

2901/105
PETROLEUM GEOLOGY AND
EXPLORATION TECHNIQUES
June/July 2023
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL
DIPLOMA IN PETROLEUM GEOSCIENCE
MODULE I

PETROLEUM GEOLOGY AND EXPLORATION TECHNIQUES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;

Mathematical tables/a non programmable scientific calculator (fx-82).

This paper consists of EIGHT questions.

Answer question ONE and any other FOUR questions in the answer booklet provided.

Maximum marks for each part of a question are indicated.

Candidates should answer the questions in English.

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that
all the pages are printed as indicated and that no questions are missing.

1. (a) (i) Define the following terms as used in seismic exploration:

- (I) interval velocity; (1 mark)
- (II) average velocity. (1 mark)

(ii) Calculate the root mean square velocity of the following rock layers as shown in figure 1. (6 marks)

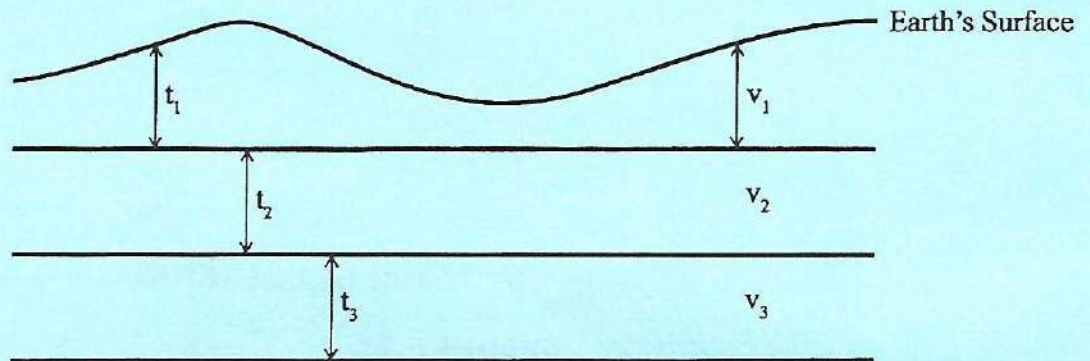


Fig. 1

Given that: $t_1 = 8 \text{ sec}$ $v_1 = 3500 \text{ m/s}$
 $t_2 = 20 \text{ sec}$ $v_2 = 4000 \text{ m/s}$
 $t_3 = 5 \text{ sec}$ $v_3 = 2000 \text{ m/s}$

- (b) Write the mathematical expression of a compressional seismic wave velocity, defining all the terms in it. (3 marks)
- (c) With the aid of a labelled diagram, illustrate a stress-strain curve of a rock. (5 marks)
- (d) Give **two** differences between compressional and shear seismic waves. (4 marks)

2. (a) Explain the terms 'compaction' and 'cementation' as used in geoscience. (4 marks)

(b) Describe **three** characteristics of reservoir rocks. (6 marks)

(c) (i) Define the term 'source rock' as used in petroleum geology. (1 mark)

(ii) Describe the following processes in the formation of source rocks:

- (I) diagenesis; (3 marks)
- (II) catagenesis; (3 marks)
- (III) metagenesis. (3 marks)

3. (a) (i) State **two** applications of gravity survey in petroleum exploration. (2 marks)
- (ii) Define the term 'gravity data reduction' as used in gravity data processing. (1 mark)
- (iii) Explain the following gravity data corrections:
- (I) drift correction; (2 marks)
- (II) free air correction; (2 marks)
- (III) latitude correction. (2 marks)
- (b) (i) Define the following terms as used in seismology:
- (I) reflection coefficient; (2 marks)
- (II) geometrical spreading. (2 marks)
- (ii) Figure 2 shows the acoustic properties of a two layered rock formation. Study and use it to answer the question that follow.

