ISSN 0145-8752, Moscow University Geology Bulletin, 2007, Vol. 62, No. 4, pp. 220–228. © Allerton Press, Inc., 2007.
Original Russian Text © M.A. Goncharov, N.S. Frolova, P.N. Rozhin, N.N. Selezneva, 2007, published in Vestnik Moskovskogo Universiteta. Geologiya, 2007, No. 4, pp. 12–19.

The Problem of Revealing the Absolute Kinematics of the Opposite Walls of Faults

M. A. Goncharov, N. S. Frolova, P. N. Rozhin, and N. N. Selezneva

Received November 21, 2006

Abstract—The existing kinematic classification of disjunctive dislocations takes into account only the relative displacements of their walls along the displacement surface in opposite directions. The topic of their absolute displacement has not yet been worked out, either in structural geology or in tectonophysics. As a result of analyzing various structural features, unconventional and often unexpected versions of their absolute displacements were worked out: the displacement of one wall along the displacement surface with an immovable second wall; displacement of both walls along the displacement surface in different (but not opposite) directions; displacement of one or both walls not along the displacement surface. It is imperative to concentrate one's attention on the geological bodies themselves, and not on the fault boundaries between them, for thorough understanding of the faulting kinematics.

DOI: 10.3103/S0145875207040023

INTRODUCTION

The existing kinematic classification of fault dislocations takes into consideration only the *relative* displacement of its walls. Therefore, the terms "overthrust" and "underthrust," similar to "normal fault" and "exsert" are often generally accepted as *synonyms*. At the same time, various scenarios of the orientation and *absolute* displacement of any wall of each wall are possible, but this problem has not been worked out, either in structural geology or in tectonophysics.

The study target was to show that very different and often unexpected versions of *absolute* displacements are concealed behind the conventional *relative* displacements of the neighboring walls of faults.

Let us begin with the simplest case. In the center of Fig. 1 a normal fault is shown just in the same manner as it is usually presented to students in courses of structural geology ("the hanging wall is downthrown, and the footwall is upthrown"). Another four versions of its opposite wall displacement are shown in four other figures, which lead to a similar structural result. Yet, it is assumed in all these five cases that, first, the displacement of walls takes place only along the displacement surface and, second, it proceeds parallel to a single straight line within this surface.

We will show below that the last two admissions are not necessary, and that neither version is achievable in any of the five versions of actual normal faults.

Faults with Walls Displaced Parallel to One Straight Line in the Displacement Plane

Revelation of the absolute displacement of any wall of a fault is possible only when the termination of a fault and its vicinities are accessible for examination. In this case, an *absolute* displacement can be measured relative to the termination of the *immovable* termination of the fault. We present as an example a small fault cutting a limestone bed (Fig. 2). A characteristic paragenesis of structural features at its terminations shows the motions of both walls of the fault, since stylolitic sutures originated at the fronts of both walls under compression conditions and owing to a mechanism of dissolution under pressure. The dissolved material precipitated nearby in the back portions of the neighboring walls of the fault, where tension cracks formed under tension conditions and absorbed this material.

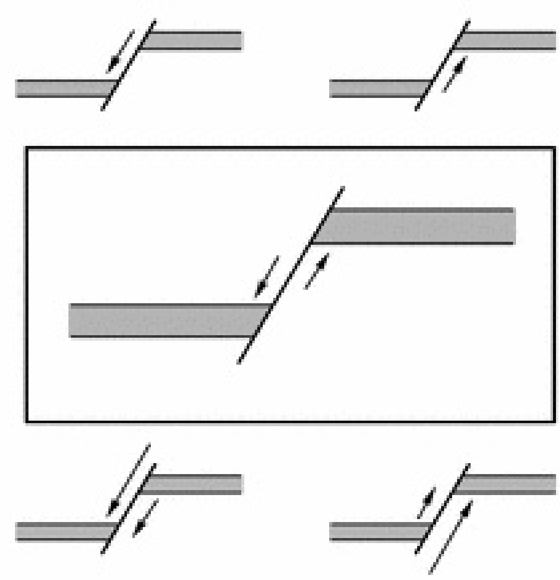

Fig. 1. Five different versions of absolute displacement of opposite fault walls. Central plate shows the traditional version. The arrow lengths are proportional to the displacement values. The term exsert is applied for designating the type of fault shown at right top and bottom.

