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Sinistral displacement along the northern extension of the Tancheng-Lujiang fault zone and compression along the northern border zone of the Sino-Korean platform

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Abstract: Within the eastern segment of northern border zone of the Sino-Korean platform, eastern Liaoning province and southwestern Jilin province, eastern China, there are many left-lateral wrench faults trending NE and compression structures trending NW. One of the main wrench faults is the Mishan-Fushun fault zone which is the northern extension of the Tancheng-Lujiang fault zone. It was formed since Indo-Sinian Stage and its large scale left-lateral horizontal movement lasted to the Early-Middle Mesozoic. Thrust and nappe structures are found mainly on southeastern side of the Mishan-Fushun fault zone; Their history can be traced back to Caledonian orogeny. In the Early-Middle Mesozoic, the wrench fault zone and the compression structures controlled the tectonic development of this region.

The Mishan-Fushun fault zone left-laterally dislocated the Sino-Korean platform, the Caledonian fold belt and the Variscan fold belt: Distances of separation are about 129–159 km. Compression within the northern border fault zone of the Sino-Korean platform led to intense shortening of the crust by 50.2–75.2%. A model showing the crust subduction is proposed in the paper, which shows basement decoupling and slipping-napping in the platform, A-type subduction along the northern border of the platform and imbrication within the fold region. There are several large molasse basins behind the subduction zone, and large amount of transitional crust-syntectic type granitic rocks in front of the subduction zone.

On the basis of correlating the regional geology and analysing the different scale of structures, the author discusses the genetic relationship between the wrench fault zone and the nappe structures of this region and their tectonics evolution during the period from Indo-Sinian to Early Yenshanian Stages.

Activity and earthquakes within the studied area are also studied.

INTRODUCTION

Wrench fault and nappe structure are two basic structures produced by horizontal movement of crust. There is a close relation in their origin. In this respect, one vivid example is put forward in the eastern segment of the northern border zone of the Sino-Korean platform of eastern China.

MACROSCOPIC STRUCTURAL FEATURES OF SEPARATION AND DEFORMATION WITHIN THE RESEARCH AREA

The research area spans the Sino-Korean platform and Jilin-Heilongjiang fold system. It is located between Songliao basin and the Sea of Japan (Fig. 1).

The northern extension of the Tancheng-Lujiang fault zone (Xu, 1980), i.e. the Mishan-Fushun or Mi-Fu fault zone and the northern border fault zone of the Sino-Korean platform compose main tectonics framework in the area.

The Mi-Fu fault zone was described by some geologists (Dong and Wu, 1982; Xu, 1985; Xu *et al.* 1987; Wang, 1986 and others). There are some different ideas about the character of the fault zone (Yao, 1987, 1988).

The Mi-Fu fault zone which strikes from NE to ENE contains one or two major faults. The fault planes are generally subvertical (the inclination are or SE. There are many oblique striae on the fault planes, and brittle-ductile tectonites are developed within the fault zone. On both sides of the Mi-Fu fault zone, there are a series of associated faults, e.g. the Yilan-Yitong fault, the Mingyue-Jian fault (the northern extension of the Yalujiang-

Qingdao fault zone, see Fig. 1). The deformation and ages of these faults are all similar.

On the northwestern side of the Mi-Fu fault zone, the northern border fault zone is represented by the Sipingjie fold-thrust zone which developed in the Early Paleozoic geological body. Possibly, it formed in the Caledonian Stage and was subjected to shearing by the Mi-Fu fault zone. On the southeastern side of the Mi-Fu fault zone, the northern border fault zone is composed of Laoniugou-Jiapigou fault, Qingchaguang-Baishuitan fault and Fuerhe-Gudonghe fault. They affected all rocks from Archeozoic to Jurassic. These faults express characteristics of intense compression.

Horizontal displacement of the Mi-Fu fault zone

The Mi-Fu fault zone displaced sinistrally three tectonics units: the Sino-Korean platform, the Caledonian fold belt and the Variscan fold belt. Their corresponding parts on both sides of the fault zone are marked by AA', BB' and CC'. Separation distances are respectively 159, 156 and 129 km (Fig. 2).

With the help of analysing some characteristics of the Mi-Fu fault zone, it is certain that the early geological bodies and their petrofacies on both sides of the Mi-Fu fault zone may contrast with each other, but the contrasted details are of different namely:

1. The width of the Caledonian fold belt is 114 km on the NW side of the fault but 34.5 km only on the SE side.
2. The Upper Paleozoic on the NW side is much more widespread than that on the SE side.
3. Qingyuan (NW side of the fault zone) and Longgang (SE side of the fault zone) uplifts did not belong to the same mass before they were dislocated (Liu *et al.*, 1984), Xu (1981, 1985) and Yang (1983) suggested that the tectostrata of the platform on the SE side of the Mi-Fu fault zone are similar to the tectostrata in western Shandong on the west side of the Tancheng-Lujiang fault zone. The same crust as that on the NW side of the Mi-Fu fault zone was consumed in part on the SE side of the Mi-Fu fault zone.

Thrust and nappe structures on the SE side of the Mi-Fu fault zone

Translation motion occurs along the fault zone and affected vast areas beyond the fault zone. The relative motion of the wrench fault has brought about a great number of associated structures. Garfunkell (1966) and Xu *et al.* (1987) have separately discussed this problem. In the research area, the Mi-Fu fault zone trending NE is linked with the Tancheng-Lujiang fault zone trending NNE (see Fig. 1), so that component of compression is increased extremely on the interior side of the arc,

