Experimental results on horizontal and vertical displacements of the earth's surface

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Abstract. This study presents the results of experimental research of the dependence of horizontal and vertical displacements of the earth's surface. The experiments were conducted on a mini-experimental setup designed by the authors. The results showed that there are some patterns in the strain of the earth's crust layers under various effects of tectonic forces, and in the dependence of displacements of the day surface on the sequence of tectonic forces application.
Keywords: formation, geodynamics, tectonics, displacement, offset, mantle, experiment.

Introduction.

The earth's surface was forming for over many millions of years, capturing huge masses of rocks. The formation depends on many factors - endogenous and exogenous ones. One of the important factors is the geodynamic setting, which depends mainly on tectonic forces caused by the interaction of adjacent lithospheric blocks and rising mantle differentiates. Due to the large extent of these processes, research was performed, mainly, using numerical models and conducting physical experiments on models.

In the article by Abidov A.A. et al. [1,2], a literature review of numerical studies of the issue under consideration is presented, as well as the results of numerical modeling of the formation of regional oil and gas structure in Uzbekistan. In modern literature, along with numerical studies, considerable attention is paid to the development of physical models of geodynamic processes, mainly based on the classical studies by Belousov V.V. and Gzovsky M.V.

Regular model experiments began at the end of the 19th century in connection with the study of the formation of the folds (Daubree, 1879 (USA); Willis, 1893 (USA); Reyer, 1894 (Germany)). Belousov V.V., Gzovsky M.V. and others made a significant contribution to the development of experimental geodynamics. In these studies, ruptures and folds of various types were modeled; the issues of a geological and geophysical nature related to the stress assessment in the earth's crust and the forecast of earthquakes were solved.

Method. To conduct experimental research for the study of vertical displacements and horizontal offset of the earth's surface, a simple mini-experimental setup was designed that allowed creating vertical and horizontal forces and measure rock mass displacements on a scale of 1: 350,000. The setup allows conducting experiments with single-layer and multi-layer samples, and modeling, on the above scale, the earth's crust in any region. The experimental setup makes it possible to study separately the action of adjacent lithospheric blocks and the action of the mantle differentiate.

Results and Discussion. A number of experiments were conducted with one-layer and two-layer models; the influence of the sequence of the action of tectonic loads on the formation of folds and ruptures was studied. The research results are shown in the form of dependencies between: V_1 - the value of the vertical displacement of the day surface; V_2 – the vertical displacement on the base; U_1 - "action of

adjacent blocks" - horizontal offset of layers. Due to the similarity of the graphical images, they are shown only for experiments of the first type.

The first type of experiment: a homogeneous soil layer is subjected to the impact of horizontal and vertical forces. The experiments were conducted in two options: 1) the impact of vertical forces only; 2) soil compression by lateral force, and then - the application of vertical forces. For each of the options, at least three experiments were conducted. Figs. 1, 2, and 3 show the averaged graphs of the dependences of the corresponding displacements.

From Fig. 1 it is seen that the relationship between the values of V_1 and V_2 in these experiments, throughout the entire displacement is linear, and is described by the equation:

$$V_1 = 0{,}951 \cdot V_2 \qquad (1)$$

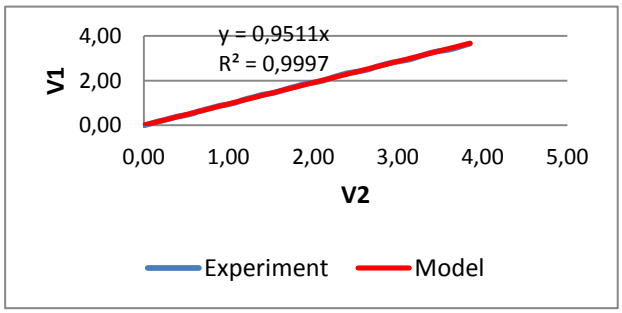

Fig. 1. Dependence of displacements V_1~V_2 under the action of "mantle differentiate".

