URČENIE POLOHY TEKTONICKÉHO ZLOMU (V TVARE PRIAMKY) VYŽARUJÚCEHO GAMA ŽIARENIE

DETERMINATION OF THE POSITION OF A TECTONIC DISLOCATION IN THE SHAPE OF A LINE, WHICH IS RADIATING GAMMA RAYS

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Abstrakt V predkladanom článku popisujeme výpočet polohy tektonického zlomu v tvare priamky, ktorý je zdrojom vyžarujúceho gama žiarenia. Odvodíme rovnicu pre dávkový príkon ako funkcie vzdialenosti od vyžarujúcej priamky. Teoretický výpočet polohy tejto priamky bol odvodený pre prípad s nulovým pozadím a aj pre prípad, keď bolo vyžarovanie od pozadia uvažované.

Summary In the present paper we describe a computation of the position of a tectonic dislocation in the shape of a line, which is radiating gamma rays. We derive the equation for dose rate as a function of the distance of the point of measurement from the irradiation line. The theoretical calculation of the position of this line is shown for the case of zero radiation of the background as well as for the case when the radiation of the background is considered.

1. INTRODUCTION

The computation of dose D measured with the detector in a time T by the point irradiation source which is moving with respect to the detector starts from equation [1]

$$D = \int_0^T \frac{A_0 \Gamma}{r^2} dt \qquad (1.1)$$

where A_0 is the activity of the point source, r is the distance from the detector to the point source, Γ is the gamma factor (a dose rate by the point irradiation source with activity 1 Bq at the distance 1 m from the detector).

In the static case when neither the source nor the detector are moving we can write

$$D = \frac{A_0 \Gamma T}{r^2} \qquad (1.2)$$

For the dose rate $\dot{D}$ it holds [2]

$$\dot{D} = \frac{dD}{dt} \qquad (1.3)$$

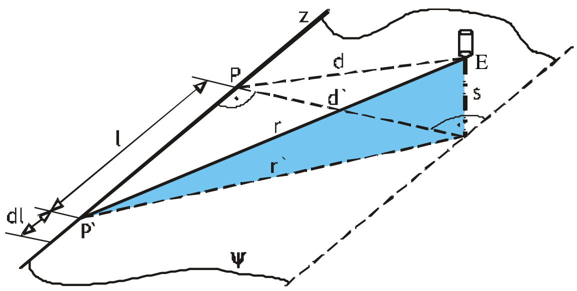
from which for the present case we get

$$\dot{D} = \frac{A_0 \Gamma}{r^2} \qquad (1.4)$$

Let us assume that the tectonic dislocation is in the shape of the infinite line z which is uniformly radiating gamma radiation (the uniform source) along its whole length and is located in the plane ψ (Fig. 1).

Let the detector be located at the point E which is at the perpendicular distance $s = 1\,m$ from the plane ψ, d' is the projection of the distance of the detector on to the plane of the dislocation. For the contribution activity dA of the element of the line dl, when ρ is the activity per 1 meter of the length of the line, we obtain

$$dA = \rho dl \qquad (1.5)$$



Obr. 1. Schéma usporiadania merania.
Fig. 1. The scheme of the measurement.

Thus for the infinitesimal dose rate $d\dot{D}$ at a distance r from the element of the line with the length dl is holds

$$d\dot{D} = \frac{\rho \Gamma dl}{r^2} \qquad (1.6)$$

and for the dose rate $\dot{D}$ from the whole line z at the point of the measurement E which is at the distance d from the given line we can write using the substitution $x = l/d$ and $r^2 = l^2 + d^2$

$$\dot{D} = \int_{-\infty}^{+\infty} \frac{\rho \Gamma}{r^2} dl = \int_{-\infty}^{+\infty} \frac{\rho \Gamma}{l^2 + d^2} dl = \qquad (1.7)$$

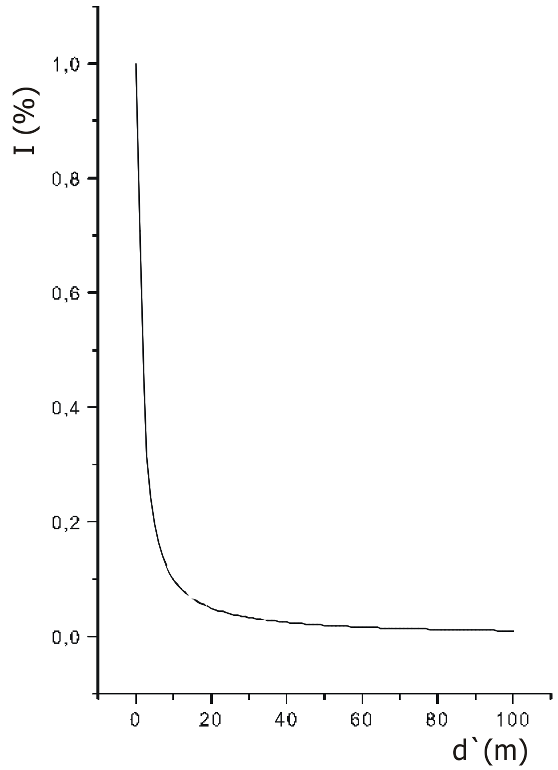
$$= \int_{-\infty}^{+\infty} \frac{d \rho \Gamma}{d^2 \left(1 + x^2\right)} dx = \frac{\rho \Gamma}{d} \left[arctg\left(\frac{l}{d}\right) \right]_{-\infty}^{+\infty} = \frac{\rho \Gamma}{d} \pi$$

