102. Concept of Time in Geology 2.

The Length of the Sinian Time estimated by the Stratigraphical Method.

By Teiichi KOBAYSAHI.

(Comm. by H. YABE, M.I.A., July 12, 1944.)

The Pre-Cambrian dim past, i. e., the Cryptozoic eons, used to be classified into the Archaeozoic and Proterozoic eras, but it is certainly not proper to call them eras because they are several times longer than the eras as understood to-day. Furthermore the traditional correlation of Pre-Cambrian geology is evidently a logical contradiction because it was made on the basis of stratigraphic relations such as discordance, intrusion and peneplanation notwithstanding the fact that what is being determined is the time relation among crustal movements and igneous activities in different shields. This question has become quite important since it was ascertained that in the Phanerozoic eon, orogeneses[1] as well as epirogeneses or at least a certain kind of epirogeneses[2] took place in more or less alternate steps as between opposing tectonic units as well as between the opposite sides of a tectonic unit. The stratigraphic relations above mentioned tell nothing but the succession of geological events which took place in each shield, and for correlation among the successions of these events in separate shields mineralogical and other methods should be used. Schuchert and Dunbar[3] wrote that.

> " the actual dating of various Pre-Cambrian formations of the world by means of their radioactive minerals has shown that there are at least seven successive times of great orogeny and granitic intrusions in the Pre-Cambrian. Yet only three or four of these have been recognized in any one continent."

The existing knowledge on the Cryptozoic eons indicates that this part of history may not be an exception for the hypothesis of crustal movements in alternate steps.

In the Pre-Cambrian Geology of Eastern Asia[4], an important achievement in recent years was the recognition of the existence of three cycles of sedimentation which alternate with two igneous cycles, but un-

1) T. Kobayashi (1941), The Sakawa Orogenic Cycles discussed from the Standpoint of Comparative Tectonics. *Mem. Lect. given in honour of Comm. Prof. H. Yabe's 60th Birthday.*

2) ——— (1942), On the Climatic Bearing on the Mesozoic Floras in Eastern Asia. *Japan. Jour. Geol. Geogr. vol. 18 ; (1944),* Reciprocal Development of Radiolarian Rocks as between Asiatic and Australian Sides ; T. Kobayashi and T. Kimura, Break in the History of Radiolaria ; the Permo-Triassic supplemented with the Sambosan Higashigawa Suite. Both in *Proc.* **20** (1944).

3) C. Schuchert and C. O. Dunbar (1933), A Text-Book of Geology, Pt. 2, Historical Geology. 3d ed. New York.

4) T. Kobayashi (1943), On the Pre-Cambrian Basement complexes in Eastern Asia, *Shigen Kagaku Kenkyusho Iho No. 1 ; (1944)* The Cardle of Geological History of Eastern Asia. A Scope on the recent Studies on Pre-Cambrian Basement and its fundamental Questions. *Geography, vol. 12, Tokyo.*

fortunately no datum is as yet available which bears on their chronology. I shall try here to estimate the length of time taken to deposit the Sinian formation.

It is well established for most, if not all, parts of Eastern Asia that peneplanation was quite advanced before the deposition of the Sinian formation. Thanks to the laborious work by Matsushita and others,[1] the stratigraphy of the formation in the Heinan (平南) geosyncline where it is thickest, is now known in detail. In collaboration with my students, on the other hand, I made a study of the Chosen group in the Yokusen (沃川) geosyncline.[2] The former was brought into being in the Sinian and the latter in the Cambrian period. These two geosynclines are a kind of parageosyncline in which no intense volcanism or magmatism took place in the early stages of their growth. The first cycles of sedimentation in these parageosynclines proceeded in a similar way. This is shown by the fact that the facies succession of the Cambrian system of Yokusen is, remarkably enough, more similar to that of the Sinian than to that of the Cambrian of the Heinan geosyncline. More precisely,