From Fig. 2, it can be seen that the relationship between the horizontal offset of the layers and the uplift of the day surface under the influence of adjacent lithospheric blocks is nonlinear and is described by the equation:

$$V_1 = -0{,}061 \cdot U_1^4 + 0{,}143 \cdot U_1^3 - 0{,}046 \cdot U_1^2 + 0{,}155 \cdot U_1 \qquad (2)$$

Fig. 3 shows the relationship between the displacements V_1 and V_2 after preliminary compression of the layers. As seen, in this case, the studied dependence, in contrast to Fig. 1, is nonlinear and is described by the following equation:

$$V_1 = -0{,}177 \cdot V_2^3 + 0{,}513 \cdot V_2^2 + 0{,}206 \cdot V_2 + 1{,}17 \qquad (3)$$

The second type of experiment: a two-layer sample consisting of soil (bottom layer) and sand (top layer) is subjected to the impact of horizontal and vertical forces. The experiments were conducted in two options: 1) under the impact of vertical forces only; 2) soil compression by lateral force, and then - the application of vertical forces.

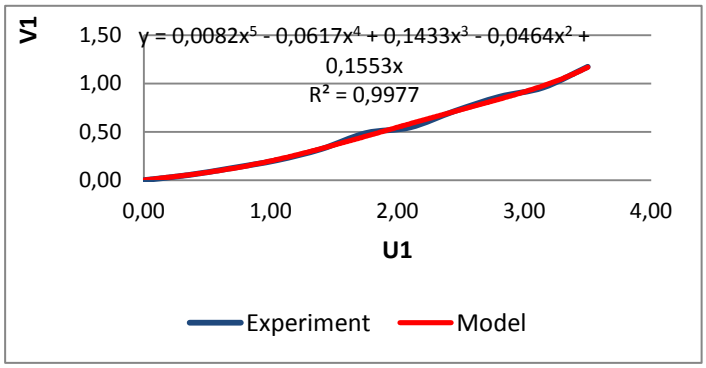

Fig. 2. Dependence of displacements V1~U1, caused by the action of "adjacent lithospheric blocks".

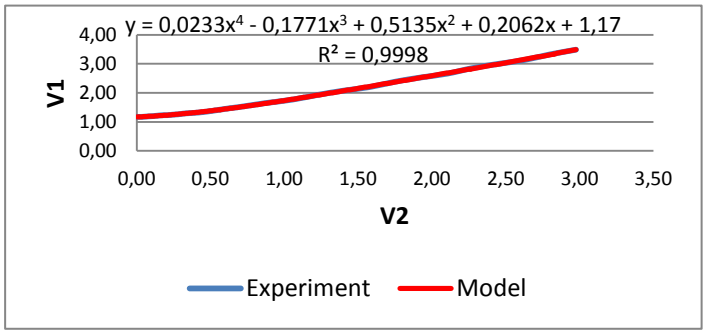

Fig. 3. Dependence of displacements V_1~V_2 under the action of "mantle differentiate" after preliminary lateral compression.

The relationship between the values of V_1 and V_2 in these experiments, similar to the experiments of the first type, is linear throughout the displacement and is described by the following equation:

$$V_1 = 0{,}994 \cdot V_2 \quad (4)$$

The relationship between the horizontal offset of the layers and the uplift of the day surface under the action of adjacent lithospheric blocks in the case of a two-layer model is nonlinear and is described by the following equation:

$$V_1 = -0{,}061 \cdot U_1^4 + 0{,}139 \cdot U_1^3 - 0{,}021 \cdot U_1^2 + 0{,}105 \cdot U_1 \quad (5)$$

Dependence between displacements V_1 and V_2 after preliminary compression of layers. As can be seen, in this case, the studied dependence, in contrast to Fig. 1, is nonlinear and is described by the following equation:

$$\mathrm{V}_1 = -0{,}188 \cdot V_2^3 + 0{,}5 \cdot V_2^2 + 0{,}236 \cdot \mathrm{V}_2 + 1{,}204 \quad (6)$$

Conclusion. Experimental studies and analysis of the results obtained show that there are some patterns in the strain of the earth's crust layers under various actions of tectonic forces, and in the dependence of displacements of the day surface on the sequence of tectonic forces application. The application of insignificant design solutions to the experimental setup, such as a change in the hydrodynamic situation during the development of mineral deposits, will allow investigating, in the future, the issue of the earth's surface subsidence.

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