where $\dot{D}$ is the dose rate radiation at the point of measurement E, d is the distance between the detector and the line (the dislocation), l is the distance between the point P and the point P', s is the distance between the detector and the soil.

The number of the pulses which the detector is recording is proportional to the dose rate $\dot{D}$ irradiated by the line z. As the detector is recording the activity of the background as well we can write

$$n - n_0 \sim \frac{\rho \Gamma \pi}{d} \tag{1.8}$$

where n is the counting rate registered by the detector for the line z with the activity A, n_0 is the counting rate for the background.



Obr. 2: Vyžarovanie priamky vo vzdialenosti d' od detektora.

Fig. 2. The radiation of the line located at the distance d' from the detector.

Next we will ignore the radiation of the background. Using equation (1.7) for the different values of the projection of the distance d' between the detector and the uniform radiating line we have obtained (Fig. 2), where the maximum occurs for $d' = 0$. It is equivalent to the situation when the detector is located directly above the radiating line.

2. DETERMINATION OF THE POSITION OF THE TECTONIC DISLOCATION FOR THE CASE OF ZERO RADIATION OF THE BACKGROUND

In the case without the radiation of the background it holds

$$n \sim \frac{\rho \Gamma \pi}{d} \tag{2.1}$$

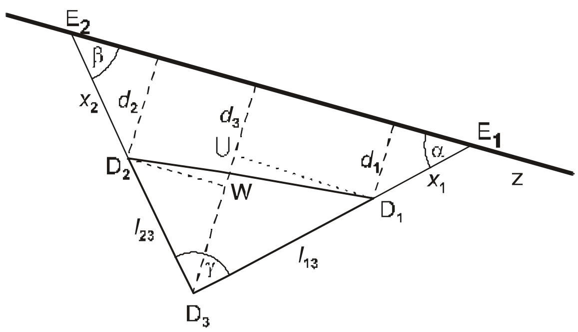
Next we consider equation

$$k \cdot n_i = \frac{\rho \Gamma \pi}{d_i} \tag{2.2}$$

where k is a proportionality constant introduced for dimensional reasons.

We will measure in a sufficiently large distance from the radiation line so as to insure that all detectors will be placed in one of the half planes determined by the line.

Lets locate two detectors D_i and D_j in plane ψ in the relative distance l_{ij} and register the counting rate in time T. The detector that has registered smaller counted rate we label. We place the third detector at a distance l_{k3} from the detector D_3 with $\gamma = 90°$ (Fig. 3). We again register the counted rate in time T. If the third detector has registered bigger counted rate than the detector D_3 we label the registered counting rate from the biggest n_1 for D_1 to the smallest n_3 for D_3.



Obr. 3. Schéma merania polohy vyžarujúcej priamky (bez pozadia).

Fig. 3. The scheme of the measurement of the position of the irradiation line (without the radiation of the background).

If the third detector has registered smaller counting rate than the detector D_3 we place the third detector just as in the previous case, but in the opposite half plane determined by the line that connects the two previous detectors. From (2.2) we have

$$k.n_i.d_i = c \quad \Rightarrow \quad d_i = d_j \frac{n_j}{n_i} \tag{2.3}$$

From Fig. (3) and from equation (2.3) we get

$$\frac{d_i - d_j}{d_j} = \frac{n_j - n_i}{n_i} = \frac{l_{ij}}{x_j} \qquad (2.4)$$

Using equation (2.4) we have obtained

$$x_j = l_{ij} \frac{n_i}{n_i - n_j} \qquad (2.5)$$

and for the distances x_1 and x_2 we get

$$x_1 = l_{13} \frac{n_3}{n_1 - n_3} \qquad x_2 = l_{23} \frac{n_3}{n_2 - n_3} \qquad (2.6)$$

