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An Interpretation of Kawajiri-Misaki Complex of Normal and Reversed Remanent Magnetization*

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Reverse-Normal intermixing magnetic polarity in Kawajiri-Misaki (Cape Kawajiri) lava flow(1) discovered by the author in Japan almost fifteen years ago and assumed to have occurred by the self-reversal due to an exsolution of titanomagnetite was reexamined recently in the laboratory. The present author reports herein the experimental results obtained together with an interpretation that differs from the author's old one.

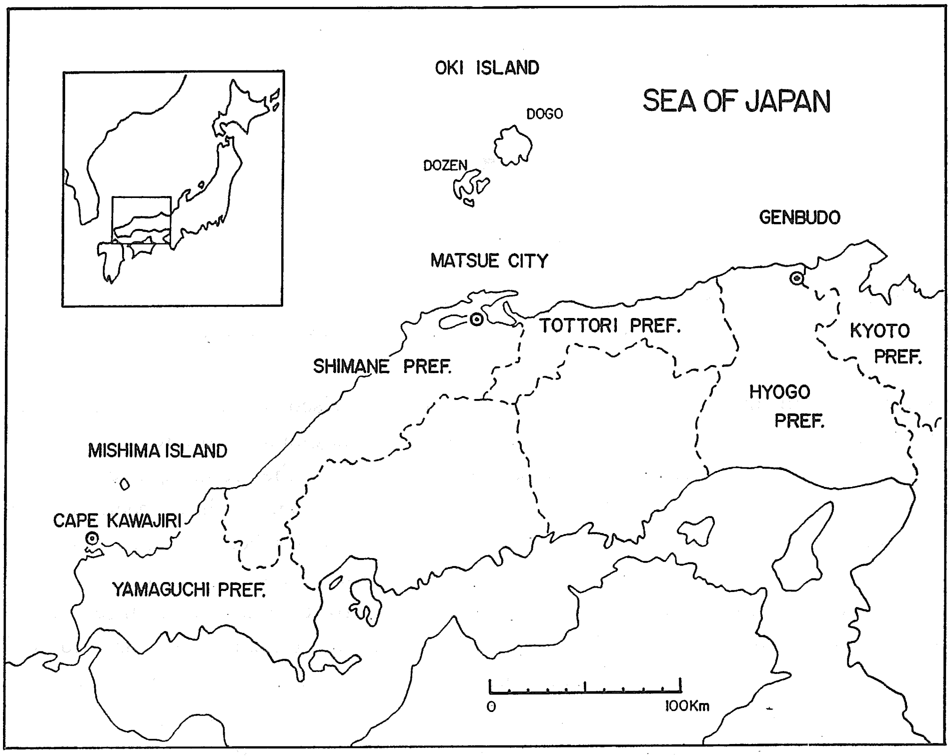

Fig. 1. A map of San-in province.

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A. C. and thermal demagnetization of remanent polarity were carried out in a μ metal non-magnetic box and the change of vectors with an increasing intensity of the applied A. C. field and also the change with an elevating temperature of demagnetization were traced in both the reverse rock specimen and the normal one. Normally magnetized specimen changed its sign of the remanent vector before the A. C. field was increased up to 200 Oe and also before the demagnetization temperature was elevated up to 300°C, whereas the vector in the reversely magnetized specimen remains unchanged at all. After this change of sign the intensity of the reverse polarity increased gradually and disappeared at the Curie point of the ferromagnetic minerals.