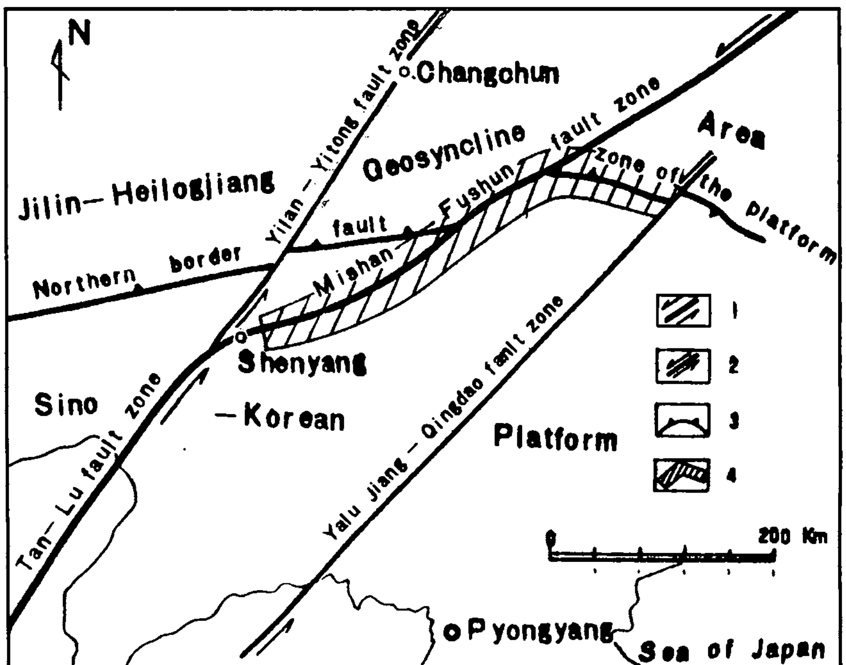

Figure 1. Tectonic sketch of the studied area. 1 = major wrench fault; 2 = secondary wrench faults; 3 = subduction belt; 4 = field investigation area.

i.e. the SE side of the Mi-Fu fault zone. A series of cross folds and faults were developed during displacement of the Mi-Fu fault zone.

Shansonggong, the SE side of the Mi-Fu fault zone (Fig. 2), was a compression area. The Archeozoic migmatite and Early Ordovician limestone overthrust on the Early Jurassic coal-bearing strata. The movement direction of the mass was from SSW to NNE. The migmatite constituted a nappe outlier, with an area of 1 km^2 and a thickness of 60 m (Fig. 3). The period of the nappe emplacement is between the Early and Late Jurassic (Wang, 1985; Mang, 1986).

Three groups of compression faults have been distinguished in the Jiapigou, the northern border area of the Sino-Korean platform (Xu, 1985; see Fig. 4).

Laoniugou-Jiapigou fault: This arcuate fault trending NW in the middle and ENE at both ends, is joined to the Mi-Fu fault zone and the Mingyue-Jian fault zone (the northern extension of the Yalujiang-Qingdao fault zone). It is suggested that the fault has undergone left-lateral shear by the Mi-Fu fault zone and the Ming-Ji fault zone. It formed probably before the Mesozoic, but more than one hundred isotopic age data (K-Ar), in which 240–140 Ma are dominant (Liu *et al.*, 1984), indicate that some dynamo-thermal events and main structures were developed during this period. The main structures include high angle thrust faults with vertical striae on the fault planes, and various brittle-ductile tectonites that indicate compression from SW towards NE.

