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Groundwater Conditions related with the Geologic Structures of Bedrocks in the Gyuk-Po Area.
격포 기반암의 지질구조와 지하수 상태

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Abstract/요약

Hydrogeological survey related to groundwater conditions was performed at the study area in Gyukpo, BuanGun, ChunlabukDo to express the relationships between groundwater conditions and the geologic structures such as joints, faults and beddings in bedrock. About 200 joints and significant faults were measured in this area. Typically, The fracture analysis on cores of 7 boreholes was tried to quantify fracture numerically. Groundwater level was periodically measured for three months. The packer tests of about 175 were carried out in 7 boreholes.

As the result, Fractures are locally developed as ground water bearing zone and an average hydraulic conductivity of bedrock is 1×10^{-5}cm/sec in this area the hydraulic conductivity of this area is correlated with fracture frequency value of F15 and is also well correlated with fracture developed and depth. In accordance with depth, fracture frequency and hydraulic conductivity are decreased. Hydraulic conductivity of granite along depth shows an obiouse change in values but that of sedimentary rocks do not shows changeless.

Groundwater movement in the bedrocks of the study area affected not by joints but faults developed in the different rock boundary. In the northern part of this area, The differences of hydraulic conductivity between granite and sedimentary rocks give rise abrupt at difference in groundwater level. In the southern part of the study area, there is no different in groundwater level of both same rock types.

기반암내에서의 지하수의 상태와 열극, 단층 그리고 층리면과 같은 지질구조와의 관계를 설명하기 위하여 전라북도 부안군 격포지역 일대에서 수리지질조사를 수행하였다. 약 200개의

열극과 단층등이 이 지역의 제한된 범위에서 측정하였다. 특히, 7개의 시추공에서 얻어진 시추코아에 대한 열극분석(Fracture Analysis)을 수행하여 수치화해 보았다. 3개월간의 주기적인 지하수위 측정과 7개 시추공에서 약 175회의 현장 투수시험을 실시하였다.

그 결과, 본 지역의 기반암은 대수층 역할을 할 수 있을만큼 절리가 발달했으며 투수계수는 1×10^{-5}cm/sec이고, 이는 Fracture Frequency Value, F15의 값과 대비되고, 열극의 발달상태 및 심도와 대비되었다. 심도가 깊어짐에 따라서 열극의 발달이 불량해지고 투수계수도 낮아짐을 알 수 있다. 퇴적암과 화강암지역의 심도에 따른 투수계수에 있어서, 화강암은 심도에 따른 변화의 양상을 뚜렷하게 보여주고 있으나 퇴적암지역은 일정하게 변화가 없는 양상을 보여주고 있다.

기반암에서의 지하수의 유동과 수위는 열극의 방향성보다는 단층에 의해서 서로 다른 암종경계특성에 의해서 영향을 받는다. 즉, 본 북부지역에서는 화강암과 퇴적암의 암종경계에 존재하는 단층에 의한 두 지층의 투수계수 차이는 지하수위의 갑작스러운 변화를 야기시키고 남부지역에서는 투수계수가 같은 동일 암종에서 단층이 존재하여도 지하수의 유동방향 및 수위 변화를 나타내지 않는다.

Introduction

Generally speaking, Groundewater conditions in bedrocks are obviously controlled by not only geologic structures such as faults, joints and dykes but also characteristics of porous media. This study typically shows such features in the limited area that groundwater conditions of bedrock are controlled by not only the hydraulic conductivity of each bedrock but also geologic structures and groundwater movement in depth.

Groundwater movement and distribution are varied by the location and orientation of fault and dyke. Especially, Frequency and roughness of fractures affect the velocity of groundwater in fractured rock(Romm 1966, Pearce & Murphy 1979). In related to the construction of underground structures, the relationship of groundwater velocity and fracture charactristices for the engineering purpose is under study in the Stripa Test Site Sweden(Gale 1985).

To get the information and data required for the analysis of groundwater level, the groundwater levels of 70 drilled holes were periodically measured for three months. Fracture analysis on cores of 7 boreholes was tried to quantify fracture characteristics. In situ packer testes of about 175 were carried out on 7 drilled holes. About 200 joints and two significant faults were measured in this area.

