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 axis (tension) was sub-vertical and middle stress axis has low dip (20°) to south-east. As a whole, this NE–SW stress-regime is in conformity with the regional stress field of the North-West Caucasus. Two mechanisms are possible: (1) lateral press (pure shearing, flattening) and (2) gravitational sliding (simple shearing).

Numerous asymmetrical folds in the adit near the detachment of the nappe were observed. Low-angle long southern flanks of synclines had sub-horizontal orientation (azimuth of 300°, dip 10-20°) and northern flanks of the synclines were sub-vertical or overturned. Axial surfaces of the folds were inclined at middle or small dip angles to the north-east. Several hinge lines were measured, which had average strikes of about NW 300° and dips of 10-30°. Such strikes are in agreement with main patterns of the stress regime. It means that fractures (stress regime) and folds (strain state) have the same origin. Two competing models were considered for the explanation of the strain state as sets of deformed objects. The model of lateral pushing can possess small shortening for low angle axial surfaces for initial stages of the process and the tendency of increasing of shortening values when the axial surfaces grow to verticals (Fig. 1, sign 1, attractor A). The model of the simple shearing in a flat horizontal zone was calculated for the deformation ellipse (37 values) with the same parameters: dip angles of axial surfaces Ax (orientation of the long axis of the ellipse) and shortening values Sh (lengths of short axes of the ellipse). The correlation coefficient for these two parameters of the model was -0.992. The regression equation (straight line, Fig. 1, attractor B) was obtained as Ax = 47.8 – 0.445*Sh.

Detailed photos were used for measuring of geometrical parameters of 39 folds. These parameters were (1) dip angles of fold axial surfaces, (2) dip angles of fold flanks, (3) thicknesses of competent layers in flanks (**t**), (4) and the thicknesses of the same layers in hinge of the folds (**T**). Dip angle of flank relatively to perpendicular to axial plane and the ratio "**t/T**" were used for the shortening value estimation according to the diagnostic diagram (Yakovlev, 2002). Estimated shortening values (Sh) were 2 % to 95 % (Sh = (L1-L0)*100/L0). The dip angles (Ax) for the axial surfaces were 1° to 57° to the north-east. The tendency of increasing shortening values (Sh) with increasing sloping of axial surfaces was (Ax) found. The correlation coefficient for these two parameters was about -0.895. The regression equation (straight line) was found as Ax = 65.5 – 0.610*Sh. Regression lines for the folds and for simple shearing models are very close.

The model of simple shearing near detachment of the Vorontsovky nappe is satisfactory for the explanation of its stress-regime and of the trend of strain state. The analysis of condition of sedimentation of Oligocene-Miocene flysch of Abkhazskaya zone shows that depth of basin was about 0.5-3 km. Process of folding in Chvezhepsinskaya tectonic zone has finished before earlier Miocene and this zone was hypsometrically above of surface of the sediments of Abkhazskaya zone during Oligocene-Miocene. Total tilting of 3-5 degrees of detachment may be the reason for displacement of the nappe body from north to the south at the earlier Miocene.