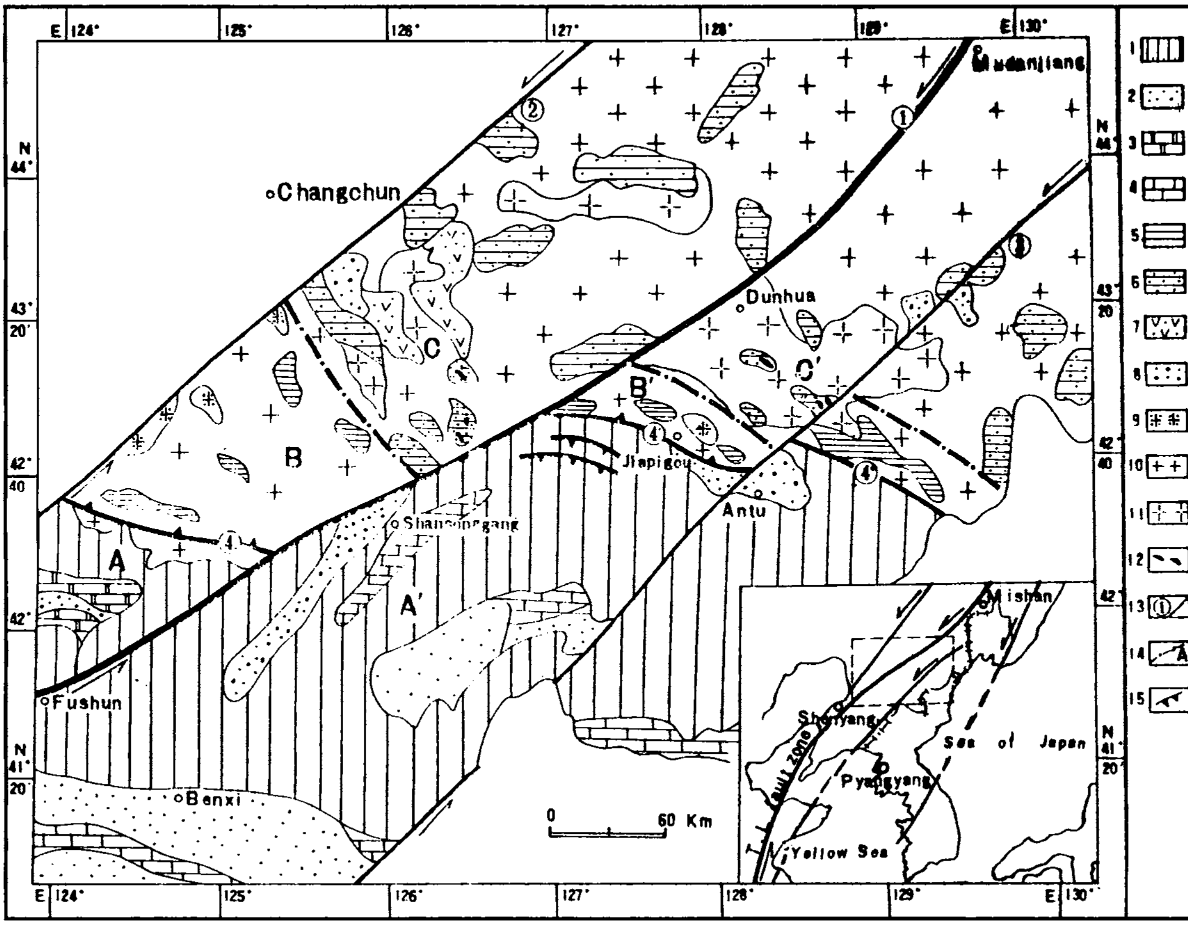

Figure 2. The correlation of petrofacies on both sides of the Mishan-Fushun fault zone. Sino-Korean platform region (1–4). 1 = Archaeozoic-Lower Proterozoic; 2 = Middle-Upper Proterozoic (Taizihe type petroclastic rock formation); 3 = Middle-Upper Proterozoic (Yenshan type carbonate facies formation); 4 = Paleozoic (coal bearing strata). Jilin-Heilongjiang fold belt (5–6). 5 = Lower Palaeozoic; 6 = Upper Paleozoic; 7 = Early-Middle Mesozoic volcanic rock formation; 8 = Early-Middle Mesozoic petroclastic rock and molasse formation; 9 = Caledonian granite; 10 = Varican granite; 11 = Indo-Sinian–Early Yenshanian granitic rocks; 12 = Caledonian or Variscan basic and ultrabasic rocks; 13 = fault and its number; 14 = boundaries of tectonic unit and its number; 15 = subduction belt. ① — Mishan-Fushun fault zone (the northern extension of the Tan-Lu fault zone); ② — Yilan-Yitong fault zone; ③ — Mingyue-Jian fault zone (the northern extension of the Yalujiang-Qingdao fault zone); ④ — Northern border fault zone of the Sino-Korean platform. AA' — Sino-Korean platform; BB' — Caledonian bordering fold belt of the platform; CC' — Variscan fold belt.

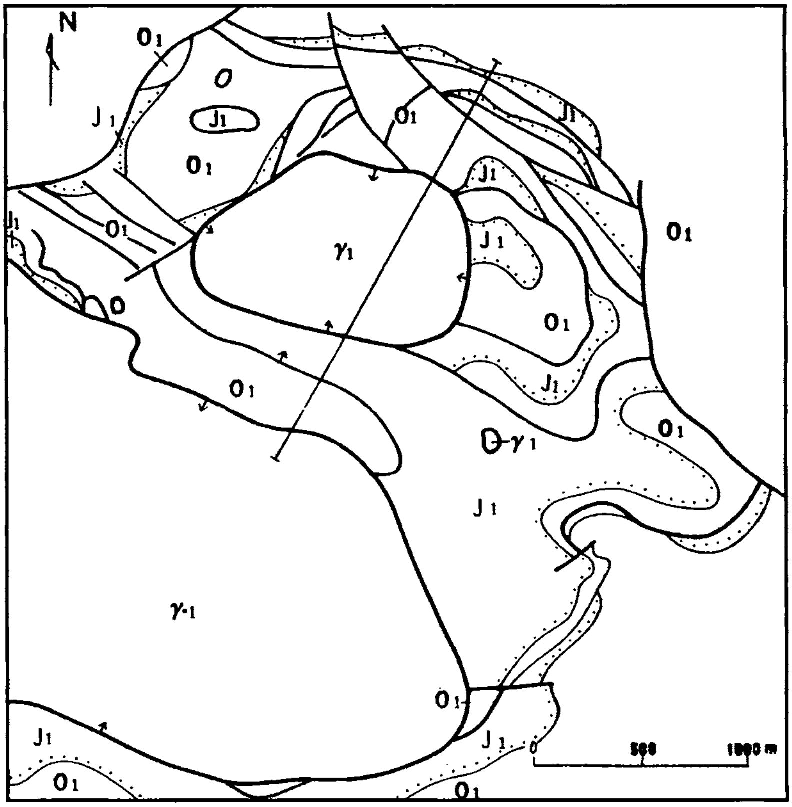

Figure 3. Nappe structures of the Shansonggang coal mining area (after Mang, 1986, revised). γ_1 – Archaeozoic migmatite; O_1 – Early Ordovician limestone; J_1 – Early Jurassic coal-bearing strata; [fault symbol] – Fault and its dip; [section line symbol] – section line.

