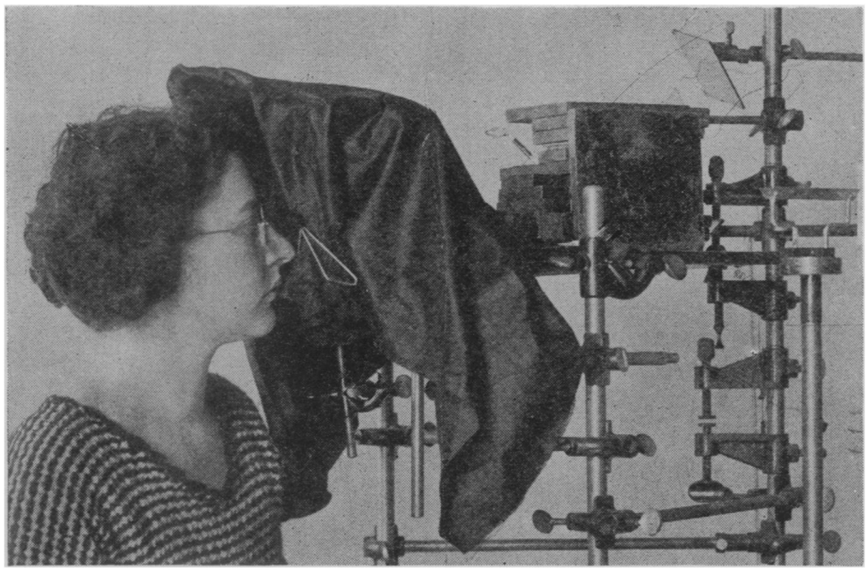
Nine Hundred Million Years Old!

Physics-Geology



MEASURING THE RATE OF RADIUM'S DECAY. With the aid of data gained by such measurements as this, scientists have been able to calculate the earth's age more accurately than ever before

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Mother Earth has given away a great many of her secrets to the generations of scientists who have queried and cajoled her, but like many another lady of advanced years she has been extremely enigmatic and non-confiding about her age.

Approached from many angles, her answers have been various and confusing, ranging from a few million years to several hundred million years. But, at last, the men of science think they have literally dug from her something like a truthful answer.

They have found a vein of lead in far-off Norway which they can point to and say definitely:

"This is 900 million years old."

Not 800 million or a thousand million, approximately; but 900 million absolutely.

To use a somewhat scientific and scholarly phrase, this beginning of geological chronology has been determined with a reasonable degree of accuracy, thanks to a comparatively new discovery in physics—the remarkable, constant, but slow chemical change that takes place in a radioactive substance, the metal uranium.

Every one has heard of radium and its remarkable properties, but the other substances of similar behavior are perhaps not so familiar. One of these is the metal uranium. This, in contra-distinction to radium, is not at all a rare substance. It has been used experimentally in steel making, and its compounds furnish a yellow pigment useful in painting on glass and porcelain. Like all the radioactive substances uranium is not stable. It breaks down slowly, very slowly, passing from one form into another until it finally becomes—lead!

Even scientific men have hardly had time to become used to this curious property of transmutation (as it it called) of the radioactive substances. It brings back the old days of the alchemists, who worked diligently in the vain hope of changing lead into gold. Here, rather sardonically, as it seems, Nature transmutes for us a more expensive and valuable metal into lead.

This change is very slow, only five per cent. of the uranium being converted into lead in about 400 million years; yet so delicate are modern methods of chemical and physical measurement that even this minute rate of change is capable of measurement. The rate of decay can be measured so closely that when we say 400 millions we do not mean 300 or 500.

More closely than this we can hardly measure at present; radioactive substances have not been known long enough; but when 50 or 100 years shall be behind our observations, a much more accurate figure will be available. The problem is like that of measuring the very small annual motions of the "fixed" stars: the longer the observations are continued the more accurate the result.

This parallel holds good in another respect which, as shall shortly be seen, is of great importance. We cannot alter the motions of the stars; we can only watch and measure. Likewise, nothing that we can do effects any alteration in this slow change of uranium into lead. Subjection to a white heat, or to a temperature of hundreds of degrees below zero in a bath of liquid air does not disturb this process in the slightest. The most vicious chemical treatment that we can devise seems to be without effect on its steady march.

Here at last it appears that we have a process which no conditions that may reasonably be supposed to have existed in the geological past could perceptibly alter.

Now the ores of uranium frequently contain lead. Why should they not, if they are old enough? They may be unknown millions of years old, and a considerable percentage of the uranium should have been converted into lead in such a period of time. We know the rate of this conversion with a fair degree of accuracy, and we have good reason to believe it unalterable. Is it not a mere matter of chemical analysis, to ascertain the ratio of lead to uranium, to determine the length of time that this rock has been in business?

No, not quite yet. Lead is one of the most commonly occurring metals—far more abundant than uranium, and occurring under such conditions in many ores that there is no suspicion that it has ever been anything else than lead. May there not have been some lead originally present in the uranium ore? And if so, how are we to distinguish between this aboriginal lead and that which was later added to it by the decay of the uranium?

