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Sifting Throught The Sediments of Time: Using Thermonuclear Events To Measure Environmental Erosion Rates

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Hiroshima. Nagasaki. Chernobyl. While it is unlikely that the intentions of world leaders ever extended beyond the international conflicts at hand, they inadvertently created one of the best geochronometers available worldwide. Little did they know, the particles from the thermonuclear reactions allowed geologists to gain a better understanding of the chronological processes in order to paint a precise picture of sediment movements today. Why do geologists owe so much thanks to the testing and use of thermonuclear weapons? Two words: fallout radionuclides.

In the 1950s and ’60s thermonuclear weapons testing proliferated worldwide, changing not only global sentiments but also atmospheric composition. For the first time in the history of our planet, Caesium-137 (^{137}Cs), a radioactive element, was introduced into the atmosphere. What goes up must come down, and as the ^{137}Cs in the atmosphere moved around the world, it began to be absorbed by the soil at the surface.

In a stable landscape, sediment builds up gradually over time, forming layers of rock. Therefore, every layer since the 1950s and ’60s contains traces of ^{137}Cs. As the sediment absorbs radioactive fallout, the radioactive particles stick to the surface of the individual sediment particles, which make up what is known as the sediments’ grain coating. The grain coating provides a time-specific tag on the sediment that can be used to associate the sediment directly with the time period in which it was deposited.

To the non-geoscientist, the idea of only being able to narrow down the sediment’s location to a decade over time may seem relatively general, but compared to current methods, using fallout radionuclides is thousands of times more specific. Sediment particles the size of finely-ground kitchen spices do not contain much useful information, so scientists who look further into the past and on broader time scales use a technique called Optically Stimulated Luminescence (OSL). This alternative technique captures samples in darkness and measures the minute, trapped electron particle energy inside the sediment grains to determine the last time the sediment was exposed to light, often with margins of error of thousands of years. OSL is difficult to manage because the context for this dating method is based on relative dating, or comparing nearby layers of sediment.

While OSL is scientifically viable and suitable for more long-term measurements of sediment age, the use of fallout radionuclides allows scientists to analyze sediments on a human, rather than geologic, time scale.

This ability has direct and extensive applications to geological research which can impact our understanding of erosion and climate change processes. The fallout radionuclides are depth-dependent and deposited chronologically, which means that the more recently the sediment grains were at the surface, the shallower they are in the soil. As erosion occurs, the soil is worn away, exposing older and older soil layers.

Today, scientists, including Dr. Amanda Schmidt at Oberlin College, are measuring and examining the sediments they collect in stream environments for fallout radionuclides. Devices such as gamma ray counters analyze the sediment and produce

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spectra which show both the fallout radionuclides present in a sample and each radionuclide's individual strength. For example, if a sample from a river was analyzed for ^{137}Cs, a spectra either indicates a low concentration, high concentration, or no concentration at all. While no concentration would indicate that the sediment was at the surface before the thermonuclear weapons testing began (since ^{137}Cs did not exist in the atmosphere at that point), a high concentration would indicate that the sediment was at the surface while the testing was at its peak, and a low concentration would indicate deposition at a time after the peak of weapons testing, as ^{137}Cs still existed in the atmosphere at that point, but was much less concentrated.

These markers can help us to understand the movement of soil across time, mapping how quickly erosion is occurring in different environments. If we can develop a picture of erosion speed, we can begin to correlate that with land use and different environmental factors in an area. Based on these correlations, we can better understand the impact of different land use and other environmental factors on the landscapes that surround us and use that data to inform agricultural policies.

For example, Dr. Schmidt is currently using fallout radionuclides to date sediment in China, a country whose Communist land use policies have been under examination for their effect on erosion. By tracking the erosion speed with this methodology she is able to collect evidence supporting or opposing claims about the effects of policy and will potentially conduct research that will influence land use policy not only in China but worldwide.

Because this method allows geologists to examine sediment on a human time scale as opposed to a geologic one, it allows us to examine contemporary scientific issues related to climate change. Considering the short time scale that climate change is occurring on, it is immensely useful to be able to use geology and its relationship with atmospheric composition to collect data on the rate that they are being affected.

As we continue to develop more specific and descriptive methods of examining our planet in its most recent years, we will continue to gain insight into the more and more rapidly changing environmental dynamics of our planet. It is important to remember that even though Geology traditionally operates on the time scales of milenia, it can still be used to draw conclusions about current scientific phenomena.