TITLE:

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CITATION:

Kawai, Naoto ...[et al]. Application of Rock Magnetism to the Formation of Mountains (Himalaya-Tibetan and Circumpacific Mountain Chains). Memoirs of the College of Science, University of Kyoto. Series B 1959, 26(2): 229-234

ISSUE DATE:

1959-11-15

URL:

http://hdl.handle.net/2433/258569

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MEMOIRS OF THE COLLEGE OF SCIENCE, UNIVERSITY OF KYOTO, SERIES B,
Vol. XXVI, No. 2 Geology and Mineralogy, Article 11, 1959

Application of Rock Magnetism to the Formation of Mountains
(Himalaya-Tibetan and Circumpacific Mountain Chains)

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(Received Oct. 18, 1959)

Abstract

Results of rock-magnetism obtained at Imperial College of Science and Technology and those at the University of Kyoto are applied to elucidate a mountain making mechanism of the Himalaya-Tibetan and Circumpacific mountain chains. The gravity anomalies in the Japanese Islands are used to estimate the shape of the continental base plunged into the substratum.

Since SUESS' hypothesis[1], it has been stated by many geologists that thick layers of sediments were deposited in the Tethys Geosyncline. These were squeezed out by the compression due to the Gondwana land movement relative to the Siberian and Baltican table lands, and thus the mountain chains of the Himalaya-Tibetan zone were formed.

The above hypothesis is now being proved quantitatively by the Rock Magnetism Group at Imperial College, London [2),3),4)], by using the fossil magnetization found in the Decan Traps of India.

The results so far obtained by CLEGG *et al.*[4] show that India has moved significantly northwards since late Cretaceous or Miocene times, when it has come in contact with the Euro-Asian continent. This is clearly indicated in the remanent magnetism of the Miocene lava whose magnetic dip was found to be approximately 12° downwards.

The difference of the dip from that present geomagnetic field is about 10°, which shows northward drift of India by an amount of about 5.3° along the meridian.

Since a northward shift of 1° along the meridian corresponds to a linear distance of 111 km, it seems quite reasonable to assume that India has drifted approximately 590 km to its present latitude. In so doing, the soft sediments, sandwiched between the hard continental masses, have been squeezed and compressed together, as shown in Fig. 1.

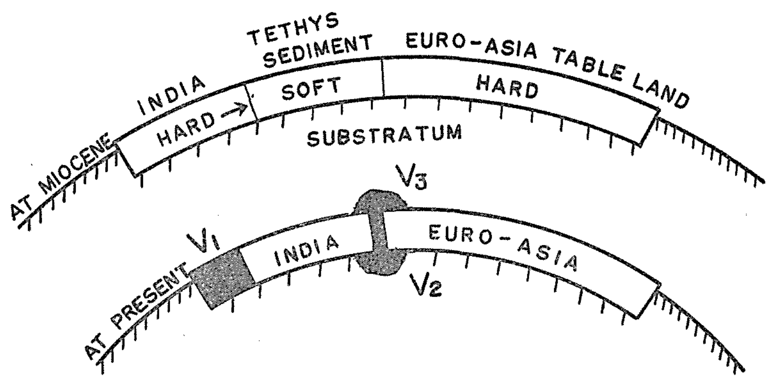

Fig. 1. Schematic diagram showing the bulges V_2 and V_3 produced by the squeeze of the Tethys· sediments.

From the above geological data, the following points may be emphasized: Volume V_3 of the sediments which were squeezed and compressed upwards over the surface of the earth plus the volume V_2 compressed downward into the substratum is nearly equal to the volume V_1, or the space corresponding to the *volume shift* of India.

Thus,
$$V_1 = V_2 + V_3 \qquad (1)$$

With metamorphism that would have taken place due to the squeezing, some reduction in the volume of the sediments should have occurred.

Hence,
$$V_1 > V_2 + V_3 \qquad (2)$$

Assuming the mean thickness of the Indian continent from seismological data to be about 30 km, we find that the volume V_1 works out to be approximately 0.8×10^7 km^3.

An estimate for the volume V_3 may be obtained from the data of explorations of the Japanese Group of Karakorum-Hindu-Kush, which have been amassed at the University of Kyoto. These explorations were carried out in 1956-7 into the central zone of the mountain chain, and a number of rock samples were collected. From determination of the Curie point of ferrites contained in these samples, we can determine the amount of the upheavals[5], or the thickness of the erosion. Therefore, by adding the thus-determined thickness of the eroded land to the present height of the mountains, we can obtained the shape of the original upward bulge, that is V_3. Thus, V_1 may be obtained from the Indian results showing continental drift of 590 km.

