A Cloud Strip as a Streamline of Radioactivity Radon

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Abstruct

Underground solid matter emits ground current, sound wave, light, electromagnetic wave, ion, radon, salts, groundwater, etc. as a process leading to destruction. In particular, an abnormal increase in the concentration of radon in the atmosphere has been observed as a presage of an earthquake in the Hyogo South Earthquake in 1995. A large amount of radon released from the ground continuously in time moves along the path while emitting radiation, and nitrogen, oxygen, and water in the atmosphere are ionized one after another, become continuous condensation nuclei, collect the surrounding moisture, and form a single cloud below the dew point temperature. The streamline of radioactivity radon is calculated by Newton's equation of motion as a single-article cloud grain. Therefore, if a cloud strip can be observed as a presage of an earthquake, the epicenter can be identified.

Keyword: Cloud Strip; streamline radioactivity radon; earthquake; Hyogo South Earthquake

1. The Process of Generating Clouds

When different substances A and B are contacted and pressed, a clear variation in the charge and electric field of the test sample surface is observed in the compression destruction of the rock so that the electron moves toward one substance due to the friction and positive and negative static electricity is charged. However, since the Earth's crust is negatively charged, the ⊖ charge locally stays in the crust. The ⊖ charge in the crust attracts the ⊕ charge moisture in the atmosphere by a weak coulomb force.

In addition, solid crust matter emits ground current, sound wave, light, electromagnetic wave, ion, radon, salts, groundwater, etc. as a process leading to destruction. In particular, an abnormal increase in the concentration of radon in the atmosphere as a pre-earthquake sign has been observed as shown in Fig.1 [1]. It is believed that microcracks in rocks caused by stresses on the crust before an earthquake brings about radon to rise along crack-lines such as faults, increasing the amount of radon dissipated from the ground.

Measurements at Kobe Pharm. Univ. 25 km from the epicenter of the M7.3 Hyogo South Earthquake that occurred on January 17, 1995.[1]

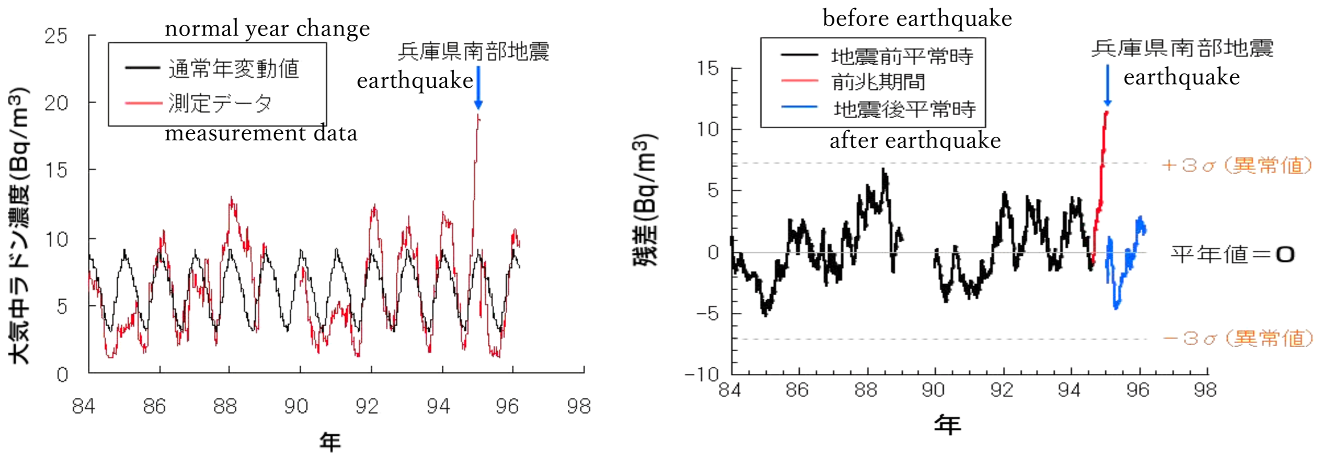


Fig.1 Changes in atmospheric radon concentration before and after earthquakes

A large amount of radon released from the ground continuously in time moves along the path while emitting radiation, and nitrogen, oxygen and water in the atmosphere are ionized one after another as shown in Fig. 2. It becomes continuous cloud condensation nuclei, collects the surrounding moisture, and forms a cloud below the dew point temperature. This is the same phenomenon in the cloud chamber that examines the traces of cosmic rays [2].

