the declaration.

7 Q. Okay. I'd like to turn to Figure
8 1.

9 A. Yes, I'm there.

10 Q. It may help to also reference
11 paragraph 20 of Exhibit 1014.

12 Reference numerals 24 and 26 in
13 Figure 1 are indicative of lateral bores,
14 is that right?

15 A. I'm sorry, can you repeat what
16 you just said?

17 Q. Yep. Reference numerals 24 and
18 26 of Figure 1 of Exhibit 1014 are
19 indicative of lateral bores, is that right?

20 A. 24, yes, that's a lateral bore.
21 And 21 is -- yes.

22 Q. And reference numeral 36
23 references flow control valves, is that
24 right?

25 A. 36, yes.

1 Q. And flow control valves 36
2 control fluid flows and fluid flow rates
3 between different well zones 34 of a
4 particular lateral bore, 24, 26, is that
5 right?

6 A. Uh-huh, that is connect, yes.

7 Q. Okay. How does a fluid control
8 valve control fluid flow and fluid flow
9 rate?

10 A. The valve basically changes its
11 opening. That's the universal principle.
12 So by adjusting the opening of the valve,
13 the flow is regulated.

14 Q. Okay. If the pump control rate
15 for this site was held constant, then you
16 could still change fluid flow rate between
17 well zones 34 using the fluid control
18 valves, correct?

19 A. What pump are you referring to?

20 Q. I presume that this Figure 1 well
21 site would include a pump. Would it not?

22 MR. HOPKINS: Objection. Form.

23 A. I don't see a pump here in Figure
24 1.

25 Q. So might there not be a pump in

1 Figure 1?

2 A. I don't see a pump in Figure 1.

3 This is valves that are adjusted to control
4 flow rate.

5 Q. Okay. I'd like to turn to
6 Exhibit 1018.

7 A. Yes, sir, I'm there.

8 Q. This is the Rashid reference,
9 correct?

10 A. Correct.

11 Q. You've reviewed this reference?

12 A. Yes, I reviewed that reference.
13 It's in the list of corroborating
14 references that we have at the end.

15 Q. And I'd like to focus on Figure 6
16 of Rashid and specifically paragraph 67.

17 A. Figure 6 and paragraph 67. Let
18 me find that.

19 Q. Figure 6 of Rashid depicts mass
20 storage 610. Do you see 610 in Figure 6?

21 A. Yes.

22 Q. And within that mass storage 610
23 are well models 626 and network model 628.

24 Do you see that?

25 A. Yes.

1 Q. Okay. Turning to paragraph 67 of
2 Rashid.

3 A. Yes.

4 Q. It states, starting in the middle
5 of the paragraph: For example, a field
6 optimization program 624 may be used to
7 implement a field-wide distributed realtime
8 production optimization solution, e.g.,
9 based upon a set of well model 626 and
10 network model 628 stored locally in mass
11 storage 610 and/or accessible remotely from
12 a remote server 618.

13 Did I read that correctly?

14 A. Yes.

15 Q. This paragraph of Rashid does not
16 state that electric fracturing pumps are
17 controlled based on well model 626 of
18 Figure 6, does it?

19 A. This is a general description.
20 He's concerned with the flow -- the storage
21 and flow of information, which is why he
22 leaves the term well model general --
23 generic rather.

24 Q. This paragraph relates to
25 production, correct?

1 A. Yes.

2 Q. And not to fracturing?

3 A. Yes. I have to reread the
4 preamble to this. But to the best of my
5 recollection, I mean yes. I'm reading even
6 further down that the term "well model" may
7 be used to refer to a simulation model for
8 a single wellbore. So it's not particular
9 to fracturing, no.

10 Q. This paragraph 67 of Rashid does
11 not state that model 626 or 628 are
12 retrieved from mass storage 610 based on
13 sensor data, does it?

14 A. I don't see any reference to that
15 in paragraph 67, that is correct.

16 Q. And it also does not state, this
17 paragraph 67 of Rashid, does not state that
18 model 626 or 628 are received from mass
19 storage 610 based on formation response
20 data, is that right?

21 A. I don't see that either. The
22 model is whatever has been put there in 626
23 and that's what it refers to, it being
24 paragraph 67 refers to, just the model.

25 Q. So paragraph 67 of Rashid does

1 not describe how model 626 or 628 are
2 retrieved from mass storage 610, does it?

3 A. How they're retrieved, in an
4 electronic way. They don't give details,
5 but they just say -- the model is stored
6 and then retrieved. So I don't see
7 anything more specific than that there.

8 Q. Okay. I'd like to turn back to
9 your declaration and specifically
10 paragraphs 191 and 192.

11 A. 191 and 192, yes, sir, I'm with
12 you.

13 Q. In these paragraphs in your
14 declaration, paragraphs 191 and 192, you
15 refer to structural elements of the '058
16 Patent's claims.

17 Do you see that?

18 A. Yes.

19 Q. What do you mean by "structural
20 elements"?

21 A. Yes. There are various actions
22 referred to in the general, the overall
23 process outlined and described to some
24 detail in '058.

25 These are associated with

1 specific elements. For example,
2 transmitting data, or retrieving data, or
3 updating a model, things like that.

4 I was asked to offer an opinion
5 as to any of these particulars, whether
6 novel or whether they were well-known for
7 the fracturing operation. That's why this
8 ground 5 part E is there.

9 Q. And you opined that these
10 elements were known and conventional as of
11 September 17, 2019, is that right?

12 A. Yeah, my opinion was that these
13 elements were known in the field. They
14 were conventional elements. One wouldn't
15 have to invent something new to implement
16 those actions.

17 Q. And then paragraph 193, you
18 provide a table identifying a prior art
19 reference that allegedly discloses each
20 claim element, is that right?

21 A. Indeed. Rather than vaguely
22 claiming, well, these were well known, I
23 tried to put some specific references, just
24 a selection of many references available,
25 that specifically point to some of these

1 items that were identified in '058.

2 Q. Is it your opinion that each
3 claim element was known and conventional
4 because it was disclosed in the prior art
5 reference identified for that element?

6 A. I'm not sure I understand the
7 question correctly, but let me answer it
8 the best way I understand it.

9 So is it true that these elements
10 were known because they were included in
11 the cited references -- yes, that's what I
12 believe.

13 Q. I'd like to focus a bit on the
14 dependent claim, really the technology in
15 the dependent claim that discusses a
16 diverter drop.

17 A. Yes.

18 Q. Apologies for my disorganization.

19 A. No problem.

20 Q. Are you familiar with the term
21 "diverter" in the context of hydraulic
22 fracturing?

23 A. Yes.

24 Q. What is a diverter in that
25 context?

1 A. Yeah. So when you try to push
2 water through the rock and force the rock
3 to open up where -- at points where you
4 have started, you have initiated fractures,
5 it could be that the fluid goes to some of
6 these fractures in a way that is not what
7 you would like, namely, the water
8 propagates more and opens up the fracture
9 more than you really care.

10 And why is that? Why is it not
11 desirable? Because you may end up having a
12 network that will not actually serve the
13 purpose of producing from that fractured
14 network.

15 So you want to stop the water, or
16 at least diminish, reduce the water from
17 flowing through that particular path. And
18 that's when you use a diverter.