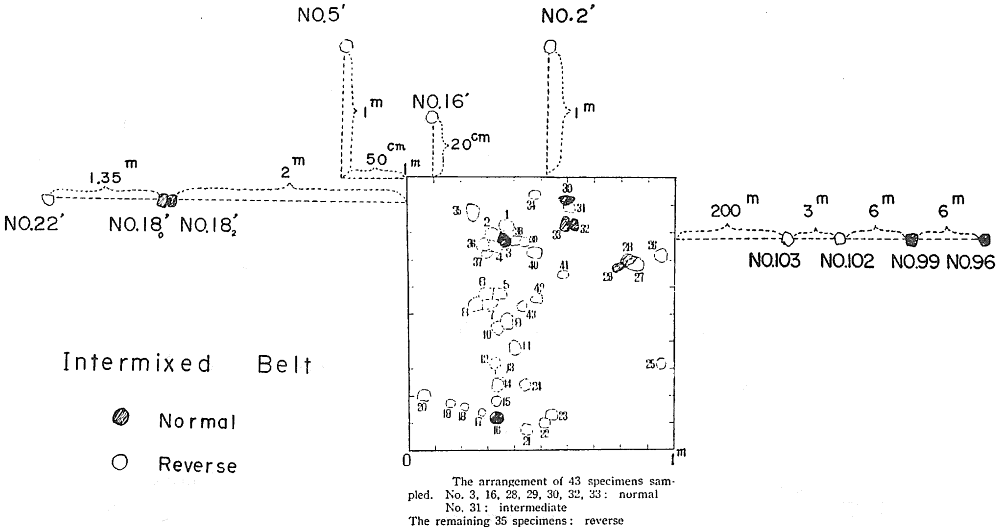

Fig. 2. Sampling points of intermixed belt of Cape Kawajiri. The mark of square represents the part of side by side intermixing already reported.

So, a question arose as to whether or not a large viscous magnetic component had been produced in the direction of a relatively recent magnetic field and it superimposed upon the original reversely magnetized vector. If so, the geomagnetic field under which the lava had cooled and subsequently magnetized should have been not normal but reverse. It could not have been the self-reversal as has been already proposed by himself. (1) Then, the author tried to recall the details of the rock storage experiments he has continued for more than seven years. If the rock contained a large soft component, then in the applied laboratory field a viscous remanent vector should have newly been produced and an appreciable change of direction of the polarity should have been observed. Despite the comparison of the old data of the original measurement and those of remeasurements after the storage, he could not find any difference in direction. The normal component that disappeared in a relatively initial stage of the demagnetization, therefore, can not be assumed as the so-called unstable remanent one. The soft domains, if they did exist, should strongly be bound in a direction opposite to that of the hard magnetic domain.

