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Geological Structures of the Yeongchun Area, Danyang Coalfield, Korea

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ABSTRACT: The Yeongchun area is located at the central part of the Danyang Coalfield, where Precambrian granitoids, Cambro-Ordovician Choseon Supergroup, Carboniferous-early Triassic Pyeongan Supergroup, middle Triassic-Jurassic Bansong Group and extrusive tuffs are exposed. The rocks in the area underwent four phases of deformation, which are ⓐ D_1: Movement of the Okdong Fault, ⓑ D_2: Formation of NW-SE trending folds and stretching lineations, ⓒ D_3: Movement of the Gagdong Thrust Fault and associated structures of NNE-SSW trending folds, and ⓓ D_4: E-W trending strike-slip faults and folds. During the D_3-event, flexural slip deformation intensively affected rocks in the area.

Strain measurements show relatively low strain intensity in the area. The types of strain ellipsoid are prolate in the hangingwall area and those near to the footwall area range from plane strain to weak oblate. The oblate type is developed in the region far from the footwall area.

INTRODUCTION

The study area, at the central part of the Danyang Coalfield, is located in the northeastern part of Danyang-gun, Chungcheongbuk-do at latitude 37° 02′30″~37°07′30″ and at longitude 128°25′00″~128° 32′30″ (Fig. 1).

Numerous authors have studied geology around Yeongchun and its adjacent area (Kobayashi, 1953: Brill, 1957: Lee, 1966: Son et al., 1967: Kim, 1971: Cheong, 1971: GMIK, 1975: Kim, 1981: KMPC, 1962~1991). Kobayashi (1953) described the volcanic rocks within the Bansong Group and Brill (1957) reported the geology of the Danyang Coalfield.

In 1962, the Geological Investigation Corps of Taebaegsan Region (GICTR) published the geological map of Taebaegsan Region including Yeongchun and Okdong Quadrangles (1 : 50,000). Kim (1971) reported sedimentary environment of the Paleozoic and the Mesozoic sedimentary rocks in this region. Cheong (1971) and Son (1975) investigated the geological relationship between the Choseon and the Pyeongan Supergroups in the area. Geological and Mineral Institute of Korea (GMIK) published the atlas of the Danyang Coalfield (1 : 25,000) in 1975.

This paper describes the structural elements and their relations, and establishes the sequence of geotectonic evolution of the area.

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GEOLOGY

The study area (Fig. 2) is composed of the Precambrian granitoids, the Paleozoic and the Mesozoic sediments and volcanic rocks. The names of the formations in the area are followed by the GICTR (1962)'s classification.

Precambrian Granitoids

Precambrian granitoids are distributed in the eastern part of the Okdong fault (OF) (Kim et al., 1989). The rocks are medium to coarse grained and display massive and granular textures. Porphyritic texture also can be found in places. Along the contact boundary between the Precambrian basement and the Cambrian Jangsan Formation, biotite schists and mylonitic quartz schists are cropped out, of which thickness ranges from 5 m to 20 m.

Cambro-Ordovician Choseon Supergroup

The two types of Cambro-Ordovician Choseon Supergroup are exposed in the area, which are the Duwibong and the Yeongweol type Sequences. The Duwibong type is cropped out in the eastern part of the Gagdong Thrust Fault (GTF) and the Yeongweol type in the western part of it.

The Duwibong type is composed of eight forma-

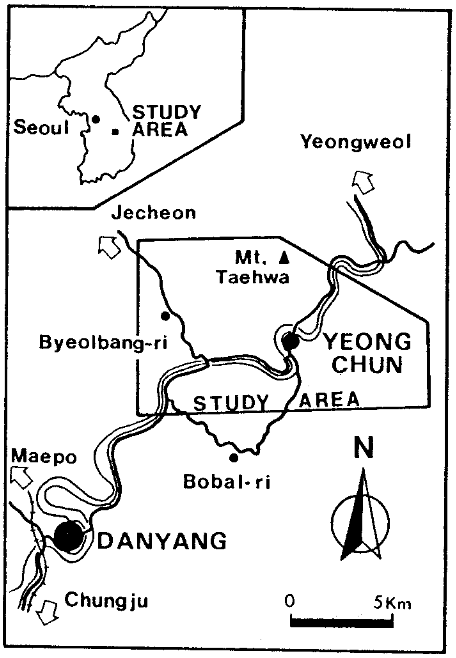

Fig. 1. Location map of the study area.

tions, namely, the Jangsan, the Myobong, the Pungchon, the Hwajeol, the Dongjeom, the Dumugol, the Maggol and the Goseong Formations in ascending order.

The Goseong Formation, the uppermost part of the Duwibong type Sequence, consists of medium dark grey to dark grey limestone and shale which can be correlated with the Duwibong and the Jigunsan Formations in the Taebaegsan region (Cheong, 1971: Son, 1975). The shale beds, however, have poor lateral continuity. Therefore, this formation is difficult to divide into the Duwibong and the Jigunsan Formations in the area.

The Yeongweol type is in contact with the Bansong Group along the GTF and is composed of two formations, the Wagok and the Mungok Formations (GICTR, 1962).

Carboniferous - Early Triassic Pyeongan Supergroup

Because of the lateral discontinuity of the formations, the names of the formations of the Carboniferous - early Triassic Pyeongan Supergroup are followed by GICTR(1962)'s classification, such as the Hongjeom, the Sadong, the Gobangsan and the Nogam Formations.

The Carboniferous Hongjeom Formation rests on Ordovician limestone and their contact relation is generally known as a parallel unconformity (GICTR, 1962: Won and Lee, 1967: Lee at al., 1985: Chun et al., 1989). But at Ondalsung in the southern part of the area, their relation is angular unconformity (Son, 1975).

Middle Triassic-Jurassic Bansong Group

Middle Triassic - Jurassic Bansong Group can be divided into two members, such as the conglomerate and the sandstone and shale-dominant Members. The Conglomerate Member is generally composed of well rounded pebbles and the long dimension of pebbles ranges from 10 cm to 50 cm. Purple shale and sandstone are interbeded in conglomerate layer. The sandstone and shale-dominant Member is mainly composed of dark grey shale and sandstone intercalated with the thin bedded conglomerates.