19 Now, a diverter technology comes
20 in various kinds. Regardless of the kind
21 that you use, the particular hardware that
22 you use, the purpose is always to make sure
23 that fluid does not go into one path and it
24 is allowed to flow into other paths that
25 are desirable.

1 Q. Is it useful to know how a given
2 well responds to a diverter drop?

3 A. Yes, it is.

4 Q. Why is that?

5 A. Because you want to know what
6 will be the outcome of using that diverter.

7 Q. What specifically is a diverter
8 drop? What does the term "drop" refer to?

9 A. There is an actual little ball
10 that you may drop there and it goes there
11 and it plugs itself --

12 Q. Okay.

13 A. -- to the ring and it stops the
14 flow. It's one technology and there are
15 others. This is an evolving area, by the
16 way. It's an interesting technology.

17 Q. In what way is it evolving?

18 A. In that people are trying to find
19 better ways to do this more effectively, to
20 make sure that the diverter goes exactly
21 where you want it to go and you can
22 actually stop the exact paths that you want
23 to stop.

24 Q. Is the use of diverter drops
25 improving fracturing operations?

1 A. Yes. Are you asking -- let me
2 qualify this -- are you asking whether
3 diverter drops can improve fracturing
4 operations? Yes.

5 Now, going back to your previous
6 question, in general, does it always work?
7 No. Sometimes the diverter goes where you
8 want it, sometimes it does not.

9 So assuming it works as intended,
10 yes, it does help operations.

11 Q. Can you pull up Exhibit 1024,
12 which is the Dawson reference?

13 A. Yes, I have it right here.

14 Q. The Dawson reference, Exhibit
15 1024, is directed to determining the
16 effectiveness of a diverter, is that right?

17 A. Yes, correct. That's correct.

18 MR. WALTERS: We've been going
19 for another hour plus. Is it a good
20 time to take a break?

21 And, Matt, I may be close to
22 done.

23 MR. HOPKINS: Understood.

24 MR. WALTERS: So can we break for
25 15 minutes?

1 MR. HOPKINS: We have lunch here.

2 It's 1:00. I don't know if you want

3 to do a longer --

4 MR. WALTERS: I may be done. So

5 I'd rather go and finish, but if you

6 guys want to take a longer break,

7 that's fine.

8 MR. HOPKINS: Yeah, let's just

9 take a longer break for lunch. Let's

10 do that.

11 MR. WALTERS: Okay. How long?

12 MR. HOPKINS: Let's say 45

13 minutes.

14 THE WITNESS: Perfect.

15 MR. WALTERS: All right. So

16 reconvene at, what, 12:35 -- or, no,

17 you're on Eastern. So 1:20?

18 MR. HOPKINS: Sure. Sounds good.

19 MR. WALTERS: Okay. All right.

20 Thanks.

21 (Recess taken from 11:37 a.m. to

22 12:21 p.m. CST)

23 BY MR. WALTERS:

24 Q. Welcome back, Dr. Nikolaou.

25 A. Thank you.

1 Q. During the break, did you discuss
2 the substance of your testimony at all with
3 counsel?

4 A. No.

5 MR. WALTERS: I don't have any
6 further questions. So I'll pass the
7 witness.

8 MR. HOPKINS: Counsel, I'd like
9 to take a 15-minute break and then
10 proceed with cross. Is that okay?

11 MR. WALTERS: That's okay.

12 MR. HOPKINS: Thank you.

13 (Recess taken from 12:21 p.m. to
14 12:35 p.m. CST)

15 EXAMINATION BY

16 MR. HOPKINS:

17 Q. Dr. Nikolaou, I'm going to ask
18 you a few questions about some testimony
19 that you gave earlier today.

20 A. Yes.

21 Q. Earlier today counsel asked you
22 whether step 1182 of Figure 11 of Pankaj
23 related to the production operations as
24 opposed to controlling a fracturing pump,
25 is that right?

1 And you responded: That is
2 correct.

3 Is that consistent with your
4 declaration?

5 A. Yes.

6 Q. May I turn your attention to page
7 97 of your declaration?

8 A. Paragraph 97 of my declaration.
9 Yes, I'm there.

10 Q. In your declaration you referred
11 to step 1182.

12 A. Yes.

13 Q. And this was used -- strike that.

14 So again, counsel -- or counsel
15 earlier today asked you whether step 1182
16 of Figure 11 of Pankaj related to the
17 production operations as opposed to
18 controlling a fracturing pump, is that
19 right?

20 You responded: That is correct.
21 Yes?

22 A. Yes. Step 1182 in Figure 11 is
23 the overall outcome of having performed
24 everything that preceded it. So it
25 includes the outcome of optimizing

1 fracturing treatment parameters to achieve
2 the stimulation objectives, which would
3 eventually be translated to maximizing
4 production.

5 Q. And are there any changes to how
6 fracturing pump operates in step 1182?

7 A. Any changes on -- changes I'd
8 like to make in my declaration or include
9 here in the statement or -- can you
10 elaborate?

11 Q. During step 1182, are there
12 changes to how a fracturing pump is
13 controlled?

14 A. Oh, in step 1182, the fracturing
15 pump is no longer at play because
16 fracturing has already been completed. It
17 has been already performed. And 1182
18 refers to performing production operations.

19 So the outcome of having
20 controlled the pump in the way that was
21 specified in the previous steps eventually
22 leads to a certain production operation,
23 which is implemented as indicated in step
24 1182.

25 Q. Now, earlier today you were also

1 asked how does Pankaj disclose selecting a
2 representative system model.

3 A. Yes.

4 Q. In response, you answered as
5 follows: Pankaj talks -- first of all,
6 Pankaj is a wider, has a wider scope. It
7 looks at the entire operations for a well
8 from the beginning all the way to drilling
9 the well, completing the well, starting
10 production and producing from that well.

11 So Pankaj talks about using a
12 model for the well in various places.

13 In particular, for the fracturing
14 exercise, he refers to software such as
15 UFM, which takes inputs and certain
16 variables and produces outputs that can be
17 used in the fracturing operation.

18 Is this consistent --

19 MR. WALTERS: Objection. Go
20 ahead, I'm sorry, I thought you were
21 done.

22 BY MR. HOPKINS:

23 Q. Is this consistent with what you
24 said in your declaration?

25 MR. WALTERS: Objection. Form.

1 A. Yes, it is.

2 Q. Is there anything you'd like to
3 change or add to this answer?

4 A. To the answer I gave to counsel a
5 little earlier today or to the answer I
6 gave in my declaration?

7 Q. I withdraw that question.
8 I'd like to turn your attention
9 to paragraphs 91 through 93 of your
10 declaration.

11 A. 91 through 93, yes.

12 Q. And, again, the answer you gave
13 counsel today, is that consistent with your
14 answer -- sorry.

15 And, again, is your declaration,
16 these paragraphs, consistent with the
17 answer that you gave counsel with regard to
18 the question I asked?

19 A. I believe so.

20 (Continued on next page to
21 include signature and jurat.)

22

23

24

25

1 MR. HOPKINS: I pass the witness.

2 MR. WALTERS: I don't have any
3 additional questions.

4 (Time noted: 12:42 p.m. CST)

5

6

7

DR. MICHAEL NIKOLAOU

8

9 Subscribed and sworn to before me

10 this ____ day of _____, 2024.

