Structural Analysis of the Danyang Area, Danyang Coalfield, Korea

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ABSTRACT: The Danyang area consists of the thrust and folded sedimentary rocks of Paleozoic and Mesozoic Era. The area is bounded by major tectonic units which are the Gagdong Thrust to the west and the Okdong Fault to the east. According to the structural analyses, the area is affected by polyphase deformation. This study establishes deformational sequence in the area. Mylonite zone along the Okdong Fault corresponds to the first generation of structures (D1). D2-structures are discrete shear zone in the Jangsan Formation and bedding parallel extensional deformation in the Cambro-Ordovician sequences. D3-structures were formed prior to the sedimentation of the Jurassic Bansong Group, which are the NW-trending fold and linear structures. After sedimentation of the Bansong Group, the area is strongly affected by the Daebu Orogeny which produces NE-trending thrusts, folds and linear structures. Earlier structures were tightened and rotated toward NE. Some thrust faults did not propagate into the Bansong Group. It is suggested either the Bansong Group acted as a decoupling horizon or rest on unconformably on the thrust faults. The area is weakly affected by D4-event of which structures are E-W trending folds and faults. The Jureyoeng Fault clearly cut the earlier folds and thrust faults. The rocks within the fault zone were sliced and rotated during the strike-slip movements. Block rotation and transpressional features can be commonly observed.

INTRODUCTION

The Danyang area is located in the southwestern part of the Danyang Coalfield and is overlain by crystalline basement rocks and overlying Paleozoic-Jurassic cover rocks within a NE-trending belt (Fig. 1).

The area has been studied since 1925, where Kawasaki reported some older Mesozoic plant fossils. Major works in the area have been investigated for coal measures and geology of coalfield (Kobatake, 1942, Brill, 1958, Lee and Kim, 1966, Son et al., 1967, Park et al., 1975, Kim, 1981, Lee et al., 1985). Stratigraphic and Paleontologic studies on the Danyang Coalfield has been carried out by Cheong (1971) and Chun et al. (1989). Structural analysis of the Danyang area was studied by Cho et al. (1986), who analyzed geological structures using by remotely sensed data such as landsat TM data and aerial photographs together with field data.

The Danyang area has a complex tectonic history which is still incompletely understood. This paper describes the structural elements and their relations, geometry and characteristic features of major thrust faults and faults, and discusses the deformational sequences.

GEOLOGY

The stratigraphy of the area was first described by GICTR (1962), who mapped the distribution of Upper Paleozoic rocks in the NW of the Danyang sheet. Subsequent geological map of the Danyang Quadrangle was published by Won and Lee (1967).

The stratigraphy of Paleozoic and Mesozoic rocks was correlated with the sequence of the Taebaeksan Region. Most of these workers accepted the original rock units established by Kobayashi (1953) with minor modifications. Cheong (1971) attempted to establish the stratigraphy of Upper Paleozoic rocks and correlated it with the stratigraphy of Upper Paleozoic sedimentary rocks in the Samcheong Coalfield. The rocks in the area range in age from the basement rocks of Precambrian to dyke rocks of Cretaceous. The nature of the formations in this paper is followed the classification by GICTR (1962) and Cheong (1971).
Precambrian Basement Rock

The basement rock of Precambrian age is largely exposed in the eastern part of the area (Fig. 1b). The granitic rock is the main rock unit of the basement and is overlain by Cambrian basal quartzite. The granitic rock is intruded by basic dyke rocks and pegmatite veins. Banded gneiss partly occurs as a xenolith in granitic rock. The granitic rock is medium to coarse grained and shows massive structure. Intense mylonitic foliation is also developed along the contact boundary between basement and cover rocks. The boundary fault was designated the Okdong Fault by Kim et al. (1989). Small outcrops of the basement rocks are occurred within the Paleozoic succession due to minor imbrication by
later deformation along the Jugryeong Fault Zone (Fig. 1b)

**Cambro-Ordovician Choseon Supergroup**

The Choseon Supergroup is generally divided into five type sequences depending on their lithofacies and fauna assemblages, namely Duwibong, Jeongseon, Pyeongchang, Yeongweol and Mungyeong Sequences in the Korean peninsula. Among these, the Duwibong and Yeongweol Sequences are exposed in the area (Fig. 1b). These two sequences are bounded by the Gagdong Thrust Fault. The Duwibong Sequence is mainly exposed in the eastern part of the Gagdong Thrust Fault and the Yeongweol Sequence in the western part of it.

