by the General Electroforming Laboratories of the Silver Shop, Washington, D. C. In this process, a thin coating of silver is first plated on the glass blank for permanent protection. A coating of nonbonding material is then applied to the entire surface. The reflecting surface is then formed by electrodepositing silver (or other suitable material) on the nonbonding coating. Copper is next deposited to a thickness of 3/32 in., to form the body of the reflector. When the reflector is removed, it is thus composed of a copper backing with a silver reflecting surface on the concave side. Although silver was used for the prototype projectors as an expedient, the reflecting surface will eventually be made of a metal less subject to tarnishing. As only a portion of the complete ellipsoid is required for each reflector, and as the glass blank approaches a complete ellipsoid in extent, three reflectors can be electroformed simultaneously.

The Geological Survey is contemplating the utilization of the ER-55 projector in various ways.

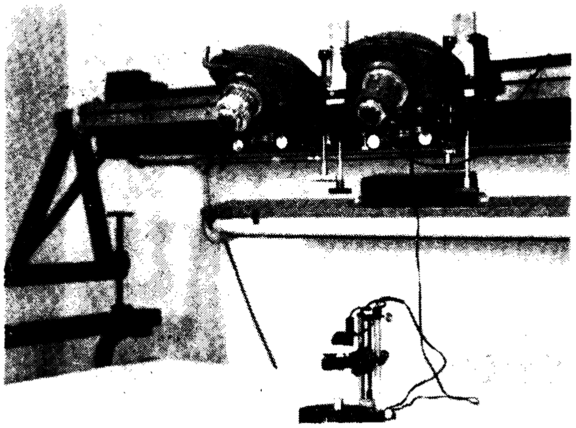

FIG. 4. Pair of ER-55 projectors mounted on standard multiplex supporting frame. The projectors are arranged for vertical photography.

For using vertical photography (see Fig. 4), ER-55 projectors can be mounted in pairs on a standard multiplex supporting frame. The main advantage of using the ER-55 projectors for mapping with vertical photography is that the area to be mapped can be photographed at higher altitudes as compared to multiplex flying, because of the improved illumination and resolution, and larger mapping scale. Since mapping costs generally decrease rapidly with an increase in flying height, the advantage is a substantial one.

The use of ER-55 projectors for compiling single-model convergent photography will provide, in addition to improved illumination and resolution and larger scale, all the inherent advantages of convergent photography.

Stereotriangulation of low-oblique photographic flights can be accomplished with a Twinplex plotter fitted with four twin ER-55 projectors. A simple swing adjustment applied to each projector-couple makes this instrument readily applicable to the bridging of either convergent or transverse low-oblique photography. The Geological Survey prototype Twinplex plotter is fitted with two twin ER-55 projector units. When completed four twin-projector units will be mounted on this instrument.

The ER-55 projector meets certain requirements, promises certain economies and constitutes a step forward in the field of simple double-projection plotters. It is expected that it will take its proper place with other photogrammetric instruments, each of which fills a certain need and is best adapted for the performance of certain jobs.

In addition to its use in stereoplotting instruments of the direct optical projection type, the principle of this invention can be used in other types of stereoplotting instruments and in enlarging or rectifying equipment. As pointed out in the patent application, the same principle can also be used in scientific fields other than photogrammetry. For example, an ellipsoidal-reflector system would provide brilliant illumination of a microscope slide. Or, such a system could be used in the reverse direction as a light gathering means for determining light values. In short, an unsymmetrical ellipsoidal-reflector system may prove advantageous whenever it is desired to concentrate light with the maximum efficiency and to obtain freedom from chromatic aberrations.

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A Note on the Lead Isotope Method of Age Determination

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Recently several papers have been published which attempt to interpret variations in the isotopic abundances of common leads. An important contribution was made in 1951 by Alpher and Herman (*1*) who showed that the observed lead abundances could be related approximately to the ages of lead minerals by simple mathematical formulas. They assigned dates to a number of analyzed lead ores and calculated the constants in these formulas by a least squares analysis. This calculation was later repeated by Collins, Russell, and Farquhar (*2*), who used data from additional lead samples of known age.

