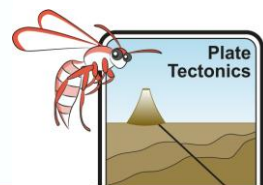


Planetary Differentiation – Teacher Notes



Planetary differentiation - A theory supported by scientific data

DEFINITION A scientific theory is an hypothesis supported by data.

Data must be:

OBSERVABLE (5 senses)

MEASURABLE (SI – International units)

and

REPEATABLE

before it is

REPORTABLE (as Scientific data)



We will be dealing with mixtures and compounds. What is the difference between a mixture and a compound?

A **mixture** A mixture contains two or more substances physically combined (can be separated by physical means)

A **compound** A compound contains two or more substances chemically combined (cannot be separated by physical means).

Our planet has an atmosphere, a hydrosphere, a biosphere and a lithosphere. Is our planet a mixture or a compound? Explain your answer.

Our planet contains both mixtures and compounds. E.g. air (atmosphere) is a mixture of gasses, water (hydrosphere) has the compound di-hydrogen oxide H₂O, soils (biosphere) contain a mixture of minerals, water and living things (compounds) and rocks can be both mixtures and compounds.

Early scientists realised that rocks below the Earth's surface must be denser than those forming the crust because the estimated density of the planet as a whole was 5.52g/cm³. This was very much larger than most rocks found on its surface (2.67g/cm³ on average).

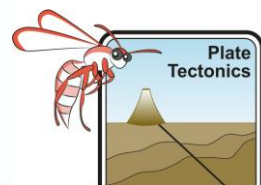
Worksheets on 'Hollow Earth' and 'Rock Density' in this package also cover these concepts.

Scientists hypothesised that:

1. During the first 300 million years the planet was much hotter than it is at present and rocks would be molten allowing minerals to be mobile.
2. Gasses would be driven upwards to form our atmosphere.
3. Denser materials would be pulled by gravity towards the center of the Earth.
4. Five layers characterised by minerals of increasing density would be created (inner core, outer core, lower mantle, asthenosphere and crust.)

Students may have learned about the layers of the Earth, earthquakes and volcanoes in Primary School

Planetary Differentiation – Teacher Notes



Gravity separation of solids of different densities - Teacher demonstration

Materials

- One large measuring cylinder or test tube
- Sufficient water to 2/3 fill the container
- A teaspoonful, or prepared equal volumes of clean dry sand, iron or copper filings and lead shot.
- Teaspoon or spatula
- Stop watch or equivalent
- Graph paper, pencil and ruler

Rapid gravity separation can be demonstrated by dropping a mixture of clean washed sand, metal filings and lead shot into a column of transparent viscous fluid such as glycerol ($C_3H_8O_3$). (Glycerol is a mild laxative).

The viscosity of glycerol slows downward movement of solids enabling students to see and later measure their relative speeds.

A large volume of glycerol is necessary to fill a measuring cylinder and be visible to the class. The longer the cylinder, the better it is to separate out different densities and form obvious layers on the bottom of the cylinder.

Glycerol can be recovered after the experiment by filtration and re-used.

Water can also be used but descent is rapid and the times for different components difficult to measure.

Swarf or cotton wool at the bottom of the cylinder will reduce the chance of a Pyrex or glass cylinder breaking.

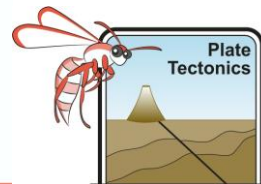
Lead shot is cheaply available from fishing shops or get lead from motor mechanics who use it to balance wheels. Copper pieces can be snipped from electrical cable.



The density of gold is included so that students may infer its behaviour from the other measurements given. Geologists suggest that gold is found in the Earth's core. Most gold deposits at the surface originate from a time when the Earth was markedly hotter and convection currents and plumes were able to flow from the core to the crust.

Were you able to collect scientific data from the teacher demonstration to support the hypothesis that planetary differentiation may depend on density differences? Explain your answer. **No.** Although the result was observable it was not measured or repeated.

Planetary Differentiation – Teacher Notes



AIM To collect scientific data to support the hypothesis that planetary differentiation could be the result of density separation.

Materials per student or group

- One measuring cylinder or large test tube
- Sufficient water to 2/3 fill the container
- A teaspoonful of prepared equal volumes of clean dry sand, iron/copper filings and lead shot or other solids
- Teaspoon or spatula
- Stop watch or equivalent
- Graph paper, pencil and ruler

You will be experimenting to see what happens when a mixture of solids falls through the column of water (or glycerol).