General Geology

The geology of the area is composed of Precambrian gneiss, Jurassic biotite granite, porphyritic andesite of unknown age, sedimentary rocks, rhyolite, volcanic complex of the later

Cretaceous and basic volcanic rocks of Tertiary. Gneiss and granite are distributed along the northern coastal line and generally contacted with other rocks by faults. Porphyritic andesite of small exposure is found at the low hill area near the western coast around Banweol. Basic volcanic rocks are distributed at the coast around Yongdu-dong, Jungmag-dong where are covered with rhyolite. Volcanic complex is exposed at a high mountain zone in the eastern part of the study area.

There are two main faults of N 40°~50° E direction in this area. The one is parallel to the northern coastal line and the other is found from Gyeongha. The fault plane of the former can be observed at outcrop but the latter is covered with alluvial deposits. However, this has a key bed which is sedimentary rock intercalated with volcanic complex. They are characterised by the right lateral strike slip faults. The displacement of this fault is more extended than 1km along the fault plane observed. The main fault in the Banweol area has a different second order fault system in the northern and southern area of it. The second order fault system has antithetic fault which is characterised by left lateral strike slip fault and has an obtuse angle to the main fault at the northern area. At the southern area, it is synthetic fault. Also the second or third order faults contain polished calcite vein. Altered zone can be found along these fault planes. As the main fault strikes N 40°~50° E and has a right lateral sense, the primary stress direction might be due to N 70°~80° W. Primary fold can be formed by this compression. The primary fold axes were dragged by second or third order faults. The thrust was occurred also by the primary stress and was nearly perpendicular to the stress direction. It is considered to be a strike slip fault and it might be left lateral second order fault system. Fault systems in this area may be formed after the intrusion of basic volcanic rock, because the rock is bounded by faults.

To represent the orientation of joint in the study area, About 200 joints are measured and plotted on a joint rossets. Joint rossete does not indicate typical orientations of joint sets but shows that joints are similary oreinted to the main fault trending N 40°~50° E and N 10°~15° W.

In situ Packer test

The common method of hydraulic test is that water is injected directly into the bedrock through a peforated tube located between two inflated packers. Packer test length in discontinuous rocks may be optimized by using R.Q.D. arguments. Packer test tube may be installed above or below the water level and the test length should be at least 10 times the hole raius. 9 boreholes were drilled for subsurface investigations and the packer tests were performed in 7 boreholes as shown in Fig.1.

Test holes of NX size in diameter were drilled and the packer test were performed for every 1.5m interval upward from the bottom of the holes. This test has been carried out