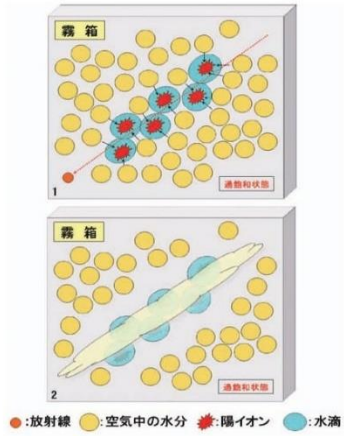


図 2　霧箱の中で起こっていること

Fig.2 Occurrence in the cloud chamber

2. The Basic Equations of Radon Flow

As a calculation model, it is considered that the vertical z axis stands on atmosphere ground boundary layer about 100 meters above the earth surface, and the horizontal x-axis is downwind direction in the x-y face and that wind velocity $(V_x,\ 0,\ V_z)$ And the earthquake focal depth ℓ_o, the charge Q of the crust, the charge q of the cloud. It also takes into account with Stokes' viscous resistance and gravity. The basic equation of radon flow is as follows.

$$m\frac{d^2x}{dt^2}+6\pi\mu r\left(\frac{dx}{dt}-V_x\right)+\frac{Qq}{4\pi\varepsilon_0\varepsilon_r}\cdot\frac{\partial}{\partial x}\left[\frac{-1}{\sqrt{x^2+y^2+(z+\ell_o)^2}}\right]=0$$

$$m\frac{d^2y}{dt^2}+6\pi\mu r\left(\frac{dy}{dt}\right)+\frac{Qq}{4\pi\varepsilon_0\varepsilon_r}\cdot\frac{\partial}{\partial y}\left[\frac{-1}{\sqrt{x^2+y^2+(z+\ell_o)^2}}\right]=0$$

$$m\frac{d^2z}{dt^2}+6\pi\mu r\left(\frac{dz}{dt}-V_z\right)+\left(m-\frac{4\pi r^3\rho}{3}\right)g+\frac{Qq}{4\pi\varepsilon_0\varepsilon_r}\cdot\frac{\partial}{\partial z}\left[\frac{-1}{\sqrt{x^2+y^2+(z+\ell_o)^2}}\right]=0$$

From here, the description of the symbol is simplified as follows.

$$C(z)=6\pi\mu r\,,\quad Q'=\frac{Qq}{4\pi\varepsilon_o\varepsilon_r},\quad G(z)=\left(m-\frac{4\pi r^3\rho}{3}\right)g\,,\quad \sqrt{}=\left[\frac{-1}{\sqrt{x^2+y^2+(z+\ell_o)^2}}\right]$$

$$m\frac{d^2x}{dt^2}+C(z)\left(\frac{dx}{dt}-V_x\right)+Q'\cdot\frac{\partial\sqrt{}}{\partial x}=0$$

$$m\frac{d^2y}{dt^2}+C(z)\left(\frac{dy}{dt}\right)+Q'\cdot\frac{\partial\sqrt{}}{\partial y}=0$$

$$m\frac{d^2z}{dt^2}+C(z)\left(\frac{dz}{dt}-V_z\right)+G(z)g+Q'\cdot\frac{\partial\sqrt{}}{\partial z}=0$$

