Observations of Lg and Rg waves from the Black Sea basin earthquakes

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The results of seismic sounding of the Earth crust southwards of the Crimean Peninsula have shown that in this part of a deep-water zone of the Black Sea the granite layer is absent. For this reason it became expedient to investigate the recently discovered Lg and Rg waves propagating in the sial (continental) layer of the Earth's crust: faults and disturbances of the granitic layer make these waves damp or disappear completely.

Some preliminary data on the damping of Lg and Rg waves propagating through the central part of the Black Sea Region can be found in the paper by Prof. M. Båth [2].

To make this investigation the authors studied the seismograms of the Moscow and Simferopol seismic station with records of over 70 earthquakes in Greece, Turkey and South Europe. The location of the stations and epicentres are given in the supplemented map (fig. 1).

The investigation confermed that in the greater part of cases the Lg and Rg waves were propagating through the central part of the Black Sea being essentially damped. This can be seen from the map where black circles stand for epicentres with intensive Lg and Rg waves as recorded by a proper station and open — for the absence or damping of the waves. Triangle marks analogous epicentres taken from the paper by M. Båth [2].

It should be noted that in separate cases some controversial data were recorded indicating both, intensive Lg and Rg and their almost complete disappearance on propagation routes next to each other in direction. On our opinion this can be explained by peculiarities of the effect exercised by the focal mechanism of the earthquakes under consideration. The distinguishing of Lg and Rg waves on the seismograms of the Simferopol station was sometimes hindered by the superposition of oscillations with small epicentral distances (less than 6°). Cases of intensive and damping Lg and Rg waves are cited in the supplemented seismogram copies (figs. 2 and 3).

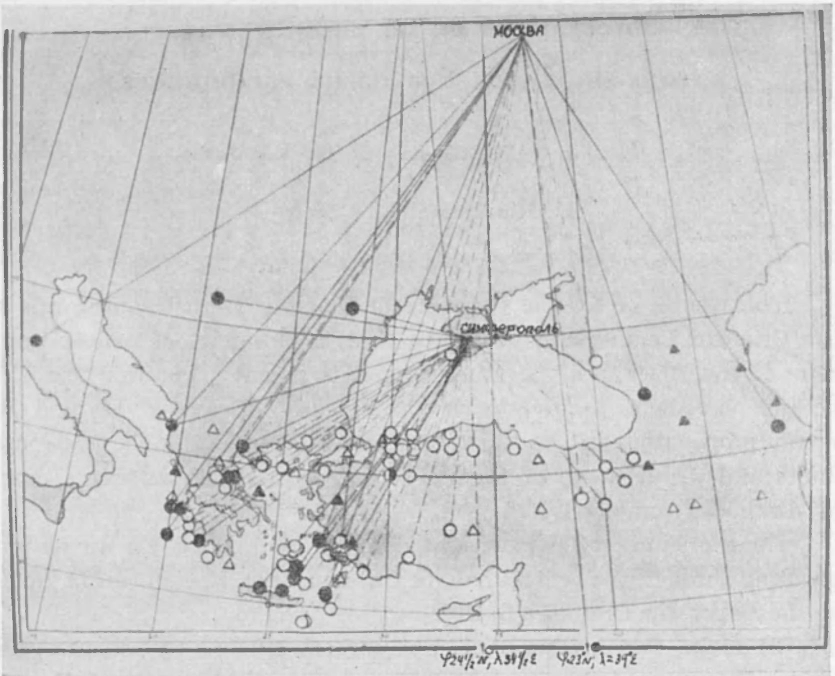


Fig. 1 - The map of Epicenters and Stations. M - Moscow; S - Simferopol.

The authors have determined the velocities of Lg_1, Lg_2, Rg and one additional wave Rx which proves to be the most distinct one on the seismograms of the vertical component.

The enclosed table I gives the values of velocities, periods and ranges of the observed variations of these quantities.

Table I

Namen of Wave	Lg_1		Lg_2		Rg		Rx	
	V	T	V	T	V	T	V	T
Mean velocity (km/sec) and average period values (sec)	3,55	9	3,29	8	3,01	12	2,90	10
Range of velocity variations.	3,38-3,70		3,10-3,49		2,76-3,16		2,92-2,18	

The problem of the nature of Lg and Rg waves is now under discussion. Some scientists think these waves to be related to the existence