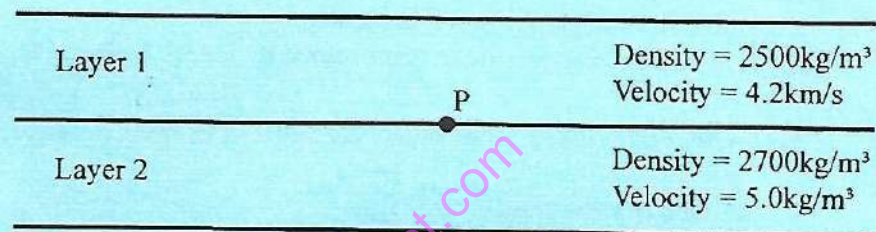


Fig. 2

- (I) determine the reflection coefficient at the interface P. (5 marks)
- (II) give the percentage amount of the transmitted energy at the interface P. (2 marks)

4. (a) (i) Name **three** stages of geological field mapping. (3 marks)
- (ii) Give **two** uses of a geological hammer. (2 marks)
- (b) Give **one** reason why limestone forms a suitable:
- (i) source rock; (1 mark)
- (ii) reservoir rock. (1 mark)
- (c) Explain the **four** types of hydrocarbon migration. (8 marks)

- (d) Figure 3 shows a time distance curve of seismic waves. Study and use it to answer the questions that follow.

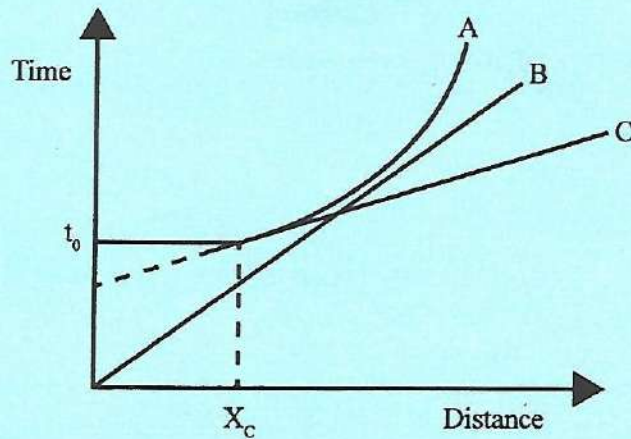


Fig. 3

- (i) Identify the parameters represented by t_0 and x_c . (2 marks)
- (ii) Name the seismic waves represented by letters A, B and C. (3 marks)
5. (a) Explain the following seismic data processing methods:
- (i) frequency filtering; (2 marks)
- (ii) deconvolution; (2 marks)
- (iii) migration. (2 marks)
- (b) With the aid of a labelled diagram, illustrate the principle of electromagnetic survey method. (6 marks)
- (c) (i) State **six** activities in the pre-mapping stage of geological mapping. (6 marks)
- (ii) Outline **two** physical properties used to identify rocks in the field during geological mapping. (2 marks)
6. (a) Explain **four** components of a petroleum system. (8 marks)
- (b) List **two** types of hydrocarbon traps giving examples for each. (4 marks)
- (c) Explain **four** factors influencing hydrocarbon migration. (8 marks)
7. (a) (i) Explain **two** data corrections applied to magnetic data. (4 marks)
- (ii) Give **two** sources of errors in the magnetic data. (2 marks)
- (b) (i) Explain **two** factors that cause variation of rock resistivity. (4 marks)
- (ii) Explain **three** parameters estimated using resistivity logging method. (6 marks)
- (c) Describe the self-potential logging method. (4 marks)

8. (a) Table I gives three stages of source rock maturation and their descriptions. Study and use it to answer the questions that follow.

Table I

State of source rock maturation	Description
A	Microbial activities are dominant
B	Borders metamorphism
C	Hydrogen concentration increases as oxygen diminishes

- (i) identify the stages A, B, and C. (3 marks)
(ii) give **two** reasons for each answer given in (i). (6 marks)
- (b) (i) Figure 4 shows a resistivity log curve. Study and use it to answer the questions that follow.

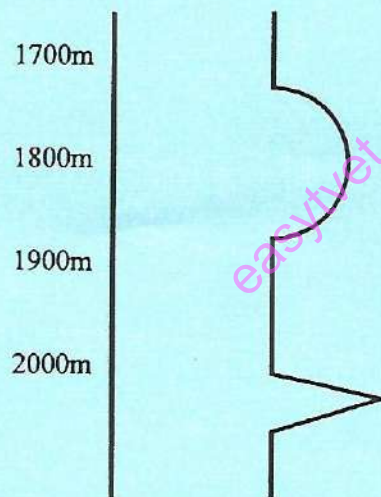


Fig. 4

- With the use of a labelled diagram, illustrate a geological log represented by the resistivity log curve indicating the shale and sandstone formation. (6 marks)
- (ii) List **two** sources of self potential in well logging. (2 marks)
- (iii) State **three** factors that affect velocity of a seismic wave in a potential petroleum source rock. (3 marks)

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