American geologist who surveyed geology of Mongolia in the 19th century

Raphael Pumpelly

By

Yuhei Takahashi

Contents

- Personal history of Pumpelly
- On mineral “pumpellyite”
- History of geological survey in Mongolia
- What is geological mapping? (for non-geologists)
- **Pumpelly’s Travel in Japan, China and Mongolia**
- Appendix; Outline of geology and mineral resources in Mongolia

Pumpelly, Raphael (1837.9.8-1923.8.10)

- Born; Sep 8, 1837, Owego, New York
- Study; Graduated from Freiberg University of Mining and Technology in 1859
- In 1860, he was engaged in mining operations in Arizona. From 1861 to 1863, he surveyed Yesso Island (Hokkaido) of Japan and coal fields of northern China.
- After this, he surveyed the Gobi desert (Inner Mongolia) and explored Mongolia and Siberia.
- After visiting Mongolia, he became Professor of Mining Science at Harvard University, then, organized the Northern Transcontinental Survey, and then was appointed Director of the US Geological Survey, New England branch , in 1884.
- His exploration in Turkestan (1905) is generally more famous than exploration in Mongolia.

Pumpellyite

- This mineral occurs in the metamorphic rocks formed under low temperature and high pressure conditions. It also occurs at copper and manganese mineral deposits.
- This mineral was named after Pumpelly.

Loc. Higashi-chichibu village, Saitama Pref., Japan
Pale greenish gray colored fiber mineral is pumpellyte in gabbro of Mikabu Green Rocks.
Sample is 6 cm in width (left) and photo of mineral is 1.7 cm in width (right).

History of Geological Survey in Mongolia

– Epoch of hero –

- **R. Pumpelly** (USA): A geologist who traversed Mongolia in 1864. Before coming to Mongolia, he surveyed Hokkaido, north island of JAPAN.
- **V. A. Obruchev** (Russia):
  Surveyed Mongolia for 60 years since 1892. Published a complete geological map of Mongolia in 1957.

This map is exhibited in the museum in Mongolian University of Science and Technology. Photo by Takahashi. ↑

- **R. Ch. Andrews** (USA): Known for leading a series of expeditions into the Gobi Desert and Mongolia in the early 20th century.

Photo of Andrews. Cited from Wikipedia →

History of Geological Survey in Mongolia

- Under socialism -

- In 1925, Mongol Science Committee was settled in Russian Science Academy. Geological survey in western Mongolia commenced.
- In1939, Mining Mineral Resource Trust (Geological Survey) and Geological Institute in Science Committee (Science Academy in Mongolia) were established.
- From 1950 to1969, Zuun bayan oil field was in operation.
- In 1965, Sharin gol coal mine operation was started.
- Since1968, geological mapping has been developed.
- In 1978, Erdenet copper mine was established.
- In 1978, Baga nuul coal mine was started.

History of Geological Survey in Mongolia

-After Socialism, Cooperation with western countries-

- In ’90s Japanese organizations worked in Mongolia (GSJ, MMAJ, Hayashibara Museum).
- In 1992 Shivee Obo coal mine was started.
- Since 1997 foreign mining company investments became popular because of new mining law.
- Since 2002 prospecting in Oyu Tolgoi deposits has been started by Ivanhoe Mines, and since 2012 mining has commenced.
- Many countries are focusing on coal deposits of Tavan tolgoi coal field and others.
- Uranium deposits are also targets of foreign investments.

Location of Mongolia

Image of HP in MonMap

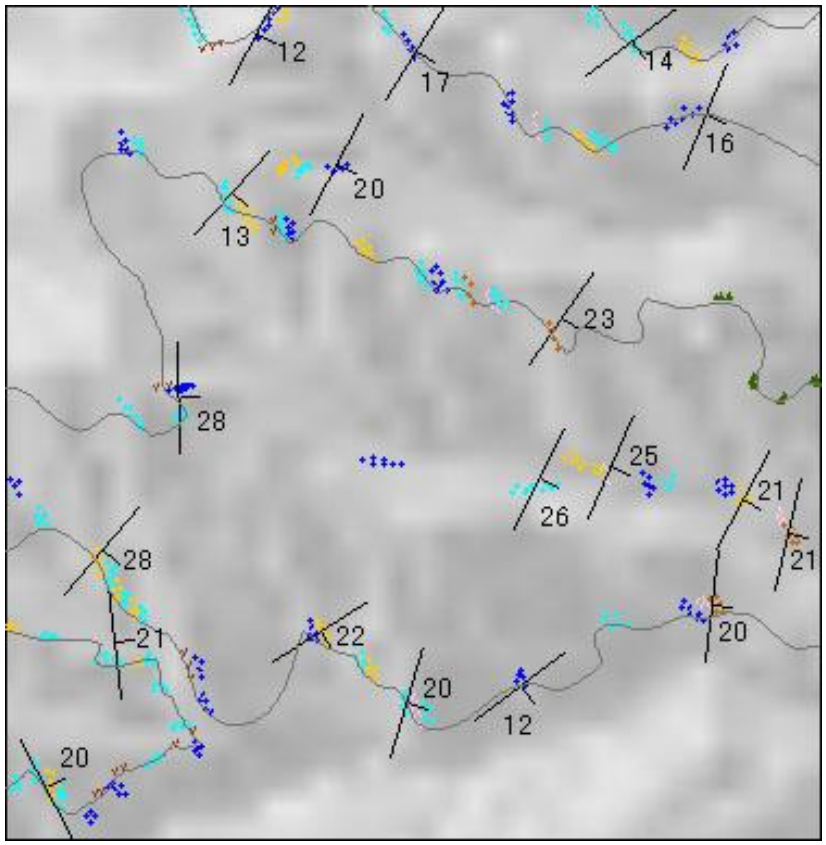
Mongolia bounds Russia in north and China in south.

