each plane varied from 150 to 250. Strain ratios and axes orientations of local strain ellipsoids were calculated with software developed by M. Brandon.

The main results of the study are the following. Despite of variations in strain ratios, orientation of the elongation axis (X) in local strain ellipsoid is always parallel to axes of regional-scale folds and thrusts strike. Variations in Lode coefficient v and magnitudes of natural deviatoric strain (Ed) shows that in north-east direction (from TFF to CTT) Ed decreases and the strain ellipsoid shape gradually changes from prolate to oblate shape.

Within the Uzunahmat zone we estimated shortening of a few large folds using strain-involved cross-section balancing method by Ramsay and Hubert (1983) and method by Yakovlev (2007). According to plane-strain estimations, close to CTT shortening of beds in domains bounded by thrusts varies from 51.9 to 57.2 %. Close to TFF, shortening reaches 37.5-41.8 %. Involving estimation of non-plane component (F-factor by Ramsay and Hubert, 1983) increased amount of shortening, and close the CTT it is estimated as 64.2-66.3 %, whereas close to TFF it is estimated as 55-56.2 %. The difference between these estimations increases in accordance with Ed variations, but increasing of total shortening correlates with decreasing of Ed.

The amount of shortening calculated by methods of Ramsay and Hubert (1983) and Yakovlev (2007) has been compared. For upright folds shortening estimated by both methods is similar, whereas for inclined folds estimations based on F-factor are approximately 10 % less than those based on Yakovlev's approach as the latter involves regional-scale rotation of domains.

Restoration of pre-folding structure of middle part of the Tallas Alatau was done for three regional-scale cross-sections using software developed by Yakovlev (2007). The initial length of beds of all three cross-sections has been estimated to 92 km. Although total shortening (65-75 %) was similar throughout the study area, mechanism of regional-scale deformation was different and in its western part (deep units are exposed) the shortening is related to intense folding, whereas in its eastern parts (shallow units are exposed) significant amount of shortening is related to displacement along thrusts. This implies that, despite of variations in tectonic styles, the main structural domains were formed in the same stress filed during the same deformational stages.

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Measurements of shortening values of similar type separate folds: Methods and results

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The geometry of similar folds contains the important information about the types and values of strain of collision zones. Correct models of folds formation are the basement of the quantitative study methods. Finally the estimation of the folds strain allows us to reconstruct the common structure of hinterland on the depth 20-40 km. Two types of folds (single viscous layer folds and multi-layer folds), were studied in Chiaur tectonic zone of Greater Caucasus.

The mechanical final element model of single viscous layer folds (Hudleston, 1973) includes the exact calculated geometry of a single layer fold (SVLF). Parameters of these folds geometry are the angle between flanks (**α**), thickness of the layer on the flank (**t**) and on the hinge