Hopeless as it may appear, even this is possible; for Nature, by one of the strangest freaks to be found in all her behavior, is good enough to mark the lead which comes from the decay of ura- (*Turn to next page*)

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Earth's Age—*Continued*

nium. The mark is almost imperceptible; in its physical properties uranium-lead is not to be distinguished from the common variety. Even the chemist has to work very carefully to detect the difference. But delicate as is this task, it is not the most difficult with which the chemist may have to deal, and the distinction between these two kinds of lead can be exactly and safely made.

One of the most successful applications of this new geological timepiece was made upon a certain mineral from Norway. The rock in which it occurs is of a type long recognized as very old, as it underlies all other rocks which contain fossil remnants of life. This particular type of rock (called by the geologists "pre-Cambrian") undoubtedly dates back almost or quite to the period when life itself was first beginning to be.

By good chance it apeared on chemical examination that the lead in this mineral was entirely of the kind resulting from the decay of uranium, thus simplifying the problem considerably; and its proportionate amount indicated that this particular specimen of rock had been laid down about 900 million of years ago—not 800, nor 1000. Nine hundred hundred millions of years! The mind cannot grasp such a figure. The oldest historical records of Egypt or of Babylon date back perhaps six or seven thousand years. The wonderful wall paintings left by pre-historic man in the caves of the Pyrenees are perhaps twice as old as Babylon. The years of man himself may run into six figures—a few hundred thousand at most; and beyond man stretches an endless chain of varied forms of life, strange, bizarre, monstrous, back to an origin which we cannot descry.

In that long period whole continents have slowly risen from the sea, sunk as slowly beneath its waters, and risen again. As old as the hills? Nay, before the present mountains were brought forth there was life on earth.

It was not until after the opening of the present century that geologists were able to make any definite estimate of the age of the earth. Many earlier attempts have been made to solve this problem, but without success. The results of these methods differed widely among themselves, and in some cases gave absurdly small figures.

One of the most notable of these earlier suggestions was based upon the fact that the sea is salt. This may seem nothing remarkable, yet there is reason to believe that it was not always the case—that at one time the ocean, like the Great Lakes, was fresh water.

It was held at one time, perhaps more widely than now, that at an early period in its history the earth was hot, too hot to carry any water on its surface. All the water of our present oceans would then have existed as steam in the atmosphere. Any of this steam that happened to condense and fall to the earth would instantly have suffered the fate of water drops falling upon a hot stove, and would have been returned as vapor to the atmosphere whence it came.

But in process of time the earth would have cooled sufficiently to be a little below the boiling point of water; it would be no longer hot, but merely warm. Condensed steam, falling as warm rain upon the earth, could now accumulate in the hollows of the surface, and the oceans begin to be.

The primitive ocean thus started must have been fresh water, as soft as the water now caught in our rain barrels, but as time went on there would be a slow accumulation of salt in solution in the sea. Part of this may have been leached out of the rock at its bottom, but this supply must have been soon exhausted. By far the large part of the salt of the sea has been brought to it in very dilute solution by rivers.

What we call fresh water as found in rivers always contains traces of salt in solution. Rain as it falls is a very pure grade of water, but as it trickles over and through the soil it takes up a small amount of soluble material that eventually finds its way into the ocean, which it never leaves. The ocean water, when evaporated by the heat of the sun, leaves its dissolved material behind, and rises as vapor into the atmosphere to fall again as rain, and collect more soluble matter which it brings back to the ocean. And so the cycle proceeds, year after year, age after age.

Now since the salt of the ocean has been derived almost entirely from the rivers flowing into it, it would seem that if we could ascertain the average annual amount of salt at present discharged into the sea, we might arrive at a rough estimate of the number of years required to accumulate the present stock.

An attempt was made to do this by determining the small percentage of salt carried by great representative rivers such as the Amazon, the Nile and the Mississippi, and estimating on this basis the total annual influx of salt into the sea from all the rivers of the earth. Some allowable latitude was expected in this calculation, but even so the result was disappointing. By this method the age of the ocean came out only about 100 million years.

Rather a long period of time, many persons would say, but far too little to satisfy the geologists, who are the most time-hungry people in existence; for into less than this space of time would have to be crowded the whole long history of life on earth.

Moreover, this estimate involved another rather questionable assumption—that the present rate of supply of salt to the ocean fairly represents the average rate through all past time. If the map of the earth had not changed during the long period since the beginning of the ocean, this assumption might be tenable; but this is far from being the case.

Shells and marine fossils are found far inland in our present continents. Once the ocean was there; and where the ocean now is, there were doubtless land areas that have since been submerged.

No better success resulted from such other methods of estimating the age of the earth as were available until quite recent years. The trouble was the same with all—the only clocks available for measuring geological time could not be relied on to have maintained a uniform rate under the very severe conditions to which they were subjected during past ages.

The mental attitude of scientific men at the close of the nineteenth century was much like that of the visitor to the museum—it must have been millions of years, but whether a hundred or a thousand million, one guess was as good as another.

But the last ten years have brought a notable change in this respect, as can be seen by the superficial inspection of the writings of geologists. The older writers were very cautious about committing themselves to definite figures, but today we find geologists speaking with considerable confidence of a date perhaps 900 millions of years ago, computed, as has been explained, from the most curious of clocks—a metal that slowly turns into lead.