Helium-3 capture in lunar regolith and the age of the moon

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Helium has been an important part of solar physics for more than a century, and is also of interest to creation scientists in seeking to understand decay rates within the earth. It is one of the most abundant elements in the universe, and is also plentiful in the earth arising as alpha particles from radioactive decay of thorium and uranium. Jules Janssen and Norman Lockyer first, but separately, detected helium during the 18 August 1868 eclipse of the sun (figure 1). Both noticed a new spectral line in imagery, and Lockyer named the newly discovered element after the Greek god of the sun—*Helios*. The recent RATE project has of course been looking at the abundance of helium nuclei (alpha particles containing two protons and two neutrons) in the earth from the decay of radioactive elements in zircon crystals, and found evidence that there is still too much helium in the earth if it is as old as secular science believes. As a result, Russell Humphreys, as part of the RATE team, has tentatively suggested that there may have been a period of accelerated nuclear decay during the Flood year to account for the evidence.[1]

Helium-3 and the lunar regolith

There is however another isotope of helium, helium-3 that is formed in a different way than helium-4. It is claimed by some commentators that there is an abundance of He-3 on the moon because it has been bombarded by the solar wind for 'billions of years', and that it is too much for the moon to be as young as creationists hold.[2]

Helium-3 arises from the radioactive decay of tritium, a 'heavy' isotope of hydrogen containing one proton and two neutrons. Through beta decay one of the neutrons in the nuclei emits an electron and is converted into a proton; thus the new atomic nuclei has two protons and one neutron turning an isotope of hydrogen into an isotope of helium ($^3_1H \rightarrow \, ^3_2He + e$). This decay process has a half-life of about 12.3 years. Helium-3 also arises from complex nuclear processes in the sun and the sun's corona involving interaction between protons, deuterium and alpha particles, and the products can be emitted in relatively high concentrations from powerful solar flare events.[3] In the depth of the earth, He-3 may arise from the radioactive decay of lithium-6.

Although it is a relatively rare isotope of helium, the moon's surface layer of soil, a fine layer called the regolith, is in fact relatively enriched in places in He-3 compared to the earth. Helium-3 found in natural gas wells within the earth is found to be around 10,000 times rarer than He-4, although the abundance of He-4 may also be the cause of this smaller ratio. But in the lunar regolith the ratio is estimated to be 28 parts-per-million (ppm) of He-4, and estimated up to around 44 parts-per-billion (ppb) of He-3 in polar regions with weak sunlight.[4] However, in areas exposed to strong solar radiation levels may be as low as 1.4 ppb due to degassing, although the Apollo and Luna missions measured an average of 6.2 ppb in different places. Another study suggests some lunar polar areas sheltered from direct sunlight may contain as much as 50 ppb.[5] This is then a variable ratio of approximately 1:20,000 to 1:560.

Helium-3 and tritium in the solar wind

Most of the He-3 in the lunar regolith is thought to have come from the solar wind, a fast stream of protons, electrons, alpha particles and other ions, some of which is absorbed in the lunar surface because the moon does not have a significant magnetic field or a dense atmosphere. The earth has both and charged particles are deflected by the magnetosphere, or captured within the Van Allen belts and released back into space; thus He-3 nuclei do not impact the surface of the earth in the same way they do at the moon's surface. If the moon has had a weak dipolar magnetic field in the past then that might help to direct and concentrate charged particles towards the polar-regions where the cold conditions then help to lock-in the helium. It is also more strongly bound in a mineral called ilmenite ($FeTiO_3$), this a result of its atomic structure, whereas the looser regolith exposed to strong sunlight cannot hold onto helium isotopes well.[6] He-3 is incidentally considered very valuable because of its potential use in nuclear fusion and it may even make economic sense to mine it from the moon or use as fuel for space travel.

But what can be said about the claim that there is too much He-3 on the moon if it is recent? We may, I believe, make the following initial comments. Firstly, it is likely that a lot of the lunar H-3, He-3 and He-4 are released back into space and therefore its concentration in the regolith is possibly in a steady state, although we should bear in mind lunar-polar concentrations are only estimates. Secondly, amounts arriving from the sun may vary due to different levels of solar activity; such as coronal mass ejections, high-speed solar wind streams from coronal holes and occasional very high-energy proton and other ion storms. A strong S3 10MeV high-energy proton storm will increase the proton flux 10,000 fold above background levels and may last for several days (to 1,000 cm^{-2}s^{-1}sr^{-1}) with event frequency around 1 per year.[7] Such solar storms, and coronal mass ejections, may enhance the
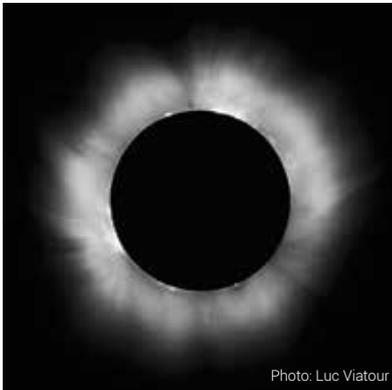
Figure 1. (Top) Drawing of the 18 August 1868 solar eclipse by Captain Bullock on expedition in the Celebes Sea showing the variable solar wind stream. (Middle) Eclipse of 11 August 1999 highlighting the corona and solar wind, taken in France. (Bottom) Image of the Full Moon taken 22 October 2010, from Madison, Alabama, USA.

background solar wind contribution significantly, and alter isotope ratios. The RATE group suggested that solar activity might have been much higher during periods of accelerated nuclear decay, i.e. during early creation week and the Genesis Flood.[8]

The decay rate from H-3 to He-3 is however relatively short being a matter of around 12.3 years, and from

this we can assume for the sake of the following calculation that over a 6,000-year period virtually all tritium arriving with the solar wind will be turned to He-3. We may also assume that there is a significant direct contribution of He-3 from the sun's corona. So it is possible from this to make some basic calculations simply based upon the background solar wind; that is by ignoring additional possible contributions and losses as outlined above.

