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Ages of Some Precambrian Metamorphic Rocks in North China

By

Takeru YANAGI and Masaru YAMAGUCHI

Abstract

Rb-Sr age determination is undertaken on minerals and whole rock samples of crystalline rocks collected from several localities in the Precambrian Platform of North China. Results are 1874 m.y. for the biotite augen gneiss, 1405 m.y. for the biotite muscovite gneiss, 1401 m.y. for the muscovite biotite microcline gneiss, 1430 m.y. for the biotite hornblende schist and 183 m.y. for the biotite hornblende andesite.

Three distinct epochs of metamorphism with acid igneous activities of every 500 m.y. may be distinguished in the Precambrian history of the North Chinese Platform by compilation of previous age data together with the results of this paper.

Introduction

Precambrian rocks are widely exposed in North China. Stratigraphic aspects of these rocks have long been studied since the work of WILLIS and BLACKWELDER in 1904. Now the geological history and the petrological characters of the Precambrian Platform in China are getting clear by the workers in China (e.g. MA et al., 1963; LI et al., 1963; WANG, 1963; CHENG et al., 1964) and in U.S.S.R. (e.g. VINOGRADOV et al., 1962) with the aid of the age determinations, most of which were done by the K-Ar method.

The knowledge of the Chinese Platform is very interested in Japan, because there is a controversy about the possibility of existence of the continental crust under the Paleozoic eugeosynclinal deposits of the Japanese Islands. These islands are constructed between the stable Chinese Platform and the Pacific Ocean. This problem has recently been discussed by MATSUMOTO et al. (1968), through radiometric dating of crystalline rocks which are presumed to be Precambrian in age by several workers in Japan. And they concluded that little evidence is available to support a view that the Pre-Sinian rocks, if ever existent, have remained unaltered under such a polycyclic orogenic zone as that of Japan.

In this paper several Rb-Sr age determinations were made on crystalline rocks from the Chinese Platform to contribute for the solution of the Precambrian history. The samples used in this experiment, which belong to the collection of the late Prof. T. TOMITA of Kyushu University, have been obtained by field works of Prof. S. MATSUSHITA of Kyoto University, Prof. T. ISHIKAWA

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of Hokkaido University and Dr. K. MATSUDA of Yokohama City.

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Geological relations

The structural development of the Precambrian system in the Chinese Platform was summarized by MA and others (1963). Age determinations for the crystalline rocks were made by LI (1963), CHENG and LI (1964), CHENG and others (1964) and VINOGRADOV and TUGARINOV (1962). Age studies are now in progress at the Laboratory of the Absolute Age Determination, Institute of Geology, Academica Sinica.

Recent knowledges of the Precambrian system in Eastern China were reviewed and summarized by YAMASHITA (1965). Before these workers, TOMITA (1942) studied petrologically on the crystalline rocks of the Pre-Sinian system of the Chinese Platform and distinguished three stages of intrusion of granitic rocks before the deposition of the Sinian system.

According to those works of MA and others (1963) and CHENG and LI (1964) (cf. YAMASHITA, 1965), the geology of the Chinese Platform is as follows.

The most ancient rocks of the Chinese Platform are crystalline rocks represented mainly by biotite granulites, biotite hornblende gneisses, pegmatites and migmatitic granites which belong to the Taishan group in Shantung, Anshan group in Liaotung and Tengfeng group in Shansi respectively. These groups are composed of the lower formation of metamorphosed basic volcanic rocks, the middle formation of metamorphosed calcareous sedimentary rocks or basic volcanic rocks, and the upper, metamorphosed fine sedimentary rocks with lenticular marbles. There are interbedded thick layers of banded iron ore deposits at different horizons. These formations are displaced by the intrusion of granites.

Younger formations, deposited upon the peneplane surface of the older crystalline rocks above mentioned, are composed of crystalline schists and mica gneisses with abundant carbonate rocks. The formations are divided into two, the Wutai group and the Jianping group, both cropping out in the region of Wutaishan in Shansi. The Wutai group is a eugeosynclinal deposits with metamorphosed basic subaqueous volcanic rocks, while the Jianping group is a miogeosynclinal deposits with clastic sedimentary rocks and abundant carbonate rocks. These formations are displaced subsequently in various places in the Chinese Platform by the intrusion of granites and pegmatites. Some of these granites are called the Taoke granites in Shantung.