The Duwibong Sequence is divided into seven lithostratigraphic units in the Danyang area, namely, the Jangsan, Myobong, Pungchon, Cheondongri, Dumugol and Maggol Formations in ascending order (Won and Lee, 1967). The Dongjeom Formation in the area was found by our own detailed mapping, which lay between the Cheondongri and Dumugol Formations. The Dongjeom Formation in the area has 60 ~ 100 m in thickness and thin beds of shale and limestone were intercalated. Therefore, the Duwibong Sequence in the Danyang area generally corresponds to one of the Taebaeksan Region. The Dongjeom Formation is repeatedly exposed by the minor thrust fault around the Cheondongri village.

Limestones of the Yeongweol Sequence are exposed in the western part of the Gagdong Thrust Fault and this study dealt with unclassified formations. GICTR (1962) reported the Samtaesan and Heungweolri Formations are exposed in the area.

The detailed description of lithostratigraphic units can be found elsewhere (Won and Lee, 1967, Lee et al., 1985, Lee, 1987).

**Carboniferous-Triassic Pyeongan Supergroup**

The geology and stratigraphy of the Pyeongan Supergroup in the Danyang area have been studied in detail by numerous authors (Brill, 1958, Son et al., 1967, Lee et al., 1985, Park et al., 1975, Kim and Kim, 1986, GICTR, 1962).

Son et al. (1967) and GICTR (1962) divided the Supergroup in the area into four lithological units, but Cheong (1971) correlated the Pyeongan Supergroup in Danyang Coalfield with the sequences of the Samcheog Coalfield. Subsequent mapping of the coalfield has followed Cheong's classification with minor modification (Park et al., 1975, Lee et al., 1985). This study compiled the field data of Lee et al. (1985) and carried out the structural mapping. This study adopted the Cheong's classification of the supergroup.

The Pyeongan Supergroup exposed in the area consists of the Manhang, Geumcheon, Jangseong, Hambaeksan, Dosagog and Gohan Formations. The contact relation between the Ordovician Maggol Formation and Carboniferous Manhang Formation in the area is generally known as parallel unconformity (GICTR, 1962, Won and Lee, 1967, Lee et al., 1985, Chun et al., 1989) or fault contact (Son et al., 1967). According to our investigation the contact zone is highly strained and has a sharp fault boundary (Fig. 2a). Also, large scale of boudin is formed by deformation in the limestone of the Maggol Formation (Fig. 2b). The detailed description of formations can be found in Son et al. (1967), Won and Lee (1967), Park et al. (1975) and Lee et al. (1985).

**Late Triassic - Early Jurassic Bansong Group**

The Bansong Group is exposed in the NE-trending narrow belt and rests unconformably on the Pyeongan or Choseon Supergroups. The Bansong Group consists of conglomerate succession at the base and alternation zone of shale and sandstone with thin coal seams at the upper part. The Bansong Group was designated by GICTR (1962) and later it was divided into three lithostratigraphic units, namely the Sapyeongri Conglomerate, Hyeoncheonri and Deogcheonri Formations (Cheong, 1971). The conglomerate sequence can not be traced laterally and locally sandstone beds directly rests on the Paleozoic sequences. In this study, the Bansong Group designated by GICTR (1962) is adopted. According to the study of plant fossil assemblages in the area, the age of the formation ranges from Late Triassic (Chun et al., 1989) to early-middle
Jurassic (Yang, 1987).

