EARTH SCIENCES

CORRELATION-REGRESSIVE ANALYSIS OF GRAVIMETRIC AND SEISMIC DATA

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Abstract

The article is devoted to the issue of correlation and regression analysis of gravimetric and seismic data. Analysis of geophysical data shows that there is a correlation relationship between geological and geophysical data. This relationship can be studied using methods of probability theory and mathematical statistics. In a particular case, such a relationship can be between geophysical and geological parameters, for example, between gravity exploration data and seismic exploration data on the depth of the geological boundary under study. Such correlation analysis is initially carried out on standard seismic-gravimetric profiles with known values of gravimetric and seismic-geological data. The correlation relationships established on the standard are used to predict geological characteristics based on gravimetric data within the studied (forecast) territory. The Geophysics department of the ASOIU has developed software for correlation and regression analysis of gravity and seismic data MRA-COMSCOM, which allows predicting seismic-geological boundaries in a profile and area version for complexly constructed areas. At the same time, the MS Excel program is currently widely used for correlation-regression analysis of data. The article describes the results of correlation-regression analysis of a seismic-gravimetric profile model using the capabilities of the Excel office program.

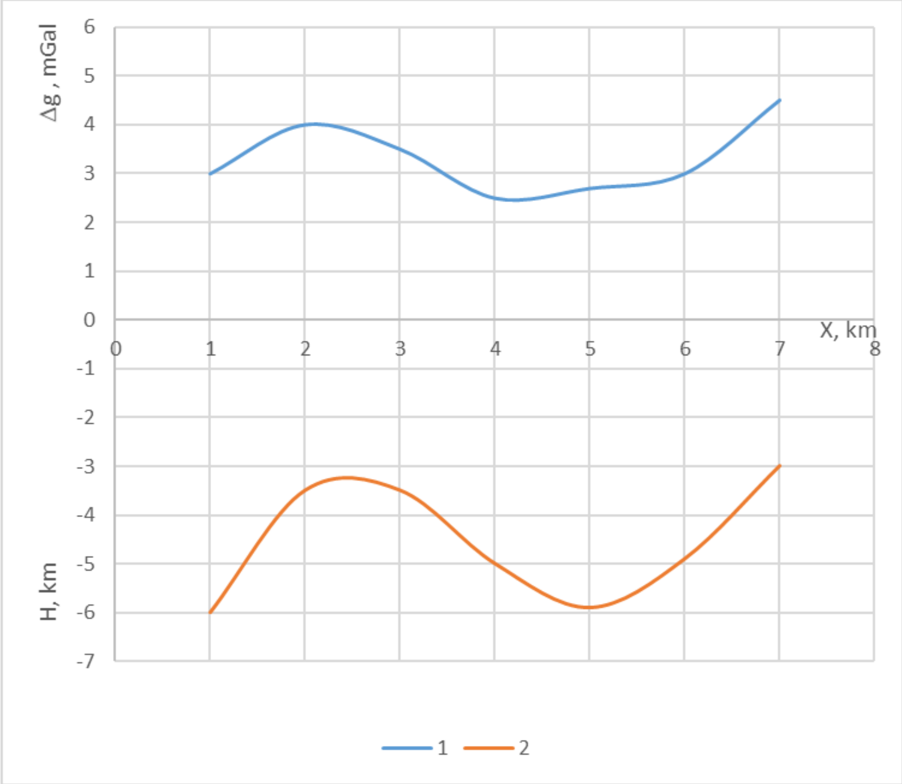
Keywords: correlation, regression, forecasting, correlation coefficient, regression, linear relationship.

Introduction

Complex interpretation of gravity and seismic data using statistical methods of mathematics is widely used to solve geological problems [1,3,10,11]. Construction of structural schemes for a set of geological and geophysical information using static methods is used mainly in the modification of multivariate regression analysis (MRA) and correlation methods of field transformation (CMFT). In the case of MRA, a statistical relationship is established between the depths of various geological boundaries according to seismic exploration (or drilling) data and the observed values of gravity and its transformants. In the case of reliability, these relationships are extrapolated to areas not studied by seismic exploration or drilling. Since in the complexly structured regions of Azerbaijan and in particular in the Middle Kura Depression, due to complex seismological conditions, it is not possible to obtain unambiguous reference seismic data on the structure of the lower Mesozoic stage, MRA is used using only conventional seismic horizons and data from detailed and high-precision gravity exploration, which correlate well with the curve of the local gravity anomaly[4-6]. At present, the MS Excel program is widely used for correlation and regression analysis of data [2,7-9,12-13]. The purpose of this article is to apply the capabilities of the correlation and regression analysis of the MS Excel office program using the example of a model seismic-gravimetric profile.