On the intensively eroded surface of these basement rocks, in the various regions of the Platform, there are relatively weakly metamorphosed Huto and mostly non-metamorphosed Sinian sedimentary rocks. The Huto group occupies an intermediate stratigraphic position between the crystalline rocks of the Wutai group and the Sinian deposits. This group is composed of conglomerates, sandstones and slates in the lower part, slates and carbonate rocks in the middle, and clastic sedimentary rocks sometimes accompanying intermediate volcanic rocks in the upper. Subsequent acid intrusions are common with local migmatization. In the region of Wutaishan, a part of the Huto group, which is composed of a sequence of schistose conglomerates, schistose sandstones, quartz sericite schists with conglomerates, quartzites and green schists in ascending order, was once designated as indepedent group, i.g. the Sitai group (TOMITA, 1942, VINOGRADOV et al., 1962). These formations are intruded by the Beitai granites.

The Sinian deposits are non-metamorphosed or weakly metamorphosed sedimentary rocks with abundant limestones and dolomites containing *Collenia* relicts. The Cambrian sedimentary rocks rest on this group with or without eroded surface.

Ages of the Precambrian rocks of the Chinese Platform were determined extensively by the K-Ar and the U-Th-Pb methods by workers in China and in U.S.S.R. A histogram of the ages of the rocks is shown in Fig. 4, including our results of measurements on rocks of the Wutai group and the Jianping group.

Based on these age determinations, MA and others (1963) divided the Precambrian history of the tectonic development of the Chinese Platform into four megacycles, that is, over 2400–2500 m.y., 2500–2400 m.y. to 1900–1800 m.y., 1900–1800 m.y. to 1400–1300 m.y., and 1300 m.y. to 600 m.y. These cycles correspond to periods of sedimentations and subsequent tectonic movements accompanied by regional metamorphism with magmatic activities of the following four groups, (1) the Taishan and the Anshan groups, (2) the Jianping and the Wutai groups, (3) the Huto group, and (4) the Sinian group respectively. In the region of Wutaishan, K-Ar ages for micas of the Wutai group and the Jianping group range from 2100 m.y. to 1700 m.y. K-Ar ages for muscovites and biotites of granites and pegmatites intruded into these groups range from 1860 m.y. to 1680 m.y. (VINOGRADOV et al., 1962). VINOGRADOV and the other (1962) gave a probable age of 1800 m.y. to these pegmatites and of 2200 m.y. as the metamorphic age to the Wutai group. They also showed ages in the range of 1350 m.y. to 1650 m.y. for the Huto group, which were estimated from isotopic compositions of lead extracted from dolomites of the Huto group.

K-Ar age determinations were made on glauconites collected from various stratigraphic horizons of the Sinian system by the Laboratory of Absolute Age Determination in China (1965). The ages of these glauconites range from 1185 m.y. to 737–642 m.y. and the Sinian system was divided into three series, over 1150 m.y., 1150 m.y. to 1050 m.y., and 1050 m.y. to 740–642 m.y. The three series may be correlated to the Nankou series, the Chihsien series and the Chingpeikou series of KAO (1934) respectively (cited from MATSUSHITA, 1967).

Description of samples

Biotite augen gneiss (CHS-1)

The biotite augen gneiss is from the vicinity of the Mt. Beitai, Wutaishan in Shansi. This rock is dark coloured due to the abundance of biotite, and consists of biotite with a green axial colour, plagioclase, quartz and small amount of microcline. In the biotite a few inclusions of epidote and apatite are present. Most of the crystals of plagioclase are 0.3 to 0.5 mm in diameter and are oligoclase (An_{15}) in composition. Some of the plagioclase crystals of diameter of about 5 mm are porphyroblastic with abundant inclusions of epidote and biotite. The microcline is among the common constituent minerals. Trace amount of apatite and sphene are also present. No sign of alteration of the minerals is found.

Biotite muscovite gneiss (CHS-2)

The biotite muscovite gneiss is from Huyukou, Wutaishan in Shansi. This rock consists of biotite, muscovite, microcline, plagioclase and quartz. This rock has a distinct banded structure composed of reddish bands rich in quartz and feldspar and dark bands rich in biotite and muscovite. The biotite and the muscovite occur in nearly equal amount, arranged parallel with each other and make a good foliation. The biotite shows a greenish brown axial colour. It is sometimes altered to chlorite. A very characteristic feature of this rock is the presence of dusty inclusions of fine minerals in quartz which occur abundantly in the central part, but are less abundant or absent in the periphery. The plagioclase is usually free from inclusions. However, some relatively large crystals of the plagioclase include small grains of biotite and muscovite. Plagioclase and microcline are the major constituent minerals of this rock, occurring in nearly the same amount. The crystals of the plagioclase are 0.5 to 0.15 mm in diameter and are oligoclase in composition with faint zonal structures. Trace amounts of apatite, epidote and sphene are also present.

