Geology of the Yang-tze Valley.

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very much smaller parts of Kan-su, Shen-si, Ho-nan and Kwan-si provinces.

The Name. About 3,660 years B. C., Yu, the great and enterprising hero of ancient China, travelled through central China and surveyed several mountains, rivers and lakes. Among nine important rivers pointed out by him, the river now called by us the Yang-tze-kiang was named, at that time, simply Kiang. The name Hang was also given to the present Han-kiang, a tributary of the Kiang. Ho was the name of the present Hoan-ho, and Lo and Wei were the names of tributaries of the Ho. Thus we see that, in ancient times, there was a special name for each stream such as Kiang, Ho, Lo, Wei, etc. As the geographical knowledge of the Chinese became wider, many streams were to be named, so that "Kiang," originally a proper noun, was used as a common noun. Min-kiang was the name given to the river in the Min district, and Kan-kiang to that in the Kan district. The Han also was called the Han-kiang, and thus the name Kiang became too ambiguous to be used to point out the present Yang-tze-kiang only. To avoid this ambiguity, the river was called the Chan-kiang because it is very long, or the Ta-kiang because it is very large. The source of the Kiang on the Tibetian plateau bears the Mongolian name Muruss, and lower in its course it is called by the Tibetian names Di-chu and Ja-chu, the latter of which represents another source of the Kiang (Ya-lung-kiang). In the province of Ssu-ch'uan it is called the Kin-sha-kiang (the Golden-Sand river).

About 400 A.D. the emperor Yan, of the Sui dynasty, dug a great canal from the capital by Hoan-ho to the lower part of the Kiang, passing through the plain of Ho-nan and An-wei, cutting the low hill of Yan-cheou, and entering the Kiang from the bank opposite Chin-kiang. The canal Kiang-nan-ho was also excavated

southward from Chin-kiang to Han-cheou passing by Su-cheou and Hu-cheou. As these canals on both sides of the Kiang at Chin-kiang were the great highway from the central provinces to the flourishing Kiang-nan plain, thousands of cargo- and passenger-boats crossed the Kiang south- and northwards. At the crossing point there stood on the northern bank a little town called "Yang-tze," so the ferry was called the Yang-tze ferry. The lower course of the Kiang near Chin-kiang, therefore, was called Yang-tze-kiang as a part of Chan-kiang or Ta-kiang.

Yang-tze-kiang is, at present, known all the world over as the name of the whole course of the great river, but orginally it was known simply as the Kiang. Chan-kiang or Ta-kiang is the name by which it is generally known name among the Chinese.

II. Hydrography.

The Yang-tze-kiang can be divided into two parts. The upper half passes through the high mountainous plateau which gives to the river bed an average slope of from 8 to 12 feet per mile, while the lower half runs through well cultivated and fertile country with an average slope of less than 2 feet per mile. The lower half can also be divided into three parts, the upper, middle and lower. So we have in all four parts.

1. The source, (the upper half not navigable)
2. The upper Yang-tze, (navigable for native junks)
3. The middle Yang-tze, (navigable for shallow draft steamers).
4. The lower Yang-tze, (navigable for ocean steamers).

The upper Yang-tze lies chiefly in the province of Ssu-ch'uan. It is navigable by large junks of 30-100 tons. Small steamers may also be used here, but the risk is very great. The average slope of the river bed is 1.7 feet per mile. The middle Yang-tze

is navigable by large flat-bottomed steamers in all seasons. The average slope of its bed is 0.3-0.22 foot per mile. The lower Yang-tze is navigable by ocean steamers in all seasons. Its average slope is less than 0.22 foot per mile.

The length of the upper Yang-tze from Sui-cheou-fu in Ssu-ch'uan to I-chang-fu in Hu-peh is 600 miles. That of the middle section from I-chang to Kiu-kiang in Kiang-si is about 550 miles. That of the lower portion from Kiu-kiang down to the mouth is about 450 miles. The width of the river varies. In the upper part, generally, it runs through a deep cut channel the narrowest part of which is only a thousand feet wide. In the middle, it flows for the most part through a flat plain, so it widens considerably, making islands in many places. From half a mile to one mile is the common width, but where it becomes still wide, the water becomes shallow making bars or islands. In the lower portion, the river meanders through the flat Alluvial plain, and its width often exceeds a mile. The lowest 100 miles is several miles wide.