Tools and methods

To perform correlation-regression analysis using the Excel office program, a seismic-gravimetric profile model was initially constructed consisting of one curve of local gravity anomaly and a model seismic boundary (Fig. 1). As can be seen, the gravity curve is characterized by one maximum of gravity (left branch) with an intensity of approximately 2 mGal and a minimum of gravity (right branch) with the same intensity. The minimum of gravity is complicated by a relative maximum of very weak intensity, which does not correspond to the right branch seismogeological boundary. In turn, the seismogeological boundary is dislocated and consists of an anticline and a syncline with an amplitude of 2.5 km. At the beginning, it is necessary to evaluate the quality of the correlation between these curves. In Excel, statistical analysis can be performed in several ways. We used the additional function "data analysis", which must be activated in the Excel properties "options". After activating this function, the "data analysis" button appears on the menu ribbon in the main menu "data". After clicking this button, select the "correlation" option in the drop-down



Legend:
1 is the local gravity anomaly curve (blue); 2 is the seismogeological boundary (red).
Fig. 1. Model of seismic-gravimetric profile

menu. After this, it is necessary to fill in the rows with the original data. This is a column with discrete gravity values taken from the local gravity anomaly curve and the depth values of the geological boundary model based on seismic exploration or drilling data (Fig. 2). Then we click the

H, km	Δg, mGal
-6	3
-3.5	4
-3.5	3.5
-5	2.5
-5.9	2.7
-4.9	3
-3	4.5

Fig. 2. Table of gravity and seismogeological boundary values

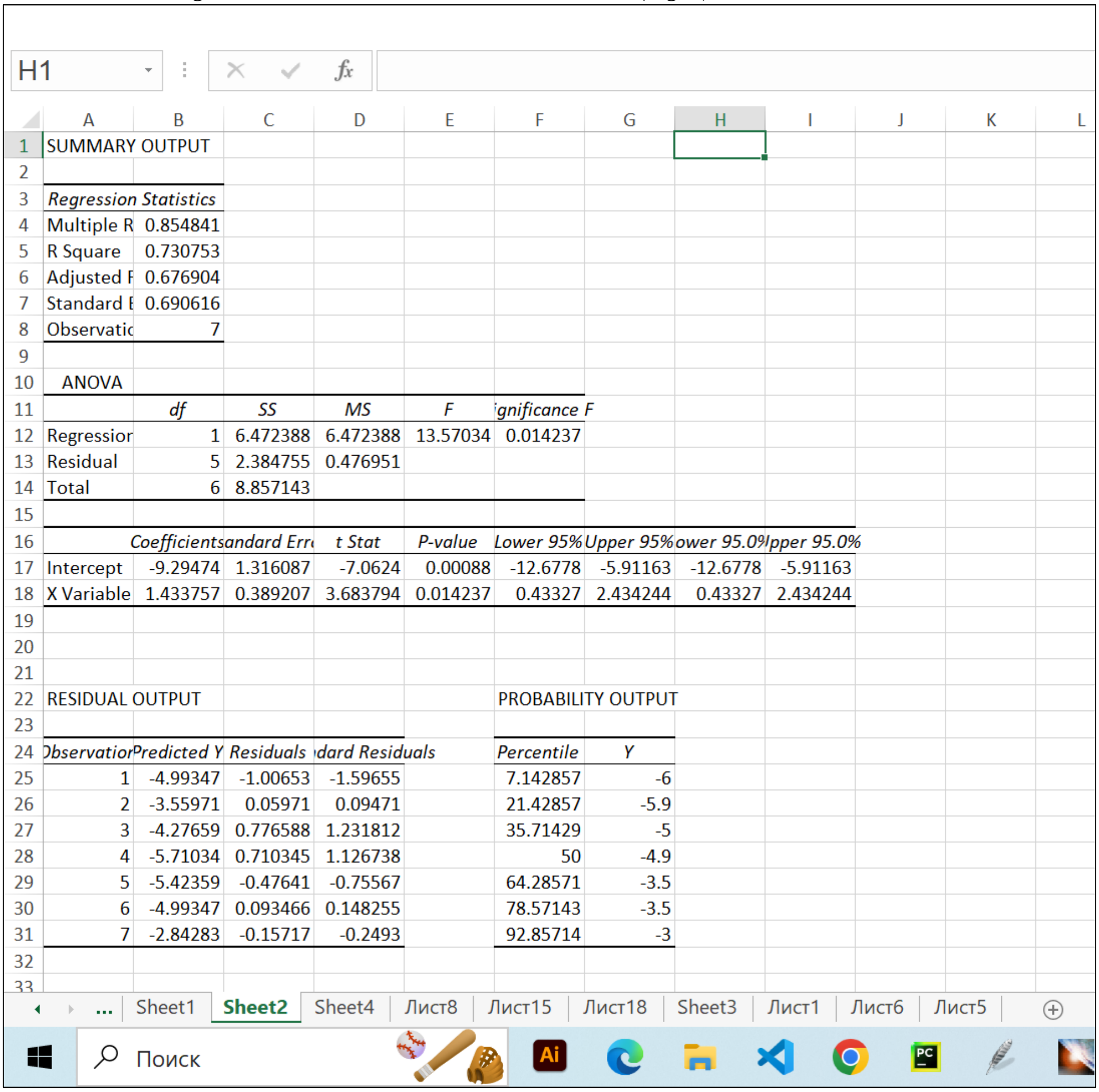
OK button and receive the following characteristics of the correlation relationship on a new sheet (Fig. 3).

