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Long term time variability of cosmic rays and possible relevance to the development of life on Earth

A.D.Erlykin, A.W.Wolfendale

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An analysis is made of the manner in which the cosmic ray intensity at Earth has varied over its existence and its possible relevance to both the origin and the evolution of life. Much of the analysis relates to the 'high energy' cosmic rays ($E>10^{14}eV;=0.1PeV$) and their variability due to the changing proximity of the solar system to supernova remnants which are generally believed to be responsible for most cosmic rays up to PeV energies. It is pointed out that, on a statistical basis, there will have been considerable variations in the likely 100 My between the Earth's biosphere reaching reasonable stability and the onset of very elementary life. Interestingly, there is the increasingly strong possibility that PeV cosmic rays are responsible for the initiation of terrestrial lightning strokes and the possibility arises of considerable increases in the frequency of lightnings and thereby the formation of some of the complex molecules which are the 'building blocks of life'. Attention is also given to the well known generation of the oxides of nitrogen by lightning strokes which are poisonous to animal life but helpful to plant growth; here, too, the violent swings of cosmic ray intensities may have had relevance to evolutionary changes. A particular variant of the cosmic ray acceleration model, put forward by us, predicts an increase in lightning rate in the past and this has been sought in Korean historical records. Finally, the time dependence of the overall cosmic ray intensity, which manifests itself mainly at sub-10 GeV energies, has been examined. The relevance of cosmic rays to the 'global electrical circuit' points to the importance of this concept.

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