1) the sediments in the early phase of the cycle are characterized by sandy rocks which merge upward with shaly rocks, as seen in the Chokken (直覡) division inclusive of the Tahoshangshan (大和尙山) in the Sinian formation; in the Cambrian system in Kogendo the Sohsan (壯山) quartzite is overlain by the Beiho (猫峰) shale.
2) Sediments in the middle phase is mostly calcareous as represented by the Shidogu (祠堂隅) division inclusive of the Kuantung (關東) in the Heinan geosyncline as well as by the Taiki (大基) limestone formation in the Yokusen geosyncline, and
3) variation of facies attains its maximum in the Kuken (駒覡) division inclusive of the Nanshan (南山) as well as the Kasetsu (花折) group plus the Seison (細松) slate, both being products in the last phase of the cycle of sedimentation. The difference between these Sinian and Cambrian sediments is that, while intraformational conglomerates are common in the latter, *Collenia* reefs are sometimes found in the former. But they are alike in showing the shallowness of their bottoms where they were deposited.

After the first cycle had thus finished, the next one commenced with a sandy sediment which was thin and local as exemplified by the Bunsanri (文山里) and Doten (銅店) quartzites which are incomparably thinner than the sandy sediments in the early phase of the first cycle.

Because the development of these geosynclines in their early stage is alike, I first calculated the rate of sedimentation for the Cambrian formation in the Yokusen geosyncline and followed it by checking the validity of this rate for the Ordovician formation of the geosyncline. This gave 45 million years as the length of the four-fifths of the Ordovician period. Incidentally the Tsuibon (斗圍峰) limestone at the

---

1) S. Matsushita (1941), Correlation between Syogen System in the Central Area of Kokaido, Korea and the Sinian System in the Kuantung Province, South Manchuria. *Japan. Jour. Geol. Geogr. vol. 18.*

2) T. Kobayashi I. Yosimura, Y. Iwaya and Y. Hukasawa (1942), The Yokusen Geosyncline in the Chosen Period. Brief Notes on the Geologic History of the Yokusen Orogenic Zone 1. *Proc.* **18** (1942).

top of the Ordovician formation there, is an approximate equvalent of the Black River of North America; and the Chikunsan (機雪山) shale beneath the limestone, of the Llandeilian of Europe.[1] The number of years above given appears a little shorter than what might be expected. But applying tentatively the same rate to the Sinian formations in the Kuntung district and Kokaido, 395 and 600 million years were obtained respectively for the durations of their sedimentation (See table 3.) I rechecked the dependability of this method by assuming that the speed of sedimentation among limy, shaly and sandy sediments was in the ratio of 1:2:3, or 1:3:4, or 1:3:5. With the three sets of ratios, 54, 51 and 57 were given as answers in units of a million years for the Ordovician formation and 462 and 586, 448 and 576, and 467 and 581 for the Sinian of the two areas as shown in the table. Because the expected time-length of the Ordovician of the Yokusen geosyncline is 51 to 57 million years, 450 to 550 million years

TABLE III. Estimation of the Sinian Time-Length.

Formation		Rakuroan			
		Sinian		Chosen	
				Cambrian	Ordovician
Area		Heinan Geosyncline		Yokusen	Geosyncline
		Kokaido	Kuantung		
Maximum thickness of Sediments in metres.	Sandy.	2500	1650	300	50
	Shaly.	5145	2830	1000	320
	Limy.	2570	2950	400	400
	Total.	10215	7030	1700	770
Estimated Time-Length in Million years.		600	395	100	45
Total thickness converted into sandy sediment with the ratio of 1:2:3.		20500	16160	3500	1890
Estimated Time-Length.		586	462	100	54
Total thickness converted into sandy sediment with the ratio of 1:3:4.		28215	21940	4900	2610
Estimated Time-Length.		576	448	100	51
Total thickness converted into sandy sediment with the ratio of 1:3:5.		30785	24890	5300	3010
Estimated Time-Length.		581	467	100	57

1) T. Kobayashi (1934). The Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Pt. 1, Middle Ordovician Faunas. *Jour. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 3, pt. 8.*

may be taken as the approximate duration of the Sinian time.[1)]

