bryonating chicken eggs or on artificial medium. In a study of the etiology and pathology of the CRD complex of chickens (*4*), the agent was isolated by the following procedure. Tracheal scrapings from a chicken were added to broth and penicillin was added to control bacterial contamination. Penicillin does not affect PPLO (*5*) but does suppress growth of certain contaminating bacteria. After this mixture had been incubated, a portion was injected into the yolk sac of embryonating chicken eggs. The presence of the CRD agent was revealed by specific respiratory lesions in the embryo.

In a later investigation of field cases (*6*), contaminated suspensions were retested. However, in addition to penicillin, 0.15 ml of aqueous 5-percent Seitz-filtered TA solution (*7*) was added to each milliliter of the broth suspension containing the tracheal scrapings. Treated suspensions were subjected to several serial embryo passages to determine whether the CRD agent was present. The harvested allantoic fluid from the serial passages was bacteriologically cultured, and TA was not added after the first embryo passage. Characteristic respiratory lesions in the embryo were regarded as positive evidence that the scrapings contained the CRD agent.

Use of TA made it possible to identify CRD in seven of ten cases in which the tracheal suspensions were heavily contaminated with bacteria. Unfortunately, TA may prove toxic for embryos. Some embryos inoculated with the suspension containing TA died early. Others exhibited marked stunting, underdevelopment of the mandible, and micromelia. When TA alone was inoculated into yolk sacs of 7-day-old embryos, the same teratologic syndrome affected most embryos (Fig. 1).

A similar syndrome has followed injection of insulin, boric acid, or pilocarpine hydrochloride into developing 4-day-old chicken embryos via the yolk sac. The best method to reduce or prevent this teratologic effect was to inject nicotinamide (NA) simultaneously. The protective effect of NA suggested that the skeletal defects were caused by a disturbance of carbohydrate utilization (*8*).

Another series of experiments was therefore carried out to determine whether NA would neutralize the effect of TA. The following mixtures of a 5-percent solution of NA and a 5-percent solution of TA were tested: (i) 0.5 ml TA and 0.5 ml NA; (ii) 0.3 TA and 2 ml NA; and (iii) 0.15 ml TA and 2 ml NA. After 10-min incubation, the material was inoculated into yolk sacs of 7-day-old embryos. NA did not neutralize the teratogenicity of TA. The concentrations of NA employed may not have been adequate, the embryos may have been too old, or the syndrome, although similar to the one described by Landauer (*8*), may have been caused by another type of disturbance in the developing embryo.

Fig. 1. Embryo on left: 14 days postinoculation. Yolk sac inoculated at 7 days with 0.2 ml of a dilute solution of thallium acetate (0.15 ml of a 5-percent solution in 1 ml of water). Stunting, micromelia, and shortened mandible. Embryo on right: Uninoculated control (same age as inoculated embryo). [Photo by C. Brandt]

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References and Notes

1. D. G. Edward, *J. Gen. Microbiol.* 1, 238 (1947).
2. H. E. Morton and J. G. Lecce, *J. Bacteriol.* 66, 646 (1953).
3. F. S. Markham and S. C. Wong, *Poultry Sci.* 31, 902 (1952).
4. H. Van Roekel *et al.*, *Univ. Massachusetts Agr. Expt. Sta. Bull.* No. 486, in press.
5. H. M. Powell and R. M. Rice, *J. Lab. Clin. Med.* 29, 372 (1944).
6. This investigation was supported in part by funds provided by the Agricultural Research Service, U.S. Department of Agriculture, contract Aai-10373. Contribution No. 993 of the University of Massachusetts Agricultural Experiment Station, Amherst. We wish to thank Henry Van Roekel for reviewing the manuscript.
7. Thallium acetate CP, obtained from Fairmount Chemical Co., Inc., 600 Ferry Street, Newark 5, N.J.
8. W. Landauer, *Proc. Natl. Acad. Sci. U.S.* 39, 54 (1953).