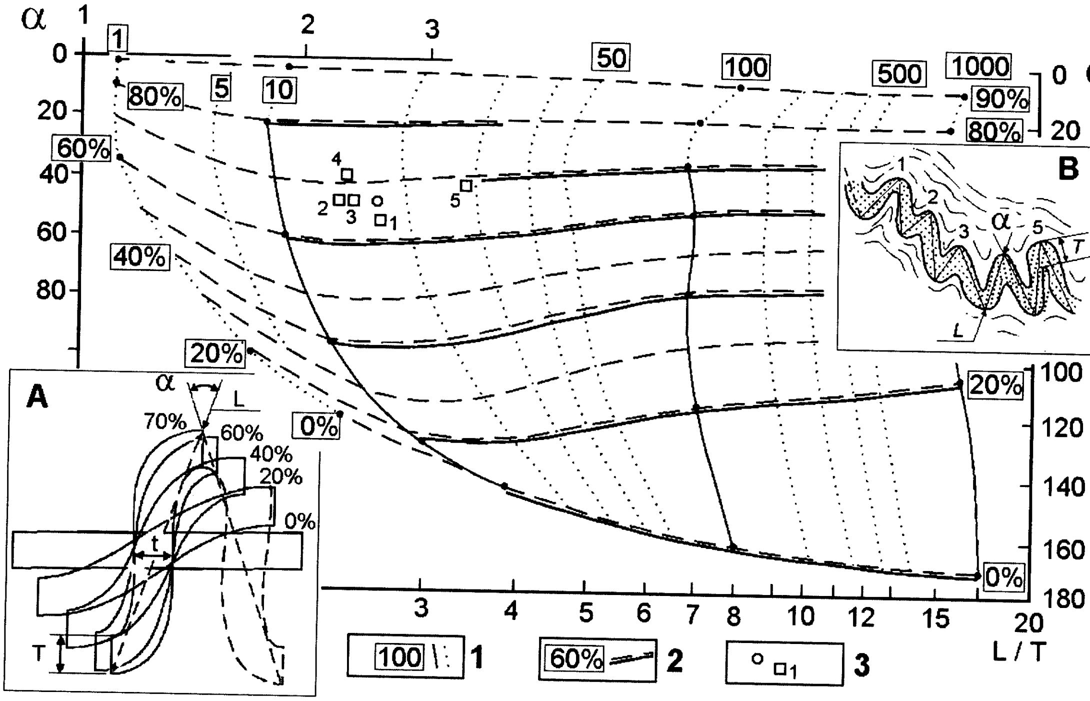

Fig. 1. Diagram for the measurement of shortening value and viscosity contrast based on parameters of geometry of single viscous layer folds. Ordinate axis is angle between flanks, abscissa axis is ratio length/thickness. A – Scheme of measurements of angle and length of flanks and layer thickness in models and natural folds. There is model for contrast viscosity 100 [1]. B – Scheme of measurements of parameters of geometry in natural folds. 1 - Sub-vertical isolines, after model parameters and interpolated isolines, the viscosity contrast value **VC**. 2 - Sub-horizontal isolines, the shortening value **Sh**, 3 – points plotted after measurements for 5 folds in natural series of folds and averaged values point (circle).

