of reconciling a proper care for the security of the United States with essential handing over of information to the new body is solved in a manner which is eminently reasonable from the American point of view, but which may not seem so free from danger to the U.S.S.R. If other countries are prepared to accept the avowed intention of the United States to preserve a proper regard for the interests of all nations until such time as her trusteeship of what is admittedly an ephemeral possession of a unique weapon can be handed over to the United Nations Organisation, all will be well. The danger lies in international tensions over peace treaties, bases, or economic problems of trade, which might precipitate crises aggravated by the unilateral possession of the new weapon of destruction. From the technical point of view the suggested action seems very reasonable, and the system of control would work if proper provision is made for the fact that new discoveries may alter profoundly the basis of the proposals. There runs through the whole report a spirit of optimism which is highly infectious, and it is necessary to remember that confidence in complete physical understanding and knowledge has often been upset in the past by further scientific investigation. The great weight of technical skill and opinion embodied in the proposals renders it improbable that further knowledge will invalidate them in the near future, but allowance must be made for such an eventuality.

Consideration of these valuable proposals should be tempered by the realization that other countries, which are short of coal and other sources of power, may be more directly interested in the peaceful production of power by atomic methods than is the United States, which is so richly endowed by Nature. The suggestion that the handing over to the United Nations Organisation of information and executive power in atomic energy should take place by stages, and rather slowly, may result in an atomic arms race during the period of trusteeship by the United States. If promptly acted upon, these proposals could save the world. If political dilatoriness and self-seeking lead to stalling tactics and lack of agreement, they may have precisely the opposite results.

M. L. OLIPHANT

AN ESTIMATE OF THE AGE OF THE EARTH

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EVER since the publication by Nier and his co-workers[1] of the relative abundances of the isotopes in twenty-five samples of lead from common lead minerals of various geological ages (Table 1), I have entertained the hope that from these precise data it might be possible to fathom the depths of geological time. The calculations involved are, however, somewhat formidable, and a systematic investigation became possible only recently, with the acquisition of a calculating machine, for which grateful acknowledgment is made to the Moray Endowment Research Fund of the University of Edinburgh. The results have fully justified expectation and indicate that the age of the earth, reckoned from the time when radiogenic lead first began to accumulate in earth-materials, is of the order 3,000 million years.

In his first paper, Nier pointed out that those samples of lead "which contain relatively more Pb^{206} also contain relatively more Pb^{207} and Pb^{208}". The abundances of these isotopes, listed in Table 1, are all relative to $Pb^{204} = 1$. Since Pb^{204} is not generated by any naturally radioactive element, it can be taken as an invariable constituent of the *primeval lead* occurring in the earth at the time of the earth's origin. Calling the lead with the lowest relative abundances (No. 19) "the least contaminated lead", Nier suggested that all the other samples could be regarded as made up of this "least contaminated lead" plus additions of Pb^{206} and Pb^{207} generated from uranium, and of Pb^{208} generated from thorium. The minerals from which the samples of lead were extracted are all essentially free from radioactive elements, and hence the excess isotopes must have been generated before the minerals were formed. This point is, of course, of fundamental importance. It can easily be calculated that if the excess isotopes in the Joplin leads (Nos. 9–11) had been formed in the ore itself, the necessary amounts of the radioactive elements would have been 6·2 gm. U I, 24 gm. AcU and 20 gm. Th per gm. of galena—impossible amounts, hundreds of millions of times greater than any actual traces that may locally be present. Post-deposition contamination of lead being thus completely ruled out, it follows that before its concentration in ores, the lead must have been

TABLE 1. ISOTOPIC ABUNDANCES ($Pb^{204} = 1$) OF LEAD (NIER *et al.*) FROM MINERALS OF VARIOUS AGES.

