INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY

Which Came First? Relative Time Puzzles

Lesson Plans and Activities

By Polly R. Sturgeon

Targeted Age:
Middle to High School

Activity Structure:
Individual Activity

Indiana Standards and Objectives:
7.ESS.3, 7.ESS.4, ES.5.4, ES.5.6, Env.3.1

MATERIALS NEEDED

- Relative Time puzzles
- Pencil

Introduction

In this lesson, students will order rock layers to establish relative age. Students will use geologic principles to establish the relative age that created layers of rock and provide evidence for the geologic history of the Earth.

Vocabulary

Absolute age – the numeric age of a rock layer or fossil

Erosion – the mechanical abrasion of material on the Earth's surface by glaciers, wind, and water

Fault – a fracture in the Earth's crust where one side moves relative to the other

Fold – bent or curved strata formed by compressional forces

Intrusion – igneous rock formed by the crystallization of magma that pushed into preexisting strata

Relative age – the chronologic sequence of a rock, fossil, or geologic feature in comparison to other rocks, fossils, or features without a specific numeric age

Strata – layers of rock

Unconformity – a surface of erosion or nondeposition that separates rock layers of considerably different ages

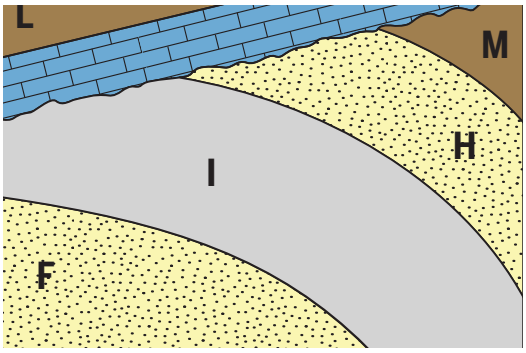
Geologists study rock layers (strata) to better understand the climates, environments, and organisms that have existed throughout Earth's 4.6-billion-year history. The study of strata and their relative position began in the early 19th century when geologists used direct observations of rock layers to correlate strata from one place to another. Unlike the determination of a specific numeric age through advanced technological methods, these observations allow scientists to determine the relative age of rock layers.

Relative age is the chronologic sequence of a rock, fossil, or geologic feature in comparison to other rocks, fossils, or features without a specific numeric age. Relative age is determined by the following principles.

The **Principle of Uniformitarianism** states that changes in the Earth's crust result from continuous and uniform processes, such as storms, earthquakes, volcanism, and weathering. These modern processes are the same processes that have occurred throughout geologic time, and their results can be observed in the rock record.

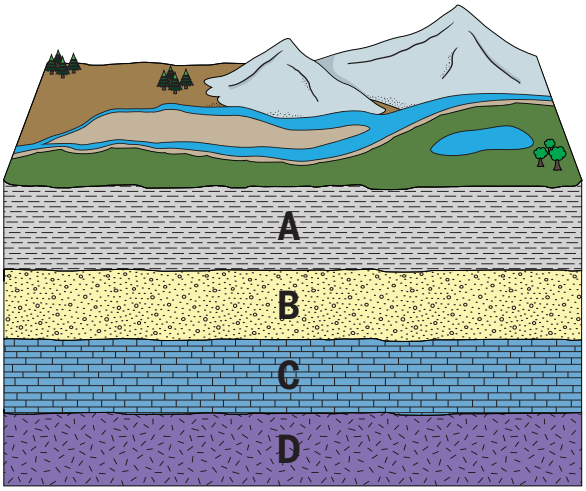
The modern ripple marks along Lake Michigan (left) are formed by the flow of water over sand. The fossilized ripple marks (right) were formed by similar processes.

The **Principle of Original Horizontality** states that sediments are deposited in flat, horizontal layers parallel to the Earth's surface. Layers of sedimentary rock that are not horizontal have been altered by subsequent tectonic forces, such as folding or faulting.



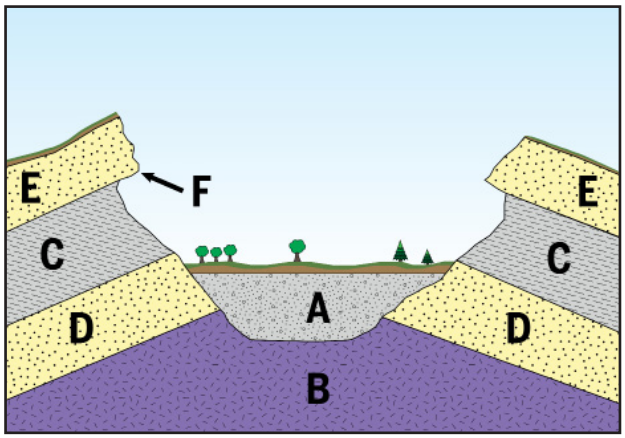
Layers F, I, H, and M were first deposited in horizontal layers, then folded.

The **Principle of Superposition** states that younger layers of rock lie on top of older layers of rock. Each layer is older than the one that exists above it.



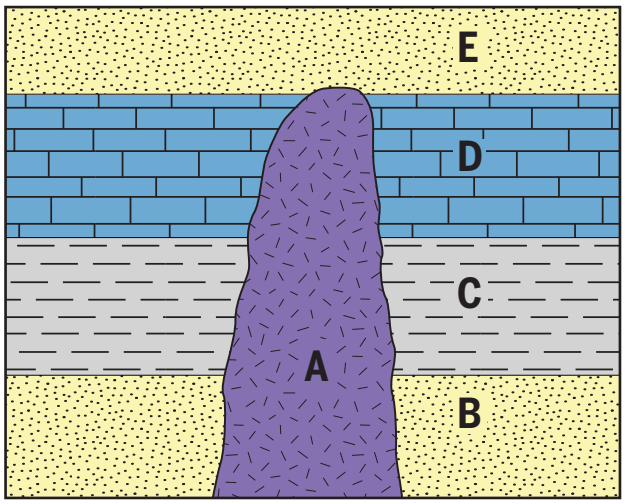
Layer D was deposited first, and is therefore oldest, because it is at the bottom. Layers C, B, and A are successively younger rock units.

The **Principle of Lateral Continuity** states that rock layers extend horizontally in all directions. Breaks or separations within rock layers are caused by barriers at the time of deposition or subsequent erosion.



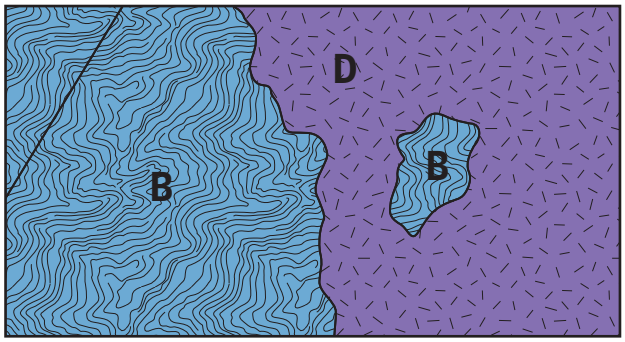
Layers B, D, C, and E were deposited as continuous layers prior to folding and erosion (F).

Cross-cutting relationships involve features, such intrusions or faults, that cut across older rock layers. The cross-cutting feature must be younger than the units it cuts through.