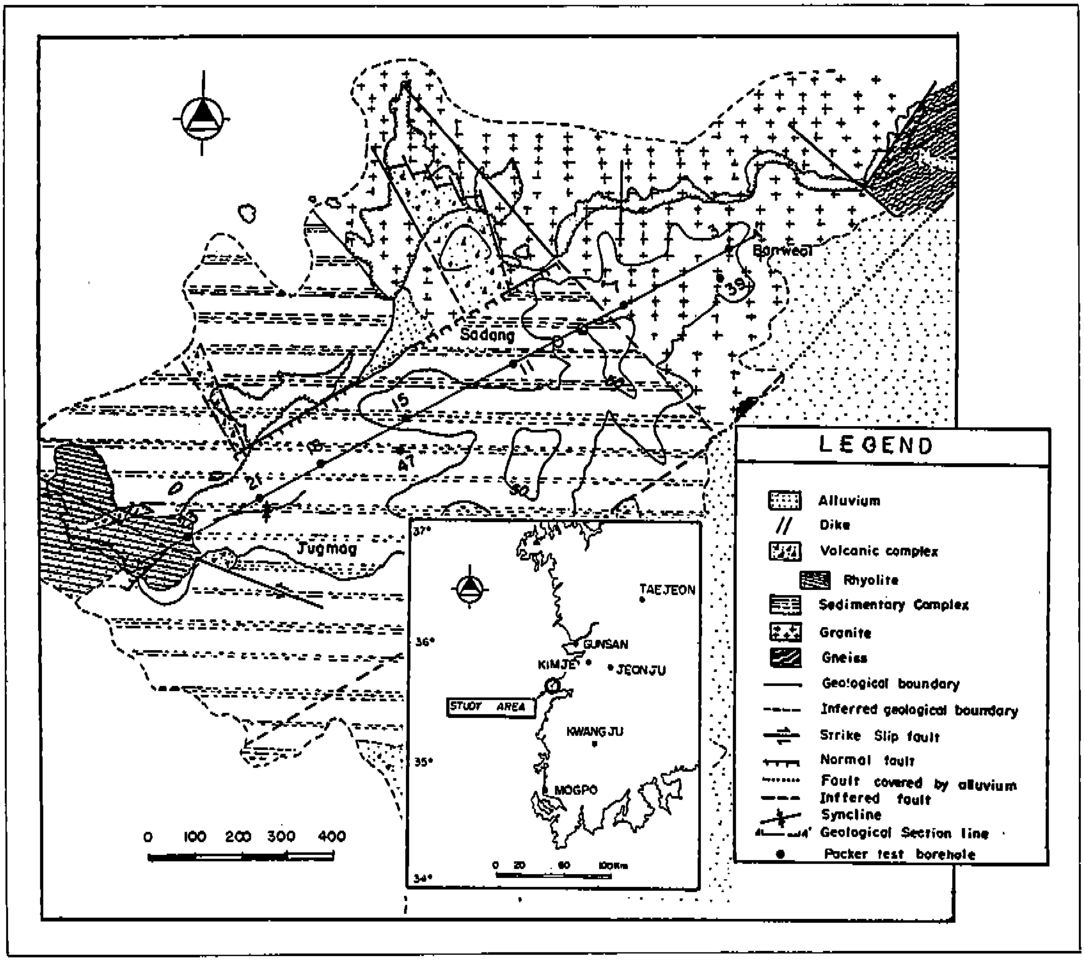

Fig. 1 Location and Geologic Map of Study Area

in 3 holes in granite and 4 holes in sedimentary rock and totally 175 test data were collected.

The hydraulic conductivity from field data in this area were estimated by using Thiem's equation (1).

$$K = \frac{2.3\ Q}{2\ LH} \ln \frac{L}{R} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

Where K : hydraulic conductivity (cm/sec)
Q : Volume flow rate (cm^3/sec)
L : Length of packer (cm)
H : Head (cm)
R : Radious of hole (cm)

Hydraulic conductivity and Fracture frequency value

The number of joint set suggested by Barton, which is an function of six parameter for the rock mass quality, was obtained through measurement of 13 core samples of granite, 24 of metamorphic rocks and 9 of sedimentary rocks. It is modified to fracture frequency values to apply drilled core sample. It is assumed that two joints developed parallel to each other can be defined a perfected joint set. Following description shows the numerical joint frenquency value and joint set number.

Fig.2 indicates hydraulic conductivity related to fracture frequency in the bedrocks. The higher value of fracture frequency is, the higher hydraulic conductivity coefficient is. If fracture frequency is an indicator of bulk-hydraulic conductivity, this suggests that such geologic structures as joints and faults as secondary porosities have water bearing capability in bedrocks and one should expect hydraulic conductivity

Descriptions of Joint	Number of joint set	Joint frequency value
massive, no or few joints	0.5~1.0	F1
one joint set	2	〃
one joint set plus random	3	F3
two joint set	4	〃
two joint sets plus random	6	F6
three joint sets	9	F9
three joint sets plus random	12	F12
four or more joint sets, random		〃
heavily jointed "sugar cube" tec.	15	F15
crushed rock, earth like		〃

to increase with fracture density. Even the fact that the higher frequency value correlates with the higher permeability is shown in Fig.2, it is dangerous to accept a direct relationship between fracture density and hydraulic conducti-