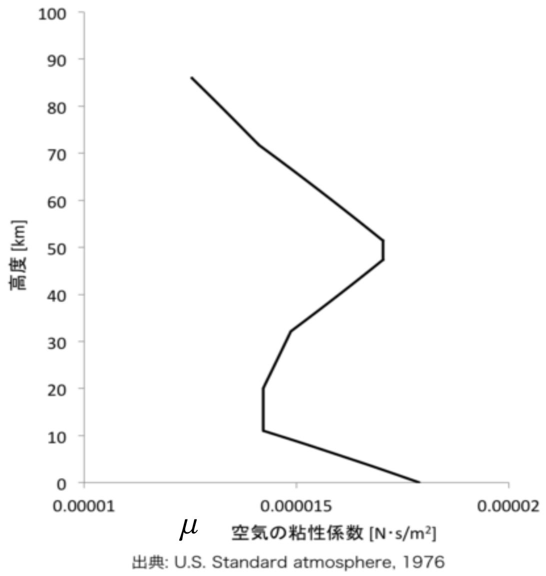
3. The Solution of the Radon Flow Equations

As the numerical magnitude of each term of the basic equation, the charge term $Q'\sim10^{-20}$ is very small compared to the viscous terms $C(z)\sim10^{-9}$, the wind velocity terms $mV_z\sim10^{-13}$, and the gravity term $G(z)\sim10^{-12}$, so it can be Q' omitted. PC numerical analysis of differential equations also prevents charged cloud grains from approaching the origin by coulomb forces. As a result, the basic equations can be simplified.

Since air density ρ is a function of altitude z, it is a primary approximation of the viscous term $C(z)$, the gravity term $G(z)$. The same is possible with wind velocity.

$C(z) = -az + b \qquad G(z) = \alpha z + \beta \qquad (\, a, b, \alpha, \beta > 0 \,) \qquad z < 10{,}000$ m、

$V_x(z) = \varepsilon z + V_{x0} \qquad V_z(z) = -\eta z + V_{z0} \quad (\, \varepsilon, \eta > 0 \,)$



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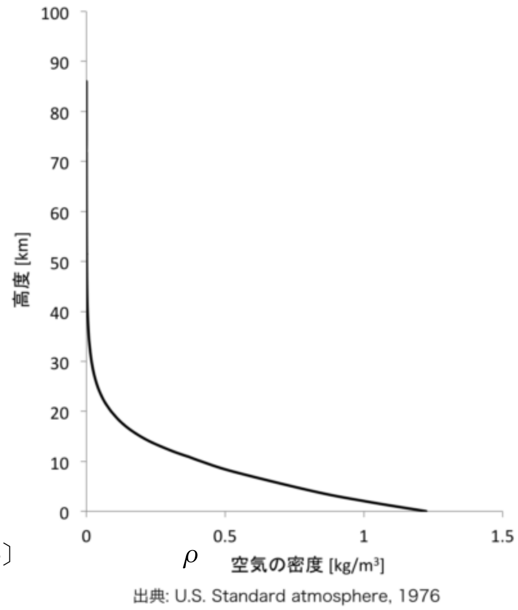


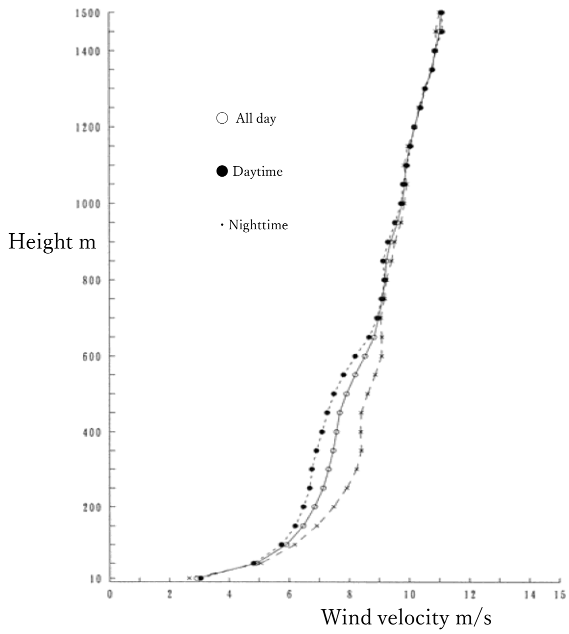
To analyze basic equations in primary mathematics
dx/dt coefficients for *C* must be a constant, $C(z)=C_0$.
Atmospheric ground boundary layer z=0 *is* $C_0=b$,
The highest attitude $z=z_t$ is $C_0=-az_t+b$