Intrusive rocks

Paleozoic and Mesozoic sedimentary rocks were intruded by rhyolite and quartz porphyry exposed along the fault zone in Kosuri village, and these intrusive rocks are believed to be post-tectonic intrusive rocks.

DESCRIPTION OF MAJOR THRUST
FAUL TS AND FAULTS

The Paleozoic and Mesozoic sedimentary rocks in the area are folded and thrust within the NE-trending belt. The study area is bounded by major thrusts and faults, from W to E, the Gagdong, Dojeonri, Seuleumsan, Kichon and Rodong Thrusts and the Okdong and Jugyeong Faults (Fig. 3 and 4). The characteristic features of these major tectonic units are described.

The Gagdong Thrust Fault (GTF)

The GTF is one of the major thrust fault in the Korean Peninsula, which has been known since Kobayashi (cf. Son, 1975). The GTF extends northeastswards from Danyang to Jeongscon and separates the Duwibong Type Sequence to the east from the Yeongweol type succession to the west (Fig. 1b). The lithological differences between these two types of successions were first noted by Yoshimura (1940) and the differences of fauna assemblages was described by Kobayashi (1966).

Kobayashi described the thrust fault as the Byeolgokri Thrust to the southwestern extension and
as the Kongsuweon Thrust to the northeast extension of the GTF. Yoshimura (1939) named the Deogpori Thrust to the northeastern extension of the GTF. The thrust fault has been well known as the Kongsuweon Thrust Fault until GICTR (1962) had named this the Gagdong Thrust Fault.

The GTF clearly shows the characteristic feature of the thrust geometry and Ordovician limestone is thrust over Jurassic clastic sediments. The GTF has a NE-strike and dips gently to moderately steep to the NW (Fig. 4). The GTF is cut by the Jangseong Fault which has a sinistral strike-slip motion. Fault clay and fault gouge can be found along the fault. The Gagdong Nappe mainly consists of the Yeongweol type succession.

The Hyeoncheonon Thrust Fault (HTF)

The HTF was first recognized by GICTR (1962) and was designated the Hyeoncheon Thrust Fault by Son et al. (1967). The HTF can not be traced in the southern part of the Jangseong Fault and within the Bansong Group to the NE (Kim, 1981). It was suggested either conglomerate horizon of the Bansong Group acted as a decoupling horizon or the Bansong Group rested unconformably on the thrust zone of the Paleozoic succession. This fact is so important to understand the tectonic evolution of the Korean Peninsula and it will be studied in detail near future.

The Dojeonri Thrust Fault (DTF)

The DTF was first recognized by GICTR (1962) and was designated the Dojeonri Thrust Fault in this study. The DTF branches off from the Seuleumsan Thrust Fault at the Mt. Seuleum in the SW and extends toward the N at the western part of the Kosuri village where DTF is covered by the conglomerate horizon of the Bansong Group. The thrust sheet carried the Ordovician Maggol Formation and upper succession of the Pyeongan Supergroup.

The Seuleumsan Thrust Fault (STF)

The STF is one of the major thrust faults in the area and extends to the southern part of the Jangseong Fault to the SW and Yeongchun area to the NE. The STF was named for the Seuleumsan Thrust Fault by GICTR (1962), Son et al. (1967) and Cheong (1971) considered that the STF joins to the Seollon Thrust Fault at the northern part of the Danyang area. The thrust sheet carried the Ordovician Maggol Formation and Carboniferous Manhang Formation.

The Kichon Thrust Fault (KTF)

The KTF was described as a reverse fault by GICTR (1962) and was named Apyeong Thrust Fault by Park et al. (1975). The KTF branches off from the STF and occurred within sedimentary succession of the Pyeongan Supergroup. The KTF is a part of the imbricate thrust faults due to the footwall imbrication of the STF. The thrust sheet carried the Ordovician Maggol Formation at the base and the most of succession of the Pyeongan Supergroup.

