UNIVERSITY OF PETROLEUM & ENERGY STUDIES

End Semester Examination – December, 2017

Program/course: M.Tech PE **Semester : III**

Subject: Geophysical Data Interpretation **Max. Marks : 100**
Code : MPTI-809 **Duration : 3 Hrs**
No. of page/s: 06

<u>SECTION A:</u> Answer all the questions. **[4*5=20 marks]**

1. Draw a two way time (TWT) contour maps representing a dome and a basin.
2. Draw a subsurface condition indicating a reverse fault with an unlimited closure having dip of the bed against the fault plane.
3. Evaluate the porosity of sandstone formation, if the interval transit times of the formation, matrix and fluid are 70 µs, 55 µs and 190 µs respectively.
4. Why bulk density log cannot be used as a lithology indicator? What will be the bulk density of a sandstone reservoir fully saturated with water and having porosity 25%.

<u>SECTION B:</u> Answer all the questions. **[4*10=40 marks]**

5. a. Write a short note on leaking and sealing faults. What are their roles in hydrocarbon exploration? [04 marks]
   b. Explain how a HK type 4 layer resistivity curve will be interpreted using a two layer master curve? [06 marks]
6. A gravity survey is conducted over a highly compacted ore deposit (horizontal cylinder shape). Bouguer anomaly values reduced along a profile are given below.
   a. What is the depth to the center of ore deposit?
   b. What is excess mass in metric tons by the deposit?

Distance (m)	Gravity anomaly (mGal)	Distance (m)	Gravity anomaly (mGal)
0	0.25	3600	4.00
400	0.35	4000	3.50
800	0.50	4400	2.60
1200	0.80	4800	1.50
1600	1.50	5200	0.80
2000	2.60	5600	0.50
2400	3.50	6000	0.35
2800	4.00	6400	0.25
3200	5.00		

7. Stratigraphic features frequently are better imaged by Coherence Cube processing, a recently perfected methodology that maybe applied either after or during the processing of 3Dseismic data and utilized during the interpretation to further reveal the stratigraphic trap. Anon- traditional procedure, Coherence Cube processing, which was developed in the geophysical labs at Amoco and licensed exclusively to Houston-based Coherence Technology Company, processes 3D seismic data not for imaging reflections, but for imaging discontinuities by analyzing waveform similarity. Traces that are similar to each other are mapped with high-coherence coefficients, and when similarities end, discontinuities maybe inferred. As a consequence, when visualized in a 3D volume or cube, coherence coefficients enhance the detection and understanding of stratigraphic features (as well as faults) that are often not visible in traditionally processed data.

   Stratigraphic features are frequently difficult to see in seismic data due to the low level or chaotic nature of the seismic reflections they provide. Coherence Cube processing brings stratigraphic features into focus as it computes the variations in the waveform regardless of the amplitude of the reflectors. Lateral definition of these stratigraphic features can be seen best in the horizontal or time domain. In areas of high dip or where stratigraphic features transit different strati- graphic horizons, flattening of key surfaces, horizon slices, maybe beneficial in obtaining a greater understanding of the stratigraphy contained in the dataset. However, interpretive bias can enter the dataset when using horizon slices in tracing strati- graphic features, since a geoscientist is required to go through the difficult, time-consuming and subjective process of picking the horizon.

   The Coherence Cube technique increases the probability of finding hydrocarbons by indicating stratigraphic (and structural) traps that were not visible with traditional procedures. Estimates of 3D dimensional seismic coherence are obtained by calculating localized waveforms within the regular grid of a 3D seismic dataset. A sharp discontinuity is produced by stratigraphic boundaries. In areas such as the Gulf of Mexico, where high seismic amplitudes frequently indicate hydrocarbon accumulations, their stratigraphic milieu is more readily identified from coherence data because they provide a different perspective in combination with amplitude data.

   a. Briefly explain how ‘coherency attribute’ helps in detecting a fault?
   b. For a basin having only fault-related traps, 3D seismic volume on a time slice of 540 ms shows two anomalies A and B with high amplitudes. A is associated with lower coherence coefficient while B is with comparatively higher coherence coefficient value. Out of A and B which anomaly should be drilled and why?