Volcanic Rocks

Kobayashi (1953) first described volcanic rocks within the Bansong Group, which mainly consisted of tuffs, basalts and rhyolites. Son et al. (1967) reported these rocks as quartz porphyries in the study area. From the field and laboratory works, these rocks are interpreted as tuffaceous rocks which contain glass shards, rock fragments and angular quartz grains (Fig. 3).

Tuffs are subdivided into the lower and upper tuff layers (Fig. 4). The lower tuff layer is distributed along the contact zone between the Bansong Group and the Nogam Formation, and generally shows massive and porphyritic textures. This rock occasionally shows graded bedding and most of phenocrysts are feldspar.

The upper tuff layer extruded onto the Bansong Group and contains the rock fragments derived from the limestone of the Choseon Supergroup.

Thus, these volcanic rocks indicate two different ages related to the sedimentation of the Bansong Group. Age of the lower tuff layer should be prior to and the upper layer should be posterior to the Bansong Group, respectively.

GEOLOGICAL STRUCTURES

The area is affected by polyphase deformations and reveals complicated structures. The main tectonic units, from west to east, are the GTF, unnamed

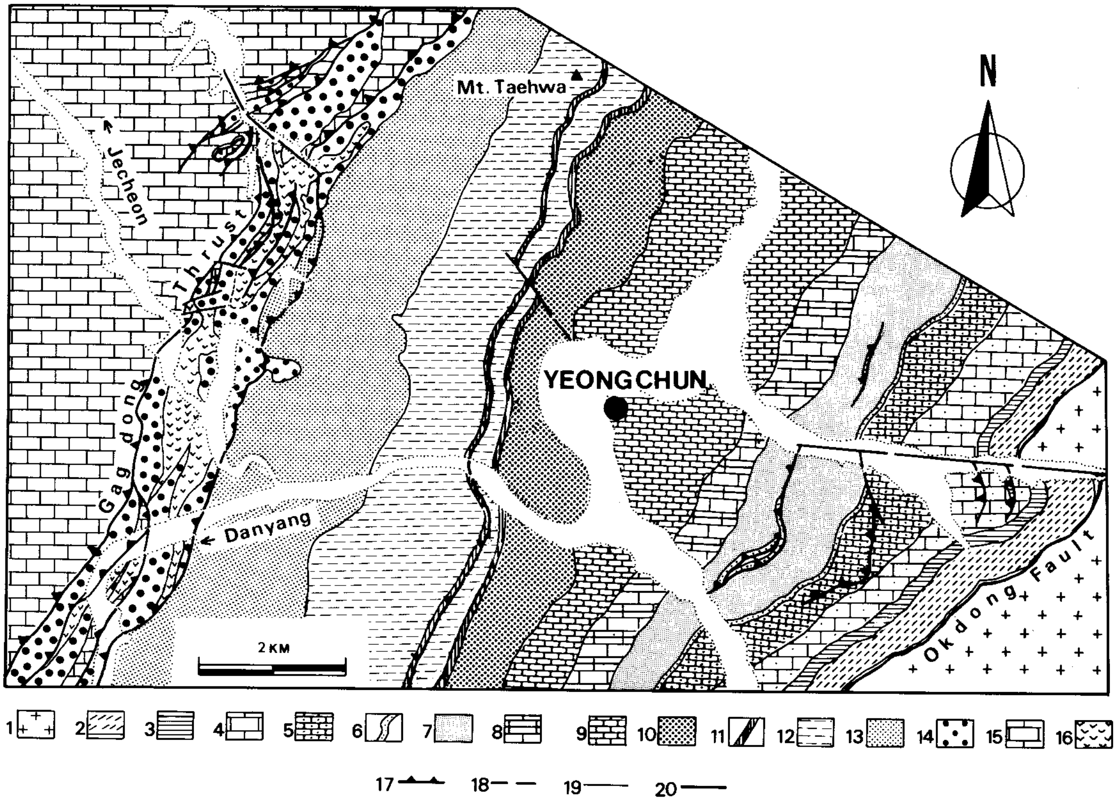

Fig. 2. Geologic map of the study area. 1. Granitoids, 2. Jangsan Fm., 3. Myobong Fm., 4. Pungchon Fm., 5. Hwajeol Fm., 6. Dongjeom Fm., 7. Dumugol Fm., 8. Maggol Fm., 9. Goseong Fm., 10. Hongjeom Fm., 11. Sadong Fm., 12. Gobangsan Fm., 13. Nogam Fm., 14. Bansong Group, 15. Limestones of the Yeongweol type, 16. Tuff, 17. Thrust fault, 18. Inferred fault, 19. Geologic boundary, and 20. Fault.

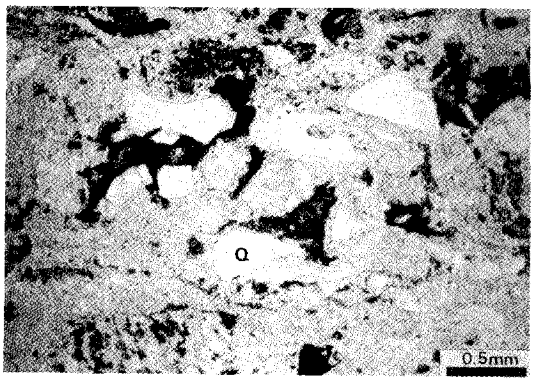

Fig. 3. Microstructures of tuff. glass shards, rock fragments and angular quartz grains(Q) are observed.

thrust fault and the OF. These structures controlled the trends of axial traces of folds and lineations, which are classified into three directions such as NW-SE, NNE-SSW and E-W. In order to understand the structural evolution, the study area is divided into five structural domains (Fig. 5).

Domain 1

Domain 1 is the hangingwall area of the GTF, which is mainly composed of the Wagok and the Mungok Formations of the Yeongweol type. The distribution of the poles to bedding planes forms a girdle of which π-axis trends 277° and plunges 18° (Fig. 5). These attitudes are commonly found in the area far from the GTF. On the other hand, axial traces of folds in the area near to the GTF trend NNE-SSW which is parallel to the GTF. Crenulations and intersection lineations are randomly distributed on the stereo-net (Fig. 6).