No.	Source of lead, locality and geological age of ore deposit	Pb^{206}	Pb^{207}	Pb^{208}	Total (incl. $Pb^{204} = 1$)	Pb^{207}/Pb^{206}
1	Galena (2)*, Casapalca Mine, Peru. Late Tertiary, 25 m.y.	18·85	15·66	38·63	74·14	0·831
2	Bournonite (2), Casapalca Mine, Peru. Late Tertiary, 25 m.y.	18·67	15·45	38·15	73·27	0·828
3	Wulfenite and Vanadinite, Tucson Mts., Arizona. Miocene, 25 m.y.	18·40	15·53	38·1	73·03	0·832
4	Galena, Sonora, Castle Dome, Arizona. Tertiary, 25 m.y.	19·22	16·17	39·15	75·54	0·841
5	Galena, Freiberg, Saxony. Tertiary, 25 m.y.	18·07	15·40	38·0	72·47	0·833
6	Galena and Anglesite, Durango, Mexico. Tertiary, 25 m.y.	18·71	15·70	38·5	73·91	0·839
7	Galena, Metaline Falls, Washington. Laramide, 60 m.y.	19·30	15·73	39·5	75·53	0·815
8	Cerussite (2), Wallace, Idaho. Laramide, 60 m.y.	16·04	15·11	35·26	67·41	0·942
9	Galena I, Joplin, Missouri. Late Mid. Cretaceous, 100 m.y.	21·65	15·88	40·8	79·33	0·733
10	Galena II (4), Joplin. Late Mid. Cretaceous, 100 m.y.	21·65	15·74	40·36	78·75	0·727
11	Galena III (4), Joplin. Late Mid. Cretaceous, 100 m.y.	22·38	16·15	41·63	81·16	0·722
12	Galena in Dolomite, Austria. Triassic, 175 m.y.	17·75	16·21	38·05	73·01	0·913
13	Galena, Nassau. Late Carboniferous/Early Permian, 220 m.y.	18·10	15·57	37·85	72·52	0·860
14	Galena, Eifel. Carb./Permian, 220 m.y.	18·20	15·46	37·7	72·36	0·850
15	Galena, Saxony. Carb./Permian, 220 m.y.	17·36	15·46	37·38	71·20	0·890
16	Galena, Clausthal, Harz Mts. Carb./Permian, 220 m.y.	18·46	15·66	38·6	73·72	0·848
17	Galena, Przibram, Bohemia. Carb./Permian, 220 m.y.	17·95	15·57	37·9	72·42	0·868
18	Galena, Yancey Co., N. Carolina. Late Carboniferous, 220 m.y.	18·43	15·61	38·2	73·24	0·847
19	Galena (2), Ivigtut, Greenland. Late Pre-Cambrian, 600 m.y.	14·65	14·65	34·48	64·78	1·000
20	Galena, Franklin, New Jersey. Pre-Cambrian (—)	17·15	15·45	36·53	70·13	0·901
21	Galena, Tetreault Mine, Quebec. Pre-Cambrian, 800 m.y.	16·27	15·16	35·60	68·03	0·932
22	Galena, Broken Hill, N.S. Wales. Pre-Cambrian, 1,200 m.y.	16·07	15·40	35·5	67·97	0·958
23	Cerussite, Broken Hill, N.S. Wales. Pre-Cambrian, 1,200 m.y.	15·93	15·29	35·25	67·47	0·960
24	Native Lead, Långban, Sweden. Pre-Cambrian (—)	15·83	15·45	35·60	67·88	0·976
25	Galena, Great Bear Lake, Canada. Pre-Cambrian, 1,330 m.y.	15·93	15·30	35·3	67·47	0·960

* Numbers in brackets indicate the number of determinations made. In all such cases the results closely agreed and the average figures are those here given.

dispersed through radioactive source-materials in which the primeval lead was slowly modified by additions of radiogenic lead. Calculation of the requisite amounts of uranium and thorium (relative to the lead in common rocks) indicates that the source materials could have been any of the common crustal rocks, granitic types and their derivatives being the most probable in most cases.