8. a. Derive an expression for acceleration due to gravity for a spherical body.

   b. A spherical cavity of radius 8 m has its centre 15 m below the surface. If the cavity is full of sediments of density 1.5×10^3 kg/m3 and is in a rock body of density 2.4×10^3 kg/m3. What is the maximum value of its gravity anomaly in mGal?

<u>SECTION C:</u> Answer all the questions. **[20*2= 40 marks]**

9. **<u>Case study: Growing Importance of non-seismic methods in hydrocarbon exploration</u>**

Petroleum exploration involves high science & high technology with huge expenditure. In the low price regime of petroleum, it is necessary to minimise exploration costs. Thanks to modern techniques in Gravity-Magnetic (GM) and Magneto-telluric (MT) that are popularly known as Non-seismic methods through which sub-surface imaging is cost effective, cover large areas rapidly, non-invasive and environment friendly way. India is importing nearly 80% of its petroleum requirements in spite of having 26 sedimentary basins along with large offshore exclusive economic zones. Its exploration efforts are hampered partly due to half of these basins are seismically challenging and lack of awareness about modern GM & MT techniques. Since the dawn of 21st century across the world more than hundred giant Oil & Gas fields including thirty super giants were discovered. India being a sub-continent might have huge deposits of petroleum, hither to hidden and are to be discovered. The first step in exploration is imaging of sub-surface. During early twentieth century imaging was carried out with the help of Gravity-Magnetic surveys. Soon Seismic imaging changed the Oil & Gas exploration and continues to play a vital role though it has limitations such as limited energy penetration in trap covered areas and environmental issues. Here the importance and advantage of Gravity-Magnetic over Seismic is that the GM data can be acquired from air and cover large areas in short time overcoming logistic difficulties. Latest developments in instrumentation, high speed computers with ability to handle large volume of data, improvements in Satellite positioning made GM & MT techniques made possible dramatic changes in the exploration arena. Some of the latest techniques are Microgravity, Airborne Gravity Gradiometry (Tensor gravity) and Borehole Gravity (BHG). The acquisition cost of GM & MT data is considerably less. In today's risk averse and environmentally aware exploration world, in geologically complex areas non-seismic techniques are the best bet for unrevealing the mysteries of sub-surface. Currently, Russia, China operates more than hundred GM & MT Geophysical Field Parties for Oil and Gas exploration. Australia, Brazil, and even less developed countries like Peru, Ghana, Tanzania, Angola, etc. have fully covered their countries with Aero Gravity-Magnetic surveys. Tensor Gravity data helped to reprocess seismic data for imaging below pre-salt structures in the extensively explored Gulf of Mexico and Brazil Offshore, resulting discovery of giant fields. Realising the importance of Non-Seismic techniques in petroleum exploration in India Oil and Natural Gas Corporation (ONGC) through its premier research Institute viz. Kesava Deva Malaviya Institute of Petroleum Exploration (KDMIPE), Dehra Dun revived a GM (R&D) field Party. ONGC also introduced MT surveys in 2008. Since then the GM Party acquired GM & MT data in Cambay, Caurvey, KG and PG and Vindhyan basins. The data was processed and interpreted in-house at KDMIPE, and trained manpower has been created in a short span of time. The Party carried out Microgravity surveys in Periyapattinam, Kanjirangudi fields, Cauvery basin and Ankleshwar field, Cambay basin to identify low density sands that are envisaged to be gas bearing and validated by drilled wells. Basement maps have been prepared based on GM & MT data in trap covered Vindhyan basin and Mandapeta field, KG basin. The Vidhyan map indicated that a ridge connecting basement exposed Bundelkhand with Hosangabad is the one separating Chambal Valley and Sone Valley. Whereas, Basement map of Mandapeta brought out clearly major and minor faults. Combining ship borne Gravity-Magnetic data with Satellite Gravity and published literature KDMIPE estimated COB along east and west coast of India. In and around Lakwa-Geleki fields about 800 wells were drilled, yet basement was eluding. Our study in these areas not only given basement depth map but also identified major structural elements. It is time to strengthen GM & MT studies for hydrocarbon exploration in India, especially in all the category III & IV basins. In simple terms, Magnetic data infers basement configuration along with faults of a sedimentary basin. Gravity data identifies the low density zones if any and MT data over these low density zones discriminates between water and hydrocarbons. In this way integration of all these data can unravel the mysteries of the sub-surface and considerably reduce exploration risk with minimum cost.