Layers B, C, and D, and E are successively older than intrusion A.

Inclusions are pieces of an older rock that are contained inside of a younger rock. A rock layer that contains inclusions must be younger than the rock from which the pieces came.



Rock B is older than Rock D. A piece of the older rock is included inside of the younger rock.

An **unconformity** is a surface of erosion or non-deposition that separates rock layers of considerably different ages. There are three different types of unconformities.

1. An **angular unconformity** occurs when horizontal sedimentary rock is deposited on top of tilted and eroded rock layers. The lower older layers are inclined by folding or faulting, then eroded, and younger sediments are later deposited on top of the erosional surface.

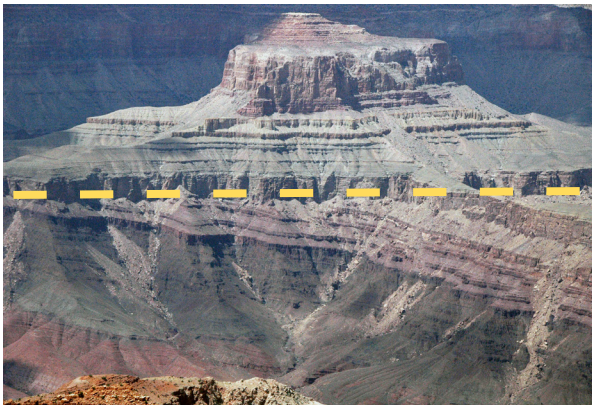
Siccar Point in Scotland is an angular unconformity where older vertical sedimentary rocks are overlain by younger slightly inclined sedimentary rocks.

Photo by Stuart Sutherland, Wikimedia Commons.

2. A **disconformity** occurs when horizontal sedimentary rock is deposited on top of an older eroded sedimentary rock. The parallel strata are separated by an erosional surface.

The massive cliffs at Shades State Park are a disconformity where Mississippian-age siltstone is overlain by significantly younger Pennsylvanian-age sandstone.

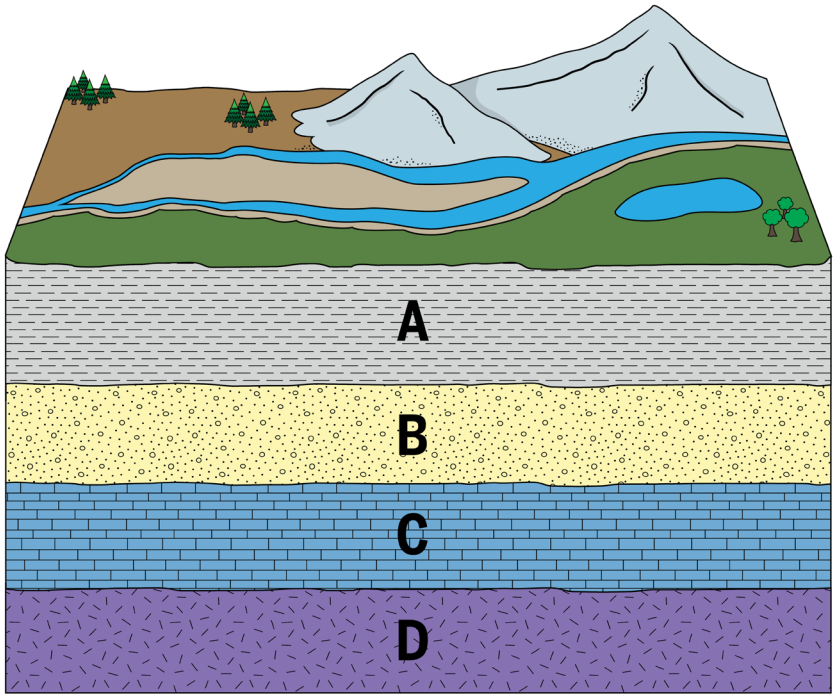
3. A **nonconformity** occurs when horizontal sedimentary rock is deposited on top of older eroded igneous or metamorphic rock. The rock types are separated by an erosional surface.



The Grand Canyon is a nonconformity where Precambrian-age metamorphic rocks are overlain by horizontal Cambrian-age sedimentary rocks.

Photo by James St. John, Wikimedia Commons.

Geologists use these guiding principles to determine the relative order that geological events occurred. Distribute the following Relative Time puzzles and ask students to number each rock unit in relation to their age, from oldest to youngest. Answers are provided below.