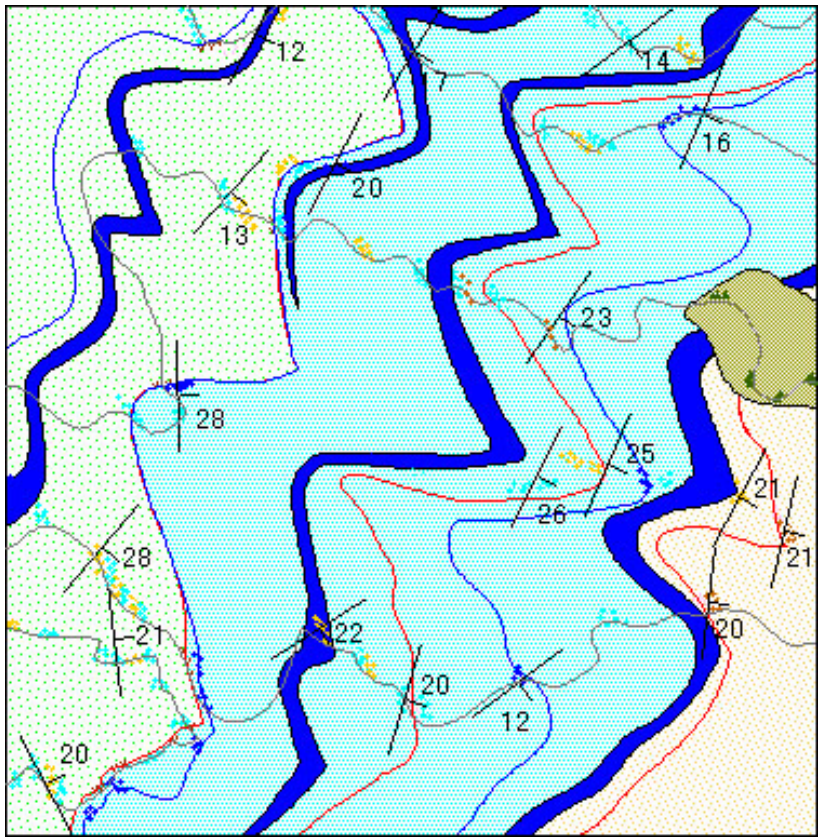
What is geological mapping?

Rock type, structure and mineralization are described in field.

The samples are analyzed by various laboratory works for more detailed description

Showing distribution of rock types and geological structure on map





This is **“Geological map”**. Prospecting area will be selected based on this map, . Then more detailed surveys will be done.

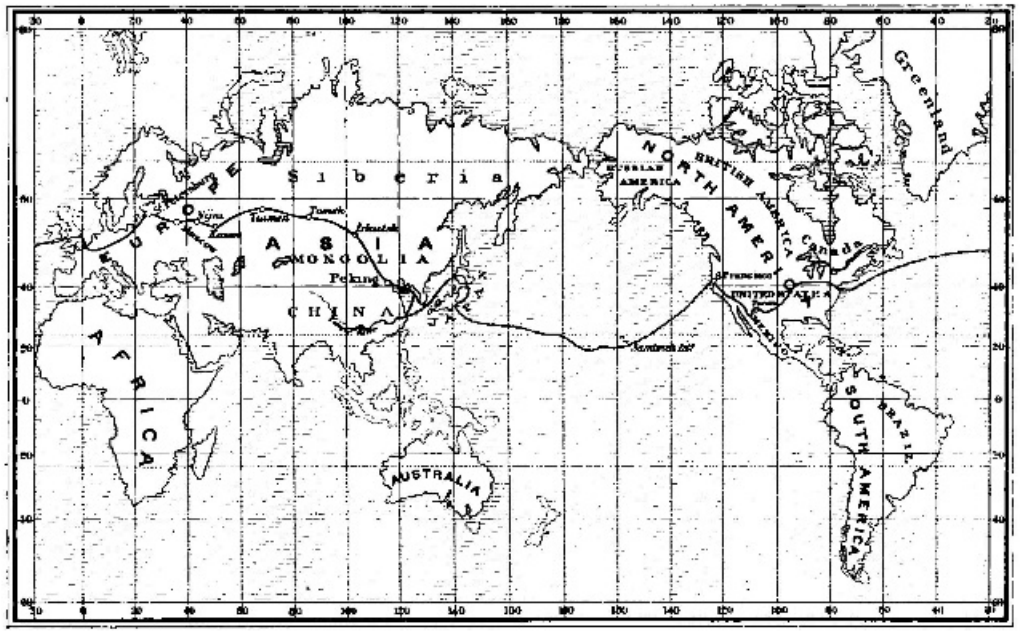
→ Please see examples of geologic maps and rock samples.

Research travel of Pumpelly

References

- Pumpelly (1867) Geological Researches in China, Mongolia, and Japan during the years 1862 to 1865. The Smithsonian Institution, 143 p, 9 plates.
- Pumpelly (1870) Across America and Asia: Notes of a Five Years' Journey around the World, and of Residence in Arizona, Japan, and China, 454 p.
- 藤川 徹・伊藤 尚武訳(1982)シュリーマン 日本中国旅行記／パンペリー 日本踏査紀行. 新異国叢書 第II輯 第6巻、350 p. Translation of Chapters of travelling in Japan in Pumpelly (1870).

Pumpelly's route from 1861 to 1866



- In 1861, Abraham Lincoln took office as President in US.
- In 1861, American Civil War started. (Until 1865)
- In 1862, Emancipation Proclamation was declared. (奴隷解放宣言)
- 1869, Transcontinental Railroad was opened.

Stay in Japan

Apr 23, 1861 (文久元年三月十四日)

Japanese Government asked US minister, Harris, to dispatch mining engineers for develop in Yeso (Hokkaido).

(箱館奉行村垣淡路守・津田近江守：蝦夷地における鉱山開発のため米公使 Harris に鉱山技師の周旋を依頼)

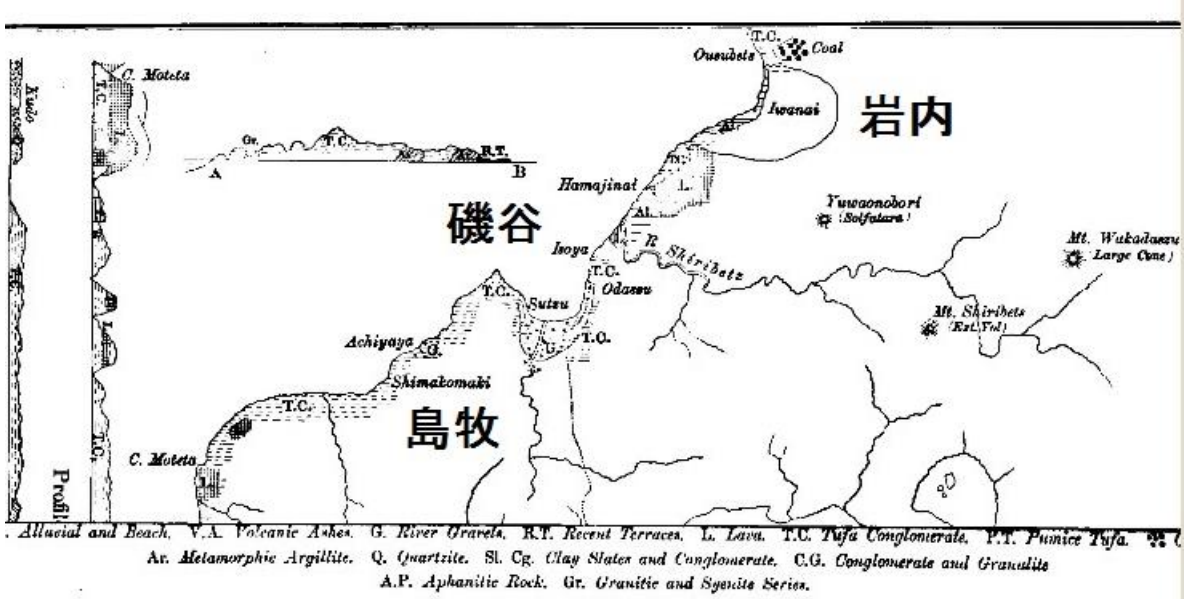
Nov 23, 1861 (文久元年十月廿日)