Muscovite biotite microcline gneiss (CHS-3)

The muscovite biotite microcline gneiss is from Huyukou, Wutaishan in Shansi. This rock consists of muscovite, biotite, microcline, plagioclase and quartz, showing a distinct banded structure. The bands rich in quartz and feldspar present a reddish colour. The biotite and the muscovite occur as small flakes and in a less amount. The biotite presents a greenish brown axial colour. It is sometimes altered to chlorite. Grains of the plagioclase are 0.7 to 0.05 mm in diameter and are oligoclase (An_{15}) in composition. The microline is the major constituent minerals of this rock with the distinct microline-perthite structure. Quartz crystals are streched parallel to the foliation, having the same characteristic inclusions as those of the biotite muscovite gneiss (CHS-2).

Biotite hornblende schist (CHS-4)

The biotite hornblende schist is from Yantou, Wutaishan in Shansi. This rock consists of brown biotite, hornblende and plagioclase, showing a distinct banded structure. The biotite is coarse grained, brown in axial colour, with distinct pleochroic halos around the inclusions of epidote. The flakes of biotite arranged parallel with one another and make a good foliated structure. No sign of alteration of the biotite is found. The hornblende has a distinct zonal structure. The colour is bluish green in the Z axis, and is deeper near the periphery than in the central part. Most of the hornblende crystals are pophyroblastic and contain small inclusions of epidote, calcite, biotite and rutile. The grains of plagioclase, 0.5 to 0.05 mm in diameter, are albite showing a very faint zonal structure. A small amount of calcite, epidote, rutile is also present in this rock.

Biotite hornblende andesite (CHS-5)

The biotite hornblende andesite is from Wutaishan in Shansi. This sample has phenocrysts of green biotite, plagioclase, apatite and hornblende. The hornblende is completely altered to aggregates of chlorite and calcite. The phenocrysts of the plagioclase are also altered to those of chlorite, calcite and albite. The biotite has many inclusions of magnetite and is changed to chlorite near the periphery. Plagioclase in the groundmass is fairly saussuritized. Calcite and chlorite are abundant as the result of alteration of plagioclase and hornblende.

Biotite gneiss (KS-1)

This sample is from Haeju, Huanghaedo, central Korea. This rock consists of reddish brown biotite, microcline, plagioclase and quartz. The biotite occurs as small flakes and in a little amount. It is sometimes altered to chlorite. The biotite contains many inclusions of magnetite. Distinct pleochroic halos are observed around inclusions of zircon. The plagioclase, occurring as grains of 0.2 to 1 mm in diameter, is oligoclase in composition, showing a dinstinct zonal structure. Most of the plagioclase crystals are fairly saussuritized. Muscovite and calcite recognized in a small amount are regarded as the products of alteration from the plagioclase. The microcline is the major constituent of this rock. It has no sign of alteration. Quartz shows a mosaic texture. The distribution of the same dusty inclusions in the quartz as mentioned before (cf. CHS-2) has no correlation to the grain boundary of the minerals and seems to indicate a texture of the rock before the recrystallization. Apatite and epidote are also present as minor constituent minerals.

Preperation of samples and chemical treatment

A rock sample is crushed into grains of 1 to 0.5 cm in size. A reduced aliquot is cleaned with hot non-mineralllized water, and then recrushed with a steel mortar. The powder is then ground with an agate mortar and used as a whole rock sample. The rest of the sample is crushed with the steel mortar to pass through the sieve of 80 mesh. The fine powder is poured off with distilled

