EMANATION CONTENT OF HOT SPRINGS AND ARTESIAN WELLS IN PEIPING AREA.

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Abstract

By means of Schmidt's "shaking method", the emanation content of certain springs and artesian wells in the Peiping area was tested. Radon, thoron, or both together, were found in these water sources. Tests were made both in the spring of 1932 and 1935. No noticeable variation of the emanation content in these sources has been observed.

The measurement of emanation content in water has been a method for the determination of the distribution of radioactive substances in the Earth's crust. The measurement has been made at various places so that data are now available for studying the nature and origin of emanations and their relation with temperature, seasons, medical purity, the rate of flow and the geological conditions of the water sources. H. Schlundt[1] observed that water in several deep wells at Columbia, U.S.A., contains only radium emanation. H. W. Schmidt and Karl Kurz[2] determined some 100 springs in Hessen, Germany, and found that some of the springs contain both radium and thorium emanations (radon and thoron) while others contain only radium emanation. Emanations often come from radioactive substances dissolved in water.

1. H. Schlundt: J. Phys. Chem., Vol. 9, pp. 320-332. (1905).
2. H. W. Schmidt and Karl Kurz: Phys. Zeitchr. Vol. 7, pp. 209-224 (1906).

This was shown by J. R. Wright and G. W. Heise[3] that the emanation in most of the Philippine waters was absorbed from materials with which the ground water had been in contact. R. R. Ramsey[4] observed that an increase or decrease of emanation coincides with a season of rain or a very dry weather. Contrary to this, A. Steichen[5] showed that on account of the difference in local condition, the spring at Tuwa, India, contains a smaller emanation content when it yields much water. Repin[6] pointed out that the water from a number of sources which were admittedly goitrigenous was markedly radioactive. He thought of a possible connection between the active constituents and some disease. A number of observers found that emanation content is greater in hot springs than in cold springs.

It is the purpose of this paper to present the results of similar work on the emanation content of some typical springs and artesian wells in the Peiping area. They are as follows:

1. T'ang Shan Hot Spring 湯山溫泉 .
2. Wen Chüan (Warm Spring) 溫泉
3. Jade Mountain 玉泉山水
4. Artesian well No. 3, Tsing Hua University
5. Artesian well No. 1, Yenching University.
6. Artesian well No. 6, Peiping Union Medical College.
7. Artesian wells Nos. 1, 2, 3, and 5, Peiping Union Medical College.

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3. J. R. Wright and G. W. Heise: J. Phys. Chem. Vol. 21, pp. 525-533, (1917).

4. R. R. Ramsey: Indiana Acad. Science. Proc. p. 489, (1914). Phil. Mag., Vol. 30, pp. 815-818, (1915).

5. A. Steichen: Phil. Mag. Vol. 31, pp. 401-403, (1916).

6. Repin: Comptes Rendus, Vol. 147, pp. 387-388, Aug.; pp. 703-705, Oct., (1908).

Experimental

Apparatus: The method of measurement was the "shaking method" used by H. W. Schmidt[7]. Figure 1 shows the general view of Schmidt's portable emanation electroscope. Two fine parallel glass fibres are attached to the aluminum leaf so that the deflection of the latter can be read with high precision by means of a telemicroscope T. The voltage calibration of two aluminum leaves for the electroscope are supplied by E. Leybold's Nachfolger A.-G., Germany. The cylindrical ionization chamber has a capacity of 5.26 cm. and a volume of 1000 cc. The shaking can has a volume of 1700 cc. while that of the rubber bulb and connecting tubes is about 300 cc.

The natural leak of the electroscope was tested at the place where the experimental determinations were made. Its value varied slightly about an average of 0.00014 divisions per second. Therefore, the rate of dispersion minus the natural leak was used in the calculation for the concentration of radium emanation in Maches or in Emans per litre of water (see Table 1).