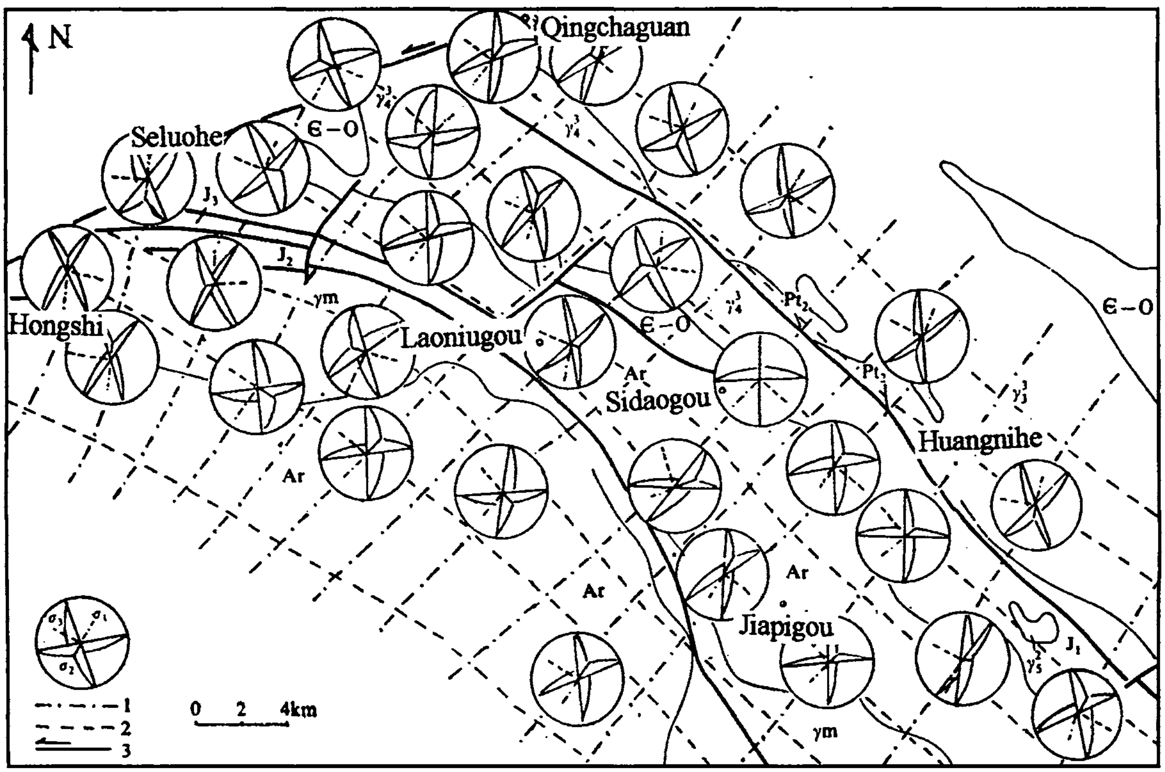

Figure 4. Mesozoic paleostress trajectory in the Jiapigou area on the northern body of the Sino-Korean platform. σ_1 – Projection of maximum principal stress axis; σ_2 – Projection of middle principal stress axis; σ_3 – Projection of minimum principal stress axis. 1 – Trajectory of maximum principal stress; 2 – Trajectory of minimum principal stress; 3 – Mishan-Fushun fault zone.

Qingchaguan-Beishuitan fault zone: Is composed of several thrust faults dipping NE at different angles. The youngest rocks affected by the fault zone are of Late Jurassic age. Mylonite, schuppen structures and listric thrust faults developed within the fault zone. Some isolated geological bodies deformed intensely in the north of the fault zone. Their petrofacies and ages are various. They are possibly the relic sheets of thrust nappe.

Fuerhe-Gudonghe fault: Mainly occurs within granitic rocks of the Late Variscan or the Indo-Sinian stages. Many oblique thrust faults trending WNW have been found.

All the above three faults except the Laoniugou-Jiapigou fault experienced shear with curving by the Mi-Fu fault zone, others intersected the Mi-Fu fault zone at large angles, and all of them were generated in granitic rocks of the Late Variscan or the Indo-Sinian stage and the Late Paleozoic strata. These are the direct evidence for the thrust and nappe structures developed at cross direction of the Mi-Fu fault zone during the Early-Middle Mesozoic.

Analyses of basin formation and origin of granitic rock

Indirect evidence of transverse compression during movement of the wrench fault is the formation of some depression basins, which run parallel to the strike of the compression structures. There are thick unstable petroclastic rock formation accumulated in the basins, which are situated in northern border of the Sino-Korean Platform (SE side of the Mi-Fu fault zone, Fig. 2). There are conglomerates and gravel-bearing from the Middle Jurassic to the Early Cretaceous accumulated in the basins. Their degrees of sorting and sphericities are not good (Xu *et al.*, 1985). These should be the indirect product of the compression from SW to NE by analysing from distribution state, material component, subsidence rate, formation texture and composition maturity of the basin (Yao, 1987). The facts above suggest that the crust has been shortened.

Analyses of the origin of granitic rocks also verified that SE side of the Mi-Fu fault zone was a contractional area. In the research area, granitic rocks of the Middle-Early Mesozoic are found mainly in the syncline fold area of SE side of the Mi-Fu fault zone (Fig. 2). According to analyses of the information which was supplied by Xu *et al.* (1985), these granitic rocks have several features in common.

The rock bodies occur as stocks are distributed planarly and petrofacies belts are undeveloped. The main petrological type are monzonitic granite, plagioclase granite, granodiorite and granite porphyry. They belong to silicon supersaturation series in petrochemistry, rich in sodium and poor in aluminium. The auxiliary mineral assemblages are almost always zircon-apatite-magnetite.

These features lie between the syntexis (I) type and transformation (S) type which were indicated by Chappell and White (1974), Xu *et al.* (1983) and Wu (1985). This is one kind of transitional type granitic rocks and it is similar to faulted granite type determined by Wang and Ouyang (1984). The origin of the type of granite has relation to A-type subduction (Jia and Shi, 1986). As far as the research area is concerned, such a large quantity of granitic rocks that were generated in the area, could be related to stress state of compression in SE side of the Mi-Fu fault zone. It is possible that the granitic rocks are a derivative of crustal shortening, i.e. while the Mi-Fu fault zone was being sheared, the crust of the SE side was compressed and a series of underthrust or upthrust faults occurred in this area. A lot of crust wedged downward to the north due to shearing of the faults and high temperature was produced. In addition the action of water, which permeated along the faults, led to local melting and developed syntectic magma, which welled up as granitic rocks. This is also one of the indirect evidences of crustal shortening.

MICROSCOPIC STRUCTURAL FEATURES OF DISLOCATION AND DEFORMATION IN THE RESEARCH AREA

Microscopic and macroscopic deformation structures are similar in geometry. Also, the analyses of the former can provide important information about kinematics and dynamics for macroscopic structures (Sibson, 1977; Xu, 1984). The author has made some attempt to analyze microscopic structures.

The conjugate joints formed at some period were measured and analyzed, a map of Mesozoic paleostress trajectory within the Jiapigou area was drawn (Fig. 4), showing that the principal stress axis is S-N to SSW-NNE, which coincided with the macroscopic structures.

The author studied systematically the different kinds of tectonite in this region. Through detailed observation of more than one hundred orientation slices, it has been found that the effects of ductile deformation increase towards the fault(s).

Depending on the analysis of macrostructure kinematic markers the direction of movement can be inferred (Simpson and Schmid, 1983; Lister and Snoke, 1984). Under the microscope, the oriented specimens show the macrostructure kinematics markers such as asymmetric pressure shadows, S-C foliation planes, mica "fish" and the sheared stack of cards model, etc. All of them verified that the SE side mass of the Mi-Fu fault zone moved towards the NNE in the Early-Middle Mesozoic (Yao, 1987).

Dynamic analysis of tectonite fabric is an effective approach to determine the direction of main stress and mass movement (Nicolas and Poirier, 1976; White, 1976; Evans and White, 1984). After determining the optical axes of quartz microstructural elements from the tectonite slices on a rotating stage, the author has analysed the data using a PC microcomputer. The state of stress reflected by the petrofabric analyses is consistent with the distribution of macroscopic structures (Fig. 5).