We define

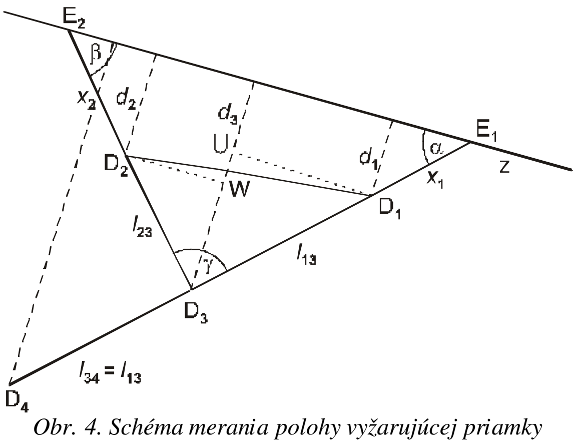
$$u = x_1 + l_{13} = l_{13} \frac{n_1}{n_1 - n_3} \qquad (2.7)$$

$$v = x_2 + l_{23} = l_{23} \frac{n_2}{n_2 - n_3} \qquad (2.8)$$

where u is the distance of the point E_1 from detector D_3 and v is the distance of the point E_2 from detector D_3. The two points E_1 and E_2 determine the position of the line z (dislocation).

3. DETERMINATION OF THE POSITION OF THE TECTONIC DISLOCATION FOR THE CASE WITH THE RADIATION OF THE BACKGROUND

If we consider the case with the radiation of the background as well we locate in plane ψ two detectors D_i and D_j in the relative distance l_{ij} and we register counting rate in time T. The detector that will register smaller counted rate we label D_3. Perpendicular to the abscissa that connects both detectors we place the third detector at a distance l_{k3} from the detector D_3 and in the same way but into the opposite half plane we place the fourth detector (Fig. 4).



Obr. 4. Schéma merania polohy vyžarujúcej priamky s uvažovaním pozadia.
Fig. 4. Measurement of the position of the radiating of the background is considered.

We again measure the counting rate in time T. We label the registered counting rate from the biggest n_1 for D_1 to the smallest n_3 for D_3. In the text below we write equation (1.8) as follows

$$k.(n_i - n_0) = \frac{\rho \Gamma \pi}{d_i} \Rightarrow k.d_i = \frac{c}{(n_i - n_0)} \qquad (3.1)$$

where k is a proportionality constant introduced for dimensional reasons. We adopt

$$\frac{d_i}{d_j} = \frac{n_j - n_0}{n_i - n_0} \qquad (3.2)$$

Then from equation (3.1) and (Fig. 4) it follows

$$\frac{d_i - d_j}{d_j} = \frac{n_j - n_i}{n_i - n_0} = \frac{l_{ij}}{x_j} \qquad (3.3)$$

If we put $l_{13} + l_{34} = 2.l_{13} = l_{14}$ we can write

$$\frac{d_3 - d_1}{d_1} = \frac{l_{13}}{x_1} = \frac{n_1 - n_3}{n_3 - n_0} \qquad (3.4)$$

$$\frac{d_4 - d_1}{d_1} = \frac{l_{14}}{x_1} = \frac{2l_{13}}{x_1} = \frac{n_1 - n_4}{n_4 - n_0} \qquad (3.5)$$

$$\frac{d_3 - d_2}{d_2} = \frac{l_{23}}{x_2} = \frac{n_2 - n_3}{n_3 - n_0} \qquad (3.6)$$

From equations (3.4) and (3.5) we calculate the counting rate of the background.

$$n_0 = \frac{2n_1 n_4 - n_3 n_4 - n_1 n_3}{n_1 - 2n_3 + n_4} \qquad (3.7)$$

From equation (3.4), (3.6) we find

$$x_1 = l_{13} \frac{n_3 - n_0}{n_1 - n_3} \qquad (3.8)$$

$$x_2 = l_{23} \frac{n_3 - n_0}{n_2 - n_3} \qquad (3.9)$$

From (Fig. 4) and from the Pytagoras theorem it holds

$$(x_1 + l_{13})^2 + (x_2 + l_{23})^2 = (E_1 E_2)^2 \qquad (3.10)$$

$$(E_1 E_2) d_3 = (x_1 + l_{13})(x_2 + l_{23}) \qquad (3.11)$$

Finally we define

$$u_p = x_1 + l_{13} = l_{13} \frac{n_1 - n_0}{n_1 - n_3} \qquad (3.12)$$

$$v_p = x_2 + l_{23} = l_{23} \frac{n_2 - n_0}{n_2 - n_3} \qquad (3.13)$$

where u_p is the distance of the point E_2 from the detector D_3 and v_p is the distance of the point E_1 from the detector D_3. The z line position is determined by points E_1 and E_2 (Fig. 4).

4. CONCLUSION

With the help of simplified conditions we have derived equation for the calculation of the dose rate for the radiating line.

The equation for the calculation of the position of the above mentioned line for the case without the radiation of the background has been deduced.

Finally we have derived the equation for the calculation of the position of the radiating line for the case when the background is radiating, as well as for the activity of the background.

The determination of the tectonic dislocation is important by building of dwelling and houses. There are two critical points:
1. Risk of the building stability
2. Danger the population health, by radioactive radon.

REFERENCES

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