Based on the above case study answer the following questions:

a) Compare the advantages and disadvantage of seismic and non-seismic methods of hydrocarbon exploration.[05]
b) Prepare a flowchart representing the interpretation flow for detecting a hydrocarbon zone based on non-seismic methods [05]
c) "Soon Seismic imaging changed the Oil & Gas exploration and continues to play a vital role though it has limitations such as limited energy penetration in trap (igneous) covered areas." – Why it difficult to produce the high resolution seismic image for deeper structures? [05]
d) "Magnetic data infers basement configuration"- Justify the statement. [05]

10. This is an exercise to locate any structural features on the seismic data that could act as trap for hydrocarbons. Working geophysicists called interpreters do this on seismic data all the time.

I. A seismic profile was shot from South to North, with the low CMP numbers in the South. A borehole was drilled on this seismic line at CMP 740 and from this we know the lithology and stratigraphic sequence at that location. Geophysical measurements taken down this borehole allow us to link the horizons on the seismic section to the real lithology. This is called the well tie.

II. Using the results of the well tie, we can identify the following horizons and rock units:

Horizon	**Rock Type**
Trough at 424ms	Purbeck Sandstone
Peak at 710ms	Kimmeridge Clay
Zero crossing positive to negative at 959ms	Corallian Limestone

Using this information we are now ready to interpret the seismic profile.

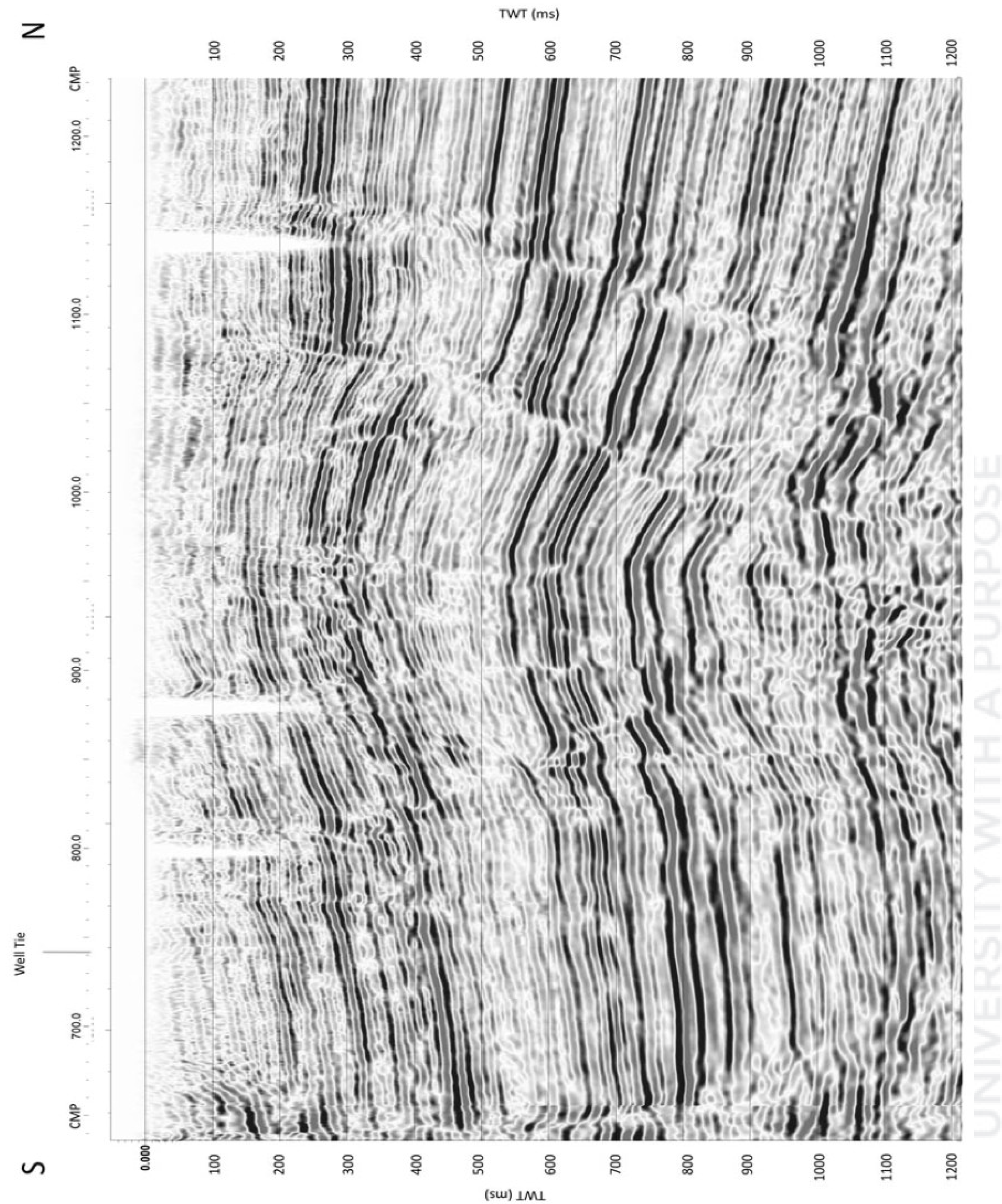
III. Locate the well tie position on the top of the seismic section, and directly under that point mark the time of the horizons specified in the well tie using a different coloured pencil for each one. The very black events are peaks, the greyer ones troughs and zero crossings are white.