Blake and Pumpelly departed from US.

Pumpelly surveyed silver deposits in Arizona in 1861. Indian attacked the camp and he escaped to Mexico, then reached California. Pumpelly and Blake departed from California to Japan .

Stay in Japan

- On Feb 21, 1862 (文久二年一月廿三日) , Blake and Pumpelly arrived at Yokohama.
- On May 9, 1862 (同年四月十一日) , Blake, Pumpelly and Rice(US secretary) arrived at Hakodate.
- Field excursions were done.
- Mining school was opened.
- On Dec 4, 1862 (十月十四日), contracts of them was finished.



<u>Kayanuma Coal Mine</u>

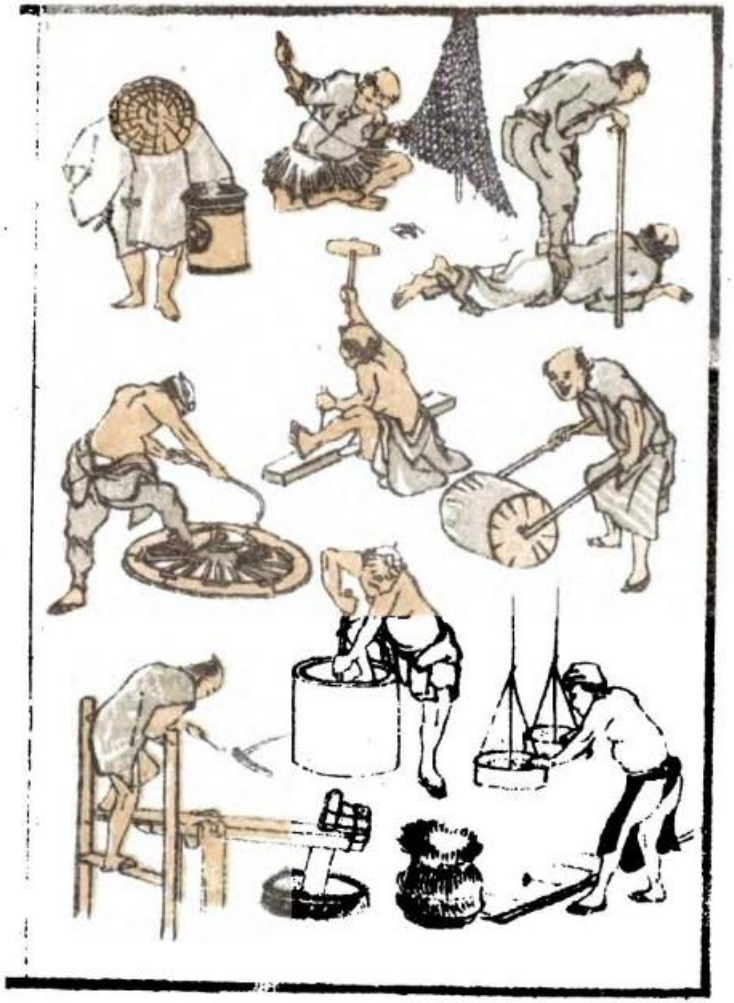
1856 Local people discovered occurence.

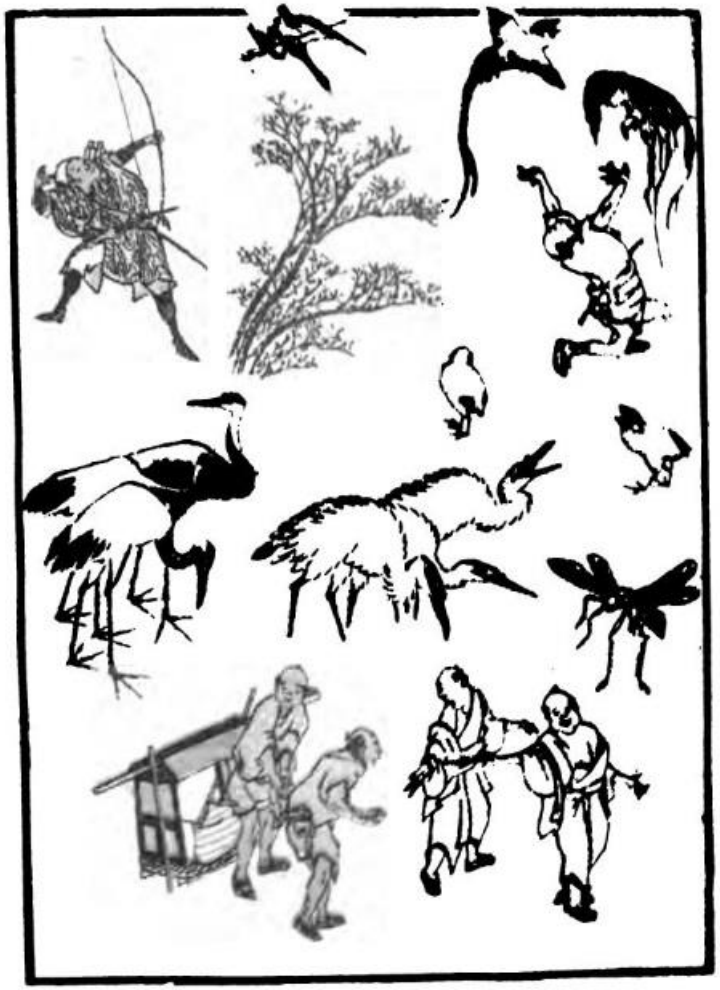
1862 Pumpelly confirmed that the coal in Kayanuma was good quality.