$$m\frac{d^2z}{dt^2} + C_0\frac{dz}{dt} + (C_0\eta + \alpha)z = C_0V_{z0} - \beta$$

$$m\frac{d^2x}{dt^2} + C_0\frac{dx}{dt} = C_0(\varepsilon z + V_{x0})$$

Initial condition is $t=0 \quad x=z=0, \quad dx/dt=V_{x0}, \; dz/dt=V_{z0}$
It solves differential equations as follows. 〔5〕
Characteristic equation $\mathrm{m}\lambda^2 + C_0\lambda + (C_0\eta + \alpha) = 0$

The root $\lambda_{1,2} = [\, -C_0 \pm \sqrt{{C_0}^2 - 4m(C_0\eta + \alpha)} \,]/2m$ ・



Wind velocity distribution by altitude〔4〕

$$z = Ae^{\lambda 1 \cdot t} + Be^{\lambda 2 \cdot t} + \frac{C_0V_{z0} - \beta}{C_0\eta + \alpha}$$

$$x = m\varepsilon\,(e^{-C_0/m \cdot t} - 1)\,[\,\frac{A}{m\lambda_1 + C_0} + \frac{B}{m\lambda_2 + C_0} + \frac{V_{z0} - \beta/C_0}{C_0\eta + \alpha}\,]$$

$$+ C_0\varepsilon\,[\,\frac{A(e^{\lambda 1 \cdot t} - 1)}{\lambda_1(m\lambda_1 + C_0)} + \frac{B(e^{\lambda 2 \cdot t} - 1)}{\lambda_2(m\lambda_2 + C_0)}\,] + t\,[\,\frac{C_0V_{z0} - \beta}{C_0\eta + \alpha}\varepsilon + V_{x0}\,]$$

here $A = \dfrac{(C_0\eta + C_0\lambda_2 + \alpha)V_{z0} - \lambda_2\beta}{(\lambda_1 - \lambda_2)(C_0\eta + \alpha)}$, $B = \dfrac{(C_0\eta + C_0\lambda_1 + \alpha)V_{z0} - \lambda_1\beta}{(\lambda_2 - \lambda_1)(C_0\eta + \alpha)}$

4. Correction by the air viscosity coefficient

The viscosity coefficient $C(z)$ of air was set to constant C_0 so that the differential equation could be solved. If the solutions in coefficient $C(0)$ are $z_2(t)$ and $x_2(t)$ in the viscosity at $z = 0$ at 100 m above ground, the solutions in the viscosity coefficient $C(z_t)$ at $z=z_t$ are $z_1(t)$ and $x_1(t)$, and the solution in any z can be approximated according to the interpolation equation as follows.

$$z(t)=(z_2-z_1)z(t)/z_t+z_1$$

$$\therefore\quad z(t)=z_1\cdot z_t/\left[z_1-z_2+z_t\right]$$

$$x(t)=x_1+\left[x_2-x_1\right]\cdot z(t)/z_t$$

The trial results of $[z_1(t), x_1(t)]$ and $[z_2(t), x_2(t)]$ and $[z(t), x(t)]$ are almost the same as shown in Table 1. And any may be adopted practically.

