Mixture 5% of naphthalene

T	P	
241°	45.6	$S + L + G$
237°	43.7	$S + L + G$
cooled down to 200°	"	remains $S + L + G$

The experiments were arranged in the well-known way [1]). The pressures were read on a manometer of SCHÄFFER and BUDENBERG, and provided with the required correction. The heating was brought about by means of α-monobromonaphthalene boiling under low pressure.

Anorg. Chem. Labor. of the University.

Amsterdam June 23, 1910.

Chemistry. — "*Investigations on the radium content of rocks.*" I. By Dr. E. H. BÜCHNER. (Communicated by Prof. A. F. HOLLEMAN.)

(Communicated in the meeting of June 25, 1910)

Introduction. The fact that everywhere in the atmosphere radio-active emanations are found, in connection with the observation — at different places of the surface of the earth — of a very penetrating radiation, suggest very clearly that radio-active substances are found everywhere in the earth's crust. As far as radium is concerned this conclusion was experimentally confirmed for the first time by STRUTT [2]), who by means of the new methods of radium-determination could ascertain not only that a number of typical rocks contain radium, but even succeeded in measuring how great the content of radium was. The quantitative character of his results gave a still greater significance to his investigation in another respect, namely with reference to the question whether radio-active processes can be the cause of the internal heat of the earth. It was already known — from calculations by RUTHERFORD — that the presence of a quantity of radium of 4.6×10^{-14} gr. per gramme of the earth would be sufficient to keep the surface of the earth at a constant temperature, in other words to maintain the thermal equilibrium of the earth. And now STRUTT arrived at the surprising result, that on an average about 1.5×10^{-12} gr. of radium is present per gramme of rock, considerably more than the quantity calculated by RUTHERFORD. It appears

[1]) See SMITS, Z. phys. Chem. LII, p. 587.

[2]) Proc. Roy. Soc. A 77, 472 (1906) and 78, 150 (1906).

immediately from this value that calculations of the age of the earth or of the time during which life on earth has been possible, as they have been given among others by Lord KELVIN, must be thoroughly revised; on account of the presence of radium, the earth can have had its present temperature for a very long time already. But leaving this on one side, the too great amount found by STRUTT brings us in a great difficulty, a solution of which may be looked for in different directions; a perfectly satisfactory explanation, though has not yet been given. That the earth should get hotter, as has been asserted, is of course out of the question, if it were only on ground of the consideration that the cooling, in consequence of radiation of heat, can never have gone beyond the point at which the radiation was in equilibrium with the heat which was generated in the interior of the earth and flowed to the surface. So we shall have to take recourse to other suppositions, e. g. that radium is of cosmic origin, or that the desintegration proceeds more slowly under the conditions of the interior of the earth — high temperature and pressure — and accordingly generates less heat, or that the radium accumulates in the earth's crust, in other words that the different rocks at the surface of the earth contain more of it than the interior.

I will not enter as yet into what is to be said in favour or against these hypotheses, as first of all the fact itself requires confirmation. Also some English investigators have seen this; thus EVE[1]) has investigated some ten rock varieties from the neighbourhood of Montreal, and shortly ago COLERIDGE FARR and FLORANCE[2]) rocks from New-Zealand. It is further particularly JOLY[3]) who has occupied himself with these questions; among others he examined the radium content of the different rocks through which the St. Gotthard and Simplon tunnels have been bored. Though the values found by JOLY are on the whole much higher than those of the other investigators mentioned, yet they all arrive at the same result in so far that really the radium content is of the order of magnitude of 10^{-12} gr. per gramme of rock as was found by STRUTT. So we have investigations of rocks from England, Canada, British India, and New-Zealand; the continent of Europe is, however, hardly represented. As however extension of experimental material is very desirable in view of the far-reaching conclusions which may be attached to the results of these investigations, I have taken up the investigation of a number of European and Dutch-Indian rocks.

1) Phil. Mag. [6] 14, 231 (1907).
2) Phil. Mag. [6] 18, 812 (1909).
3) Phil. Mag. [6] 18, 140 (1909); also Radioactivity and Geology, Londen 1909.