For the purpose of exploring the deformation mechanism and determining ultramicro deformation stages, the Transmission Electron Microscope (TEM) technique has been used. Samples of mylonite, formed in granitic rocks of the Indo-Sinian stage, were obtained from the Jiapigou area (Fig. 4), the joining part of the wrench fault zone and the nappe structures. Microsection samples show a lot of marks of ultramicro deformation, e.g. dislocation line (d), dislocation loop (b), dislocation wall (sj), dislocation network (m) and subcrystalline grain (sg, Fig. 6). The coexistence of the dislocation lines, dislocation loops and subcrystalline grains indicates that the recovery stage is dominant during ductile deformation stage in this area.

The most important feature of mineral crystal plastic deformation is dislocation. Research on crystal internal dislocation is the foundation of understanding deformation of the crust (Xu, 1984; Yang *et al.*, 1985). The author suggested (Yao, 1987, 1988) that the crust of the SE side in the Mi-Fu fault zone has been subducted and shortened on a large scale during the sinistral horizontal displacement of the fault zone in the Early-Middle Mesozoic. To a great extent, this is realized by means of the ductile deformation and dislocation.

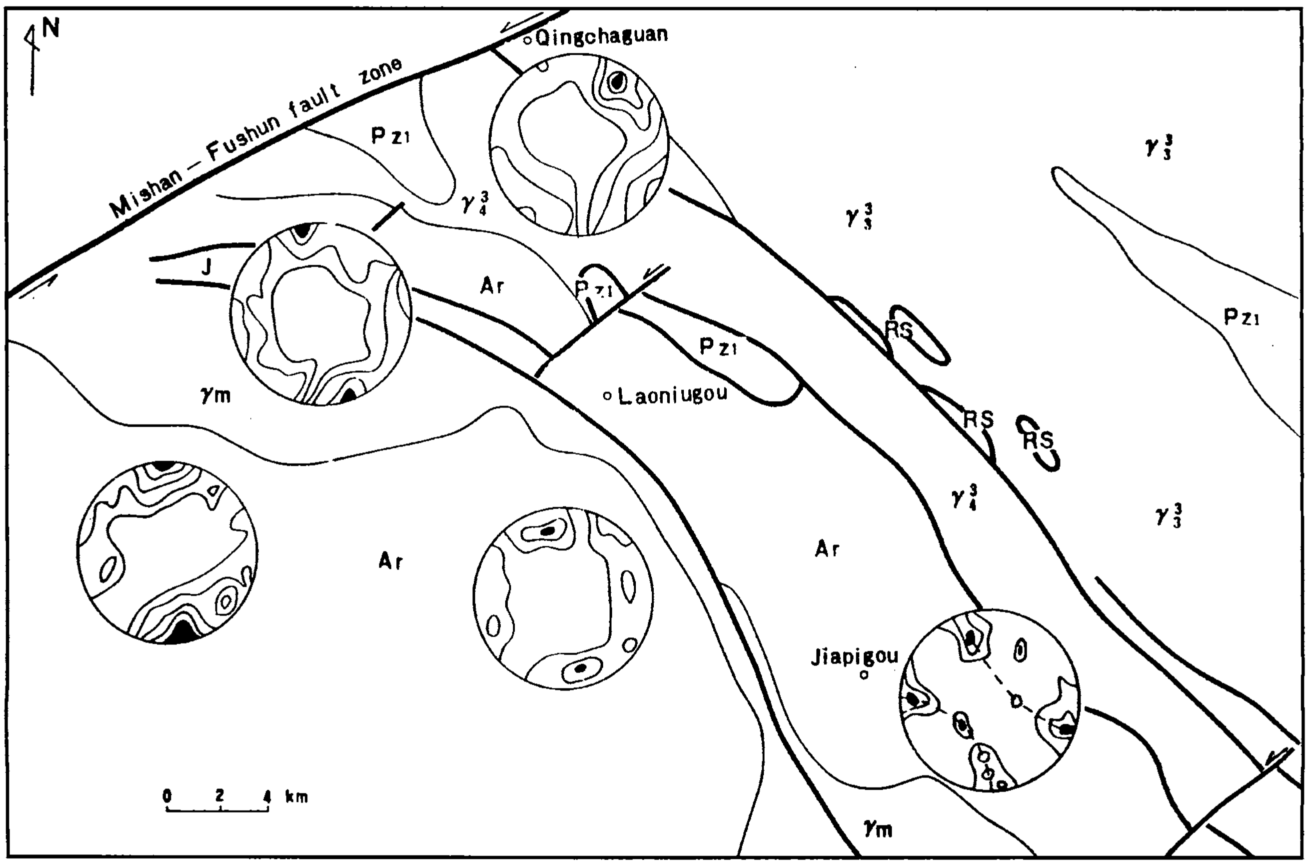

Figure 5. Sketch map of petrofabric analyses in the Jiapigou area. Ar = Archaeozoic; Pz_1 = Lower Palaeozoic; J = Jurassic; γ_m = Archaeozoic granite; γ_3^3 = Late Caledonian granite; γ_3^4 = Late Variscan granite; RS = relict sheets of thrust nappe. 121Q: 1-6-12-18; Foliation: 275°/SW 75°; I type extreme density; σ_1: NNE-SSW. 151Q: 1-6-12-18; Foliation: 85°/SE 70°; I type extreme density and AC type large circle, B+S type tectonite fabric; σ_1: S-N. 102Q: 1-4-8-12; Foliation: 275°/SW 40°; I type extreme density; σ_1: S-N. 100Q: 1-4-8-12; Foliation: 90°/S 80°; I type extreme density and AC type large circle belt, B+S type tectonite fabric; σ_1: NNW-SSE. 100Q: 1-4-8-12; Foliation: 315°/NE 85°; type extreme density; two large circles belts, their symmetric plane is consistence with the foliation; σ_1: NNW-SSE.