This mine closed in 1969.

Pumpelly (1867) reproduced woodprints.

He was interested in Japanese life style and culture.





To China

- End of Feb, 1863 (文久三年一月上旬)

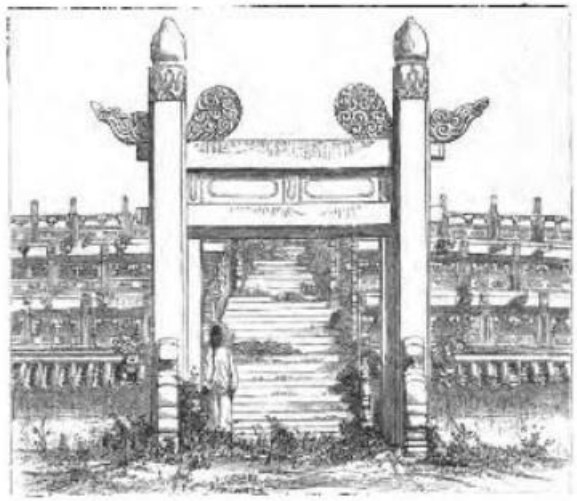
  Blake and Pumpelly arrived at Nagasaki. Blake and Pumpelly separated, and Pumpelly stayed in Nagasaki for a while before departure to China.

- End of March, 1863 (同年二月上旬)

  Pumpelly arrived at Shanghai. Then he went to the interior of China along the Yangtze River.

Pumpelly's Stay in China

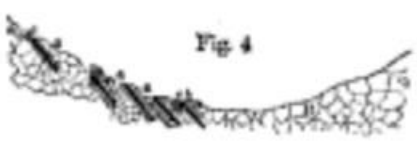
In1863, he surveyed the coal mines because of demand of Chinese government.



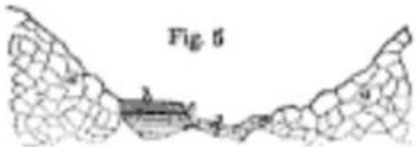
... Geological researches in China, Mongolia, and Japan, during the years 1862 to 1865 – Raphael Pumpelly

The coal is drawn out on sleds, by men, through *b* and *a*, only one-half the breadth of *b* being cut into steps for drainage.

Chingshui Mines.—These mines are in a narrow valley, about five miles W. N. W. of Chaitang, in the midst of the porphyry mountains. There seem to be several seams, but the confusion caused by the numerous dykes of porphyry is very great. In two of the seams the roof is formed by these dykes, at least for a considerable distance, while others are cut through by them, and in places only fragmentary portions of a seam, and its accompanying beds are left. Fig. 4 gives a general idea of the relation between some of the seams, and the porphyry as seen in the side of a mountain valley. Fig. 5 is a section of a fragment of the coal series only a few square



a. Porphyry. b. Coal series. c. Coal seams.



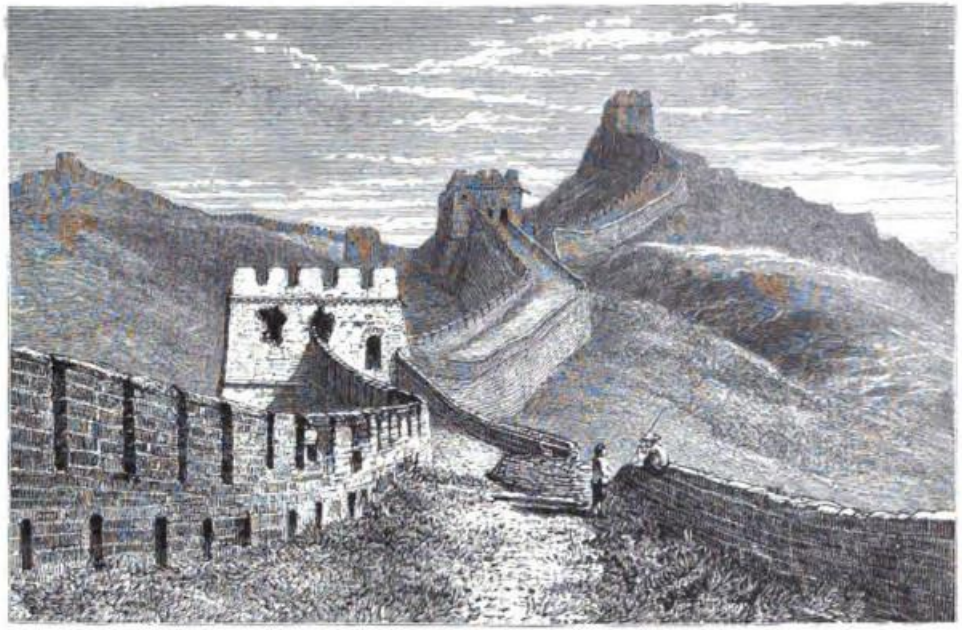
a. Porphyry. b. Coal series. c. Coal seam. d. Creek rubble.

rods in extent, cut off on one side by the porphyry, and on the other by the creek. The coal of this locality is very bituminous, and I failed, during my short visit, to find any indications of the metamorphism, often observed in the action of dykes on coal, especially where basalt has broken through tertiary brown coal formations.

Chiguhui Coal Mine

Travel in southern part of Mongolia (Inner Mongolia)

In spring 1864, he went to the Great Wall, then went westward.



Great Wall

To the west area

- Pumpelly went westward from the Great Wall. He surveyed around boundary of Mongolia. He didn't get permission to travel from Chinese Government.
- He accompanied his Chinese servant, medical doctor Pogojeff, Russian Legation (公使館), and Pogojeff's Cossack servant.
- Historical background;

  Arrow War (アロー戦争) in 1856-1860 (The War of China vs. England and France). Treaty of Tianjin (天津条約) in 1858 and Convention of Peking (北京条約) in 1860.

  → Chinese government permitted foreigners' free travel in the land.

Geological observation

- Near Tutinza, metamorphic rocks , Devonian limestone and Triassic coal exposed.
- At plateau area, volcanic rocks and marine sediments distributed.
- At Hanoor, a postal relay station was located. From here, a caravan route extended westward.
- Pumpelly passed Borotsedji and Narin Gol. While passing these, he visited plateaus and valleys. Plateau is composed of trachyte.

*The above town or village names can not be found on my map.

A robbery in the hotel

- At Tau-li-chen village, the buildings were made with starve bricks (日干しレンガ). They stayed there in one night.

A house made with starve bricks at Syria.