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Isotopic Composition of Common Lead from Southern Africa

The apparent extreme age of some pre-Cambrian rocks in southern Africa has been further demonstrated by recent publication (*1*) of the isotopic composition of common lead minerals from this region, showing ages in excess of 2×10^9 years. This report (*2*) supplements the earlier work with isotopic analyses of 16 samples from pre-Cambrian rocks in southern Africa (Table 1). The experimental procedure used is described elsewhere (*3*).

The merits and limitations of the so-called "common lead age" method have been discussed by several writers (*4*). If the broad assumptions necessary for the method are granted, equations such as the following may be used for determining the time of mineralization, t_m (in billions of years), measured from the present:

$$x_m = 18.87 - 11.54\,(e^{.154\,t_m} - 1) \quad (1)$$
$$y_m = 15.77 - 0.0836\,(e^{.972\,t_m} - 1) \quad (2)$$
$$z_m = 39.15 - 42.74\,(e^{.0499\,t_m} - 1) \quad (3)$$

x_m, y_m, and z_m are the ratios of Pb^{206}, Pb^{207}, and Pb^{208} to Pb^{204}, respectively, measured for each sample. The particular values of the lead constants shown were determined from a number of dated galenas at this laboratory (*3*). The three isotopic ages obtained from Eqs. 1–3 for each mineral are averaged together to give the age shown in Table 1. The error associated with each sample age is a measure of the spread in values of the three isotopic ages, compounded with a small uncertainty in the isotopic composition.

With the exception of the Elba (No. 5) galena, all the samples from the basement complex of Southern Rhodesia show great age, possibly indicating a single major period of mineralization in the range of 2.2 to 2.5×10^9 years ago. The time of the Elba mineralization is uncertain because of a considerable spread in the three isotopic ages (0.5 to 1.6×10^9 years). Nevertheless, the Elba sample probably represents a different and later period of mineralization.

Three samples (Nos. 8, 11, and 14) from South Africa give apparent ages that are considerably younger than their pre-Cambrian environment. The geologic environment for these three minerals makes a real age less than about 800 million years very unlikely. The isotopic and geologic data therefore suggest that these three leads may have been originally deposited with an anomalously large amount of radiogenic lead.

The Keimos (No. 15) galena contains excessive amounts of radiogenic lead, exhibiting an anomalous composition very similar to that characteristic of lead deposits in the Mississippi Valley (*3, 5*). The composition of the Witwatersrand (No. 16) sample shows contamination with uranium lead and is similar to that reported by the Toronto group (*1*). No reliable age assignments can be made for either of these leads. In any event, the Keimos anomaly merits further investigation in view of an apparently normal geologic environment and derivation.

Table 1. Lead isotopic composition of galena specimens from South African pre-Cambrian rocks

Locality	Geologic occurrence	Lead isotopic composition 206/204	207/204	208/204	Apparent common lead age (10^9 yr)
Southern Rhodesia					
1) S. T. Mine near Bindura*	Veins of galena in arkosic metasediments	14.16	15.06	34.22	2.2 ± 0.1
2) Kingsley Hoard Mine, Bindura, Mazoe Dist.	Replacement ore in arkosic and semipelitic metasediments	13.99	14.89	33.97	2.3 ± 0.2
3) Hardy (gold) Mine, Darwin Dist.	Gold vein in basement complex	14.02	14.74	33.85	2.4 ± 0.2
4) St. Ives Mine, near Turli, Bubi Dist.	Quartz vein in volcanic greenstone country	13.74	14.57	33.69	2.5 ± 0.2
5) Elba (gold) Mine, Wankie Dist.	Gold vein in basement complex	16.79	15.46	37.97	1.0 (?)
6) Cobra (gold) Mine, Gwanda	In greenstone country near granite contact	14.00	14.89	34.05	2.3 ± 0.2
7) C. S. C. Mine, Wedza, Marandellas Dist.	W, Pb deposit in marbles, pelitic metasediments, and Fe quartzites	14.15	15.17	33.86	2.3 ± 0.2
Southwest Africa					
8) Ombonna 89, Otjiwarongo Dist.†	Vein in reddish phase of Salem (?) granite	18.71	15.52	38.95	< 0.8
Union of South Africa					
9) Leeuwenkoof 97, Pretoria Dist.	Replaces dolomite of Transvaal system	14.92	15.06	34.21	2.1 ± 0.2
10) Uitloop 291, Potgietersrust Dist.	Quartz vein in granite older than Bushveld igneous complex	14.97	15.07	34.71	2.0 ± 0.2
11) Stavoren (tin) Mine, Potgietersrust Dist.	Cassiterite pipes in granophyres of Bushveld igneous complex	18.14	15.76	38.47	< 0.8
12) Appelfontein 71, Zoutpansberg Dist.	Quartz vein in "Old Granite"	15.94	15.40	36.76	1.4 ± 0.3
13) Rosetta Mine, Barberton Dist.	Quartz vein in Jamestown complex intrusive into Figtree schists	12.58	14.11	32.77	2.9 ± 0.1
14) Dyasonsklip, Gordonia, about 15 mi SW of Uppington	Vein in Namaqualand granite-gneiss	18.09	15.57	37.80	< 0.8
15) Keimos, Orange River Valley, Cape Province‡	Associated with either Namaqualand pegmatites or older Archean intrusive rocks that are cut by the pegmatites	20.41	15.66	41.49	Anomalous
16) East Geduld (gold) Mine, Witwatersrand		18.03	15.98	34.48	Anomalous, probably pre-Cambrian

