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The East-to-West Trend Tensile Quantity and Tensile Rate of the Lithosphere in Kilju-Myongchon Basin

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Abstract We calculated the tensile quantity and tensile rate of the lithosphere of Kilju-Myongchon basin, Cenozoic rift basin of our country. That is since the middle Miocene, after the NamSok Formation is deposited, the East-to-West trend tensile quantity in Kilju-Myongchon basin is approximately 0.9～1.5km. And the tensile quantity of the plane typical non-rotational fault masses is lots bigger than the tensile quantity of the plane typical rotational fault masses. And Kilju-Mongchon basin is an asymmetrical rift basin that tensile action of the lithosphere is more active in the east of the basin. In the western basin consisted of the plane typical rotational fault masses, tensile rate of the lithosphere is lots smaller than the other tensile rate of the lithosphere of the eastern basin consisted of the plane typical non-rotational fault masses.

Key words Kilju-Myongchon basin, tensile quantity, rift basin

Introduction

The great leader Comrade **Kim Il Sung** said as follows.

“**Intensifying geological prospecting is of great significance in developing the national economy. Economic construction is a struggle to exploit nature, and geological prospecting is its first process.**”(“**KIM IL SUNG** WORKS” Vol. 39 P. 271)

It is very important to calculate the tensile quantity of sedimentation basin that was formed and evolved by tensile tectonic movement in geological structure solution and oil-gas exploration of localities concerned [1－4]. Kilju-Myongchon basin is one of Cenozoic Tertiary, which is located in the northeastern of our country.

It is joined with Kwanmo block, Hyesan-Riwon basin by bordering with Kyongsong-Kilju fault on the west, and joined with the East Sea of Korea on the north and east direction. The east and west part is high, and the middle part is low. Kilju-Myongchon basin is the foreland basin formed on the craton.

Kilju-Myongchon basin is laid to north-northeastern. Kilju-Myongchon basin is divided into two blocks by Kilju-Myongchon fault. West block is called as Orangchon basin and east block is called as Chilbosan horst.

The basement rock is pararocks and effusive rocks in Machonryong group. Depositional sequence consists of lower, middle, upper layer, and the dips are below 30°.

1. General Characteristics of the Basin

In this paper, we calculated the tensile quantity and tensile rate of the lithosphere in the part excepting the east part of Kilju-Myongchon fault, that is, the part between Kyongsong-Kilju fault and Kilju-Myongchon fault (Orangchon subsidence zone). Kilju-Myongchon basin is a long basin northeastern-southwestern, including some part of North Hamgyong Province, the north of the basin is extended to Kyongsong bay and the south is extended to the sea of Kimchaek.

The gross area of the basin is more than about 2 300km^2. Among them, the land area is 1 300km^2 and the area extended to sea is expected more than 1 000km^2(Fig. 1).

In Kilju-Myongchon basin, some exploration geophysics as well as gravity prospecting, magnetic prospecting, analog seismic soundings were advanced in 1968～1972. In addition, some drilling explorations were advanced for coal, geothermy and oil detection, then several tens oil detection drill holes were digged. Thus, the scale, sequence and geological structure features of the basin were generally explained.

The bedrocks of Kilju-Myongchon basin consists of the rocks of paleoproterozoic Machonryong group Pukdaechen formation in west, Danchon complex granite in east. The sedimentary beds of Kilju-Myongchon basin consists of continental deposits, marine deposits and an effusive rocks of Neocene, total thickness is more than 3 200m.

Kilju-Myongchon basin is a rift basin that is asymmetry syncline in structure, is deeper in east.

The basin is divided with 6 sag areas and 4 up warping regions, they are combined with fault zones, the intensity and amplitude of the sinking varies with the locality.

The faults formed during the Tertiary period of Kilju-Myongchon basin are normal north-eastern or northwestern trending faults, the folds include some various types as well as linear anticlines in the center of the basin, the fold structure formed by normal faults, dome anticlines formed by base elevate.

