favors an extraterrestrial origin of tektites. If some day it should be proved that tektites come from outer space, then the following possibilities would have to be considered because of the similarity of tektite and crustal rare-earth patterns: (i) that another body extremely similar to the earth in geochemical differentiation and mixing exists in space; (ii) that the tektite parent body itself was once part of the earth; (iii) that the rare-earth pattern in question is more widely distributed in the solar system than presently seems probable (in which case the practice of deriving cosmic abundances from chondritic meteorite analyses would have to be critically re-evaluated) and; (iv) that the identity of tektite and crustal rare-earth distribution patterns is fortuitous (*13*).

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Theoretical Basis for Logarithmic Correlations of Fractionated Radionuclide Compositions

Abstract. *A theoretical basis for logarithmic correlations of fractionated radionuclide compositions is described. Implications for nuclear chemical studies of bomb debris and application to the prediction of partition of* Sr^{90} *and other biologically important radionuclides among particles of various sizes, and consequently between local and world-wide fallout, are indicated.*

Fractionation of radionuclides in nuclear-bomb debris was previously defined as "any alteration of radionuclide composition occurring between the time of detonation and the time of radiochemical analysis which causes the debris sample to be nonrepresentative of the detonation products taken as a whole" (*1*). In land-surface bursts, the alteration produced by the gravitational and meteorological separation of particles of different size, shape, density, and composition was called primary fractionation. The effects of primary fractionation (*1*) were such that the radionuclide composition of different samples could be correlated empirically by expressions of the type

$$\log_{10} (f_i/f_{89}) = a_i + b_i \log_{10} (f_{95}/f_{89}) \quad (1)$$

where f_i is the fraction of the total mass-*i* chain produced by the bomb which was found in a given sample and a_i and b_i are constant for a given value of i in a given detonation. The constancy sometimes persists from one detonation to another. The values of f_i, f_{89}, and f_{95} for a given sample are usually assumed to be equal to the fraction of a single surviving member of the chain, which member is determined by radiochemical analysis of the sample. A correlation for La^{140} data is shown in Fig. 1. The purpose of this communication is to show a theoretical foundation for relations of this type.

Stewart (*2*) has considered particle formation in bomb debris from a theoretical standpoint and arrived at the conclusion that the particle size frequency function was lognormal (*3*). It is an interesting property of the lognormal frequency function in terms of a quantity x that multiplying it by x^n produces another lognormal frequency function (*4*). Moreover, the variance σ^2 of the distribution remains unchanged. There is found only a shift in the mean from μ to $\mu + n\sigma^2$ and a shift of the ordinates by a factor

$$e^{n\mu + (n^2 \sigma^2/2)}.$$

The physical consequence of this property of the lognormal frequency function is that if a particle frequency function is lognormal with particle diameter x so are the particle surface frequency function and the particle mass frequency function. Furthermore, all the normalized distribution curves will differ only by the location of the mean (*5*).

We can now make two assumptions. First, that the mass-95 chain, which behaves in a refractory manner, distributes itself uniformly throughout the molten debris so that the fraction of this chain in particles of a given size range will be equal to the fraction of the total mass of particles contained in that size range; secondly, that by the time the mass-89 chain has decayed from Kr^{89} to a condensible form, the particles have frozen and the mass-89 chain must distribute itself according to the available surface.

From these mass-chain distributions the ratio f_{95}/f_{89} for particles of diameter x can be calculated as

$$\frac{f_{95}}{f_{89}} = \frac{x}{x_m} \exp (5\, \sigma^2/2),$$

where x_m is the modal particle diameter.

The mass-89 and mass-95 chains represent two extremes of behavior. The other mass chains studied (*1*) behaved either like one of these or part way between the extremes. It is to be expected that an intermediate cause will have an intermediate effect, and therefore that the distribution of all such mass chains with particle diameter will be lognormal with the same variance σ^2. The ratio f_i/f_{89} for mass chain i which distributes

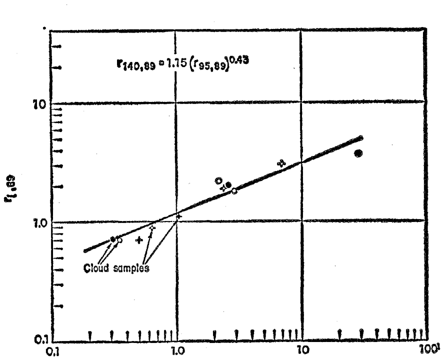

Fig. 1. Logarithmic fractionation correlation for La^{140}. Solid circles, coral surface burst; open circles, submegaton deep-water surface burst; solid stars, deep-water surface burst; open stars, shallow-water surface burst; $r_{i,j} = f_i/f_j$.

itself among the particles according to x^{k_i} where $2 \leq k_i \leq 3$ is given (5) by:

$$\frac{f_i}{f_{89}} = \left(\frac{x}{x_m} \exp \frac{-(k_i+2)\,\sigma^2}{2}\right)^{(k_i-2)}$$

so that

$$\frac{f_i}{f_{89}} = \left(\frac{f_{95}}{f_{89}}\right)^{(k_i-2)} \left(\exp \frac{\sigma^2}{2}\right)^{(3-k_i)(k_i-2)} \quad (2)$$

By taking logarithms, letting $(k_i - 2) = b_i$ and

$$a_i = \frac{b_i\,(1-b_i)\,\sigma^2}{4.606}$$

this expression becomes identical with Eq. 1.

