P048 AUTOMATIC PROCESSING AND INTERPRETATION OF ENGINEERING SEISMIC DATA IN MOUNTAIN CAUCASUS AREA

R.M. GYLYJOV and V.B. PIIP

Moscow State University, Geological faculty, Vorobjovy Gory, 119899 Moscow, Russia

Abstract

A comprehensive interpretation of the data of engineering refraction seismic along seven profiles has been made in district of a health resort Red Field valley in Caucasus Mountain. The application of a method of homogeneous functions for interpretation has allowed completely to automate the processing and interpretation of the data. The detailed structural interpretation was produced: the layers, faults, rockslides, zones of disturbed rocks are allocated, the structure of bedrock is clarified up to depth of 50 m. The cross sections, obtained by this method, are 2D inhomogeneous and continuous in that sense that in each point of a cross section velocity, and consequently also velocity gradient is defined. It has allowed constructing not only surfaces of layers, but also horizon velocity maps-slices that is to proceed to three-dimensional interpretation. The cross sections are verified by comparison of vertical velocity curves in points of intersections of the seismic profiles. The horizon velocity slices and cross sections of physical properties (elastic modulus, shear modulus and Poisson's ratio) were constructed with using of cross correlation ties. Knowledge of a detailed geological structure allows to avoid hazards often flowing into finance loss and even more human casualties. The objectives of this paper are to demonstrate possibility of homogeneous function method for imaging complex geological environments of mountain area.

Introduction

Red Field valley is a picturesque place with beautiful mountain relief developed by Caucasus Mountains. It is a generally accepted place for health-resort and mountain tourism. And by this time this place is in a process of building of new sport, tourism complexes. In areas of complex structural geology, with folds, thrusts and imbricate structures that are typical of many mountain belts the interpretation of refraction seismic is very complex. Most difficult procedure is identification of waves at traveltime curves of first arrivals from different sources. In addition traditional methods (plus-minus, reciprocal times, delay times and others) have very poor possibilities for imaging of complex geological structure of the cross sections.

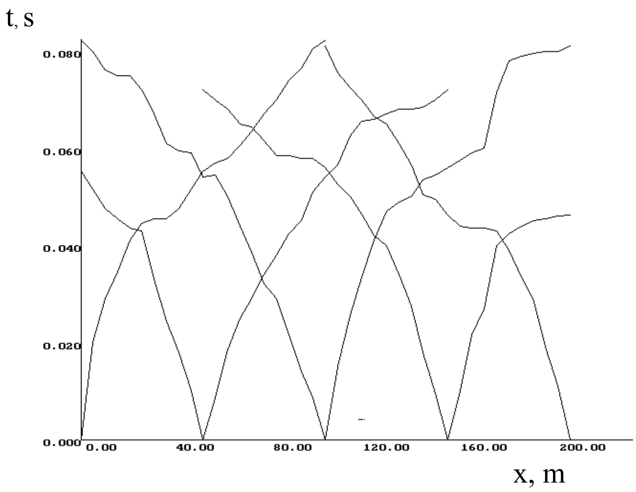

Figure 1. Observed traveltime curves for the cross section along profile 7.

Method of interpretation

For interpretation was used method of homogeneous functions. This method based on the local approximation of real velocity fields by

homogeneous function of two coordinates. It is a method using simple inversion of refraction traveltimes for the determination of 2D velocity and interface structure. Homogeneous velocity functions can include straight-line seismic boundaries. The contour lines of homogeneous functions are arbitrary curves that are similar to one another. The traveltime curves recorded at the surface of media with homogeneous velocity functions are also similar to one another. For two reverse traveltime curves, non-linear transformations exist which continuously convert the direct traveltime curve to the reverse one and vice versa. This fact has enabled us to develop an automatic procedure for the identification of waves refracted at different seismic boundaries using the reverse traveltime curves. Homogeneous functions of two coordinates can describe media where the velocity depends significantly on two coordinates. However, the rays and the traveltime fields corresponding to these velocity functions can be transformed to those for media where the velocity depends on one coordinate. The 2D inverse kinematic problem, i.e. the computation of an approximate homogeneous velocity function using the data from two reverse traveltime curves of the refracted first arrival, is thus resolved. In the case of complex shooting geometry, the common velocity cross section can be constructed by applying a local approximation. This method enables the reconstruction of practically any arbitrary velocity function of two coordinates. The computer program 'GODOGRAF', based on this theory is a universal program for the interpretation of any system of refraction traveltime curves for any refraction method for both shallow and deep seismic studies of crust and mantle.
In results we receive a cross sections represented as a field of velocity contours with constant interval. Geological interpretation is produced for ready cross section. Seismic boundaries are distinguished as lines with high density of contours or lines where gradient values change sharply. Faults and fractures are imaging as line where contours are shifted. Folding, karst and other local inhomogeneity have their image in such cross sections.