Comparing solar wind fluence and lunar regolith concentrations

Observations taken at the ACE satellite suggest a typical solar wind speed of around 450km/s, or some 45,000,000 cm/s, while the density of the solar wind is averaged around 6 protons per cubic cm.[9] So in one second 270,000,000 protons are available to arrive per cm^2 at the moon's surface. In terms of concentrations of alpha and proton concentrations in the solar wind, measurement suggests a ratio of between 1 in 12 to 1 in 30 He-4 nuclei to hydrogen nuclei, or 3.3 to 8%.[10] Anglin *et al* suggest a tritium-proton ratio of 2×10^{-5} averaged over several solar flare events.[11] The deuterium hydrogen ratio has been estimated at 1/61,000.[12] Other studies suggest a tritium/hydrogen ration of 10^{-11} in interstellar space, although this assumes over time most tritium converts to He-3 and is not really representative of the solar wind near earth orbit.[13] Cameron however suggests a direct He-3/He-4 ratio of 1.6×10^{-4} in the solar system as a whole,[14] although Ramaty and Kozlovsky have argued that the He-3/He-4 ratio may increase to 10^{-2} in association with powerful solar flares at certain high energy levels.[3] The tritium/hydrogen ratio may also increase with such flares, but there is not a direct correlation between that and the He-3/He-4 ratio. Fowler and

Colgate even report He-3 numbers *eight times* higher than He-4 in rare solar flares.[15] Other research from the Isee 3 spacecraft suggests the solar wind has a relatively high He-3/He-4 ratio of 4.8×10^{-4}.[16]

But I think here it is appropriate to assume H-3 contribution of 2×10^{-5}, and He-3 contribution of $1/12 \times 1.6 \times 10^{-4}$ of the average proton density. So in every one second it is estimated that around 3,600 (and occasionally much higher at around 225,000) He-3 particles will arrive at the lunar surface per cm^2 ($270,000,000 \times 1/12 \times 1.6 \times 10^{-4}$) with the tritium contribution around 5,400 cm^{-2} s^{-1} ($270,000,000 \times 2 \times 10^{-5}$), converting over several decades to He-3. This gives a combined contribution of 9,000 particles cm^{-2} s^{-1} assuming relatively benign solar activity.

The regolith mineral ilmenite has a molecular mass of 152 ($FeTiO_3$) and its density is around 2 g/cm^3. So one gramme will have 3.96×10^{21} molecules (given Avogadro's number of 6.02214×10^{23}), and 1 cm^3 will have 7.92×10^{21} molecules. From the above we may take the unmeasured higher estimate of 44 ppb of He-3 in the regolith where degassing is weakest, so 3.48×10^{14} nuclei in 1 cm^3 of ilmenite will be of He-3. Now in 6,000 years there are 1.9×10^{11} seconds, and given a combined flux of 9,000 He-3 and tritium ions per second arriving at the lunar surface per square cm, about 1.71×10^{15} ions may arrive at the moon's surface in 6,000 years. This is about five times the estimated amount of He-3 in one cubic cm of lunar polar regolith. This calculation has also ignored the effect of powerful solar flares and proton storms that may enhance the proton flux and He-3/He-4 ratio substantially, although these are historical events that are unmeasured. One may also call into question the accuracy of the estimate of lunar-polar concentrations that are as yet also unmeasured, but if the moon has had a weak dipolar magnetic field in the

past, as Humphreys has inferred from data,[17] that would help to direct and concentrate charged particles towards the polar regions.

Summary

Although He-3 is formed in a different way than He-4, there are no reasons to believe that the abundance of this isotope in the lunar regolith is a major problem for creation science, and indeed *measured* lunar concentrations of He-3 are significantly less than the possible solar fluence over 6,000 years. By using average values and estimates from the solar wind and ignoring additional contributions, while seeking to minimise losses, there is found to be sufficient time to account for the concentration of helium-3 in the lunar regolith. Contributions from flare related and high-energy particle events are also likely to have a major impact, the historic frequency of which is unknown.

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Meiotic recombination— designed for inducing genomic change

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Creationary biologists have recognized that the diversity seen within created kinds today cannot be adequately explained by the shuffling of pre-existing gene versions (alleles) and accidental errors that accumulate within the genome.[1] Within the context of creation, the development of genetic diversity has been a means by which God has enabled his creatures to adapt to the many different environmental niches they occupy today (Genesis 1:22; 8:17; Isaiah 45:18). Further, it has played an important role in adding variety, beauty, and productivity in various domesticated plants and animals.[2]

There is certainly no logical reason to believe that unguided chance processes can bring about a functional genome.[3] Neither is there sound reason to believe that accidental changes to the genome are a productive source of useful genetic diversity. Logically, therefore, the genome must contain biological information that allows it to induce variation from within.[4] One mechanism involved in this is meiotic recombination.[5] Continued scientific research is elucidating some amazing details of this process.

Meiosis is a special type of cell division necessary for the formation gametes (eggs or sperm) so sexual reproduction can take place. In most plants and animals, chromosomes come in pairs (homologs, one derived from each parent), but gametes only carry one of each homolog. Early in meiosis, each chromosome must be