Images are from HP of Museum, University of Tokyo

- For a few minutes in morning, the room was empty because all were outside to equip departure. During this time, the bag with silver coins went missing. They looked for it in the hotel and found it in a barrel.
- Pumpelly didn't describe a criminal (犯人).

Trouble with villagers

- At Murh-kwo-ching, Pumpelly's group had a trouble with villagers because Pumpelly group would stay in a farmhouse without permission.
- Ladies of villagers said "Go out the house!", "Disrespectful! (無礼な)" and "Red hair Demons!".
- Son of the farmer was mentally handicapped. Medical doctor Pogojeff was kindly caring for him. Mother of the son was impressed with Doctor's kindness, and supplied a room and dinner.
- Next morning, many villagers came to this farmhouse. The farmhouse changed into a clinic. The doctor cared for them as much possible, especially eye disease.

Lakes run dry

- They passed three lakes, Chaganoussu, Hoyurnoor and Kirnoor.
- Water of the Kirnoor was diminishing. Chaganoussu was diminishing, too. Hoyurnoor had dried up for a few years. Pumpelly wondered if these phenomena were tentative or by climate change.

※Pumpelly returned back to Beijing and again came to Japan. He stayed in Nagasaki for a while. Then he departed to traverse Mongolia in winter.

From Beijing to Nagasaki

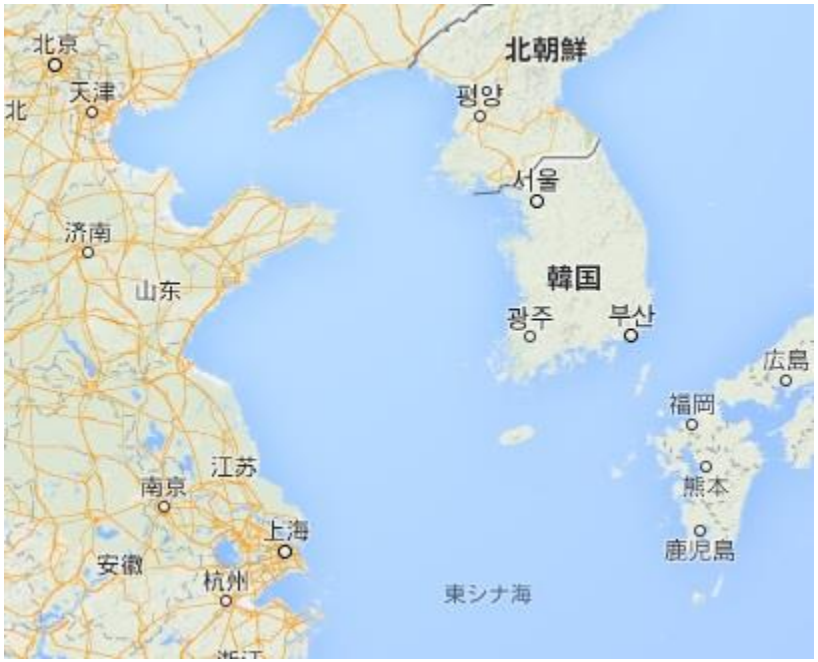
- In May, 1864, Pumpelly arrived at Shanghai from Beijing. He was planning a route through Mongolia and Siberia to Europe with Thomas Walsh in early autumn.
- In Nagasaki, he spent comfortable summer time under John G. Walsh, brother of Thomas Walsh. He got information of many civil wars* in Japan and attacking foreigners*, but felt Nagasaki was peaceful.
- Mr. Walsh became busy due to consul work, so schedule of traverse in Mongolia would be later than first planed.

*: 1862; Incident in Namamugi,
1863; Anglo-Satsuma War,
1864; Incident in Ikeda-ya,
1864, 1865, Choshu War

Left; Civil army in Choshu (Kihei-tai). Right; Government (Bakufu) army. From Wikipedia.

To Beijing from Nagasaki

- He departed from Nagasaki and traveled in East China Sea by ship. It was fine for a few days in the sea. On Yellow Sea, he watched a large crowd of jellyfish.
- Near Shandong Peninsula(山東半島), it became bad weather. In a storm, they went northward between Korea and Shandong Peninsula for a few days and reached Bay of Pe-chele.
- He went to Beijing by a small ship.



From google map

Departure from Beijing to Zhagjiakou

- At Beijing, Mr. St. John, a secretary of US Legation (米国公使館), participated our party. They purchased carts. Mr. Gen. Vlangali, Russian churchman, prepared many letters of introduction.
- They departed from Beijing, Nov. 12.
- Just after departure, they faced a valley. They moved their loads on horses to mules (ラバ) at Shaho (昌平). Horses had injured hooves (蹄) before arriving at Naukan.
- It took four days from Beijing to Kalgan (Zhagjiakou, 張家口).
  They found Mongolian guide(s) who could lead them to Khyakhta (キャフタ).

Toward Mongol Plateau in snowstorm

- At four PM, November 21, they departed to Mongol Plateau. Weather was snowstorm.
- This party was composed of 26 camels and 4 carts. They used 17 hours for moving in a day. Carts were used for sleeping space in night. A cart had two wheels and no spring. It was 3 feet (0.9 m) in width and 7 feet (2.1 m) in length. The cart was covered with many blanket. It was supported with saddle of a camel.

Transport with camels
(Photo by Takahashi.)

Battle with terrible cold on Mongol Plateau

- On the first few days, he was not familiar with coldness in this time. He battled with coldness. (−12℃ at Kargan)
- Within a cart, temperature was almost same as outside. The cart only shut off the wind. His naked hands could not touch the blanket and furs (毛皮) due to their coldness.

Winter view of Mongolia, in December, 2013.
Photo by Takahashi.

Ger (yurts)

- In the fourth day, he separated from the party with riding a Tatar (Mongol) horse and went to rising smoke. It was a community of gers within valley. In a ger, warm tea was served.
- Tallow (fat) was put and water was poured in a large cauldron over fire. After boiling, leaves from tea brick was added to hot water with salt and fat of a sheep's tail . The woman served it in wooden cups,

putting cheese.

Gers in summer of Mongolia.
Photo by Takahashi.

Description of geology

- On the morning of November 27, they observed metamorposed sandstone, quartzite, and limestone in highly-inclined beds at hills of Mingan.
- On broad plain of Olannoor, they found pebbles of chalcedony, agate and carnelian (red chalcedony).

- Some of containers of smell tobacco (hoorog) are made with agate.

