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Seismic data acquisition in logistically difficult area of Karbi-Anglong, Assam - a case study

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Summary

The upper Assam shelf, a south-east dipping shelf is the foreland part of Assam-Arakan Basin. It is bounded by the shield of Mikir hills towards its west and Mishmi hills along its north-eastern boundary and mostly covering Naga- thrust fold system. The upper Assam shelf contains about 7000m thick sediments of mostly Tertiary and Quaternary age. Seismic data acquisition work has been carried out in the Karbi Anglong area which is one of the most challengeable tasks for any organization in terms of socio- environmental issue, logistical approach and difficult terrain with forest covered area. The area of study located in the southern part of Assam and Assam-Arakan basins with exceedingly undulating and customarily inaccessible and covered by vegetation, dense forest. The area has moderately rugged topography varying upto 700m which falls in the Karbi-Anglong district in Assam state. The area of study is totally virgin and there is no geo-scientific data acquired so far in this area. The objective of this study is to evaluate the 2D seismic data acquisition parameter and prospect generation for exploratory drilling location. More than 300 GLKM seismic data has been acquired in the different field season during 2009-2011. Acquired seismic data processed, interpreted and identified few prospects location with various remarkable faults and thrusts. Seismic study suggested that the Eocene formation in Hatikhali area seems more prospective in terms of hydrocarbon entrapment showing good reflection in the seismic section. Based on this work, some exploratory drilling locations are also proposed which is under review.

Keywords: Seismic Data Acquisition, Assam Arakan Basin

Introduction

The operational area is situated in between Lumding in northern part and Halflong area in the southern periphery of the operational area. The eastern part is surrounded by Mishmi hill and covered by Naga fold-thrust belt and western part covered by Shillong plateau and Mikir hill. The location map of the study area is shown in **Figure 1.** The entire area is covered by thick vegetation and moderately rugged topography varying from 300m to 700m. Many parts of the operational areas are not approachable due to non-availability of motorable roads. Apart from rugged topography, the socio-political conditions in the area contemporaneous major constraints in smooth field operations. The socio-political conditions in the area extant major constraints for smooth field operations. Oil India Limited (OIL) started 2D seismic data acquisition during the field seasons 2006-2009, but could not continue due to insurgency and environmental problems. OIL again initiated seismic data acquisition in 2009 and continued till 2011 and acquired 300 GLKM of 2D seismic data successfully. During the acquisition, OIL has lost valuable time due to insurgency, adverse law and order situation and abduction of crew members including misapplication of mammoth amount of man power and exertions. In spite of great difficulties and adverse environmental conditions prevailing in the entire area of operations, OIL has successfully completed the seismic data acquisition work.

In this paper attempt has been made to study the seismic parameters for data acquisition and to identify the drillable prospect location in this area. To design the seismic parameter prior to seismic data acquisition work experimental survey has been carried out at different depth and charge size. More than 60 number of uphole survey carried out with each of 40 m depth to identify the sub- weathering formation and source and receiver statics. Charge and depth optimization carried out in one of the seismic line using infield ProMax Processing software for providing higher S/N ratio with wider bandwidth.

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Figure 1: Map showing the location of the study area. Lumding situated in the northern part and Halflong situated in the southern part.

Geology of the area

The present study area is situated in the southern part of south Assam shelf. There is no well information for identifying different formation boundaries. Some geological field modeling study carried out across the study area in south-west to north-east direction. One well Rajaphe-1 was drilled during 1992-93 with a depth of 3872 m which was located in Nagaland about 50 km from the NE direction of the study area. The presence of oil (1%) at Tura formation was reported, however no oil encountered at Sylhet formation. In this study area, only information available is only 2D seismic data and geologically modeling work. Based on the present scenario, identifying the prospects at different formations are studied utilizing 2D seismic survey works.

Seismic study suggested that the Eocene formation in Hatikhali area seems more prospective in terms of hydrocarbon entrapment showing good reflection in the seismic section. ONGCL has probed some oilfields located in the NE side of the study area and also identify potential reservoir of hydrocarbon of gas at the southern part of the study area. The present Hatikhali structure is moderately large and details study is required for understanding the prosperous of the area.