Domain 2

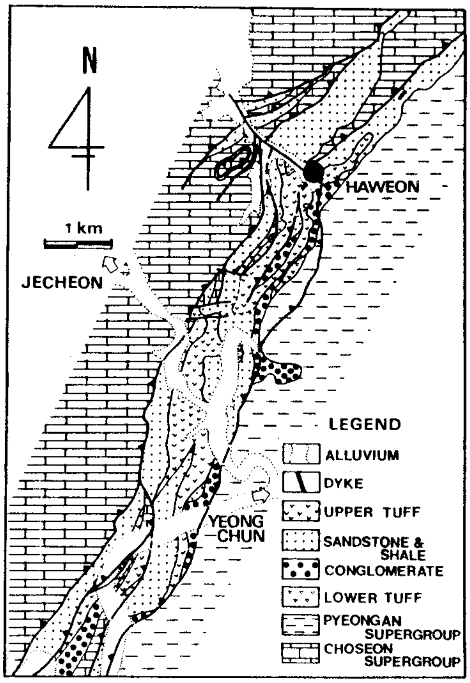

Fig. 4. Geologic map of the western part of the study area.

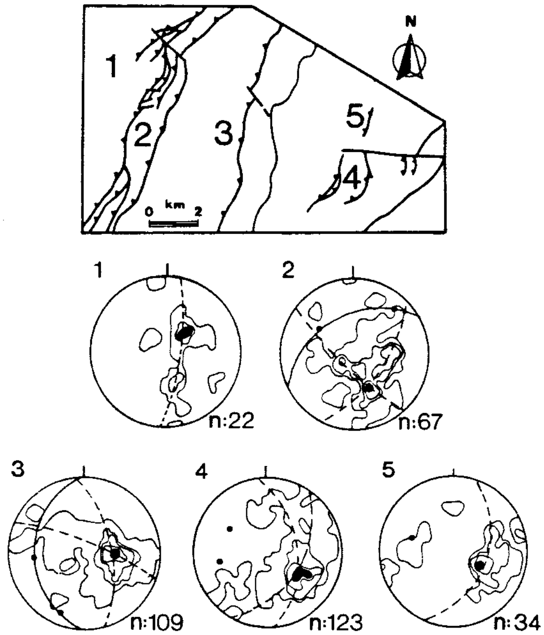

Fig. 5. Stereoplots of poles to bedding planes in each Domain.

The area is situated at the eastern part of the GTF and bounded by the Pyeongan Supergroup on the east. The area is mainly composed of the Bansong Group and extrusive tuffs, which have been strongly affected by the movement of the GTF and associated NW-trending tear faults at Haweon (Fig. 4). The tear faults clearly cut the GTF and associated minor thrust faults, but its extension can not be observed further the southeast of Haweon town.

According to the stereoplots of poles to bedding planes, fold axes trend NW (307° : trend of π-axis) and NE (042°), and weakly E-W with gentle plunging angles (Fig. 5). The distribution of poles to cleavage planes also forms a girdle of which π-axis trends 270° and plunges 26° (Fig. 7) because of the infulence of the E-W trending folds. The distribution of lineations is scattered, but their plunges are weakly concentrated on westward (Fig. 6).

Domain 3

Domain 3 is mainly composed of the Pyeongan Supergroup, of which several formations are repeated by the NNE - SSW trending unnamed thrust fault. This fault is truncated by the sinistral strike slip fault. The trends of π-axis of bedding plane indicate that NNE - SSW trending open to gentle folds (203° : trend of π-axis) and E-W trending gentle folds (206°) are developed in the Domain area (Fig. 5). NNE - SSW trending folds accompany the minor crenulation folds, and the strikes of the axial plane cleavages are subparallel to that of the GTF. The poles to cleavage planes form a girdle and π-axis of them has SSW trend (Fig. 7). It is suggested that cleavage planes are folded during the thrusting and later folding events.

Intersection, crenulation and stretching lineations have the trend of NNE - SSW and plunge at low angles (Fig. 6). The variation of orientation of these lineations is due to the effect of the GTF movement and E-W trending fold.

Domain 4

The area is the southern part of the E - W trending strike - slip fault and is composed of the Duwibong type. The fold axes predominantly trend NW - SE and weakly E - W (Fig. 5). The girdle of S - poles to cleavage planes also implies the presence of the folds with NNE - SSW and E - W trend (Fig. 7). Intersection and crenulation lineations show various orientations, but weakly show NNE and W trend (Fig. 6). The orientations of the stretching lineations also have

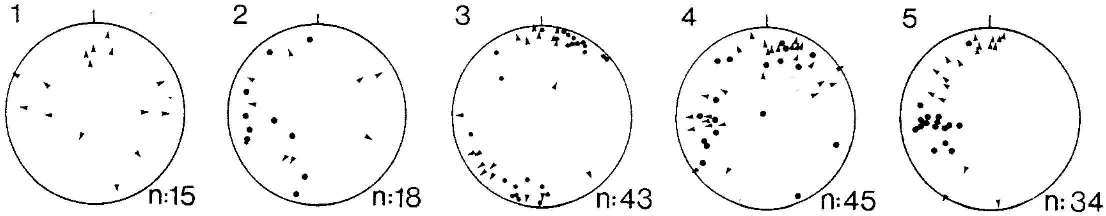

Fig. 6. Stereoplots of stretching, crenulation and intersection lineations in each Domain(dot; stretching lineation, arrow; crenulation and intersection lineations).

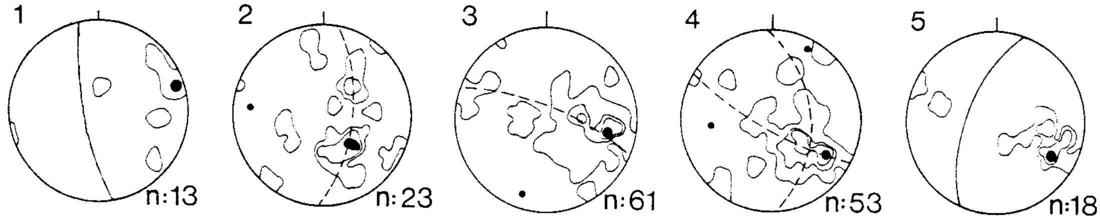

Fig. 7. Stereoplots of poles to cleavage planes in each Domain.

similar patterns.