In the upper Yang-tze, the current is firmly restricted by rocky banks and it can not widen during the flood season, so the river rises a hundred feet or more in the highest water. A town standing on a rather high cliff above the river in the dry season is often in danger of being swept away by the overflow of the torrent in the highest flood. Indeed such accidents are not rare at Kui-cheou-fu in eastern Ssu-ch'uan. In I-chang-fu the difference in the water marks is 40-46 feet at the maximum. In Han-kow it is about 40 feet, and in Kiu-kiang nearly 36 feet.

The current velocity in the upper course varies greatly. In the same place it varies in different seasons. Some winter rapids often disappear in summer, when the water rises. At I-chang-fu, the current velocity varies from 4.2-5.0 feet per second. At Han-kow,

the current velocity is 4.2-5.0 feet per second in low, and 6.6-9.3 feet per second in high water. In the highest water 13.5 feet per second has been observed. At Kiu-kiang, the current is 1.7 feet per second in low, and 3.3-8.5 feet per second in high water. At Wu-hu the tide affects the velocity of the current, but not the height of the water during high water. When the river is low, however, a rise and fall of 0.5.-2.0 feet takes place by the influence of the tide. At Chin-kiang, the current varies from 2.5-3.4 feet per second when weak, to 6.0-8.0 feet per second when strong. Often 10 feet per second has been observed. Tide causes the changes both in velocity and water marks. At Woo-sung, 40 miles from the mouth, the current reverses, and considerable rise and fall of the water surface take place in flood and ebb.

III. Mountains and Plains.

The source of the Yang-tze is in the "Chan-tan" plateau, some 14,000-17,000 feet above the sea level lowering slowly east and southward. On the eastern border of this plateau, is the Ta-hsüeh (Great Snow Mountain) range which is cut by Di-chu and Ja-chu, the two main sources of the Yang-tze forming precipitous mountaneous countries. The Ta-hsüeh range is said to be 22,000-24,000 feet above the sea level at its highest points. On the eastern side of the snow clad mountain, there is the Pa-shu basin of the upper Yang-tze, its mean elevation being 2,000 feet above the sea. This basin gradually rises eastward to form the Tso-si range which is cut by the Yang-tze in the San-sha (Three Gorges), and lower toward the east by the Hu-kwan basin or the basin of the Tung-ting lake. The greater part of the Hu-kwan basin is low level land traversed by a network of canals, and dotted with numberless lakes and pools. On the east of the Hu-kwan basin,

is the third range of Kiang-hu, which is partly cut through by the Yang-tze on its way from the Hu-kwan basin to the Alluvial plain of San-kiang.

Pa-shu basin on the upper Yang-tze is enclosed on all sides by high mountains and plateaus. On the west, is Ta-hsüeh mountain 10,000-24,000 feet in elevation. On the south, is the Yun-nan-Kwei-cheou or Yun-Kwei plateau some 5,000 feet or more in elevation. On the north and east are Ta-pa-shan and Tso-si-shan, 5,000-10,000 feet high. If the three great gorges between Ssu-ch'uan and Hu-peh provinces were entirely shut up, the basin would change into a lake, the maximum depth of which would perhaps exceed 500 fathoms. It is most probable that in some past geological time, there was once such a lake which overflowed eastward and gradually emptied as the erosion of the great gorges proceeded. The numerous streams in the Pa-shu basin now running through the bottom of the ancient lake give the province its name of Ssu-ch'uan or Four Streams.

The Hu-kwan basin or basin of the Tung-ting lake is also enclosed by higher mountains. This basin is hardly above the sea level, so that its drainage is very imperfect. It is most probable that this basin also was once covered for the most part with water which was gradually displaced by the sediments of several rivers entering that ancient lake or inland sea. The Kiang, the Han, the Sian, the Yuen etc., are the chief streams which worked the sedimentation. Tung-ting lake and many other lakes and pools are a kind of remnant lakes or parts of the ancient lake or inland sea, which are not yet fully filled up with sediment.