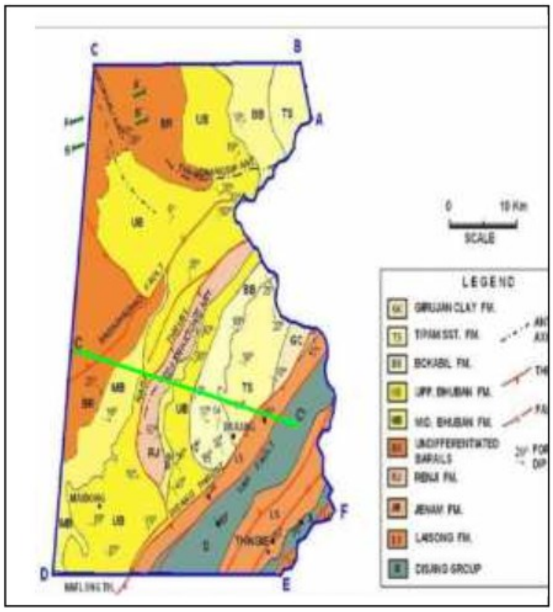

Figure 2. Geological map of the study area shows different exposed geological formations on the surface (DGH docket).

Different surface geological formations are observed based on field mapping data in the study area. Three major anticlines namely Hatikali and Thangnangsip anticlines in the shelf part in the north and Nutanhajong anticline in the Naga Schuppen zone are present in the area. Mostly Sylhet, Kopili and Barail shales are the source rocks. Basal clastics, sands within Sylhet, Kopili and Barail may act as regional cap rock. In addition to that shales within the reservoir also can act as cap rock. It is also suggested that in the east of Naga thrust, Disang and Barail shales may act as source rock. Barail and lower Bhuban sands act as reservoir rocks and middle Bhuban act as regional cap rock Prospective zones in the Hatikali, Thangnangship and Nutanhajong anticlines are expected to be in the fractured

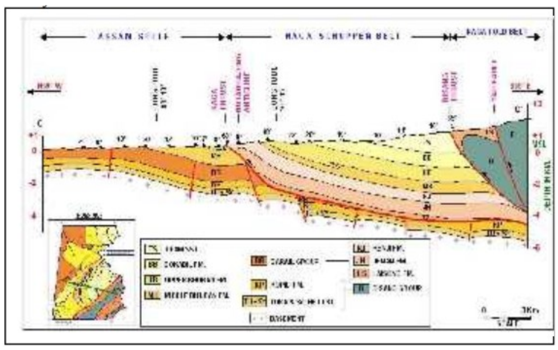

Figure 3. Geological cross section along the profile C-C' (reference: DGH docket)

Logistics and Topography

The study area is situated in the southern part of Assam state and covers Karbi-Anglong and Dima Hasao districts. The western part of the block is connected by road and railway and the rest of the part are not well-connected by road. Lumding is the nearest railway station situated in the northern part and is well connected to Guwahati and Dibrugarh while meter gauze from Lumding to Silchar connects through villages and towns on the southern parts of the area. There is scarcity of connecting roads to other parts of the block except few slip roads and foot paths. The northern part is covered by Dhansiri reserve forest and Langting Mupa reserve forest. The entire area is covered by thick vegetation and is moderately rugged topography. Many parts of these forests are not approachable due to lack of motorable roads. **Figure 4** shows the difficult terrain with mixed dense forest in the operational area. The only highway is passing through the western part of the block. The details logistics with the seismic lines and the landmarks points are shown in Figure 8.

Figure 4. Figure shows difficult terrain and dense forest

Experimental survey

Experimental survey works carried out different depths at 12m, 14m, 16m, 18m, 20m, 22m, 25m for single hole utilizing three different charge sizes for 2.5 kgs, 3.5 kgs and 5 kgs. The spread length covers 120 channel with group interval of 40 m and shot interval of 80 m having near offset 60 m and far offset 4820 m. Analysis of charge depth optimization carried out in the field site using ProMax Processing software. The Schematic experimental pattern including shot hole depth and charge sizes (**Figure 5) and** the corresponding amplitude spectrums (**Figure 6a**) are known. It is studied that the charge size with higher depth provides better S/N ratio with wider spectrum. Spectral analysis of different charge size and depth (20 m 2.5 kg;, 20 m, 3.5 kg and 20 m 5.0 kg) are studied which is shown in **Figure 6a**. The best S/N ration with wider band 20 m depth with charge size 5 kg continued for the seismic survey work. This test line survey has been carried out at Line B. Shot hole depths are drilled with 5 m offset. The experimental shot hole depths locations are shown in red circles and marked from A to U. Receivers are kept at 40 m offset and marked as blue triangle. Along the line 18 m depth holes are carried out and 12m, 14 m, 16 m are drilled in the front side and 20 m, 22 m and 24 m are drilled behind the experimental line B. The ground roles are observed due to low velocity layer at shallow depth.