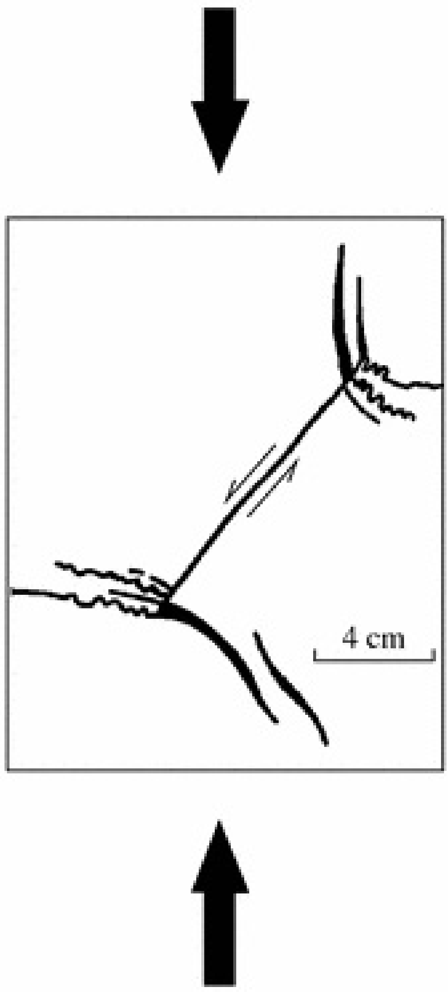

Fig. 2. Typical structural paragenesis (combination of sinuous stylolitic sutures and more even tension cracks) at both terminations of a small shear fault cutting a limestone bed and formed in a single compressional stress field. It is shown by large arrows, which indicate activity in both fault walls (see the text for explanations), modified after [8].

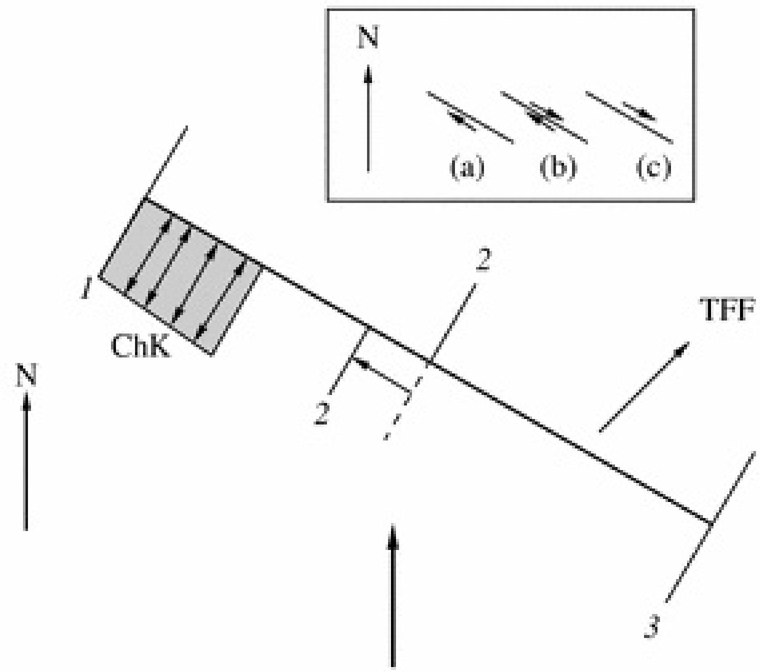

Fig. 3. Strike-slip fault, at whose terminations the amplitude comes to naught (dikes *1* and *3* are not displaced). Only the southwestern wall experienced displacement (toward northwest), which was registered due to displacement of dike *2*. Folding occurs at the front of the wall due to horizontal compression. This scheme is the simplest model of the Talas–Fergana Fault (TFF). The TFF functions under the N–S-oriented compression caused by northward impact from the Hindustan indenter (large arrow). For this reason, only the southwestern wall of the fault is active. The Talas–Fergana Fault is believed to be a right-lateral strike-slip fault (b); but only its southwestern northwestward-moving wall was active, and its northeastern wall was passive. Therefore, its imaging in maps with *only one* arrow is correct only in case (a). In case (c) it is incorrect and distorts the real kinematics of the strike-slip motion. ChK is Chatkal–Kurama system of neotectonic uplifts and basins.

Faults with Only One Wall Displaced Along the Fault Plane

A considerably larger Talas–Fergana fault, which is a right-lateral strike-slip megafault, shows a different pattern (Fig. 3). The Chatkal–Kurama system of recent uplifts and basins originated on its southwestern wall near its northwestern termination under conditions of horizontal compression, which was caused by a decrease in the northwestward displacement amplitude of this wall (down to zero at the fault's termination). The *activity* in the southwestern wall of the fault upon relatively *passive* motions of the opposing northeastern wall was caused, most likely, by active northward propagation of the Hindustan indenter (see Goncharov et al. [6], Chs. 1 and 4).

The northeastern termination of the Altyn Tagh strike-slip fault at the southern border of the Tarim Basin is rather remarkable (Fig. 4). The strike-slip fault dies out as the absolute northeastward displacement of the southeastern wall is compensated by overthrusts and the fault horsetails. It is remarkable that the trends of these overthrusts, and of uplifts parallel to them, deviate from the purely normal relative to the strike of the strike-slip fault shown in Fig. 3. This deviation can be explained by the fact that the *regional* roughly N–S-oriented stress, which is shown by a large arrow in Fig. 3, also influences the idealized *local* strained state as it is shown in Fig. 3.

However, contrary to strike-slip faults, wall displacements down the dip (and updip) of the fault planes are typical of overthrusts and underthrusts as well as of normal faults and exserts. Therefore, their terminations in *vertical sections* are either concealed at inaccessible depths or eroded. (Their terminations in a horizontal section are recorded but they are little informative in the aspect discussed here). That is why additional data are necessary for determining the orientation of the absolute displacement of the walls of such faults.

Overthrusting and Underthrusting

How can we distinguish overthrusting from underthrusting? We can tell the difference between them, if we take into consideration the *rank of the geodynamic*