Several years ago[2], I showed, using the data then available on the uranium, thorium and lead contents of rocks, that the atomic weights of ore-lead derived from granitic or basaltic sources should vary with the age of the ore in accordance with the varied proportions of Pb^{206}, Pb^{207} and Pb^{208} generated in the source-rocks up to the time when the lead ore was formed. Since the recorded atomic weights of lead from ores of widely different ages failed to show the expected variation with time, it was inferred that ore-lead could not have come from granitic or basaltic sources. This inference must now be withdrawn, not only because Nier's work shows that the isotopic constitutions and the resultant atomic weights do, in fact, vary with time, but also because the data for uranium and thorium in rocks on which I relied have since been shown to be misleading[3]. Nier and his collaborators[1] have already pointed out that their results "are not in disagreement with the theory that ore-lead has its origin in the igneous rocks or magmas of these rocks". Allowing for certain subsidiary possibilities, such as the upward migration of primeval or 'old' lead from deeper sources, and the probability that some sedimentary leads (for example, No. 12) may be of marine origin, I am in complete accord with Nier's conclusion, which is, indeed, fundamental to the present study of some of the further implications of his work.

Fig. 1, in which the relationships between the data of Table 1 are graphically displayed, clearly shows that, with a few minor irregularities, Pb^{206}, Pb^{207} and Pb^{208} vary systematically among themselves and with the totals of the isotopic abundances. I, I' and I'' represent the results for the "least contaminated lead" (Ivigtut, No. 19), and J, J' and J'' those for the lead with the highest abundances (Joplin III, No. 11). Assuming provisionally that lead of the J type has evolved from lead of the I type by radiogenic additions, it is possible to construct curves I–J, I'–J' and I''–J'' showing the gradual changes in the abundances of the respective isotopes which would be brought about by the presence of appropriate amounts of uranium and thorium in the source-rocks. The derivation of these curves is illustrated by Fig. 2. The curve RIJ represents the cumulative growth of Pb^{206} during the last few thousands of millions of years within, say, 1 gm. of a source now containing 1×10^{-6} gm. uranium. $RI'J'$ represents the corresponding increase of Pb^{207}. The relative positions of the two curves can be fixed by the following considerations:

(*a*) The age, t_m, of the Joplin ores is about 100 m.y.[4].
(*b*) $Pb^{206} = Pb^{207}$ in lead of Ivigtut constitution, whence it follows that the curves must cross at a point $I = I'$.
(*c*) The position of I must be such that the ratio UJ'/UJ = excess Pb^{207}/excess Pb^{206} in Joplin III lead, which ratio is found to be 0·194 from the following data:

Lead	Pb^{204}	Pb^{206}	Pb^{207}	Pb^{208}
Joplin III (11)	1	22·38	16·15	41·63
Ivigtut (19)	1	14·65	14·65	34·48
Excess isotopes in Joplin III	–	7·73	1·50	7·15

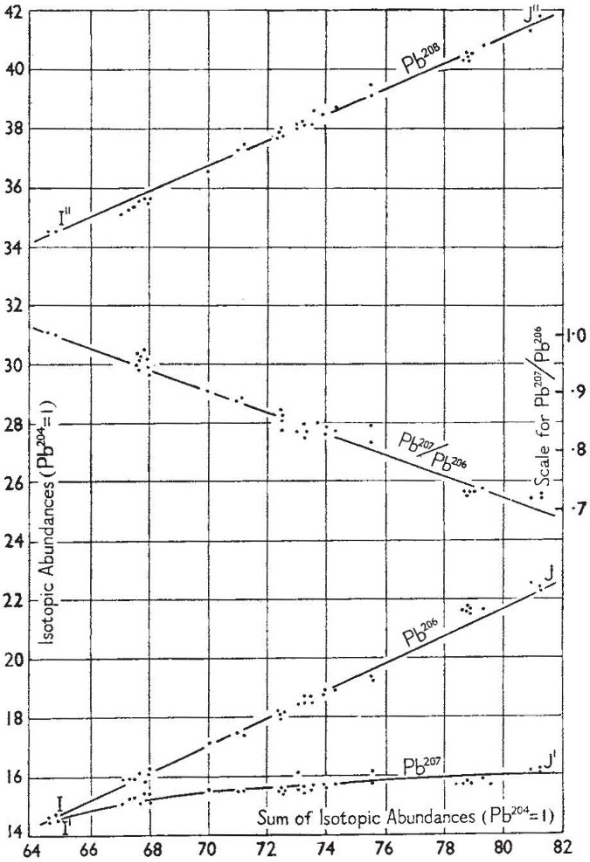

Fig. 1.