Table 1 Stream coordinates due to differences in air viscosity resistance

Time (h)	Calculation at viscous $C(z_t)$ the top of the cloud		Calculation at viscous $C(0)$ the boundary layers		Practical value by interpolation equation	
	x_2 (m)	z_2 (m)	x_1 (m)	z_1 (m)	x (m)	z (m)
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	24,115.0	377.3	24,117.7	377.7	24,117.2	377.6
2.0	52,581.8	679.7	52,591.0	680.3	52,587.7	680.1
3.0	84,536.0	922.0	84,554.2	922.8	84,545.4	922.4
4.0	119,285.3	1,116.2	119,313.4	1,117.0	119,296.9	1,116.6
5.0	156,274.5	1,271.9	156,312.8	1,272.7	156,287.1	1,272.2
6.0	195,058.7	1,396.6	195,107.1	1,397.4	195,071.5	1,396.8
7.0	235,281.6	1,496.6	235,339.5	1,497.3	235,293.9	1,496.7
8.0	276,657.4	1,576.7	276,724.2	1,577.4	276,668.8	1,576.8
9.0	318,957.2	1,640.9	319,032.0	1,641.5	318,967.4	1,641.0
10.0	361,997.5	1,692.4	362,079.4	1,692.9	362,006.4	1,692.4
11.0	405,631.2	1,733.6	405,719.5	1,734.1	405,638.9	1,733.6
12.0	449,740.5	1,766.6	449,834.4	1,767.0	449,747.1	1,766.7
13.3	509,132.3	1,800.7	509,232.4	1,801.1	509,137.5	1,800.7
48.0	2,099,026.4	1,900.0	2,099,152.5	1,900.0	2,099,026.4	1,900.0

5. Forms of ionization particles

The mass of m ionization particles near condensation nuclei, which is a cloud grain, is considered in three forms depending on the behavior of radon, and the streamlines of each are numerically compared, but as a result of numerical calculations, (1) (2) and (3) are the same in four effective digits. This is for a certain reason that ionization particles including radon are moving with the wind.

(1) The moisture particles gathered around ionization air and water move ... Density is 1000kg/m^3 , no different from ordinary water

(2) The particles of ionization water vapor dissolved in radon gas move ... Radon's water solubility is 0.22ml/ml [6]. The density 1002kg/m³ of dissolved water is 0.2% heavier than water

(3) The radon gas particles move while ionizing the surroundings ... Radon gas density is 9.7 kg/m³ [6]

6. Approximation calculation of radon gas sources

The streamline is a multiplier curve through the origin of the radon source as shown in Fig. 1 and approximates $z = z_t(1 - e^{-kx})$ simple exponential function. By measuring the position differences (Δx, Δz) of the three places in the cloud strip, the distance to the origin x_1 can be approximated.

$$\frac{z_{31}}{z_{21}} = \frac{z_3 - z_1}{z_2 - z_1} = \frac{1 - e^{-kx_{31}}}{1 - e^{-kx_{21}}} \quad , \quad \frac{x_{31}}{x_{21}} = \frac{x_3 - x_1}{x_2 - x_1} = \frac{\log(z_t - z_1) - \log(z_t - z_3)}{\log(z_t - z_1) - \log(z_t - z_2)}$$

The unknown factors are k, z_t and they can be solved as follow that while k and z_t are slightly changing until the difference between both sides of the equation is 0

$z_1 = z_t(1 - e^{-kx_1})$ From this, the distance to origin $x_1 = -\frac{1}{k}\log(1 - z_1/z_t)$

Table 2 Data for exponential approximation by 3-point measurement

Time (h)	x (m)	z (m)	$z = z_t(1 - e^{-kx})$
5.67	181,968	1,358.3	Calculation of z_t result 1,839.0
5.83	188,499	1,377.9	
6.00	195,072	1,396.8	Calculation of k result 6.364x10^{-6}
① 6.17	201,684	1,415.1	
② 6.33	208,335	1,432.6	Calculation of x_1 result 230,572
③ 6.50	215,022	1,449.5	(Errors of x_1 ～15% in ①)
6.67	221,746	1,465.9	