Domain 5

Domain 5 is the northern part of the E-W trending hinge fault. The large-scale gentle folds with NWW-SEE (286°) trend are developed (Fig. 5) and the cleavage planes dominantly have the strike of NNE (Fig. 7). Intersection and crenulation lineations are well developed around thrust fault and almost plunge into N~NW (Fig. 6). On the other hand, stretching lineations uniformly plunge into the west.

DEFORMATIONAL SEQUENCE

The rocks in the area were affected and controlled by polyphase tectonic movements (Kobayashi, 1953: Lee and Kim, 1966: Kim and Koh, 1992: Kim et al., 1992). Kobayashi (1953) recognized tectonisms related with volcanisms and proposed that the first deformation occurred during late Triassic and the second from Jurassic to early Cretaceous. Lee and Kim (1966) reported the structural history of the area and proposed the Yulri disturbance, which was orogenic uplift of the Precambrian sediments prior to Cambrian period. On the other hand, Kim and Koh (1992) established the deformational sequence of Danyang area and divided into four deformational events from Cambrian to Cretaceous periods. In this study, all structural elements are seperately plotted on the stereograms in each stuctural domains. According to the structural analysis using these structural elements, two phases of structural elements can be defined in the Bansong Group while three phases in the Paleozoic sequences. Based on the structural analysis and relation to major and minor structures, deformational sequence in the area also can be established as four events.

D_1-Deformational Event

The OF was formed along the contact boundary between the Precambrian basement rocks and the Cambrian Jangsan Formation, and mylonites and talc schists exposed along this contact boundary (Kim et al., 1989).

Microstructures of mylonites, originated from the Jangsan Formation, show that quartz grains are strained and exhibit the dislocation substructures such as undulose extinction, deformation band, aggregates of subgrains and dynamically recrystallized grains (Fig. 8). The grain boundaries are sutured and curved. Partially, the unrecrystallized quartz porphyroclastic cores are mantled by new grains and weak S/C composite fabrics are developed, which imply the dextral movement sense. Mica beard is developed around the quartz porphyroclasts.

Several discrete narrow shear zones are found in the lower part of the Jangsan Formation and the number of these shear zones tend to increase toward the OF.

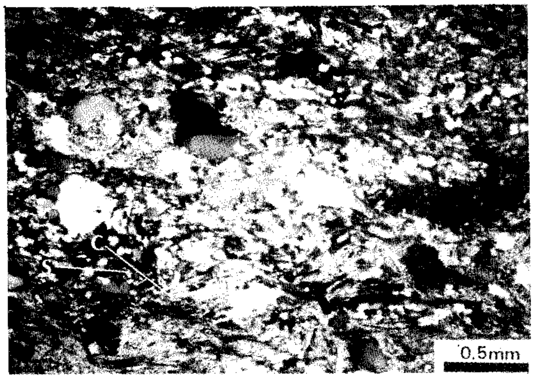

Fig. 8. Microstructures of mylonite originated from the Jangsan Formation.

D_2 - Deformational Event

NW - SE trending open folds and stretching lineations were developed during this event and were formed prior to the deposition of the Bansong Group. As the result of those, the contact relation between the Pyeongan Supergroup and the Bansong Group shows angular unconformity. NW - SE trending folds and lineations generally developed in the Wagok and the Mungok Formations of the Yeongweol type which are hangingwall area of the GTF (Fig. 9). Kim et al. (1992) determined the direction of the paleostress affected during D2 - deformational event such as NE - SW, which corresponds to NW - SE trending folds and lineations. In the area of the eastern part of the GTF, NW - SE trending folds are scarce because of the influence of the GTF developed during D_3 - event.

D_3 - Deformational Event

This event postdated the sedimentation of the Bansong Group and upper layer of tuffaceous rocks. During the event, the NNE - SSW trending of the GTF and associated folds are developed and commonly recognized in the area.
The GTF thrust the Choseon Supergroup over the Bansong Group and diverged into many thrust faults and back thrust faults. These form imbricate fans (Fig. 10) and show the variable splay patterns in Domain 2, which are rejoining, diverging splays in the Hyangsanri area and isolated splay in the Haweon area (Fig. 4). These structures repeatedly exposed the Choseon Supergroup (Yeongweol type), the Bansong Group and extrusive tuffs and developed the hangingwall anticlines (Fig. 11). The synthetic, antithetic normal faults (Fig. 12) and M - shape parasitic folds developed in the hangingwall area, and klippe structure is also found in the Haweon area. The GTF and associated several minor thrust faults are truncated by the sinistral strike - slip faults and tear fault which have the strikes of NW-SE and E-W. The formation of these faults is synchronous with that of the GTF.

Domain 2 and 3 are intensively affected by the GTF. Fig. 13 illustrates the relationship between the strikes of fault planes and the pitches of striae. In Domain 2, faults have the range of strike from NW to NE and have a character of thrust fault. The faults in Domain 3 also have the range of the strike from N to NE. These indicate that the GTF transported from NWW to SEE, which coincided with NWW-SEE trending paleostress axis (Kim et al., 1992).
The GTF developed the NNE - SSW trending gentle to open folds in the eastern part of it. These folds have axial - plane crenulation cleavages, and intersection and crenulation lineations also are developed. In the hangingwall area, extensional veinlets are developed and their trend are perpendicular to NNE - SSW. It indicates that extensional stress acted parallel to the strike of the thrust fault (Fig. 14). In Domain 4, dome and basin structures are weakly developed by the superposition of NNE - SSW trending folds and pre - existed NW - SE trending folds (D_2) (Fig. 15).

Flexural Slip Deformation

In the study area, the layer - parallel fexural slip deformation is one of the important deformation mechanism related with thrusting and folding in D_3 event (Ramsay, 1974: Cobbold, 1977: Behzadi and Dubey, 1980: Ridley, 1986: Tanner, 1989). Fig. 17 schematically illustrates the features of flexural - slip model in the study area. Competent layers generally have the features such as interlayer duplexes and en - echelon arrayed tension gashes (fractures) due to brittle behaviour of it. On the other hand, cleavage duplexes and minor parasitic folds were developed in incompetent layers with higher ductility. During the formation of cleavage duplex, penetrative layer - parallel shortening is involved (Cooper et al., 1983). Nickelsen (1986) classified cleavage halo types from 1 to 4 which are associated with layer - parallel shortening. According to this classification, the cleavage halos in the Gobangsan Formation correspond to type 3, of which layer parallel shortening is estimated ranging from 9% to 26%.