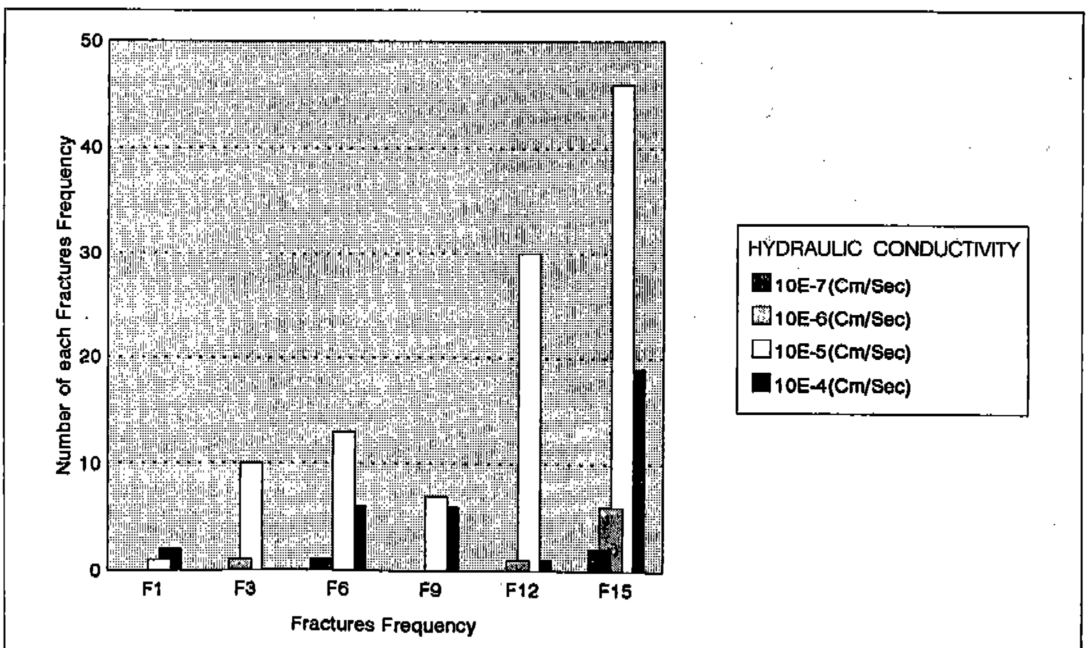

Fig. 2 Relationship between Fracture Frequency and Hydraulic Conductivity

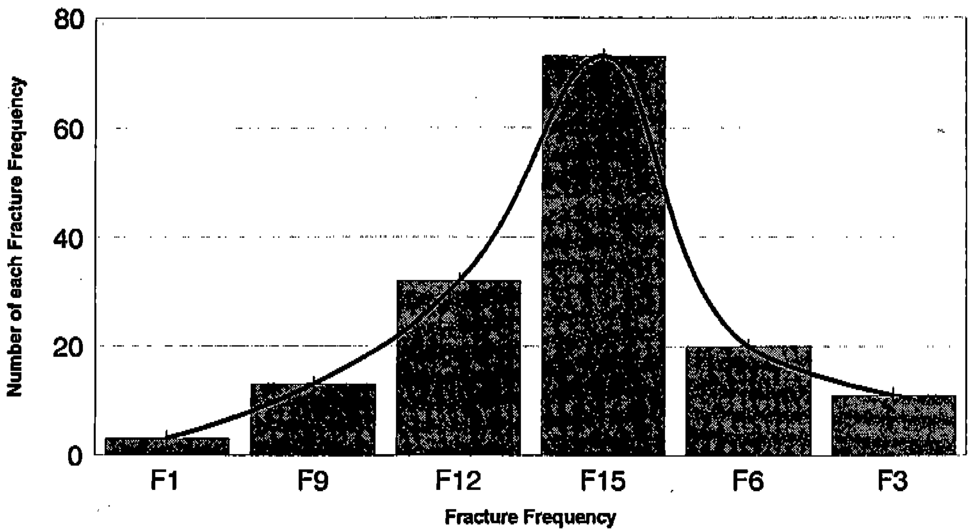

Fig. 3 Distribution of Fracture Frequency Values

vity at this area. Average value of hydraulic conductivity in this area as the representative one is estimated to 1×10^{-5}cm/sec statistically. This is correlated with the hydraulic conductivity measured at the location of fracture frequencyy value of F15 and F15 of fracture frequency shows the highest number of fracture frequency in this area As showing in Fig.3.

Thus F15 is equivalent to the representative fracture contributor quantitatively to hydraulic conductivity of this area for engineering purpose.

Hydraulic conductivity and Depth

It is shown in Fig.4 that the hydraulic conductivity is inversely propotional to depth in this area. Such a relationship can be suggested that the frequency of fractures developed in bedrocks decreased with depth. Main contributor of F15, the highest frequency of fracture, is rapidly decreased with depth as shown in Fig.5. In other word, such fractured rocks could not be considered to be water bearing formation by fractures as secondary porosities. The vertical distribution of groundwater in this area decreased with depth dependently by the decrease of fracture frequency.

