Calcium-41 for Radiometric Dating

Why in News?

Scientists have suggested using **Calcium-41 for** Radiometric Dating as an alternative to **Carbon-14** for determining the age of fossilized bones and rocks.

- They have suggested a technique called **Atom-Trap Trace Analysis (ATTA)** as a solution, because ATTA is sensitive enough to **spot Calcium-41, which is a rare isotope.**

What is Calcium-41 and ATTA?

- **Calcium-41:**
  - Calcium-41 is a **rare long-lived radioisotope** of calcium with a half-life of 99,400 years.
  - Calcium-41 is produced in the **Earth's crust when cosmic rays from space collide with calcium atoms** in soil or rocks.
  - This isotope has the potential to be employed in dating methods for objects that are older than what can be accurately determined **using carbon-14 dating.**
- **ATTA:**
  - It is based on **laser manipulation and detection** of neutral atoms.
  - The sample is vaporized, and the atoms are laser-cooled and loaded into a light and magnetic field cage.
  - By tuning the laser's frequency**, Calcium-41 atoms can be detected through electron transitions.**
    - **Electron transition**: In an atom, an electron in one orbital **can transition to the next if it's given a specific amount of energy;** then it jumps back by releasing that energy.
  - The researchers reported being able to spot one **calcium-41 atom in every 10^{16} calcium atoms** with 12% precision in seawater.
    - It is selective and avoids confusion with potassium-41 atoms.
- **Applications of ATTA:**
  - The successful application of a calcium isotope opens the **possibility of extension to other metal isotopes.**
    - ATTA can be adapted to study other isotopes, such as argon-39, krypton-81, and krypton-85.
  - In warmer climates, glaciers retreat and allow rock below to accumulate calcium-41. In colder climates, glaciers advance and block the calcium-41 from reaching the rock. This way, scientists **hope to use ATTA to study how long some rock has been covered by ice.**

What is Radiometric Dating?

- **About:**
  - Radiometric dating is a method used to **determine the age of rocks, minerals, and fossils** based on the decay of radioactive isotopes.
  - It relies on the principle that certain **isotopes of elements are unstable and spontaneously decay over time** into more stable forms. The rate of decay is measured by the **half-life, which is the time it takes for half of the parent isotope** to decay

into the daughter isotope.
    - Different isotopes have different half-lives, which makes them useful for dating different time ranges.
        - For example, **carbon-14 dating is effective for dating organic materials up to about 50,000 years old**. When an organic entity is alive, its body keeps absorbing and losing carbon-14 atoms. When it dies, this process stops and the extant carbon-14 starts to decay away.
        - Using the difference between the relative abundance of these atoms in the body and the number that should've been there, researchers can estimate when the entity died.
- **Limitations with Carbon-14:**
    - Carbon-14 is an unstable and weakly radioactive isotope of carbon. It has a half-life of 5,700 years and is **used to estimate the age of carbon-based materials.**
    - Carbon dating using Carbon-14 is limited to objects up to 50,000 years old due to carbon-14's 5,700-year half-life.

Source: TH