Lastly, volume V_2 may be obtained from the analysis of Bouguer gravity anomaly. No sufficient gravity data has ever been obtained in the Trans-Himalaya zone. Therefore, the above-mentioned examination is still impossible at present.

But this method of elucidating the mountain making mechanism is applicable to the Circumpacific mountain chains, to which the Japanese Islands belong and whose gravity data[6),7)] (Fig. 2) and thickness of the erosion[5)] have well been observed.

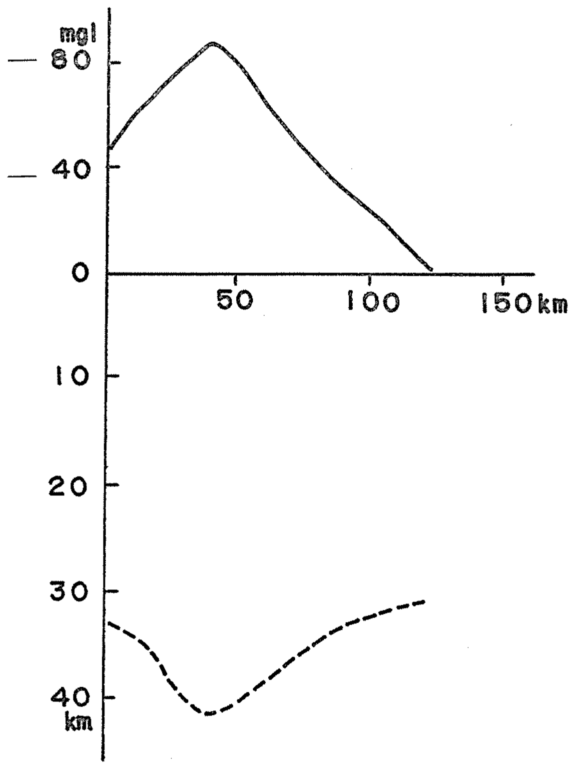

Fig. 2. Gravity anomaly of Japanese Island and the estimated shape of the downward bulge plunged into the substratum along the cross-section from Tokyo to Toyama.

On the other hand, RUNCORN's results[8)] showing the pole position of the earth in the remote geological time indicates the existence of very intense compression of the oceanic basement due to the relative drift of America against Europe (Fig. 3). This drift can be considered to have continued until the Triasic age.

