and it seems likely that glomerids are thrown and smashed in nature as they are in the cage. Mongooses also eat eggs, and captive specimens have been known to break these by hurling them (*8*). We found that snails, including such hard-shelled forms as *Nerita reclivata,* and even hazelnuts, are successfully dealt with in the same way. The behavior may occur whenever preliminary pawing and mouthing of a hard "attractive" object fails to yield the edible contents.

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3. We thank Dr. R. F. Lawrence, Natal Museum, Pietermaritzburg, for sending and identifying the millipedes. The tests with the African mongoose were done at the New York Zoological Park. The other captive predators were housed at Cornell University. The ants were native to Florida, the grasshopper mouse to Arizona, and the jay to New York. Dr. N. Snyder supplied the snails.
4. The small European glomerid, *Glomeris marginata,* produces a sticky defensive secretion; Y. C. Meinwald, J. Meinwald, T. Eisner, *Science* **154**, 390 (1966).
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23 December 1966

Primary Oxidation Variation and Distribution of Uranium and Thorium in a Lava Flow

Abstract. *An Icelandic basalt lava flow has a systematic oxidation variation, formed during the initial cooling, with a resultant maximum oxidation just below the center of the lava. The ratio of thorium to uranium shows a clear dependence on this primary oxidation variation. Between-lava comparisons of thorium and uranium may be critically dependent on the position of the samples in each lava.*

Uranium and thorium abundances in basic igneous rocks are receiving considerable attention, largely because of their value in petrogenetic studies and because of the need for a better understanding of the limits of radioactive contributions to geothermal energy sources.

Heier (*1*) interpreted low concentrations of Th and U in Japanese basalts as being a function of the degree of association of orogenic activity with extrusion, and therefore implied a dependence of the concentration of the elements on depth of generation. Heier and Rodgers (*2*) demonstrated the potential of the Th/U ratio to petrogenetic studies by their observation of an increase in the ratio with degree of differentiation of basic igneous rocks. Orogenic activity may result in a greater range of the Th/U ratio across an alkali to tholeiitic suite of lavas than in a similar suite in a nonorogenic area, according to the work of Heier *et al.* (3) on samples from Japan and Hawaii.

Important in any such study, as well as in any detailed interregional (or interlava) comparisons of petrological properties, is, of course, the choice of representative sample material. Major problems include the detection of initial cooling (primary) modification of an initially homogeneous melt and of alterations after cooling (secondary).

Heier and Rodgers (*2*) discussed briefly the secondary alterations relevant to the Th/U ratio, and Heier and Adams (*4*) have suggested that this ratio decreases with increasing metamorphic grade. Examination of a long core of New Hampshire granite by Rodgers and others (*5*) showed the depletion of U by weathering, to a depth of 92 m (300 ft). Hamilton (*6*) also described the effect of weathering on concentrations of U. Nishimura (*7*) examined Th and U across the contact of a granitic intrusion with its host rock, but surprisingly he found no significant variation in the ratio. Heier and Rodgers (*2*) have used the conventional approach in minimizing secondary effects, according to their description of the use of roadcuts to obtain "fresh" samples. On a coarse scale, whether or not a sample is "fresh" can be determined in outcrop (*8*).

Primary modifications are not so readily detectable. Primary differentiation of the Tasmanian dolerite (*9*) did not significantly affect the Th/U ratio, which suggests a system closed to oxygen (*10*). We draw attention here to another primary modification process and describe its effect on concentrations of Th and U and the Th/U ratio.

Watkins and Haggerty (*11*) have described an oxidation variation between the cooling faces of a single 11-m thick Tertiary Icelandic lava, which is a sys-