Russell, Farquhar, Cumming, and Wilson (*3*) have recently proposed a method whereby the variation in common lead abundances can be used for dating certain galena samples. A possible objection to the proposed method is that the mathematical formulas used will not be correct if the galenas used by Collins, Russell, and Farquhar for the original calibration have not been correctly dated. The purpose of this note is to demonstrate that common lead abundance-time expressions can be obtained without the use of dated samples.

TABLE 1

Source	Isotopic abundances ($Pb^{204} = 1.00$) 206	207	208	Ages (in 10^9 yr) By Pb^{206} curve	By Pb^{208} curve	Mean
Ivigtut, Greenland	14.85	14.94	35.07	1.91	1.75	1.83
Yellowknife Area, N.W.T., Canada *†	14.34	15.26	34.46	2.14	2.05	2.10
Horseshoe Island, Great Slave Lake, N.W.T., Canada	14.16	15.08	34.28	2.22	2.14	2.18
Phoenix Mine, Norseman, Western Australia	14.21	15.23	34.19	2.20	2.18	2.19
Borderland Mine, Busia, Eastern Province, Uganda†	14.05	15.10	34.24	2.27	2.16	2.22
Risks Mine, Kakamega, Kenya Colony†	14.05	15.05	34.21	2.27	2.17	2.22
Copperhead Mine, Bullfinch, Western Australia	14.19	14.92	33.80	2.21	2.38	2.30
Inguladhal, Chitaldrug District, Mysore State, India	14.17	14.74	33.80	2.22	2.38	2.30
Sioux Lookout, Ontario	14.05	14.92	33.85	2.27	2.35	2.31
Steep Rock Lake, Ontario†	13.94	14.83	33.75	2.32	2.40	2.36
Rosetta Mine, South Africa	12.65	14.27	32.78	2.85	2.87	2.86

* Average of results of four samples from Negus and Con Mines. The analyses were sufficiently similar to permit averaging.

† These isotopic analyses have not been published previously. We are grateful to R. W. Boyle, A. M. Macgregor, and J. P. Marble for making these samples available.

The equations of the abundance-time curves are (*2*):

$$x_m = a - \alpha V(e^{\lambda t_m} - 1) \tag{1a}$$
$$y_m = b - V(e^{\lambda' t_m} - 1) \tag{1b}$$
$$z_m = c - W(e^{\lambda'' t_m} - 1) \tag{1c}$$

where x_m, y_m, z_m; a, b, c are the abundances relative to Pb^{204} of Pb^{206}, Pb^{207}, and Pb^{208} at times t_m and the present, respectively. V and W are the present relative abundances of U^{235} and Th^{232} with respect to Pb^{204}, α is the present ratio of U^{238} to U^{235}, and λ, λ', and λ'' are the decay constants of U^{238}, U^{235}, and Th^{232}.

The values for a, b, c, V, and W were originally found by a least squares method (*1, 2*). The data which are most likely to be in error are the ages of the samples, t_m. However, the values of a, b, and c will be affected but slightly by changes in t_m. This is confirmed by the fact that the values for a, b, and c from Alpher and Herman's paper, based on different data and calculated with an incorrect decay constant, are within 1½% of those found by Collins *et al.*

Furthermore, it is generally assumed that the failure of lead isotope abundances to fit the theoretical curves is caused by variations in the distribution of lead, uranium, and thorium since the solidification of the earth's crust. This would imply that the older lead samples should fit the theoretical curves more closely than the younger ones. It would therefore seem reasonable to use the data from older samples to estimate new values for V and W, while taking for a, b, and c the values found in (*2*).

