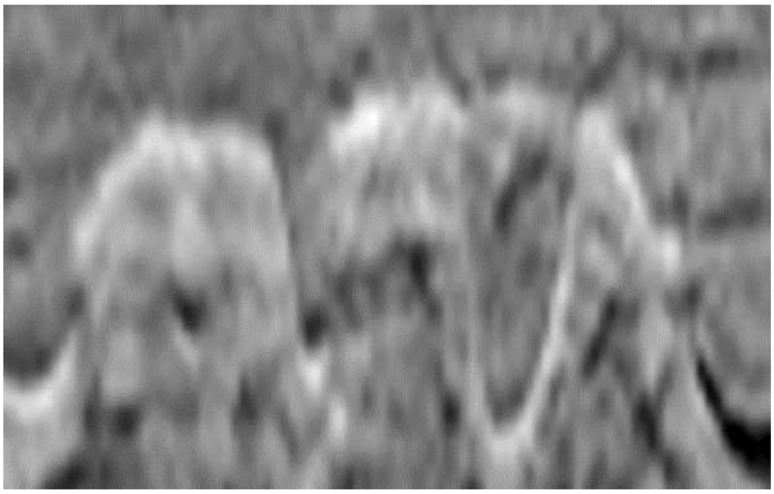
Report

PL 1048 Relinquishment



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Date: 2023-03-20

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1 License history

License details

PL 1048 was awarded in APA 2019 on 14th of February 2020 to Lundin Energy Norway AS (Operator 50%) and DNO Norge AS (50%). After acquiring Lundin in 2022, Aker BP ASA became operator 1st of January 2023 after an interim period since 30th of June 2022 where their fully owned subsidiary ABP Norway AS operated the license.

PL 1048 is covering 538 km^2 in blocks 30/1, 30/2 and 34/11 in the Rungne Sub-basin of the Northern Viking Graben.

Work programme

The focus of the license was to evaluate the prospectivity of the large, mounded structures in the Upper Hordaland Group where the application had identified four large leads at around 1000 meters of depth.

The work program covered seismic re-processing to improve the rather poor seismic quality despite modern broadband 3D seismic survey (CGG-NVG) and geological and geophysical studies.

EM feasibility study and geological/geophysical studies was also part of the work program.

License meetings

The license held four combined MC/EC meetings (16th of April 2020, 17th of November 2020, 17th of November 2021 and 30th of November 2022) in addition to work meetings.

Extension and relinquishment

The license applied for a one-year extension in 2021 to allow completion of a XRD/Qemscan based mineralogical study of the injectites and their host rock. The study was delayed due to Covid-restrictions.

By the end of 2022, the license decided not to drill and to relinquish the license. The main reason for the decision was lack of expected HC-related seismic response and AVO anomalies. Reservoir, trap and source/migration chance was all regarded as relatively high and the main risk was believed to be in-effective seal.