San-Kiang plain or the plain of the lower Yang-tze comprises the large and flourishing region near Shang-hai, Su-cheou, Nan-king, Wu-hu, etc. The many hills and hill-ranges on the plain resemble

islands in a sea. These hills and hill-ranges have in most cases very precipitous sides, which suggest that they stood once in an ancient sea which was gradually transformed into the present plain.

Delta formation is now rapidly going on near the mouth of the great river. Besides the Pa-shu and Hu-kwan basins and San-kiang plain, there are many valleys among which the most important are those of Han, Sian and Kan. The valleys of Chien-dong-kiang in the province of Chet-kiang and of Min-kiang in the province of Fu-kien are next in importance.

The mountain tract east of the Kan valley in Kiang-si and south of the Chien-don-kiang valley in Chet-kiang is the Min-chet mountain tract which borders the easternmost part of the Yang-tze valley.

The whole Yang-tze valley contains four mountain tracts and three plains:

1. Ta-hsüeh mountain tract.
2. Tso-si mountain tract.
3. Kiang-hu mountain tract.
4. Min-chet mountain tract.

Between 1 and 2, is the Pa-shu or Ssu-ch'uan basin Between 2 and 3, is the Hu-kwan basin. On the north of Min-chet and east of the Kiang-hu mountain tract, are the San-kiang plain and the delta of the Yang-tze mouth. Between 3 and 4, is the hilly land of Kiang-si and Hu-nan. This hilly land, comprising the valleys of Sian and Kan, may be considered as a kind of depression between these two mountain tracts.

The Ta-hsüeh mountains run NNE to SSW in the western part of the provinces of Ssu-ch'uan and Yun-nan, but gradually bend eastward in the northern part of Ssu-ch'uan. The Tso-si mountains also run SW to NE from Kwei-cheou to Hu-peh, while the Kiang-hu

mountains generally run WSW to ENE. Lastly the Min-chet mountains run NNE to SSW or in some parts N-S. All these ranges run in similar but slightly different directions. Ta-hsüeh, Tso-si and Kiang-hu mountains diverge northeastward and converge southwestward where they form the Yun-nan-Kwei-cheou plateau. The Kiang-hu and Min-chet mountains diverge southwestward and converge northeastward where they form the mountaneous tract of Fu-kien, Chet-kiang, An-wei and Kiang-si. The study of mountain strikes in the Yang-tze valley suggests that, where two or more mountains converge, mountainous land or plateau is formed, while where mountain strikes diverge, hilly land or plains or basins are formed.

IV. Geology.

Several authors have described the geology of the Yang-tze valley. Among them, we may mention Leclère (on Yun-nan and Kwei-cheou), Richthofen (on Ssu-ch'uan and Shen-si), Willis and Blackwelder (on Han valley and the Yang-tze gorges), and Loczy (on Kiang-su, Kiang-si, the Han valley, and western Ssu-ch'uan). Pumpelly also described the geology of the Yang-tze from its mouth to the entrance of the gorge above I-chang. The descriptions of these authors, on the whole, are fragmentary and very difficult to reconcile with one another. For example, we feel some difficulties in comparing accurately the horizon of the Kui-cheou formation of Willis with the Kwan-yuen coal-bearing strata of Richthofen. It is much more difficult to compare the phyllite formation found by Loczy at Kiang-si with the metamorphic rocks found by Leclère at Kwan-si.

We must, therefore, be satisfied, for a while, with a very roughly generalized classification of rocks, which though very illogicalin

many points, yet is convenient for understanding the geology of this region. The following is a generalized statement of the Yang-tze valley's geology :

a. Quaternary.
b. Red Sandstone Formation.
c. Coal-bearing Sandstone Formation.
d. Great Limestone Formation.
e. Sinic or Metamorphic Formation.
f. Gneiss Formation.
g. Plutonic Rocks.
h. Volcanic Rocks.

a. Quaternary.

Quaternary deposits are Alluvium, Diluvium, river bed, or flood-plain formations, and delta On the middle and lower Yang-tze, there are wide plains, the area of which amounts in the middle Yang-tze to 15,000 sq. miles and in the lower to 24,200 sq. miles. The greater part of these plains is Alluvium consisting of clay, sand, and sandy clay. Gravel is very rare. In some parts, raised beds of gravel and sand are found at a height not attainable by the present river water. In the west of Yan-cheou, in the province of Kiang-su, there is a mud hill several miles long and elevated 50-200 feet above the neighbouring Alluvial plains. Such an elevated gravel bed or mud hill can be considered as of Diluvium formation. Loczy describes old Alluvium in the neighbourhood of Shang-hai.

b. Red Sandstone Formation.

