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Shear fracture strength of faults: Relation between fault-strikes and displacement vector fields (II)

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INTRODUCTION: Shear fracture strength of faults is very important and essential for discussing the earthquake generation and the driving force of the crust. Results of some stress measurements at sites close to faults suggest that the strength of faults is very small. A model of fault zones proposed on the basis of the results suggests that the strength is about 10 MPa in the upper crust. This implies that faults are 'weak'.

In order to confirm 'weak faults' to be a general property of faults, the relation of the direction between fault-strikes and displacements is investigated in this study for major faults and the earthquakes that have occurred in northeastern Honshu for the period from Jan. 1997 to Dec. 2007.

THEORY: The followings are assumed for the present investigation:

1) Stress field is uniform each small part of the crust.

2) The displacement direction does not vary with depth.

3) Shear fracture strength is negligibly small for every fault.

4) The coordinate shift of a GPS station in GRS80 system represents the displacement of the station in the absolute coordinate system.

There are no shear stresses on the fault planes on the assumption (3). Thus, a fault surface is parallel to a principal plane of the uniform stress field. If we adopt a displacement field where displacement directions are parallel to one of the principal axes of stress in order to produce a uniform stress field, fault planes are parallel or perpendicular to the displacement direction. It is derived from the assumption (2) that the strike is parallel or perpendicular to the displacement direction.

Headquarters for Earthquake Research Promotion has reported the properties of 19 major active faults in northeastern Honshu. GSI opens the coordinate shifts of GPS stations to public. JMA and NIED release the data of earthquake focal mechanisms. These data are employed for this study. Here, two fault strikes are estimated from a focal mechanism solution of an earthquake. From these two strikes, 4 possible directions of displacement are obtained. From them, we chose two directions that are relatively consistent with the displacement direction for the comparison.

RESULTS: The strike direction is consistent with the displacement direction in the period of 1997 to 2007 within a difference of about 20 degree for 12 among 19 major faults. The difference is larger than 30 degree for 3 faults, Oritsume, Kitamami-teiti seien (partly consistent), Futaba faults or fault zones. The others are Noshiro, Kita-Yuri, Tsukioka faults or zones and Kushigata mountain range faults.

Except for northern and central Miyagi Pref., at least one of the strike directions of CMT is consistent with the displacement direction around the epicenter within the difference of about 15 degree for the earthquakes of M larger than 4.5. For northern and central Miyagi Pref. where large earthquakes of their magnitudes about 6.0 have occurred, displacement direction ranges from N210E to N230E in degree. The 10 of 11 earthquakes of M larger than 4.0 have the strikes consistent with the displacement directions ranging from N200E to N240E in the solutions of P initial motion and/or CMT.

CONCLUSION: Although there remain some problems to be studied, the strike of a fault is found to be nearly parallel or perpendicular to the displacement direction. Yabe et al. (in preparation) have measured stresses and compiled the stress data in this district. The principal directions for the stresses have been obtained at 10 sites by DRA. Except for two sites, the difference of the principal direction from the displacement direction is smaller than 20 degree. From this, it is reasonable to consider that the stress field is produced by the assumed displacement field. Therefore, the present results support the concept of 'weak faults' at least for the faults of which length is larger than about 3 km.