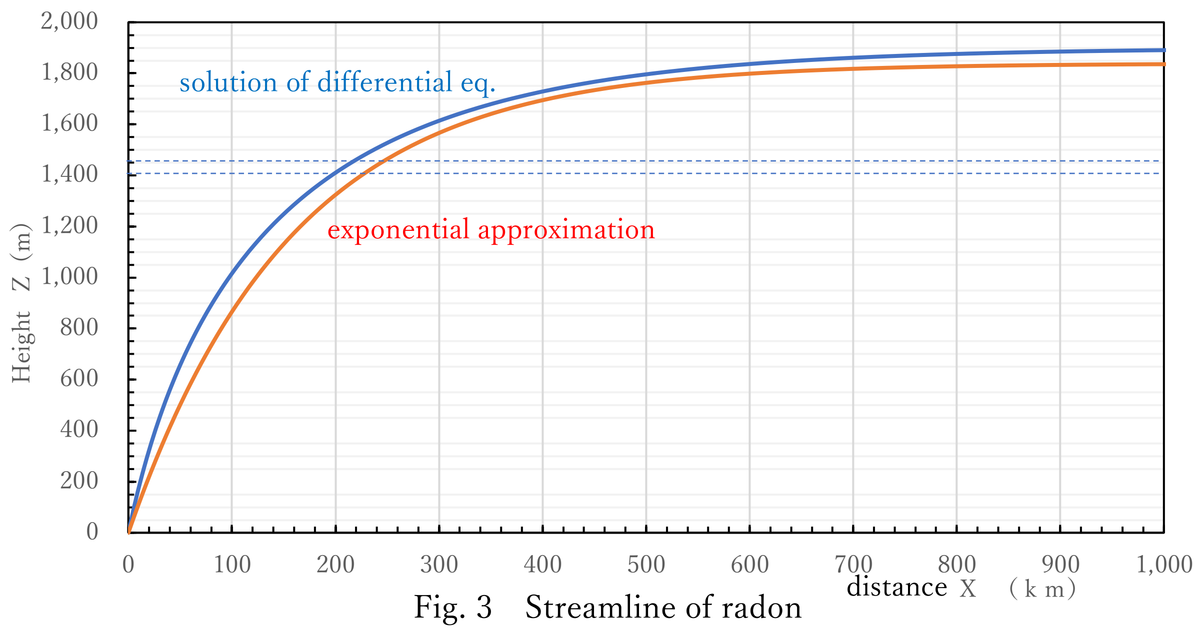


Fig. 3 Streamline of radon

7. Behavior without horizontal wind velocity

If the horizontal wind velocity is $V_x(z) = \varepsilon z + V_{x0} = 0$, it is $\varepsilon = V_{x0} = 0$. As a result of **3.** x = 0 it is an upright cloud. However, the microscopic electric field effect of Q' by contact friction is verified here. Since there is no factor that determines the x.y axis, Newton's equation of motion is as follows in the polar coordinate display:

$$r \text{ direction} \quad m\left[\frac{d^2r}{dt^2} - r\cancel{\left(\frac{d\theta}{dt}\right)}^{2}\right] + C(z)\left(\frac{dr}{dt} - \cancel{V_r}\right) + Q' \cdot \frac{\partial\sqrt{\ \ }}{\partial r} = 0$$

$$z \text{ direction} \quad m\frac{d^2z}{dt^2} + C(z)\left(\frac{dz}{dt} - V_z\right) + G(z)g + Q' \cdot \frac{\partial\sqrt{\ \ }}{\partial z} = 0$$

Since it is $\ell_o \gg r, z$ near the origin, it is $\frac{\partial\sqrt{\ \ }}{\partial r} = \frac{\partial}{\partial r}\left[\frac{-1}{\sqrt{r^2+(z+\ell_o)^2}}\right] \fallingdotseq \frac{r}{{\ell_o}^3}$, Q' is neglected in derection z.

$$m\frac{d^2r}{dt^2} + C_0\frac{dr}{dt} + \frac{Q'r}{{\ell_o}^3} = 0$$

This differential equation is solved under the initial conditions *r=r₀,* and *dr/dt = 0 at t=0.*

$$z = Ae^{\lambda 1 \cdot t} + Be^{\lambda 2 \cdot t} + \frac{C_0V_{z0} - \beta}{C_0\eta + \alpha}$$

$$r = \frac{r_0}{\lambda_4 - \lambda_3}\left(\lambda_4 e^{\lambda 3 \cdot t} - \lambda_3 e^{\lambda 4 \cdot t}\right) \fallingdotseq r_0$$

$$\lambda_{3,4} = \left[-C_0 \pm \sqrt{{C_0}^2 - 4mQ'/{\ell_o}^3}\ \right]/2m$$

Since dr/dt >0, *r* is an increase function. but as a result of the numerical calculation, it rises upright with little change in diameter in the vicinity of the origin.

