(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).

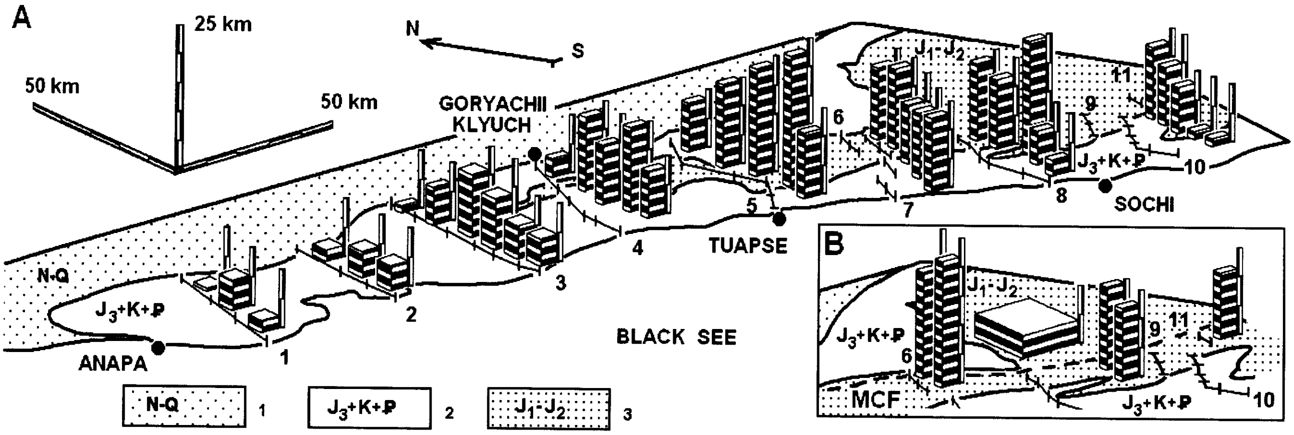

Fig. 1. The distribution of magnitudes of mountain building into the structure of North-West Caucasus (after Yakovlev, 2008). A – Sketch geological map, sections and cells, diagrams of magnitudes. B – Additional map (for sections 6, 9, 11) with the magnitude for the sub-platform block to the North from Main Caucasian Fault (MCF). 1 – Neogene and Quaternary, 2 – Upper Jurassic, Cretaceous and Paleogene carbonate-terrigenous flysch sediments, 3 - Lower and Middle Jurassic slates.

The geometry of folded domain may be interpreted as a kind of strain ellipsoid. The long axis of ellipsoid lays in axial plain, medium axis is hinge line of folds and short one is perpendicular to axial plain. The parameters of the domain are (1) the shortening value of folds (as short axis), (2) the dip angle of axial plain, (3) the dip angle of envelope plane for domains part of cross-section, (4) the length of a part of line of section and (5) tilting angle of section line. The pre-folded state of layering of this domain can be restored due to three kinematic operations with the ellipsoid. There are (1) rotation up to horizontal position of envelope plain, (2) simple horizontal shearing up to vertical position of axial plain, (3) pure shearing in horizontal axis (i.e. extension) up to folds will disappear (i.e. when the ellipsoid became sphere after this last operation). The lines of the domains part of the section are changing their length and a tilting angle as the result of these operations. This line finally has certain position into horizontal layering (Yakovlev, 2002, 2007). It means also that this line in pre- folded state has "stratigraphic" heights (depth) of started and of ended points. Each fault plane in nature is boundary between adjacent domains, and the plane can be considered as a part of domain. The pre-folded inclination of the fault plane can be found by the same kinematic operations. Vertical and horizontal magnitudes may be calculated based on this idea.

