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Weathering in Iowa: Not What You May Think

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Alexa Sedlacek "Weathering in Iowa: Not What You May Think"

1. When I look at the limestone bedrock of Iowa, as I did just the other day with my daughter (figure 2—[credit: Aaron Spurr, Quarry October 2, 2016]), I see long-term carbon storage. I do not mean a place to sequester modern atmospheric CO_2 into the subsurface. Rather, limestones in Iowa and around the world represent carbon that was removed from the atmosphere through geologic processes and stored in these carbonate rocks. Carbon storage in rocks such as limestone and fossil fuels are responsible for the large scale changes in atmospheric CO_2 concentrations throughout Earth's history.

2. If you ask UNI students to describe the carbon cycle, they may mention photosynthesis and respiration. Some students discuss the connection between human activity and the increasing concentration of atmospheric CO_2. When our students describe the source of excess CO_2, most mention human burning of fossil fuels, but they lack a clear picture regarding where this CO_2 will go in the future. Will it build up forever or will it be stored in the oceans? A general understanding of the carbon cycle is usually limited to short time periods, and is called the short-term carbon cycle. However, to understand the ultimate fate of anthropogenic CO_2, we need to understand how slow geologic processes act to remove carbon from the atmosphere and lock it away in geologic record. This is dictated by the long-term carbon cycle that operates over million-year timescales.

3. The process, a climate feedback called Earth's Thermostat, is simple. When CO_2 concentrations increase in the atmosphere, climate warms. As global temperatures rises, the rate at which chemical weathering occurs increases, and CO_2 is removed from the atmosphere more rapidly. Eventually chemical weathering removes enough CO_2 to cool climate. Once temperatures cool enough, the rate of chemical weather decreases, CO_2 accumulates in the atmosphere, and the planet warms. This thermostat process has kept the planet's temperature within a habitable range for billions of years. Understanding this process allows geologists to investigate Earth's recovery from Snowball Earth conditions, when most of the planet was covered with snow and ice, and it allows us to understand how Earth cools after periods of extreme global warming.

4. During the Devonian (about 419-359 million years ago), a period well documented in Iowa's geologic record, climate cooled dramatically. This is attributed, in part, to the radiation of plants on land and the corresponding increase of photosynthesis around planet. The Devonian limestone

bedrock found throughout the Cedar Valley was deposited in a shallow sea that covered much of the continent's interior. Animals like corals, brachiopods, and crinoids, found in limestones across the state, built their shells and skeletons from carbonate. The carbon they contain was removed from the atmosphere by chemical weathering. During the Devonian marine biodiversity levels were high, and plants and animals invaded the continents. By the end of the Devonian, large forest ecosystems were established. Earth's ecosystems changed, biogeochemical cycles adjusted, marking a major transition in the short-term and long-term carbon cycles. Some terrestrial plant material fell into stagnant swamp environments. Because swamp water is poorly oxygenated, the plant material that fell into it did not fully decompose, and eventually this organic material compressed into the first coal deposits. Coal, and all other fossil fuels, represent atmospheric carbon removed by photosynthesis that was never returned to the atmosphere. Atmospheric CO_2 levels plummeted, and shortly after the Devonian, they reached concentrations similar to pre-industrial levels. Although atmospheric CO_2 concentrations varied greatly since the Devonian, they never again reached the high values that characterized the atmosphere before the expansion of land plants across the continents.

5. Plant and animal life's success during the Devonian Period contributed to the Devonian mass extinction. Climate cooled because terrestrial land plants removed more atmospheric CO_2 and widespread carbonate deposition locked carbon into solid limestone, and many plants and animals could not adapt to cooler temperatures, leading to the extinction of many warm-adapted animals. In addition, rivers transported plant material and nutrient rich soils to the oceans, a process similar to the transport of agricultural fertilizers downstream to the oceans. Today, a dead zone has formed at the Mississippi River's mouth, and similar dead zones are found globally. During the Devonian, the new source of nutrients also caused anoxic conditions in the oceans, leading to the extinction of groups of corals, brachiopods, crinoids, that previously dominated the shallow oceans.

6. Human activity represents another major shift in the long-term and short-term carbon cycles. Our species' impact on climate is directly related to our ability to target fossil fuels and rapidly return carbon stored for millions of years in rocks back to the atmosphere. At UNI, the fuels we use to support our lifestyles are part of this process. However, through research and action, we can work towards addressing the issues associated with climate change. Every discipline on campus can provide students with tools to address climate change. By studying geology, we evaluate how Earth's climate system responded to past changes in greenhouse gas concentrations. We know that intervals of rapid change are often linked to elevated extinction rates followed by slow recovery. Life recovers, ecosystems reestablish, and new species appear, but full recovery may take millions of years. Over time, as climate warms, Earth's Thermostat and the long-term carbon cycle will remove the CO_2 currently accumulating in the atmosphere, but the rock record shows that this process will take thousands to millions of years. In the meantime, it is up to each of us to use our abilities, passion, and background to develop multifaceted approaches to solving climate related problems. For my part, I will continue researching and teaching the interplay between the long- and short-term carbon cycles, and I will

remind my daughter and her friends that the rocks and fossils they love each represent a tiny carbon reservoir that collectively resulted in major change.