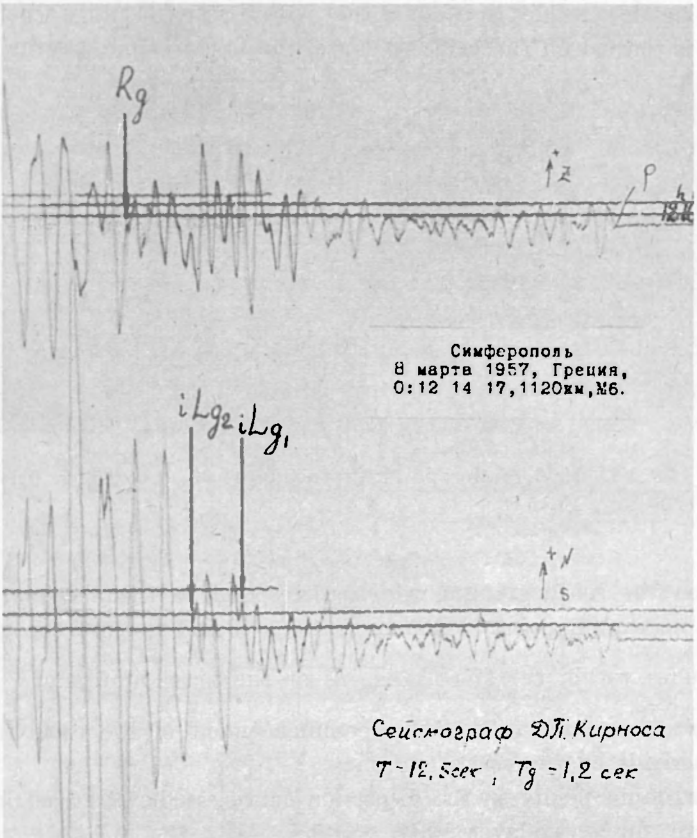


Fig. 2 – 8. III. 1957, Simferopol Greece, 0 : 12 14 17, 1120 km, M=6 Kirnos. Seismograph, T=12 sec., Tg=1,2.

of waveguides (corresponding to continuous velocity changes in the Earth's crust layers). Others assume that Lg and Rg are surface waves of a rather short period representing the first or the second mode of Love and Rayleigh waves respectively [3]. It should be noted that the possible arrivals of dispersed oscillations from a non-stationary source are related to the existence of maximum points on the dispersion group velocity curve. The maximum point on the group velocity dispersion curve (fig. 4a) testifies to the fact that within a period range where maximum is formed on the velocity curve, the first in time are the oscilla-