2 Database

2.1 Seismic data

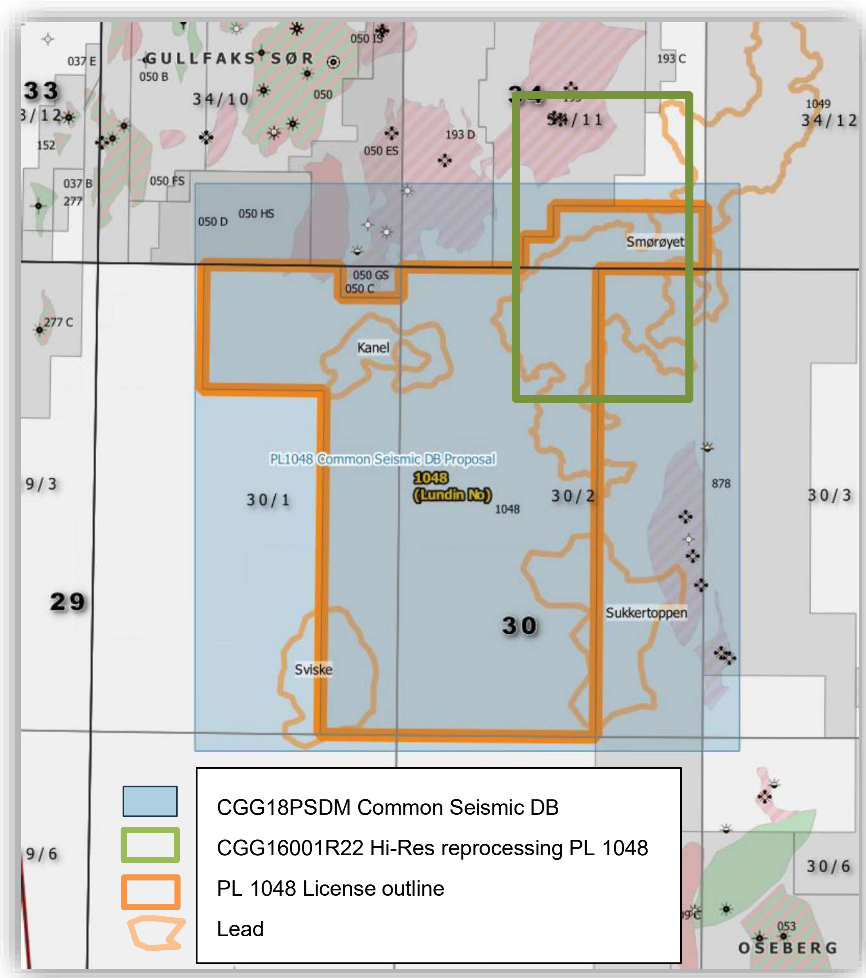

Figure 1 PL 1048 Seismic DB

The seismic database for PL 1048 consisted of a rectangular subset of CGG18PSDM (Figure 1) which covered the license area.

2.2 Well data

The well database for PL 1048 consisted of closest wells in addition to the shallow discovery 25/2-21 Liatårnet which was traded by the partners. In addition, many other wells in the Northern North Sea were used for analog studies.