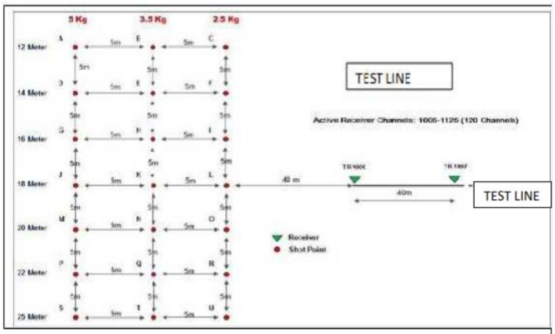

Figure 5. Schematic experimental shot pattern and shot hole depth in a test line.

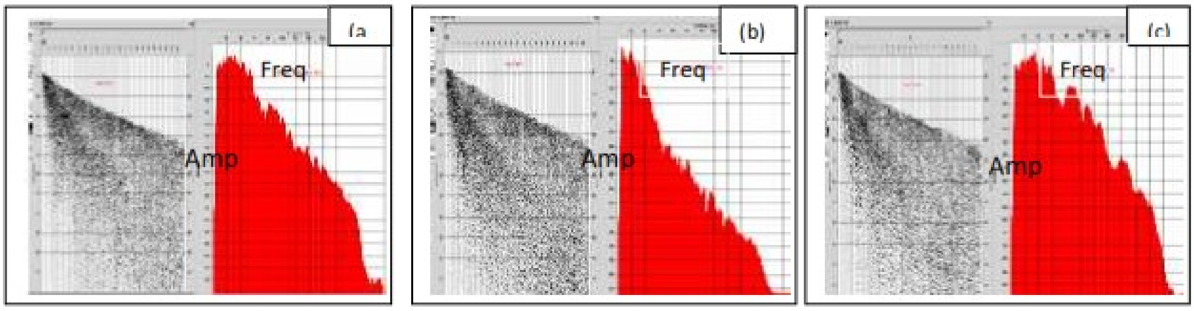

Figure 6a. Spectral analysis of charge size and depth optimization. (a) 20 m depth with 2.5 kg charge size, (b) 20 m depth with 3.5 kg charge size and (c) It shows that charge size 5 kg with 20 m depth shows better signal strength with extended bandwidth.

FFID	Depth	Charge	Bandwidth				Bandwidth	Freq (Peak)	Notches
			Freq (Min)		Freq (Max)				
	(m)	(Kg)	(Hz)	dB Power	(Hz)	dB Power	(Hz)	(Hz)	
5	12	2.5	5.68	-9.55	56.8	-10.1	51.12	29.4	Not Seen
6	12	3.5	5.05	11.7	42	10.4	36.95	17	34.1Hz/ 11.6dB 36Hz/ 12.2dB
7	12	5	4.74	-12.4	31.6	-10.7	26.86	17	Not Seen
8	14	2.5	5.05	-12.8	53.3	-10.1	48.25	29.7	48.0Hz/-10dB---51.1/-9.94dB
9	14	3.5	4.74	-11.8	44.8	-10.4	40.06	17.4	Not Seen
10	14	5	4.74	-10.8	40.1	-10.2	35.36	25.3	Not Seen
11	18	5	4.74	-11.3	93.8	-11.3	89.06	28.7	52.4Hz/-10.3dB---54.3Hz/-9.93dB 69.1Hz/-11.3dB---70.7Hz/-11.2dB 78Hz/-10.6dB---82.7Hz/-10.1dB
12	18	2.5	5.05	-12.5	87.4	-10.3	82.35	46.4	65.3Hz/-11.3dB---80.8Hz/-10.2dB
13	20	5	4.74	11.5	60.9	10.4	56.16	34.7	Not Seen
18	20	2.5	12.9	9.49	86.2	10.4	73.3	46.4	Not Seen
19	20	5	12.3	-9.88	77.7	-10.2	65.4	44.8	60.3Hz/-10.3dB
20	23	6	4.42	-11.6	40.7	-10.4	36.28	26.2	Not Seen
21	23	5	4.74	-10.7	59	-10.8	54.26	34.4	Not Seen
22	15	5	4.42	-11.8	51.8	-10.8	47.38	27.8	47.4Hz/-11.5dB---49.9Hz/-10.1dB
23	16	7.5	4.42	-12.7	34.4	-11.9	29.98	6.95	28.7Hz/-11.9dB---30Hz/-10.6dB
24	16	3.5	11.4	-10.2	57.1	-10.2	45.7	27.1	Not Seen
25	15	5	4.74	-10.5	36.3	-11.1	31.56	8.21	Not Seen