IV. Taking one horizon at a time, follow the peak or trough across the whole section (it may be easier to use a lead pencil to mark your progress). A zero crossing is the changeover point from either a peak to a trough (positive to negative), or a trough to a peak (negative to positive). The horizon may not be continuous all the way across the profile. Try to think about possible structures to explain any jumps or breaks in the horizon, (faults for example). Remember if you think you see a break that could be a fault, you should see a similar break in the horizons above and below. When you are confident you can see where the horizon goes, colour it with your chosen colour.

V. Mark any faults on the section with a lead pencil. Try to describe it, e.g. it is a normal/reverse fault, downthrow side to the north/south, throw approximately xxms

Finally when you have traced all the horizons and marked any faults, look at the whole picture and answer the following questions:

a) Can you see any dipping horizons or structures?
b) Where might there be an accumulation of oil or gas?
c) How would it have got there?


N
S
TWT (ms)
CMP
Well Tie
700.0
800.0
900.0
1000.0
1100.0
1200.0
0.000
100
200
300
400
500
600
700
800
900
1000
1100
1200
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SET-2 **Roll No: ---------------------------**

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SECTION A: Answer all the questions. **[4*5=20 marks]**

1. What do you mean by seismic attribute? Briefly explain any one attribute along with its utility.
2. Write the formula for evaluating the water saturation from the log data.
3. What is the principle of induction logging?
4. What do you understand by liquid junction potential in SP logging?

SECTION B: Answer all the questions. **[4*10=40 marks]**

5. Explain how the petrophysical properties obtained from well log data are interpolated in the entire reservoir zone. How the QC of the interpolation is done?
6. What are Direct Hydrocarbon Indicators? List three seismic DHI's with brief explanation of each.
7. Why there is a need for well to seismic tie? What are steps for obtaining a successful well to seismic tie?
8. a. Derive an expression for acceleration due to gravity for a spherical body.
   b. The peak gravity anomaly over a 2D line mass of circular cross section of density contrast 500 kg/m^3 is 1.674 mGal. The anomaly decreases to 0.873 mGal at distance of 500 m along a principle profile then find out the depth to the line mass.

SECTION C: Answer all the questions. **[20*2= 40 marks]**

9. A gravity survey is conducted over a highly compacted ore deposit (horizontal cylinder shape). Bouguer anomaly values reduced along a profile are given below.
   c. What is the depth to the center of ore deposit?
   d. What is excess mass in metric tons by the deposit?

Distance (m)	Gravity anomaly (mGal)	Distance (m)	Gravity anomaly (mGal)
0	0.75	2400	35.0
200	1.01	2600	16.80
400	1.41	2800	8.85

600	2.05	3000	5.07
800	3.13	3200	3.13
1000	5.07	3400	2.05
1200	8.85	3600	1.41
1400	16.80	3800	1.01
1600	35.00	4000	0.75
1800	70.80		
2000	99.0		
2200	70.8		

10. From the given well log data identify Gas-oil contact (GOC), Oil-water contact (OWC). Evaluate shale volume, porosity from density log, corrected porosity, water saturation and hydrocarbon saturation at a depth 7200 ft. [Attach the interpreted well logs along with the answer sheet]