	Column 1	*Column 2*
Column 1	1	
Column 2	0.854841	1

Fig. 3. Results of correlation analysis of seismic-gravimetric data

As can be seen from the figure, the correlation coefficient of the linear dependence is 0.854841. This means that the relationship between seismic and gravimetric data is good and positive since the correlation coefficient has a positive sign.

Next, it is necessary to perform a regression analysis of the model seismic-gravimetric profile data. To do this, select the regression function in the "data analysis" menu and fill in the rows with the initial data. After performing this function, we obtain the following results (Fig. 4).



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.854841
R Square	0.730753
Adjusted F	0.676904
Standard E	0.690616
Observatic	7

ANOVA

	df	SS	MS	F	ignificance F
Regressior	1	6.472388	6.472388	13.57034	0.014237
Residual	5	2.384755	0.476951		
Total	6	8.857143			

	Coefficients	andard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept	-9.29474	1.316087	-7.0624	0.00088	-12.6778	-5.91163	-12.6778	-5.91163
X Variable	1.433757	0.389207	3.683794	0.014237	0.43327	2.434244	0.43327	2.434244

RESIDUAL OUTPUT

Observatior	Predicted Y	Residuals	dard Residuals
1	-4.99347	-1.00653	-1.59655
2	-3.55971	0.05971	0.09471
3	-4.27659	0.776588	1.231812
4	-5.71034	0.710345	1.126738
5	-5.42359	-0.47641	-0.75567
6	-4.99347	0.093466	0.148255
7	-2.84283	-0.15717	-0.2493

PROBABILITY OUTPUT

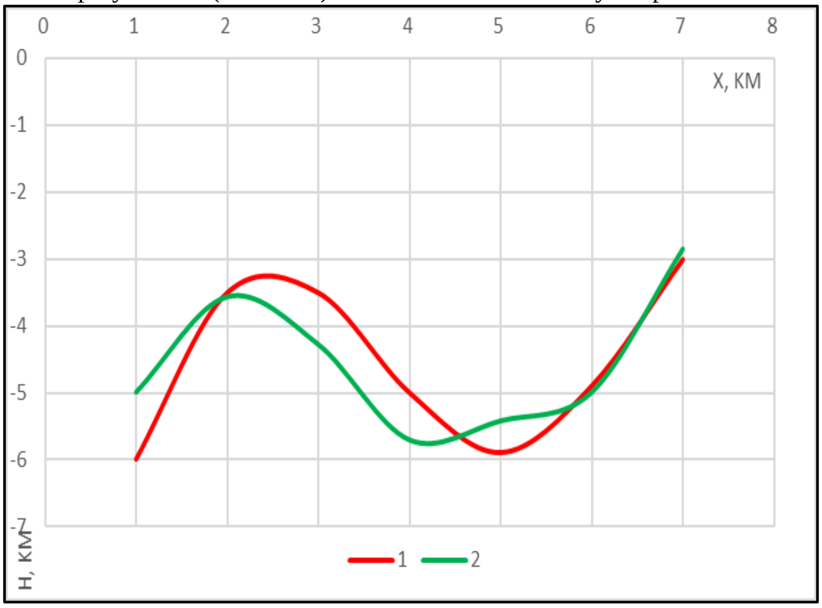
Percentile	Y
7.142857	-6
21.42857	-5.9
35.71429	-5
50	-4.9
64.28571	-3.5
78.57143	-3.5
92.85714	-3