HYPOTHESIS (Make a scientific guess or estimate of what will happen when the mixture you have been given falls through the liquid).

The materials will be separated by their densities as they fall – or the reverse. (A negative hypothesis is as valid as a positive hypothesis)

METHOD

1. Gently sprinkle the mixture onto the top of the liquid in the test tube
2. Measure the time it takes for each component of the mixture to reach the bottom of the water.
3. Clean your equipment as directed by your teacher and repeat your measurements twice more.

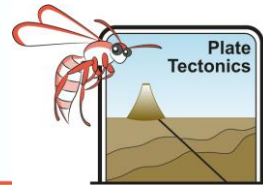
Your teacher will tell you the density of the components after you have collected your data. This is primary data (data you have collected yourself).

Observations

Component	Time taken to reach bottom (seconds)				Density of component (g/cm ³)
	First test	Second test	Third test	Average	
Sand (dry)					1.62
Iron					6.98
Nickel					8.91
Lead					11.34
Gold	No data	No data	No data	No data	19.30

Water has a density of 1g/cm³

Planetary Differentiation – Teacher Notes



Why did we require three tests? **To achieve accuracy**

What did you observe? **Lead fell fastest followed by iron and lastly sand. The materials separated into layers of different density into at bottom of cylinder**

Did the data support your hypothesis? **Yes or No (depends on hypothesis)**

How could this experiment be improved to provide better data? **Repeat – longer tube & more viscous liquid to separate densities – different materials**

What force caused the mixture to move to the bottom of the container? **Gravity**

Write the density of each component into the final column.

Draw a graph comparing the density of the component with the speed it took to reach the bottom.

HINTS

1. What should the title of the graph be? **A comparison of X and Y**
2. What should the X-axis be? **Time (seconds)**
3. What should the Y-axis be? **Density (g/cm³)**
4. What type of graph should it be? **Line graph**



Is there a correspondence between density and rate of falling (gravitational pull)? **Yes**

An inference is a judgement made from the evidence provided.

Can you infer what time it would take for the gold to reach the bottom? **Yes.**

This process is used in mining to separate denser minerals from crushed rock. Gemstones can also be classified by dropping them into viscous liquids. The rate of movement through the liquid reflects the density and chemistry of the stone.

Conclusion

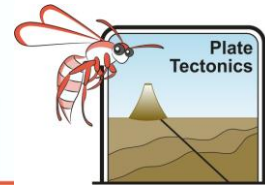
How does this experiment help to explain how early Earth became layered into crust, mantle and core?

Residual heat created molten rock that allowed materials to separate according to their densities.

Did the experiment prove this idea/hypothesis?

No. It only supported the hypothesis. Nothing is “proven “ in Science. If new technologies produce different more accurate results we must be willing to change our ideas.

Planetary Differentiation – Teacher Notes



Some scientists call this movement of iron towards the core “The GREAT IRON CATASTROPHE” or “THE GREAT IRON EVENT”. Early Earth was hotter because heat energy came from both gravitation collapse of planetary dust (heat of formation) and from radioactive decay. Of course once the heat of formation was radiated into space it became cooler and there was less movement of molten materials.

Extension Homework (for patient persistent students)

Movement of materials of different densities in liquids is fast. Geological processes however are slower.

This activity may take several days to produce data that is observable, measurable and repeatable. You will need to test locally available materials, as the results will vary with acidity of jelly crystals, strength of jelly formed, local temperature and size of iron filings.

AIM To see if iron filings will move through a jelly

Materials

- 1 packet of jelly crystals
- 400mL hot water
- 2 beakers
- Metal filings (about 4 tablespoons)

Method

1. Mix jelly and water and divide into 2 beakers (one control and one experimental beaker) and leave to partially set (about 1 hour).
2. Heap the iron filings on the top of one beaker of set jelly.
3. Leave until fully set and observe.

Molten rock is extremely slow moving unlike liquid jelly or glycerine. Surface tension delays movement and plumes of iron form moving down to the base of the beaker. When the magnetic core of the Earth was established this process would speed up due to magnetic attraction. This can be demonstrated by placing a bar magnet under the beaker. The jelly becomes rapidly shredded and iron forms a lower layer.

If the jelly has a high percentage of food acid, di-hydrogen sulphide gas bubbles (rotten egg gas) may form at the side of the iron filings.

If the jelly is too firm the tongue of descending iron will not develop.