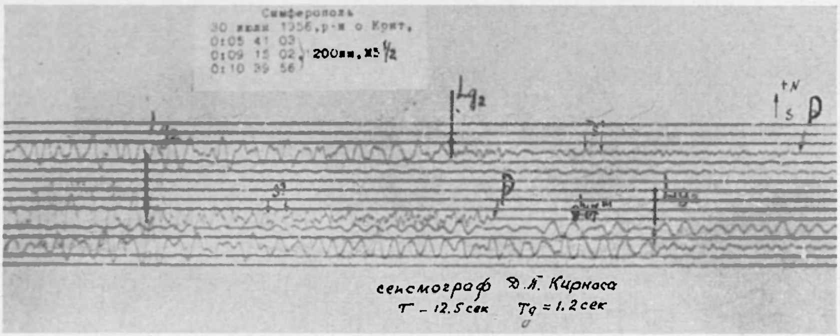


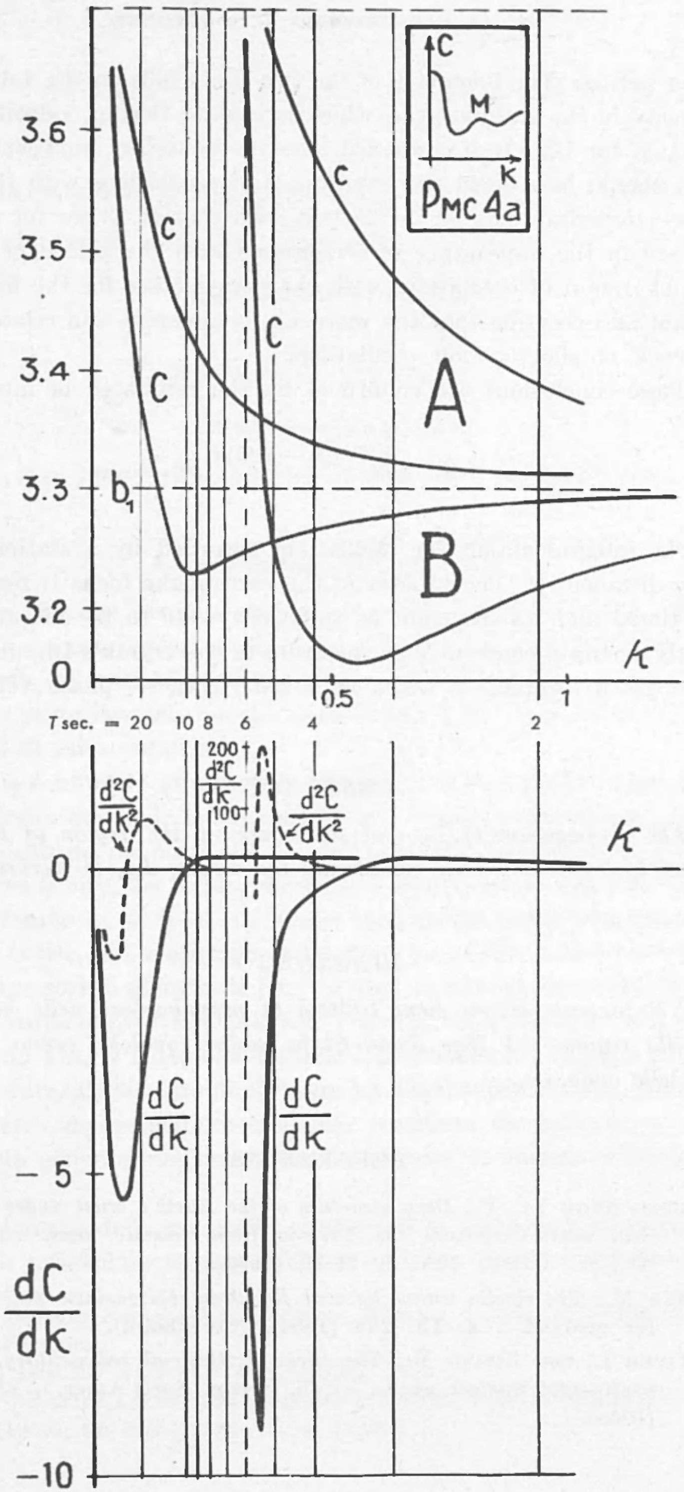
Fig. 3 – 30. VII. 1956, Simferopol. I. Crete 0:05 41 03, 0:09 15 02, 0:10 39 56, 1200 km, M=5 $^1/_2$.

tions on the seismogramme which correspond to the absciss (period) of the maximum point. Such oscillations should acquire the greatest amplitudes within the given range as at the maximum point $\dfrac{dC}{dK} = 0$ all this corresponds to a visible commencement of the oscillations or their arrivals on the seismogramme.

Maximum points on the dispersion curve can be observed in some case only for a two-layer crust.

Their occurence is impossible if there is only one layer. It is that which accounts for the existence of Lg and Rg waves for a continental Earth's crust consisting of two layers.

The existence of Lg_2 wave can be accounted for in a simpler way by considering the propagation of Love waves in the granite layer (20 km thick, at a distance of 2.400 km which is equal to the distance from Moscow to the greater part of the Greek epicentres) lying on a " basalt " semi-space. The dispersion curves of the group velocity for the main wave and the first mode (fig. 4) occupy two domains A and B. Domain A is characterized by a simple dependence between the group velocity and the period. On the domain B this dependence is two-digit; the second group of oscillations with the same velocity corresponds to a



C
M
K
Pмс 4а
3.6
3.5
3.4
3.3
3.2
0
b_1
C
C
C
C
A
B
k
0.5
1
T sec. = 20 10 8 6 4 2
200
$\frac{d^2C}{dk}$
100
$\frac{d^2C}{dk^2}$
$\frac{d^2C}{dk^2}$
k
0
$\frac{dC}{dk}$
$\frac{dC}{dk}$
−5
$\frac{dC}{dk}$
−10

Fig. 4

smaller period. The boundary of the two zones falls on the value of the S velocity in the granite layer, which is next to the Lg_2 velocity. As is calculated for the given simplified case the boundary between zones A and B should be seen in the appearance of oscillations with the period of 4 sec. superimposing on oscillations with that of 13 sec for the main tone and in the appearance of oscillations with the period of 1 sec at the background of oscillations with the period 5 sec for the first mode. It is not an exception that the wave Lg_2 is apparent and related to the occurence of short period oscillations.

These conclusions are confirmed by the estimated of integral

$$I(t) = \int_{-\infty}^{+\infty} e^{ik[\Delta - c(k)t]} dk.$$

The integral stands for oscillations recorded by a station located at the distance Δ. The process in the earthquake focus is regarded as short-timed and its spectrum as sufficientlywide to be adopted a sufficiently accurate constant (the spectrum of the Dyrak's Impulse which, in the given formula, is taken as a unit) $c(k)$, — phase velocity.

ABSTRACT

The propagation of Lg and Rg waves in the region of Black See is investigated. Some idea concerning the nature Lg_2 is worked out.

RIASSUNTO

Nel presente lavoro viene trattata la propagazione delle onde Lg ed Rg nella regione del Mar Nero. Si fa inoltre, qualche cenno sulla natura delle onde Lg_2.

REFERENCES

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