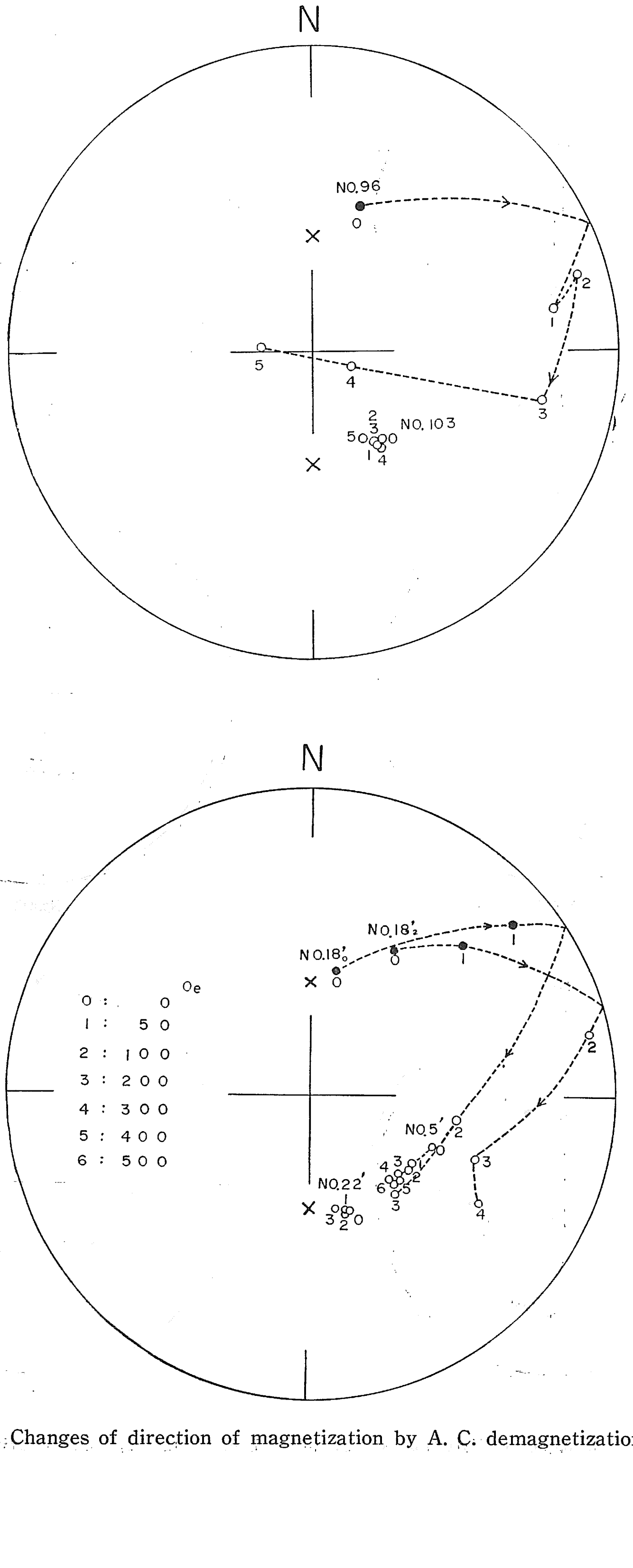

Fig. 3. Changes of direction of magnetization by A. C. demagnetization.