All 11 sections were divided to 244 domains and their geometry parameters were measured. The reconstruction of pre-folded states gives 535 km length of sections totally instead of 347 km of recent structure. The shortening values for sections vary (from 1 to 11): 16, 12, 33, 32, 52, 51, 40, 38, 39, 32, 41 % (35 % as average). Distributions of more detail data of shortening value and other parameters were studied. Stratigraphic columns for each domain were compiled from literature data and total thicknesses of sedimentary cover were calculated. Vertical positions of stratigraphic units from bottom of Oligocene unit were calculated as "0". Depths of Jurassic bottom vary from -3.5 km to -17.3 km and -13 km as average. Domains in pre-folded sections were aggregated to structural cells so that their widths were near equal to sedimentary cover thickness. Boundaries of cells were selected as hinge of local anticlinorium (synclinorium) in structure. The shortening values of such cells have tectonic origin and the influence of structural disharmony is absent. Lengths of these 42 cells along sections (Table, col. 1) and vertical positions of bottom of Jurassic unit (Table, col. 4), also as some other units were used for the construction of quasi-3D model of pre-folded (post-sedimentation) stage of structure. Volume of rocks in cell after folding must be kept, thus the thickness of cover must be larger after the shortening. There is opinion that folding has finished before mountain building. Thus new positions of bottom of units (Table, col. 5 = 4*3) were calculated. These data and recent lengths of cells were used for the construction of post-folded stage of 3D model of sedimentary cover. Each domain has exact vertical position of section line in pre-folded layering, thus the average values of section line for all cells were calculated. New positions of this parameter after shortening were calculated also. Of course, average recent hypsometry of section line for each cells were obtained also. The difference between the post-folded and recent depths is a magnitude of mountain building (Table, col. 7), and all volume of rocks above was eroded. This parameter was added to the post-folded depth of stratigraphic units and recent positions (post mountain building) of depths were

Table 1. Examples of structural cells parameters calculations (cells indexes were "a" – "e" from N to S).

	1	2	3	4	5	6	7	8
Cell index	Pre-fld. L, km	Post-fld. L, km	SHORT. value	Pre-FLD. DEPTH	Post-FLD. DEPTH	Recent DEPTH	MAGN. UPRIS.	Diff. Bas. Col.(6-4)
2b	16,1	11,1	31%	-16,7	-23,3	-18,8	5,5	-2,1
5d	13,2	4,4	67%	-16,1	-49,8	-26,6	22,6	-10,5
8d	12,7	9,8	23%	-10,75	-13,96	-7,95	6,01	2,80

calculated (Table, col. 6 = 5+7). The difference between initial post-sedimentation position of top of metamorphic basement and the recent position (Table, col. 8 = 6-4) are important parameters related to geodynamics. The values for these parameters are varying (Yakovlev, 2008): shortening are from -10 to 67, 35 % average; post-folded depths of basement are from -3.6 to -49.8, -21.9 km average; recent depths are from -2.2 to -31.7, -13.0 km average; magnitudes of mountain buildings (Fig. 1) are from 0.3 to 22.6, 9.8 km average; difference of depths (pre-folded and recent) are from -14.6 to +7.5, 0.0 km average.

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The identification of gravitational mechanism of Vorontsovsky nappe (south margin of North West Caucasus) based on stress and fold related strain study

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The Vorontsovsky nappe is located near town Sochi within the Abkhazskaya sub-platform tectonic zone to the south of the main linear folded structures of the North-West Caucasus. The Eocene age flysch deposits of the nappe of total thickness of about 1.3-1.5 km are argillites, aleurolites and marlstones mainly. There is monocline structure (azimuth 330-20°, dip 20-40°) near its frontal part. Autochthon flysch of Oligocene age consists of clays and aleurolites. The distance of the displacement from the root zone (Chvezhepsinskaya tectonic zone of the Caucasus) is about 10-15 km. Data on paleostress and on strain were collected in surface structures over the area of about 3 x 6 km between rivers Sochi and Mamaika and in the underground adit (Yakovlev et al., 2007).

Data of the fracture orientations, striations in slickensides and extension were used for the reconstruction of paleostress fields by several methods (Goustchenko, 1979; Yakovlev et al., 2007). About 250 measurements of these stress signs at 15 outcrops were collected. Local stress states and the common stress regime were reconstructed. The obtained maximum stress axis has a strike to south-west 225° and dip 20°. The minimum stress