Photo by Takahashi

Meals while traveling

- The party stopped at an hour before sunset to give the animals rest, 6 to 7 hours of 24 hours.
- One large tent was for the whole party. In the middle size tent, Mongolians put up their tripod and cauldron, and another fireplace for Pumpelly and his member.
- Meal; Obtaining a kettle of water by melting snow, they put frozen vegetables from Kargan and fresh meat from Mongolians, adding a pound of fat of the sheep's tail. They put canned provisions; peas (エンドウ豆), beans, ox-tail soup, mock-turtle soup*, Frankfort sausages, salmon and tomatoes. (* (子牛の頭などで作った)スッポンまがいのスープ)

  (In this report, Mongolian's cooking was not described.)
- They had coffee, and a bottle of boiling coffee was rolled carefully in a blanket for next morning.

Examples of meal in Mongolia

Photo by Takahashi

Boundary between Inner Mongolia and Outer Mongolia

- On November 29, 1864, the morning was pleasant, with a southwest wind and 17℉ (−8℃).
- Afternoon, they crossed the boundary between Inner and Outer Mongolia(s). The boundary was marked by rough piles of stones.

Fighting with Mongolians and English man pulled the pistol

- On December 6, one of the carts was upset (転覆), breaking one of the shafts.
- A violent altercation (口論) arose between the owner of the cart and Mongolian who caused accident. English drew his revolver.
- When Mongolians from a village saw the pistol, they drew their long knives. Pumpelly's situation seemed to be serious.
- The camel drawing St. John's cart had turned and fled due to fighting noise. The wheels left the body and the contents of the cart flew. The owner of the cart could not help laughing. Now it became peaceful.

Honest Mongolians

- All his money in gold was in one of the slender cloth pockets of the vehicle. The 12 to 13 Mongolians were already picking up the scattered articles. They seemed no likelihood of recovering money.
- A strange Mongolian called Pumpelly and Englishman. He pointed out a pile of shining sovereigns (英国金貨). He gathered them out of sands. Not one was missing.
- They had a higher opinion of the honesty of Mongolians. Buddhist commandment "Thou shalt not steal (汝、盗むことなかれ)"was more generally observed than was that of the religion in more civilized countries.

Mongol ponies in cold area

- On December 8, temperature was −20℉ (−29℃) in morning. Strong wind whistled around the carts. It was too cold to remain in active in the carts with the icy blankets. Their horses were much fatigued (弱っている) by travelling 17 hours daily.
- Mongol ponies were covered with a long, shaggy coat of hair. No other water than the little snow, no other food than a little frozen grass. These ponies picked up the grass before sunset. They served the party well through the journey to the Siberian frontier.

Mongol ponies. Photo by Takahashi

Arrived at Urga (Ulaanbaatar)

- On December 11, Pumpelly observed a hill with flat top which was composed of volcanic rocks.
- On December 12, they were ascending a broad valley bordered by round-topped hills of slate. From Horteryn Daban, they were going down hill and found flat gravelly plain or valley.
- Among the hills, they were descending to the Tola River which continued to the town of Urga, or Kuren, was located near the Tola River.
- They headed to the house of Mr. M. Chischmareff, a Russian consulate (領事), with letters. The house was a large, two-story building. The consulate was absent. His wife and the secretary received the letters.

The town of Urga

- On December 13, Pumpelly took a walk in the city. Population was 16,000, and half of it were Lamas. The Grand Lama was as usual a Tibetan and only 16 years old. The palace had a roof highly ornamented with gilded spire and ball (金箔の塔と玉が飾られている).
- Pumpelly saw many large buildings. One was like a ger but great size, 30–40 feet (9–12m) high and 60–70 feet (18–21m) in diameter. Entering one large temple, he saw an immense image of Buddha of wood, covered with sheets of gilded copper. In front of the temple, there were many cylinders, or praying machines (マニ車).

Praying machines (from Nire Kaoru HP)

Ulaanbaatar

Ulaanbaatar in late ’90s. After 2000, many high buildings have been constructed because of economic development due to mining boom. A statue of Lenin was removed.

Buddhism in Mongolia (Impression of Pumpelly)

- The Buddhist faith was introduced into Mongolia directly from Tibet. Although in Mongolia the religion of Buddha has become corrupted by preexisting Shamanism, it still retains more of original purity than among the other branches. That is, Buddhism in Mongolia is different from in India, China and Japan.
- Mongolian, under leadership of Chingis Khan and his descendants, overthrew the dynasties of all Asia and eastern Europe, sending terror even to the shores of the Atlantic. Pumpelly thought “This people is now perhaps the most peaceful among the world”.

Old Buddhism temple in Mongolia

Manzushri Monastery.　Photo by Takahashi..

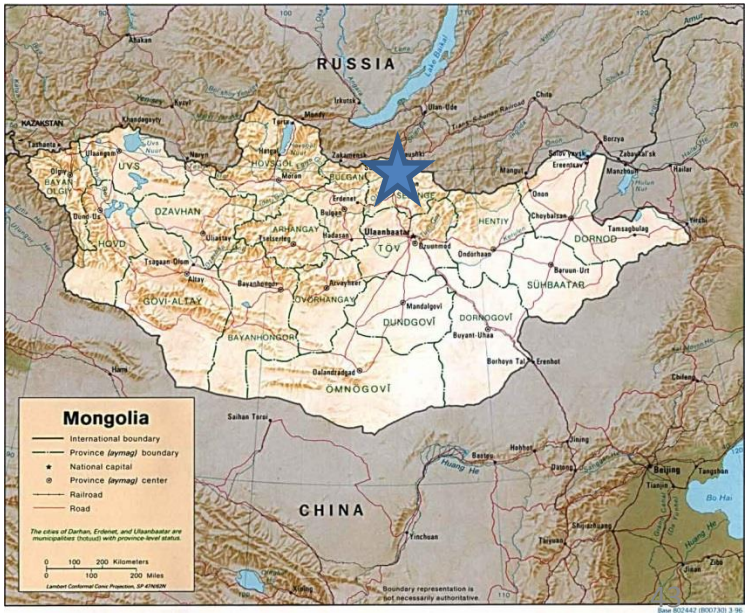
A Russian legation (公使館員) and his wife

- On December 14, they left Urga for Khyakhta.
- On December 15, temperature was -20 ℉ (-29℃). They saw a train of camels and carts coming toward them. In front of the train, Europeans rode. They were Mr. Papoff, the Russian legation of Beijing, and his bride, a Russian lady.
- Pumpelly knew that the lady had never experienced such the cold and the long journey. They were going to China. Fortunately they escaped facing the constant north wind.