Youngest

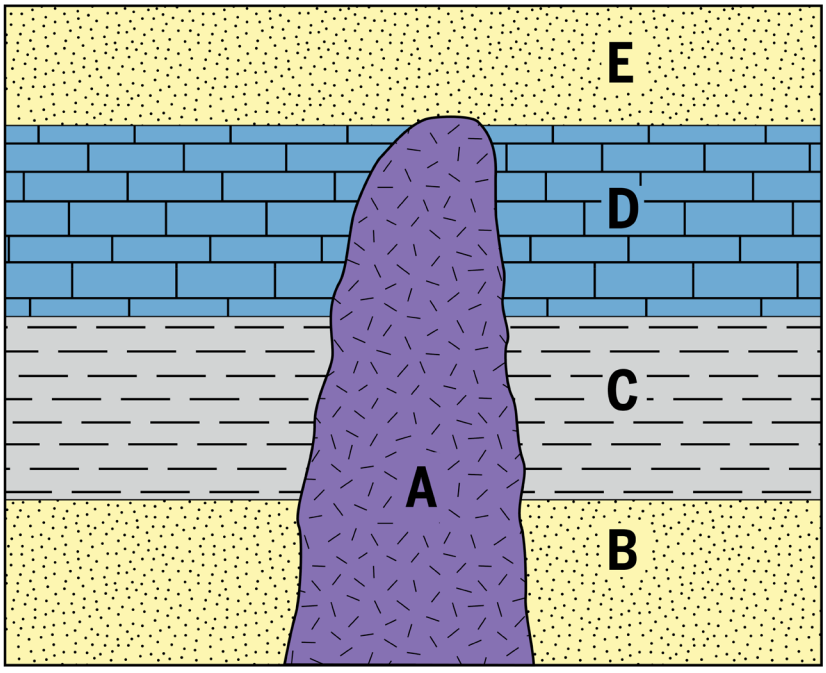
A

B

C

D

Oldest



Youngest

A

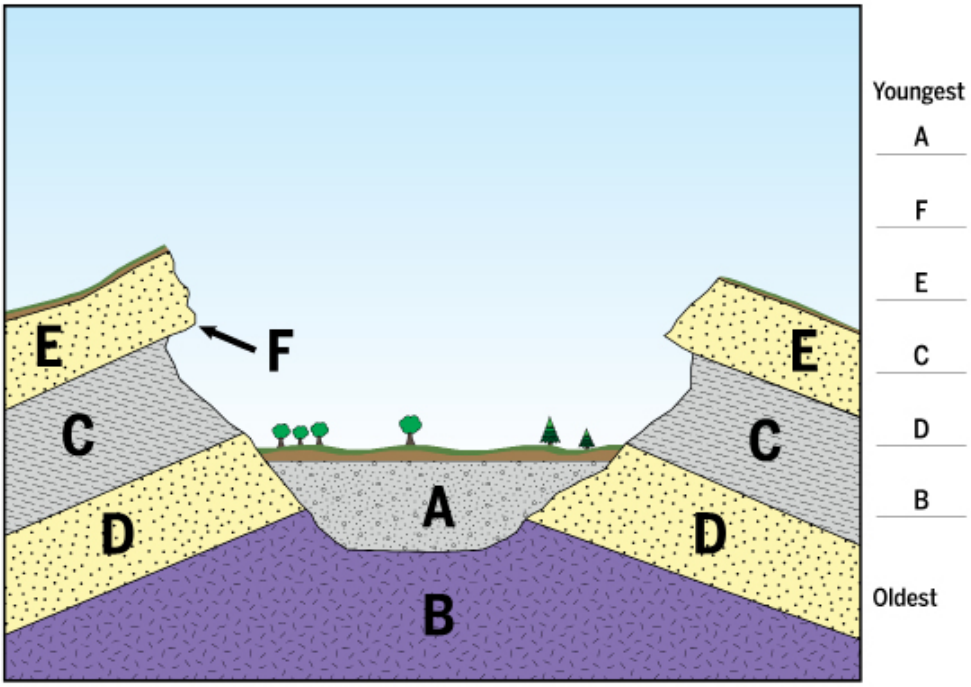
E

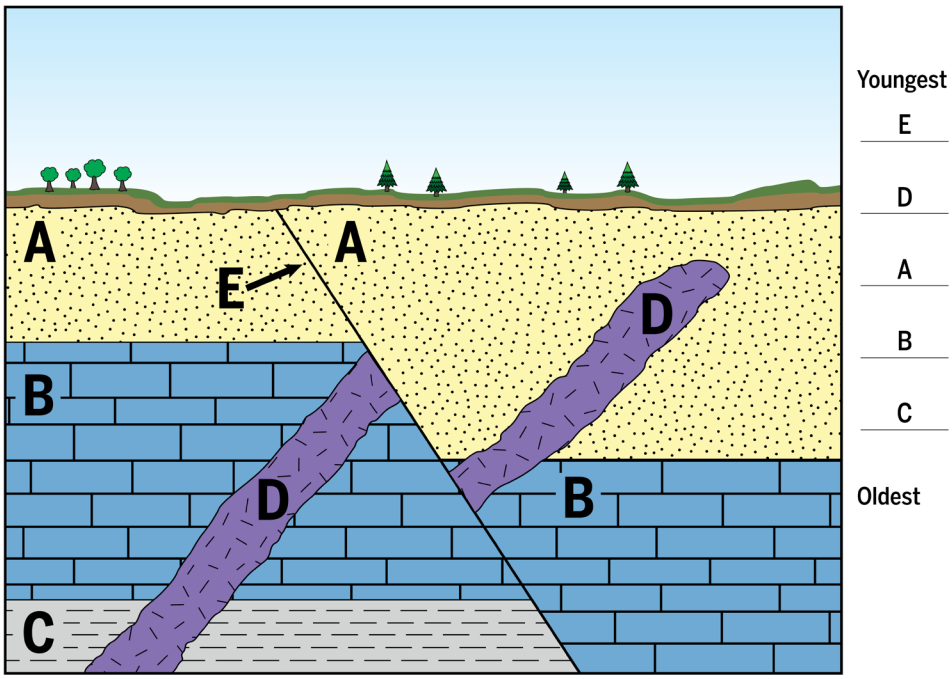
D

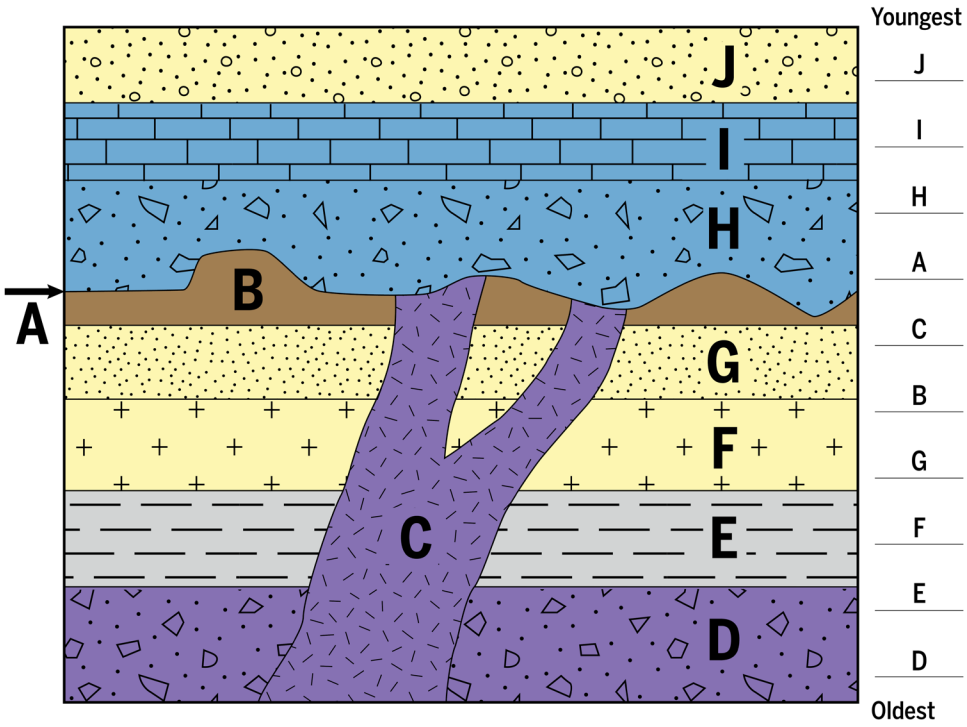
