One of the primary reasons driving mankind's quest to colonize other celestial bodies is the greater availability of resources once reserves on Earth dry up. However, for this we require a non- destructive analysis technique for the elemental composition of materials. One of the best ways for doing so are X-ray fluorescence lines (XRF).

X-rays have always been instrumental in analysis and have widespread use in both medical science and material science. Mosely first demonstrated the potential use of X-rays for analysing elements and established that the x-ray spectrum of a particular line was related to its atomic number. This empirical relation is widely known as Moseley's law. Very soon companies started using techniques for finding the chemical composition of elements and by the late 1920s the first X-ray spectrometers were being used in industrial purposes. After that there was no looking back.

Space exploration is a costly affair, and it would become very expensive to bring back samples from the surface of a planet. Even if the retrieval of samples were possible, one must send multiple expeditions to map even a relatively small region. XRF is also fast, precise and requires less time compared to other analysis methods. It is also remote and can be done by satellites which are at a distance from the surface, rather than rovers.

The method by which XRF lines help us in material identification is given as follows.

Any celestial body revolving around the sun is hit with solar X-ray radiation. When these X-rays irradiate on a surface, it can either pass through the surface or be absorbed. The absorbed X-rays interact with the surface. When this happens, the primary X-rays knock out an electron from it's orbital. This causes our atom to be highly energized and therefore unstable. To restore equilibrium, an electron from an outer orbital fills up the gap in this orbital. Since this is at a lower energy level, the excess energy is emitted in the form of fluorescent X-rays.

This difference between the expelled and replacement electron is unique for a particular element, and thus the energy of our fluorescent X-ray is also unique.

Satellites are equiped X-ray spectrometers which can detect the energy of this fluorescent X-ray and hence identify the composition of the surface.

There are many other methods for the analysis of material composition such as ICP-OES and ICP-MS, but they are destructive methods which cannot be done remotely. Hence XRF is one of the most popular tools for surface analysis in space

Bibliography

https://www.thermofisher.com/blog/ask-a-scientist/what-is-xrf-x-ray-fluorescence-and-how-does-it-work

https://www.chemeurope.com/en/encyclopedia/Moseley%27s\_law.html

https://www.sciencedirect.com/topics/physics-and-astronomy/x-ray-fluorescence-spectroscopy#:~:text=XRF%20is%20preferred%20because%20it,elements%20present%20in%20the%20sample.

https://www.horiba.com/ind/scientific/technologies/energy-dispersive-x-ray-fluorescence-ed-xrf/what-is-x-ray-fluorescence-xrf/

https://www.agilent.com/en/support/atomic-spectroscopy/inductively-coupled-plasma-optical-emission-spectroscopy-icp-oes/icp-oes-faq#:~:text=Inductively%20Coupled%20Plasma%20Optical%20Emission%20spectroscopy%20(ICP%2DOES)%20is,elements%20are%20in%20a%20sample.