The results may contribute at the same time to the solution of the question if the radium content, which may differ pretty considerably for different rocks, is connected with other properties, e.g. chemical composition or age.

As a first series the results of the investigation of ten rocks of the West-coast of Sumatra are given in this communication. I gladly avail myself of the opportunity to express my cordial thanks also here to professor MOLENGRAAFF at Delft for the kindness with which he placed the required material at my disposal.

Method. The methods to determine such slight quantities of radium quantitatively, have been given by STRUTT and BOLTWOOD and others.

The principle on which they rest is this: the solution containing radium is stored till the equilibrium quantity of emanation has formed; then it is expelled by boiling, collected, and conveyed to a so-called emanation-electroscope, in which the measurement takes place in the well-known way. As is known, the quantity of emanation is proportional to the radium which is present in the solution, and so we can calculate from the accelerated movement of the gold leaf in the electroscope, how much radium is present. The easiest way to do this is by subjecting a solution with a known quantity of radium to the same process: expelling the generated emanation by boiling, conveying it to the electroscope and measuring it.

Starting from these principles, I arranged the experiments as follows: 25 grams of the rock which had been ground to a fine powder beforehand was fused in a platinum dish together with 80 à 100 grams of potassiumsodiumcarbonate in a furnace during four or six hours. Then the melted substance was chilled, after which it easily separated from the dish; it was then reduced to powder in a high mortar, and digested on the waterbath in a beaker for some hours, the mass being continually stirred by means of a hot-air-engine. Then it was filtered at the pump, and the filtrate was poured into a flask, which was kept firmly closed. The remaining carbonate mixture, which still contained silicates[1]) was then evaporated to dryness with hydrochloric acid; after having been moistened again with hydrochloric acid, and after having stood for twenty minutes, hot water was poured over it, and it was filtered again. Thus an acid solution was obtained, which was also preserved. A remaining residue of silicic acid was dissolved in boiling sodiumhydroxyde, and

[1]) Washing till all the sodium silicate has disappeared from the precipitate, takes very long, and often gives a turbid filtrate; therefore the method indicated in the text was chosen, as a much shorter one.

the solution was added to the before mentioned alkaline filtrate. So the total quantity of the rock is found back in two solutions, an alkaline and an acid one, which were separately preserved and boiled to prevent precipitation of a voluminous silicic acid precipitate.

After the solutions had been set aside for at least a month, the emanation was expelled in the way as will be clear from the sub-

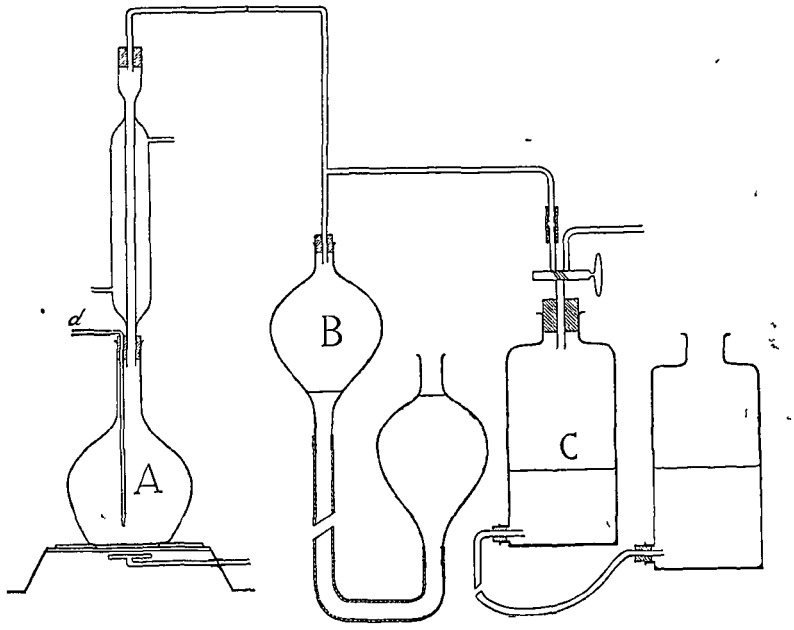

Fig. 1.