Table 1. Rb-Sr analytical data

Sample	Rb^{87} μmol/g	Rb ppm	Sr^{86} μmol/g	Sr ppm	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
Biotite augen gneiss (CHS-1)						
Coarse biotite	2.72	836	0.0266	29.9	102.3	3.400 ±0.009
Coarse biotite	2.77	849	0.0315	34.2	88.0	3.013 ±0.009
Fine biotite	2.72	836	0.0424	43.8	64.2	2.374 ±0.007
Whole rock	0.600	184	0.653	581	0.92	0.7211±0.0014
Biotite muscovite gneiss (CHS-2)						
Biotite	2.24	686	0.0130	15.3	172.6	4.078 ±0.012
Muscovite	1.39	427	0.0245	24.1	56.8	1.809 ±0.004
Whole rock	0.328	101	0.0190	169	1.73	0.7390±0.0014
Muscovite biotite microcline gneiss (CHS-3)						
Whole rock	0.495	152	0.0204	19.0	24.3	1.177 ±0.003
Biotite hornblende schist (CHS-4)						
Biotite	0.666	204	0.00757	7.88	88.0	2.469 ±0.007
Plagioclase	0.0793	24.3	0.776	689	0.102	0.7029±0.0010
Whole rock	0.1738	53.4	0.523	465	0.332	0.7106±0.0010
Biotite hornblende andesite (CHS-5)						
Biotite	1.036	318	0.170	151	6.10	0.7224±0.0014
Non-magnetic fraction	0.315	96.6	1.10	973	0.287	0.7076±0.0014
Biotite gneiss (KS-1)						
Biotite	3.68	1130	0.00471	8.79	782	11.97 ±0.03

water. Biotite and muscovite are separated with a Frantz isodynamic separater. Sometimes biotite and muscovite are separated from other minerals by tapping on a paper. Biotite and muscovite are ground carefully in the agate mortar with alcohol to eliminate inclusions, the fine powder is then poured off with distilled water. After dryness, separations are repeated with the isodynamic separator. After the separation, the samples are cleaned with non-mineralized water.

Although most of the chemical treatments are same as those of YAMAGUCHI and others (1969), some improvements are added to the analysis of rubidium. Concentrations of rubidium and strontium are determined separately, using different samples. About 0.04 to 0.1 g of sample is taken into a teflon beaker, added appropriate amount of tracer solution of rubidium 87 and decomposed with hydrofluoric and perchloric acids. After the decomposition, a drop of sulfuric acid is added to the sample to convert it to sulphates. Free sulfuric acid remaining in the sample is eliminated and then the concentration of rubidium of the sample is determined with a Hitachi RMU-5G mass spectrometer with a 20 cm analyzer tube.

About 0.1 to 0.5 g of sample is used for the analysis of strontium. Strontium is determined by the isotope dilution method, using a mixed strontium 84+86 tracer. The detail chemical procedure for the determination of concentrations and isotope ratios of strontium of the samples have been described elsewhere (YAMAGUCHI et al., 1969).

Result of the Chemical analyses

Concentrations of rubidium and strontium, and isotope ratios of strontium 87 to 86 are given in Table 1. Ages for minerals and a rock are shown in Table 2 and Figs. 1, 2 and 3. In order to eliminate unpredictable isotope fractionation effects all measured isotope ratios of strontium 87 to 86 are normalized, on the assumption that strontium 86/88=0.1194 by the method of YAMAGUCHI and others (1969). Ages are calculated using the decay constant of 1.39×10^{-11}/year for rubidium.

The chemical analysis is made twice on coarse grained biotite of the biotite augen gneiss (CHS-1). The concentrations of rubidium and strontium are not convergent and differ over analytical errors as shown in Table 1. But these two different values and the results of fine biotite and a whole rock sample of the biotite augen gneiss lie on an isochron, giving an age of 1874 m.y. Therefore the difference of the concentrations of rubidium and strontium between the two coarse biotite analyses may be attributed to the amount of inclusions of apatite or other minerals, or to the inhomogeneity of composition of the biotites. Results of the analysis of biotite, muscovite and a whole rock sample of the biotite muscovite gneiss (CHS-2) give an isochron age of 1405 m.y..