The red sandstone formation is the youngest of the folded strata in the Yang-tze valley. It is found under alluvial clay at the edges of flat plains, but, in hilly or mountainous land, it often forms the

uppermost strata filling up the basins or valleys surrounded by older formations. Its folding is, in general, very slight, the dip angle being usually less than 10°, but, in rare cases, more than 15°. The upper part of the formation is generally red shale thinly bedded, but the lower part becomes sandy and is thickly bedded. Basal conglomerate is found in most cases where the lowest part of the formation is exposed. The pebbles forming the basal conglomerate are limestone, quartzite, or hard sandstone, which compose the palæozoic strata. The total thickness of this formation can not be fully ascertained, owing to the erosion of its upper part. On the banks of the Chien-dong-kiang at Chet-kiang, we observed steep cliffs of the red sandstone formation bedded nearly horizontally, which we considered to be 1,000 feet or more in height. In the province of Ssu-ch'uan where the formation is most perfectly preserved, we have found it 2,000 feet thick in a cliff side. This formation, as a rule, fills up the basin of the older formations. In Kiang-si and Chet-kiang, it sometimes covers granite or phyllite and sometimes coal-bearing sandstone. In Ssu-ch'uan, it overlies coal-bearing sandstone in apparent comformity. The latter however has a steeper dip angle than the former. Fossils have not yet been found in this formation as far as we know. Petroleum and salt water wells as well as gas holes are worked in this formation in Ssu-ch'uan and Hu-peh. It is most probable that the red formation was deposited under the water of a salt lake or inland sea, not favorable to animal or plant life. It is younger than the Jurassic and older than Diluvium, so that its stratigraphic position is Cretaceous, Tertiary or Cretaso-Tertiary.

c. Coal-bearing Sandstone Formation.

The coal-bearing sandstone formation consists of an alternation

of sandstone and shale, quite different in color and aspect from the red sandstone formation. The sandstone is generally white or grey and the alternating shale dark grey or black. The coal seams are found mostly in the lower part. The thickness and number of the coal strata are various, and the quality of the coal also varies from anthracite to bituminous. The volatile matter in some coal is less than 5%, but in the bituminous variety it exceeds 15% or sometimes even 20%. The age of the coal ranges from the Carboniferous in the Palæozoic to the Jurassic in the Mesozoic. In the eastern part of the Yang-tze valley (Kiang-su, An-wei, Chet-kiang and Kiang-si), the older coal such as Carboniferous or Permo-Carboniferous predominates. The coal bed lies in or upon Carboniferous limestone. In the western provinces (Ssu-ch'uan, Kwei-cheou, and Yun-nan) there is younger coal, the age of which has been found to be Lias-Rhaetic, overlying Triassic limestone. Richthofen found coal in the northern part of Ssu-ch'uan, and called it Kolenfürende Formation von Kwan-yuen. Willis, in his route from the Han valley to the Yang-tze gorges, found a coal bed, which he called the K'ui-cheou bed. It was determined to be Permo-Mesozoic by David White.

The coal-bearing formation occurs in the eastern part in a synclinal basin of Sinic formation, or an erosion basin of gneiss or granite. In the western part, it lies in synclines of limestone, forming apparently conformable stratification. As regards the thickness of this formation, Willis estimated the K'ui-cheou bed to be 1,550 feet or more. Richthofen's Kwan-yuen bed was estimated by him to be 3,600 feet thick.

d. Great Limestone Formation.