The time t corresponding to I can be found by trial; for it must be such that, in lead generated from a given amount of uranium,

$$\frac{Pb^{207} \text{ generated from } t \text{ to } t_m}{Pb^{206} \text{ generated from } t \text{ to } t_m} = 0{\cdot}194.$$

The value of t that gives this ratio when $t_m = 100$ m.y. is 2,760 m.y. The positions of I and the two curves being now determined against an arbitrary vertical scale, the latter can be readily transformed into one of isotopic abundances, since U, J' and J are also fixed, and we know that the point $U = 14{\cdot}65$, $J' = 16{\cdot}15$ and $J = 22{\cdot}38$. Completing the vertical scale of Fig. 2, the corresponding points for Pb^{208} can be inserted, since $T = 34{\cdot}48$ and $J'' = 41{\cdot}63$. I'' is necessarily vertically above I. The resulting curve $I''J''$ coincides exactly with that representing the cumulative growth of Pb^{208} in 1 gm. of a source now containing $3{\cdot}17 \times 10^{-6}$ gm. thorium; that is, the present value of the ratio of thorium to uranium in the source material of Joplin III lead would be 3·17. The latest estimates of this ratio from direct determinations are about 3·4 for granitic rocks and 3·3 for basaltic rocks[3].

From the data employed in constructing Fig. 2, the very similar curves IJ, $I'J'$ and $I''J''$ are added to Fig. 1, with isotopic abundances as abscissæ instead of time. It will be seen that they are very nearly the best curves that could be drawn through the points plotted. This coincidence demonstrates that the excess isotopes are essentially of radioactive origin; and that in the source-materials the average values of the ratio lead/uranium have been every-

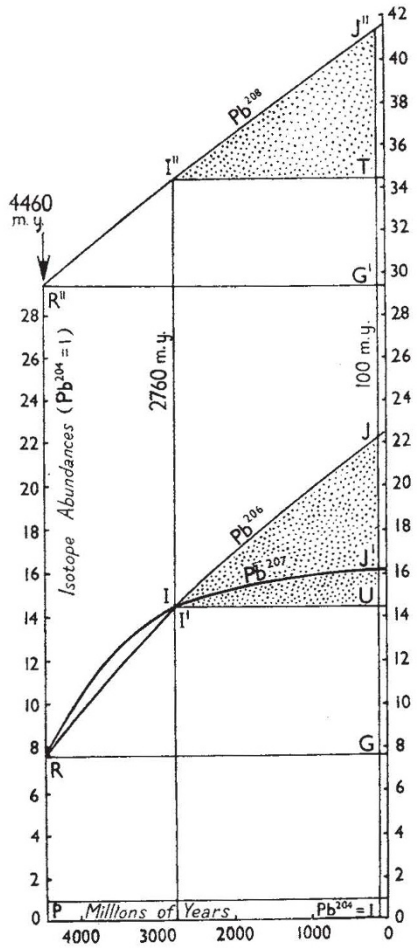

Fig. 2.

where nearly the same at any given time, as also have been the average values of thorium/uranium. It is obvious, moreover, that in the course of its evolution the Joplin III lead must have passed through a stage at which Pb^{206} was equal to Pb^{207} and that the point representing this stage cannot be far from I and I'.

The continuation of the curves for Pb^{206} and Pb^{207} beyond I and I' in Fig. 2 brings them to a point R, at $t = 4{,}460$ m.y., where they again coincide. This corresponds to the time at which, on the assumptions made concerning Joplin lead, U I and AcU first began to disintegrate. The age of the earth must therefore lie between the approximate limits of 2,760 m.y. and 4,460 m.y. Similarly, the constitution of the primeval lead must fall between the approximate limits determined by the ordinates of R and I, and R'' and I''.