This is the only method now applicable to the estimation of the Sinian duration. To make the estimate more accurate, more study is needed on the rate of sedimentation among various facies as well as on the physical condition not only of the geosyncline but also of its surroundings. In view of these considerations, certain reasons occur in my mind to suggest that the Sinian duration is a little shorter than $\pm 5 \times 10^8$ years. One of them is the upwardly increasing tendency in the amount of chemical or calcareous sediments relative to that of terrigenous sediments, coupled with the tendency of the size of the grain in the terrigenous sediments to decrease in the same direction. These tendencies can be recognized not only in these formations of the two geosynclines but also in the whole Rakuroan (樂浪) complex in Eastern Asia, suggesting that peneplanation on land went on through the tranquil Rakuroan time. A clino-unconformity was recently discovered by Saito[2)] between the middle and upper divisions of the Sinian formation in the Fanho (汎河) district northeast of Fengtien (奉天) while another clino-unconformity was reported by Yamane[3)] between the Lower Sinian Hoshan sandstone and the Cambrian formation in the Yuho Valley (峪河) in the extreme south of the Tahangshan (太行山) range. But these are two local exceptions. The absence of distinct discordance in the rest of Eastern Asia is a strong evidence of the tranquility of the time. This belief is further supported by the variation in facies and thickness which, insofar as the Shansi basin and its surrounding, are concerned,[4)] is somewhat stronger in the Sinian than in the Chosen group showing that the area of sedimentation and accordingly the surrounding lands also, became more monotonous as time proceeded. Conglomerates containing large boulders are reported to occur at a few places near the margin of the Hwangho basin in the Sinian formation, especially at its base, but not in the Cambro-Ordovician Chosen group.

---

1) The most difficult is the determination of the annual rate of sedimentation of the different facies. Assuming the three sets of ratios among the facies given above, 10.6 to 12.25 metres of limestones must have been deposited per million years during the Rakuroan eon. I was quite unprepared for the finding that this rate of sedimentation is not much different from that of the Akiyoshi limestone in the Province of Nagato, which was calculated here.

This limestone, 450 m. at the thickest, comprises the Upper Visean, Moscovian, Sakmarian and Artinskian stages according to Ozawa, Hanzawa and others; the Permian and Carboniferous periods are estimated by Stille to be respectively 30 and 60 million years. Assuming that this limestone occupies a half of the Permo-Carboniferous period, it is a deposit of 45 million years. In other words, 10 metres of limestone was deposited per million years.

2. R. Saito (1943). Succession of the Pre-Cambrian Group in South Manchuria and North China. *Mem. Geol. Inst. Manchukuo, no. 10.*

3) S. Yamane (1931). The Geologic Structure of Southwestern Shansi and adjoining Districts of Chih-li (Hopei) and Honan, North China. *Japan. Jour. Geol. Geogr. vol. 8.*

4) T. Kobayashi (1942). The Rakuroan Complex of the Shansi Basin and its Surroundings. Miscellaneous Notes on the Cambro-Ordovician Geology and Palaeontology 8. *Japan. Jour. Geol. Geogr. vol. 18.*

It must also be remembered that, while the time-intervals indicated by local disconformities in the Sinian succession of the Heinan geosyncline are discounted in the preceding estimation, the thickness of the Sinian formation given above is the sum of the maximum thickness of its minor divisions or stages given by Matsushita, but the sum of his series in the Kuantung district and Kokaido are respectively 6550 m. and 7700 m. instead of 7630 m. and 10215 m. The above mentioned facts as a whole appear to justify the reduction of the number of years given above by one-fifth or at least one-seventh, but it is hardly justifiable to reduce it by one-half.

When Grabau[1] redefined the Sinian in 1921, he took it for the oldest period of the Palaeozoic era. But now it can be concluded that the duration of *the Sinian is by no means shorter than that of an era.* Probably it occupies the larger part of the Neo-Cryptozoic eon. Needless to say, the reference of the Sinian which does not comprise any fossil time, to the Phanerozoic eon should be abandoned, because it evidently gives rise to a great confusion in the concept of geologic time.

1) A. W. Grabau (1922). The Sinian System. *Bull. Geol. Soc. China, vol. 1.*