# EARTHQUAKES AS POSSIBLE CONSEQUENCE OF PERTURBATIONS IN METRIC OF SPACE-TIME

S. Selak
Geomagnetic Institute, Grocka

The removal of flatness in metric of space-time leads to the general relativity and to the Einstein solution of the gravitational problem. As we do not possess an obvious presentation about physical significance of perturbations in metric tensor components of the Minkowski space-time, an attempt of their possible interpretation was performed in the previous paper [3] by putting the following question in the Machian sense: does a relevant cosmological reality repercute on the formulations of basic physical laws in our surroundings? This question was considered in the light of the another one from the framework of theoretical cosmology: can the existence of an active scale transformation, as a physical realization of conformal transformations, be the reality of our world? The dilatation, i.e. the change of scale, means there that each physical object changes its dimensions. Al o, the internal structure of the physical object, as seen by an observer moving together with it in scale, remains the same in time. Permitting such reality of our world, we assumed that the process governing the increase of dimensions of all physical objects in nature, is responsible for the reproductions of the time and length "standards". Consequently we discerned the meaning of time in two ways: (i) the "time" based on the reading of clocks which suffer dilatation and do not follow the flow of proper time, and (ii) the time as it is accepted in special relativity. In order to obtain reproductions of the "fixed" units of time and length $U_T$, $U_L$ related to the world which would not suffer dilatation, we introduced certain space-time functions $\xi(x)$ and $\eta(x)$, where x were space-time coordinates of one conditional system. So we had

$$U'_T = \xi(x)\ U_T, \qquad U'_L = \eta(x)\ U_L \tag{1}$$

and in this way we started finding the transformations which would demonstrate:

(i) how the fixed point in our world changes its coordinates with respect to world suffering no dilatation in time,

(ii) how the fixed instant of the proper time reflects itself as our "information" on time in space.

Besides, the law determining the behaviour of the function $\xi(x)$ was prescribed in order to support the observed fact of the agreement between the rate of increase of the Earth's radius and that of the universe, according to Hubble's law.

An important consequence appears from such an approach to the gravitational problem: the natural constants are space-time functions. According to our statements the energy tensor becomes

$$\tau^{ik} = \varepsilon(x)\ T^{ik} \tag{2}$$

where $T^{ik}$ is its form in the world which would suffer no dilatation and $\varepsilon(x)$ is space-time function responsible in translating it into reality of our world. From

$$\tau^{ik}_{;k} = 0 \tag{3}$$

we get the condition showing in which way $\varepsilon(x)$ reflects the behaviour of the gravitational "constant". In (4) the result was

$$\gamma = \gamma_0 \left(\frac{t_0}{t}\right)^3 \tag{4}$$

where $t_0$ is the age of the model universe.

The variability of $\gamma$ can lead us to thing that earthquake phenomena appear as a consequence of irregularities in behaviour of functions which were held to be responsible for reproductions of the time and length "standards" in our world. As was shown in (3), these functions determine the perturbations of the metric tensor components of Minkowski space-time and describe the occurence of the gravitational field: considering time-part of metric, we had that an interval of proper time t and corresponding "information" on time, are connected by

$$\Delta t' = \frac{\Delta t}{\xi(x)} \tag{5}$$

where

$$\xi(x) = 1 + \varepsilon(x) \tag{6}$$

and the function $\varepsilon(x)$ was called the dilatation function. Now, instead of (6) we suggested

$$\xi(x) = 1 + \bar{\varepsilon}(x), \quad \bar{\varepsilon}(x) = \varepsilon(x) + \delta\varepsilon(x) \tag{7}$$

and $\delta\varepsilon(x)$ is the term accompaning occurence of the earthquake phenomena.

Starting from such concepts our aim is to support the following empirical relation of Tsubokawa (stated by Rikitake, 1972)

$$\log \Delta t = 0{,}75\ M - 4{,}27 \tag{8}$$

where $\Delta t$ (in the sense of our compreheinsion this is $\Delta t'$) is the time-interval (measured in years) between the detection of anomalous land-deformation and an earthquake occurence and M the magnitude of the quake concerned. M is supposed here to be quantity dependent on our "information" of time, starting from the instant when irregularities of the dilatation function take place to the instant of the earthquake occurence. On the other hand, we know, according to Gutenberg (see Bullen, 1959), that the damping effect may be represented by the presence of a factor of the form $e^{-kD}$, where D is the distance travelled by a wave and k is of the order $10^{-4}$ $km^{-1}$. The time-interval in which P-waves travel to $k^{-1}$ is

$$\tau = \frac{k^{-1}}{\alpha} = \frac{k^{-1}}{\{(\lambda+2\mu)/\rho\}^{1/2}} \tag{9}$$

where $\alpha$ is the velocity of P-waves, $\rho$ mass-density and $\lambda$, $\mu$ elastic parameters. The magnitude M of an earthquake we define as

$$M = a \ln \frac{\Delta t'}{\tau} \tag{10}$$

where a is a certain constant. As (7) can be the first approximation of $e^{\bar{\varepsilon}(x)}$, (10) becomes

$$M = a \ln \frac{\Delta t e^{-\bar{\varepsilon}(x)}}{\tau} \tag{11}$$

By taking logarithms of (1), in this case we get

$$\ln \Delta t' = \ln \Delta t - \bar{\varepsilon}(x) \tag{12}$$

Now, if we take $\alpha = 7\ km.s^{-1}$, which is the characteristic value of the P-wave, this gives $\tau \approx 1{,}43 \times 10^3$ s and (11) becomes

$$a^{-1}M \simeq \ln \Delta t(yr)\ e^{10-\bar{\varepsilon}(x)} \tag{13}$$

From (12) and (13) we get

$$\ln \Delta t' \simeq a^{-1}M - 10 \tag{14}$$

which is in good agreement with (8), if $a^{-1} = 1{,}7$.

If the process leading to the occurence of the earthquake influences changes of our "information" on time, then possibility of its prediction can be suggested. Consider two atomic clocks $C_1$ and $C_2$ at points $A_1$ and $A_2$. $C_1$ and $C_2$ start at the same instant and at any subsequent instant, as their distances of the Earth's center are approximately equal, they give the same "information" on time $T_1' = T_2'$. In our opinion, if

$$\Delta T'_{1,2} = T_1' - T_2' \tag{15}$$

appears, then an earthquake can be expected either in the neighbourhood of $A_1$ or $A_2$. This uncertainty can be removed with the aid of the third clock $C_3$ at any point $A_3$. In general, if a certain region could be covered by <u>n</u> clocks, at any $C_i$ we should form $\sum_k \Delta T'_{i,k}$. For $C_i$ where

$$\sum_k T'_{i,k} = \max. \qquad (16)$$

we should have a point at which an earthquake can be expected.

## REFERENCES

[1] Bullen, K.E., 1959, An Introduction to the Theory of Seismology, Cambridge.

[2] Rikitake, T., 1972, Geophys. Surv., 1, 4.

[3] Selak, S., 1978, Astroph. Sp. Sci., 56, 275.

[4] Selak, S., 1979, Astroph. Sp. Sci., 60, 465.

[5] Selak, S., 1979, Astroph. Sp. Sci., 61, 517.