* Samples 1–7 and their descriptions were supplied by R. M. Tyndale-Biscoe, acting director, and A. M. Macgregor of the Geological Survey of Southern Rhodesia.
† Samples 8–14 and 16 and their descriptions were provided by L. T. Nel, director, and B. Wasserstein of the Geological Survey of South Africa. Survey museum numbers corresponding to table numbers are as follows: No. 8, 4523a; No. 9, 4415; No. 10, 4480; No. 11, 3487; No. 13, 758; and No. 14, 4512. Samples 12 and 16 are from Wasserstein's personal collection.
‡ Sample and description supplied by A. Poldervaart, geology department staff, Columbia University, New York, N.Y.

The Rosetta galena (No. 13) was identical to that submitted by Nel to the Toronto group, and the isotopic composition here reported agrees well with the earlier measurement (*1*). Our age of 2.9×10^9 years is essentially identical to the 2860×10^6 years reported in the Canadian work (*1*).

A more complete history of this important area may be reconstructed with the aid of additional isotopic analyses of common leads and of uranium-bearing minerals. The tentative nature of the age determinations in this paper must be emphasized in view of the uncertainties in the values of the constants used in the lead growth Eqs. 1–3 and of possible inhomogeneities in the Pb/(U + Th) ratios in the crust.

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References and Notes

1. P. E. F. Gretener, R. M. Farquhar, J. T. Wilson, *Trans. Roy. Soc. Can.* 48, 17 (1954). See also, J. T. Wilson *et al.*, *Nature* 174, 1006 (1954).
2. Lamont Geological Observatory contribution No. 164. Work supported in part by Research Division of U.S. Atomic Energy Commission under contract AT(30-1)-1114.
3. G. L. Bate, "Variations in the isotopic composition of common lead and the history of the crust of the earth," Ph.D. thesis, Department of Geology, Columbia University, New York (1955).
4. E. McCrady, *Trans. Am. Geophys. Union* 33, 156 (1952); R. D. Russell *et al.*, *ibid.* 35, 301 (1954).
5. R. M. Farquhar and G. L. Cumming, *Trans. Roy. Soc. Can.* 48, 9 (1954).
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Tetrazolium-Reduction Test for Milk

Tetrazolium salts are redox indicators; their oxidized state forms colorless or pale yellow solutions in water. When reduced, they become insoluble in water and form highly colored crystals of formazan. The formazan of triphenyltetrazolium chloride (TTC) is red, that of neotetrazolium chloride (NT) is purple, and that of blue tetrazolium (BT) is dark blue.

In 1951 Schönberg (*1*) introduced the use of TTC in the indirect determination of the bacterial content and the keeping quality of milk. He concluded that the TTC-reduction test is best suited as a rapid screening test for milk samples with a high bacterial content. Later (*2*) he pointed out that the reliability of the results obtained with TTC in diffuse daylight of changing intensity may be questioned because light has a