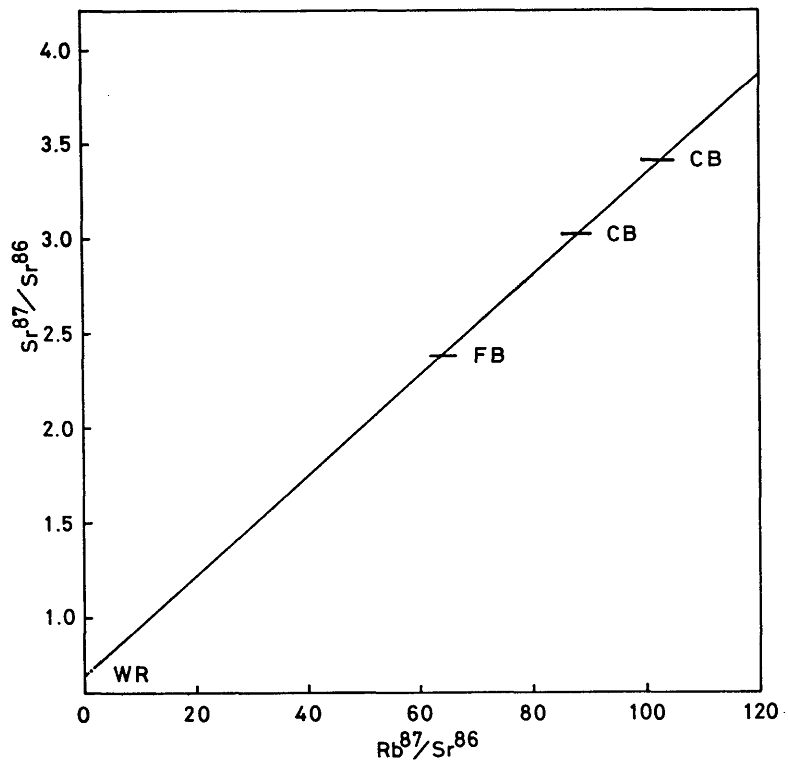

Fig. 1. Rb-Sr isochron diagram for the biotite augen gneiss (CHS-1). The slope gives an age of (1874±65) m.y. with an initial $Sr(87/86)_0=$ 0.697±0.005. Samples CB, FB and WR are coarse grained biotite, fine grained biotite and a whole rock sample respectively.

As the rock sample of the muscovite biotite microcline gneiss (CHS-3) is too small in amount and the amount of biotite separated are not enough for the chemical analysis, concentrations of rubidium and strontium and a isotope ratio of strontium 87/86 of the biotite are not available. However, the rock contains very small amount of strontium, and has a high ratio of strontium 87/86 (Table 1), the contribution of a error in estimation of the initial strontium 87/86 ratio to an age of this rock would be small. The initial ratio of strontium in this rock is assumed to be 0.700 and the age calculated is 1401 m.y..

Results of analysis of biotite, plagioclase and a whole rock sample of the biotite hornblende schist (CHS-4) are shown in Table 1. These results lie well on an isochron and give an age of 1430 m.y. which is somewhat older than the ages of the biotite muscovite gneiss (CHS-2) and the muscovite biotite microcline gneiss (CHS-3).

Large phenocrysts of biotite are present in the biotite hornblende andesite (CHS-5). Since the andesite is fairly altered, a whole rock sample was not analyzed. The plaioclgase is altered to the aggregates of albite, calcite and chlorite. Analyses have been undertaken on the purified biotite phenocrysts and a non-magnetic fraction composed of altered plagioclases, apatites and calcites. These minerals give an isochron age of 183 m.y.

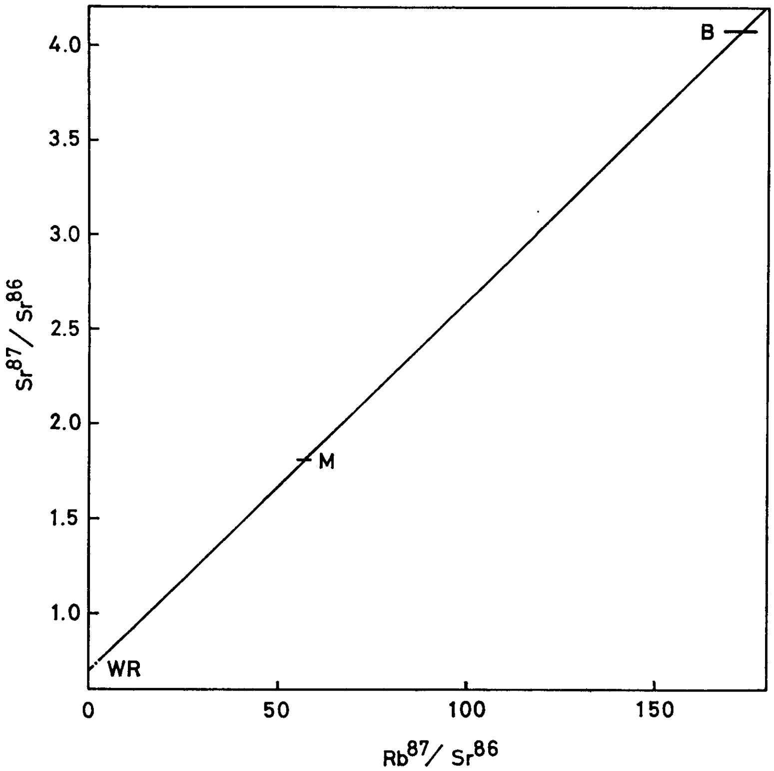

Fig. 2. Rb–Sr isochron giagram for the biotite muscovite gneiss (CHS-2). The slope gives an age of (1405±47) m.y. with an initial $Sr(87/86)_0 = 0.703 \pm 0.002$. Samples B, M and WR are biotite, muscovite and whole rock samples respectively.