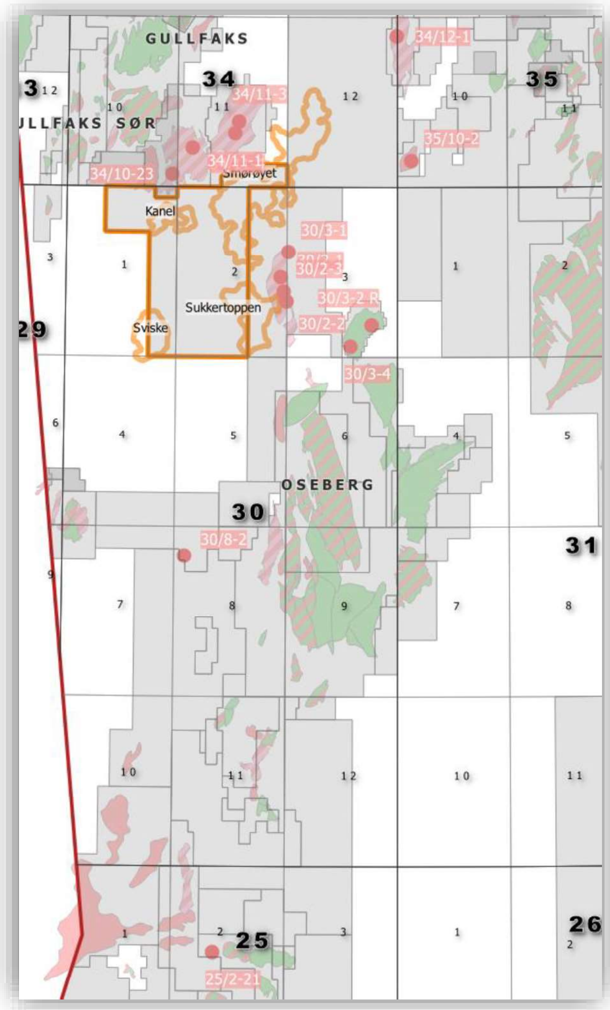

Figure 2 PL 1048 Well DB

Well	Field_Pr	Rationale	Ye	Lundin access	Catego
25/2-21	Liatårnet	Oil discovery in Skade Fm	2019	None	CWDB
30/2-1	Huldra	Close well	1982	Rel 20 years	CWDB
30/2-2	Huldra	Close well	1984	Rel 20 years	CWDB
30/2-3	Huldra	Close well	1992	Rel 20 years	CWDB
30/3-1	Huldra	Close well	1979	Rel 20 years	CWDB
30/3-2 R	Veslefrikk	Close well	1981	Rel 20 years	CWDB
30/3-4	Veslefrikk	Close well	1985	Rel 20 years	CWDB
30/8-2		Upper Hordaland mound. Shallow gas	1996	Rel 20 years	CWDB
34/11-1	Kvitebjørn	Close well	1994	Rel 20 years	CWDB
34/11-3	Kvitebjørn	Close well	1996	Rel 20 years	CWDB
34/11-4	Valemon	Close well	1998	Rel 20 years	CWDB
34/10-23	Valemon	Close well	1985	Rel 20 years	CWDB
34/12-1	Afrodite	Close well	2008	Trade	CWDB
35/10-2		Close well	1996	Rel 20 years	CWDB

Table 1 PL 1048 Well DB

3 Geological and geophysical studies

3D seismic reprocessing

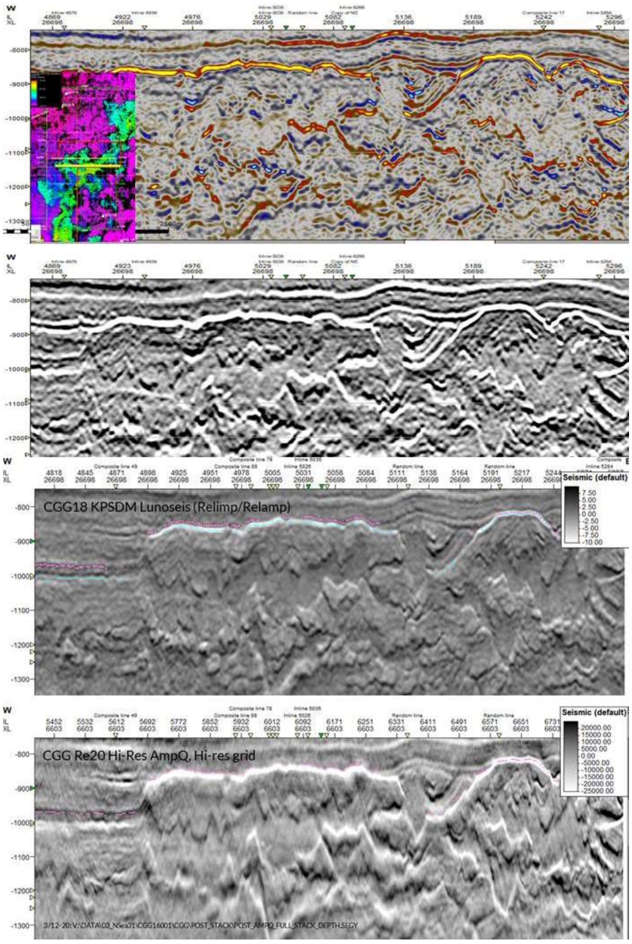

Table 2 Uppermost sections are CGG18PSDM i colour and monochrome displays. Third display is Lundin's Lunoseis (Relimp/Relamp) version of CGG18PSDM and bottom display is re-processed CGG18PSDM (Relimp)

200km^2 of the CGG-NVG 3D seismic was re-processed in the NE part of the license (Figure 1) over the largest lead, Smørøyet. In parallel, an in-house post-stack seismic re-processing/conditioning, combining relative acoustic impedance and reflectivity, was performed for the complete license seismic database and the uplift of this was comparable to the full reprocessing.

Extraction of injected sand bodies using machine learning

In cooperation with Earth Science Analytics, a sand intrusion probability volume was extracted using machine learning, from 15000km^2 of the CGG-NVG 3D seismic survey. Geobody extractions from this allowed regional mapping and connectivity studies of reservoir sand and to calculate the bulk rock volume of the leads.

RWI project and supplementary XRD, QemScan and SpecCam analyses.

The NOROG Released Well Initiative (RWI) delivered XRF and high-quality photos of drill cuttings for all exploration wells.The photos proved crucial in identification of sand which is often ambiguous from logs in bio-silicious host rock. The extended RWI dataset of XRD, Qemscan and Speccam analyses for the 70 most recent wells contained few relevant samples and it was decided in the license to run similar analyses on 100 samples in nearby wells. The analyses confirmed sand in a bio-silicious mud-rock.

