Sinkholes and Acid Rain

How are sinkholes formed?
Some types of rock, especially limestone, can be dissolved by weakly acidic water. Carbon dioxide in the air and soil reacts with water to form a weak carbonic acid. Slightly acidic water can slowly dissolve limestone, especially along fractures or other weak areas. As fractures enlarge, they can become caves. As the caves become larger, they are sometimes unable to support the weight of the rock over them. If the roof of a cave collapses, it forms a **sinkhole.**

What type of rocks are commonly used for building?

Limestone is a sedimentary rock made mostly of the mineral calcite ($CaCO_3$). Limestone is usually formed from shells of once-living organisms or other organic processes, but may also form by inorganic precipitation. Limestone is very common in architecture, especially in Europe and North America. Many landmarks across the world, including the Great Pyramid in Giza, Egypt, are made of limestone. Limestone was most popular in the late 19th and early 20th centuries. Train stations, banks and other structures from that era are normally made of limestone. It is used as a facade on some skyscrapers, but only in thin plates for covering, rather than solid blocks.

Granite is another common building material. Granite is a igneous rock that is usually composed of the minerals quartz and feldspar (SiO_2). Granite is used for gravestones and memorials. Granite is a hard stone and requires skill and time to carve by hand. Until the18th century, granite could only be carved by hand tools with generally poor results. It was not until the1880s that machinery allowed granite to be more commonly used. Granite reacts much more slowly with acid than limestone.

Limestone chemically reacts to weak acids by going into solution. This happens gradually over time with rain water. Rainwater (pH of ~5.6) becomes acidic as it comes in contact with carbon dioxide in the atmosphere and the soil, creating a mild carbonic acid (HCO_3^-). As this acid flows through carbonate rocks, the rocks are dissolved and the calcite ($Ca2^+$) is taken up into solution.

What is acid rain?
Acid rain is defined as any type of precipitation with a pH that is unusually low. Acid rain accelerates weathering in carbonate rocks and accelerates building weathering. The principal cause of acid rain is sulphur and nitrogen compounds from human sources, such as electricity generation and motor vehicles. During the Industrial Revolution, the burning of fossil fuels in industrial facilities increased emissions of sulphur and nitrogen oxides to the atmosphere have increased. Occasional pH readings of well below 2.4 (the acidity of vinegar) have been reported in industrialized areas.

Discussion Questions:

How long do you think it takes for sinkholes to form?

What type of bedrock do you think sinkholes usually from in?

What is the impact of acid rain on limestone monuments?

What is the impact of acid rain on granite monuments?

Make a hypothesis (prediction and supporting reason) about whether limestone or granite monuments will weather due to acid rain.