The Rodongri Thrust Fault (RTF)

The RTF is the easternmost thrust fault of the Seuleumsan Imbricate Zone (Fig. 3 and 4). GICTR (1962) described a part of the RTF and Lee et al. (1985) recognized this. But the thrust fault was named RTF in this study. The RTF extends to northeastward Yeongchun area and occurs parallel to the strike of the Jangseong Formation on the hangingwall.
The Okdong Fault (OF)

The OF was first described by GICTR (1962). The name of the OF was originated from the Okdong Coal Mines where the Pyeongan Supergroup is in contact with Ordovician limestone. Thus, the fault, here, has a characteristic feature of normal fault. The contact boundary between the Cambrian basal Quartzite and Precambrian basement has a linear contact boundary from the Okdong village to the NE to Jeomchon City to the SW. This linear contact boundary was considered as a fault and was named the Danyang-Jeomchon-Hwanggan Thrust Fault by Kim (1970). Numerous authors recognized talcose mica schist at the base of Cambrian basal quartzite along this linear contact boundary (Lee, 1966, Won and Lee, 1967). This talcose mica schist has been studied in detail as a mineral resources (Seo, 1985). Kim et al. (1989) recognized this mica schist as mylonitized quartz schist and named this linear contact boundary as the Okdong Fault. This mylonite zone was reactivated as a sole thrust during Jurassic Daebo Orogeny (Kim et al, 1989). The OF was considered as a part of the Honam Shear Zone by Cluzel et al. (1990) who interpreted this strike-slip shear zone of dextral sense. Mica of this talcose mica schist along the OF was dated by Yun (1983), of which ages yielded 565±5 Ma, 266±5 Ma and 233±5 Ma, respectively. Strike of the mylonitic foliation is N50°E and dips at 60°NW.

The Jugyeong Fault (JF)

The JF was first described by Kobatake (1942), of which has a E-W trend, while most of tectonic units in the area have NE-trend. The JF is a strike-slip fault of sinistral sense (Kobayashi, 1953, Won and Lee, 1967). Kang (1984) and Kim (1970, 1972) named this fault as the Danyang Fault. Paleostress analysis using minor faults and joints had been done by Cho and Park (1983).

The JF occurs as a single fault in the Sangbangri village to W, while it forms a fault zone in the Yangjimal village to E. Where the JF formed a fault zone, the Paleozoic succession were faulted and sliced within the fault zone (Fig.1b and 3). The effects of block rotation and transpression can be seen (Sanderson and Marchini, 1984, Ramsay and Huber, 1987, Vegas et al, 1990). Amount of displacement is about 3.3~3.6 km along the JF.
GEOLICAL STRUCTURES

The Paleozoic and Mesozoic sedimentary rocks in the area are folded and thrust by polyphase deformation. Most of authors considered the Danyang area was affected by several deformation (Kim, 1972; Cho et al., 1986). They distinguished four deformational events, but these were difficult to separate because fold axes and structural elements were almost parallel to each other and interference figures are scarce.

In order to understand the polyphase deformational events in the area, the structural elements were collected from Paleozoic and Mesozoic sequences, respectively. The area is divided into six structural domains (Fig.5) depending upon the structural homogeneity and tectonic features. Some areas are subdivided into northern and southern areas in order to clarify the structural patterns and all structural elements are plotted in each domains (Fig.6).

The structural elements are stretching and mineral lineations, intersection lineations, mullion structures in the competent beds (Fig.7a) and fold axes (Fig.7b). All elements are separately plotted depending on the sedimentary rocks of the geological ages (Fig.8).

Domain 1: The area of the Gagdong Nappe (Fig. 3 & 5) and mainly consists of the limestone formation of the Yeongweol Sequence. The distribution of the poles to bedding planes forms a girdle of which \( \pi \) axis trends 295\(^\circ\) and plunges at 30\(^\circ\). Most of linear structures such as lineations and fold axes are concentrated around the \( \pi \)-axis and generally trends NW-SE. But E-W trending lineations are also visible in Fig. 6 1.

