Earth's crust versus the prep. room – why the differences?: teachers' notes

Level

This activity is designed for students aged 14-16, although it could be used with 11-14 year-olds.

Topic

The aim of this 'starter' activity is to introduce students to the common elements found in the Earth. Many of the elements already familiar to students may not necessarily be at all common in the **Earth's crust**. Students should consider why this might be. The activity can thus be used to underpin topics on useful materials from the Earth and on the extraction of metals. Some teachers may wish to construct their own sets of questions based on the data in the tables to adapt the activity to a particular age or ability range.

Description

Students study, compare and answer questions on graphs showing the elemental composition of the **Earth's crust** and of the aggregate composition of the compounds found in a typical school prep. room.

Context

Pupils will need to be familiar with the idea of an element and know that elements are represented by symbols. Ideally they should have some ideas about the properties of different groups of elements and compounds, for example that virtually all alkali metal compounds are soluble in water as are nitrates and many sulfates.

Teaching points

The suite of chemicals studied by chemists is different from the suite commonly considered by Earth scientists.

The extent to which students can appreciate the following teaching points will depend on their ability and prior knowledge of chemistry. The data are easily adaptable to suit a variety of abilities and age ranges.

The chemicals found in the prep. room have, in general, been chosen to illustrate chemical reactivity and the usefulness of substances. However, the chemicals found in the Earth's crust are found there because, in general, they are chemically unreactive - silicates, for example. Many of the elements that are commonly used in chemical reactions (*ie* in the prep. room) are not common at all in the Earth's crust. However, silicon, the second most common element in the Earth's crust, is very rarely found in chemical reactions and so is not present in the prep. room.

There are two other factors to consider.

One is solubility in water. In general, very soluble compounds will be found dissolved in the oceans rather than as solids in the Earth's crust.

Secondly volatility is important. Compounds composed of small molecules tend to be volatile and therefore exist as gases in the atmosphere rather than as solids in the Earth's crust.

Timing

This activity could be done in about 10–15 minutes, perhaps at the start of a lesson. Alternatively, it could be given more lesson time if considered in depth or if students plot the graphs for themselves.

The activity could also be set as a homework exercise or used in case of teacher absence.

Activity

Each group of students will need the *Student's worksheet*, including a copy of the graphs *Composition of the Earth's crust*, *Composition' of the prep. room, Composition of the Earth's oceans* and *Composition of the Earth's atmosphere*.

Alternatively, if the students are to plot the graphs themselves, students will need a copy of the data table (Table 1), either on paper or electronically (this is available to download as an Excel file). If they are to plot the graphs electronically, they will need access to a computer with suitable spreadsheet software.

Extensions

Students can also compare the 'composition of the prep. room' with the compositions of the oceans and of the atmosphere.

Some teachers may wish to supply the composition data either on paper or electronically and ask the students to plot the graphs themselves either by hand or using a spreadsheet thus incorporating an ICT exercise into the activity. In this case different types of graphs or charts could be tried and discussed.

Element	Symbol	Amount in prep. room		Amount in crust		Amount in ocean		Amount in atmosphere	
		(times found in inorganic chemicals)	%	(grams / tonne)	%	(mg / dm^3)	%	(by weight, ppm)	%
Oxygen	O	62	23.8	466000	46.8	Not given	Not given	251834	24.7
Silicon	Si	0	0.0	277200	27.8	3	trace		
Aluminium	Al	7	2.7	81300	8.2	0.01	trace		
Iron	Fe	6	2.3	50000	5.0	0.01	trace		
Calcium	Ca	10	3.8	36300	3.6	400	1.2		
Sodium	Na	15	5.7	28300	2.8	10500	32.2		
Potassium	K	13	5.0	25900	2.6	380	1.2		
Magnesium	Mg	8	3.1	20900	2.1	1350	4.1		
Titanium	Ti	1	0.4	4400	0.4	0.001	trace		
Hydrogen	H	19	7.3	1400	0.1	Not given	Not given	0.27	trace
Phosphorus	P	3	1.1	1050	0.1	0.07	trace		
Manganese	Mn	2	0.8	950	0.1	0.002	trace		
Fluorine	F	0	0.0	625	0.1	1.5	trace		
Barium	Ba	4	1.5	425	trace	0.03	trace		
Strontium	Sr	0	0.0	375	trace	8	trace		
Sulfur	S	22	8.4	260	trace	885	2.7		
Carbon	C	13	5.0	200	trace	28	0.1	126	trace
Zirconium	Zr	0	0.0	165	trace	0	trace		
Vanadium	V	0	0.0	135	trace	0.002	trace		
Chlorine	Cl	15	5.7	130	trace	19000	58.2		
Chromium	Cr	2	0.8	100	trace	0.00005	trace		
Rubidium	Rb	0	0.0	90	trace	0.12	trace		
Nickel	Ni	2	0.8	75	trace	0.002	trace		
Zinc	Zn	8	3.1	70	trace	0.01	trace		
Cerium	Ce	0	0.0	60	trace	0.000001	trace		
Copper	Cu	8	3.1	55	trace	0.003	trace		
Yttrium	Y	0	0.0	33	trace	0.0003	trace		
Lanthanum	La	0	0.0	30	trace	0.000003	trace		
Neodymium	Nd	0	0.0	28	trace	0.000002	trace		
Cobalt	Co	1	0.4	25	trace	0.0001	trace		
Scandium	Sc	0	0.0	22	trace	0.00004	trace		
Lithium	Li	2	0.8	20	trace	0.17	trace		