Under the coal-bearing formation, there is always limestone,

the age of which ranges from Mesozoic to Palæozoic. The color and quality of limestone vary greatly. Some is white and somewhat crystalline. In other places it is earthy or rich in clay, often forming calcareous shale or marl, the color varying from grey to dark grey or black. Generally, it is thickly bedded and sometimes massive. In Hu-peh and Ssu-ch'uan, limestone folded in contorted ways forms a great expanse of plateau, while in the eastern provinces such as Chet-kiang and Fu-kien, it forms isolated masses or lenses. The Carboniferous limestones containing fusulina and fragments of crinoid stems are found in both the eastern and the western provinces. An orthoceras bed, which belongs to the Middle Palæozoic, occurs at Kwei-cheou, Ssu-ch'uan and Hu-peh. Willis describes Cambro-Ordovician limestone in Ki-sin-lin, a water shed between the Han valley and the Yang-tze gorges. Limestone younger than the Carboniferous also occurs in the western provinces. Leclère describes Carboniferous and Permo-Triassic limestone in the provinces of Kwei-cheou and Yun-nan. Richthofen also describes Triassic or Permian limestone in northern Ssu-ch'uan. It can be seen that, in the eastern provinces, the limestone is scanty and its age mostly limited to the Carboniferous or Permo-Carboniferous; while in the western provinces, limestone predominates both in extent and in thickness, and ranges from Cambro-Ordovician to the Triassic age.

The thickness of the limestone rarely exceeds 1,000 feet in the eastern provinces, but in the western provinces, limestone cliffs of 3,000 feet can often be observed in the Yang-tze gorges. Willis estimated 8,000 feet of limestone in his section at Tanin-ho. Limestone of enormous thickness seems to form the Yun-nan-Kwei-cheou plateau, which on an average attains an elevation of 5,000 feet above sea level.

e. Sinic or Metamorphic Formation.

Sandstone and shale together with their metamorphic varieties such as phyllite, clayslate, mica, schist, schistose sandstone, etc., underlying the great limestone formation, form the Sinic formation. Its age ranges from the lower Palæozoic to the pre-Cambrian. Loczy described it as phyllite or Lu-shan formation in Kiang-si. In the profile of Willis, the place of this metamorphic series is taken by metamorphosed limestone or Ki-sin-lin limestone.

Sandstone and shale in the Sinic formation are commonly different from those in coal-bearing sandstone formation, in that the former have plenty of quartz veins which are quite lacking in the latter. When metamorphism goes on further, schistosity imparts a silky appearance due to the micaceous ingredient. The Sinic formation, being subjected to high crustal pressure, naturally shows highly folded features having a high dip angle, often vertical and inverted. The stratification surface is commonly wavy and the strata are often contorted and sheared.

This formation is widely exposed in the eastern provinces where it occurs in contact with granite and gneiss in many places. In the western provinces, heavy limestone covers the lower strata which therefore are exposed only in open anticlines of limestone on the erosion valley or basin. Leclère describes a metamorphic formation near the boundary of the provinces of Kwan-si and Kwei-cheou. The thickness of this formation can not be ascertained. In the eastern provinces, it is greatly eroded and folded in complex ways. In the western provinces, its exposure is not enough to make it possible to measure its thickness.

f. Gneiss Formation.

Gneiss formation in the Yang-tze valley is found in Tsin-lin-shan, Huai-nan-shan, and the Yang-tze gorges. It is also found on the coast of Fu-kien. The gneiss on the Fu-kien coast is granitic gneiss containing both muscovite and biotite. It is generally decomposed into red soil rich in mica and forms very low undulating hills. Gneiss exposed on Tung-cheng-hsien about 60 miles north of An-king is white muscovite gneiss generally fine grained or compact. The Huang-ling gneiss (so called by Willis) found in the Yang-tze gorges about thirty miles above I-chang is granitic gneiss. It is massive gneisoid gray granite (properly quartz diorite) with quartz, plagioclase, biotite, and hornblende.

g. Plutonic Rocks.

The plutonic rocks in the Yang-tze valley are granite, quartz porphyry, and diorite. In Fu-kien, Chet-kiang, Kiang-si and Hu-nan, granite is exposed in large areas. Generally the granite region forms low plains or hill land on account of its easy erosion, when it is decomposed. On the other hand, it sometimes forms high peaks. Lu-shan (5,000-6,000 feet) at Kiang-si, and Hoan-shan (5,000 feet or more) at An-wei are examples. In Hoan-shan, granite forms needlelike peaks and ninety nine such peaks are said to be present in a range about five miles long. On the boundaries of Chet-kiang, Fu-kien, Kiang-si, and An-wei, there are plenty of high peaks of this kind. Quartz porphyry occurs in the periphery of granite, or in the form of a dyke or boss. In a gneiss region, granite often forms isolated abrupt peaks or conical hills. Diorite, as far as we know, does not occur in an extensive body. It is very local, and usually forms dykes.