Primeval lead	Pb^{204}	Pb^{206}	Pb^{207}	Pb^{208}	Pb^{207}/Pb^{206}
Upper limit, at $t = 2{,}760$ m.y.	1	14·65	14·65	34·48	1
Real values (to be determined)	1	x	y	z	>1
Lower limit, at $t = 4{,}460$ m.y.	1	7·8	7·8	29·5	1

Inspection of Figs. 1 and 2 shows that it would be possible to construct similar curves through the points representing any given pair of lead samples with a suitable difference in age and constitution. The curves for different pairs would in general have different vertical scales, but ideally the various sets of curves for Pb^{206} should all pass through the point x on the corresponding scales, and those for Pb^{207} should pass through y. This consideration suggests a method for determining x and y and the corresponding value of t_0, the age of the earth. Using the following symbols, with t_m for the age of the lead ore,

	Pb^{204}	Pb^{206}	Pb^{207}	Pb^{208}
Ore-lead (= source-lead)	1	a	b	c
Primeval lead	1	x	y	z
Radiogenic lead (from t_0 to t_m)	—	$a - x$	$b - y$	$c - z$

we have :

$$\frac{b - y}{a - x} = r = \frac{Pb^{207} \text{ generated by 1 gm. U from } t_0 \text{ to } t_m}{Pb^{206} \text{ generated by 1 gm. U from } t_0 \text{ to } t_m}.$$

Preliminary tests having shown that t_0 is within the range 2,760–3,100 m.y., r can be systematically computed for various values of t_0 such as 2,760, 2,900, 3,000 and 3,100 m.y. For each assigned value of t_0 we have :

$$ar - xr = b - y \text{ for one sample of lead, and}$$
$$a'r' - xr' = b' - y \text{ for another sample ;}$$

$$\text{whence, } x = \frac{b - b' + a'r' - ar}{r' - r}; \quad y = b + rx - ar.$$

By plotting x and y against time, two converging lines are obtained. Taking another pair and constructing the corresponding lines, it is then possible to find graphically the value for t_0 at which the respective values for x and y coincide or most nearly coincide. The method is very sensitive to small variations in the data, and it is therefore the more remarkable that in a fair proportion of combinations the value for t_0 where the x-lines cross is almost exactly the same as that given by the intersection of the y-lines. When the two values for t_0 differ appreciably, their average is taken. In some combinations the x-lines (and/or the y-lines) are coincident or parallel and no result is possible. The following examples illustrate the method and the range of results obtained :

	PAIR A		PAIR B	
	Broken Hill (23)—Joplin (11)		Broken Hill (23)—Tucson (3)	
$t_0 = 3{,}100$ m.y.				
r	0·3106	0·2385	0·3106	0·2349
ar	4·948	5·338	4·948	4·332
x	11·37		11·44	
y	13·87		13·89	
$t_0 = 3{,}000$ m.y.				
r	0·2939	0·2244	0·2939	0·2209
ar	4·682	5·023	4·682	4·065
x	12·50		11·74	
y	14·32		14·06	

The solutions for the above combination are listed below, together with the results from a few other combinations of pair A with other pairs.

Combination of Pair A with	t_0 (m.y.)		x	y
Pair B, Broken Hill (23)—Tucson (3)	3090	A	11·48	13·91
		B	11·47	13·91
Pair C, (23)—Peru (2)	3040	A	12·03	14·17
		C	11·98	14·11
Pair D, (23)—Nassau (13)	3000	A	12·50	14·32
		D	12·48	14·28
Pair E, (23)—Clausthal (16)	2995	A	12·56	14·34
		E	12·61	14·32
Pair F, (23)—Mexico (6)	2915	A	13·54	14·62
		F	13·52	14·61

The average result of eleven such combinations with Broken Hill (23) in common is $t_0 = 2{,}990$ m.y.