Fig. 4. Results of regression analysis of seismic-gravimetric data

As you can see, the results of the regression analysis are displayed here: regression analysis statistics, variance analysis results, and regression analysis coefficients. The statistics of regression analysis include the correlation coefficient value calculated in the previous step, the R Square coefficient equal to 0.730753, which characterizes the quality of the model, the adjusted R-square is a corrected measure of goodness of fit for linear models (model accuracy), the value of which is 0.767904, the standard deviation equal to 0.690616 and finally the number of data equal to 7. The analysis of variance includes the degree of freedom df equal to 1, the variance of deviations SS (the sum of the squares of the deviations of the predicted value from the mean) equal to 6.472388, the standard error MS (the mean value of the sum of squares divided by the degrees of freedom of the regression and residuals) equal to 6.472388, the Fisher coefficient F equal to 13.57034 and the significance F equal to 0.014237. Next, the coefficients of regression analysis are given: coefficients of the regression equation, t-statistics, Pearson's p-coefficient, lower and upper confidence intervals of statistical parameters. At the end, the results of the forecast are given: initial depths, residual deviations and probabilities of the values of the depths of the studied boundary. Thus, we obtained the following regression equation:

$$H=-9.29474 + 1.433757 \Delta g \quad (1)$$

A graphical representation of the results of the seismic boundary prediction on the reference model profile is given below (Fig. 5). As can be seen, good agreement is observed in the interval of 5.8-7 km and at the point of 1.8 km on the observation profile. In other areas, a discrepancy of approximately 0.6 km is observed. It should be noted that the regression analysis was carried out for the linear version of the dependence of the initial data. Let us analyze possible options for the dependence between seismic exploration and gravity exploration data (Fig. 6). The figure shows three options for approximating the curve of the dependence of the depth of the model boundary on the values of the local gravity anomaly: linear trend analysis, logarithmic trend analysis and polynomial (nonlinear) trend analysis. In all three cases, we can say that the effect is the same. Thus, the linear option for predicting the model boundary is optimal.



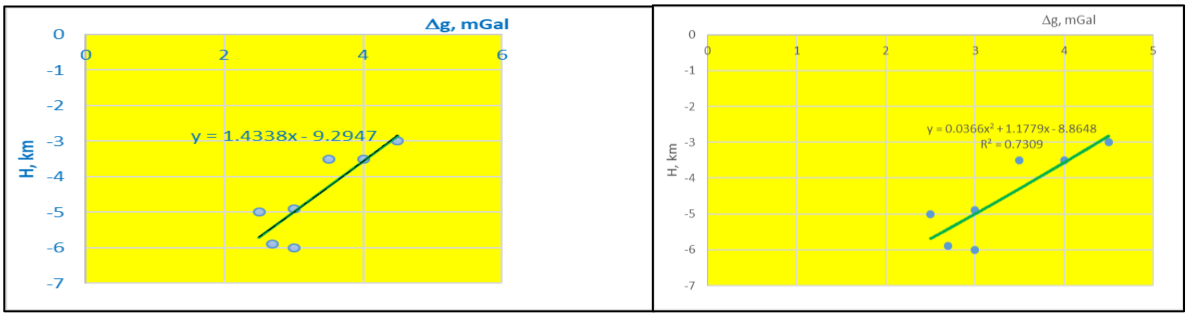
H, km	-5	-3.6	-4.3	-5.7	-5.4	-5	-2.8

Legend:

1- actual curve of the model seismic boundary (red);

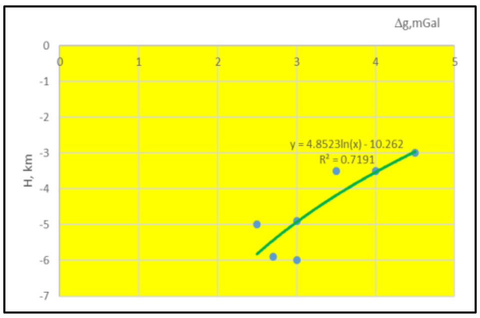
2- predicted curve of the model seismic boundary (green)

Fig. 5. Results of the seismic boundary prediction on the reference



Linear trend

Polynomial



Logarithmic trend

Fig. 6. Results of trend analysis of seismic-gravimetric data

Conclusions:

1. The statistical foundations of correlation methods for interpreting geophysical data and methods for establishing correlations between geological and geophysical data are considered. The possibilities of correlation-regression analysis of data in the MS Excel office program are studied for using these capabilities in the complex interpretation of geological and geophysical data by correlation methods.

2. A model of a seismic-gravimetric profile is compiled, which consists of a curve of a local gravity anomaly and a seismic-geological boundary based on seismic exploration data. The curve of a local gravity anomaly has one maximum and minimum of gravity and approximately displays a dislocated geological boundary obtained from seismic exploration data.

3. Correlation and regression analysis is performed between the model data of gravity exploration and seismic exploration using the capabilities of the MS Excel office program. A correlation relationship between these data is established and statistical characteristics of these relationships are given. Based on regression and trend analysis, a regression equation was compiled, with the help of which an optimal forecast of the seismic-geological boundary on the reference profile was made.

4. The MS Excel program has good capabilities for statistical analysis of geological and geophysical data and can be very useful at the preliminary stage of complex interpretation of gravimetric and seismic data of complex areas using multidimensional regression analysis methods and correlation methods of separation and transformation of fields.

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