Domain 2 and 3: The area of the Seuleumsan Nappe and imbricate zone where the Pyeongan Supergroup and the Bansong Group are exposed (Fig.3 and 5). The attitudes of the strata of the Bansong Group are similar in Domain 2 and 3. Lineations and folds axes dominantly trend to SW, but W-trending linear structures are also weakly seen. E-W trending chevron type folds are commonly found at the beneath of the GTF, while macro-scale folds trend to SW. Maxima of poles to bedding planes of the Pyeongan and Choseon Supergroups have a similar trend. But lineations SW and fold axes are scattered (Fig.6 –2 & 3). NE-SW trending linear structures are dominant and NW and E-W trending linear structures are also recognizable.

Domain 4 and 5: Area between the Seuleumsan Imbricate Zone and the OF, and mainly composed of the Pyeongan and Choseon Supergroups (Fig.1b, 3 and 5). General orientation of maxima of poles to bedding plane are similar to those of Domain 2 and 3. But the lineations and fold axes more concentrated in the area of the north. Refolded fold pattern can be seen in map scale in Fig. 1b where the folds are related with the Jugryeong Fault movements.

Domain 6: Area in the southern part of the JF (Fig. 1b). General attitudes of strata are similar to those described above (Fig.6)

In general, attitudes of strata are almost similar to one of the Mesozoic and Paleozoic sedimentary rocks. But it can be separated into 3 different orientations, namely NW, NE-SW and E-W trends. NE-SW trends of lineations and fold axes are dominant and E-W trends are weakly developed in Mesozoic and Paleozoic rocks. NW trending one is only recognized in the Pyeongan and Choseon Supergroups. Therefore, the age of the formation of the linear structures can be classified into three stage related with the sedimentation of the Bansong Group. NW trending linear structures should have been formed prior to the sedimentation of the Bansong Group, NE-SW trends should be related with Jurassic Daebot Orogeny and E-W trends might be post to the Daebot Orogeny. The patterns of the structural elements in Mesozoic and Paleozoic rocks in the study area are very similar to those in the Yeongweol-Yemii area (Kim et al., 1991).

Structural map in the area is shown on Fig. 9, where lineations and fold axes are almost normal
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Fig. 6. Lower-hemisphere, equal area stereographic projections of the structural elements in each structural domain. n: number of measurements, filled triangle: fold axis, filled circle: lineation.

Fig. 7. a) Mullion structures in the Maggol formation. b) Steeply plunging anticline in the Manhang Formation.

Triassic to early Jurassic based on the plant fossils (Yang, 1987; Chun et al., 1989). So, we can classify the deformation events from the deposition of the Bansong Group.

The Daebi Orogeny is generally believed one of major orogenies and strongly affected the Korean peninsula. NE-trending folds and thrust faults are formed during the Daebi Orogeny. The GTF and associated structures were formed in the area and this movements can be designated D_{3ab} in the area.

The GTF and related folds and thrusts were cut by the JF which should be post dated to the Daebi orogeny. It is designated D_{4} but age of deformation is not clear yet. The HTF can not be traced in the Bansong Group. It might be indicated either the Bansong Group acted as a decoupling horizon to the thrust movement or the Bansong Group deposited posterior to the thrust movement. It should be

DEFORMATIONAL SEQUENCE

The study area is overlain by rocks of which age ranges from Precambrian to Jurassic and the area is also affected by polyphase deformation. Therefore, the authors separate the structural elements from the succession of different geological ages.

Age of the Bansong Group is generally known late
controversial but authors considered the possibility of thrust movement prior to the deposition of the Bansong Group. It is also designated D3-a(?) in the area.