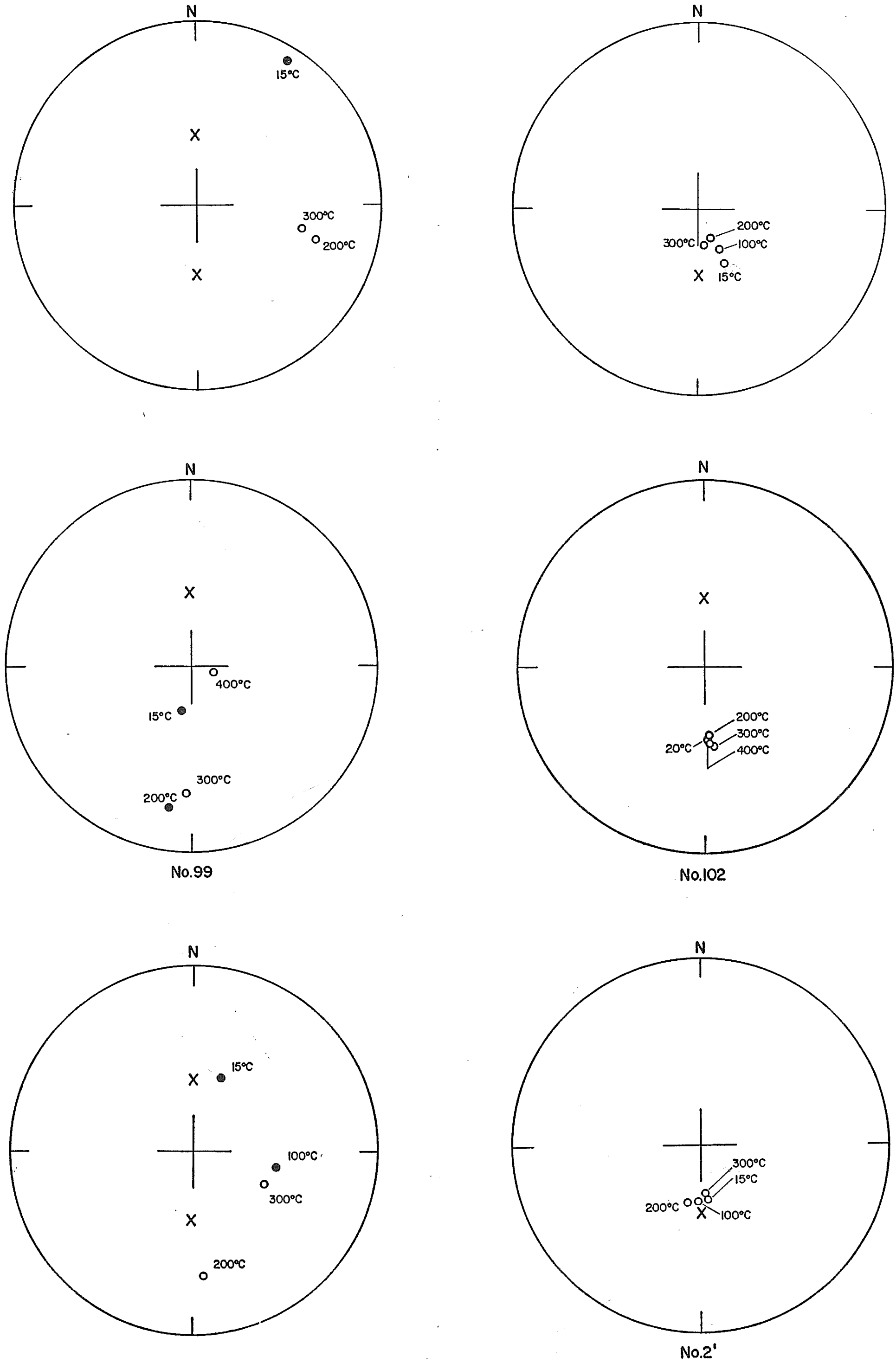

Fig. 4. Changes of direcfion of magnetization by thermal demagnetization.

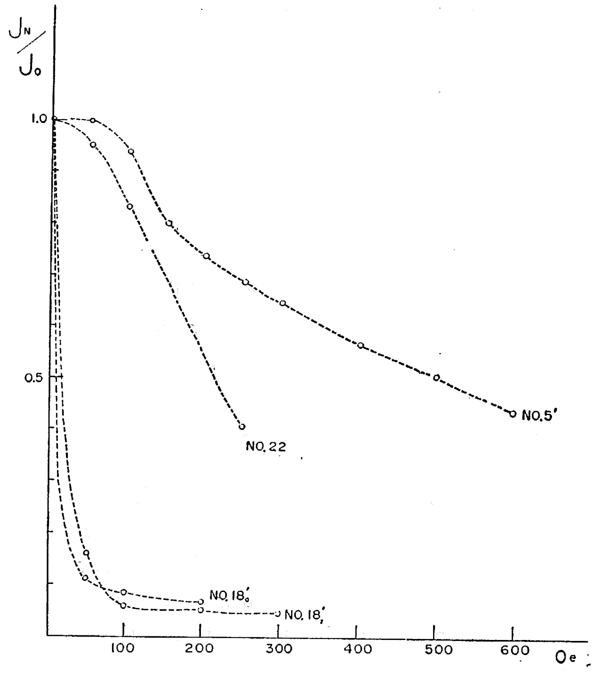

Fig. 5. Changes of intensity of magnetization by A. C. demagnetization.

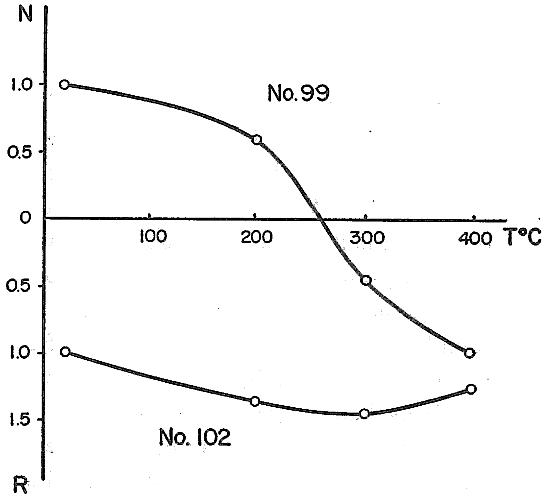

Fig. 6. Changes of intensity of magnetization by thermal demagnetization.