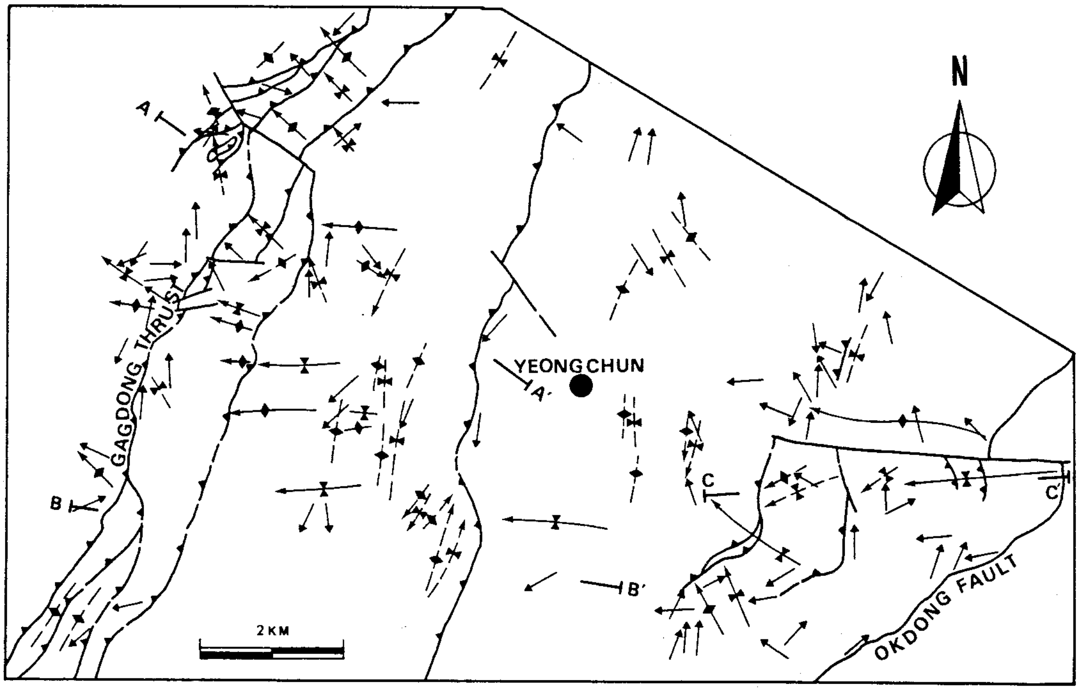

Fig. 9. Structural map of the study area showing the fold axial trace of folds and minor fold axes (the trends of axial traces of folds are divided into two groups, a; NW-SE,E-W b; NNE-SSW).

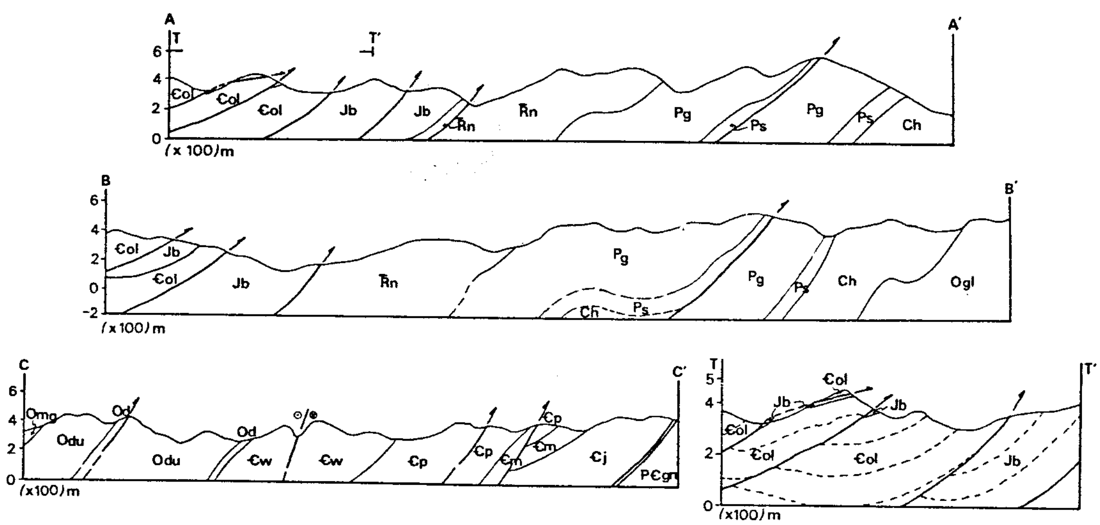

Fig. 10. Geologic cross sections along A-A' (T-T'), B-B', and C-C' lines from Fig. 9.

Where the thickness of the competent layer is considerably thinner than that of the incompetent layer, domino or bookshelf structure is developed in the competent layer (Fig. 18). These structures developed the antithetic shear rotating rigid blocks. Local polishing surfaces with striated calcite and/or quartz fibers are partly developed on the 'movement horizons' (Tanner, 1989).

D_4 - Deformational Event

This is the last event in the area and developed

Fig. 11. NNE-SSW trending thrust fault associated with hangingwall anticline.

Fig. 12. Antithetic normal faults developed in the hangingwall area.

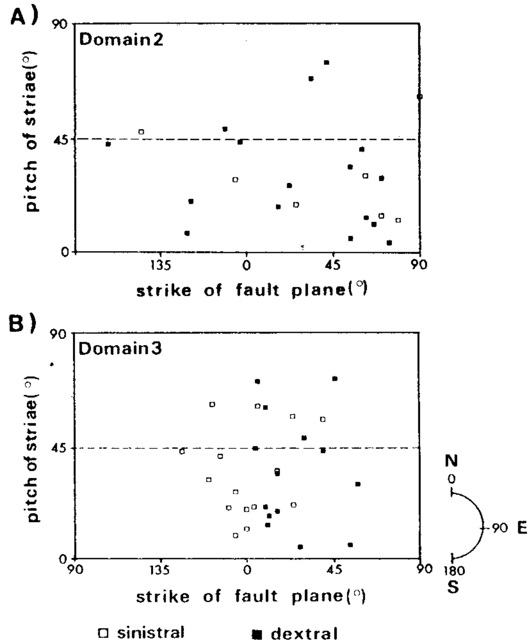

Fig. 13. The relationship between strikes of faults and pitches of striae in Domain 2 and 3.