Basic varieties such as serpentine, gabbro, etc., are very scanty in the Yang-tze valley. Willis describes basic intrusive in his route through the Han valley. We have also seen a very nice specimen of asbestus from Hsin-an-fu in the Han valley, and some serpentine-like rock from the boundary of Shen-si and Ssu-ch'uan.

Old eruptive rocks give contact metamorphism to the Sinic and great limestone formation, and produce contact minerals and metallic lodes. Plenty of veins of metallic sulphides (galena, zinc blende, stibnite, copper pyrites, etc.) occurring in Chet-kiang, An-wei, Hu-peh and Hu-nan, belong to this origin. Granite seems not to give a contact effect to coal-bearing sandstone formation.

h. Volcanic Rocks.

Volcanic rocks in the Yang-tze valley are chiefly in forms of dykes and sheets. Volcanic cones are seen in Liu-ho-hsien north of Nang-king. The existence of craters is not yet fully established. Fan-shan, described in Richthofen's letter, and Ta-tung-shan north of I-chang are fine conical peaks on the northern side of the great river, and can be seen from shipboard between Nan-king and Chin-kiang. Plenty of masses of basalt are described by Richthofen in the northeastern part of An-wei. The north-eastern part of Chet-kiang is also rich in volcanic rocks, porphyrite, liparite, and basalt. Reddish and greenish tuff breccia is quarried in the environs of Nin-po-fu and Han-cheou-fu. Abundant tuff plates and blocks are exported from Nin-po and Han-cheou as building and paving stones. In Chu-san island we observed an extensive basaltic flow overlying older rocks such as quartzite and siliceous shale. Several isolated rocky islands or hills such as Kim-shan and Chao-shan near Chin-kiang are found to be composed of limestone intruded through by andesite or porphyrite dykes.

Numerous sheets and dykes of porphyrite are described by Leclère as found in Yun-nan and western Kwei-cheou. Prof. Yamada found an extensive diabase or diabase porphyrite sheet always existing under the Triassic formation in northern Yun-nan, south-western Ssu-ch'uan and western Kwei-cheou. Mt. Omi, a famous mountain in western Ssu-ch'uan, is said to be composed of limestone covered by thick diabase porphyrite sheet.

Volcanic action influences the formation of metallic lodes, so that the country rich in volcanic rock is also rich in useful minerals. The greater part of the mineral products of Chet-kiang and the Yun-nan-Kwei-cheou plateau may be considered as of volcanic origin.

Hot springs are not abundant. We know of hot wells in Chian-cheou near Amoy, and of a hot spring in Hoan-shan north of Hui-cheou, in southern An-wei. But these two come out of the granite. There is said to be a solfatara near Nang-king and another in Won-tang about twenty miles south of Chun-king.

V. Tectonic Geology and Geological History.

Our classification of the strata in the Yang-tze valley into "the Quaternary," "the red sandstone formation," "the coal-bearing sandstone formation," etc., as given above is not the proper method of classification, because the geological age of each member is so indefinite that one formation may represent older Palæozoic and middle Mesozoic. For example, the great limestone formation on one side represents the Triassic or Jurassic age, and on the other side, the Cambro-Ordovician. In our present stage of investigation, however, we must be satisfied with such field observation till future investigations enable us to put each stratum in the Yang-tze valley in its proper horizon.

As far as our geological map shows, granite or granitic rocks, the deepest approachable foundation of our crust, is overlain by gneiss and the Sinic formation. The Sinic formation, in its lower part or part of contact, shows a highly schistose or sometimes gneissose appearance. The stratification is very complicated, the angle of the dip being generally high, vertical or even somewhat inverted. The eruption of granite therefore took place after the stratification of the Sinic formation, and the eruptive force and crustal lateral pressure combined, caused great disturbance in these lowest lying strata. The Sinic formation is always overlain by the limestone formation, but Willis, on his route through the Yang-tze gorges, found limestone (Ki-sin-lin limestone of the Cambro-Ordovician) directly overlying Huan-ling gneiss. In this latter case, the Sinic formation is composed of limestone instead of phyllite, mica schist, quartzite, etc. which constitute the Sinic formation in other places. The upper part of the great limestone formation contains coal, and gradually changes into the coal-bearing sandstone formation. This change of limestone into the sandstone series took place in the latter part of the Carboniferous age in the eastern provinces, but in the western provinces limestone continued to be deposited up to the early part of the Mesozoic. The coal formation or coal-bearing sandstone formation began with the Carboniferous age, and finished at the Jurassic. Then came the deposition of the red sandstone formation, which occupies the latter part of the Mesozoic and perhaps the Tertiary; and lastly, Quaternary.