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

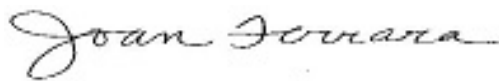
REPORTER CERTIFICATE

I, JOAN FERRARA, do hereby
certify:

That said proceedings were taken
at the time and place herein named;
and that the transcript is a true
record of the testimony as reported by
me, a disinterested person, and was
thereafter transcribed.

I further certify that I am not
interested in the outcome of the said
action, nor connected with, nor
related to any of the parties in said
action, nor to their respective
counsel.

IN WITNESS WHEREOF, I have
hereunto set my hand this 16th day of
January, 2024.



JOAN FERRARA, RMR, FCRR

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

DEPOSITION ERRATA SHEET

Case Caption: PROFAC HOLDING v. HALLIBURTON
ENERGY

DECLARATION UNDER PENALTY OF PERJURY

I declare under penalty of perjury
that I have read the entire transcript of my
Deposition taken in the captioned matter or
the same has been read to me, and the same is
true and accurate, save and except for
changes and/or corrections, if any, as
indicated by me on the DEPOSITION ERRATA
SHEET hereof, with the understanding that I
offer these changes as if still under oath.

DR. MICHAEL NIKOLAOU

Subscribed and sworn to on the ____ day of
_____, 2024, before me,

Notary Public, in and for the State of

DEPOSITION ERRATA SHEET

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

SIGNATURE: _____ DATE: _____

DR. MICHAEL NIKOLAOU

DEPOSITION ERRATA SHEET

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

Page No. ____ Line No. ____ Change to: ____

Reason for change: _____

SIGNATURE: _____ DATE: _____

DR. MICHAEL NIKOLAOU

0 058 8:22 12:11 13:22 14:9,16,23,24 15:11,13 16:7,13,14 27:5,11 48:17 53:3 56:3 64:18 67:2,18,24 68:3,25 69:1 75:15,24 77:1 1 1 14:23 48:20,22 52:25 56:2 68:22,25 69:4,16,20 70:8,13,18 71:20,24 72:1,2 1,000 34:2,9 100 59:13,14 1001 27:6 1003 11:11,13 1005 49:5 1014 69:22 70:11,18 1018 72:6 1024 80:11,15 10:25 48:12 10:36 48:13 10:49 56:9 10:54 56:10 11 53:7,11,14,20 54:7,17,21,23 56:19 57:7 58:7 59:21,22 60:1 82:22 83:16,22 1176 54:10 57:2,21 58:8 59:22 60:22 1177 57:22 60:1,2,12 1178 57:4,7,10 1180 53:7,20 55:23 56:23 1182 53:8,20 54:20,23 55:2,5,21 56:13,18 58:5 82:22 83:11,15,22 84:6,11,14,17,24 119 59:23,24 60:15,16 61:23 11:37 81:21 11th 7:23 12:21 81:22 82:13 12:35 81:16 82:14 15 80:25 15-minute 82:9 17 76:11	182 54:24 191 75:10,11,14 192 75:10,11,14 193 76:17 1:00 81:2 1:20 81:17 1A 64:18 1C 48:22 51:25 2 2 11:15 12:1,22 20 70:11 2011 65:10,12,16 66:4,10,12,15 2012 66:7,9,10,11 67:6,7,10 2019 76:11 21 70:21 24 70:12,17,20 71:4 26 70:12,18 71:4 3 3 27:8,10 66:20 34 71:3,17 36 70:22,25 71:1 4 44 27:9,10 45 81:12 47 27:9,10 5 5 11:16 76:8 6 6 50:25 51:18 61:23 72:15,17,19,20 73:18 61 62:13,14 610 72:20,22 73:11 74:12,19 75:2 618 73:12	624 73:6 626 72:23 73:9,17 74:11,18,22 75:1 628 72:23 73:10 74:11,18 75:1 67 72:16,17 73:1 74:10,15,17,24,25 7 74 50:25 53:25 59:11 63:23 76 52:7 53:25 54:3,6 59:11 63:24 8 81 64:9,10,17 89 16:2 9 97 83:7,8 A a.m. 48:12,13 56:9,10 81:21 absolutely 34:23 44:1,22 47:8 48:10 absorbed 34:5 accessible 73:11 accomplish 45:18 accuracy 23:12 24:3,4,7,9 25:17,18,19,22 accurate 23:25 24:10,14,16 26:1,6,8,10,16,24 27:1 accurately 22:2,13 23:9 44:9 achieve 25:4,5 39:2 41:23 42:12,19 44:5 62:18 84:1 achieved 51:10 actions 16:11 58:25 75:21 76:16 actual 29:12 30:20 54:1 79:9 add 31:9 36:13 additives 36:13 adhere 37:15 adjust 40:6 63:1 adjusted 72:3 adjusting 21:22 62:17 71:12 adjustments 63:9,16
---	---	--

advance 32:23
affect 21:20
agree 45:9 67:1,16
ahead 31:6 36:4,5 63:13
algorithm 44:3
algorithms 38:22 39:1
alleged 7:6,7
allegedly 76:19
alleging 13:25
allergy 68:10,12,13,20,24 69:3
allowed 78:24
American 66:13,16 67:7
analysis 32:13
and/or 27:15 33:4 62:18 73:11
answering 22:6
answers 22:19,21
anticipating 24:6
anticipation 26:13
Apologies 77:18
apologize 32:23
Appeal 13:3,11
application 19:3 64:20
applied 22:3,14 23:10 44:3
applying 65:2,5
area 16:1,4 33:15 79:15
areas 51:4
art 14:9 42:6,10 76:18 77:4
aspects 15:14
assess 25:21
assessed 24:5
assuming 80:9
attention 83:6
attorneys 10:1
automated 15:24

B

back 16:2 48:15 50:12 64:8 75:8 80:5 81:24
ball 79:9

based 25:24 29:4 48:24 53:2,9,18 54:14,18 55:7,11,25 56:4 57:19 58:2,11,22 59:18 60:5,20 61:3,8 63:2,19 64:5 73:9,17 74:12,19
basic 14:10 21:2 31:2
basically 13:6 20:7 39:10 59:11 68:15 71:10
basis 16:20
beat 64:13
beginning 49:14 51:20
behaves 57:16
benefit 25:25 32:12
big 7:14
binder 12:23 13:16
binders 8:12,14 13:14 14:22
bit 12:6 15:15 30:4 77:13
blank 52:19
Board 13:3,11
bore 70:20 71:4
bores 70:13,19
break 47:16,18,24 80:20,24 81:6,9 82:1,9
breaks 48:8
brick 34:3,4,5,10
briefing 9:5
briefly 22:17 35:9
bucket 34:7
build 15:3 28:19 29:13 46:20 47:5,7
building 7:24 30:10 34:23 45:5 47:1
built 30:1
bypassing 19:5