As already mentioned, some of the combinations fail to give results. This brings out the important fact that not all the samples of lead can be regarded as 'normal' in the sense of being products of continuous contamination in a single source. For example, a lead ore might be due to concentrations of rock-lead plus lead from older ore deposits which became involved in the cycle of magmatic or geochemical activity responsible for the lead ore in question. In such a case the total of the isotopic abundances would be

less than the normal figure for the age of the ore, the ratio total Pb^{207}/total Pb^{206} would be greatly increased, and the ratio radiogenic Pb^{207}/radiogenic Pb^{206} would also be increased. The lead samples of Idaho (8) and Saxony (15) show these peculiarities. Again, a lead ore might come from a source to which additions of the radioactive elements had been made at some time after the origin of the source but before the date of ore formation; or from a source from which radiogenic lead became concentrated in a higher proportion than primeval lead. In both these cases the total abundances would be increased, while the ratios mentioned above would be decreased. The Joplin leads (9–11) reveal these peculiarities very strikingly, though Joplin III is more nearly normal than the other two. Ivigtut (19) and, to a less degree, Tetreault (21) show similar abnormalities, but with modifications that are probably to be referred to a low uranium content in the source. The Austrian sedimentary lead (12) has so high an abundance of Pb^{207} that it must have had an entirely different kind of origin from all the other samples investigated. A marine origin, with selective concentration of Pb^{207} by organic intervention, may be provisionally suggested. Rejecting all the 'suspect' samples (and those for which a numerical age cannot at present be estimated) leaves us with those listed in Table 3.

From the Broken Hill (23) series of results already exemplified, and also from two similar series with Broken Hill (22) and Great Bear Lake (25) respectively in common, all the suspect samples except Joplin III were omitted. Finally, a series was worked out from all the possible combinations of the normal samples (that is, excluding Joplin III). The average solutions, together with the average solutions for a series from which the suspect samples were not excluded, are listed in Table 2.

TABLE 2.

Series of combinations	Number of good combinations	x	y	t_0	Range of t_0
General (including suspect samples)	27 (incomplete)	12·00	14·20	2950	2700–3150
Broken Hill (22) in common (including Joplin III)	14	11·45	14·06	2960	2760–3140
Broken Hill (23) in common (including Joplin III)	11	12·41	14·29	2990	2900–3090
Great Bear Lake (25) in common (including Joplin III)	7	12·58	14·28	3025	2900–3125
Normal samples only (excluding Joplin III)	13	12·52	14·29	3015	2725–3150

It is of interest to notice that the values for t_0 vary less widely than those for x and y, and that the value for t_0 derived from the first series differs but slightly from the last result, which is probably to be regarded as the best. It may be concluded with a high degree of probability that the age of the earth is not far from 3,000 m.y. Adopting this estimate, the corresponding values for x and y are 12·50 and 14·28.

From these values the abundance of Pb^{208} in primeval lead (z) and the present-day value of the ratio thorium/uranium in the source materials can now be approximately determined. Writing p for the ratio thorium/uranium, we have, for any sample of lead:

$$\frac{c-z}{a+b-x-y} = \frac{Pb^{208}\text{ generated by 1 gm. Th (now) from } t_0 \text{ to } t_m}{Pb^{206}+Pb^{207}\text{ gen. by 1 gm. U (now) from } t_0 \text{ to } t_m} \times \frac{Th}{U} = Rp$$

(R being calculable for the interval concerned).

Hence, $c - z = Rp(a + b - x - y)$

for one sample of lead, and

$$c' - z = R'p(a' + b' - x' - y')$$

for another sample.

Solving for p and z in 24 successive pairs, the average values are found to be $z = 31{\cdot}82$ and $p = \text{Th/U} = 3{\cdot}83$ (with a range from 2·5 to 5·24). In granitic rocks recently analysed for both uranium and thorium[3], Th/U is found to average about 3·4.