Comparing the eastern part with the western, some remarkable contrasts are observed. In the eastern provinces, the Sinic formation predominates, while in the west, the limestone formation. In Kiang-si, we travel many days over Sinic formation, while in western Hu-peh, it requires a week or more to cross the limestone

plateau. In the eastern provinces, the higher parts of the mountains are composed of granite and Sinic formation, but in the western provinces, of limestone. Briefly speaking, the eastern part of the Yang-tze valley has mountain land of folded Sinic formation, while the western part is chiefly occupied by limestone plateau.

The granitic foundation is exposed to a height of 5,000 feet or more in the Min-chet mountain tract, in Tsin-lin-shan and in Ta-hsüeh mountain tract. Westward from the Min-chet mountain tract the granite gradually sinks below the Sinic formation which chiefly forms the hills and mountains of Kiang-si and Hu-nan. Further west of Hu-nan, the Sinic formation again sinks below the limestone which forms the greater part of the mountains and plateaus of western Hu-peh and eastern Ssu-ch'uan. The greater part of the middle of Ssu-ch'uan is occupied by coal-bearing sandstone and red sandstone formations, so that limestone is exposed only on the open anticlines of overlying strata. Thus we see that the foundation of the strata gradually lowers from east to west, from the Min-chet mountains to the Pa-shu basin. On the western side of the basin, however there is the abrupt rise of the Ta-hsüeh mountain where granite and gneiss are exposed to a height of over 8,000 feet. Speaking in a tectonic sense, the Yang-tze valley, as a whole, is one large basin having on its western, northern, eastern and perhaps southern margins, a high-rising granitic foundation. This great granitic basin is filled up with the Sinic formation, and in the remaining basin a still greater extent is occupied by limestone. The Sinic and limestone formations thus nearly leveled the granitic basin, and on this leveled surface there came the coal-bearing sandstone and red sandstone formations. Of course, mountain making force worked continually, and the folding process produced many anticlines and synclines, anticlinoria and synclinoria. Upward

and downward dislocations or faults also took place. Thus the general configuration of the mountains and plains was finished. The great Yang-tze basin, therefore, was the seat of a great lake or inland sea whose margin first became land, gradually narrowing the water, the last position of which was, in all probability, western Hu-peh and eastern Ssu-ch'uan where the limestone is most thickly developed from the oldest Palæozoic to the Mesozoic. The production of many mountain ranges by horizontal pressure and accompanying crustal movements then ensued. Several mountains, plateaus, plains and basins were formed and the present Pa-shu and Hu-kwan basins and many other minor basins were formed and filled with water. The secondary lakes now appeared. These lakes had to find outlets for their overflows. The water of the Pa-shu basin naturally flowed into the Hu-kwan basin, and thence to the eastern sea. Erosion by overflowing waters and upheaval by mountain-making pressure cooperated, and the precipitous gorges of the Yang-tze, where to-day the channel 3,000 feet or more in depth delights the traveller with its magnificent panorama were produced during lapse of many million years.

It is a very curious fact that in China, the coal formation began in the Carboniferous age and ended at the Jurassic, while, in Japan, it began in Cretaceous time and ended in the Tertiary. In Tertiary time, while, in Japan, animal and plant life flourished in spite of the violent volcanic eruptions then taking place, China seems to have been quite unfit for animal and plant life, for there only the barren red sandstone formation can be conjectured as the deposition in Tertiary time. So we can suppose that the secondary lakes mentioned above were very saline or stagnant and unfavorable to life, but the subsequent erosion of outlets and the emptying of the bad water restored life and health to the valley of the Yang-tze.