C

calculation 20:17
call 34:25
called 5:2
candidates 28:16
capability 21:17
captures 46:20
care 78:9

carry 15:23
case 6:10 8:18 17:15 25:16 34:12,22
cases 6:1,3,5 7:4,5,11 17:8 19:1 20:15 33:17
caution 9:24
cetera 60:19 64:12
change 71:16
Chem32 5:25
chews 35:23
cite 70:5,6
cited 10:5 11:9 77:11
claim 14:2 48:20,22 52:25 56:2 65:5 68:22,25 69:4,16,20 76:20 77:3,14,15
claiming 76:22
claims 13:22 68:3 75:16
classes 28:23
classic 32:14
clean 8:24 9:1
close 80:21
collected 58:11,22 60:5 61:19
collecting 59:9 62:8
column 27:8,10 51:18
combination 14:8
combine 57:24
combined 58:1
communicate 39:8
communication 69:8,15
companies 5:15,24 17:3
comparing 43:1
completed 84:16
completing 49:15 55:19
compromise 23:18
computer 16:10,15,16,23 28:5 68:4
computerized 15:23 17:8
concentration 50:5 52:10 54:4
concept 18:13
concepts 29:9 31:12
concerned 24:19 63:5 73:20
concrete 28:11

conditions 37:5,11 38:5 39:25
40:10,21 41:5,8,24 42:12,20 43:8,16
44:6 46:15 47:3,5,7

configured 37:3

connect 27:23 28:6 29:23 71:6

connected 33:12

connecting 28:20

connection 11:6,19 29:25 46:24

consequences 23:7 24:1,6

considered 42:21

consistent 83:3

constant 71:15

construct 27:15,19 28:1 30:7

constructing 29:8

consulting 17:2,3,7

contend 51:14

context 5:13 6:8 15:16 77:21,25

continue 14:5 51:21

continued 16:3

continuum 7:15

contradicts 67:25

contributes 43:3

control 16:3,7 17:19,22,25 18:1
24:11,23 38:22 39:1 44:3 53:21 70:23
71:1,2,7,8,14,17 72:3

controlled 36:21 37:4,22 38:22
73:17 84:13,20

controlling 24:20,21,25 25:1,3 37:9
39:21,23 53:1,8,18,24 56:3,20 57:6
68:5 82:24 83:18

conventional 32:15 76:10,14 77:3

conversations 10:1

copies 8:24 9:1

correct 8:6 9:11,20 12:11,12,15,25
13:24 14:2 32:4,5 37:11 38:23 39:21
42:3,16 44:14,22 47:8 49:2,3 50:16,
17 53:5 54:19 55:8,13,14 56:22 57:8,
9 58:8 59:19 60:2,7,14,23 61:5 64:21,
22 69:2 70:3 71:18 72:9,10 73:25
74:15 80:17 83:2,20

correctly 6:14 22:8 25:14 73:13 77:7

corroborating 14:12 70:5 72:13

cost 25:24 32:12

counsel 8:2 9:9,12 12:24 13:15
14:21 48:8 56:6 65:14,18 82:3,8,21
83:14

court 5:17,20 6:2,11

cover 66:19

create 20:3 37:3,4 43:15 57:25 59:1

created 39:17 41:5

creates 18:17

creating 43:7 51:4

creation 40:20

cross 82:10

crunching 20:19

CST 48:13 56:10 81:22 82:14

CV 17:4

D

D.C. 7:23

data 27:14 29:4,20,21,22 45:21,25
46:3,6,9,18,25 48:25 52:9,12,20
54:15 55:25 58:12,18,22 59:7,8,18
60:5,21 61:4,15,20 62:9 64:2,4,5
74:13,20 76:2

Dawson 80:12,14

day 11:3,4 16:5

days 10:8,24

decision 12:5 13:4,10,12

declaration 8:20,21 10:4,6 11:8,9,
11,12,20,24 12:14 13:21 14:11 53:17
64:9 70:6 75:9,14 83:4,7,8,10 84:8

define 24:25 27:15 28:8 30:5

defining 29:8

definition 64:23 65:4,24 66:13,16,21
67:1,9,17

definitions 67:25

degradations 25:24

degree 23:14

deliver 25:11 39:9,18

density 35:15

dependent 77:14,15

depending 36:20 37:21 38:9,14 45:3
46:4

depends 21:25 24:17,24 27:4 41:15

43:1,24 47:9

depicts 72:19

deposed 5:9,11 6:2,7,9,15 7:3,8 48:3

deposition 9:22 10:17,19,21

describe 14:15 20:7 53:8 75:1

describes 21:20 29:14 54:16 55:2,6

description 15:1 29:25 62:1 73:19

design 15:5 38:7 40:5 51:2,13 52:13,
22 54:1 61:13

designs 51:4

desirable 22:1,10,11,22 23:6,23
32:6,20 39:18 40:7 41:1,23 42:11,24
43:7 46:15 47:2 78:11,25

desire 25:2 26:16

desired 21:21 25:4,12

detail 8:13 75:24

detailed 23:16 31:4

details 14:14 17:5 30:20 31:12 36:8
63:14 75:4

determined 60:20 61:3,8

determining 80:15

detrimental 23:25

developing 23:16

dictionary 65:23 66:13,16 67:8

difference 41:16

differences 41:16 44:20 45:2

differently 36:20,22,23 37:21,24
40:3 43:18

difficult 34:7

dimensions 21:10

diminish 78:16

direct 21:15

directed 80:15

directly 8:18 22:6

disagree 67:5

disclose 49:9 50:18

disclosed 50:19 77:4

discloses 14:1 50:15 53:17 58:6
76:19

discuss 9:25 49:4 82:1

discussed 46:23

discusses 59:25 77:15
discussing 48:6 59:21 64:18
discussions 10:6
disorganization 77:18
distance 33:8,25
distinction 7:13
distributed 73:7
District 5:17,20
diverter 77:16,21,24 78:18,19 79:2, 6,7,20,24 80:3,7,16
doctor 68:14
document 12:7,18,21,22 13:14,17, 20
documents 8:7,10,17,23,25 9:3,5, 17,18,19 11:5,7,19,25 12:3 66:9
downhole 38:10 39:7 40:4
downloading 66:6
downstream 17:10,13
draws 62:19
drill 33:2 34:10 35:10
drilling 18:2,4 49:14 55:19
driving 34:18
drop 77:16 79:2,8,10
drops 79:24 80:3
duly 5:2

E

e.g. 27:12,14 52:9 60:18 73:8
earlier 37:19 47:17 56:13,18 82:19, 21 83:15 84:25
earth 18:15 19:5 43:23 55:12,25 57:11,16 58:2
easier 42:19
easiest 66:1
easily 33:14 34:1
Eastern 81:17
eclipse 57:23 60:13 61:22,23
education 15:6
effect 41:1 46:21
effective 25:6 45:11

effectively 24:12,22 79:19
effectiveness 40:10,15,17 80:16
effort 23:15 26:9,11
efforts 23:18
elaborate 15:14 16:12 17:5 84:10
electric 15:2 30:13,14,16,24 37:2 68:5 73:16
electrical 38:21
electronic 16:16 75:4
element 76:20 77:3,5
elements 75:15,20 76:1,10,13,14 77:9
encompass 30:8
encountered 29:5
Encyclopedically 68:13
end 19:7 38:1,4,13,19 70:6 72:14 78:11
engineer 30:19 31:10 39:12,14 43:6, 15
engineers 31:11
enhance 26:3,18 32:3,6,20 40:19,23 41:6,24 42:12,20 43:8 44:24
enhanced 34:25
entire 37:12 49:13 57:1
environment 64:21
equations 20:6
equipment 16:17 18:16 35:4,7 68:6
error 21:24
essence 7:16
essentially 25:10,25 35:23
Eurocat 6:1
events 66:22
eventually 6:1,10 30:9 61:16 84:3, 21
everyday 34:15
evolving 79:15,17
exact 5:20 79:22
EXAMINATION 5:5 82:15
examined 5:3
executed 52:8
exercise 45:17 49:20 52:24 54:14