C

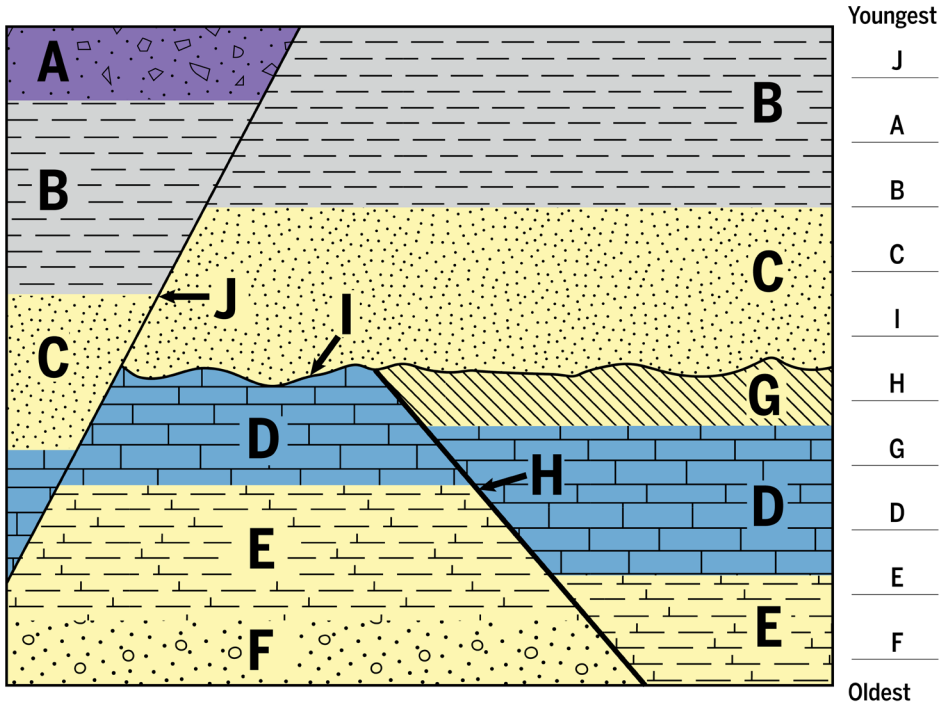
B

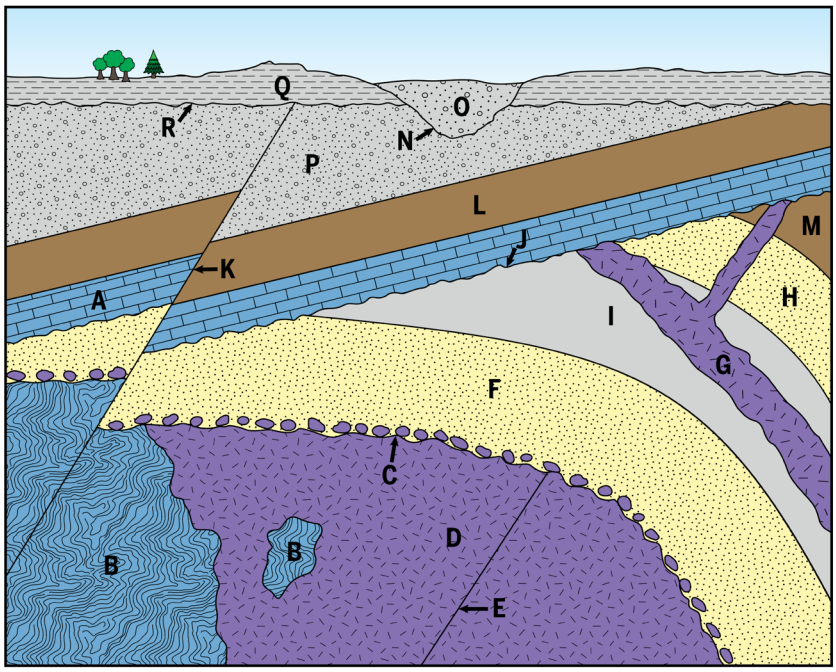
Oldest


E
F
E
C
C
D
A
D
B
Youngest
A
F
E
C
D
B
Oldest

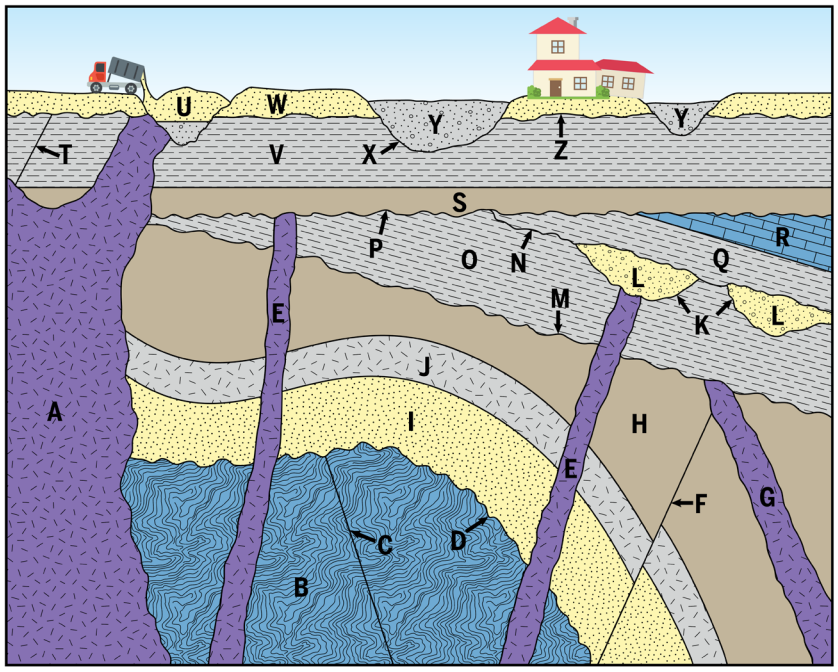

A
A
E
D
B
D
B
C
Youngest
E
D
A