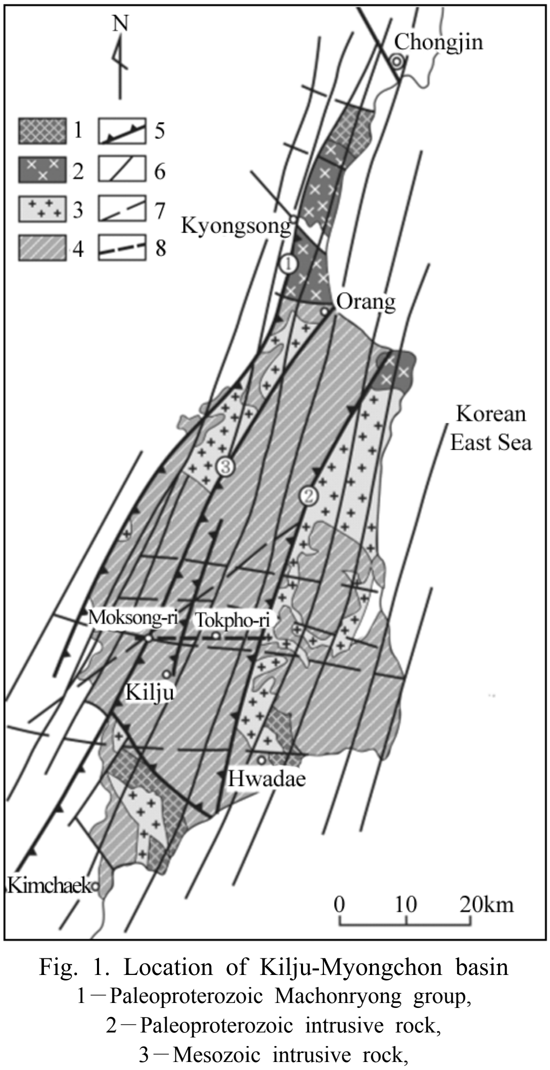

Fig. 1. Location of Kilju-Myongchon basin
1－Paleoproterozoic Machonryong group, 2－Paleoproterozoic intrusive rock, 3－Mesozoic intrusive rock, 4－Miocene-Pliocene sedimentary bed, 5－Deep fault, 6－Fault, 7－Space photograph lineation, 8－Location of section; ①－Kyongsong-Kilju fault, ②－Kilju－Myongchon fault, ③－Onchon fault

2. Tensile Quantity and Tensile Rate of the Lithosphere Account

We calculated the east to west trend tensile quantity and tensile rate of the lithosphere of Kilju-Myongchon basin after the middle Miocene under the condition that the area of the section is no change before and after deformation. Here, tensile quantity is the longitudinal length of tensile structure consisted with normal faults (or fault mass) is increased by horizontal tensile action; the tensile rate of the lithosphere is the specific value of originally length to increased length [1].

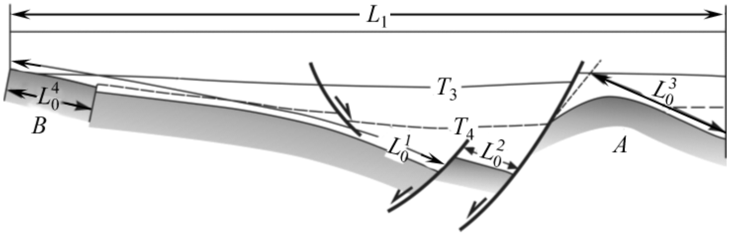

Fig. 2. A method of measurement on longitudinal length of bed
L_0 —Horizontal length of basin base, L_0^i —Length of base plane of fault block, T_i —Boundary surface of layer, A—Length compensation about denuded basin base, B—Length compensation about thinned out bed

In the tensile structure without clear deformation(or plastic deformation) at the inner of the fault mass, we can assume that the longitudinal length of the basin base is constancy during deformation, thus we can get the tensile quantity E by measuring the longitudinal length L_0 of the basin base and longitudinal length L_1 of the section [1, 2].

In Kilju-Myongchon basin, the fault plane was retreated by stratigraphic erosional and basin base was elevated and denuded by fault mass movements, so we revised the length with regard to that when we measured the length of L_0^i (Fig. 2).

In this way, we regarded the longitudinal length of Namsok formation in late low Miocene sedimentary cover of Kilju-Myongchon basin as the initial length and calculated the east to west trend tensile quantity of the subsequent period. When measuring the length of the sedimentary cover, we added the length of the lower bed to the length of the sedimentary cover at the thinning of the sedimentary cover. For example, at B of Fig. 2, from the thinning of the T_4 boundary, we revised the length of T_4 boundary as well as L_0^4.

As you can see at the east-west trend section of Kilju-Myongchon basin, the basin has no plow typical normal fault masses and consisted with plane typical non-rotational normal fault masses and plane typical rotational normal fault masses (Fig. 3). Where, plane typical non-rotational normal fault mass is the fault mass that the fault surface is plane without rotation of fault mass, plane typical rotational normal fault masses is the fault mass that the fault surface is plane with rotation of fault mass. The plow typical normal fault mass is a fault mass with plow typical fault surface.

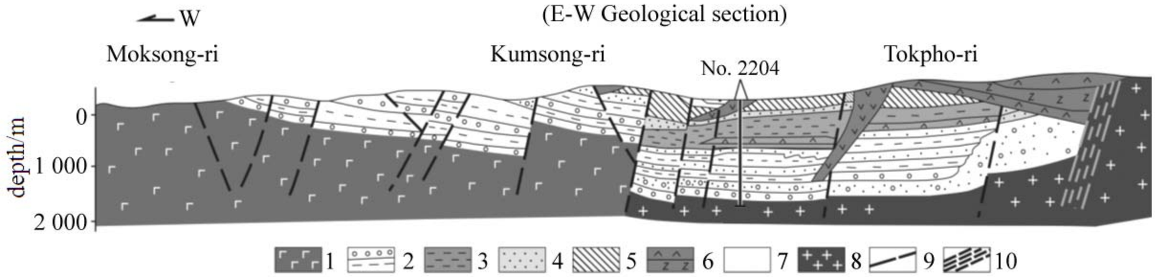

Fig. 3. East-West trend geological section of Kilju-Myongchon basin
1－Namsok formation, 2－Phyongryuk formation, 3－Hamjin formation, 4－Kumso formation,
5－Kocham-Kidong formation, 6－Chilbosan formation, 7－Quarternary stratum,
8－Mesozoic granite, 9－fault, 10－fault zone

