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Experience of faults typology in linear folding and statistic study of their system based on results of balancing sections for North-West Caucasus

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The conventional scheme of folding of Caucasus is structure type of accretionary prism (Dotduev, 1986; Robinson et al., 1996). It represents mono-vergent system of thrusts with surfaces inclinations about 30-50 degrees to the north. The structure is complicated by folds and it has the common low-angle detachment on boundary “sedimentary cover/rigid basement”. However, in this case it is not clear, what is difference between hinterland structure and foreland one. The task of this research is the consideration in details a character of faults structures of hinterland on the basis of the field-study structural data and learning of parameters of deformations.

Detailed structural cross-sections have been fulfilled by two groups of researchers for North-West Caucasus: by T. Giorgobiani and Ye. Rogozhin (Giorgobiani and Zakaraya, 1989; Sholpo et al., 1993). All geometrical elements of each fold and of fault were measured in the field. Structural sections of scale 1:10 000 were drawn up based on results of these measurements and these sections reflected only the fixed natural structure. It was not contributed almost any corrections to profiles as kind of interpretation. In total, 11 profiles of aggregated length about 350 km have been constructed and published.

All profiles have been divided into domains which represented sections of structure with homogeneous folds in width of 1-2 km on the average. Boundaries of sharp changes of a lithology and sufficient ruptures were used as boundaries of domains. In total, 244 domains have been selected. The method of balancing of sections (Yakovlev, 2009a) has been used for retro-deformation of initial structure of region. Three parameters were measured in each domain: 1) an inclination of an axial plane of folds, 2) value of shortening to perpendicular to axial plane based on a interlimb angle, 3) an inclination of a envelope plain of folds. These three parameters have relation to ellipsoid of strain for whole domain. Three kinematic operations were used for the restoration of prefolded state of domain. It is sequence: 1) turn up to a horizontal position of an envelope of folds, 2) horizontal simple shearing up to vertical position of an axial plane, 3) a stretching up to disappearance of folds. For the restoration of an initial inclination of a plane of fault the same operations were used. For each domain the “stratigraphic” column embracing whole sedimentary cover was constructed. All layers had “stratigraphic depth” which was digitized from level “0” (sea level). Displacement amplitude on each fault was defined on a difference between depths of the layers contacting on sides of fault (vertical amplitude) and prefolded inclination fault plane (horizontal amplitude, result of calculations). The received materials have been used as a basis of statistical investigation.

This material contained 119 values of the modern and prefolded inclinations of plains of faults and displacement amplitudes on them (58 thrusts and 61 normal faults) that has allowed to receive some statistical parameters (Yakovlev, 2009b). Average mean value of dip angle of the modern surface of faults has been found about 80° to the north. It was manifestation of southern vergence of whole structure. But dispersion of values concerning an average looks symmetric and not narrow. The fifth part of fault (10 faults and 13 normal faults) has inclination to the south. Restored amplitudes of horizontal displacements are about 1800 m in averaged for thrusts and 800 m for normal faults. The fixed large amplitudes from 8.3 to 19.6 km aren’t exact. Placement of inclinations of faults across structure strike show some divergence and a random distribution at the same time. Only several thrusts, which have a large amplitude, have the modern inclination of surface to the north and belong either to structure center, or to its southern flank. Thereby the uniform mono-vergent to south imbricate fault array doesn’t prove to be true at statistical level. Values of the general shortening of folded structure on 11 cross-sections, including displacements on both normal faults and thrusts, have been calculated. Average general shortening value was determine as 35 %, and it reached 67 % on separate segments . Shortening due to thrusts was compensated by the registered stretching in normal faults. Summarized part of shortening on thrusts has no more than 0.1 as averaged from the general shortening. It means that the natural structure is folded as total, instead of thrust related according to conventional schemes.

Made earlier a balancing section on southern restriction of the Greater Caucasus in the Chiaur zone has shown that regional boundary fault has character of normal fault with amplitude of 10-15 km on a level of the basement top and that numerous thrusts on a Earth’s surface are local structures only. It shows the identical shortening of a

sedimentary cover and the basement into a southern part of hinterland. Identical shortening eliminates existence of the general detachment and underthrusting of the Transcaucasian blocks under the Greater Caucasus (Yakovlev, 2005).

Obtained data allow to describe some types of structures which contain faults (Yakovlev, 2009b).