An approximate average for the uranium content of the source materials of the various samples of lead can be arrived at by transforming the relative abundances into actual amounts of lead. The latest work on the lead content of granitic rocks[6,7] indicates that the older average of Hevesy and Hobbie[8] (Pb = 30 × 10^{-6} gm./gm.) is too high, and that 20 × 10^{-6} is a more probable value. Goldschmidt and Hörmann[9] find the same figure to be characteristic of sandstones and shales. Taking the total of the abundances for late Tertiary lead (Table 1) as 74, we can write

$$74n = 20 \times 10^{-6}\text{; whence } n = 0{\cdot}27 \times 10^{-6}.$$

The amount of Pb^{206} generated by the uranium I in 1 gm. of source-rock from t_0 to t_m is then given by $(a - x) \times 0{\cdot}27 \times 10^{-6}$. The present amount of uranium I in the source (assuming it to be granitic) is found by dividing this amount of Pb^{206} by the amount generated by 1 gm. uranium I (now) from t_0 to t_m. The results are tabulated in Table 3. The average content of uranium I (= 0·993 uranium) is 3·23 × 10^{-6}, which corresponds well with the average uranium data for actual granites. Recent analyses give 2·77 × 10^{-6} (Keevil[10], 1938), 3·82 × 10^{-6} (Evans and Goodman[3], 1941) and 3·35 (Keevil[3], 1944). Almost equally consistent results are found by assuming a basaltic source with Pb = 5 × 10^{-6} gm./gm.[6,8]; uranium then is equal to 0·81 × 10^{-6}, against an actual average of 0·88 × 10^{-6} (Evans and Goodman[3] and Keevil[3]). However, neither field associations nor the lead contents of basaltic rocks favour a basaltic source for lead ores. The results are internally consistent with the inference that the granitic rocks and their derivatives are the main source of lead ores. There are reasons for suspecting that the Joplin ores may have had an ultrabasic source, but this possible exception need not be discussed here.

TABLE 3.

Lead samples	Excess Pb^{20} $(a-x)$	$n(a-x)$ × 10^{-6}	Pb^{206} from 1 gm. UI	$n(a-x)$* / Pb^{206} from 1 gm. UI
Peru (1)	6·35	1·71	0·49905	3·43 × 10^{-6}
Tucson (3)	5·90	1·59	,,	3·19
Mexico (6)	6·21	1·68	,,	3·37
Metaline Falls (7)	6·80	1·84	0·49438	3·72
Nassau (13)	5·60	1·51	0·47278	3·19
Clausthal (16)	5·96	1·61	,,	3·41
Bohemia (17)	5·45	1·47	,,	3·11
N. Carolina (18)	5·93	1·60	,,	3·39
Broken Hill (22)	3·57	0·96	0·32778	2·93
Broken Hill (23)	3·43	0·93	,,	2·84
Great Bear Lake (25)	3·43	0·93	0·30755	3·03

* The last column gives the amount of UI per gm. of source-rock, assuming that the latter contains 20 × 10^{-6} gm./gm. of lead; and that $n = 0{\cdot}27 \times 10^{-6}$ and $x = 12{\cdot}5$.

The results of the analysis of Nier's isotopic abundances summarized in this preliminary announcement depend, of course, on the accuracy of the data in Table 1 and of the disintegration constants adopted in the calculations: $\lambda_{UI} = 1{\cdot}52 \times 10^{-10}$/year; $\lambda_{AcU} = 9{\cdot}72 \times 10^{-10}$/year; and $\lambda_{Th} = 4{\cdot}99 \times 10^{-11}$/year. Adopting these figures, and assuming that the 'normal' samples of

ore-lead are concentrations of rock-lead, it is shown that the age of the earth is not far from 3,000 m.y.; that corresponding to an age of exactly 3,000 m.y. the constitution of the earth's primeval lead is about

Pb^{204}	Pb^{206}	Pb^{207}	Pb^{208}
1	12·50	14·28	31·82

and that the most probable sources of ore-lead (with the provisional exception of the Joplin ores) are granitic rocks now containing, on average, about $3{\cdot}3 \times 10^{-6}$ gm./gm. uranium, with the ratio thorium/uranium about 3·8. It is hoped to publish a detailed account of the investigation elsewhere.

