Understanding porosity

Introduction

This is an activity on assessment of student's understanding of porosity. The activity was originally produced by David Thompson (Thompson, 1979) in an article that defined porosity, listed porosities and bulk densities of various common materials and described a series of simple experiments, designed for students in the age range 16 – 18, and which fulfilled the requirements of the geology syllabi at that time. Thompson's original assessment activity has been updated.

Pore systems in rocks allow the storage, transmission and filtration of various fluids and gases (groundwater, brines, mineralising solutions, oil, oil-gas, and natural gas). An understanding of the ideas of porosity and permeability is essential for Earth scientists working as petroleum engineers, hydrologists, hydrogeologists, pedologists, petrologists, sedimentologists, civil engineers, hydraulic engineers, soil mechanic engineers, water engineers and filtration engineers.

Definitions

Total porosity is the total void space in a rock, whether it contributes to fluid flow, whereas **effective porosity** is the interconnected pore volume or void space in a rock that contributes to fluid flow (or permeability) in the rock.

Porosity may be expressed as a percentage or a proportion of unity.

Total or absolute porosity % $= \frac{\text{(bulk volume} - \text{grain volume)}}{\text{(bulk volume)}} \times 100$

or $= \frac{\text{(pore volume)}}{\text{(bulk volume)}} \times 100$

Effective porosity (the amount of interconnected pore space) % $= \frac{\text{(interconnected pore space)}}{\text{(overall volume)}} \times 100$

Note: *Effective porosity is typically less than the total porosity and is a function of:*

- *variations in grain size;*
- *grain shape (roundness or sphericity);*
- *grain size distribution;*
- *packing;*
- *fabric;*
- *cementation;*
- *clay content;*
- *clay types (swelling or non-swelling);*
- *clay flocculation status;*
- *compaction (lithostatic and tectonic stresses) and*
- *degree of weathering of the rock compared with its parent mass (including the degree of leaching of the rock).*

The assessment of understanding porosity

<u>Multiple choice questions</u>

Question 1. Which **one** of the following statements best represents the effective porosity of a rock?

A. the percentage of interconnected void space with respect to the mass of the rock
B. the percentage of void space with respect to the mass of the rock
C. the percentage of interconnected void space with respect to the density of the rock
D. the percentage of void space with respect to the volume of the rock
E. the percentage of interconnected void space with respect to the bulk volume of the rock volume

Question 2. Which **one** of the following statements best represents the absolute porosity of the rock?

A. the percentage of interconnected void space with respect to the mass of the rock
B. the percentage of void space with respect to the mass of the rock
C. the percentage of interconnected void space with respect to the density of the rock
D. the percentage of void space with respect to the volume of the rock
E. the percentage of interconnected void space with respect to the bulk volume of the rock volume

Question 3. Which **one** of the following relationships represents the absolute porosity of a rock?

A. $\frac{\text{(bulk volume)}}{\text{(pore volume)}} \text{ x } 100$

B. $\frac{\text{(pore volume)}}{\text{(bulk volume)}} \text{ x } 100$

C. $\frac{\text{(pore volume)}}{\text{(bulk density)}} \text{ x } 100$

D. $\frac{\text{(bulk density)}}{\text{(pore volume)}} \text{ x } 100$

E. $\frac{\text{(bulk density)}}{\text{(pore density)}} \text{ x } 100$

Question 4. Which **one** of the following relationships represents the porosity of the rock?

A. $\frac{\text{(bulk volume} - \text{grain volume)}}{\text{(bulk volume)}} \text{ x } 100$

B. $\frac{\text{(grain volume} - \text{pore volume)}}{\text{(bulk volume)}} \text{ x } 100$

C. $\frac{\text{(pore volume} - \text{bulk volume)}}{\text{(grain volume)}} \text{ x } 100$

D. $\frac{\text{(grain volume} - \text{bulk volume)}}{\text{(pore volume)}} \text{ x } 100$

E. $\frac{\text{(pore volume} - \text{grain volume)}}{\text{(bulk volume)}} \text{ x } 100$

Question 5. Porosity is a function of which **one** of the following:

A. hydrostatic pressure of liquid and/or gas
B. density
C. mineral composition
D. permeability
E. degree of cementation.

N.B. Other correct answers could be grain size, packing of grains, grain fabric, grain angularity, grain size distribution, lithostatic pressure, degree of weathering, compaction.

<u>Multiple completion questions</u>
Answer A if only (1) (2) and (3) are correct: B if only (1) and (3) are correct: C if only (2) and (4) are correct: D if only (4) is correct: E if only (1) and (4) are correct.

Question 6. Porosity is a function of which of the following?

1. degree of cementation
2. grain size
3. packing of grains
4. mineral composition.

Question 7. Porosity is a function of which of the following?

1. degree of uniformity of grain size
2. mineral type
3. compaction
4. permeability.

Question 8. Porosity is a function of which of the following?

1. grain shape
2. degree of cementation
3. grain fabric
4. hydrostatic pressure.

Question 9. Porosity is a function of which of the following?

1. grain angularity
2. lithostatic pressure
3. grain size distribution
4. pressure of liquid and/or gas.

Question 10. Porosity may be expressed by which of the following relationships?

1. g cm^{-3}
2. as a proportion of unity
3. kg m^{-3}
4. a percentage.

Question 11. Absolute porosity is explained by which of the following statements?

1. pore volume divided by bulk volume expressed as a percentage
2. density divided by mass expressed as a percentage
3. pore volume divided by grain volume expressed as a percentage.
4. the space not occupied by solid mineral matter expressed as a percentage.

Keys to these questions are: Q1. E; Q2. D; Q3. B; Q4. A; Q5. E; Q6. A; Q7. B; Q8. A; Q9. B; Q10. C; Q11. E.

References

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