For each test 500 cc. of freshly drawn water from a given source is put into the shaking can and shaken vigorously with the air in the shaking can. The air is then circulated through the ionization chamber of the electroscope until the emanation is thoroughly mixed up with air both in the ionization chamber and in the shaking can. The apparatus was set up at a distance less than 20 meters from the water sources and was protected against winds and sunshine.

Procedure: The fundamental assumption in this experiment is that the rate of dispersion of the electroscope is proportional to the ionization of α-particles emitted from the emanation. If a sample of water containing either radon or thoron or both, is shaken vigorously with a given volume of air in the shaking can, the air will hold some emanation which is in equilibrium with that remaining in the water. The

7. Phys. Zeitchr. Vol. 6, p. 561 (1905).

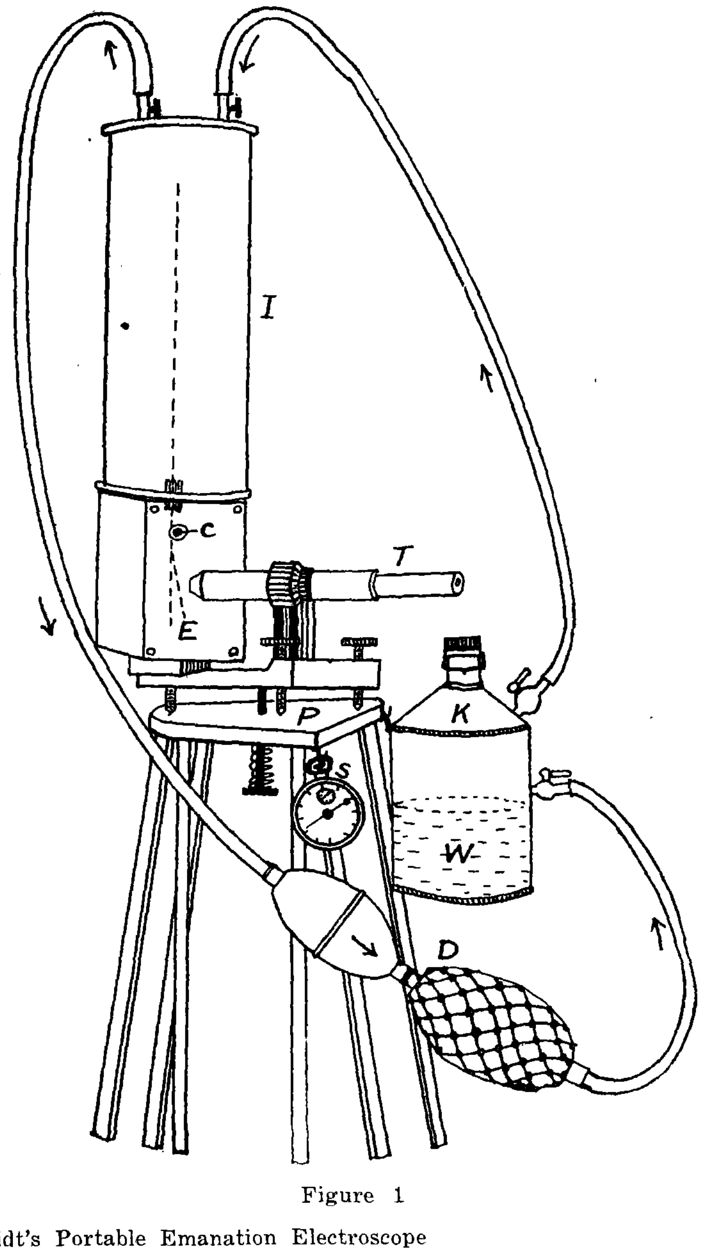

Figure 1

Schmidt's Portable Emanation Electroscope

C Charging device
D Double, constant pressure rubber bulb
E Electroscope
I Cylindrical ionization chamber
K Shaking can
P Tripod
S Stop watch
T Telemicroscope
W sample of water

equilibrium is determined by the distribution coefficient of the emanation between water and air which decreases with an increase in temperature[8]. A portion of the emanation in air is transferred to the ionization chamber by means of the circulation of the air through the double rubber bulb. From the rate of dispersion of the electroscope, the quantity of emanation that is present in a given volume of the sample water can be calculated by means of the constants of the electroscope.