Groundwater movement in the area

Groundwater monitoring was carried out to analize groundwater movement and flow direction and its levels not only by the method of installation of piezometer but also by periodical

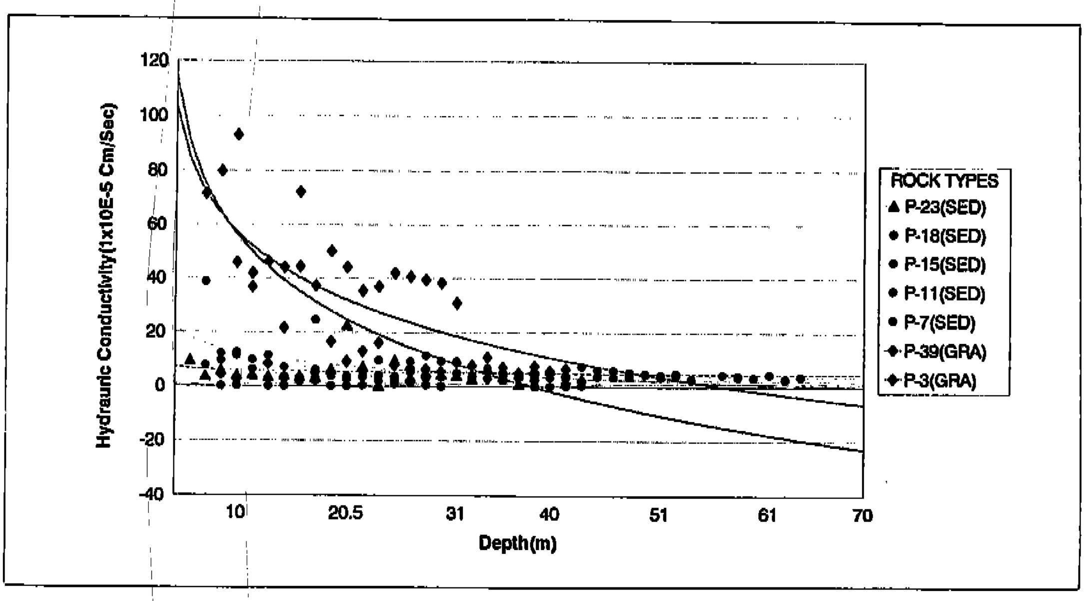

Fig. 4 Relationship between Depth and Hydraulic Conductivity

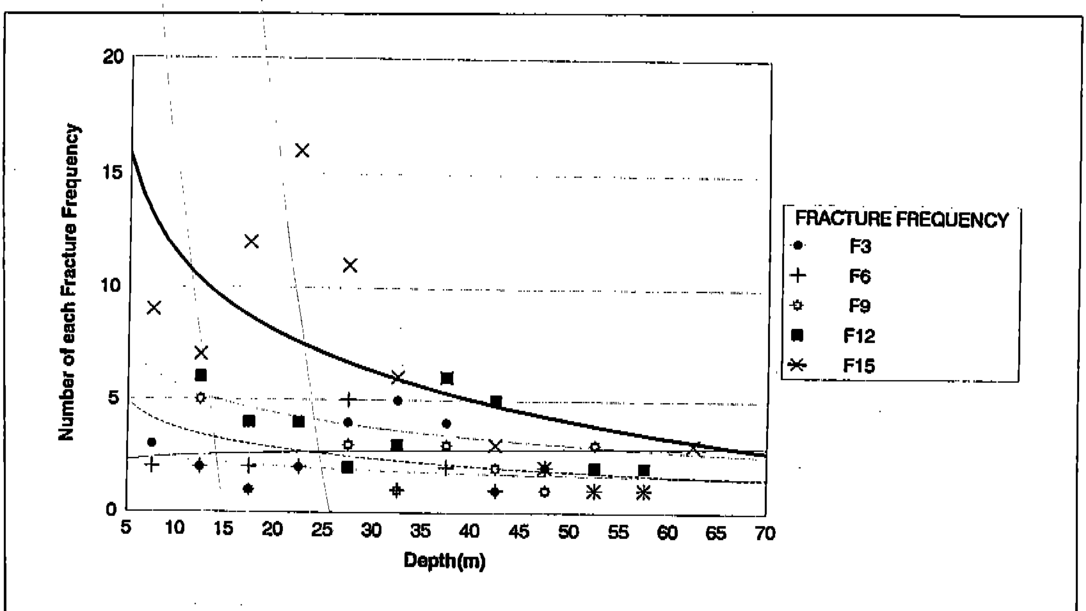

Fig. 5 Relationship between Fracture Frequency and Depth

reading of piezometric level in open hole. Piezometers placed in drilled holes are commonly constructed with impervious casing or tube. Groundwater contour lines were drawn directly from the recording data of groundwater level measurement for three months periocially.

The Fig.6(a) shows the approximate average groundwater elevations. The contours reflect a subdued replica of ground surface morphology.