SUBDUCTION MODEL AND CONSUMPTION RATIO OF THE EASTERN CRUST IN THE NORTHERN BORDER OF THE SINO-KOREAN PLATFORM DURING THE EARLY-MIDDLE MESOZOIC

Subduction model

During recent years, many researchers have discussed thrust and nappe structures associated with faults (Hobbs *et al.*, 1976; Koide and Bhattacharji, 1977; Harding and Lowell, 1979; Xu, 1981; Coward and Potts, 1983; Xu *et al.*, 1987). During the translation and deformation, wrench faults usually occur with nappe structures. To explain rationally the interdependence between wrench fault and nappe structures is of great importance to understand tectonics dislocation pattern in the area. The facts are:

1. Left-lateral wrench faults (trending NE) and the thrust and nappe structure (trending WNW to nearly E-W) constitute the main tectonics framework in the research area.
2. Many of the compression planes dipping gently S or SW occur in the northern border of the Sino-Korean platform basement. Near the fold area the dip angles of the compression planes increase rapidly into steep, or even reversed. Several mylonite belts whose width are from hundreds to thousands of meters have been discovered. The dislocation magnitude of the wrench faults reduced gradually near the contact zone between the geosynclinal and the platform, which implied that its motion has been transformed. These are direct evidences for the crust shortening (Yao, 1987, 1988).
3. In the fold area, there were widespread transitional crust-syntectic type granitic rocks ranging in age from the Indo-Sinian to the Early Yenshanian Periods which were distributed planarly, their petrofacies belts undeveloped, poor in aluminium, rich in sodium. In addition, some large-scale Early-Middle Mesozoic WNW-trending depression basins have been found in the basins. By determining the origin of the granitic rocks

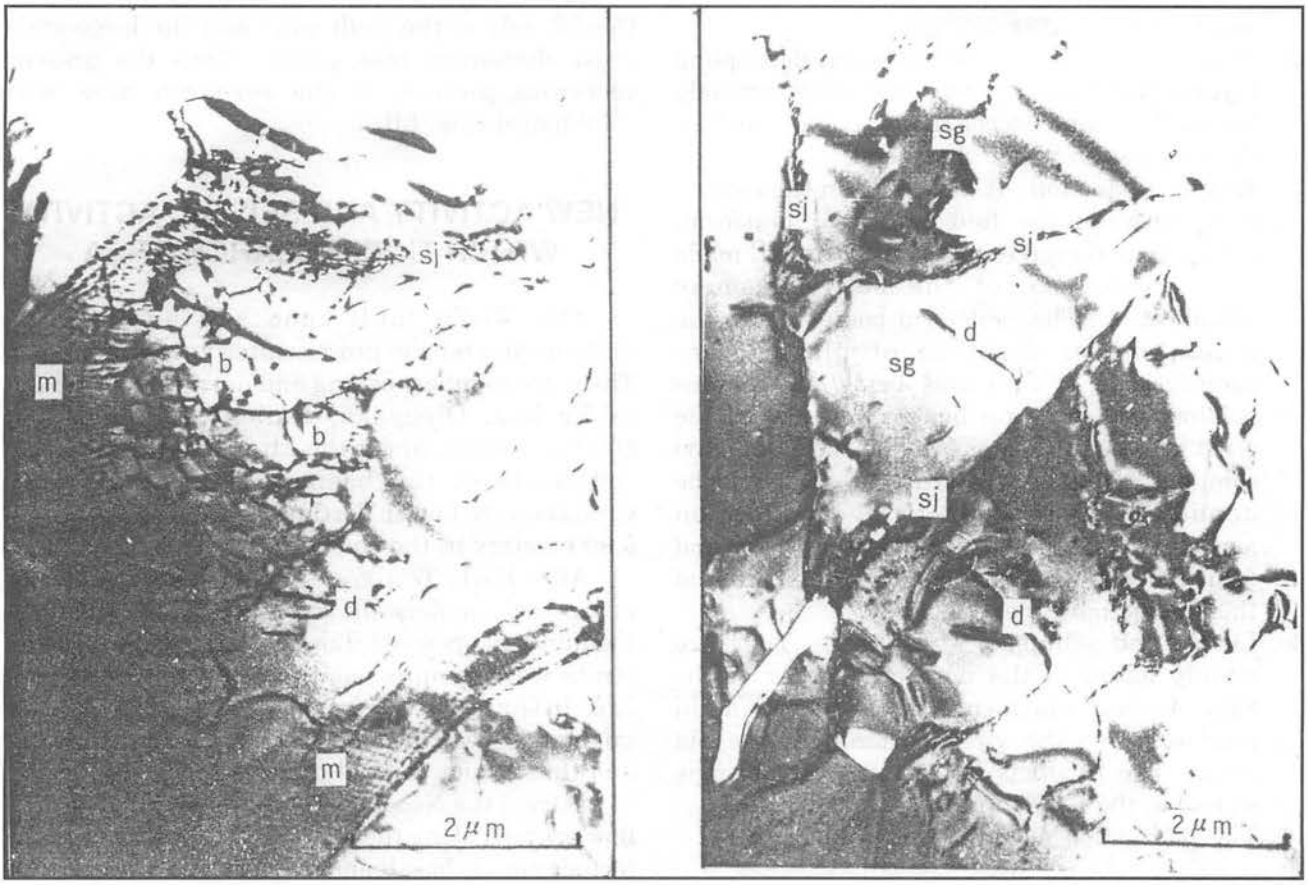

Figure 6. Ultromicro photographs showing the deformation marks at the quartz samples of the mylonite (formed in granitic rock of the Indo-Sinian stage, and are obtained from the Jiapigou area, the jointing part of the wrench fault zone and the nappe structures). d = dislocation line; b = dislocation loop; sj = dislocation wall; m = dislocation network; sg = subcrystalline grain.

and analysing the material source of the formation in the basins, indirect evidence for the crust shortening has been given (Yao, 1987, 1988).

4. The crust of the SE side of the Mi-Fu fault zone has been heterogeneous thickened, and the Moho surface is situated at depth of 40 km in Changbai (Xu *et al.*, 1985). By using some gravity measurements, Wang (1986) believed that there is a horizontal plane (decollement plane) under the northern border area of the Sino-Korean platform at depth of 5 km. By analysing physical parameters, it has been proposed that granitic rocks are below the plane.
5. The deformation characteristics revealed by different scale of microstructures are consistent with that revealed by the macrostructures (Yao, 1987, 1988).