NW-trending fold axes and lineations are well developed in the Paleozoic sequences. Therefore, this event of folding and deformation is prior to the sedimentation of the Bansong Group and is designated D3.

Muscovite and Biotite of the talcose mica schist along the OF were dated by K/Ar method, of which ages shows 562±5 Ma, 266±5 Ma and 233±5 Ma respectively (Yun, 1983). Thus, age of the formation of the OF was presumably Cambrian(D1).

The deformational sequences in the area has been briefly established, but it has not been correlated with other areas in the Peninsula yet. The characteristic features of each deformational events are described.

D1-structures

D1-structures are recognized in the mylonite zone along the OF (Kim et al, 1989). The mylonite zone occurs along the contact boundary between Cambrian basal quartzite of the Jungsan Formation and Precambrian granitoids and show a very sharp contact boundary. The mylonite zone has a few meters to 70 meters in width. Banded gneiss occurs as a xenolith within the granitoids and some xenoliths are highly elongated within the mylonite zone. Several discrete minor shear zone can be seen in the Jungsan Formation. The numbers of these shear zone increase toward the OF.

Bedding-parallel extensional deformation probably occurred during D1-event (Fig.9). This deformation is commonly seen in the Cambro-Ordovician Choseon Supergroup, which mainly consists of laminated limestones. Thick bed of limestone is pull-apart and weakly boudinaged in the laminated limestone (Fig.9a,b).

Bedding-parallel extensional structures are folded and crenulated during later event.

D2-structures

D2-structures probably developed prior to the deposition of the Bansong Group. The Bansong Group rests on the Paleozoic sedimentary sequences.
This contact relation is unconformity or angular unconformity. It means Paleozoic sequences are tilted or folded prior to the sedimentation of the Bansong Group. D2-structures can be seen in the Pyeongan and Choseon Supergroups except the Bansong Group. D2-structures are well observed in the area of the hangingwall of the GTF, which are NW-trending folds and lineations.

**D2-structures**

D2-structures are commonly recognized in the area, which are NE-trending thrusts and folds. This event postdated the Jurassic sedimentary rocks which are folded and thrust. D2-structures can be divided into two phases but the occurrences are generally similar. Some thrust faults trend NE but can not be traced into the Bansong Group. If so, it should be earlier thrust movement than the D3-b. It needs more detailed field evidence, so, here, it was classified as a D3-a event. D3-b structures are the consequences of the Jurassic Daebot Orogeny. Thrust faults were splayed and formed an imbricate zone and footwall imbrication is dominant. NE-trending folds and lineations are commonly recognized in the sedimentary rocks in the area. The GTF is one of the major thrust fault in the Taebaek region during this event. The OF is reactivated as a sole thrust of the D2-event. The Jangsan Formation formed antcline on the hangingwall of the fault in some places.

**D3-structures**

This structures are weakly developed in the area, which are the E-W trending folds and strike-slip faults. The JF is the one of the dominant structures, which cut the D3-thrusts and folds. Large scale drag folds and block rotation were developed along the JF. D3-folds were folded and formed the refolded fold pattern on the map scale. E-W trending folds are only visible in the map scale.

**DISCUSSION**

Deformational sequences in the area are still debatable, because of the age of the event. Movement of the OF clearly shows the ductile strike-slip motion. In a certain point of view, the age of the fault movement entirely relies on the K/Ar ages of one talcose mica schist. But the fault occurred as a detachment fault of basement and cover relations. Similar mylonite zone along the Precambrian basement and Cambrian basal quartzite is also reported in the Imgye area (Kim and Kee, 1991), where the mylonite zone is reactivated as a ductile thrust fault during the Bulgusa Orogeny. Therefore, D1 is the oldest deformational event in the area.

The age of D2 is also controversial. D2-structures are clearly shown in the Paleozoic rocks, not in the Mesozoic rocks. Thus, it is an indicator of deformational event of pre-Jurassic period.