57:20 58:14,23
exhibit 11:11,13,16 27:6 49:5 65:10, 12,16 66:12,15 67:6 69:22 70:11,18 72:6 80:11,14
exhibits 9:6,14 65:13
existing 52:1,2
exists 30:3
expect 9:4 43:25 52:19
expense 26:13,21
expenses 26:15
experience 15:7 17:1
experimental 27:14
expert 5:14 12:14 19:11,15 30:13,14, 15,24 31:24
explain 5:21 6:18 16:6 22:16 61:10
explains 54:3
explore 19:9
extensively 14:11
extent 22:20
external 20:11

F

fact 34:25
factors 26:21
fair 9:8 16:21 37:5,6 40:14,18 41:4 42:17,18 43:17 44:15 46:12,18 53:10 58:20 68:20 69:13
fall 68:21,25 69:15
familiar 5:19 15:13,20 16:1 68:10 69:6,11 77:20
famous 22:23
fashion 15:25
feel 47:18
field 16:24 73:5 76:13
field-wide 73:7
figure 39:13 53:7,11,14,20,23 54:7, 17,23 56:18 58:7 59:21,22 60:1 66:2 70:7,13,18 71:20,23 72:1,2,15,17,19, 20 73:18 82:22 83:16,22
figuring 41:17
filed 12:10,17

find 54:8 65:15 66:8 68:14 72:18 79:18 fine 7:13 8:16 81:7 finish 61:16,18 81:5 finished 16:2 finishing 62:7 floor 7:24 flow 16:18 21:6 25:1,11 34:11 37:17 39:9,11 44:12 60:18 70:23 71:1,2,8,13,16 72:4 73:20,21 78:24 79:14 flowing 78:17 flows 71:2 fluid 19:5 21:6 31:16,17 33:4 36:15 51:5,8 54:2 62:19 71:2,7,8,16,17 78:5,23 fluid's 36:1 fluids 33:7,9,14,24 36:10,13 focus 72:15 77:13 follow 13:8 29:13 66:23 force 78:2 form 14:3 19:20 22:4 23:11 24:2,13 25:8 26:4,19 27:3 28:4 30:1 32:8,22 37:23 39:4 40:1,12,22 41:10 42:1,14,23 43:20 44:7 45:1,13 46:17 47:4,12 54:22 64:25 67:4,20 68:1,18,23 69:10 71:22 formation 33:2 39:2,16 45:5 48:24 74:19 formations 62:20 formed 41:2 forming 39:18 forms 20:14 frac 15:3 fracking 15:19 17:16 fractural 51:5 fracture 21:7,10,11,14 34:19 35:2 39:16,19 45:4,5 50:9 51:3,8,9,13 54:11 57:13,14,24 58:6,10,21 59:1,17 60:6,21 61:4 63:3,19 64:6 78:8 fractured 18:3 78:13 fractures 18:17 19:6 35:12,20,21 38:14 39:19 40:24 41:2,13,18,20 57:18 62:19 78:4,6 fracturing 15:5,9,18,19 17:11,20,22,25 18:4,21 19:4,16 20:24 21:1 24:12,	21,23 25:4,5,6,12 30:13,14,16,25 31:13,19 32:11,15,17 33:17 34:13,22 35:6,7 36:18,20 37:2,10,14,21 38:2,7,19,20,21 39:22,23 41:6 42:22 43:16,18 44:4 45:12 46:16 47:3 49:19,23 50:1 52:11 53:1,9,18 56:4,21 57:6,20 61:13,14,17,19 62:6,7,8 68:6 73:16 74:2,9 76:7 77:22 79:25 80:3 82:24 83:18 84:1,6,12,14,16 Frankly 29:10 free 34:19 47:18 freeway 34:18,23 freeways 35:25 front 6:23 7:1 11:13 65:11 69:24 full 17:3 G gas 15:18 33:4 34:11 36:1 gave 50:13 82:19 general 15:16 18:13 41:15 43:21 50:13 73:19,22 75:22 80:6 generally 8:15,17 generate 19:4 37:10 39:24 46:14 47:2 54:12 58:17 generated 41:8 58:11,21 59:17 60:5,6,12,21 61:4 generating 64:19 generation 40:20 generic 73:23 geometry 21:14 50:10 51:9 get-go 40:6 give 22:19 29:24 46:3,9 58:1 75:4 good 5:7,8 9:15 25:7,20 43:16 44:15 47:25 51:11 66:10 80:19 81:18 goodies 35:14 Gottumukkala 69:22 great 70:1 ground 76:8 guide 22:24 gun 35:13 guys 81:6	H hand 23:20 45:18 happen 20:7 happening 39:7 happy 17:4 hardware 78:21 heard 22:7 heat 19:4,7 held 71:15 Heritage 67:7 high 33:21 35:19 higher 31:17 38:12,16 Hopkins 8:2 9:12,18,23 10:11,15,23 13:15 14:3,6 19:20,22 22:4,15 23:11 24:2,13 25:8 26:4,19 27:3 32:8,22 37:23 39:4 40:1,12,22 41:10 42:1,14,23 43:20 44:7 45:1,13 46:17 47:4,12 54:22 56:6 64:25 65:18,22 67:4,20 68:1,18,23 69:10 71:22 80:23 81:1,8,12,18 82:8,12,16 hour 47:15 80:19 hydraulic 15:18 19:3,6 20:24 21:1 31:13,19 34:13 35:5 51:3 52:11 77:21 I idea 29:18 identified 11:25 67:10 77:1,5 identify 11:18 identifying 76:18 immediately 17:14 33:18 impact 40:10 impart 35:14 implement 16:10,17 44:11 73:7 76:15 implemented 17:24 18:1 84:23 implementing 61:15 62:7 important 8:19 improve 15:17 23:18 33:20 80:3 improvement 42:21,25 improving 79:25
---	--	--

