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Inclined zones of ductile simple shear in folded structures of the North-West Caucasus - comparison of natural data and model.

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Quantitative analysis of the geometry of folded structures. One of the methods for studying mechanisms of fold structure formation is analysis of geometry of the areas of folds with a homogeneous geometry in structural cross-sections. We call such areas domains. Their geometry can be characterized by three parameters, such as, the dip of axial planes AX, the dip of folds enlelope plane EN, and the value of fold shortening in the direction of the perpendicular to axial planes SH. Domains can be distinguished in natural cross-sections, as well as in experimental model ones [Yakovlev, 1987]. The representation of parameter measurements on scattering diagrams (AX-EN, AX-SH, EN-SH) allows us to distinguish model structures of different genesis by characteristic ranges of point spreading. Application of these diagrams for comparing sets of measurements of natural structures with model ones allows us to make assumptions about the origin of the natural structures [Yakovlev, 2001] within the scale of the whole folded sedimentary cover. Studying of structures of the Great Caucasus has shown that the domain geometry can be stipulated by the "general bending" mechanisms, forming particular anticlinoria and synclinoria, as well as with "local" mechanisms. The geometry of domains for "general bending" mechanisms may be combinations of 1) AX with the dip to the south + EN with the dip to the north and 2) AX with the dip to the north + EN with the dip to the south. The domains formed by "local" mecanisms are mainly developing near large thrust [Yakovlev, 2001]. This "near-thrust geometry" may has combinations 3) AX with dip to the south + EN with dip to the south and 4)

AX with dip to the north + EN with dip to the north.

Domains of shear zones into Alpine folded structure of the North-West Caucasus. For the structure of the North-West Caucasus, paleo-stresses fields [Saintot, Angelier, 2002] are well studied by using the fault slip data sets analysis. To study deformation fields by data on plicative structures of the North-West Caucasus, 12 structural cross-sections [Giorgobiani, Zakaraya, 1989; Sholpo et.al., 1993] were studied, for which 250 domains were distinguished and its geometry parameters were measured. The width of the domains transversely to the strike was 300 m to 1 km mainly and to 2-3 km, depending on the homogeneity of the structure and on the size of the folds. During measurements of the dip angles of the planes, horizontal north direction was taken as 0. The largest part of the domains possessed normal "bending" geometry, only 59 domains (with "near-thrust geometry") were characterized by the southern vergency (combination 4 - AX has a dip of 90 to 150 and EN has a dip of 0 to -50, i.e. dip to the north) and 20 domains had the northern vergency (AX has a dip of 30 to 90 and EN has a dip of 0 to +50, i.e., dip to the south). Comparing the angle between the axial plane and the folds envelope plane (AX-EN) with the fold shortening value SH=(L1/L0) in the direction, perpendicular to the axial plane, we found a good correlation: the angle increased with the increase of the shortening value. Performing the averaging for each interval for the value SH (0,1-0,2; 0,2-0,3 and so on), we found that its value is about -0,935 (Table 1, [Yakovlev, 2003]). Table 1 Averaged data of folded domains geometry for different rank of shortening. AX EN AX-EN SH N domains 120 -22 142 0,18 1 107 -38 145 0,25 7 102 -39 136 0,35 3 106 -31 137 0,44 13 100 -31 131 0,53 12 101 -27 128 0,64 13 97 -34 131 0,74 9 99 -20 119 0,87 1 100 Choice of the model for the explanation of the natural data. An assumption was stated that these empirical data relate to a real natural process of the formation of an inclined zone of plastic (not brittle) deformation, in which, according to the thrust type, a simple shear is combined with a horizontal flattening during its development. For such zone, two variants are resonable and are possible: A) with the dip of zone, parallel to layering (kind of sediments formation duplex) and B) with the dip of zone of 45 degrees, along the direction of the maximum tangential shearing. Calculations were performed, and it was obtained that the initial location of the domain (AX=99, EN=-20, SH=0,87) experienced changes of the geometry (deformations) with various combinations of simple shear increments and flattening within the frameworks of model A and model B. It was found that the geometry change most close to the natural process corresponds to the model with the initial angle of dip of plastic shear zone of 45o and increments of 1% of flattening and 6o of simple shearing. In this case, at the stage of the process development corresponding to the situation AX=107, EN=-38, SH=0,25 the accumulated deformations can be estimated as SH=(L1/L0)=0,75, and the shear of 71o. At the same time, the inclination of the zone increased from 45 to 60 degrees. This modelled domain geometry

has parameters AX=109, EN=-41, SH=0,275. Localization of "near-thrust-geometry" domains within the structure of the North-West Caucasus. Analysis of the distribution of the domains over the area, take into consideration for the data of geological maps and of faults parameters, has shown a substantial difference of the structure to the west and to the east of the meridian of Tuapse city. In the eastern part, zones, parallel to the whole structure of the Caucasus and to the main thrusts, are distinguished. These zones possess southern vergency in the southern part of the structure and the northern vergency in the northern part of the structure. In the western half of the North-West Caucasus, five diagonal zones are distinguished, which form two rhomb-type figures [Yakovlev, 2003]. Three zones possess the northern vergency, and another two - the southern vergency. The presence of such zones can give explanations to some features of the structure of the North-West Caucasus. In particular, the counter vergency of two of five parallel zones in the northern part of the west half of the structure can explain the exits of the most old Middle-Jurassic rock outcrops, located out of the geometrical axis of the whole structure. It should be mentioned that rhomb-shape figures, bounded by zones of inclined plastic shearing, partially define the configuration of the mountain building of the North-West Caucasus. In the eastern part of the structure, we should expect purely thrust style of deformation, and in the western part, extension along the stricke of the whole structure of the North-West Caucasus should exist. Such situation of extension was fixed earlier, based on the fault slip data sets study, as one of the the stress state regime, to the west of the Tuapse meridian [Saintot, Angelier, 2002].

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