Figure 6b. Frequency –Amplitude spectra map for different charge depth analysis carried through experimental survey.

Seismic data acquisition

A high quality 60-fold 2D seismic data was acquired with latest state of art 24 bit telemetry system using compatible accessories like cables, geophones. Latest mechanized shot hole drilling rigs has been to drill to a depth of 20m. More than 300 GLK of 2D seismic data was acquired. OIL has faced problems of insurgency, abduction, adverse law & order situation during the seismic data acquisition. However, view above points Oil has successfully completed the acquisition work by overcoming these problems. The examples of the raw shots show the better quality of seismic data **(Figure 7).**

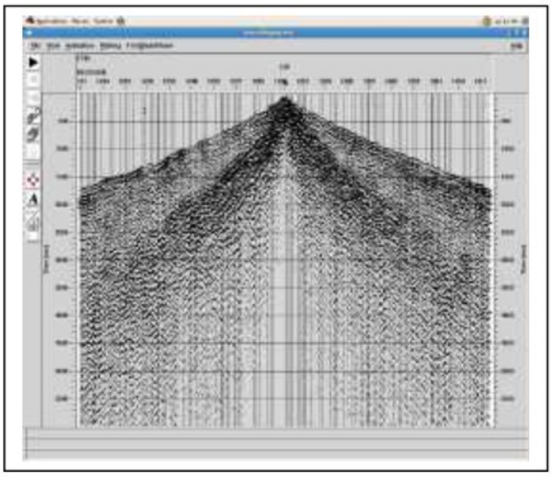

Figure 7. Raw shot records indicating good energy penetration

Seismic data Processing

The acquired seismic data was processed at OIL's in-house processing center, Duliajan. The results of the few processing sections (Line A, B, C and D) are shown in the following **figures 8**. The results suggest that the profiles which are passing from NW-SE directions (Line A and B) are dipping with varying depth. It is studied that the NW part of the study area, basement depth is shallower compared to the SE part. However, WS-NE profiles (Line C and D) are moderately dipping. The area is faulted and thrusted and due to this reason, the energy penetration is comparatively less in the study area. The sample processing sections NW- SE orientation are shown in line A and B and the SW-NE oriented seismic sections are shown in line C and D (**Figure 9).** The interpreted seismic section (line B) is shows in Figure 10 with different thrust/fault and geological formations.