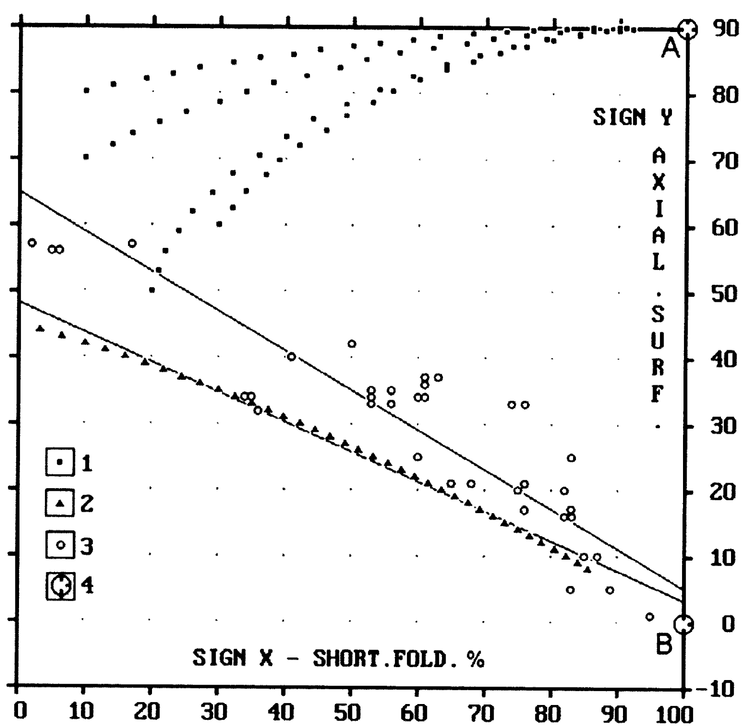

Fig. 1. Diagram for comparison of parameters of models with natural folds. Ordinate axis is dip angle of axial surface of fold; abscissa axis is shortening value in perpendicular direction to axial surface of fold. Regression lines for natural folds points and for model are shown. 1 – points of trend of lateral shortening model (4 cases), attractor A; 2 – points of trend of horizontal simple shearing model, attractor B; 3 – natural folds points; 4 – models attractors.

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Variations in deformation characteristics along the front of the Alpine-Carpathian wedge (Waschberg-Ždánice Unit, Austria-Czech Republic)

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The emplacement of the nappes of the Alpine-Carpathian orogenic wedge on top of the European continental margin includes complex deformation of both - the autochthonous European foreland and the thrust nappes. Seismic mapping in industrial 2D and 3D seismic datasets was focused on two main regions within the Waschberg-Zdanice Unit in Lower Austria at the transition zone between the Eastern Alps and the Carpathians. The two mapping areas are approximately 40 km apart. Main differences derive from the variation in the local stratigraphy and the topographic position of the Flysch nappes. The thrust front is laterally highly structured including duplexes, lateral ramps and inverted normal faults.

High stratigraphic resolution constrains the timing of activation of faults in the foreland and the allochthon very accurately for the time window between the Eggenburgian (20.5 Ma) and Lower Badenian stage (~ 16.0 Ma). Within this time interval we identify several distinct phases of foreland deformation, which probably are related to stress coupling across the floor thrust of the wedge, and deformation within the allochthon.

The seismic mapping and structural field data establish the following deformation features: (1) Deformation of the European foreland in front of the Waschberg-Zdanice fold-thrust units. Structures include the sinistral reactivation of Variscan strike-slip faults such as the Diendorf fault system, and extensional basins formed at releasing bends of such faults during the Eggenburgian (~ 20 Ma). (2) Inversion of Jurassic half-grabens in the European basement leading to folding of the overlying foreland basin strata. Inversion occurred in two distinct periods dated by Eggenburgian-Ottnangian (~ 18 Ma) and Karpatian (~17 Ma) growth strata. During the intervening period the fault was inactive. Karpatian inversion is characterized by blind thrusting and the formation of a growth trishear fold. (3) Out-of-sequence thrusting of surface-breaking faults cutting the growth strata panel in the backlimb of the growth trishear fold. The direction of Upper Karpatian (~ 16.5 Ma) fold-thrusting is very well constrained the 3D geometry of structures mapped in seismic and by numerous outcrop data including fault slip data from Karpatian sediments. Accordingly, thrusting was directed towards NW. Outcrop data, however, prove an overprinting event of NNE-directed fold-thrust shortening. (4) The termination of fold-thrusting is dated by the formation of extensional basins on top of the allochthon. Normal-slip reactivation of the former thrust faults led to the evolution of half-grabens and listric normal faults. Extension is dated by growth strata of Badenian to Pannonian age (~ 16.0 to 10 Ma). Outcrop and seismic data indicate that probably all of the listed deformations occurred contemporaneously with sinistral strike-slip faulting along NNE-to NE-striking wrench faults.