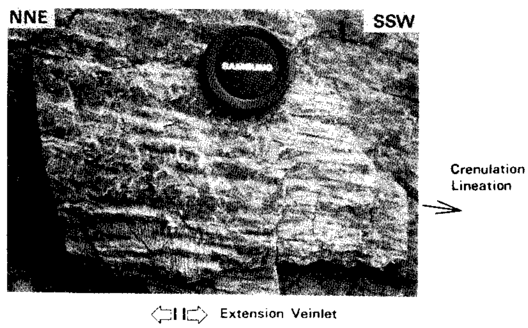

Fig. 14. The trends of crenulation lineations are subparallel to the strike of the thrust fault and perpendicular to the trend of extensional veinlets in the hangingwall area.

E-W trending large-scale gentle folds which are observed from the borehole data from south to north in the Domain 3 (Fig. 16). The formations of Pyeongan Supergroup and thrust fault (D_3) were deformed by the E-W trending fold in Fig. 16. Kim et al. (1992) determined N-S trending paleostress axis using by the fault-slip data, which corresponds to E-W trending folds. E-W trending sinistral strike-slip fault was also developed during this event (Fig. 9). The structures associated with the fault are large-scale drag folds. In Yongsumal area, thrust fault (D_3) is connected with E-W trending strike-slip fault by the minor sinistral strike-slip fault. Anticline was developed in the western part of the minor strike-slip fault and syncline in the eastern part of it.

STRAIN ANALYSIS

The principal aim of strain analysis is to estimate the amount of strain which is involved during the deformation. The strain analysis carried out using by the Rf/ϕ method (Ramsay,1967: Lisle, 1985) and the ratios of the principal axes of strain ellipsoid were obtained by the FTELAM FORTRAN PROGRAM. Deformed quartz grains in the Choseon and the Pyeongan Supergroup and conglomerate pebbles in the Bansong Group are used as strain markers.

The results of strain analysis in this study are shown in Table 1. Flinn's values (k) have the ranges from 0.004 to 2.921 and the values of ε_s range from

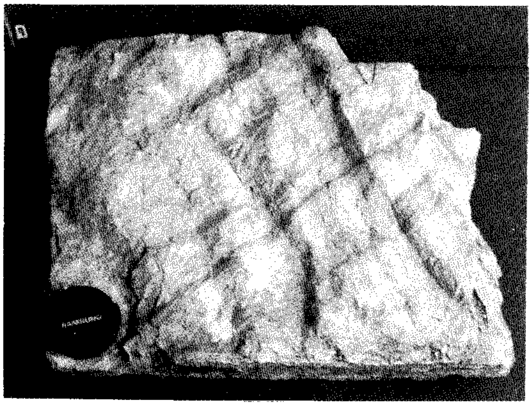

Fig. 15. The structure superposed by NNE-SSW trending folds and NW-SE trending folds.

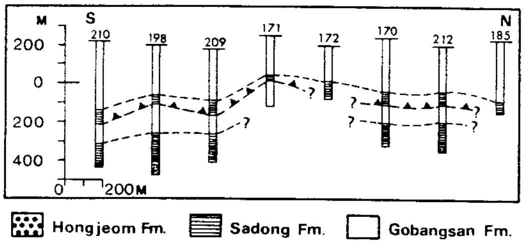

Fig. 16. The borehole data from south to north in the Domain 3.

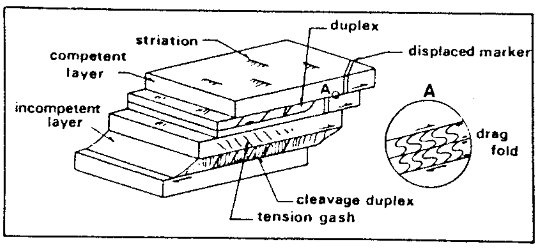

Fig. 17. Schematic diagram of flexural slip deformation in the study area.

0.287 to 0.456 which represent relatively low strain intensity. In Domain 2 and western part of Domain 3, the orientations of long axis of strain ellipsoid parallel to the strike of the thrust (NNE-SSW) due to the influence of the GTF movement (Fig. 19). The orientations of those well correspond with the trends of the crenulation and stretching lineations in Domain 2 and 3. On the other hand, those of strain ellipsoid in Domain 4, affected by E-W trending hinge fault and thrust faults movements, arranged E-W direction which is parallel to the trend of the

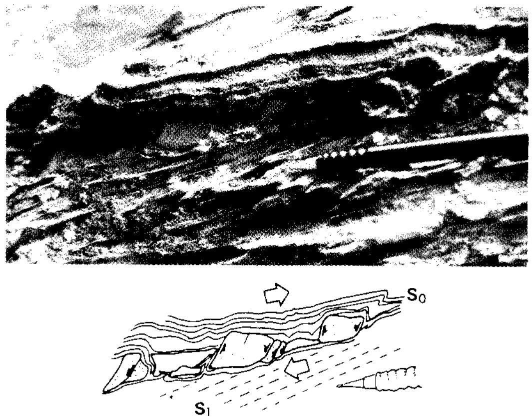

Fig. 18. Domino or bookshelf structure developed in the Dumugol Formation.

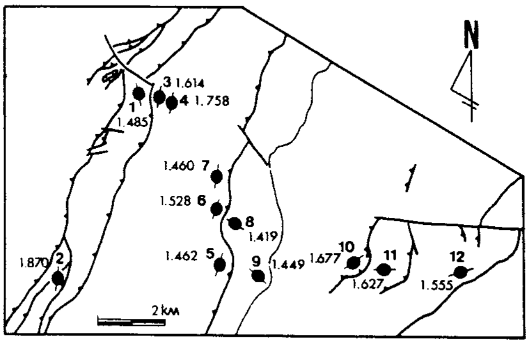

Fig. 19. Sample localities, strain ratios(R_{xz}) and orientations of long axis of strain ellipses.