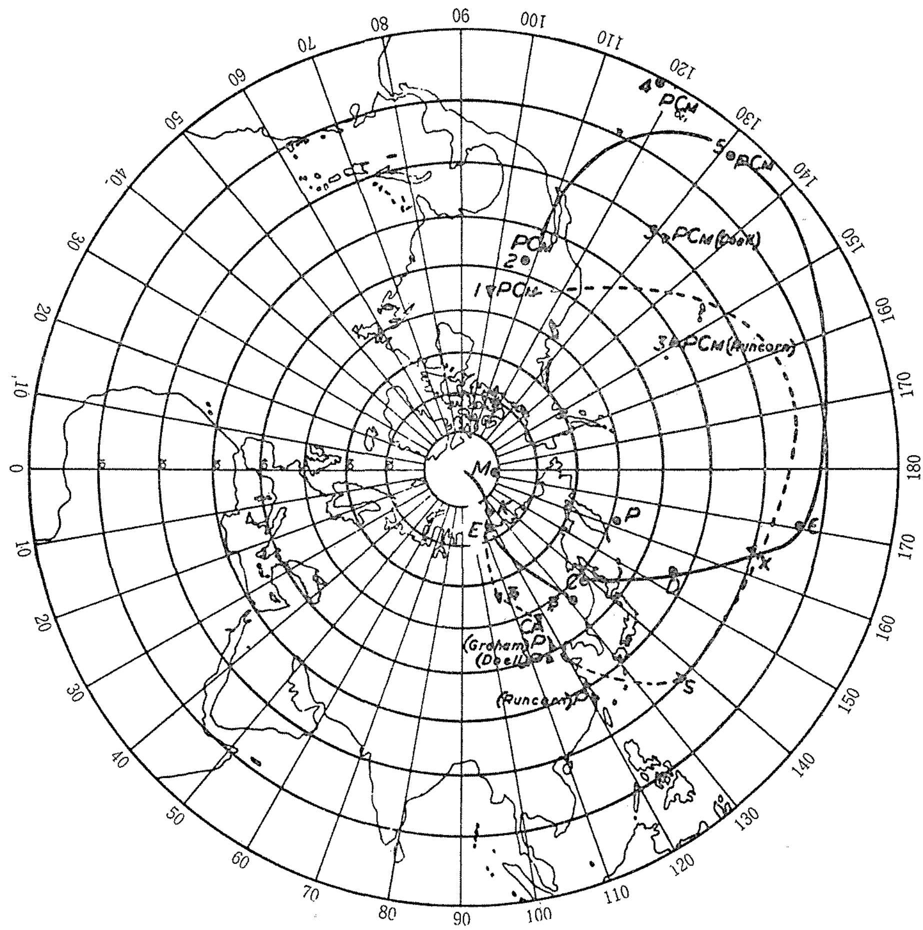

Fig. 3. Two traces of pole positions of the earth ; the dotted line is the trace obtained from American data and the full line from Britain. The two results show the westward drift of America relative to Euro-Asian Continent (after RUNCORN).

According to his observation, the linear compression of the basement of the Pacific works out to be more than 1000 km, and quite similar volume relations (1) and (2) as have above-proposed in the Himalaya-Tibetan zone are not impossible to take place along the circumpacific mountain zone. These trials are now under examination at the University of Kyoto.

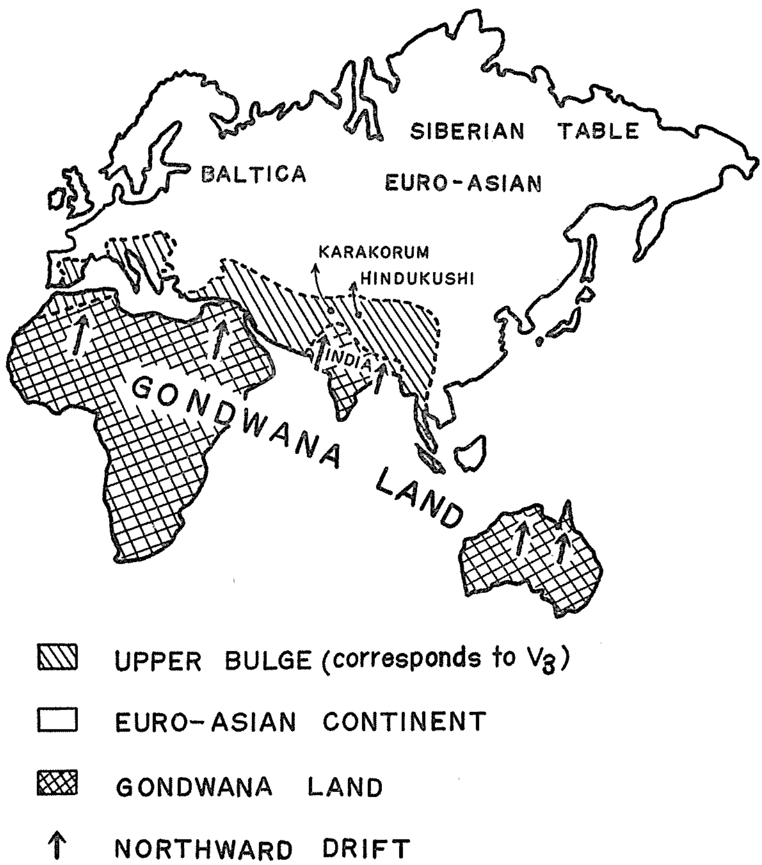

Fig. 4. Northward drift of Gondwana land, arrows showing the directions of the drifts.

Acknowledgments

The present authors' hearty thanks are first to Professor P. M. S. BLACKETT and Dr. J. A. CLEGG for their constant encouragements and discussions during the first named author was studying in Imperial College of Science and Technology, London. The authors also would like to convey their thanks to Professor N. KUMAGAI for his criticism and advices given to us, and also to Dr. N. MIYABE who pointed out the existence a very close relationships between Bouguer gravity anomaly and the amount of upheavals the first named author has found in Japan. Authors' acknowledgments are also to Professor M. MATSUSHITA whose offer of rock samples from the Himalaya-Tibetan zone stimulated this investigation very much.

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