include 9:5 71:21 84:8 included 77:10 includes 37:9 66:15 67:10 83:25 indicative 70:13,19 industry 16:25 19:8 information 45:10,16,20 46:4 57:18 73:21 informed 45:17 infringement 7:6,19 initiate 35:12 initiated 78:4 initiates 36:17 inject 31:18 35:18 36:3,9 injected 37:17 62:17,18 63:1,2,9,10, 18 injection 24:20 36:15 62:16,25 63:6, 8 inlet 31:15 input 21:8,13,20,22 50:3 64:1 inputs 20:12 21:2 49:21 50:7 59:6 instances 18:24 instituted 13:3,11 institution 12:4 13:4,9,12 integrated 54:19 55:8,10,17 57:25 58:2 integrates 57:10 intended 80:9 inter 6:23 interesting 79:16 internal 30:20 33:3,21 interrelated 29:9 interrupt 31:8 intersect 60:14 invalid 13:22 14:9 invalidity 7:7 invent 76:15 involve 21:23,24 involved 5:24 7:6,10 involvement 6:19 involves 16:14 51:3	IPR 6:16,17,22 7:10 48:3 issue 14:17 15:22 item 54:10 items 77:1 J job 18:3,4 24:15 61:17,19 jobs 15:5 17:7 K key 8:20 kind 50:5,9 78:20 kinds 7:4 78:20 knowing 46:12 knowledge 31:3 L large 33:13 43:23 lateral 70:13,19,20 71:4 latest 19:2 lawsuit 6:12 lawsuits 5:23 lay 13:6 leads 84:22 learned 57:13,20 leaves 73:22 left 20:9 legal 7:13 life 33:19 34:15 limitation 14:1 48:22 49:6 51:25 52:25 56:2 64:18 65:6 lines 27:8,10 list 17:4 72:13 literally 35:13 litigation 5:15,18,20 7:9 locally 73:10 located 7:20,22 location 34:16,20	long 11:1 21:11 23:21 29:24 32:24 47:19 50:23 81:11 longer 38:12,13,15,16 81:3,6,9 84:15 looked 13:19 luck 64:14 lunch 81:1,9 M Magellan 5:24 main 16:1 make 6:19 7:12 22:7 23:6 28:11 32:25 42:19 48:4 63:25 78:22 79:20 84:8 makes 38:8 making 46:24 63:8 manipulate 63:7 manipulated 62:16 63:7 manner 12:3 67:24 mass 72:19,22 73:10 74:12,18 75:2 matching 52:13 material 10:3,4 62:17 63:1,9,17 mathematical 18:11 20:2,4 28:5 30:1 46:24 Matt 8:2 10:15 80:21 matter 23:13 29:10 30:18 32:12 41:17 matters 5:16 maximizing 84:3 means 13:6 22:25 30:5 54:3 68:17 measured 46:22 measurements 15:4 measures 46:5,10 measuring 58:15 mechanical 30:19 31:10,11 55:12, 25 57:10 58:2 medium 68:5 meet 10:9,18,22 meetings 11:1,6 memory 53:12 mention 10:13 47:16 50:22
--	--	--

mentioned 7:5 11:8 35:25 58:17
61:22 62:5

message 69:14

messages 69:7

messaging 69:7,9,19

method 42:18,24 43:3 68:4

methods 43:1

MICHAEL 5:1

microseismic 52:11

middle 73:4

minutes 43:5 46:23 80:25 81:13

misstate 6:19

mode 36:25

model 15:3 18:7,8,10,20 19:19 20:1,
4,6,14,21,25 21:3,8,13,16,19 22:2,9,
13,18,21,22 23:2,4,6,8,13,16,19,22,
23,24 24:7,11,15,16 26:2,6,8,10,17,
25 27:1,16,20,21,22 28:2,5,9,12,14,
19 29:7,14,17 30:11 43:12,13 46:20,
22 47:1,6,8 48:24 49:10,18 50:1,16
51:15,24 52:1,13,22 53:2,10,19 54:14
55:12 56:1,5 57:11,16,25 58:2,24
59:2 61:21 62:10 72:23 73:9,10,17,22
74:6,7,11,18,22,24 75:1,5 76:3

modeling 18:12 54:11

models 18:14,15,16 19:11,12,16
20:2,3,24 22:24 28:23 51:6,18,19,22
72:23

modify 30:3

moment 36:1

Monday 10:24

money 26:11

monitoring 52:12

morning 5:7,8

mother 43:22

movements 66:23

multiple 39:19

N

nature 28:24

nearest 34:18

necessity 32:17

needed 33:18,19

network 69:15 72:23 73:10 78:12,14

nice 36:12

nicely 33:12

Nikolaou 5:1,7 48:15 56:12,17 81:24
82:17

Notary 5:3

notes 8:24 9:2

number 14:23 15:20 16:4 63:21

numbers 20:20

numeral 70:22

numerals 70:12,17

O

Object 64:25 67:4

objection 9:23 10:11 14:3 19:20
22:4,15 23:11 24:2,13 25:8 26:4,19
27:3 32:8,22 37:23 39:4 40:1,12,22
41:10 42:1,14,23 43:20 44:7 45:1,13
46:17 47:4,12 54:22 67:20 68:1,18,23
69:10 71:22

objectives 84:2

observed 52:14

obtaining 45:19

offer 76:4

offered 7:17

Office 6:24 7:2

offices 7:23

oil 15:17 16:24 32:16 33:1,4 34:4,11
36:1

open 35:24 66:9 78:3

opened 66:10

opening 50:11 71:11,12

opens 35:19 78:8

operated 17:22 40:2

operates 84:6

operation 17:20,23,25 18:21 31:3
37:14 38:8,19 39:17 40:5,25 45:12
49:23 76:7 84:22

operations 15:24 16:23 17:12 18:2
37:13 41:12,19 42:22 43:19 49:13
54:17 55:7,22 56:20,24 57:5 79:25
80:4,10 82:23 83:17 84:18

operator 62:24

opine 50:15

opined 76:9

opines 13:21

opinion 7:17 51:23 53:7,16 64:11
76:4,12 77:2

opposed 56:20 57:5 82:24 83:17

optimization 73:6,8

optimizing 83:25

option 33:22 63:4

order 11:23 26:17 66:22

outcome 21:4 39:18 62:4 79:6
83:23,25 84:19

outcome's 40:3

outcomes 23:3,19,21 24:17 26:14
38:10,20 40:8 44:21 52:23

outlet 31:15

outlined 75:23

output 20:17,20 21:9,20,21

outputs 23:3 45:7 49:22

owner 12:17

Oxford 66:13,16

P

p.m. 81:22 82:13,14

Pankaj 8:20 14:10 49:5,9,11,12,17
50:15,18,19 51:16,25 52:17 53:7,17
54:16 55:2,6,16 56:19 58:6 59:12,14,
16 62:12 65:5 82:22 83:16

Pankaj's 58:10,21 60:4 61:2,7

paper 28:4

papers 9:13

paradigm 34:14

paragraph 11:15,18 12:1 29:14
50:25 52:7 53:25 54:6 59:13,14,23,25
60:15 61:23 62:13 64:9,10,17 70:11
72:16,17 73:1,5,15,24 74:10,15,17,
24,25 76:17 83:8

paragraphs 59:11 63:23 75:10,13,
14

parameters 45:7 46:10 52:14,15
54:19 55:8,11,24 58:7,10,21 59:17
60:4,6,12,18,21 61:3,5,7 84:1