Without going into details of the radioactive transformations of radon and thoron, we may state very briefly that

(a) if a water source contains only radon, then, the activity of radon and radium A at time t is

$$I = I_0 \left\{ e^{-\lambda t} + \frac{\lambda_2}{\lambda_2 - \lambda_1}(e^{-\lambda_1 t} - e^{-\lambda_2 t}) \right\} \cdots\cdots\cdots (1)$$

where I_0 is the activity at $t=0$ and λ_1 and λ_2 are the two radioactive disintegration constants which have the respective values of 2.097×10^{6} per second and 3.79×10^{-3} per second.

Taking I_0 equal to unit, the first component, $I_0 e^{-\lambda_1 t}$, represents practically a straight line parallel to t-axis (Curve (1), Fig. 21.). The second component, $\frac{\lambda_2 I_0}{\lambda_2 - \lambda_1}(e^{-\lambda_1 t} - e^{-\lambda_2 t})$, is of the form of curve (2) which is due to RaA. The resultant represented by equation (1) is shown by curve (3) which rises rapidly at the beginning and attains a value equal to 1.99 I_0 at t=1800 seconds, then becoming almost straight and parallel to the time axis.

It is to be noted that since RaB does not emit α-particles, and that RaC appears only in comparatively minute quantity during the time of observation, its value may be neglected.

(b) if a water source contains only thoron, then the activity of thoron and ThA at time t is

$$I = I_0 \left\{ e^{-\lambda_3 t} + \frac{\lambda_4}{\lambda_4 - \lambda_3}(e^{-\lambda_3 t} - e^{-\lambda_4 t}) \right. \cdots\cdots\cdots (2)$$

8. Hevesy and Paneth's Radioactivity, Table, XXXI, p. 178, (1926).

where I is the activity of thoron and ThA at time t. I_0 is the activity at $t=0$ and λ_3 and λ_4 are the disintegration constants having the values of 1.27×10^{-2} per second and 4.78 per second respectively. Curves (4) and (5) in Fig. 2 show the first and second components, and the resultant of equation (2). The component, $I_0\ e^{-\lambda_3 t}$, is due to thoron alone. Curve (4) is for the component, $\frac{\lambda_4\ I_0}{\lambda_4-\lambda_3}(e^{-\lambda_3 t}-e^{-\lambda_4 t})$, which is due to ThA. It rises from zero at $t=0$ to a value of 0.98 I_0 at about 1.2 seconds and then coincides with curve I. Curve (5) is for the resultant of these two components. It rises from I_0 at $t=0$ to a maximum value of 1.96 I_0 at about 1.1 seconds, then slopes down almost to zero in 500 seconds.

In view of the size of scale used for time, it is evident that curves for the component, $I_0\ e^{-\lambda_3 t}$, and others during the first few seconds can not be adequately plotted.

(c) if a water source contains both radon and thoron and their initial activities in the ionization chamber are approximately of the same value, we have

$$I_t=I_o\,e^{-\lambda_1 t}+\frac{\lambda_2}{\lambda_2-\lambda_1}(e^{-\lambda_1 t}-e^{-\lambda_2 t})+e^{-\lambda_3 t}+\frac{\lambda_4}{\lambda_4-\lambda_3}(e^{-\lambda_3 t}-e^{-\lambda_4 t})\cdots\cdots(3)$$

where I_t is the resultant activity of both radon and thoron at time t. The form of the resultant is shown in curve (6), Figure 2.

Sometimes actinium (AcEm) might be present with radon, though usually in negligibly small amount. The half value period of actinium and that of its product, actinium A, are not more than 4 seconds. Hence they cannot be observed in this experiment.