joined figure. In A the solution is boiled; the water-vapour condenses in the cooler; the generated gases with the emanation collect in the flask B over a saturate common salt solution [1]); after 25 à 30 minutes the boiling is stopped; the gas is sucked from the flask B into the bottle C, which had been beforehand exhausted, and a clip is opened at *d*; air flowing in from outside drives all the emanation which might still be found above the solution in the flask or in the cooler in this way into the bottle C, again over a salt solution. Finally the emanation is now transferred from C into the electroscope, for which purpose the latter had been first exhausted. Then gas and emanation flows through a tube with lime, a tube with phosphorpentoxyde and at last a tube with cotton wool into the electroscope; when the contents of the bottle C have been quite

[1]) At 20° the absorption coefficient of emanation in water amounts to 0,28 in saturate salt solution to 0.04.

transported, the electroscope is further filled with air, so that what still remains in the drying tubes, also flows in.

The electroscope was of the WILSON type; it is represented schematically in fig. 2. It consists of a copper cylinder, 16 cm.

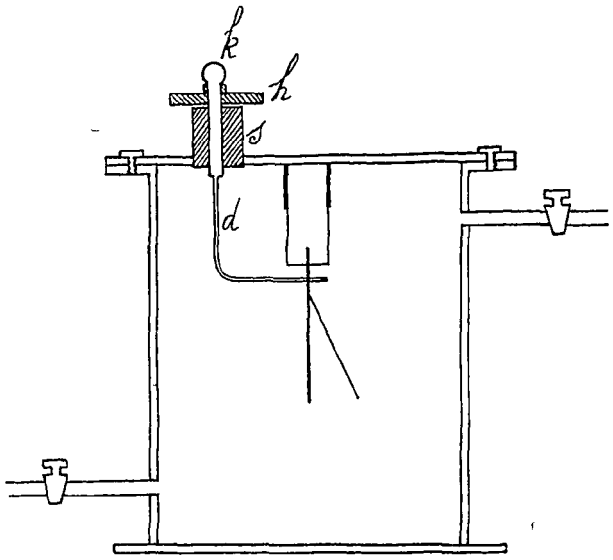

Fig. 2.

high, and with a diameter of 12 c m., so that the capacity is $\pm$ 1700 cm³. By means of two cocks the air can be sucked out, and the gas charged with emanation admitted; further two glass windows are adjusted diametrically, on a level with the leaf system. This consisted of a fixed copper strip, and a movable aluminium leaf, and was attached to a piece of amber, which tightly fitted in a copper tube, soldered to the lid; it was charged by means of the copper wire *d*, which turned airtight in an ebonite stopper *s*. For this purpose the knob *k* was connected with the negative pole of a storage battery of 160 cells [1]), the wire *d* being in contact with the leaf system. By turning the handle *h*, which was also made of ebonite the connection between *d* and the leaf system was broken; then that of *k* with the battery was interrupted, and finally *d* was turned so far till it was stopped by the wall of the electroscope, which is connected with the earth. The reading takes place by means of a telescope, the eye-piece of which is supplied with a scale; the time is noted, that the movable leaf requires to pass a definite number of scale divisions. These were the same in all the measure-

[1]) This battery was placed at my disposal by the "Amsterdamsche Universiteits-vereeniging". I will once more express my sincere thanks to the directors of this institution here.

ments, so that the inequivalence of different points of the scale has no influence. By means of the γ-rays of 1 mg. of radium bromide, which was placed at a fixed place and level above the electroscope, it was ascertained whether the capacity varied. Slight variations actually now and then occurred; therefore the measurements were all corrected to one and the same capacity. The normal leak was regularly determined and subtracted; the measurements did not take place until $2^1/_2$ a 3 hours after the introduction of the emanation, because as is known, in consequence of the formation of the active precipitate RaA, B, and C, constant values for the velocity of discharge are not obtained until then.