Regional mapping and analog studies

In addition to detail license/lead mapping, regional mapping was performed to allow integration of offset wells for a larger area. This allowed us to correlate north to 34/8-A-14H at Visund and south to 30/11-14 (Slemmestad) which both proves more than 100 meters of sand in a bio-silicious mud-rock.

EM feasibility study

An EM-feasibility study was performed and concluded that relatively small HC filled structures would be identified at this shallow depth of burial. The license decided not to acquire EM data because the leads were regarded as having too high risk.

EEI/AVO analysis

Extended elastic impedance volumes with various chi angles were generated from original angle stacks of the CGG18PSDM and from the re-processed version. Very few wells have reliable shear sonic and density logs in the shallow sections, but fluid substitution was performed on the slim hole 34/8-A-14H, which have reliable logs, to understand seismic responses.

4 Prospect update

The rationale behind the decision to apply for the license in APA 2019 was to investigate the prospectivity of the large mounds present in the upper Hordaland Group, over large part of the Northern North Sea. The upper part of the mounded layer was known to be bio-silicious rich fine grained, likely low permeable, mud rock. Blocky sand, assumed to be injectites, was known to be present in the mud rock. The working hypothesis was that if the mounds were also caused my sand injectites we had obvious large traps with thick high porosity sand reservoir below a fine-grained mud rock with sealing capacity. Indications of shallow oil and gas were present in the area which is located above deep Jurassic structures in the deeper parts of the Viking Graben and between producing fields. Via regional work the mounds could be correlated with thick sand under bio-silicious mud-rock, penetrated in Visund well 34/8-A-14, 30/11-14 and 26/10-1 Zulu East, and thus confirm the presence and quality of sand under low permeable cap rock and the exploration concept. In cooperation with Earth Science Analytics (ESA), a sand intrusive probability seismic volume was established by use of Machine Learning. This volume allowed us to establish Top Reservoir "map", thickness, and gross rock volumes (Figure 3 and Table 2). Resources were estimated from GRV using a simple approach with a 2% yield factor (product of N/G:0.6, Porosity: 0.3, Bo:1.1, Recovery:0.2) (table 2). Prospect data for the largest lead, Smørøyet, is shown in table 3.

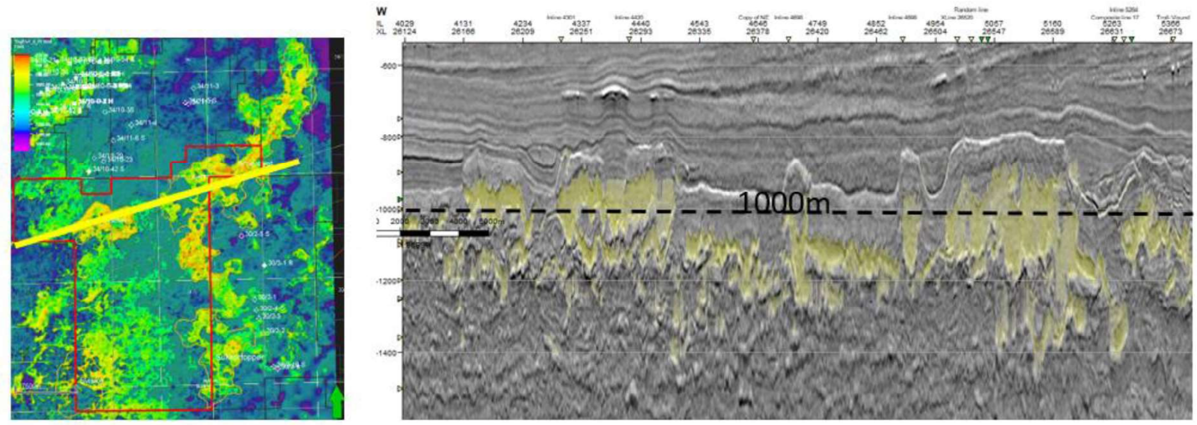

Figure 3 Top of sand intrusives extracted from ESA injectite probability volume and a horizontal plane at 1000m where no connection seem to exist between leads (left), Profile through the Kanel and Smørøyet leads with intrusive sand highlighted in yellow (right).