On the basis of above description, the author believes that crustal subduction in the area is accomplished by as follows:

1. Basement decoupling. It occurred in the basement of the platform. The crust was thickened by overstepping along decoupling planes dipping gently S or SW and large-scale shortening took place in the direction of the action by the stress.
2. Decollement. The whole basement decoupling layer slipped along a deep and approximately horizontal plane (decollement plane), so that the crust was further shortened.
3. A-type subduction. It happened in the contact zone between the fold area and platform. Continuous compression from SW to NE made the deformation of the belt extremely complicated. The geological bodies above the decoupling or decollement planes were compressed. The bodies below the planes subducted downward, heated and melted the crust in front of them, as well as with time, the compression cause the crust to uplift and be denuded. The products by denudation accumulated through short transportation and formed depression basins in the back border of the subduction zone.
4. Listric and schuppen structures. They are mainly found to the northern border of the Sino-Korean platform. This is the main mechanism for the crust shortening in the fold area. The products by pushing out are the source of the formation in the near basins.

The subduction model is shown in Figure 7.

Consumption ratio

Balanced cross-section technique is commonly used to quantitatively or semiquantitatively calculate crustal shortening formed by thrust or nappe structures (Dahlstrom, 1969; Hossack, 1979, 1983; Cooper, 1983). The author chose Shansonggang mining area on SE side of the Mi-Fu fault zone (Fig. 2) to calculate the crustal shortening ratio with the aid of the technique of Yao (1987). The calculating data and the results shown in Table 1.

The calculating results show that the shortening ratio of the research area range from 50.2 to 75.2% (natural strain ratio), that is to say a greater part of crust in this region has been subducted and transformed into accumulation materials in the basins and other products.

It is stressed that the subduction of the northern border zone on the Sino-Korean platform might begin before the formation of the Mi-Fu fault zone. In the northern border zone of the Early and Late Paleozoic (Fig. 2), which indicates that the Siberia plate collided with the Eurasia plate during the Early and Late Paleozoic (Li and Wang, 1983). Maybe this is the initial stage of the subduction (Fig. 8A). While the Mi-Fu fault zone was formed, a new deformation boundary was produced. The compression-shearing of the Mi-Fu fault zone induced different stress fields on its two sides. The compression component was intensely increased on the SE side of the fault zone and the large-scale crust shortening took place. Thus the present tectonics picture of the research area was established (Fig. 8B).

NEW ACTIVITY AND SEISMIC ACTIVITY WITHIN THE RESEARCH AREA

The Mi-Fu fault zone and nearby area underwent a tensile process after Late Cretaceous. There are numbers of long and narrow basins, such as Fushun, Qingyuan, Hailong, Huadian and Dunhua basins, along the Mi-Fu fault zone. The sediments of the basins are mainly Upper Cretaceous to Lower Tertiary from 3,000 meters to 5,000 meters in the thickness.

After Early Tertiary, the Mi-Fu fault zone and nearby area underwent a compression process. In Fushun coal opencast, Lower Tertiary coal-bearing strata were compressed and formed a overturned fold. In Qingyuan clay mine, we can see Archaeozoic migmatite overthrust on Lower Tertiary strata, and thick gouge formed on the fault plane.

During the Neogene, there were a lot of basalts flow erupted along the Mi-Fu fault zone, the basalts include olivine basalt and tholeiite, and the eruption age last to Early-Middle Quaternary. Differential uplift-subsidence occurred also at two sides of the fault zone, where the NW side is uplifted relative to the SE side.

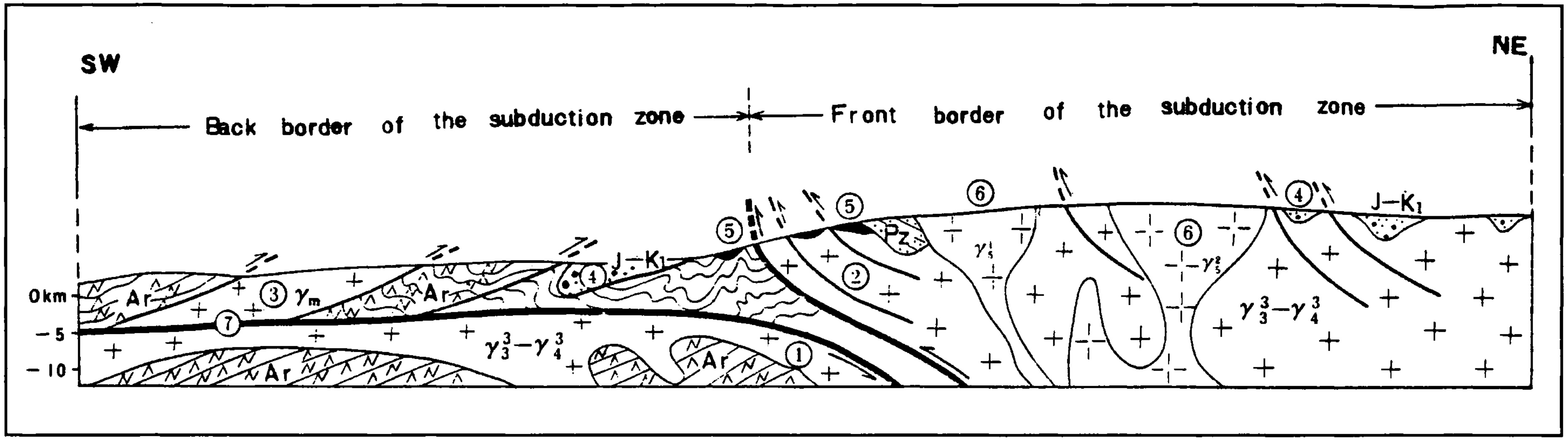

Figure 7. The Early-Middle Mesozoic subduction model in the Jiapigou area, northern Border of the Sino-Korean platform. 1 = underthrusting crustal wedge (A-type); 2 = overriding crustal wedge; 3 = basement decoupling body; 4 = depression basins; 5 = relict sheets of thrust nappe; 6 = transitional crust-syntectic type granitic rocks; 7 = decollement plane; Ar = Archaeozoic; Pz = Paleozoic; J-K_1 = Jurassic-Lower Cretaceous; γ_m = Archaeozoic granites; γ_3^3-γ_4^3 = Late Caledonian-Late Variscan granites; γ_5^1 = Indo-Sinian granitic rocks; γ_5^2 = Early Yenshanian granitic rocks.