The variations of emanation content: Ramsey[9] observed that the emanation content of certain springs vary with seasons and Kalsuyoshi Shiratori[10] observed that the emanation con-

9. R. R. Ramsey: Phil. Mag. Vol. 30, pp. 815-818 (1915).

10. Katsuyoshi Shiratori: Science Reports of Tohoku Imperial University, Sendal, Japan, Vol. XVI, No. 5, pp. 613-620, (1927).

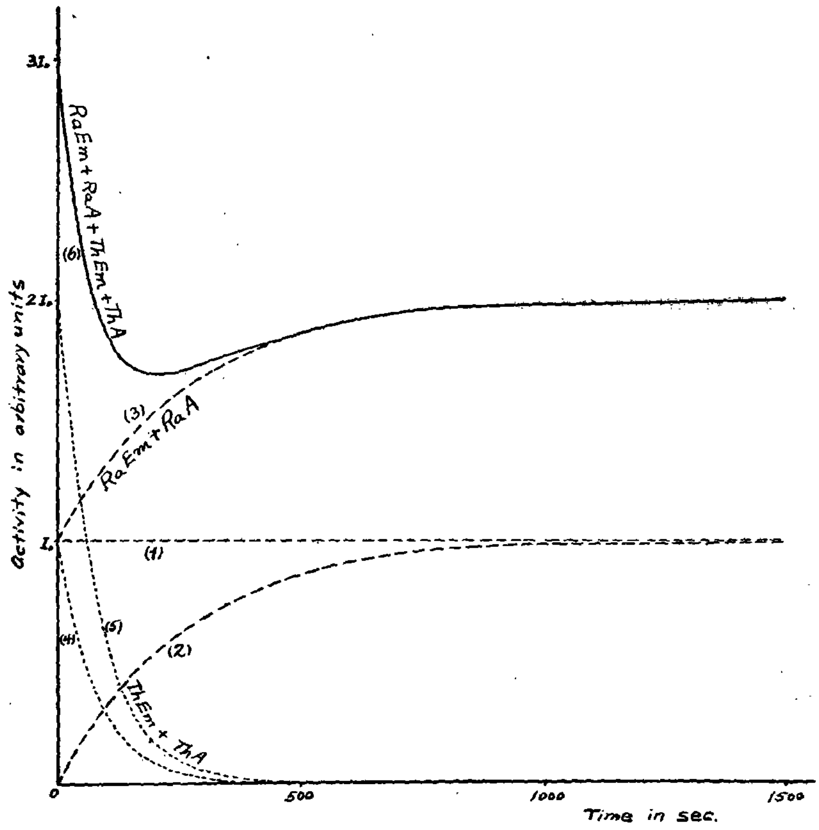

Figure 2

tent and temperature of certain hot springs were affected by earthquakes.

This experiment was started during the spring of 1932 and was repeated at about the same time in the year 1935, with a view to see whether there would be any variation of the emanation content in these water sources. The results are listed below.

Table I

Water Sources	Depth (1) in ft.	Date	Temp. of Water in °C.	Nature of Em.	(2) Concentration of Ra Em in Maches per liter of Water	(3) Quantity of Ra Em in Emans per liter or 10^{-10} Curies per liter
Tang Shan Hot Spring	——	May 8, 1932	46.5	Th Em. Ra Em.	—— 1.53	—— 5.69
		March 31, 1935	46.0	Th Em. Ra Em.	—— 1.53	5.51
Wen Chuan Warm Spring	——	May 8, 1932	32.3	Th Em.	——	——
		March 31, 1935	33.0	Th Em.	——	——
Jade Fountain	——	May 1, 1932	14.7	Ra Em.	1.01	3.64
		March 30, 1935	13.0	Ra Em.	0.985	3.55
Yenching University Well No. 1 (Power House)	122	May 1, 1935	14.0	Ra Em.	0.447	1.61
		April 6, 1935	14.0	Ra Em.	0.457	1.65
Tsinghua University Well No. 3 (Power House)	126	May 12, 1932	15.8	Ra Em.	0.492	1.77
P.U.M.C. Well No. 6 (Coal Store)	204	April 24, 1932	15.0	Th Em. Ra Em.	—— 0.296	—— 1.07
P.U.M.C. Wells No. 1 2 3 4	294 289 197 204	April 23, 1932	15.0	Th Em. Ra Em	—— 0.281	—— 0.461

(1) G. B. Barbour, Bulletin of Geo. Soc. China, Vol. IX No. 1, (1930).