Arrival at Border of Russia

- On the morning of December 21, they emerged from the forest and saw Khyakhta and Mai-mai-chin (Altanbulag).
- About noon, they reached Mai-mai-chin, Mongolian side of the frontier. It was entirely Chinese in character, such as rows of Chinese houses and neatly dressed Chinamen. They imagined themselves again south of the great wall.

  They found several caravans, some encamped, others just coming and leaving.



Entering Russia

- The passports were examined by Chinese officials, then they were permitted to pass the wall which separated the two towns.
- On the one side (Khyakhta) of stockade (柵) wall, houses, churches, and people were European.
- They passed really from Asia. Pumpelly felt change of Asian customs and languages into a refined European society.

Naushk Station, Russian, in Siberian Rail way. From HP of Mr. Sano, global traveler in 1994.

Pumpelly's route in 1864

(Map image is from HP of MonMap)

Appendix; Outline of geology in Mongolia

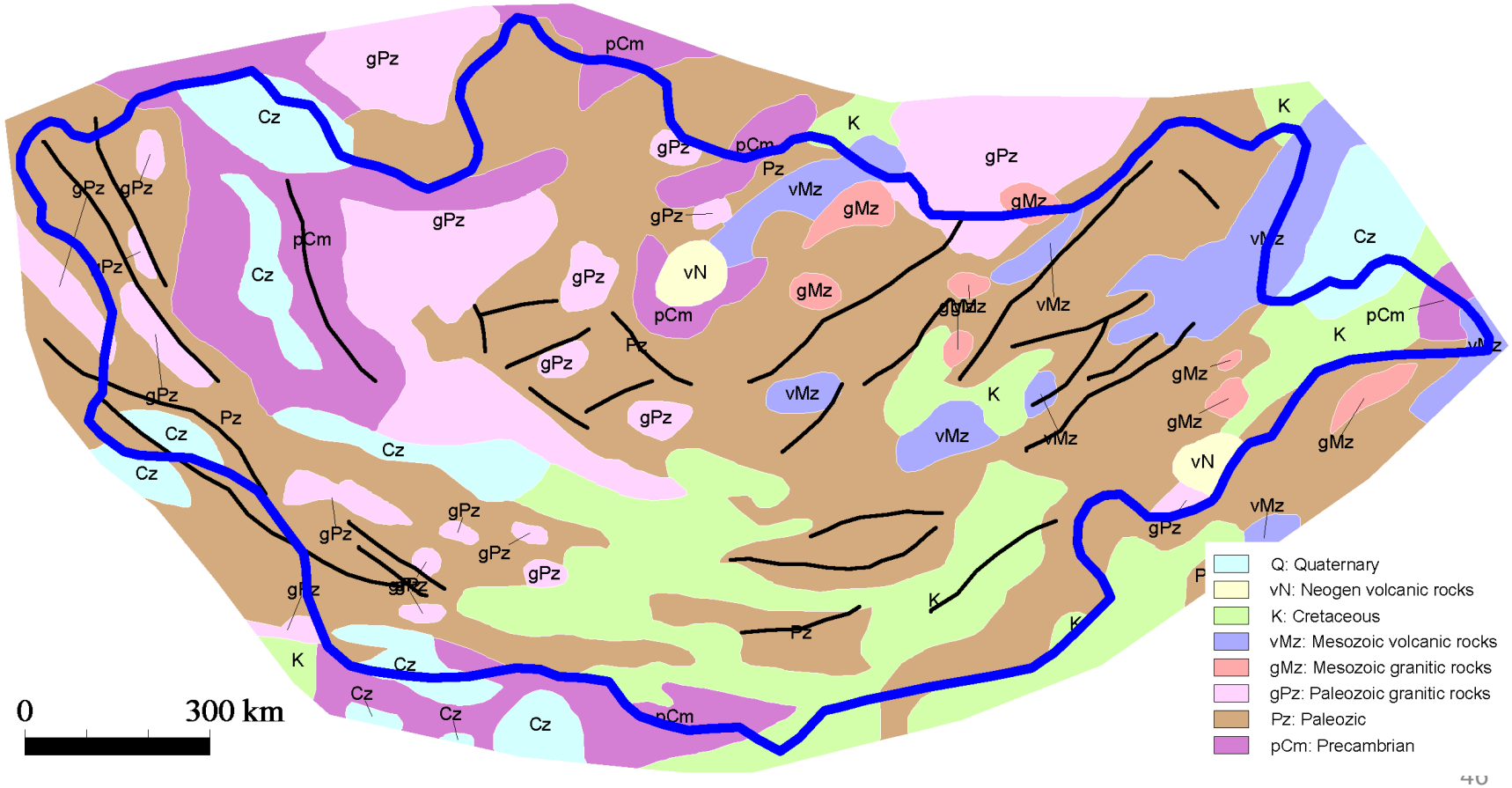
(Ma)

＊**Late Proterozoic –Paleozoic (1000–250)**: Ocean between small continents (Siberia Craton and Shino-Korian Craton). Formation of big copper deposits

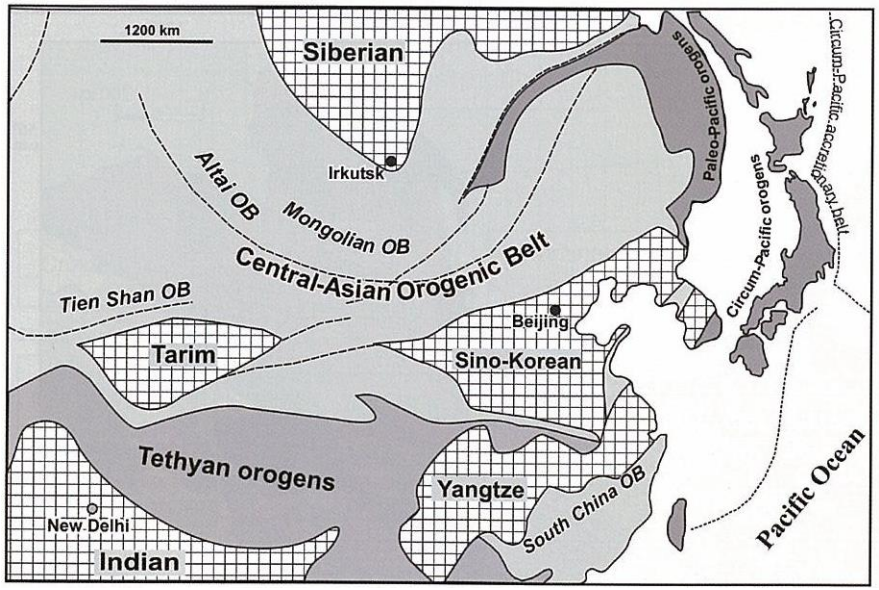
＊**Late Paleozoic –Early Mesozoic (350–250)**: Closing ocean(Mongol Okhotsk sea)