The method of investigation

The study area is located near shore of Black Sea. Geologically it is dated for a zone Estosadoksky graben and is restricted from the south by Chkhaltinsky fault, from north and east by Mzymta fault. Bedrock is flysh interbedding of flinty slate, aleurolites and sandstones with north dips up to 60^o . The seismic works were carried out by "Jaclyn and K" company (Russia). In the research area seven profiles were located mostly perpendicularly with respect to one another. The profiles by the length of 100-280 meters were oriented lengthways and across a mountain incline. Receiver spacing was 5 meters and off-shot distance was a 50 meters. The scheme of location of the profiles is given in fig.4.

Results

Obtained refraction traveltime curves (Fig.1) have a complex form**.** In result of automatic processing and interpretation the seven cross sections have been constructed and interpreted. The velocity contour lines are drawn at equal intervals (100 m/s) in these cross-sections (Fig.3). Besides the velocity cross sections the cross sections in engineering parameters such as density, Young's modulus, Poisson's ratio were constructed using velocity-density and P-velocity - S-velocity relations which were defined in laboratory for research area. To evaluate error of our computations

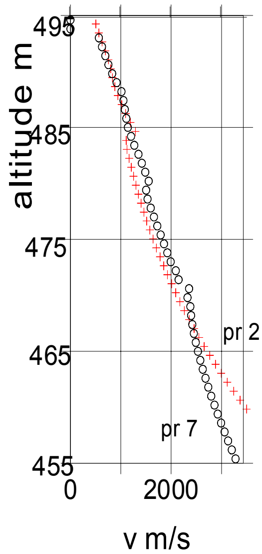

Figure 2. Vertical velocity slices in the point of intersection of the profiles 7 and 2 show good coinciding of velocity values.