B
C
Oldest


J
I
H
A
B
G
F
C
E
D
Youngest
J
I
H
A
C
B
G
F
E
D
Oldest

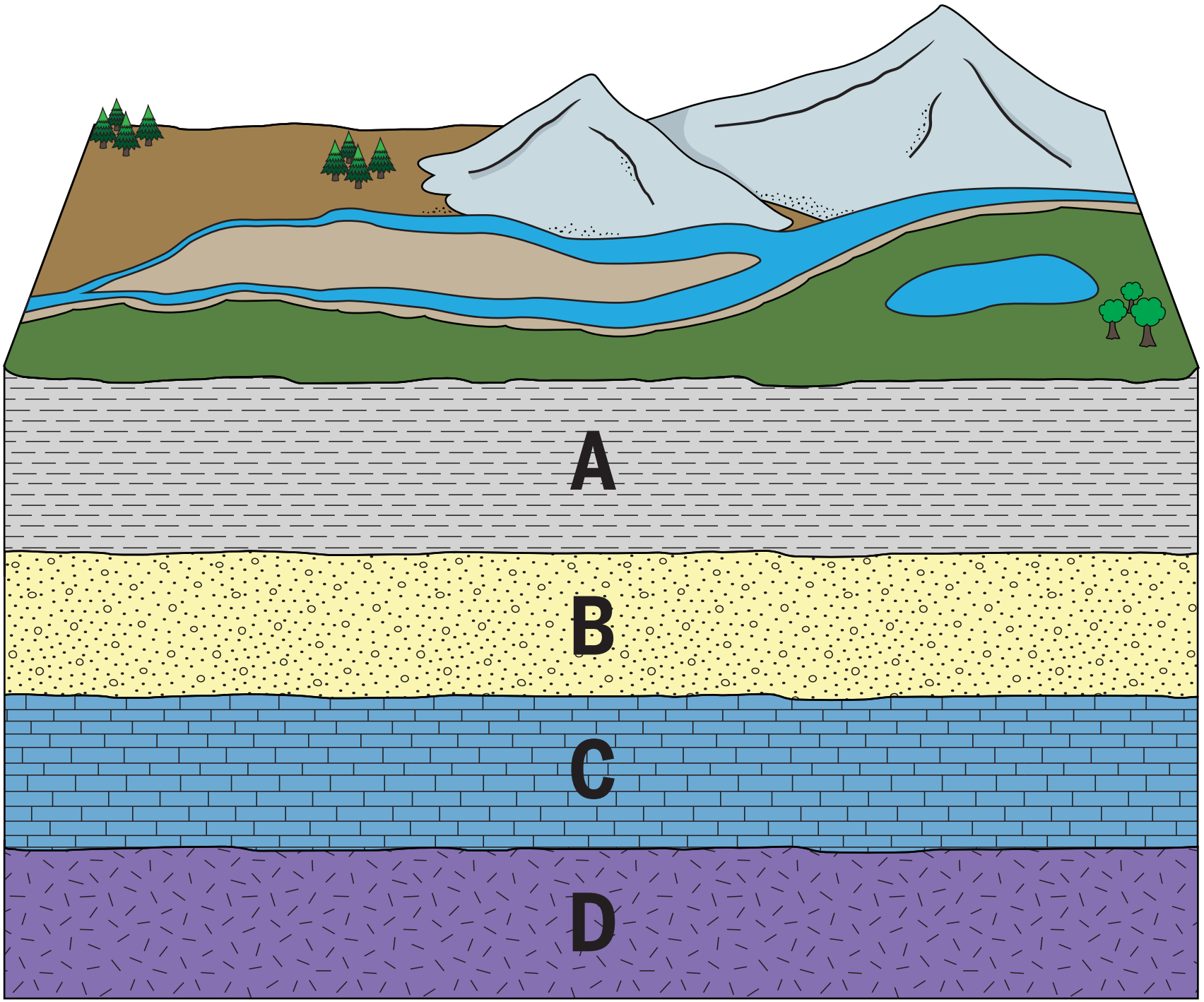

A
B
C
J
I
D
H
G
E
F
Youngest
J
A
B
C
I
H
G
D
E
F
Oldest



Youngest
O
N
Q
R
K
P
L
A
J
G
M
H
I
F
C
E
D