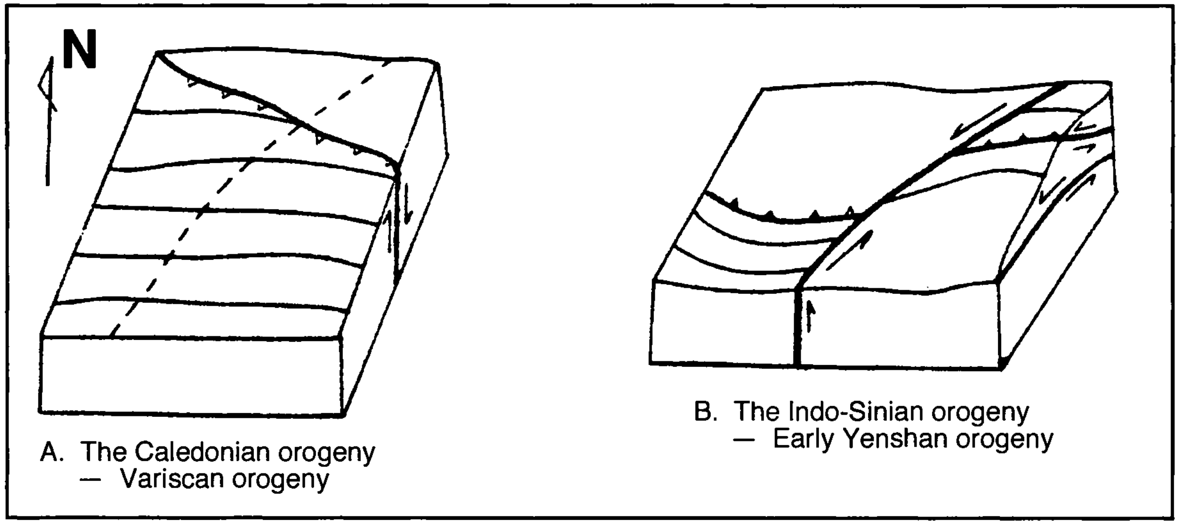

Figure 8. A space model to show evolution of the deformation and dislocation. From the Caledonian to Early Yenshanian in the studied area.

Table 1. The shortening of crust in Shansonggang mining area calculated by the balanced cross-section technique.

No. of the Profiles	The data and results of calculation by length-balanced cross-section technique							The data and results of calculation by area-balanced cross-section technique						
	l_1	l_{01}'	l_{02}'	l_{03}'	l_{04}'	l_{ot}'	e' (%)	l_1	l_{01}'	l_{02}'	l_{03}'	l_{04}'	l_{ot}'	e' (%)
EF (A-B)	8.55	8.66	8.58	–	–	17.24	–50.41	8.55	8.61	8.57	–	–	17.18	–50.23
IV (A-B)	13.88	14.35	13.95	14.05	–	42.35	- 67.23	13.88	14.37	13.98	14.07	–	42.42	–67.28
VI (A-B)	16.02	16.15	16.98	16.51	–	49.64	- 67.73	16.02	16.22	16.94	16.55	–	49.71	–67.78
VIII (A-B)	9.50	9.52	9.71	9.54	9.55	38.32	–75.21	9.50	9.51	9.70	9.55	9.53	38.29	–75.19
XI (N_{30}–N_9)	4.48	4.50	4.52	4.51	–	13.53	–66.89	4.48	4.52	4.51	4.52	–	13.55	–66.94
XII (A-B)	4.39	4.42	4.45	4.47	–	13.34	–67.69	4.39	4.40	4.43	4.42	–	13.25	–66.87

According to historical and present earthquakes records, there are numbers of earthquakes occurred at the Mi-Fu fault zone and nearby region. Characters of the seismic activity can be outlined as below:

1. Distribution direction of the earthquakes is coincided with direction of the fault zone;
2. The shallow focus earthquakes (focus depth is 2.4–30 km) are found in southwestern segment, i.e. Shenyang-Dunhua segment; The deep focus earthquakes (focus depth is 300–570 km) are found in Duahua-Mishan segment, the later result from the Pacific plate's subduction movement.

CONCLUSIONS

In the Early-Middle Mesozoic, sinistral wrench faults trending NE and compression structures oblique to the fault at large angles were developed in the research area. The northern extension of the Tancheng-Lujiang fault zone, i.e. the Mishan-Fushun fault zone dislocated left-laterally the Sino-Korean platform, the Caledonian fold belt and the Variscan fold belt. The dislocation distances are respectively 159 km, 156 km and 129 km. On the SE side of the Mi-Fu fault zone, the compression from SW to NE made the crust be shortened by 50.2–75.2%. The crust shortening types in this region are:

1. The basement decoupling and decollement took place in the Sino-Korean platform.
2. The A-type subduction occurred along the northern border zone of the platform.
3. The listric and schuppen structures developed in the geosyncline area.

Moreover, several large molasse basins (Jurassic to Early Cretaceous) have been found in the back of the subduction zone, and the transitional crust-syntectic type granitic rocks (Early-Middle Mesozoic) are distributed broadly in the front of the subduction zone. The above-mentioned inferences have been confirmed by studying on the microstructures, the origin of formation in the basins and the origin of granitic rocks.

The wrench faults and the nappe structures in the research area were joined in space and synchronized in time. They had a close genetic relation, and were coordinated in geometry, kinematics and dynamics. The wrench faults and the cross compression structures played an important role in establishing the tectonic picture in the eastern segment along the northern border zone of the Sino-Korean platform.

The Mi-Fu fault zone and nearby area underwent a tensile process and a compression process after Late Cretaceous. During the Neogene, there were a lot of basalts flow erupted along the Mi-Fu fault zone, eruption age last to Early-Middle Quaternary. Differential uplift-subsidence occurred also at two sides of the fault zone, which the NW side is uplifted relative to the SE side. According to historical and present earthquakes records, there are numbers of earthquakes occurred at the Mi-Fu fault zone and nearby region. Distribution direction of the earthquakes coincided with direction of the fault zone. The shallow focus earthquakes (focus depth is 2.4–30 km) are found in southwestern segment; The deep focus earthquakes (focus depth is 300–570 km) are found in Duahua-Mishan segment, the later result from the Pacific plate's subduction movement.

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