paraphrase 32:19 part 18:4 54:13 55:16 58:13 76:8 partes 6:23 particles 35:24 particulars 76:5 parties 9:6 pass 82:6 patent 6:24 7:2,17 8:20,21 12:11,16 13:3,10,22 14:10,16,19,23 15:11,13 16:8,13,14 27:5,12 28:10 48:18 50:23 56:3 64:19 67:3,18,24 68:3 Patent's 75:16 patents 7:7 path 78:17,23 paths 33:9,11 78:24 79:22 pattern 38:2 PDF 66:4 pending 47:20 people 10:7 18:5 28:24 38:7 40:5 79:18 perfect 23:13 81:14 perfection 23:1 performed 18:5 83:23 84:17 performing 84:18 permeability 34:6 60:19 person 8:3,5 42:5,10 petition 12:10,13 petitioner 12:9 PGR 6:16,17,25 9:6,7 12:5 13:4,11 14:17 Ph.d. 16:2 phrase 25:13 physical 20:3 physically 17:18,21 pick 19:4 20:17 picking 19:6 piece 50:2 pieces 46:4 place 40:25 41:2 55:20 placement 51:9	places 18:14 49:18 50:21 54:8 play 84:15 plugs 79:11 point 20:9 35:13 76:25 points 78:3 porous 33:5,12 portions 50:19 POSITA 41:22 42:5,7 64:12 post-grant 7:1 12:10 potentially 26:14 pour 34:4 practical 35:3 preamble 74:4 preceded 83:24 Precisely 62:23 predict 51:7 58:3 predicted 52:15 predicting 58:14 predictions 23:2,17 58:17 63:25 preexisting 52:3 preliminary 12:17,20 preparation 11:20 prepare 9:21 10:19,20 11:23 36:12 pressure 33:3,21 35:19 37:17 38:12 39:9,11 50:5 52:10 54:4 60:18 pressures 31:17 38:16 44:12 presume 12:22 18:12 44:10 45:23 71:20 pretty 11:3 51:11 previous 7:5 57:21 62:4 80:5 84:21 principle 24:14 26:5 71:11 principles 31:2 prior 14:8 43:1 76:18 77:4 Privilege 9:24 probe 69:6,9 problem 77:19 proceed 13:7 32:11 58:4 82:10 proceeding 6:16,17,18,23 7:1 9:6,7, 14 13:11 14:17 20:9 63:3,20 64:6 proceedings 7:10 48:3	process 16:3,6,11 22:24 29:13 35:8 36:7,17 37:8,9 61:11 62:4,9,25 63:3, 19 64:6 75:23 produce 25:11 33:1 produced 15:2 23:19 produces 49:22 producing 49:16 55:20 78:13 production 15:17 17:12 33:20 34:24 35:1,2 49:16 54:17 55:6,15,20,22 56:19,24 57:5 58:3,4 73:8,25 82:23 83:17 84:4,18,22 productivity 26:3,18 32:3,7,21 40:19,23 41:7,14,21,25 42:13,20 43:8 44:24 45:3 products 57:23 profile 38:1 program 73:6 prohibit 48:6 propagates 78:8 propagation 51:8 properties 35:14 proppant 21:12 35:16,20 36:14 38:15 50:6 51:5,8 52:10 54:2,4 proppants 59:5 provide 22:21 50:3,7 76:18 PTAB 12:5 48:5 Public 5:3 publications 15:21 18:25 pull 65:13 80:11 pump 15:3 16:18 24:12,20,21,24 25:1,4,10 31:14 36:11,16,21 37:10, 15,22 38:1,9,11,15 39:6,8,15,17,22, 23 40:2,25 41:6,9,12,19 44:11,13,18 45:7 53:1,9,18,21,24 54:5 56:4,21 57:6 71:14,19,21,23,25 72:2 82:24 83:18 84:6,12,15,20 pumping 50:4 54:12 pumps 30:13,15,17,21,25 31:16 37:2 38:21 44:4 59:5 73:16 pure 64:14 purpose 20:22 78:13,22 purposes 35:3 push 33:3 34:6 78:1 put 28:3 35:11 36:16 43:23 57:17
--	--	---

74:22 76:23 puts 36:16 putting 40:24 55:19 Q qualify 32:10 80:2 quality 25:21 quantitative 41:16 question 8:22 10:2,12 16:11 21:19 22:7 25:13,18 26:9 27:25 37:19,20 42:8 47:20 49:8 50:13,14 53:15 55:4 61:1,2 77:7 80:6 questions 19:23 22:19,22 82:6,18 quick 56:7 57:15 R raised 22:19 Rashid 72:8,16,19 73:2,15 74:10,17, 25 rate 16:18 21:6 25:2,11 37:17 39:9,12 52:11 60:19 71:9,14,16 72:4 rates 44:12 50:4 54:5,12 71:2 reach 34:20 read 14:19 51:25 73:13 readable 68:5 reading 60:8 74:5 real 25:18 56:7 reality 35:1 realtime 73:7 reason 67:5 reasons 33:22 64:11 recalibrate 52:12,21 recall 12:2 received 48:24 74:18 receives 31:16 recess 48:12 56:9 81:21 82:13 recite 68:4 recites 48:23 recollection 74:5 reconvene 81:16	record 56:7 65:19 reduce 78:16 refer 51:12,13 55:23 74:7 75:15 79:8 reference 14:1 49:5 63:22 69:23 70:2,10,12,17,22 72:8,11,12 74:14 76:19 77:5 80:12,14 references 10:5 11:9 14:8,13 70:5, 23 72:14 76:23,24 77:11 referred 14:11 75:22 83:10 referring 6:22,25 13:17 22:5 24:25 25:3 36:25 44:10 54:25 60:24 71:19 refers 20:18,19 30:9 49:20 54:10 55:21 74:23,24 84:18 refine 29:3 refined 51:22 reflect 23:9 reflects 22:3,13 refresh 53:11 regulated 71:13 relate 56:23 57:4 related 8:18 10:5 28:23 45:23 56:19 57:11,13 66:22 82:23 83:16 relates 16:7 73:24 relation 10:16 relative 23:12 24:9 relevance 69:18 relevant 15:6 16:25 17:14 24:3 29:3 remember 6:14 55:16 remote 73:12 remotely 73:11 remove 35:22 render 14:9 repeat 22:6 53:13,14 70:15 rephrase 42:8 represent 9:13 20:16 representative 18:7,8,9,20 19:11, 12,15,18,25 20:5,13,21,23,25 22:2,9, 12,18 23:8 24:11 26:2,17 27:16,20,21 28:1,9,12,14 29:16,17 30:10 43:12,13 48:23 49:9 50:16 51:15,24 53:2,9,19 56:4 requires 53:1 56:3 64:19	reread 74:3 research 16:1,20 17:1 reservoir 57:12 60:4,11,13,18 61:3, 7,20,24 respect 7:9 15:7,9,10,12 16:13 18:20 30:24 49:6 58:7 respective 27:13,23 28:7 29:22 respond 43:18 responded 83:1,20 responds 46:1,7,13 79:2 response 12:17,18,21 13:2 27:12,24 28:6,21 29:15,19 46:11,19 48:25 74:19 responses 39:3 responsive 27:13 result 41:13,14 results 25:5,6,12,20,21 36:18 retrieved 74:12 75:2,3,6 retrieving 76:2 reverse 21:18 review 6:23 7:1 11:5,24 12:10,20 13:7,9 reviewed 10:3 11:19 12:4 70:2 72:11,12 reviewing 12:2 ring 79:13 rock 33:2,3,5,8,12,15 35:20,23 36:18 57:12,16,17,25 62:1,2,3 78:2 rocks 33:11,23 room 7:25 8:4,5 10:16 roughly 34:9 36:7 rules 48:6 run 51:7 52:16 S sand 35:17,21,23 Save 66:6 saved 66:8 scale 20:3 scenario 63:24 scenarios 54:1
---	--	--