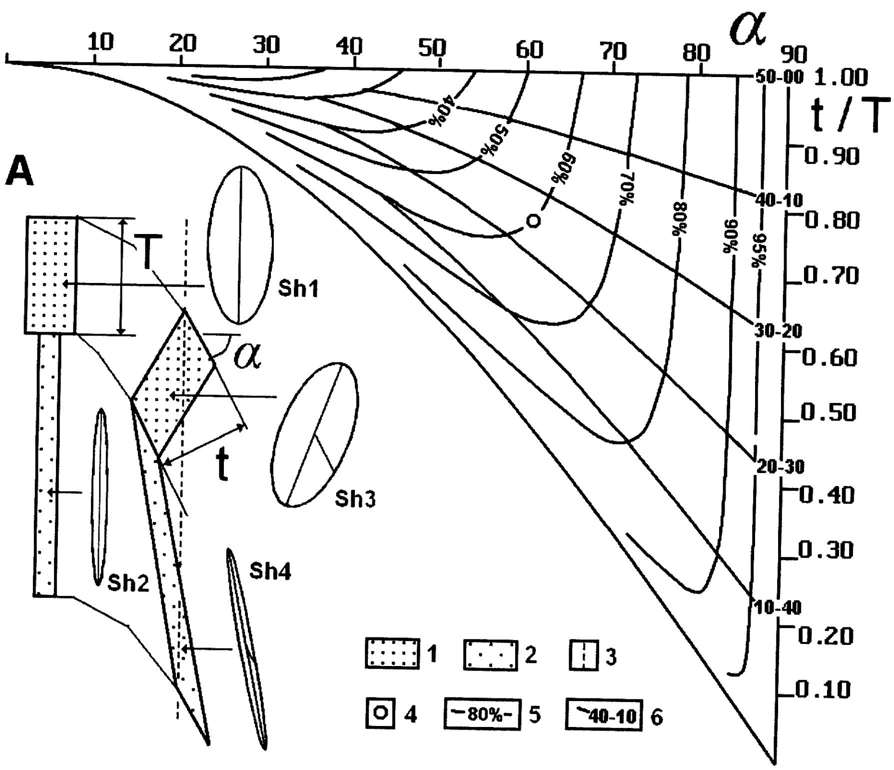

Fig. 2. Diagram for the measurement of shortening value for multilayer folds based on geometry of competent layer. The angle of flank dip **α** is abscissa axis, the ratio **t/T** is ordinate axis. A – Cinematic model of multilayer fold (hinge plus flank), intra-layer strain including (total shortening value is 60%, strain values Sh1=36%, Sh2=79%, Sh3=33%, Sh4=75%, α=61, t/T =0.78). 1 – competent layer; 2 – incompetent layer; 3 – orientation of axial plane of fold, 4 – parameters of model (fig. A) as point on the diagram, 5 – shortening value **Sh** isolines, 6 – trend of calculated model process, increments of rotation (0,4°*100) and flattening (0,1%*100) as **Mc**.

(T), and the length of the flank (L). Three models have the value of shortening (Sh) and the ratio of the viscosities of the layer and the matter around (VC, viscosity contrast). The diagrams (Fig. 1) were constructed which have "**α**" and "**L/T**" (or "L/t") axes (Yakovlev, 1978). The isolines of Sh and VC were the content of the diagrams. Natural folds (73 series) were studied based on measurements of folds geometry. The shortening values were 25 % to 82 % (56 % the average), and the VC values (sandstone/slate) were 2 ÷ 15. The distribution of Sh values was in reasonable accordance with some different parts of structure of this zone.

The kinematic model of multilayer folds was used because the correct mechanical model of multilayer buckling is not existing now. The geometrical properties of physical mechanisms (buckling-rotation, pure shear as flattening and simple shear) were used for the construction of multilayer folds (MLF) geometry (Fig. 2, A; Yakovlev, 2002). This model also allows the connection of the local strain in the layers with the common strain in the fold. The parameters of the layer geometry, as well as the shortening value (Sh) and the combination of mechanisms (Mc), are the results of PC program calculations. The dip angle of layer on the flank "**α**" and the ratio "**t/T**" represented the axes of the plotted diagram (Fig. 2), which also contains isolines of Sh and Mc. The geometrical parameters of 36 natural multilayer folds were measured. The shortening values were close to the previous case: 27 % ÷ 83 % and 57 % the average. There are 8 local sites, in which the shortening values of both MLF and SVLF were obtained. The high correlation coefficient (0.94) for these Sh values has shown that the kinematic model of the multilayer folds is close to the numerical mechanical model of single viscous layer folds. Thus, application of both methods for study of two types of folds in Chiaur zone of Greater Caucasus shows that both methods are reliable.

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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

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There are two ways for the reconstruction of folded structure: (1) the interpretation of common geological and geophysical data based on theoretic models and (2) usage the detail structural data, which can be observed and measured on the Earth's surface. Second way allows reconstructing objects from small to large ones based on study of their geometry and formation mechanisms. The system of seven hierarchic levels of folded structures was used as common basement of work (Yakovlev, 2002).

Next levels are used in this work: level 3 as domains (units of folds in layering package), level 4 as structural cells (local anticlinoria near 5-10 km width in whole sedimentary cover), level 5 - the tectonic zones. The structure of folding of North-West Caucasus was studied earlier by T. Giorgobiany and Ye. Rogozhin in 11 sections (there are references in Yakovlev, 2007). Alpine sedimentary cover consists of argillite and aleurolite flysch of Lower-Middle Jurassic and of Upper Jurassic–Paleocene calcareous flysch (Fig. 1). Total thickness of the cover is near 10-17 km. The review of recent opinions on the structure and on development of Greater Caucasus was published by Saintot et al. (2006).