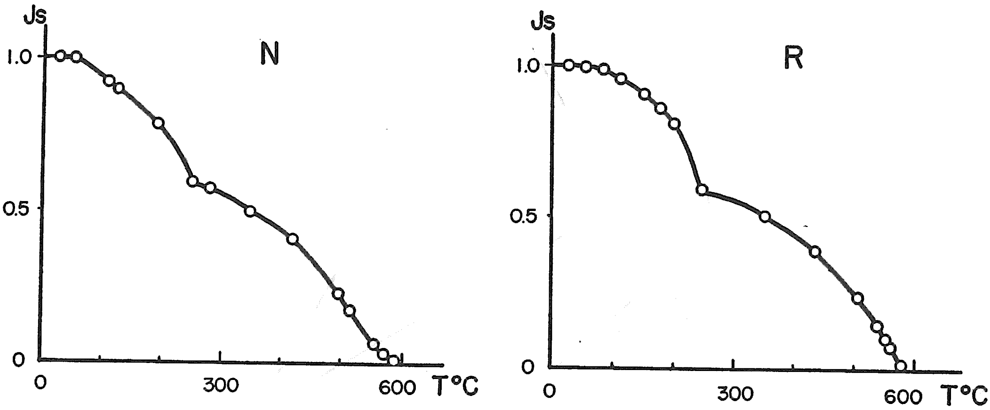

Fig. 7. Typical Js−T curve

Thermo-magnetic curve of the rock-forming ferromagnetic crystal showed a rapid fall of Js value from the initial stage of the heating and indicated a coexistence of a low Curie titanomagnetite with higher Curie ones, although the separation of the former was difficult. This magnetic phase with low Curie point might have borne the soft and normal component which was cleaned up easily by both the A. C. and thermal demagnetization. It thus seems reasonable to assume that the hard and reverse component was represented by the magnetic minerals with higher Curie points. Next comes the important part of his new interpretations.

It is a general characteristic of the Tertiary volcanic rocks of San-in province exposed along the Sea of Japan that the original volcanic magma was not only extremely alkali-rich and titaniferrous but also was in a conspicuously reduced condition even after the solidification. The hot lava flow, therefore, have a strong tendency of being easily oxidized at low temperature. The oxidation is only partly suppressed when the lava was intruded into a closed chamber of the crust and rapidly chilled as in the case of Genbudô basalt whose reverse magnetism was found by late Professor M. Matuyama(2). When the lava formed and solidified, an oxidation of an original titanomagnetite with low Curie point was inevitable and proceeded most rapidly when the temperature would be cooled down below 300°C. Low temperature oxidation of the magnetic mineral seems to be a typical characteristic of the Tertiary lava flows found in the Sea of Japan coast of San-in province. It then becomes reasonable to suppose that the original titanomagnetite obtained its thermo-remanent magnetism in a relatively later stage of cooling below 300°C. The geomagnetic field that had applied upon the rock in the cooling was parallel in direction to that of the present field. As oxidation proceeded, oxidized magnetite acquired the reverse chemical remanent vector. Thus, the self-reversal might have taken place by the reverse chemical remanent magnetization due to oxidation after the original acquisition of the normal remanent vector and the intermixing magnetic polarity have been given rise to. The results of chemical analysis of Kawajiri rocks show the oxidation phenomenon(3).

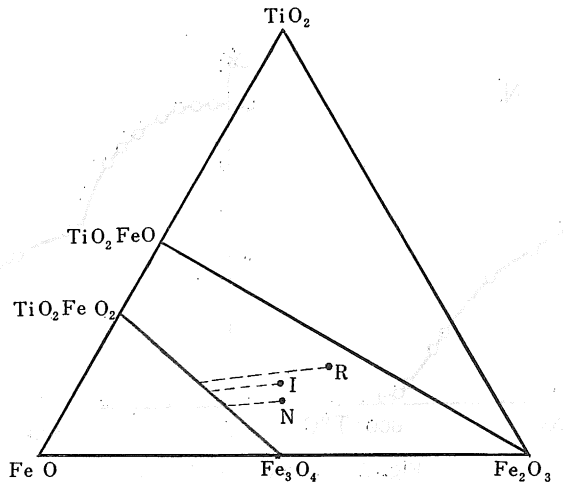

Fig. 8. Chemical composition represented on FeO-Fe_2O_3-TiO_2 diagram in mol percent.
N : normal, R : reverse, I : intermixed.

Hence, Kawajiri-Misaki lava flow seems to be a natural example showing the low temperature oxidation. On the other hand, the oxidation temperature seems to be very much limited. It should be lower than the Curie point of the original titanomagnetite. The oxidation at such a low temperature seems to be too sluggish to have occurred. It might have taken place, therefore, for a long time interval.

In concluding, the author would like to emphasize the theory of self-reversal, not field-reversal, in Kawajiri-Misaki lava flow is not at all touched by this new assumption. But the author is now proposing the possibility of self-reversal by oxidation seems to be more reasonable than his past exsolution theory.

Finally, the author wishes to express his hearty thanks to Professor N. Kawai of Ôsaka University for his valuable discussions.

References

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(3) Asami, E.: Bull. Shimane Univ., **13**, 139-143, 1964.