Fig.6(b) shows that in the northern mountainous part of the area, the granite is bounded with sedimentary rock by fault. Open fault may collect the water from the soil zones, joints and also weathered zone and serve as a main drain to lower elevation.

The sedimentary rock is less permeable than the granite except several meters from surface and so do not have water bearing characteristics because is no typical recharge area. Furthermore all the joints through the formation are as mainly horizontal fractures and may be closed by increasing lithologic pressure. Whereas, granite mass has water bearing characteristics due to recharge through the falut plane and permeable owing to development of joints and weathered zone of the upper part of rock mass. The different hydraulic conductivity between the two rock types gives rise a great difference in groundwater level, showing in Fig. 6(b), groundwater level drops very abruptly about 40m.

Even though the faults within the rhyolite in the southern flatter part of the area and within granite in northern part of this area exist, there is no difference in groundwater

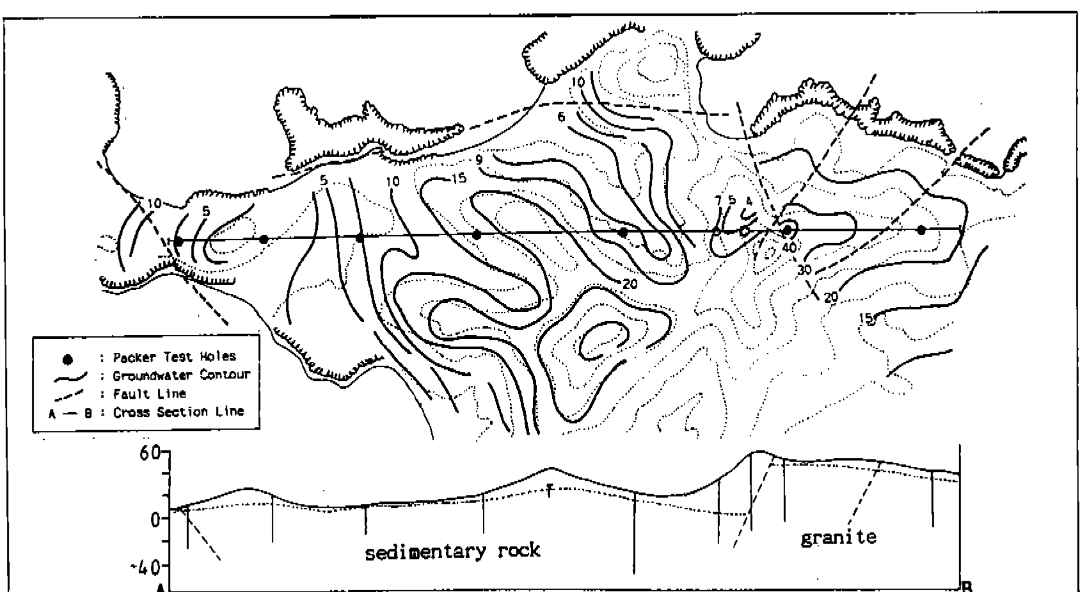

Fig. 6 Gruoundwater Contour map(a) and cross section(b)

level as Fig.6(b) because of that the hydraulic conductivity of rock masses of which both side are bounded by fault planes could not be changeless.

Conclusion and Discussion

The groundwater conditions of the bedrocks of the this area compared with geologic structures ;

(1) The fractured bedrocks in this area have the average hydraulic conductivity of 1.0×10^{-5} cm/sec. This value is coincidentally correlated with the fracture frequency value of F15. (2) Hydraulic conductivity in the area is propotional to number of fracture frequency. It suggests that the more development of joints, the higher hydraulic conductivity in the bedrocks in this area. Hydraulic conductivity is inversely propotional to depth. It also suggests that the hydraulic conductivity should be decreased with the depth because of not only entirely closed joints by increasing of geostatic pressure but also decreasing of fracture frequency. (3) The contour of groundwater levels reflects a subdued replica of the ground surface morphology. The change of lithologic boundary caused by fault made the different hydraulic conductivity in both rock masses and made a different flow pattern and the distribution of groundwater level changeable.

A relationship between the fracture frequency and the flow properties in fractured rock is definitely not able to be determined by limited factors. However, the comparision of measured hydraulic conductivity to fracture density shows obviously a certain of relationship. Therefore, If the fracture geometry is well defined in the limited area, groundwater bearing characteristics in the fractured rock can be interpreted by using fracture geometry models which provides the basis for estimation of fluid velocity distribution in the fractured rock mass.

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