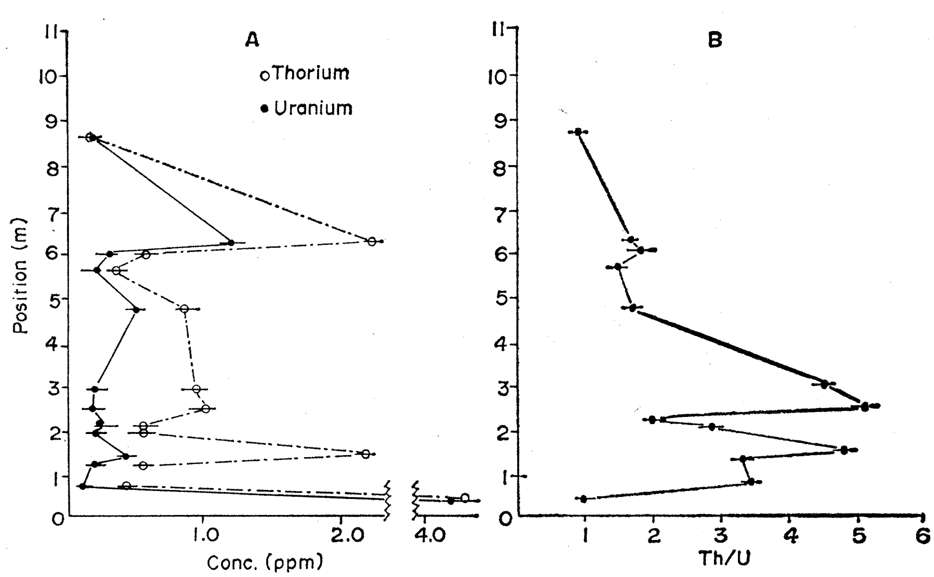

Fig. 1. (A) Variation of the concentration of U and Th with position in the lava flow. (B) Variation of the Th/U ratio with position in the lava flow. Abscissa in both diagrams is distance from base of lava in meters.

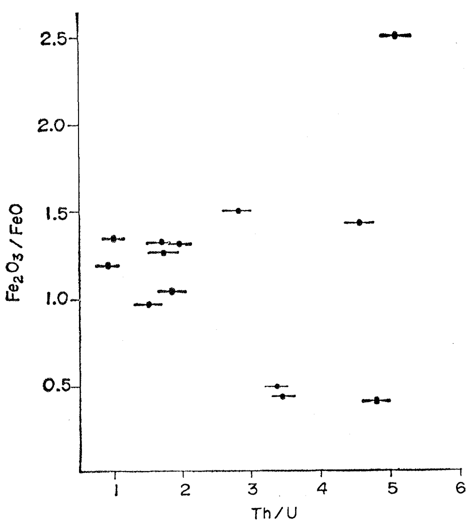

Fig. 2. Variation of the Th/U ratio as a function of the Fe_2O_3/FeO ratio.

tematic function of the initial cooling history. This oxidation variation was detected initially by examination of polished sections and has pronounced magnetic expression. General increase of oxidation inward from the outer edges of the flow and definition of the maximum oxidation state by the presence of pseudobrookite [which cannot be formed below 585°C (*12*)] are convincing evidence for a high-temperature origin of the variation during initial cooling. Detection, by electrochemical means, of a zone of high oxidation toward the center of a modern cooling lava in Hawaii (*13*) shows clearly that high oxygen fugacity can form toward the center of a lava flow during initial cooling.

Concentrations of Th and U were determined in 13 specimens from the original traverse of the Icelandic lava flow (*11*), in order to examine the possible effect of primary oxidation variation. Each rock sample, of average mass 5 g, was ground to a fine powder, mixed with sodium carbonate (1 part sample, 5 parts $NaCO_3$), and then fused in a carbon crucible. The cake was completely dissolved in 4*N* HCl, and an aliquot of U^{232} and Th^{234} tracer was added. Chemical separation of U and Th was carried out with the use of anion exchange, as described by Ku (*14*) and others. Isotopic analysis was made on an α-particle spectrometer, with average counting periods of 4000 minutes; calibration was carried out with Mississippian Spergen limestone (*15*). Activity ratios confirmed that equilibrium was reached. The chemical yield for Th ranged from 17 to 41.8 percent, with an average of 25 percent; and from 15.2 to 60 percent, with an average of 32 percent, for U. Each run was duplicated and four runs were made for each sample. Sensitivity was concluded to be 20 percent (*16*). Data are included in Table 1.

Figure 1A shows the absolute concentrations of Th and U, and Fig. 1B the Th/U ratio, at different positions in the lava. With the exception of the possibly anomalous sample from the base of the lava, absolute concentrations are generally within ranges previously found in basalts. The Th/U ratio varies by a factor of 5. Both concentrations and ratio vary systematically with the position in the flow. Configuration of the Th/U ratio closely resembles the general shape of the temperature-distribution curve during the late stages of initial cooling and the associated variation of intensity of magnetization (*11*).