Western part of the section is consisted with the plane typical rotational normal fault masses and eastern part of the section is consisted with the plane typical non-rotational normal fault masses.

The EW trend section passed Moksongri, Kumsongri, Tokpori, is placed at the area that the beds are generally developed in Kilju-Myongchon basin, the section was studied in details by exploration geophysics and exploratory excavation, so we can see that the tensile quantity calculated with this section represents the tensile quantity of the basin.

The east-to-west trend tensile quantity of the after Namsok formation is as follows;

In the horizontal plane typical non-rotational normal fault masses, horizontal transfer quantity(h) of fault is equal to their tensile quantity(E), the relation with the horizontal transfer quantity(h) and vertical migration quantity(t), slop migration quantity(d), dip of fault(φ) of a fault is as follows;

$$h = d \cdot \cos\varphi = t \cdot \cot\varphi \tag{1}$$

In equation 1, if we know only two among h, t, d, φ, we can get the other.

The eastern section (about 11.43km width) is a greben-horst system consisting of several typical non-rotational normal faults, so if we calculate each horizontal transfer quantity (h_i) and add them, we can get the tensile quantity.

That is, the tensile quantity; $E = \sum_{i=1}^{n} h_i = 0.57(\text{km})$

the tensile rate of the lithosphere; $e = \left[\sum_{i=1}^{n} h_i \Big/ \left(L_1 - \sum_{i=1}^{n} h_i \right) \right] \times 100 = 5.25(\%)$

In this equation, L_1 is the length of the section, e is tensile rate, $\sum_{i=1}^{n} h_i$ is a sum of each horizontal transfer quantity.

The western part(about 12km width) is a half graben system consisting of several plane typical rotational normal faults with same direction of dip, so we can get the total tensile quantity by the method that calculate the tensile quantity of each half grabens and add them. This is, the arithmetical mean of the tensile rate is soon total tensile quantity.

In the plane typical non-rotational normal fault mass, the rotation angle(the dip of basin base on the section) of the fault masses are average $\theta = 6^\circ$, dip of fault is $\varphi = 75^\circ$, $(\theta + \varphi) < 90^\circ$, thus tensile rate of the lithosphere is $e = \left[\dfrac{\sin(\varphi + \theta)}{\sin\varphi} - 1 \right] = 2.25(\%)$, the width of half graben system is $L_1 = 12(\text{km})$, so the tensile quantity of the basin is $E = L_1 \left[1 - \dfrac{\sin\varphi}{\sin(\varphi + \theta)} \right] = 0.26(\text{km})$.

Therefore, in total section, east-to-west trend tensile quantity is about 0.83km and tensile rate of the lithosphere is 5.25% in eastern, 2.25% in western.

On this section, the east-west width of Kilju-Myongchon basin is about 27km and the width of the section used to calculate is about 23km, so about 4km is remained. This remained interval belongs to western basin, is consisted mainly plane typical non-rotational fault masses, as considering that and the activity characters of the west boundary fault of the basin, Kyongsong-Kilju fault, east-west trend tensile quantity of Kilju-Myongchon basin is about 0.9～1.5km.

The result of the calculation shows that the tensile quantity of the plane typical non-rotational fault masses is much bigger than the tensile quantity of the plane typical rotational fault masses. In the western basin consisted of the plane typical rotational fault masses, tensile rate of the lithosphere is 2.25%, this is much smaller than the other tensile rate of the lithosphere 5.25% of the eastern basin consisting of the plane typical non-rotational fault masses. Thus, Kilju-Myongchon basin is an asymmetrical rift basin of which crust tensile action was more actively progressed in east part of the basin.

Conclusion

1) Since the middle Miocene, after the NamSok Formation is deposited, the East-to-West trend tensile quantity in Kilju-Mongchon basin is approximately 0.9～1.5km.

2) The tensile quantity of the plane typical non-rotational fault masses is much bigger than the tensile quantity of the plane typical rotational fault masses.

3) Kilju-Mongchon basin is an asymmetrical rift basin of which tensile action of the lithosphere is more actively progressed in the east of the basin. In the western basin consisting of the plane typical rotational fault masses, tensile rate of the lithosphere is much smaller than the other tensile rate of the lithosphere of the eastern basin consisting of the plane typical non-rotational fault masses.

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