Upright clouds taken directly above Akashi-Kaikyo Bridge in the epicenter vicinity one week before the Hyogo South Earthquake, occurred on the evening of Jan.9. (Courtesy of Mis.T. Sugie, NEWS Post Seven)〔7〕

Summary

These calculation formulas are limited that the density, number of viscosity coefficients, and vertical wind velocity of air decrease almost linearly with altitude z, and the horizontal wind velocity increases, and it is established in the range of altitude (z < 10 km).

Furthermore, the water solubility of the inert radon gas is 0.22 ml/ml, which is about 1/3 times that of CO_2 and about 1000 times that of air. In this way, radon is easily soluble in water, so if the radon source is in a sea area, radon is absorbed by seawater, and a single cloud does not occur. Only when the source of radon is near on land, does a single-article cloud seem to appear.

The radon concentration in the atmosphere is highly seasonally dependent as shown in Fig. 1. It is low in summer when the amount of moisture in the atmosphere is high, and it is high in winter when the moisture content of the atmosphere is low. This is probably due to the amount of water dissolved in radon gas and the water films.

Radon rises almost vertically because the weather is calm and mostly windless during the morning and evening calm hours. The cloud visually trails like the smoke of stick incense from a Buddhist altar.

(Gassho, pray for those who died in the earthquake)

[values used for numerical calculation] (unit system is m , kg , sec , Amp)

fog diameter $d = 1\text{x}10^{-5}$ fog mass $m = 5.236\text{x}10^{-13}$

wind velocity $V_x = 3.57\text{x}10^{-3} z + 6$ $V_z = -6.15\text{x}10^{-5} z + 0.12$

cloud top altitude z_t = cloud top2000-boundary layer100 epicenter depth $\ell_0 = 20{,}000$

charge term $Q' = 1\text{x}10^{-20}$

viscous term $C = -3.77\text{x}10^{-14} z + 1.70\text{x}10^{-9}$ gravity term $G = 4.11\text{x}10^{-18} z + 5.13\text{x}10^{-12}$

initial condition t=0 x= z =0 Vxo=6 Vzo=0.12

radon collapse process(half-life) $^{226}_{88}Ra(1600y) \rightarrow {}^{222}_{86}Rn(3.8d) \rightarrow {}^{218}_{84}Po(3.1m) \rightarrow {}^{214}_{82}Pb \Rightarrow {}^{206}_{82}Pb$

References

[1] Observation of atmospheric radon concentration before the Hyogo South Earthquake, National Institute of Radiological Sciences Leaflet, Tetsuo Ishikawa December 2018, www.qst.go.jp/site/qms/1575.html

[2] Lecture of cloud chamber, Institute of Environmental Science and Technology, February 2007. www.ies.or.jp/publicity_j/mini/2006-07.pdf

[3] www. Standard atmosphere - Calculation formula of air temperature, pressure, density, sound speed, viscosity coefficient, and dynamic viscosity coefficient at each altitude

[4] Average wind speed vertical distribution by altitude www.city.nagoya.jp/.../48Jhyoka_shiryo_01_02.pdf

[5] Official View of Higher Mathematics Translated by Kawamura & Imoto, Asakura Shoten 2013

[6] Radon Physical and Chemical Information, ILO and WHO 2018, www.ilo.org/dyn/icsc/showcard.display?p_lang=ja&p_card_id=1322&p_version=2

[7] "Earthquake clouds" witnessed in the Great Hanshin-Awaji Earthquake have "no scientific basis whatsoever" Above in news.yahoo.co.jp/.../525a9287cf4ecb98402daf1488d4c.