Table 2. Rb-Sr ages of crystalline rocks from the Chinese Platform

No.	Rock	Sample	Rb-Sr age (m.y.)	$(Sr^{87}/Sr^{86})_0$
CHS-1	Biotite augen gneiss	Coarse biotite, Fine biotite, Whole rock	1874±65	0.697±0.005
CHS-2	Biotite muscovite gneiss	Biotite, Muscovite, Whole rock	1405±47	0.703±0.002
CHS-3	Muscovite biotite microcline gneiss	Whole rock	1401±52	0.700*
CHS-4	Biotite hornblende schist	Biotite, Plagioclase, Whole rock	1430±45	0.702±0.002
CHS-5	Biotite hornblende andesite	Biotite, Non-magnetic fraction	183±38	0.707±0.002
KS-1	Biotite gneiss	Biotite	1029±42	0.70*

* Estimated

As the rock specimen of the biotite gneiss (KS-1) is small, all of the sample is used for the separation of biotite. The age is 1029 m.y. But as mentioned previously, this rock is so much altered that the meaning of this age cannot be properly interpreted.

Discussion of the results

The age of 1874 m.y. for the biotite augen gneiss (CHS-1) is very consistent with those of VINOGRADOV and TUGARINOV (1962) for pegmatites intruded into the Wutai group. However, as mentioned previously, no sign of alteration or recrystallization of minerals after the formation of this rock is found under the microscope. Therefore it is assumed that this rock is formed at almost the same time as the intrusion of the pegmatites. K-Ar ages of the Luliang group, the Jianping group and the Wutai group in Shansi were reported to be 1800 m.y., 2100 m.y., and 1700 m.y. + respectively (MA et al., 1963). These data are also consistent to the present result.

The whole rock sample of the muscovite biotite microcline gneiss (CHS-3) and the minerals of the biotite muscovite gneiss (CHS-2) give convergent ages of 1401 m.y. and 1405 m.y. respectively. The coincidence of the whole rock age and the mineral age of these two gneisses should be noted. The minerals of the biotite hornblende schist (CHS-4) give somewhat older age of 1430 m.y. than the gneisses above mentioned. These three data, however, would at least indicate the presence of metamorphism around the age of 1400 m.y.

According to MA and others (1963), the Huto group is intruded by basic igneous rocks in the region of Wutaishan. Intrusions of acid igneous rocks also took place widely after the deposition of the Huto group with local migmatization or granitization in the Chinese Platform. Some of them are pegmatites intruded into the Liaohe group in Liaoning, ranging from 1397 m.y. to 1422 m.y. in age, and those intrduded into the Luliang group in Shansi with an age of 1310 m.y. In the region of Wutaishan, the Beitai granite intruded into the formations of the Huto group, which were once considered as being separated from the Huto group and called the Sitai group. These formations are composed of chlorite