schedule 37:12,16 38:18 50:3 51:6
schedules 51:7 54:2 64:1,2
scope 49:12 68:21,25 69:4,5,16,20
select 21:2,5 27:15 28:13 29:1 30:2
selected 51:15,24
selecting 29:7 48:23 49:9 50:15
selection 76:24
semi-automated 15:25
sending 69:13
sense 38:8 45:15 46:22
sensibly 40:6
sensitive 45:4
sensor 27:13 29:20 45:20,25 46:3,5,6,9,10 74:13
sensors 15:4 45:23
sentence 60:10,17 62:15 63:5
September 76:11
sequence 46:7 48:25 64:20,23 65:4,8 66:14,17 67:2,9,17,23
serve 78:12
server 73:12
set 20:6 41:4,7 73:9
shale 33:24 34:2,9,17
share 65:20
shared 66:7
shoots 35:13
short 32:25
show 13:16
side 34:16 52:8
similar 20:3 28:23
simulation 20:18 51:6,18 52:15 60:13 61:6,8 62:6 74:7
simulator 58:16 59:3 61:13,24,25 63:25
simulators 57:22
single 14:1 74:8
sir 27:7 72:7 75:11
site 17:17 54:19 55:8,10 57:1 58:11,22 59:18 60:5,20 61:4 71:15,21
situation 5:21 21:25 24:18 27:4 29:5 43:24

situations 20:15 28:18
skill 42:5,10
skin 68:11,12,21,24 69:3
slate 52:19
slurry 21:6
software 49:20,25 50:2,8 54:11
solution 73:8
solving 20:19
sophistication 21:24
Sounds 81:18
specific 27:25 37:10 49:20 50:19 59:3 63:22 75:7 76:1,23
specifically 27:8 48:20 50:14 54:20 72:16 75:9 76:25 79:7
spend 23:15 26:11
spent 23:18
spoke 10:15
Standard 65:7
stands 49:25
start 52:2,6,18,19 53:23 55:20 56:14,15 61:14 62:25
started 78:4
starting 49:15 55:18 64:17 73:4
starts 20:8
state 20:11 73:16 74:11,16,17
stated 14:18 52:7 53:24
statement 37:6 44:16 45:14 63:6 84:9
states 27:12 59:16 60:3 62:15 73:4
stays 35:24
steady 20:11
step 54:20 56:13,18,23 57:2,4 58:8 59:19,25 62:11 82:22 83:11,15,22 84:6,11,14,23
steps 53:7,20,22 57:21 84:21
stimulate 36:19 37:20
stimulating 35:5
stimulation 31:20,24 32:2 37:9 52:13,22 55:16 84:2
stimuli 15:2 27:14,23 28:7,20 29:16,22 46:8,11,13,19,21 48:25 64:20

stimulus 46:1
stop 78:15 79:22,23
stops 79:13
storage 72:20,22 73:11,20 74:12,19 75:2
stored 73:10 75:5
Strawn 7:23 10:7,10
streets 34:16
strike 32:19 57:2 65:2 66:14 83:13
structural 75:15,19
subject 15:21
substance 9:25 48:7 82:2
substantial 12:3
subsurface 37:4,11 38:5 39:24 40:3,9,21 41:5,8,24 42:12,19 43:7,15 44:5 46:15 47:3
succession 67:12,15
suggesting 67:22
summarize 35:9 38:17
summary 14:19 51:11 57:15
Sunoco 5:25
supported 12:13
surface 62:21
sworn 5:3
system 15:23 17:20,22,25 18:7,8,10,20 19:11,12,15,18,25 20:4,6,8,12,13,16,23 22:2,9,13,18 23:8 26:2 27:16,20,21 28:2,9,12,14 29:17 30:11 43:12,13 48:23 49:10 50:16 51:15,24 53:2,10,19 56:5 69:8
systems 17:9 18:2,11 68:4

T

table 76:18
takes 49:21
taking 34:19
talking 16:9 20:1 43:6
talks 49:11,17 50:24
task 22:20 23:5 45:18
tasks 17:9
technical 5:15

techniques 61:9 technologies 14:18 technology 14:16 15:8,10,12 16:7 19:8 36:24 69:12 77:14 78:19 79:14, 16 tells 50:8 term 5:20 23:12 24:4,9 26:21 28:9,14 40:16 65:8 67:2,17,23 73:22 74:6 77:20 79:8 terms 5:22 6:18 9:10 13:7 29:11,12 37:16 test 68:21,24 69:3 testified 5:4 16:19 39:20 56:13,18 testify 6:4 testimony 48:7 82:2,18 tests 68:11,12 text 27:11 thicker 34:3,10 thing 39:5 67:11,14 things 16:15,18 20:4 26:23 36:14 46:21 50:6 54:13 57:11,12,13 58:14 66:23 76:3 Tied 32:16 time 20:9,10 26:11,22 28:17,18 48:1 80:20 times 34:2,9 today 82:19,21 83:15 84:25 today's 9:22 tools 39:13 43:6,11,14 top 19:7 33:6,16 36:2,12 51:17 training 7:14 translated 84:3 transmitting 76:2 travel 33:14,24 36:2 traveling 34:17 traverse 33:7,25 treating 45:11 treatment 31:20 40:11 50:4 51:4,5 52:8,9 54:1,2,4 61:14 84:1 treatments 31:24 32:2 trial 6:4 13:3,10 21:23 trucks 36:11	true 77:9 Tuesday 10:25 tug 23:14 turn 11:10,15 27:5 41:14 48:17 54:7 59:12,23 62:12 64:8 69:21 70:7 72:5 75:8 83:6 turning 67:6 73:1 type 31:19 69:14 typical 39:5 typo 55:1,3 U U.S. 6:24 7:2 UFM 49:21,24,25 54:10 57:22 58:16 59:2,4,6 uh-huh 64:16 67:15 71:6 ultimate 51:9 unconventional 50:1 54:11 understand 12:9,16 13:5 20:5 30:8, 15,17,22 31:1,11 40:16 41:23 42:11 46:14 48:5,9 77:6,8 understanding 14:7 65:7 understands 29:11 39:15 Understood 80:23 universal 71:11 update 55:24 57:19 59:8 61:16,20 62:10 64:2 updated 54:14 55:11 58:19 updating 76:3 upstream 17:10 utilized 9:7 V vaguely 76:21 valid 7:18 45:14 values 27:13 46:9 71:1 valve 71:8,10,12 valves 70:23 71:18 72:3 variability 43:21,24,25 44:19 variable 21:9	variables 21:20,21,22 27:12,24 28:6, 20,21 29:15,19 49:22 50:3 versus 5:25 6:1 viscosity 35:15 60:19 Vizzaro 6:13 W WALTERS 5:6 9:16 13:18 40:13 42:2,15 47:14,23 48:2,11,14 56:8,11 65:1,20,23 66:2 67:21 68:19 80:18,24 81:4,11,15,19,23 82:5,11 wanted 31:9 36:6 war 23:14 Washington 7:23 water 21:6 35:15,18,22 36:9 78:2,7, 15,16 ways 21:2 26:11 39:22,24 63:22 79:19 well-described 35:8 well-known 76:6 wellbore 54:18 55:7 59:17 62:20 74:8 wellbores 55:12 wells 18:2 32:15,17 43:18 44:4,6,19, 23 45:4 wide 21:11 wider 38:13,14 49:12 Winston 7:22 10:7,9 wireless 69:7,14,19 word 42:4 work 30:21 31:10,14 80:6 workflow 51:3 working 16:4 workings 30:20 works 80:9 worse 25:17 26:7,25 47:6,7 worth 26:9,12 52:24 wrong 22:25 39:21 Y years 16:4
---	---	---

zones 71:3,17