Table 1. Table of chemical and magnetic data. Distance is that of the specimen from the lower edge of the lava; Fe_2O_3/FeO is the ferric/ferrous ratio; Jnat, the intensity of magnetization in electromagnetic units per gram $\times 10^{-3}$; and ppm, parts per million.

Specimen No.	Distance (m)	Uranium (ppm)	Thorium (ppm)	Th/U	Fe_2O_3/FeO	Jnat (emu/g $\times 10^{-3}$)
S6	8.68	0.21 ± 0.03	0.20 ± 0.02	0.95	1.197	4.85
S10	6.28	1.24 ± .10	2.16 ± .20	1.74	1.282	4.68
S11	6.05	0.32 ± .02	0.60 ± .05	1.87	1.043	6.14
S12	5.71	.23 ± .03	.35 ± .04	1.52	0.969	5.32
S13	4.79	.52 ± .03	.90 ± .08	1.73	1.338	7.02
S18	3.01	.21 ± .01	.95 ± .08	4.53	1.429	8.46
S19	2.55	.20 ± .02	1.02 ± .09	5.10	2.500	12.85
S21	2.21	.28 ± .03	0.56 ± .04	2.00	1.334	6.88
S22	2.04	.19 ± .01	.54 ± .03	2.84	1.511	7.12
S25	1.47	.46 ± .04	2.21 ± .21	4.80	0.406	0.42
S27	1.30	.17 ± .01	0.57 ± .03	3.35	.479	.56
S30	0.79	.13 ± .01	.45 ± .03	3.46	.746	1.03
S31	.40	4.20 ± .36	4.32 ± .40	1.02	1.360	4.12

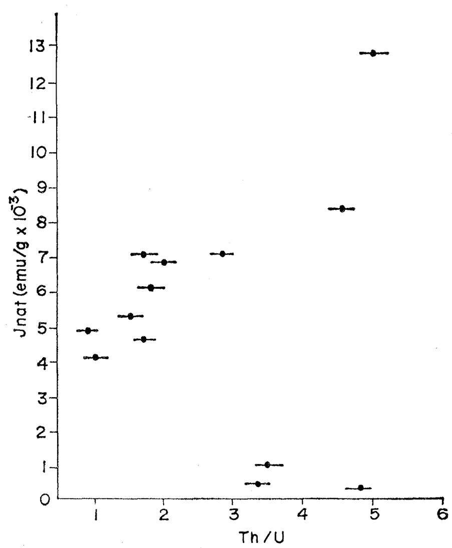

Fig. 3. Variation of the intensity of magnetization (Jnat) and the Th/U ratio in the specimens; emu, electromagnetic units.

Although readily detectable by examination of polished sections (*11*), oxidation variation can be determined only semiquantitatively by such methods. The Fe_2O_3/FeO ratio was therefore determined chemically (*17*). Results are given in Table 1 and plotted as a function of the Th/U ratio in Fig. 2. The three anomalous results outside the central field are from samples within 1½ m of the bottom edge of the lava. Within central parts of the lava, there appears to be a not unexpected (*2, 4*) relation between the oxidation state and the Th/U ratio.

The strong mutual dependence of intensity of magnetization and the Th/U ratio on the oxidation state is reflected in Fig. 3. (Values distinctly separated from the main data group are again from the lower edge of the lava.) The presence of maghemite in these specimens, together with low intensity and stability of magnetization (*18*), may be indicative of the effect of weathering (*19*); but whatever the cause, the lower edge is distinguished from the rest of the lava, as shown by data in Fig. 3.

The Th/U ratio thus varies considerably across a single lava as a function of the oxidation variation produced during initial cooling. As Watkins and Haggerty (*11*) and Kuno (*20*) have pointed out, an oxidation variation in basalts may not be readily detectable in the examination of thin sections, despite obvious effects on the iron-titanium oxides as seen in polished section. Therefore, it is suggested that meaningful between-lava comparisons of the Th/U ratio should be supplemented by examination of polished as well as thin sections. A practice of collecting at least two samples from each lava, with one from the center of the lava, is also encouraged in order to test for gross variations that may originate during initial cooling (*21*).

