Concrete: Hard as Rock – or Not?

Condensed from EdGEO *"Putting the Earth into Science"*

The Earth's rocks are continually being formed, changed, and destroyed. Solidified lava and ocean floor sediments create new rocks, while water, wind, and ice erode exposed ones. A rock's resistance to chemical weathering is determined by how susceptible the minerals in the rock are to water or acids. Rocks rich in quartz, such as granite, are highly resistant to chemical weathering. Marble and limestone, which consist of soluble calcite, are more easily weathered by rain and snow.

What about concrete? Chemically, it is considered to be very durable. For example, it is used for pipes in water treatment plants where it has to withstand both the water and the processing chemicals. Over time, however, acids can chemically weather concrete by dissolving the calcium in the cement and the aggregates which hold it together. Once the cement is weakened, the concrete loses its strength. Concrete structures are also vulnerable when water infiltrates and corrodes the internal metal used to reinforce the concrete.

In this activity, you'll examine the physical and chemical weathering of limestone (calcium carbonate), both in the laboratory and in the natural environment.

Investigation

1. View a video slide show (approximately 4 minutes) with a stonemason's commentary about repairs to the cathedral in Worcester, United Kingdom. The images show the effect of weathering on this building and the steps taken to restore the structure.
http://news.bbc.co.uk/2/hi/uk_news/8582504.stm

2. Take a close look at the effects of weathering on local buildings or headstones in a cemetery. Sketch some examples of weathering and record the following details based on your field observations:

- Age of the structure
- Signs of weathering: e.g., rounded corners or edges, pitted surfaces, loss of detail in carvings
- Material (concrete, rock type, physical description)

Activity: Thermal Decomposition of Limestone

Materials

- Safety goggles
- 3 pieces of limestone, about 1 cm cubes
- Dropping pipette
- Bunsen burner
- Tripod
- Gauze
- Heatproof mat
- Tongs
- 2 boiling tubes
- Universal Indicator solution
- Drinking straw

Safety

- Wear safety goggles throughout the investigation.
- Use one straw per person. Throw the straw away after one person has used it. Only blow through the straw; do not suck up any solution.
- Do not touch the lime (calcium oxide) that is formed from heating limestone. It will be hot after heating. It is also corrosive.
- Calcium oxide causes burns and irritates eyes, skin, and the respiratory system. The reaction of calcium oxide with water is vigorous and exothermic.

Procedure

1. Take one piece of limestone. Add a few drops of water and note any reaction.

2. Place two pieces of limestone on a tripod and gauze, and heat with a roaring Bunsen flame for 15 minutes.

3. What changes do you observe, particularly in colour?

Optional: Darken the room and note what happens when the flame is trained directly on the limestone.

4. Use tongs to place one of the heated pieces onto the heatproof mat. Gently try to crush it with the tongs. Try the same with a piece that has not been heated. Record what you find.

5. Use tongs to place one piece of heated limestone into a test tube. With a dropping pipette, add a few drops of water. Record what happens.

6. Now add more water to the test tube until it is about half full. Shake the test tube and pour off the clear liquid, half into one test tube and half into another. Add a few drops of Universal Indicator to one tube and record the pH using a colour chart.

7. Place a straw into the solution in the second tube and blow gently through the straw. Note what happens.

Discussion / Questions

1. What differences are there in the limestone before and after heating?

2. The heated limestone has decomposed to lime. What is the pH of the solution produced when lime reacts with water?

3. Name the solution produced.

4. The formula for limestone (calcium carbonate) is $CaCO_3$ and for lime (calcium oxide) is CaO. Write a balanced equation for the reaction when limestone is thermally decomposed.