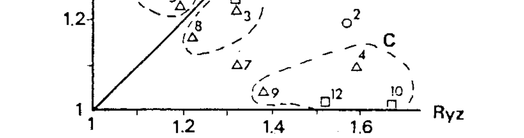

Fig. 20. Flinn diagram for plotting strain data.

stretching lineation.

Fig. 20 shows the Flinn's diagram which reveals the types of strain ellipsoid. The data from the

Table 1. The results of strain analysis in the area.

Number	Principal Axis of Strain Ellipsoid $\sqrt{\lambda_1} : \sqrt{\lambda_2} : \sqrt{\lambda_3}$	Strain Parameters Flinn's k	Strain Parameters ε_s	Orientation of $\sqrt{\lambda_1}$	Strain Marker	Remark (Fm.)
1	1.485 : 1.114 : 1.000	2.921	0.289	170°/10°	Pebble	Bansong
2	1.870 : 1.570 : 1.000	0.335	0.456	186°/22°	Pebble	Bansong
3	1.614 : 1.323 : 1.000	0.681	0.340	010°/00°	Quartz grain	Nogam
4	1.758 : 1.586 : 1.000	0.185	0.425	010°/10°	Quartz grain	Nogam
5	1.462 : 1.189 : 1.000	1.125	0.269	018°/05°	Quartz grain	Gopbangsan
6	1.528 : 1.185 : 1.000	1.564	0.302	198°/09°	Quartz grain	Gobangsan
7	1.460 : 1.326 : 1.000	0.310	0.278	188°/09°	Quartz grain	Gobangsan
8	1.419 : 1.221 : 1.000	0.734	0.249	299°/47°	Quartz grain	Sadong
9	1.449 : 1.388 : 1.000	0.113	0.287	312°/40°	Quartz grain	Hongjeom
10	1.677 : 1.673 : 1.000	0.004	0.421	236°/08°	Quartz grain	Dongjeom
11	1.627 : 1.316 : 1.000	0.748	0.345	270°/18°	Quartz grain	Dongjeom
12	1.555 : 1.518 : 1.000	0.047	0.351	252°/46°	Quartz grain	Jangsan

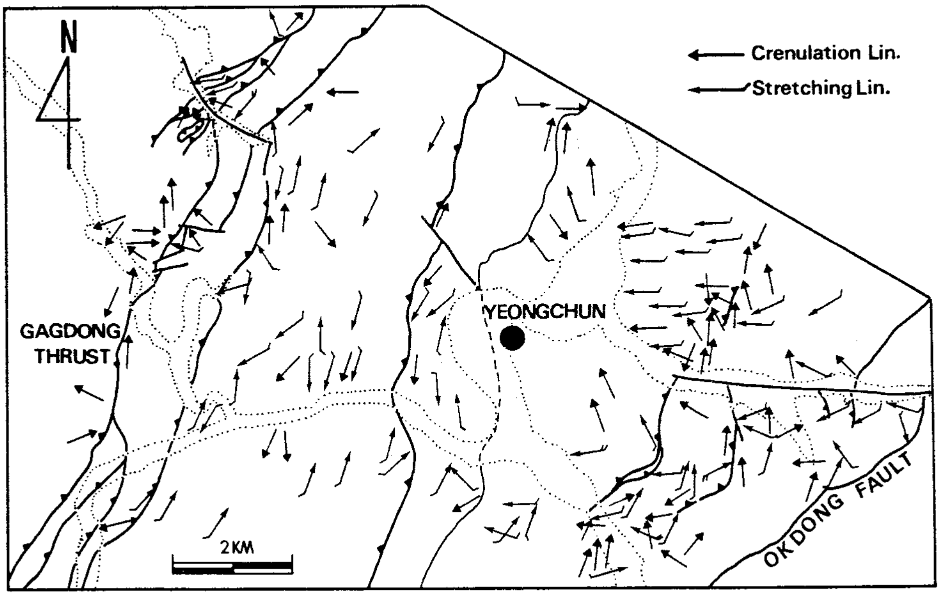

Fig. 21. Distribution of stretching and crenulation lineations in the study area.

hangingwall area are plotted in the field of apparent constriction (prolate type). The data near to the footwall area concentrate in the field of plane strain to weakly flattening. The flattening type of strain ellipsoid can be seen in the region far from the footwall area.

DISCUSSION

The deformation sequences in the area are generally similar to those in the Danyang area (Kim and Koh, 1992). But, the ages of their events are not sufficed to fix because of the reactivation of the pre-existed structures and the overprint between the co-axial structures.

The OF(D_1) shows dextral movement sense and was developed at latest during Cambrian period according to the result of the K/Ar age dating by Yun (1983) (Kim et al., 1989: Kim and Koh, 1992). This fact implies that the deformation event occurs prior to the sedimentation of the Pyeongan Supergroup and the contact relation between Choseon and Pyeongan Supergroup is angular unconformity in the area (Son, 1975). In Yemi-Okdong area, the

OF was interpreted as normal or reverse fault (Lee and Kim, 1966), which suggested that the OF was reactivated during later deformational events (e.g. Kim et al., 1989).

During the D_2 Deformational event, NW-trending folds and stretching lineations developed prior to the deposition of the Bansong Group. Volcanic activity was closed at the end of the event. Other volcanic activity was posterior to the deposition of the Bansong Group, which implies the extensional tectonism during the middle Triassic-Jurassic periods.

D_3-Deformational event occurred during the Daebo orogeny. During this event, NW trending stretching lineations (D_2) have been rotated to NNE-SSW by the movement of the GTF (Fig. 21). Trends of thrust faults in Domain 2, 3, 4 and 5 parallel to that of the GTF, and crenulation lineations are developed adjacent to the thrust faults. But it is not certain that the development of the thrust faults are contemporaneous with that of the GTF.

E-W trending large-scale folds (D_4) are well developed in the all area. E-W trending sinistral strike-slip fault also is developed and can be correlated to the E-W trending Jugryeong Fault which moved with sinistral sense and truncated the GTF (D_3).

Kim et al. (1992) determined the paleostress directions in the area using by the fault-slip data, such as NE-SW (pre-Daebo Orogeny), NWW-SEE (syn-Daebo Orogeny) and N-S (post-Daebo Orogeny), which corresponded to D_2, D_3 and D_4 deformation events respectively.