Expressions for the abundance-time curves can be obtained from the older lead ores, without assigning ages to them. Since the method does not depend on the actual values of t_m, it is not affected by uncertainty in their values. From equations 1*a* and 1*b*

$$t_m = \frac{1}{\lambda} \log \left(1 + \frac{a - x_m}{\alpha V}\right) \tag{2a}$$
$$t_m = \frac{1}{\lambda'} \log \left(1 + \frac{b - y_m}{V}\right) \tag{2b}$$

Let δ_m be the difference of these two expressions for t_m and consider finding the value of V which minimizes $\Sigma\delta_m^2$. Let $\overline{V}$ be an approximate value for V and $\overline{\delta}_m$ the corresponding approximate value of δ_m. For $\overline{V}$ we have taken 0.0714, the value found for V in (*2*). If ΔV is the difference between $\overline{V}$ and the value which minimizes $\Sigma\delta_m^2$, then

$$\delta_m = \overline{\delta}_m + \left(\overline{\frac{\partial\delta}{\partial V}}\right)_m \Delta V$$

The value of ΔV is found to be

$$\Delta V = -\Sigma\overline{\delta}_m \left(\frac{\partial\delta}{\partial V}\right)_m \Big/ \Sigma\left(\overline{\frac{\partial\delta}{\partial V}}\right)_m^2$$

The data used for the calculation are given in Table 1. About one-half of these are the results of new isotopic analyses carried out by the authors. All analyses were carried out at Toronto using the same 180° Nier type mass spectrometer. The results obtained for a calibration sample analyzed with this instrument are being published elsewhere (*3*). The following values (*2*) are used for the constants: $a = 18.45$; $b = 15.61$; $\lambda = 0.154 \times 10^{-9} (\text{yr})^{-1}$; $\lambda' = 0.980 \times 10^{-9} (\text{yr})^{-1}$; $\alpha = 139$. It is found that $\Delta V = 0.0043$, and hence $V = 0.0757$.

A new value for W may now be obtained by applying a least squares analysis to equation 1*c*, assuming c known ($= 38.40$) and taking $\lambda'' = 0.0499 \times 10^{-9}$ $(\text{yr})^{-1}$. We obtain

$$W = \Sigma(c - t_m)(e^{\lambda'' t_m} - 1)/\Sigma(e^{\lambda'' t_m} - 1)^2$$

The values for t_m are calculated from equation 2*a*, using the new value of V. The formula gives $W = 36.5$. The former value was $W = 38.2$.

The changes that these new values produce in the form of the curves are shown in Fig. 1; the new curves are solid. The difference is encouragingly small; for example, the upper limit to the age of the elements given by the intercept of the Pb^{207}/Pb^{204} curve with the time axis is changed only from 5.5×10^9 yr to 5.4×10^9 yr.

The ages obtained for the samples by fitting them to the Pb^{206}/Pb^{204} and Pb^{208}/Pb^{204} curves are given in Table 1. These appear to be in reasonable accord