B
Oldest



Youngest
U
Y
X
W
Z
A
T
V
S
P
R
Q
N
L
K
E
O
M
G
F
H
J
I
D
C
B
Oldest



Youngest

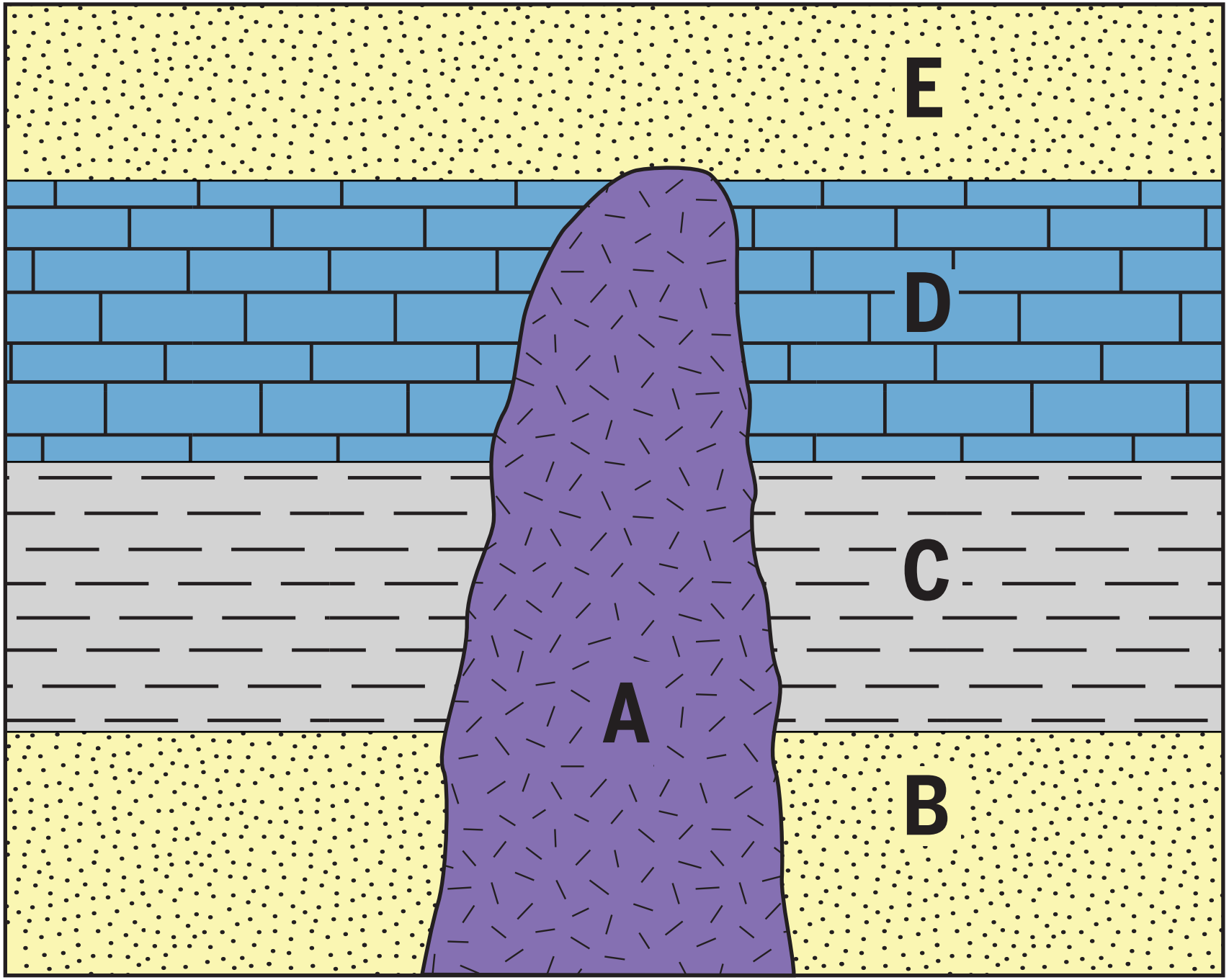
_____

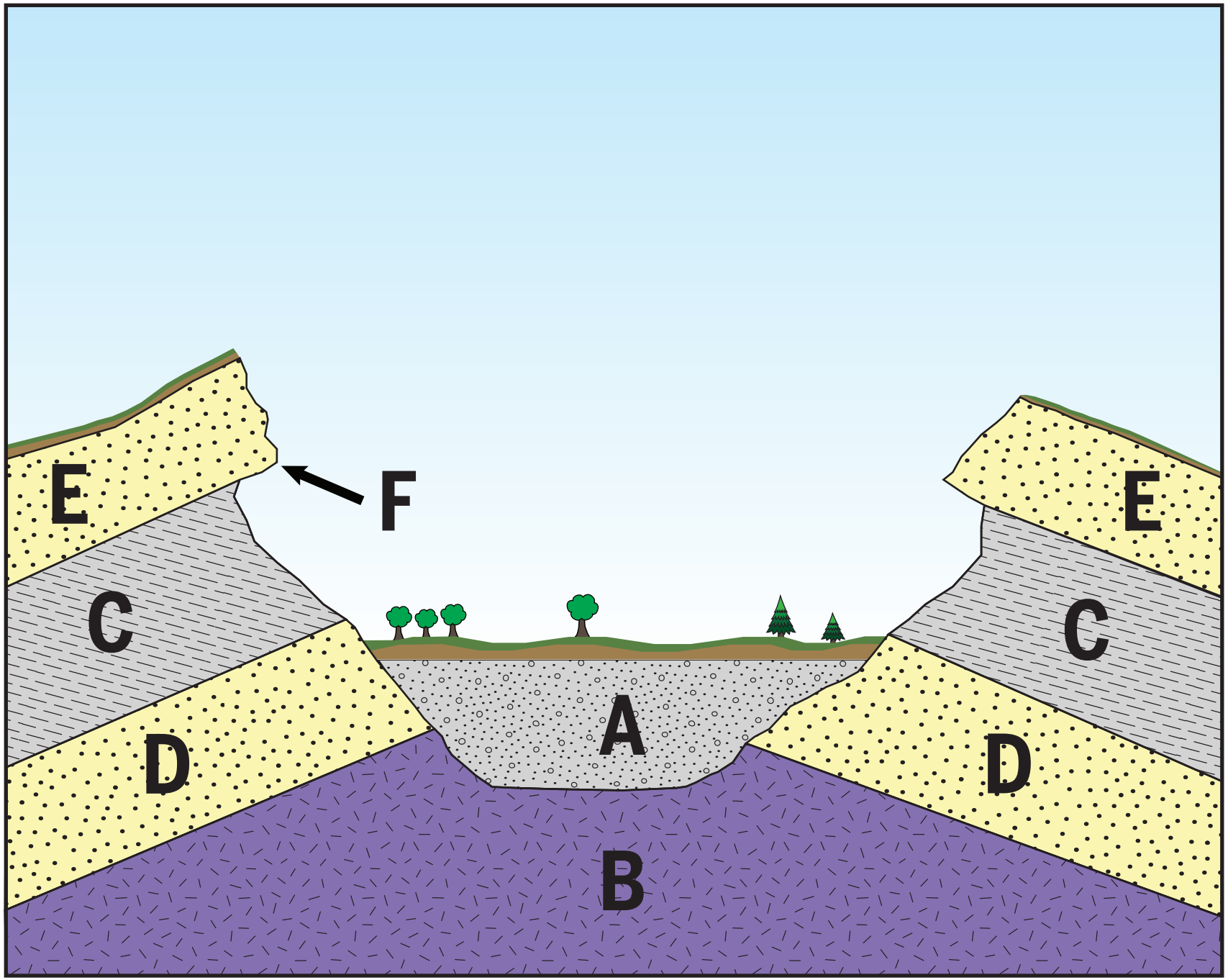
_____

_____

_____

Oldest


E
D