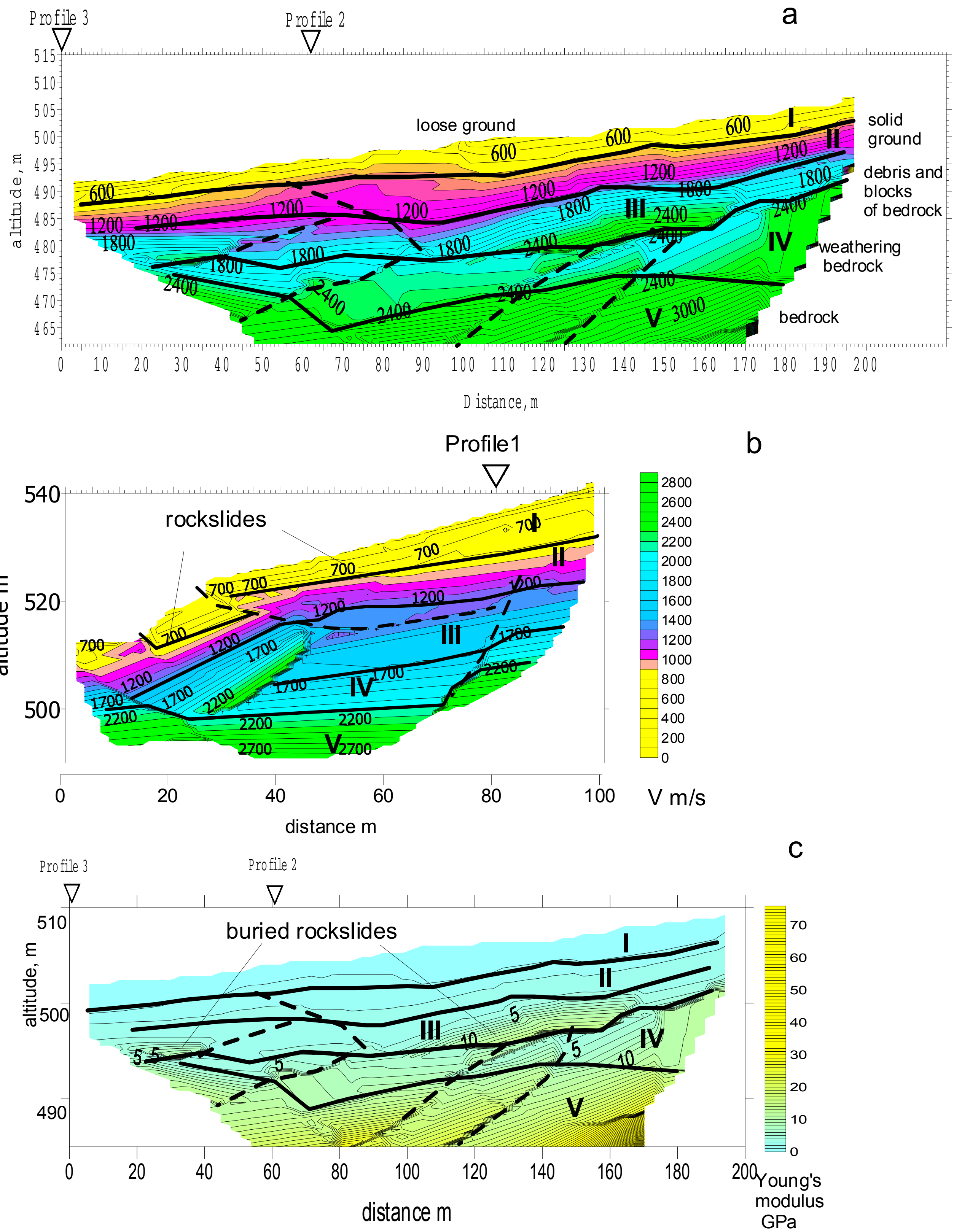

Figure 3. (a) seismic cross sections along profile 7 , (b) seismic cross sections along profile 5 and (c) Young's modulus cross section along profile 7. Thin lines are contours, bold lines are seismic boundaries. The faults are shown by dash lines. Points of intersections with other profiles are shown in the cross sections. Buried rock-slides at the profile 7 are better seen in the Young's modulus cross-section then in the velocity cross section.

we made vertical velocity slices in the points of intersection profiles (fig. 2). We received the error of depth of boundaries about 2-3 meter and 100-150 m/sec for wave's velocity. In all cross sections 4-5 layers (designed as I, II, III, IV, V in fig. 3,4) and a system of gentle faults were determined.

The layers are (from top to bottom):

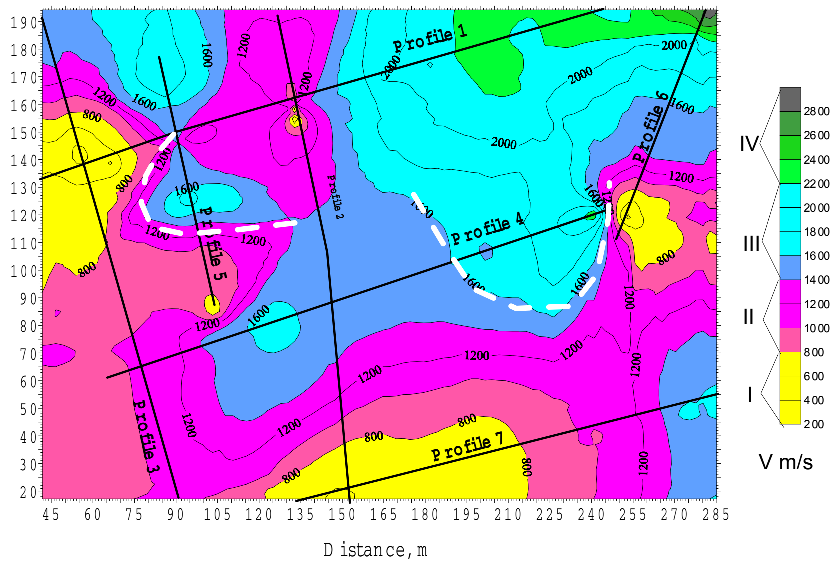

Figure 4. Velocity map-slice at the topographic level of 510 m. In this map the boundaries of the layers in average are coincided with boundaries of velocity intervals characterizing these layers. The outlines of two rockslides shown by white dash lines are seen in this map in region of the profiles 4 and 5.

loose subsurface rocks (layer I), with velocities (Vp) ranging between 400 and 800 m/s and Young's modulus values (Y) less 1 GPa; solid ground (layer II) with Vp from 800 to 1400 m/s and Y from 1 to 3 GPa; layer including debris and blocks of bedrock and buried rock-slides (layer III) with Vp from 1400 to 2300 m/s and Y from 3 to 14 GPa; weathering bedrock (layer IV) with Vp from 1900 to 2300 m/s and Y from 5 to 12 GPa; bedrock (layer V) with Vp from 2200 to 3500 m/s and Y more 10 Gpa (fig. 3).

The horizon velocity map-slices at the different levels were constructed. These map-slices image inner structure and boundaries of the layers that are located at given level. Faults, rockslides and thrusts also are reflected in velocity map-slices.

Conclusion

The application of a method of homogeneous functions allowed completely to automate the processing and interpretation of the data of engineering seismic in Caucasus Mountain area. The detailed structural interpretation was produced: the layers, faults, rockslides, zones of disturbed rocks are allocated, the structure of bedrock is clarified. The homogeneous function method affords the imaging of very different and complex geological media.

References

V.B Piip. 2001. 2D inversion of refraction traveltime curves using homogeneous function. Geophysical Prospecting, **49**, 461-482.