In conclusion a word on the ganging of the electroscope. This was generally done by dissolving a uranium mineral, and expelling the emanation by boiling, and conveying it into the electroscope; if then by chemical analysis it is determined how much uranium the solution contains, the content of radium may be calculated by the aid of the ratio of uranium and radium, which is known by BOLTWOOD's investigations. I preferred a direct method to this, viz. a comparison with a solution of a known quantity of radium bromide. For this purpose Professor E. RUTHERFORD of Manchester kindly sent me a solution, which according to his statements contained $0{,}157 \times 10^{-9}$ grammes of Ra per cm.^{3} [1]). 4 cm.^{3} of this solution were used for the comparison; the emanation which had generated after three weeks, was conveyed into the electroscope. It was found in this way that a velocity of the leaf of 10 scale divisions an hour corresponded to 1.08×10^{-11} gr. of Ra.

Results. The values obtained by the described method have been compiled in the subjoined table, which indicates the quantity of radium per gramme of rock.

Quartz porphyrite,	river Malakoetan	$1{,}3 \times 10^{-12}$ gr.
Granite,	Siboemboen	2,5
Basalt,	volcano of Asar	13,0
Andesite,	Padang	5,1
Augite andesite,	Soengei Landei	1,3
Augite andesite,	Ajer Kolbing	0,56
Granitite,	river Pasier	1,5
Granitite,	Soengei Lumani	3,1
Diorite,	Ahoer Tampoeroengo	0,30
Diabase,	Siboemkang	0,34

[1]) I gladly express my hearty thanks to Professor RUTHERFORD for the readiness with which he complied with my request.

It may further be mentioned here that all the chemicals used were examined separately in the same way to ascertain whether they contained radium; this appeared not to be the case. It is further noteworthy that every solution, both the acid and the alkaline ones, were boiled two or three times, and that the values inserted in the table are the average ones of the results obtained in the different experiments. By far the greater part of the radium is found in the acid solution; it was even often, — particularly for the rocks poor in radium — not to be demonstrated at all in the alkaline liquid.

It is seen that this investigation yields a similar result as the preceding ones: the rocks from Sumatra have a same relatively high content of radium of the order of magnitude 10^{-12} gr. per gramme.

We shall not yet draw any conclusions concerning the problems mentioned in the introduction, but postpone them till a number of rocks from *Borneo* have been discussed in a following communication.

Anorg. Chem. Laboratory University of Amsterdam.

Botany. — *"On the structure of the nucleus and karyokinesis in Closterium Ehrenbergii Men."* By Prof. C. VAN WISSELINGH. (Communicated by Prof. J. W. MOLL).

(Communicated in the meeting of June 25, 1910).

While the structure of the nucleus and the karyokinesis of *Spirogyra* have been repeatedly examined, the nuclei of the genus *Closterium* have rarely been the subject of investigation. This is the more remarkable, because the nuclei attain a considerable size. The few statements made in the literature about the structure of the resting nucleus of *Closterium* chiefly amount to this that the nucleus agrees with that of other algae, especially *Spirogyra*; thus for instance DE BARY [1]) states: Ein Zellkern von der für *Spirogyra, Zygnema* beschriebenen Structur nimmt die Mitte der Desmidieenzelle ein. DE WILDEMAN [2]) says: Le noyau des *Closterium* est du même type que celui des *Cosmarium* et des *Spirogyra*. The latter also gives some particulars of the nucleus. According to DE WILDEMAN the nucleus is formed by a rounded or rectangular mass, containing a large nucleolus at its centre. The nucleus contains hardly any

[1]) A. DE BARY, Untersuchungen über die Familie der Conjugaten, 1858, p. 40.

[2]) E. DE WILDEMAN, Recherches au sujet de l'influence de la température sur la marche, la durée et la fréquence de la caryokinèse dans le règne végétal, Extrait des Annales de la Société belge de microsc., t. XV, 1891, p. 47 and following.