Lead	OWC (m)	GRV (MMm3)	GRV in PL1048	In PL1048 (%)	2% yield	2% yield in PL1048
Smørøyet	1075	10507	4825	0.46	210	97
Smørøyet	1000	3793	2137	0.56	76	43
Smørøyet	975	2272	2132	0.94	45	43
Sukkertoppen	1075	1973	734	0.37	39	15
Sukkertoppen	1000	507	169	0.33	10	3
Sukkertoppen	975	260	57	0.22	5	1
Kanel	1000	1061	1061	1.00	21	21
Kanel	975	682	682	1.00	14	14
Sviske	1000	824	614	0.75	16	12
Sviske	975	396	283	0.71	8	6

*2%yield e.g. n/g:0.6, Por:0.3, So:0.6 Bo:1.1 Rec:0.2

Figure 4 Gross rock volumes of leads based on ESA intrusive volume. Most likely contact where leads does not seem to connect above. Recoverable volumes just indicated by a simple yield factor as risk was seen as the main issue and not the volumes which anyway would be sufficient.

AVO work showed that the top interface of the mud rock, towards overlying clastic Utsira Fm sand or claystone usually is associated with an AVO 4 response. The top of the sand below is only associated with a "hard" AVO response that is unlikely related to HC and a flatspot that would be expected in the thick sand is never seen. Modelling indicate that HC filled sand in a bio-silicious host rock could be invisible on full stack data if filled with oil or gas but should likely be seen on offset data.

The fact that no surprise discoveries have been made in this interval, despite the more than 1000 well penetrations, suggests that one of the play risks are high. The relative impedance seismic displays and the intrusive probability attribute overlay indicate that low permeable consolidated bio-silicious mud-rock is heavily fractured and that the fractures are filled with sand and often connects with, and leaks to the overburden (Figure 5).

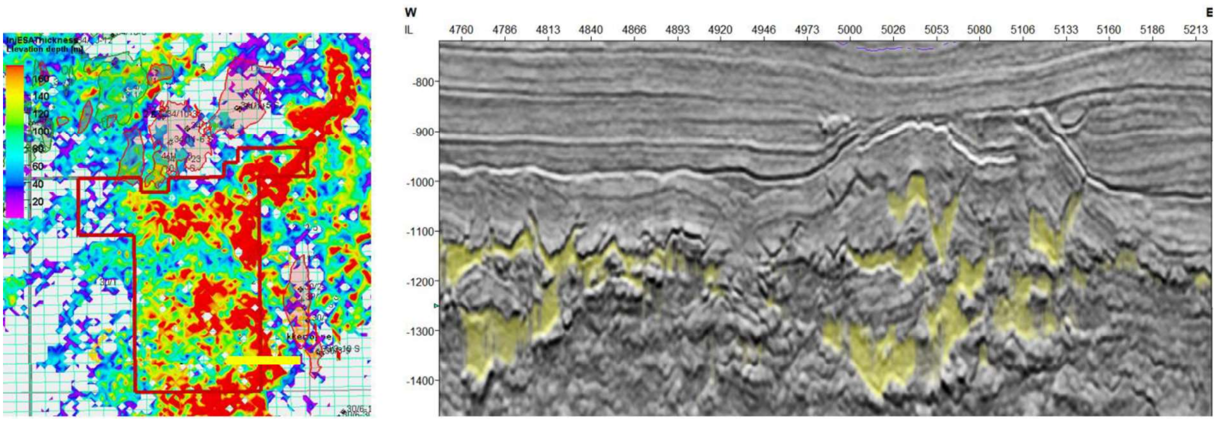

Figure 5 Seismic profile across the Sukkertoppen lead gives no hint of seismic flatspot in sand intrusives and fractures can be seen to connect with overburden.