CONCLUSION

The Yeongchun area is located in the central part of the Danyang Coalfield, where Precambrian granitoids, Cambro-Ordovician Choseon Supergroup, Carboniferous-early Triassic Pyeongan Supergroup, middle Triassic-Jurassic Bansong Group and extrusive tuffs are exposed.

The sequence of the deformations can be divided into four events; ① D_1: Development of the Okdong Fault, ② Sedimentation of the Pyeongan Supergroup, ③ D_2: Formation of NW-SE trending folds and stretching lineations, ④ Volcanism, ⑤ Sedimentation of the Bansong Group ⑥ Volcanism, ⑦ D_3: Development of the Gagdong Thrust Fault and NNE-SSW trending gentle to open folds, and ⑧ D_4: Formation of E-W trending strike-slip fault and E-W trending large-scale gentle folds. The flexural slip deformation are dominantly affected during D3 event and developed the significant structures, such as interlayer duplex, cleavage duplex, en-echelon arrayed tension gash, parasitic fold and domino or bookshelf structure.

The result of the strain analysis shows relatively low strain intensity. The type of strain ellipsoid shows prolate in the hangingwall area and that of near to footwall area has ranged from plane strain to weak oblate. The oblate type is developed in the region far from the footwall area.

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1992년 3월 25일 원고접수

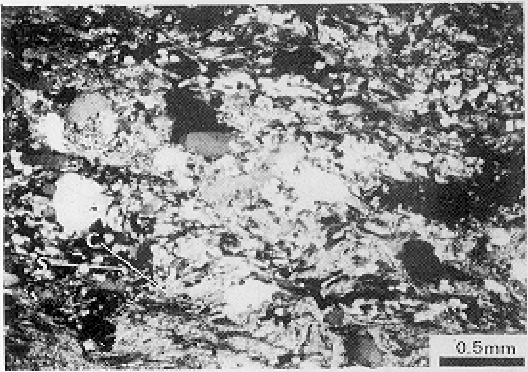
단양탄전, 영춘지역의 지질구조

김정환 · 이제용 · 남길현

요 약: 연구지역은 충청북도 단양군 영춘면을 중심으로 하는 단양탄전 중부지역으로 단양읍의 북동부에 위치하고 있다. 연구지역내에는 선캠브리아기의 화강암질암을 기저로 하여 캠브로 오도비스기의 조선누층군, 석탄기-트라이아스기의 평안누층군, 트라이아스기-쥬라기의 반송층군이 각각 부정합을 이루며 분포하고, 대부분의 지층들은 북동-남서방향의 주향과 북서 방향의 경사를 가지고 대상으로 분포한다.

전반적인 지질구조의 특성으로 미루어 보아 연구지역내의 지층들은 4번에 걸쳐서 변형작용을 받았다. 첫번째 변형시기(D_1)에 옥동단층이 형성되었으며 이를 따라 압쇄암이 분포하고 있다. 이후에 평안누층군이 퇴적되었다. 두번째의 변형시기(D_2)에는 북서-남동 방향의 축을 갖는 습곡구조와 이와 관련된 신장선구조가 발달하였다. 이후에 화산분출작용으로 인하여 응회암이 퇴적되었으며, 이 상위로 반송층군이 퇴적되었다. 반송층군의 퇴적 이후에 두번째의 화산작용이 있었다. 대보조산운동(D_3) 에 의해 발달된 각동드러스트단층에 의해 북북동-남남서 방향의 축을 갖는 gentle to open type의 습곡구조와 파랑선구조가 형성되었으며 flexural slip 변형작용이 드러스트 운동과 함께 우세하게 작용하였다. 마지막의 변형작용(D_4)에 의해 동서방향의 축을 갖는 gentle type의 습곡구조와 주향이동성 단층이 발달하였다.

변형량 분석결과, 전반적으로 암석내의 변형정도가 낮으며, 드러스트를 기준으로 상반은 prolate type, 하반은 plane strain-weak oblate type, 그리고 하반에서 비교적 먼 지역에서는 oblate type을 보여준다.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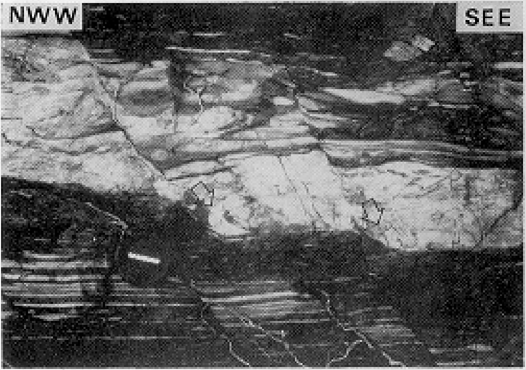
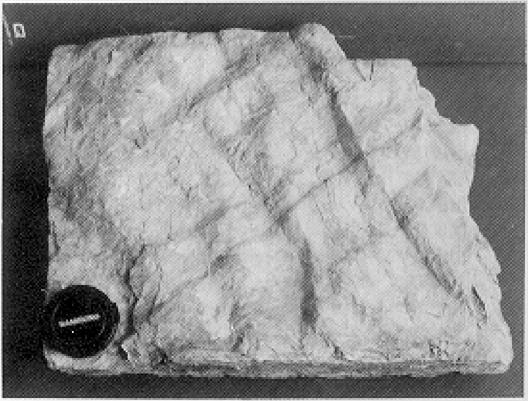


Fig. 18 [illegible]


NNE
SSW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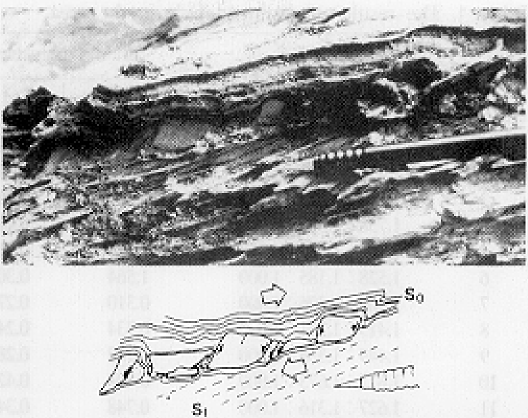
S_0
S_1