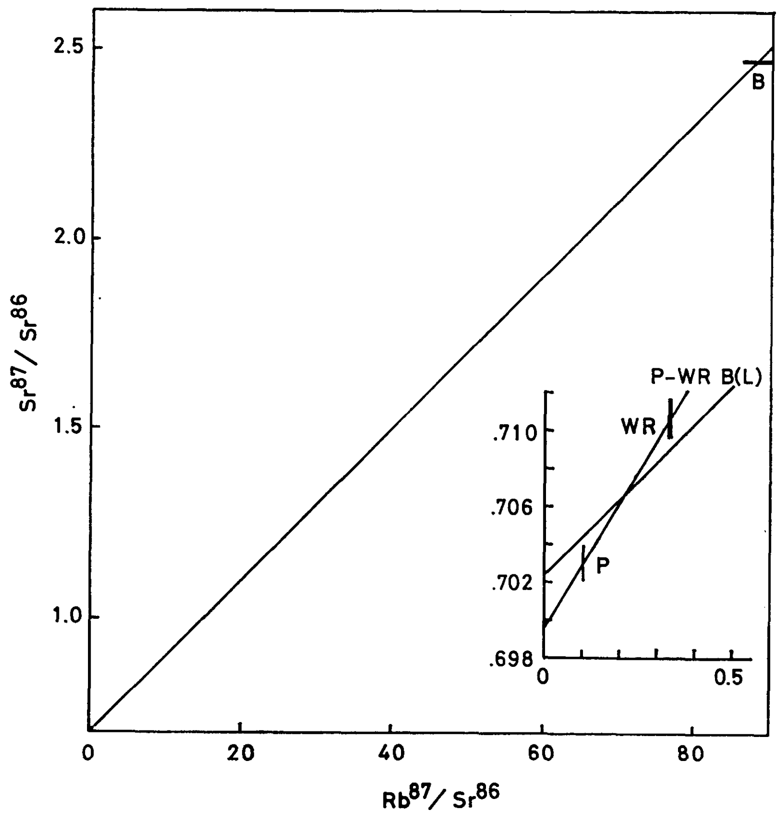

Fig. 3. Rb-Sr isochron diagram for the biotite hornblende schist (CHS-4). An isochron B(L) drawn for biotite (B), whole rock sample (WR) and plgioclase (P) by the least-squares method, gives an age of (1430±45) m.y. with an initial $Sr(87/86)_0=0.702\pm0.002$. An isochron (P-WR) drawn for whole rock sample (WR) and plagioclase (P), gives an age of (2400±800) m.y. with an initial $Sr(87/86)=0.700\pm0.002$.

schists, quartz sericite schists, schistose quartzites, schistose conglomerates and others (TOMITA, 1942). The geological evidence and the present results indicate the presence of metamorphism associated with widespread pegmatite activity around the age of 1400 m.y. in the Chinese Platform. Some crystalline schists and gneisses of the Wutai group and of the Jianping group must have been rejuvenated. As shown in Fig. 3, the Rb-Sr isochron for the whole rock and plagioclase samples of the biotite hornblende schist from the Wutai group gives an age of (2400±800) m.y. which is older than the isochron age of 1430 m.y. for the biotite, the plagioclase and the whole rock sample of the same rock calculated by the least-squares method. It is inferred that the biotite hornblende schist was poly-metamorphosed, in which the recrystallization was incomplete to homogenized the strontium isotope between the minerals of the plagioclase and the biotite. Therefore the biotite age of 1430 m.y. would probably indicate the age slightly older than the main event of the metamorphism.

The biotite gneiss (KS-1), from central Korea, with an age of 1029 m.y. is younger than those gneisses and crystalline schists in the region of Wutaishan. So far as the available age determinations on the Precambrian crystalline rocks in the Chinese Platform are concerned, the age around 1000 m.y. corresponds to the time of the deposition of the Sinian system. Crystalline rocks with the age of about 1000 m.y. are almost lacking in the Chinese Platform in North China excluding a case of a pegmatite of 739 m.y. in Liaoning (CHENG et al., 1964). CHENG and others (1964) found granites and syenites with ages ranging from 640 m.y. to 843 m.y. in Kiangsi and Yunnan, southern China.

The Shogen system in the region of Huanghaedo, central Korea, was studied by MATSUSHITA (1947), who correlated it to the Sinian system in North China. He found that the Shogen system is clearly intruded by gneissose granites with the foliation parallel to the general strike of the Shogen system in Huanghaedo. These geological relations indicate that the biotite gneiss is younger than those crystalline rocks in the region of Wutaishan, supporting the result of this paper. The age of 1029 m.y. for the biotite gneiss is inconsistent with the results of MEZHVILK (1961). He correlated some members of the Machenren series in