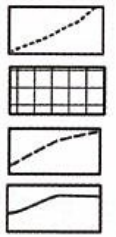
＊**Late Mesozoic (150–65)**: Inner basin, Prosperity of dinosaurs, Formation of coal

＊**Mesozoic–Quaternary (250–0.1)**: Magmatism within plate, Placer deposits



Global viewing of Mongolia



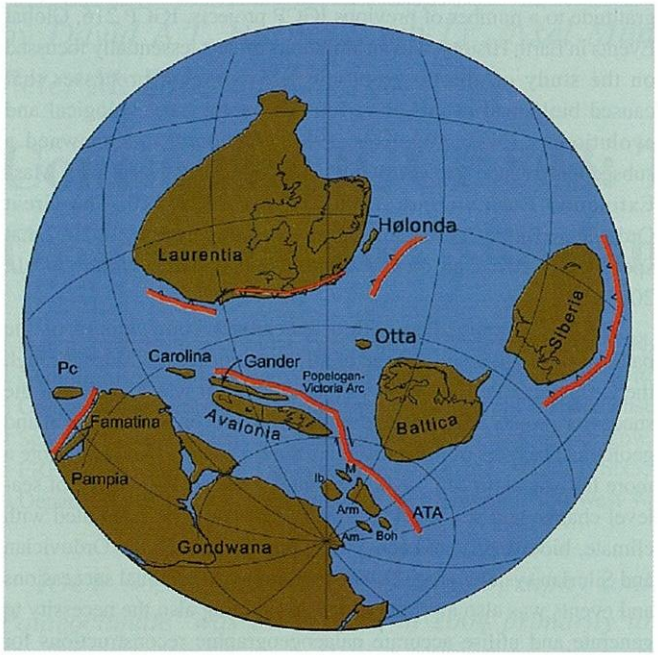


Present subduction
Precambrian continents
Main suture
Tectonic boundary

Geologic units after closing ocean

Paleoasiatic ocean
Paleotethys
Paleopacific

Safonova et al. (2011) Episodes, 34(3),186-196.



One example of small continents distribution before formation of Pangea Continent

← Geography in Ordovician

Harper et al. (2011) Episodes,34(1), 32-38.

Geology of Mongolia at early Pangea Continent

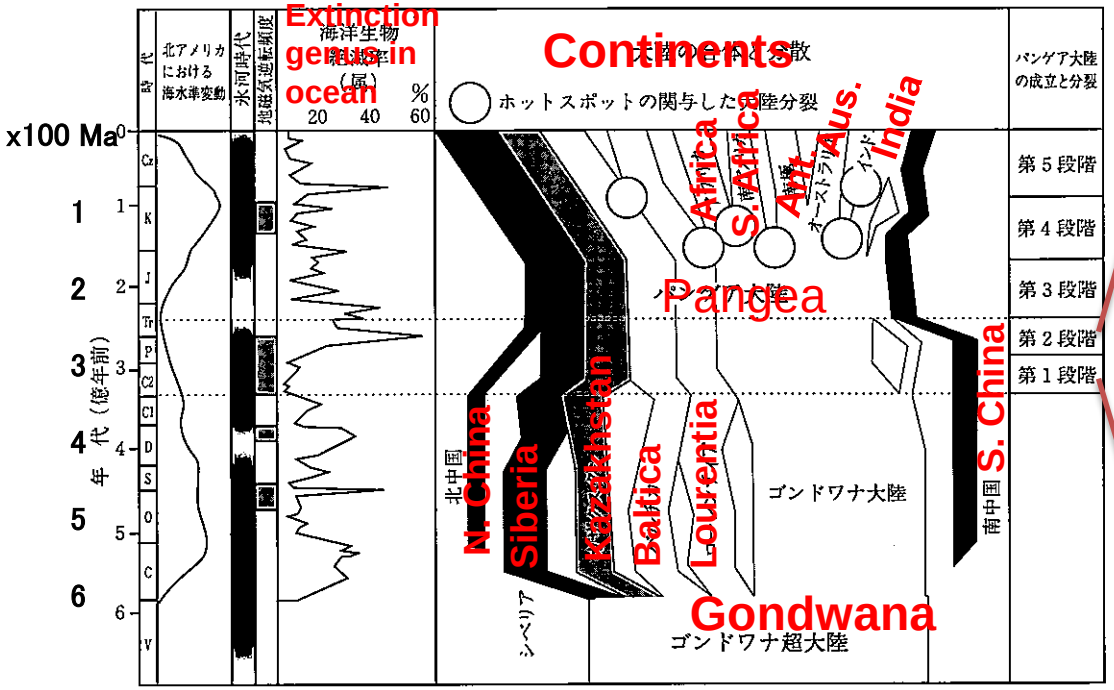


Fig 5.3 of Taira et al. (1997)

Early stages of Pangea continent
(2) 290–230 Ma,
Maximum size of Pangea
Collision ->Breakdown of orogenic belt ->Super plume->thinning of continental crust ->Flood basalt in Siberia ->Increasing of CO2-> Warming -> No mixing of sea water -> No oxygen in deep sea
(1) 320–290 Ma
Just collision time
Thick continental crust, Only one sea (Panthalassa)->Short total length of oceanic ridge->Minimum heat from the earth->Glacier in continent

Main structure and mineral deposits (Porphyry deposits, Lode gold deposits) of Mongolia were formed between Siberia and North China at commencing to form Pangea.

Production of Mineral resources

	Production (2006)	Current
Gold	23 ton	↘ ↗
Copper	130 thou ton	↗
Molybdenum	1160 ton	
Copper (SX-EW)	2500 ton	
Fluorspar for chemical	95 thou ton	
Fluorspar for steel	250 thou ton	
Coal	8500 thou ton	
Crude oil	212.3 thou barrel	

(Data from MRPAM)

Recent information

Cooperative field excursion by Japan Association of Mineralogical Sciences and Mongolian Association of Mineral Resources
September 3-6, 2012

Erdenet Mine (Copper mine)

Left; Secondary enrichment part was almost mined (dug).
Right; Survey for getting new deposits near the mine. They are seeing drilling cores.

Boroo Mine (Gold mine)

Left; Open pit for gold deposits. Right; Preparing heap leaching for low grade ore.

Participants in this excursion

Thank you for your attention