C
A
B
Youngest
Oldest



Youngest

_____

_____

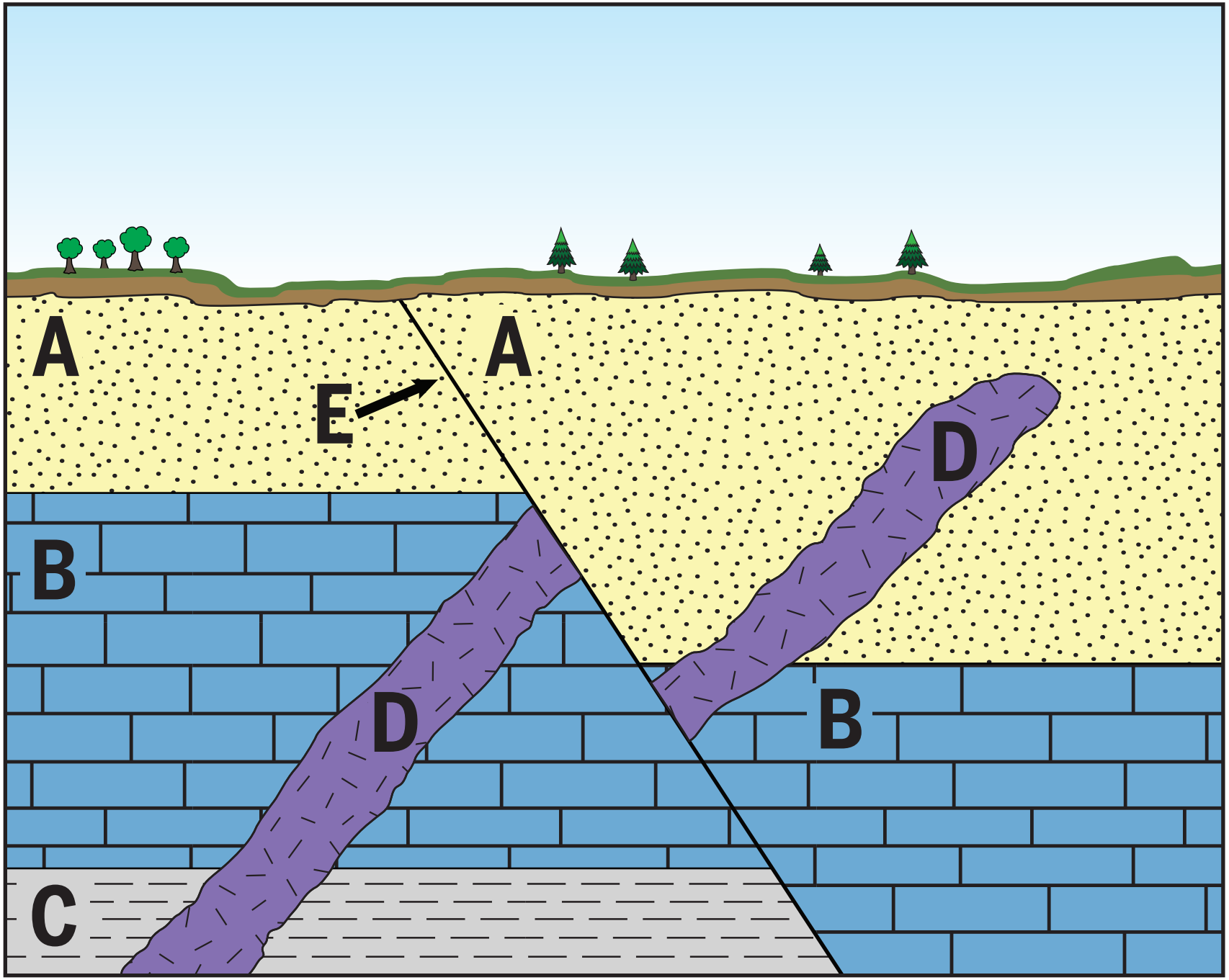
_____

_____

_____

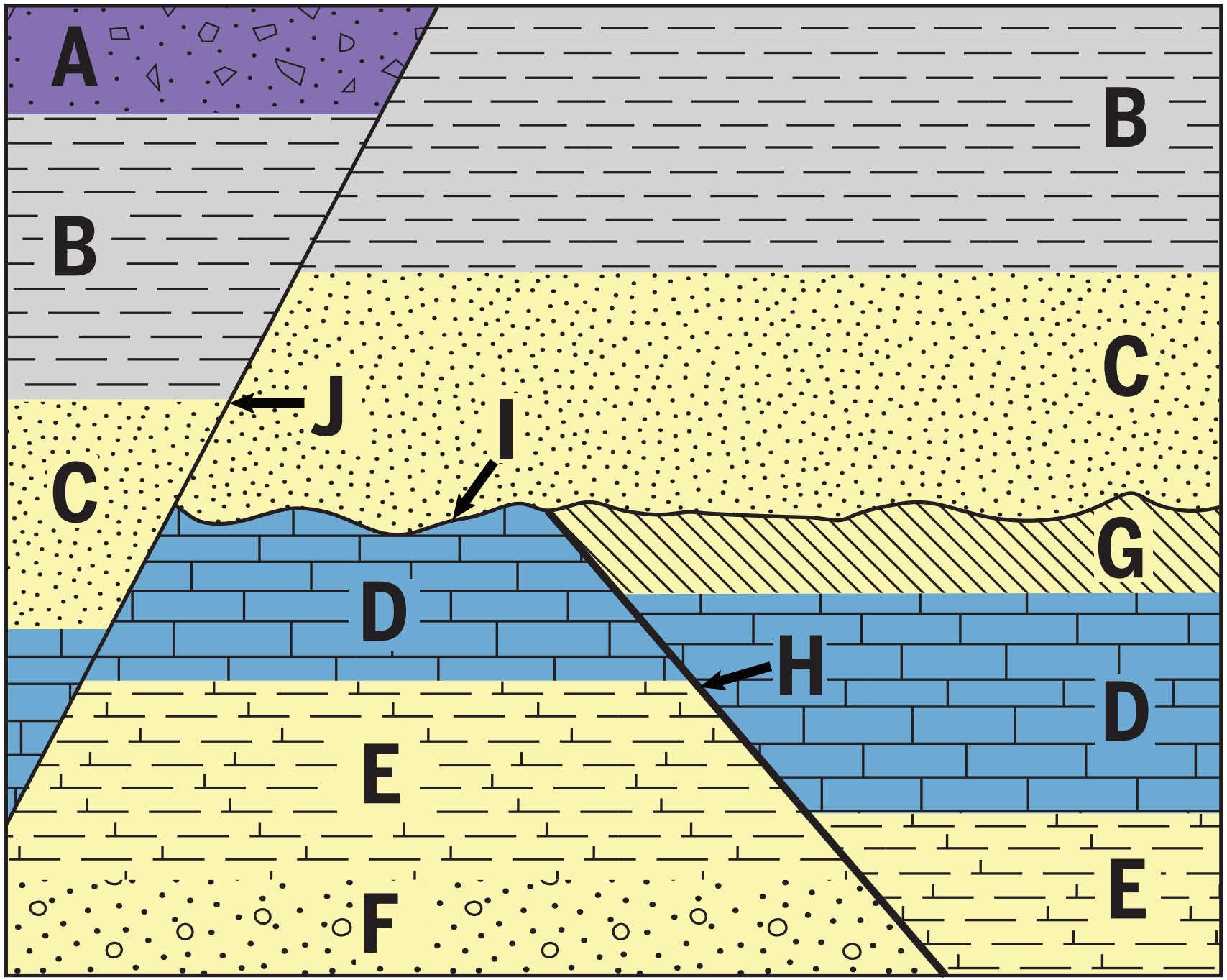
_____

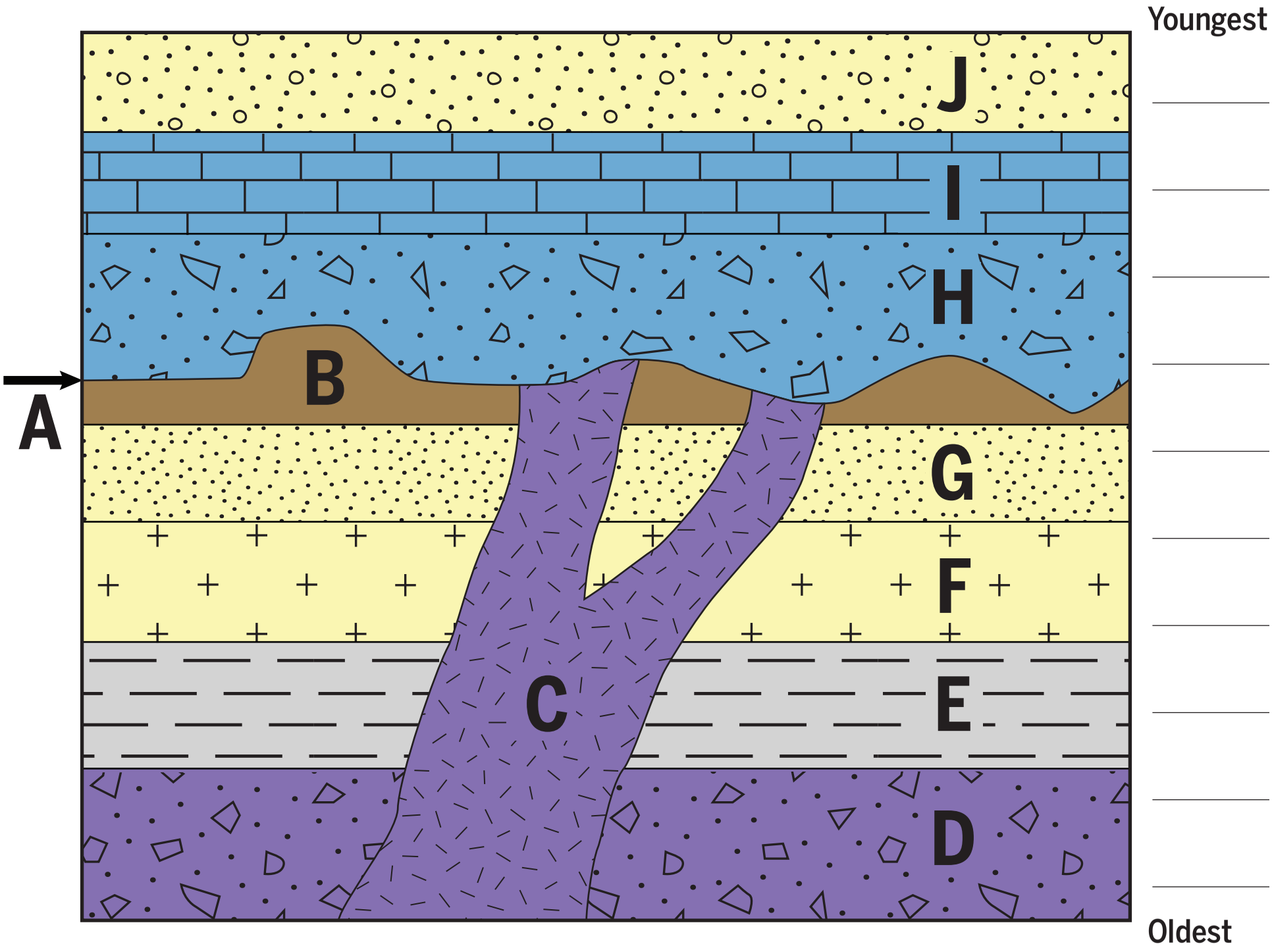
Oldest