(2) One "Mache" is a unit for concentration of emanation and is equal to 3.6×10^{-10} Curie per litre. See Hevesy and Paneth's A Manual of Radioactivity, pp. 178-9 (1926).

(3) Recently a new unit for the measurement of concentrations of emanation has been suggested: 1 "Eman" $= 10^{-10}$ Curie/litre.

Results and Discussions

The results of this experiment are summarized in Table 1 and shown in graphic form in Figure 3.

Tang Shan Hot Spring contains thoron and a large quantity of radon while Wen Chüan (Warm Spring) only has thoron of a comparatively low value. The difference in emanation content between these two springs must be due to their difference in their geological conditions, in spite of the fact that they are only 20 miles apart. The rocks at Tang Shan are limestones, while those at Wen Chüan are granites. Their geological formations are quite different from each other.

The activity curves for Jade Fountain, Tsinghua Well No. 3 and Yenching Well No. 1 are of the same form, which is due to radon. This indicates a close geological relation among the three wells. The wells at Tsing Hua and Yenching are only about one mile apart, almost of the same depth and are both free flowing. Barbour[11] found that their aquifers are in the same ground-level. Jade Fountain is only about 4 miles west of Tsing Hua and Yenching Universities and contains a concentration of radon of about twice that contained in the latter wells. We might say that the under-ground stream at Tsing Hua and Yenching comes from Jade Fountain. On the way from the latter to the former places the emanation content in the stream has dropped to half its value. It is generally known that Jade Fountain is a collection of the waters in the whole mountain area of the Western Hills, where the upper strata are diabase and the far down strata are lime-stones and granites. Thus we might say that the rocks at the water layer of the Western Hills contain radioactive substances.

P.U.M.C. is not far from Tsing Hua and Yenching, but the activity curves for its wells are quite different in form from those in the latter places. This suggests that the