D3-a is the thrust movement parallel to the D3-b. But some thrust faults predated sedimentation of the Bansong Group. If so, it will be very important because it indicates the earlier thrust movement prior to the Daebot orogeny. D3-b is the major orogeny in the Korean Peninsula.

The rocks in the area were intensely folded and thrust during this period. Earlier structures were tightened and rotated toward NE direction. Earlier structures are only preserved in the area of Gagdong and Okdong Nappes (Fig.3). The thrust sheets were transported form NWW to SEE.

D4 are the latest event in the area which are the E-W trending fault and associated fold. The JF is the one of these structures. Earlier faults and thrusts were cut by the JF. The sedimentary sequences within the fault zone were sliced and rotated. Some transpressional effects can be found. E-W trending folds are weakly developed in the area and earlier linear structures were deformed during this event.

**CONCLUSION**

The study area is located in the SW Danyang Coalfield and consists of rocks from Precambrian granitoids to Jurassic clastic sediments. The rocks in the area are folded and thrust by successive deformations. The area is bounded by major tectonic units. The names of tectonic units are different depending on the authors. This study clarifies geometry, tectonic features and the nomenclatures of the tectonic units. The GTF carried the Yeongweol
Type Sequence of the Choseon Supergroup and footwall imbrication is also recognized, where the beds of limestone and Bansong Group are repeated. The HTF can not be traced in the Bansong Group. It suggests either the clastic sediments of the the Bansong Group acts as a decoupling horizon or the Bansong Group rests on the HTF. The STF splays and forms the imbricate zone.

According to the structural analyses using structural elements, two phases of structural elements can be recognized in the Bansong Group while three phases in the Paleozoic sequences. Based on the structural analysis, deformational sequences in the area is established. D1-structure is the earliest deformational event and can be seen in the mylonitic zone along the OF. Bedding-parallel extensional deformation and discrete small ductile shear zone can be found. D2-structures are NW-trending folds and linear structures and rotated toward NE during later event. D3-structures can be divided into 2 stages and are NE trending folds, linear structures and thrust faults. Some thrust faults can not be traced in the Bansong Group. D3a event is the Daebo Orogeny. D3-structures are E-W trending faults and folds. During strike-slip movements of the JF, the rocks are faulted and sliced within the fault zone. Block rotation and transpressional effects can be found.

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REFERENCES

단양지역의 지질구조

金貞煥・高喜在

요 약: 단양지역은 단양면 서남부에 위치하며, 습곡작용과 드리스트 단층운동을 받은 중생대와 고생대 지층들로 구성되어 있다. 연구지역은 대규모의 조구조산, 동으로는 흑동단층과 서쪽에서는 각각 드리스트 단층으로 경계지워져 있다. 연구지역내에 발달하고 있는 지질구조 요소들은 해석한 결과 연구지역내의 지층들이 4번에 걸치며 변형작용을 받았다. 흑동단층을 따라서 발달하고 있는 앞뒤는 첫번째 변형작용(D1) 중에 형성되었으며, 이와 관련된 구조로는 장고구압층내에 불연속적으로 발달하고 있는 앞뒤에 조사누출구내의 지층에 협행하게 발달한 인장(引張, pull-apart)구조들이 관찰된다.
두번째 변형작용중에 형성된 지질구조(D2)로는 북서방향의 습곡구조와 선구조들이며, 이러한 구조들은 대동 누출구 내에서는 관찰되지 않는다. 한반도 전체에 영향을 준 대조조차용등의 결과로 형성된 지질 구조들은(D3) 각각 드리스트로 비교적 북동방향의 드리스트 단층들과 습곡구조 등이며, 이 기간 동안에 기존의 지질구조들은 더 tight해졌으며, 변형되고 북동방향으로 회전되었다. 최후기의 변형작용(D4) 중에 동서 방향의 축립단층과 미각한 습곡구조가 형성되었다. 축립단층내의 지층들은 주행이동 단층운동중에 회전되고 transpression의 영향을 받았다.