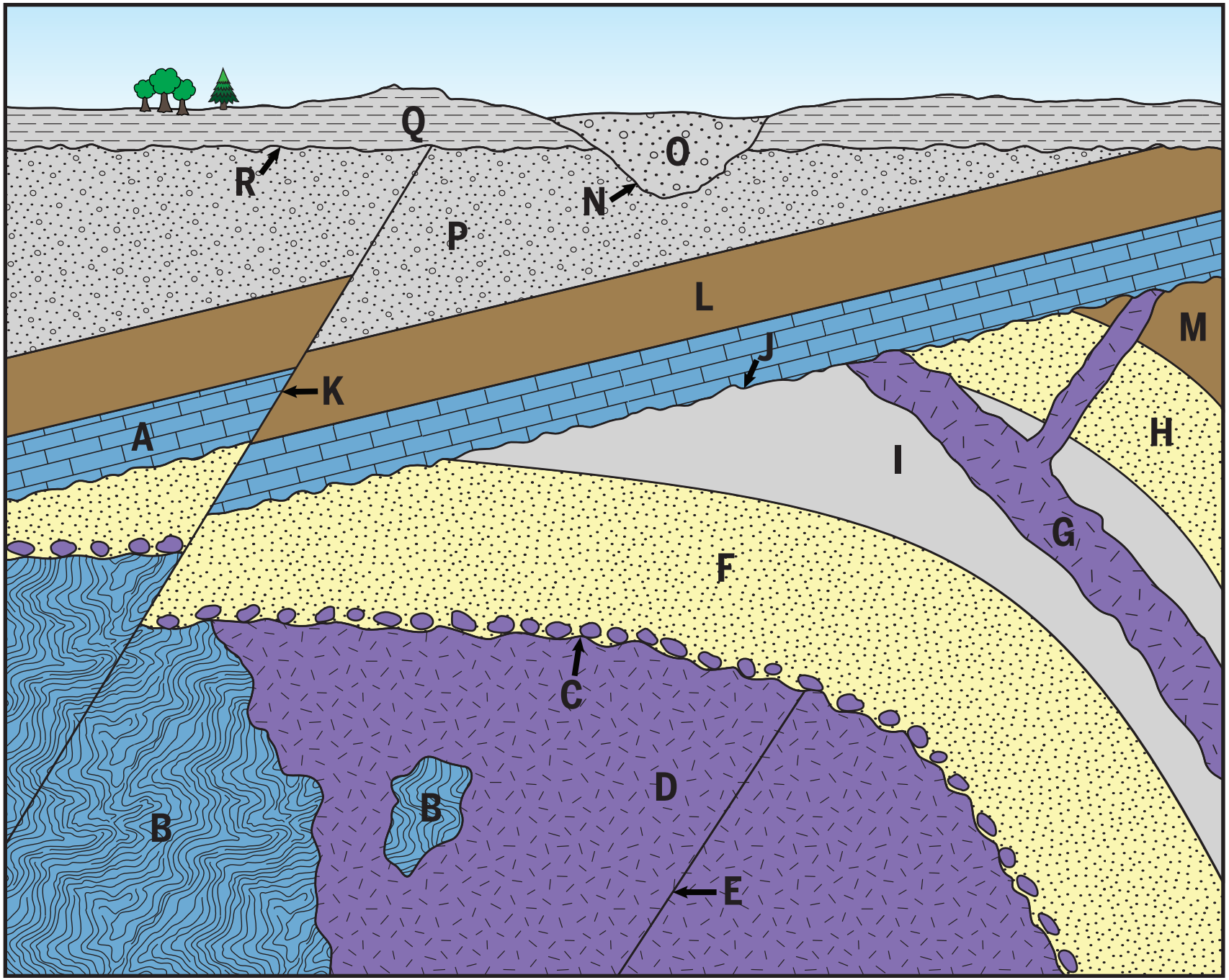


Youngest

Oldest

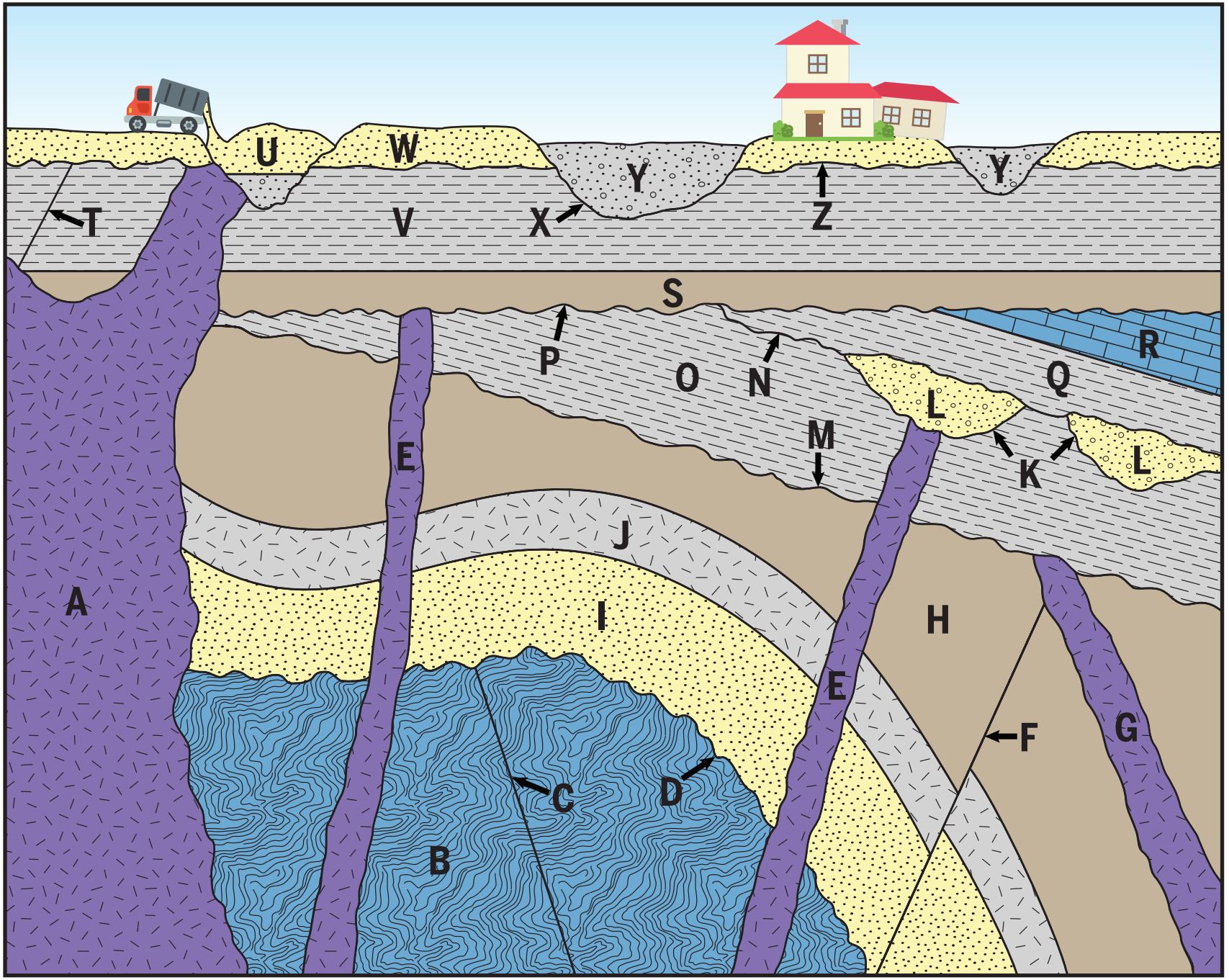

A
B
B
C
C
J
I
D
G
H
D
E
E
F
Youngest
Oldest


Youngest
J
I
H
B
A
G
F
C
E
D
Oldest



Youngest

Oldest



Youngest

Oldest