1. The most simple fault structures in zones of steady existence of facies and thicknesses are small thrust and normal fault. They are registered on a difference of depths for domains which have identical initial columns and subvertical axial surfaces. Usual relation of layer age is using (more ancient for hanging wall of thrust).

2. Difficult case arises, when the inclination of thrust surface appears more steep, than an inclination of axial surfaces in the hanging domain with more ancient rocks. After conversions "turn – horizontal shearing – a stretching" the inclination of fault plain changes a quadrant. In this case real displacement appears as a normal fault.

3. Known structures "shortcut" also meet in a folded-fault type of structure on boundary of two blocks as a combination of two faults occurring at different times. At first time under extension conditions a normal fault with a dip of plain approximately 70 ° are formed. Thrust with an inclination nearby 45 ° develops at shortening at the second stage. This thrust in structure about a surface penetrates from a hanging wall in footwall and cuts off its wedge in length along a profile to several kilometers.

4. If large ruptures are in a zone of the considerable change of thickness and lithologic facies of cover on boundary of tectonic zones, there are big complexities in determination of value of horizontal displacement.

A case with two essentially different stratigraphic columns was considered. The marking horizon of certain age is in northern unit on small depth in a first "stratigraphic" model. In a southern zone, essentially more sediments has been accumulated, and the marking horizon has a larger depth in a second "stratigraphic" model. At small thrusting of northern block to south the marking horizon will contact to very young rocks which have a small difference in depth between two "stratigraphic" models, but there is a big "age" difference. The amplitude defined on "age" criteria can reach tens kilometers, but real amplitude, defined by "models" depth difference, will have the first kilometers.

5. If a structure similar to a case 4 has the upraised southern block, a development of thrust from the north to the south can lead thrusting of young rocks on ancient age units that will create a "normal fault" situation. Determination of displacement on "models" depth will show real amplitude of thrust.

We should note that in cases 4 and 5 even-aged layers can come to contact on sides of large fault, initially distant on 4-5 km at a difference on initial depth of 3-4 km. If they have different character of a lithology owing to an belonging to different zones, the result will be perceived as «convergence facies» with amplitude in tens kilometers.

Conclusions. 1) Both thrusts and normal fault are existing in structure of zones of linear folding in North-West Caucasus. The shortening part of thrusts in general fold-thrust shortening doesn't exceed 0.05 – 0.10. 2) Correct determination of displacement amplitude on large faults at section balancing is connected to exact registration of structure in the field and with realness of "stratigraphic" models of a sedimentary cover of these two blocks. 3) The general scheme of a structure of type "accretionary prism" doesn't prove to be true for the Greater Caucasus based on data of tectonophysics researches. 4) Several types of faults breaking a structure of hinterland linear folding are offered and described.

Dotduev, S.I., 1986. On the Nappe Structure of the Greater Caucasus. Geotektoniks. 5, 94–106.

Giorgobiani, T.V. and Zakaraya, D.P., 1989. The folded structure of the North-Western Caucasus and the Mechanism of its Formation. Metsniereba, Tbilissi, Georgia.

Robinson, A.G., Rudat, J.H., Banks, C.J. & Wiles, R.L.F., 1996. Petroleum geology of the Black Sea. Marine and Petroleum Geology. 13(2), 195–223.

Sholpo, V.N., Rogozhin, E.A., Goncharov M.A., 1993. Folding of the Greater Caucasus, Nauka, Moscow. (in Russ.)

Yakovlev, F. 2005. Prognosis of structure of the main boundaries for the Earth's crust based on data of deformations estimations in a folded Alpine sedimentary cover, the example of the Great Caucasus. http://www.cosis.net/abstracts/EGU05/07160/EGU05-J-07160.pdf

Yakovlev F. 2008. The construction of pre-folding, post-folding and recent stages of quasi-3D model for alpine sedimentary cover of North-West Caucasus basing on the hinterland folding geometry. SlovTec 08. Proceedings and Excursion Guide. State Geological Institute of Dionyz Stur, Bratislava. pp. 146-148.

Yakovlev F. L. 2009a. Reconstruction of Linear Fold Structures with the Use of Volume Balancing. Izvestiya, Physics of the Solid Earth, Vol. 45, No. 11, pp. 1023–1034.

Yakovlev, F.L., 2009b. The experience of faults typology for linear folding structures, on the Greater Caucasus example, in: Faults forming and seismicity in lithosphere: tectonophysical ideas and effects. IEC SD RAS. Irkutsk, pp. 128-131.