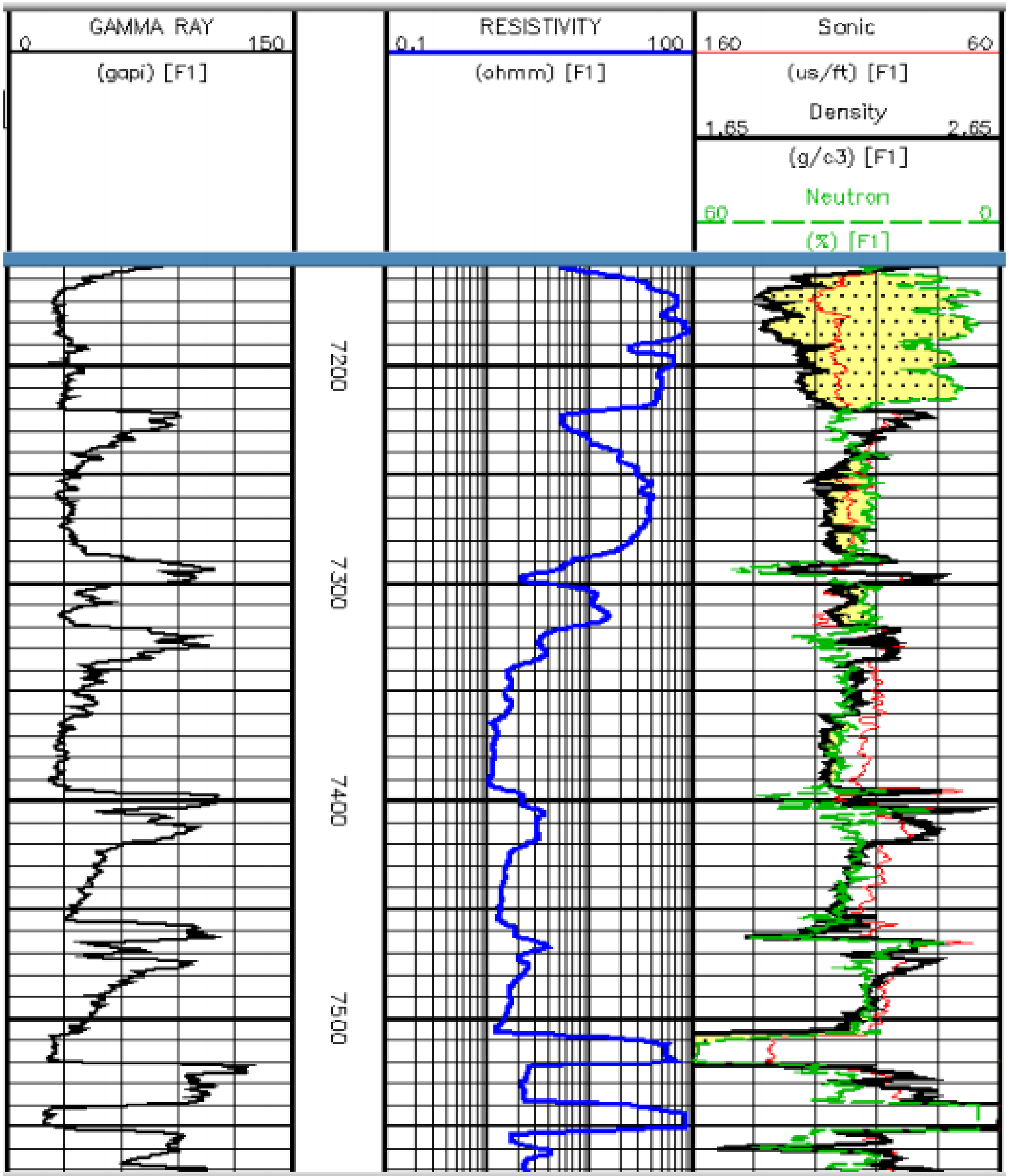
GAMMA RAY
0
150
(gapi) [F1]
RESISTIVITY
0.1
100
(ohmm) [F1]
Sonic
160
60
(us/ft) [F1]
Density
1.65
2.65
(g/c3) [F1]
Neutron
60
0
(%) [F1]
7200
7300
7400
7500

Figure: Q 10