As with all models, misimpressions may be obtained by too literal interpretation of either Stewart's approach or my modification even though lognormal distributions have been in fact observed (6). During particle formation periods, the particle population of the cooling fireball is continually changing due to the arrival of new particles and departure of old ones, with the result that fallout particles of a given size are extremely heterogeneous. A more realistic expression of the derived relation would be to say that the effects of the various particle-formation processes have the cumulative result of producing radionuclide frequency functions which are lognormal with respect to particle size, and that for Zr^{95} and Sr^{89} respectively, 3 and 2 are approximate values for the power to which the particle diameter must be raised before it is weighted by the lognormal frequency function of the particles.

The model should be more valid for air bursts, where the particles are in contact with the condensing radionuclides for longer periods of time. Airburst debris also correlates logarithmically, is extremely heterogeneous, and can be fitted with lognormal distribution functions (7).

One important consequence of this development is that, if Eq. 2 holds for actual debris, no single particle size would have a completely unfractionated composition. Thus, if the ratio f_{95}/f_{89} were representative (equal to unity), the ratio f_i/f_{89} would be unrepresentative. The maximum departure from unity would be attained if k_i were 5/2, in which case

$$f_i/f_{89} = exp\,(\sigma^2/8),$$

a significant departure from unity. Another important result is that the relationships presented offer a means of estimating the partition between local and world-wide fallout of biologically important radionuclides, like Sr^{90}, from their observed values of b_i. Additional details are in press (5; 8).

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$$\frac{d\,\Lambda}{d \ln x} = \frac{1}{\sigma(2\pi)^{1/2}} \exp\left[-\tfrac{1}{2}\left(\frac{\ln x - \mu}{\sigma}\right)^2\right].$$

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Algae: Nitrogen Fixation by Antarctic Species

Abstract. *Algae from terrestrial and fresh-water habitats in Antarctica were examined for ability to fix atmospheric nitrogen.* Nostoc commune *was the only species capable of growing in nitrogen-free medium; nitrogen fixation by this species was verified by assimilation of* N^{15}. *The importance of nitrogen-fixing algae to terrestrial life in the Antarctic is discussed.*

The Antarctic continent is an extensive land mass of over 5 million square miles, only about 5 percent of which is not covered with ice or snow. Although much of this exposed land surface consists of rugged mountains and isolated nunataks, there are areas which are conducive to extensive habitation by algae, lichens, bryophytes, and a mixture of protozoans and simple metazoans such as rotifers, flatworms, nematodes, tardigrades, and two genera of flightless insects. Among the more hospitable areas for plant growth are the Palmer Peninsula and the eastern part of South Victoria Land. In the latter area are located Marble Point and the Taylor, Wright, and Victoria dry valleys, all of which are characterized by extensive areas that are free of snow and ice. Temperatures in these localities are generally higher than in surrounding areas and the precipitation is very slight. There is evidence that the glaciers feeding into these valleys are receding and exposing new land as the ice disappears. Thus there is opportunity to study biological and physical sequences which are important in the formation of soil.

In the antarctic summer of 1959–60 collections of algal material were made from various places on Ross Island, Marble Point, and all three of the dry valleys. This material was collected aseptically and sent back to Wisconsin. Examination of the samples revealed a variety of filamentous and unicellular Cyanophyta, many representatives from the Chlorococcales of the Chlorophyta, and an assortment of pennate and centric diatoms. A list of algae identified from antarctic collections has recently been compiled (*1*). The samples were all tested for nitrogen-fixing algae by inoculation into nutrient media free from any source of fixed nitrogen. A variety of nutrient solutions were used in an attempt to include media conducive to the growth of algae belonging to different phyla. Of the 130 samples tested, approximately half of them showed growth in liquid media; samples of these cultures were then plated out on agar medium in petri dishes. The localities from which these samples had been collected included Cape Crozier, Cape Royds, Marble Point, and the top of Hogback Hill; the habitats were shallow ponds of fresh water, glacial streams, moist sand or rocks, and dry scrapings from rocks. By repeated transfer of small colonies on agar medium, 20 unialgal cultures were obtained. These cultures have all been identified as *Nostoc commune* Vauch.

Although the isolates were unialgal, they were not bacteria-free, so it is possible that nitrogen was being fixed by a contaminant and not by the alga itself. Such a contaminant would have had to be present in the antarctic flora, as aseptic techniques were used in collection of the samples and in all subsequent manipulations. The possibility of a nitrogen-fixing contaminant in the isolated cultures of *Nostoc* is unlikely, for other algal species would have been