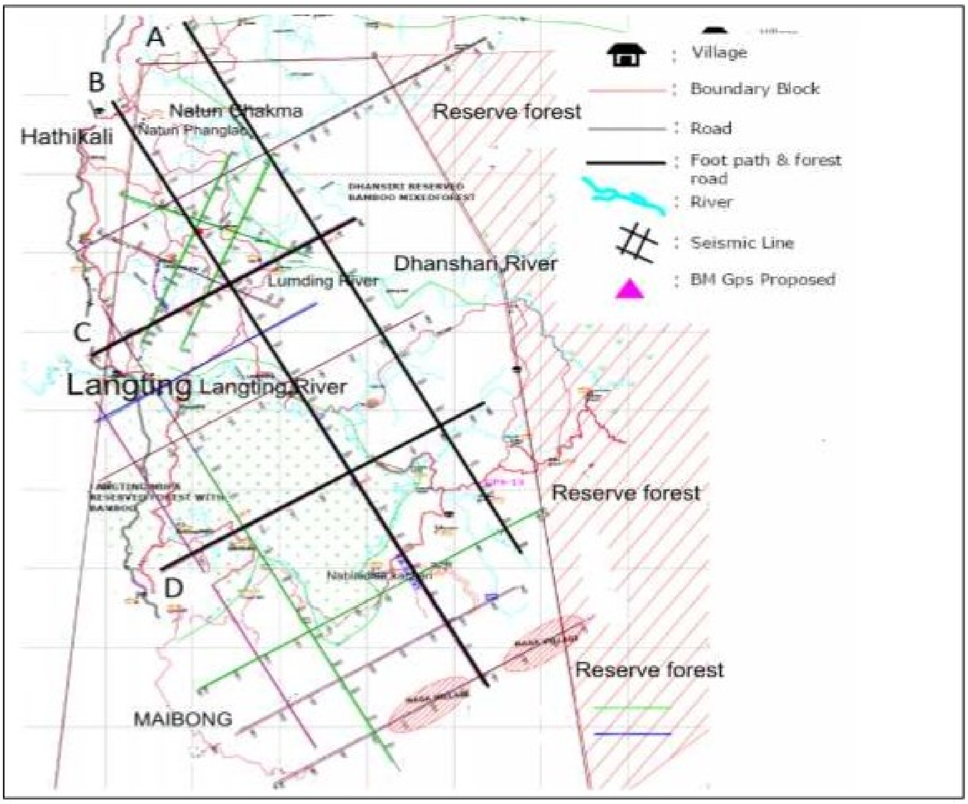

Figure 8. Map shows the seismic lines acquired during the 2009 to 2011. North-western part shows prospect which has been identified. Relinquished part shown in the eastern part. The only highway is shown in the western part of the block.