11. G. B. Barbour: Bulletin of Geo. Soc. of China, Vol. 3 No. 2, (1924).

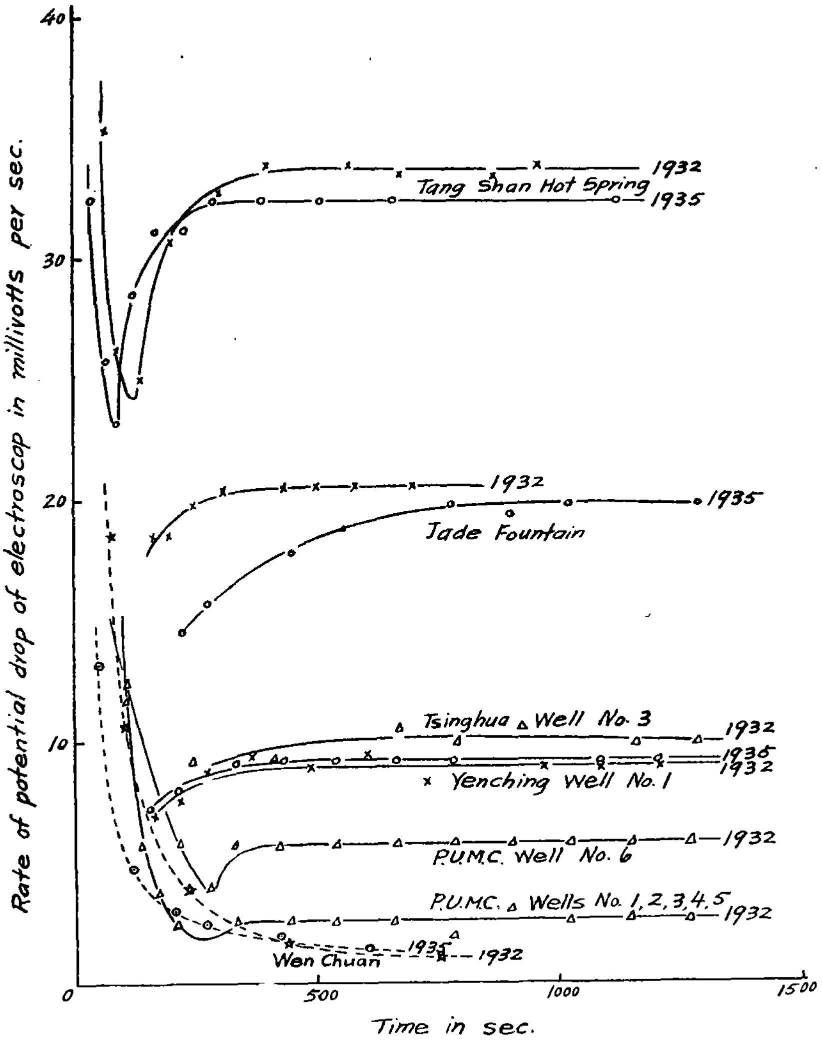

Figure 3

aquifers of wells at P.U.M.C. are not in the same water layer as those at Tsing Hua and Yenching. It is known that there are two water layers supplying water to the city of Peiping. The upper one is at about 100 ft. below the ground surface;

the stream of this water layer is very slow and cannot serve as artesian wells. B. Willis[12] says that the upper course of this stream is Sha Ho 沙河 (North of Peiping). The lower water layer is 200 ft. or more below the ground. Mr. L. C. Li of the Geological Society of China told us that this water layer comes from Yung Ting Ho 永定河 (West of Peiping). Since all the wells at P.U.M.C. are about 200 ft. deep or deeper, we might say that the emanation content of these well comes from the lower water layer. Wells Nos. 1, 2, 3, and 5 at P.U.M.C. are all connected and have no separate pipes for each of them, therefore their individual activities could not be observed.

Besides, there is no noticeable change in the emanation content of these springs and wells during an interval of three years (1932-1935).

12. B. Willis: "Physiography of North China".

文用二單變函數之較,以表驟上驟下之脈壓;而按重疊原理;以研究此種電壓在各電路上所發之脈流。玆所研究者,有十五不同之電路,計刮二十類三十六種。其間插有許多有趣之圖示,所得各脈流之特性,以一有秩序之方法,皆用算式表出之。

低頻濾波器之瞬流

朱物華　張仲桂

此篇先推求收端加電阻時,低頻濾波器瞬流之公式.依此公式算出之圖與用陰極光示波器映出之曲線相符合.自推算之結果,可得下列結論:

(一) 在濾波器收端電阻漸加時,瞬流各項之挫率漸互異.其數量由低頻項至隔阻頻之項順序漸減;其最小數仍比收端無電阻時之挫率 (R/2L) 為大.故瞬流終必變為隔阻頻之電流;而較收端無電阻時易于消滅.

(二) 當濾波器增加一段時,瞬流之項數亦加一.所加項之挫率皆比前有者為小.故少段濾波器之瞬流易于消滅.

(三) 在隔阻頻後瞬流之數量與在其前者相彷恆較隔阻頻後之安定數量大數十倍.故濾波之特性僅能見之于安定狀態.

北平泉水與自流井水所含射氣量之測定

徐允貴　謝玉銘

應用斯密特之"搖動法,"測定北平鄰近之泉水,如湯山溫泉,溫泉,玉泉山水及清華,燕京,協和醫諸校內自流井所含之射氣量。諸泉源或僅含鐳射氣,釷射氣,或二種射氣皆有之。民國二十一年與二十四年,曾測驗諸泉水各一次,所含之射氣量,絕少改變。