Block	30/2,34/11,12	Prospect name	Smørøyet	Discovery/Prosp/Lead	Lead	Prosp ID (or New!)	NDP will insert value	NPD approved (Y/N)	
Play name	NPD will insert value	New Play (Y/N)		Outside play (Y/N)					
Oil, Gas or O&G case:	Oil&Gas	Reported by company	Lundin	Reference document	APA 2019 Application			Assessment year	2019
This is case no.:	1	Structural element	Rungne/Magne Sub-b	Type of trap	Structural	Water depth [m MSL] (>0)	125 to 270m	Seismic database (2D/3D)	3D
Resources IN PLACE and RECOVERABLE		**Main phase**				**Associated phase**			
Volumes, this case		Low (P90)	Base, Mode	Base, Mean	High (P10)	Low (P90)	Base, Mode	Base, Mean	High (P10)
In place resources	Oil [10^6 Sm^3] (>0.00)	78.88	143.467	237.541	435.012	0.402	0.85	2.2	4.572
	Gas [10^9 Sm^3] (>0.00)	1.053	2.603	5.308	10.58	4.764	6.586	14.343	26.349
Recoverable resources	Oil [10^6 Sm^3] (>0.00)	26.429	51.389	101.108	201.542	0.18	0.29	1.157	2.476
	Gas [10^9 Sm^3] (>0.00)	0.445	1.132	2.79	5.889	1.571	3.013	6.107	12.108
Reservoir Chrono (from)	Miocene	Reservoir litho (from)	Skade Fm.	Source Rock, chrono primary	Kimmeridgian	Source Rock, litho primary	Draupne Fm.	Seal, Chrono	Neogene/Miocene
Reservoir Chrono (to)		Reservoir litho (to)		Source Rock, chrono secondary	Neogene Lignites	Source Rock, litho secondary		Seal, Litho	Eir/Skade
Probability [fraction]									
Total (oil + gas + oil & gas case) (0.00-1.00)	0.16	Oil case (0.00-1.00)	0	Gas case (0.00-1.00)	0	Oil & Gas case (0.00-1.00)	1		
Reservoir (P1) (0.00-1.00)	0.8	Trap (P2) (0.00-1.00)	0.4	Charge (P3) (0.00-1.00)	0.7	Retention (P4) (0.00-1.00)	0.7		
Parametres:	Low (P90)	Base	High (P10)	*Comments*					
Depth to top of prospect [m MSL] (>0)	930	987	1050						
Area of closure [km^2] (>0.0)	50	100	150	*An oil and gas case is seen as most probable from a basin modelling point of view while the lack of seismic indications and assumed limited seal capacity points to an oil case. We have selected to estimate resources only for the oil and gas case keeping in mind that even considerable gas cap of 20-60 m represents only a moderate gas volume and we find that adding additional cases to very uncertain estimates does not add value and hence we have set the probability of a pure oil or a pure gas case to 0 above.*					
Reservoir thickness [m] (>0)	20	70	200						
HC column in prospect [m] (>0)	80	110	130						
Gross rock vol. [10^9 m^3] (> 0.000)	2.70	4.70	6.70						
Net / Gross [fraction] (0.00-1.00)	0.23	0.39	0.57						
Porosity [fraction] (0.00-1.00)	0.20	0.25	0.31	*Water saturation in oil zone, Sw = 1 - OilSaturation (So)*					
Permeability [mD] (> 0.0)	30	300	1000						
Water Saturation [fraction] (0.00-1.00)	0.25	0.30	0.35						
Bg [Rm3/Sm3] (< 1.0000)	0.01562	0.01282	0.01111						
1/Bo [Sm3/Rm3] (< 1.00)	0.79	0.83	0.87						
GOR, free gas [Sm^3/Sm^3] (> 0)	1667	2353	4000						
Gor, oil [Sm^3/Sm^3] (> 0)	55	60	66						
Recov. factor, oil main phase [fraction] (0.00-1.00)	0.30	0.40	0.50						
Recov. factor, gas ass. phase [fraction] (0.00-1.00)	0.30	0.40	0.50						
Recov. factor, gas main phase [fraction] (0.00-1.00)	0.50	0.60	0.70						
Recov. factor, liquid ass. phase [fraction] (0.00-1.00)	0.50	0.60	0.70	For NPD use:					
Temperature, top res [^oC] (>0)	35			Innrapp. Av geolog-init:	NPD will insert value	Registert - init:	NPD will insert value	Kart oppdatert	NPD will insert value
Pressure, top res [bar] (>0)	10			Dato:	NPD will insert value	Registret Dato:	NPD will insert value	Kart dato	NPD will insert value
Cut off criteria for N/G calculation	1. PHIE>.1	2. Vsh<0.5	3.					Kart nr	NPD will insert value

Table 3Smørøyet Lead summary from APA 2019 application

5 Technical evaluation

n/a

6 Conclusion

The obvious traps, with sand in mounds under low-permeable ooze, are not prospective due to fractures in the top seal are likely filled with sand, and connected to the sandy overburden.