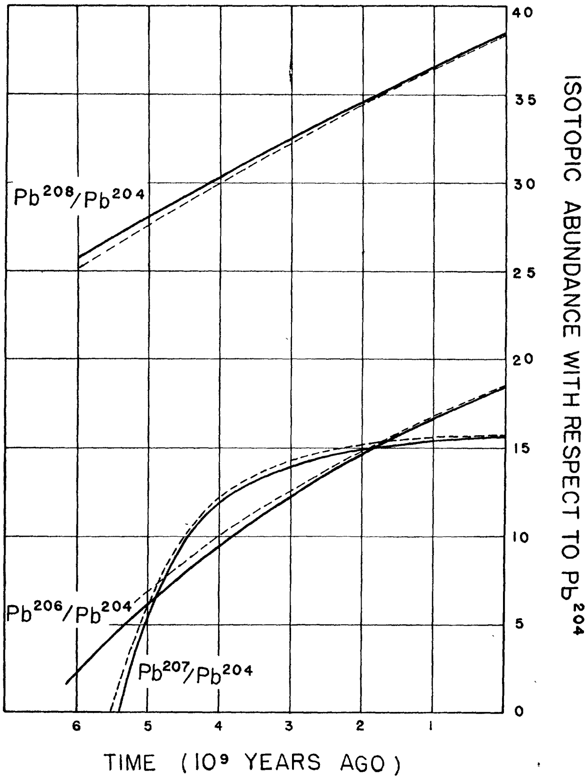

FIG. 1. Average lead isotope abundance-time curves. Broken curves after Collins *et al.* (*2*). Solid curves are those derived in this paper.

with each other and with ages obtained by other methods of geological dating. In Fig. 2 abundances of the lead samples are plotted against the mean ages. It is seen that they fit all three curves quite closely. This supports the hypothesis that the old leads should fit the curves fairly well.

In conclusion, the results above would seem to show that the uncertainties in the ages that have been assigned to common lead samples have not caused a very great error in the results obtained by Collins, Russell, and Farquhar.

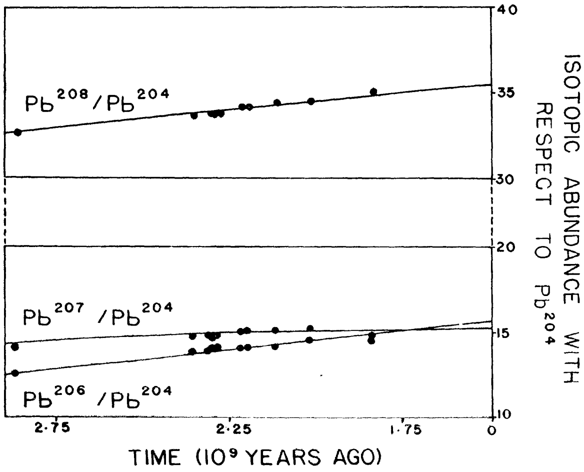

FIG. 2. Isotopic abundances of old leads fitted to the abundance-time curves.

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An Effective Safety Pipette[1]

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The increasing use of radioactive solutions, suspensions of viable microorganisms and other hazardous liquids has created a need for accurate transfer of these materials by pipette without exposure to the operator. Several remotely controlled pipettes (*1, 2*) have been designed to fulfill this need. In addition to these remotely controlled pipettes, many scientific supply houses furnish various devices labeled as "safety pipettes" to accomplish the same purpose. There are two serious difficulties with the available types of apparatus: (*a*) they are generally quite elaborate and expensive, and (*b*) the operator is unable to control the liquid in the pipette with any degree of accuracy. It is the purpose of this note to present a very simple and easily constructed piece of apparatus which eliminates the possibility of oral or cutaneous contamination of the operator when transferring toxic or hazardous liquids, yet it maintains complete and accurate delivery control.

The apparatus, as shown in Fig. 1, is constructed by sealing a piece of 5-mm OD glass tubing to a piece of 6-mm OD tubing in a T seal. The 5-mm tube is then bent to the form of a small h. The ends of the tube are cut to the specified length and fire polished. The side arm is connected to a rubber bulb of convenient size by means of a short piece of rubber tubing containing a glass bead large enough to completely close the rubber tubing. A short piece of rubber tubing is used to attach the apparatus to the pipette. The size of the rubber bulb is, of course, determined by the volume of the pipette to be used. A 1/4-oz bulb is convenient for pipettes up to 5 ml and a 1-oz bulb is satisfactory for pipettes up to 25 ml capacity.

The use of the apparatus is very simple. One first opens the glass bead valve by squeezing the rubber tubing around it and expels the air from the rubber bulb by squeezing. Release of the bead valve when the rubber bulb is collapsed produces a "portable vacuum supply." The tip of the pipette is then introduced under the surface of the liquid and the open top of the apparatus is closed with the finger tip. The pipette is filled by gently squeezing the glass bead valve. When

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