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The Bellows Structure of Japan

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There are a number of statements how a word "fold" shall be used. But the writer has a desire to propose another definition that, a fold is non-affine deformation of rocks as a mass in scale of geology. In this connection, it is clear that even massive, igneous rocks may take parts of folds. Stratified rocks, however, only make visual folds and their anisotropic nature gives much help to give external rotation to themselves, which result is nothing but folding. The common folds, in this narrow sense are chiefly of the buckle type in addition to a more or less amount of shears on planes oblique to the bedding.

As a result of attention payed on the palaeozoic area around Kyoto, by a number of workers of this University, especially S. Nakamura, and S. Matsushita, we are able to make a general view of an isoclinal structure which is the final phase of buckle folds. This remarkable feature in structure of the older sedimentary rocks gives a statistical anisotropy of the mass of land. Every fold is closed. There is no sign of a folding process after the closure. The broken anisotropic mass which detail makes picture of a regular crossing fault system was the last outcome of further stress in operation. Another effect of the same stress after the folding process has come to the stop were low angle thrusts which general strike is parallel to the general anisotropy, bisecting the angle between the regular crossing directions of the fault system. The relation is clearly mapped by Matsushita.

The same pattern of structure as the Kyoto Palaeozoic area is common all the way through the older sedimentary rocks of Japan. We see it with the thick sedimentary rocks of the outer zone or Pacific side of West Japan. In Shizuoka-ken, the Palaeogenic Setogawa system gives another good example of this final stage of buckle folds. The Ooigawa group, which has been shown as early Miocene in geologic age, has a similar structure as well. Most of the folds in the middle Miocene Kurami group are not closed, while the later Miocene to

Pliocene formations in Shizuoka-ken have another type of structure which is much more simple representing an early stage of folding. The greater parts though tilted are not folded, but for a few anticlines, which are stretched on some distance away from the inner boundary of the sedimentary zone. It is not necessary to give an account here in detail on structures of other place outside Shizuoka-ken, except that the sedimentary rocks are taken into positions like that of Shizuoka. The writer has given the name "geomonocline" to the sedimentary outer zone of Japan. The special structure of the Pacific slope under discussion is the special mark of the geomonocline.

With the observation made on the sedimentary groups of Shizuoka-ken, we may put forward an idea that the development of isoclinal bellows-like folds is started from only one simple fold which full growth is seen in a closed condition. The Pleistocene open anticline of Kunô near Shizuoka City is a good example of the first step in development. If the stress is still in operation after the complete closing of the first anticline, one or two other upfolds will make their appearances close to the first one. These second anticlines will be closed later in their full development as well as the first. Then births of later folds may be given step by step, till all the area makes the isoclinal structure.

The axial planes of the isoclinal folds are mostly sloping to the opposite side of the Pacific deep; that is to say north to north-west dips. Naturally the south limbs are hanging and this side is the very part where stronger shearing stress is in action. For this reason, high angle overthrusts are common on this side, and these are making another special mark of the geomonoclinal structure.

The development is evidently shown by the well-known experiment of Willis. If every bed is regularly thick, made of parts all the same material, and is perfectly homogeneous, it may take a form of wave-like sine curve by a certain compression as proved by Smoluchowsky. All the waves make their starts at the same time, and have their growth at equal rate. Such a bed has existence only in ideas. Natural cases are not simple, but the development form may probably be not very different from the Willis' test.

It will be noted that the orogenic movement was in operation through all the times from very early Tertiary age till the present days, and that any special orogenic event did not happen while these times. But young formation, which are not in full development of the bellows folding, show an apparent tectonic episode which took place

on some occasions between their sedimentation intervals. For example, a monoclinal flexure of the Kakegawa group (Pliocene, in Shizuoka-ken) is unconformably covered by the Soga formation (the late Pliocene) which does not show any effect of the flexure. The unconformity between these two formations, however, is not maked out very well at other places in the same area. In this way, it may be that the special times of movement in geologic history are not able to be seen in the Pacific orogenic zone excepting with very young strata.

As has been given the statement, the crossing faults in parallel to two directions which make equal angles with the general strike of the isoclinal axes are after effects of the same stress caused the folds. On the other hand, the low angle thrusts that are not general, even in the north inside area including the Kyoto area, are scarce in the south zone or the Pacific geomonocline. In the outer zone of this country, the closed bellows structure inclined north is the last stage of orogenic movement making an interesting contrast with the alpine overfold.

The Alps structure was started from a symmetrical geosyncline, which was "compressed by the two edges of vice", using the words of Collet, while the geomonocline of Japan was effected by a couple of forces acting in different levels: the high one from the north-west continent side and the low one from the south-east ocean basin side. We have but little amount of limestone on the islands. The last two facts may not be overlooked in comparing the bellows structure and the overfolded nappes.

A well-marked shear zone between the inner land and the outer geomonocline is called the median zone of Japan. The fault zone is much like the San Andreas fault of California. Some authors regard it to be a reverse fault while others are supporting the normal fault theory. There are a number of interesting question about this zone. We have but little knowledge about the real compulsion of the fault. The writer has made an investigation into the fabric analysis of a mylonite in the sheared granite of this zone. The details will be given in another paper, but the result is, in short, that the horizontal component of the a-axis is greater than the others. For this reason, it may be said that the fault at least going with the mylonite is a tear fault.

The above lines are mentioned as an abstract of the presidental address delivered in Kyoto at the annual meeting of the Geological Society of Japan, May, 1947.