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INDUSTRY AND RESEARCH

ON a number of occasions during the past year or two, the subject of research in industry in Britain has been ventilated and discussed at conferences arranged by various organisations. Although the attendance at these conferences has included some industrialists it is, to some extent, true that the discussions have been directed at industry; and that the general background of the conferences has included an assumption that industry had yet to be fully convinced of the virtues of applied science and that the vital relation between scientific research and industrial progress had yet to be completely appreciated. It was, therefore, fitting and timely that at a conference arranged by the Federation of British Industries held in the Kingsway Hall, London, on March 27 and 28, 1946, industry should have been given the opportunity of expressing its own views on this subject and of indicating the extent of its appreciation of the importance of scientific research. The conference was remarkable in that no less than twelve hundred delegates, drawn from all branches of industry, accepted invitations to attend it, and the Federation is to be congratulated on this successful outcome of its venture. Even more solid grounds for congratulation to the organisers, and to Sir William Larke in particular, were provided by the genuinely enthusiastic atmosphere and by the relevant and lively nature of the discussions which the conference evoked. There can no longer be any room for doubt as to the interest of industrialists in research.

The chairmanship of each of the four sessions of the conference was significant. At the introductory session on "Science, Industry, and the Community", the presence in the chair of Sir Clive Baillieu, president of the Federation of British Industries, provided an indication that this was a conference of industrialists. In passing it may be remarked that the opening of the discussion at this session by Sir Robert Robinson, president of the Royal Society, was symbolic of the complete dependence of the industrial application of science on the successful prosecution of fundamental, academic research. The Government's interest in industrial production was indicated by the presence of Mr. John Wilmot, Minister of Supply and Aircraft Production, at the second session, at which "Scientific Research and Production" was considered. The Minister of Supply shares with the President of the Board of Trade responsibility for the 'health of industry' in Great Britain. Further, the Government's realization of the need for adequate research was exemplified by the chairmanship of the Lord President of the Council, Mr. Herbert Morrison, at the third session, on "Scientific Research and Expansion"; his presence served as a reminder that the channel through which the benefits of the Government's practical interest may reach industry is provided by the Department of Scientific and Industrial Research. Finally, the continuity of Government policy in this matter was illustrated by the chairmanship at the fourth session, on "The Application of Research in Industry", of Sir John Anderson, formerly Chancellor of the Exchequer.

It will be convenient to review the conference under four heads provided by the resolutions submitted by Sir William Larke in his concluding address:

(1) "This conference recognizes that to ensure a reasonable standard of living the competitive power of British Industry must be firmly secured. To achieve this object it is essential to maintain technical pre-eminence in design, quality and production. This conference therefore urges every industrial concern to make the greatest possible use of scientific knowledge directly it becomes available."

The experience gained during the War of the amazing effect which a planned and co-ordinated scientific effort can have, not only on the volume of production but also on the ability to produce articles which exactly meet the requirements of the user, has been the most potent factor in spreading the gospel of the efficacy of applied research, and in this respect has created a conviction which innumerable conferences would never have achieved. The effects of the War on the industrial position of Britain have, however, been such as to make the translation of belief into concrete action a matter of desperate urgency and to render useless any slow and gradual introduction of science into the industrial framework.

There are many large industrial concerns with well-established comprehensive research departments, and the conference was given the benefit of the experience gained by the heads of some of these departments concerning the impact of research on the matters covered by the resolution. Exported goods, and, for that matter, goods for home consumption, must be of the highest quality. The use of the best and most suitable materials is vital to quality; hence research into the properties of materials, side by side with the search for new materials having particular properties, must be continuously pursued. Competitive power is dependent on maintaining low production costs. It is a fallacy that the empiricism and the trial-and-error methods of non-technical staffs really lead to economy in production. The scientific control of processes is the only certain way of reducing production costs to a minimum, and, incidentally, the data provided by scientific recording and control may well provide the background from which economic modifications of processes may emerge.

Again, in this highly technical and mechanical age, no industry can remain in the competitive market