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Contact Inhibition in Colony Formation

Abstract. *Contact inhibition of replication of the established mammalian cell line 3T3 was examined during growth of the colony and compared with that of the Chinese-hamster cell line CHL-1. The growth curves of cells in the colonies conformed to the predicted exponential and linear rates for CHL-1 and 3T3 respectively. Autoradiographs of colonies in which DNA was labeled with tritiated thymidine showed that in 3T3 colonies, only peripheral cells were labeled, while CHL-1 colonies were labeled throughout.*

Simple methods for growth of macroscopic colonies from mammalian cells in vitro have made possible quantitative studies of cellular reproduction, genetics, and interactions with viruses (*1*). With these microbiological methods, the growth of mammalian cells in a particular medium can be expressed in terms of the plating efficiency (that is, the number of cells in a population capable of initiating self-sustaining multiplication) and of the generation time in the exponential reproductive phase. Contact inhibition of replication, however, is a property of some mammalian cells cultivated in vitro; this property interferes with unlimited proliferation of all of the cells in the colony. As a result, the differences between colonies of cells with and without contact inhibition can be used to identify and analyze the property.

To examine the effects of contact inhibition in colony growth, we have compared the 3T3 cell-strain isolated by Todaro and Green (*2*) with the Chinese-hamster cell strain CHL-1 isolated by Puck (*3*). The media and methods of cultivation and plating have been described (*2, 4*). The 3T3 cells formed less distinct colonies and consistently had a lower plating efficiency and growth rate than the CHL-1 cells (Fig. 1, a and b). The average plating efficiency of 3T3 [with 50 cells as the minimum colony size (*5*)] in ten separate experiments was 29 percent, whereas that of CHL-1 was seldom less than 70 percent. The generation time estimated from a cell count of the col-

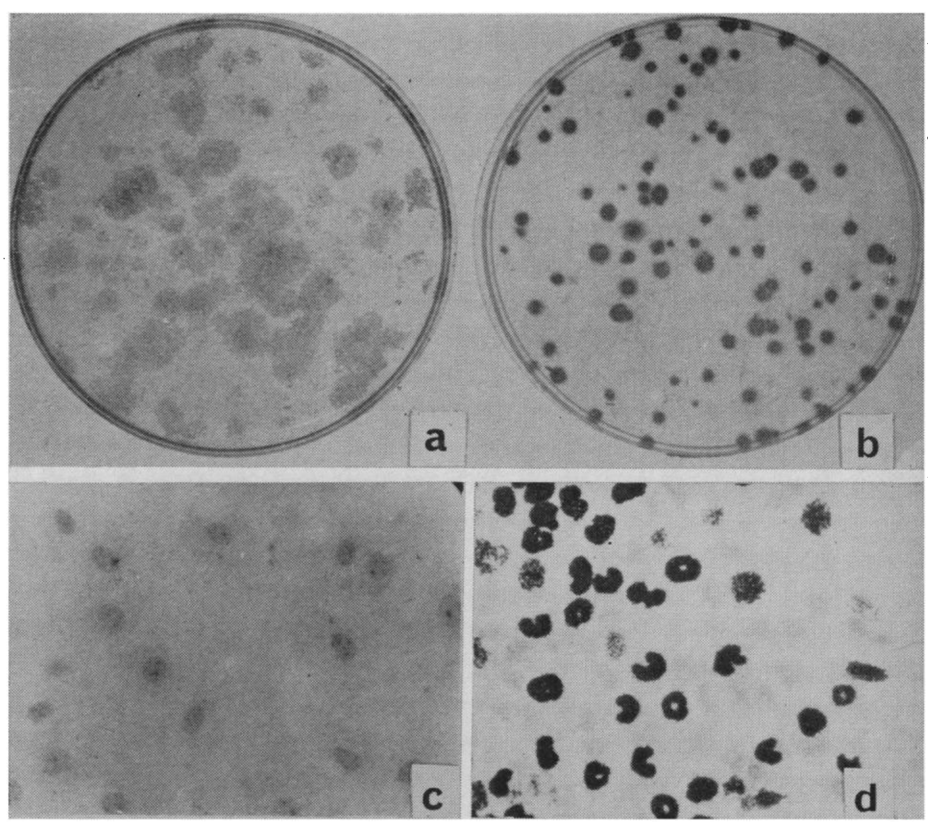

Fig. 1. Photographs of colonies of (a) 3T3 and (b) CHL-1 after the colonies were plated, incubated, fixed, and stained (actual size). (c and d) Photomicrographs of the center of colonies in which DNA was labeled with H^3-thymidine and of which autoradiographs were made (c) 3T3 and (d) CHL-1 (× 375).