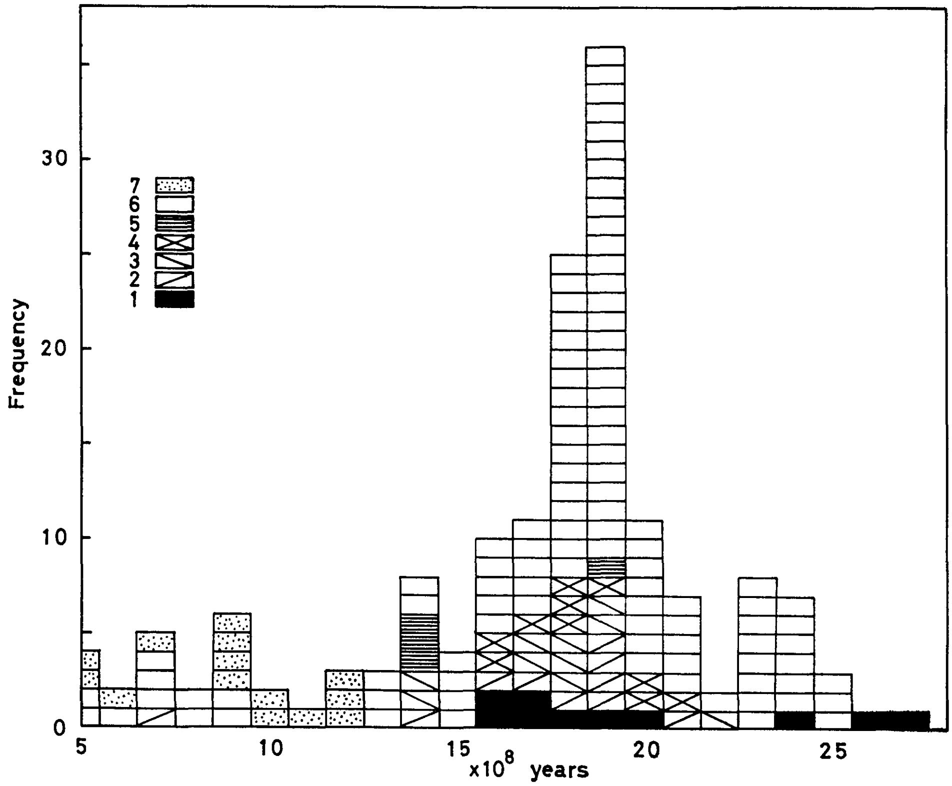

Fig. 4. Histogram of age data of crystalline rocks and sedimentary rocks from the Chinese Platform. 1: Pb^{207}-Pb^{206} age, 2: U^{238}-Pb^{206} age, 3: U^{235}-Pb^{207} age, 4: Th^{232}-Pb^{208} age, 5: Rb^{87}-Sr^{87} age, 6: K^{40}-Ar^{40} age, 7: K^{40}-Ar^{40} ages for glauconites from the Sinian system. All of ages excluding a case of (7) are for crystalline schists, gneisses, granites, and pegmatites.

northern Korea to the Sinian-Silulian deposits in Korea and those in northeast China, and concluded that the metamorphism of these members occurred during the time of late Paleozoic to early Mesozoic ages accompanying the intrusion of granites.

All of age data, now available, of the Precambrian crystalline rocks in China including the results of this paper are plotted in Fig. 4, along with those of glauconites from the Sinian system. Most of them were determined on biotites and muscovites with the K-Ar method in the laboratories of China and of U.S.S.R. Some of them were determined on zircons and monazites with the U-Th-Pb method. Although the available age data of the Precambrian rocks in the Chinese Platform are not enough to draw a conclusion, the histogram displays a characteristic pattern with a distinguished maximum frequency of age in the range of 1800 m.y. to 1900 m.y. and with smaller peaks in the range of 2300 m.y. to 2400 m.y. and around 1400 m.y. These three major peaks are periodically distributed with the interval of about 500 m.y. and are presumed to indicate epochs of metamorphism with acid igneous intrusions in the Pre-Sinina history of the Chinese Platform. It is also found that the younger Precambrian orogenic movements occurred outside the stable North Chinese Platform in southern China and in northern Korea. It is also noted that the epoch around 1400 m.y. indicates a local or weak metamorphism with the intrusion of granites and pegmatites and that it is correlated to probable Pb^{208}/Pb^{204} ages (1350–1650 m.y.) of the dolomites of the Huto group.

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Appendix

Anshan (鞍 山)	Beitai (北 台)	Chingpeikou (青北口)
Chihsien (薊 県)	Haeju (海 州)	Huanghaedo (黄海道)
Huyukou (狐峪口)	Huto (滹 沱)	Jianping (建 屏)
Kiangsi (江 西)	Liaohe (遼 河)	Liaoning (遼 寧)
Liaotung (遼 東)	Luliang (呂 梁)	Machenren (摩天岑)
Nankou (南 口)	Shantung (山 東)	Shansi (山 西)
Shogen (祥 原)	Sinian (震 旦)	Sitai (西 台)
Taishan (泰 山)	Taoke (桃 科)	Tengfeng (登 封)
Wutai (五 台)	Yantou (岩 頭)	Yunnan (雲 南)