Nitrogen	N	22	8.4	20	trace	0.5	trace	755100	74.0
Niobium	Nb	0	0.0	20	trace	0.00001	trace		
Gallium	Ga	0	0.0	15	trace	0.00003	trace		
Lead	Pb	6	2.3	13	trace	0.00003	trace		
Boron	B	0	0.0	10	trace	4.6	trace		
Praseodymium	Pr	0	0.0	8	trace	0.0000006	trace		
Samarium	Sm	0	0.0	6	trace	0.0000004	trace		
Gadolinium	Gd	0	0.0	5	trace	0.0000006	trace		
Others		10	3.8			65	0.2	12820	1.3
Others		Br = 4	1.5	Others less than 5		Br = 65	0.2	Ar = 12800	1.3
		I = 2	0.8					Ne = 12.5	trace
		Bi = 1	0.4					He = 0.72	trace
		Hg = 1	0.4					Kr = 2.9	trace
		Ag = 1	0.4					Others less than 1	

Table 1 Amounts of elements found in compounds in a typical school prep. room, the Earth's crust, the oceans and the atmosphere

Answers to questions

Q 1. Oxygen

Q 2. Silicon. Its compounds (allow 'it') are unreactive and so they remain in the crust. Also it is not used in the laboratory to illustrate any common reactions (allow 'not that many uses to have it in the lab.').

Q 3. They are present in very low percentages in crust but are quite common in the prep. room. Sodium and potassium compounds are soluble and will not remain as solids in the crust. They do, however, form compounds that illustrate many chemical reactions in the laboratory.

Q 4. Aluminium and iron. There should be no problem about using them for very many years to come. Suitable uses include aluminium in aircraft manufacture, drinks cans, window frames *etc*, iron in bridges *etc*.

Q 5. Copper, zinc and lead illustrate many important chemical reactions (allow 'they are useful metals'). The graph shows that these are present in the crust in very small amounts and so the long term future for these metals is not secure. (See also question 8.)

Q 6. Nitrates and many sulfates are soluble in water and so will not remain as solids in the crust.

Q 7. The Earth's crust is almost entirely inorganic, and so only inorganic chemicals were considered in the prep. room survey. The organic material in the Earth's crust is connected to the biosphere and, apart from fossil fuels, is mostly confined to the surface.

Q 8. To obtain the chemicals common in the prep. room but which are unusual in the Earth's crust, there first needs to be a natural concentration process to give places in the Earth where these substances are reasonably abundant. Then they need to be extracted (by mining, quarrying, pumping *etc*) and often then need to be concentrated further by a range of chemical and physical methods (*eg.* density methods, smelting, electrolysis, *etc*). Only then can we begin to think about the extraction processes used to get individual elements such as metals *etc*.

Q 9. See the graphs given for the Earth's atmosphere. The atmosphere is largely nitrogen and very little of anything else but oxygen (the 'other' is argon; the amount of carbon in carbon dioxide and methane doesn't come on to the scale).

Q 10. See the graphs given for the Earth's oceans. The data for the oceans does not include the hydrogen and oxygen of the sea water, as this would overwhelm the other figures. Apart from that, the oceans contain a hugely greater percentage of chlorine than the crust and much less silicon, aluminium and iron.

Notes

1. The 'composition' of the prep. room was calculated from the recommendations of the Royal Society on the resources needed for teaching science for 11-16 year olds (Royal Society, 1997). The elements in each inorganic chemical listed in the recommendations were recorded and summed. The 'others' category includes bromine, iodine, bismuth, mercury, silver and tin.
2. Some teachers might prefer to survey their own prep. room rather than use the Royal Society figures. To do this, note down all the major inorganic chemicals found there, then record which elements are found in them (*eg* calcium carbonate contains calcium, carbon and oxygen) and then add up all the times the element is found. Finally, use these figures to plot the graph of your own prep. room.
3. The abundance of elements in the crust, atmosphere and ocean were taken from Mason (1966).
4. For those interested in the figures used to plot the graphs, they are given in Table 1.

References

B Mason, *Principles of geochemistry*, London: Wiley, 1966

Royal Society *Science teaching resources: 11-16 year olds*, London: Royal Society, 1997 (Available at www.royalsoc.ac.uk/files/statfiles/document-131.pdf, accessed January 2003)