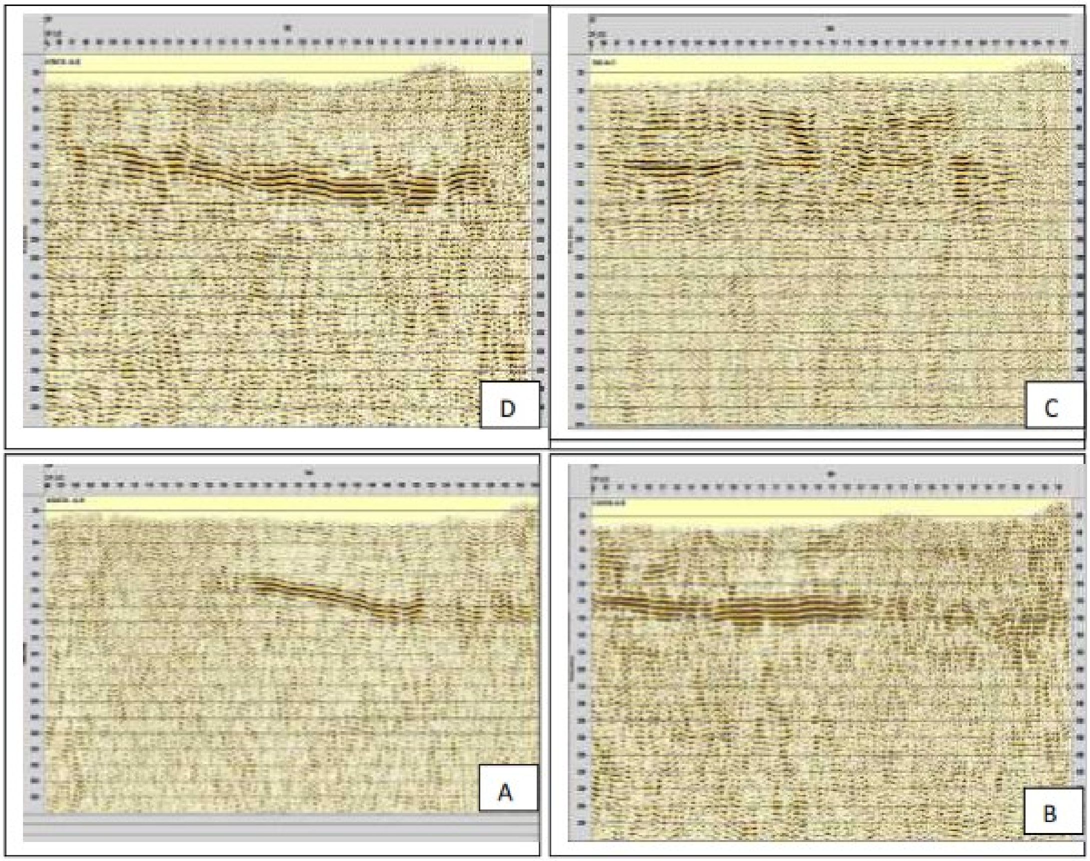

Figure 9. Seismic processing sections (Line A, B, C, and D) passing through NW-SE and SW-NE directions as shown in Figure 8.

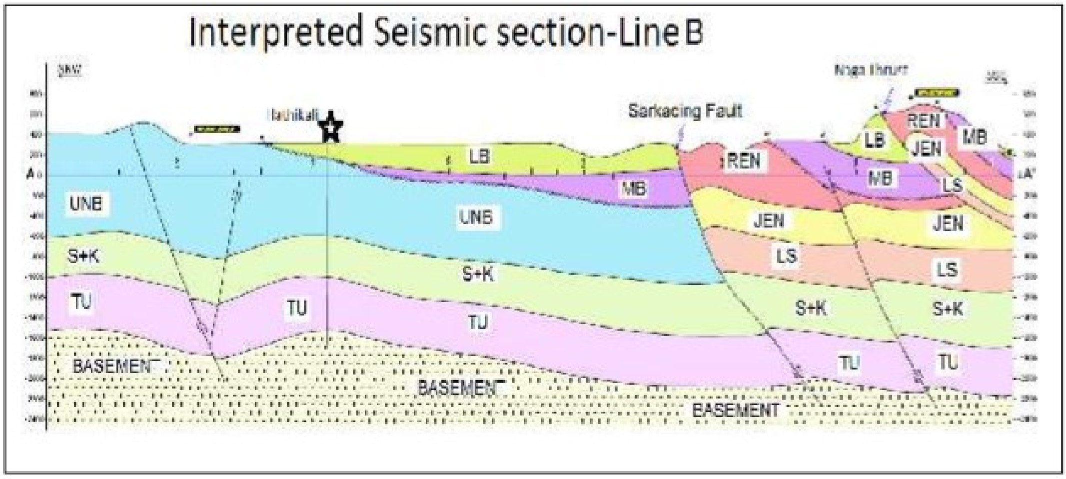

Figure 10. One of the interpreted seismic sections (Line B) is shown in Figure 10 shows different geological formation.

Interpretation of seismic data

Interpretation of seismic data was carried at OIL's in-house TEAM center and identified few prospects which are being under study. The prospect location for probable drilling location is shown in the Figure 8. The different geological formations are marked in one of the interpreted seismic section (line B) which is oriented in the NW-SE direction. In the NW part of the area, the Lower Bhuban and Middle Bhban are eroded. The part of the Renji formation is also eroded. The deeper basement is noted in the SE part compared to the NW part. The more thrusted and faulted lithology is noted in the SE part compared in the NW part of the study area. One of the interpreted seismic sections (Line B) is shown in Figure 10, shows different geological formation. The Sarkading Fault and the Naga thrust are also projected. The Prospect zones are within the Sylhet-Kopili and Tura formation.

Conclusions

The area of operation located in the southern part of Assam & Assam-Arakan basins. The operational area is highly undulating and largely unapproachable. It is covered by thick vegetation and forest and has moderately rough topography varying upto 700m. The socio-political condition in the area poses major constraints in smooth field operations; however, OIL has successfully completed the seismic data acquisition, processing and interpretation. The Study suggests that the Eocene formation in Hatikhali area seems more prospective in terms of hydrocarbon entrapment showing good reflection in the seismic section. The interpreted seismic section suggests that the basement depth is in higher in the SE part compared to the NW part. It is suggested that NW part of the study area is less thrusted and folder compared to the SE part. The dominated Sarkading Fault and Naga thrust are marked in the section. The Renji and Jenam formation are eroded in the NW part of the profile (refer Figure 10, seismic line B). More probable prospects are expected within the Sylhet-Kopili (S+K) and Tura (T) formation. Based on this work, some exploratory drilling locations are also proposed which is under review.

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