

THE OCCURRENCE OF COMMERCIAL MUSCOVITE IN PEGMATITES

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Descriptions of most mica-pegmatite districts are available, but due to a general lack of attention to precise description of mineral relationships, much of the earlier literature is of little significance. The purpose of this paper is to emphasize certain general truths which appear to govern the formation of large muscovite crystals of commercial value. Discussion will be limited to occurrences of the greatest economic importance; apparently most of the world's production of sheet mica has come from the Madras Presidency and the Province of Bihar and Orissa, India, and the states of North Carolina, New Hampshire, and South Dakota.

The development of the concept of replacement in metallic ore-bodies was followed by the concept of the replacement origin of many pegmatites. The principles of ore-body zoning around an intrusion is likewise paralleled by the zonal distribution of pegmatites, best established by Maurice¹ in the Spruce Pine district, North Carolina, on the basis of the composition of the plagioclase of the pegmatites. Close study of other pegmatite areas should reveal more instances of such zoning.

As a basis, the writer proposes to accept a modified two-stage, aqueo-igneous theory for the formation of pegmatites containing commercial sheet mica. It appears reasonable, as Landes² suggests,

that the two stages, the first of primary introduction and the second of open system replacement by hydrothermal solutions, may be merely one long-continued stage, in which the components which modify the original mineralogy were derived directly from portions of the same pegmatite closer to the source. Replacement relations in pegmatites are often difficult to interpret, and without strict definition of terms the boundary between the minerals of the magmatic stage and those of the hydrothermal stage is indistinct.

Field relations and the literature show that commercial muscovite is apparently of late magmatic and early hydrothermal origin. Much of the evidence for late formation lies in the continuity of distribution of the mica books along country-rock contacts, along interior structural features, along seams, and in shoots wandering irregularly about in the pegmatite. The definite continuity for several hundred feet of commercial muscovite shoots in large pegmatites has been often observed. Two or more such mica shoots, of different colors and with distinct differences in perfection of crystallization, are occasionally met in the same pegmatite, indicating different times of formation.

Plagioclase feldspar and quartz are the two most persistent mineral associates of muscovite. From a compositional

¹ Maurice, C. S., The pegmatites of the Spruce Pine district, North Carolina: *Econ. Geology*, Vol. 35, pp. 49-78, 158-185, 1940.

² Landes, K. K., The origin and classification of pegmatites: *Am. Mineralogist*, vol. 18, pp. 33-56, 95-103, 1933.

viewpoint, the three largest mica districts of the world yield the best and most mica from pegmatites containing plagioclase considerably more calcic than albite, with microcline absent or present only in small amount. Of the Kodarma district, the largest in India, Roy³ writes, "Workable quantities of mica occur only in those pegmatites in which albite-oligoclase is the dominant or the only feldspar present." Of the Spruce Pine mica pegmatites, Maurice⁴ says, "The predominant mineral is plagioclase, generally calcic-oligoclase." In the Nellore district, the second largest in India, Biswas⁵ emphasizes the abundance of plagioclase ranging from albite to andesine. Oligoclase is present in the mica pegmatites of New Hampshire and South Dakota, but no correlations similar to the above have been drawn.

Perfection of crystallization in the muscovite crystals is of first importance commercially; much mica is inclined to crystallographic irregularities due either to post-pegmatite earth movement or to the influence of unfavorable conditions during formation. The principal crystallographic variety is the type known as "A" or "wedge" mica, in which the mica books are shaped much like an arrowhead, and commonly taper toward the point, sometimes as much as 30°. The literature contains references to this variety in every mica district in the country, and foreign references further show its frequent presence.

Hess⁶ attributed the formation of A mica to "cooling and stoppage of solutions," and suggests that, with continued flow of solutions the A mica may recrystallize into clear, smooth books. From the large size, over three feet, reached by some A mica crystals, and from definite differences in occurrence between A and flat mica, the writer believes that continued flow of solutions merely makes the A books larger, and that, at lower temperature, coupled with other less definite factors, A mica is formed rather than flat.

Of the spatial relationships of muscovite shoots and pockets to the country rock contacts and internal structures no strong generalizations can be made, except that in many pegmatites the mica-rich portions lie along the country rock contacts and along the margins of barren quartz masses, if present. It is not unusual for the mica shoot to occur along the hanging wall alone, or to leave the contact and wander through the main pegmatite mass. In some bodies the mica occurs in segregation pockets of almost solid mica, but this type is rare. Of the continuity of mica shoots, Roy⁷ describes an Indian mine which has been worked for 1000 feet along the strike and for 400 feet down dip; 700 to 800 feet is probably about the length of the longest shoots worked in North Carolina.

The source of the muscovite of pegmatites has been held in question. The frequent occurrences of mica pegmatites in the muscovite schists and gneisses of the pre-Cambrian and Paleozoic, coupled with the rarity of commercial mica in pegmatites in the source batholiths and in mica-free rocks, led several observers, such as Holland⁸ and Smith⁹ in India, to attribute the muscovite to recrystallization of material assimilated from the country rock by pegmatitic action. Even when the pegmatites occur in mica-poor country rock, they may at reasonable depth traverse micaceous formations. If the concept of the pegmatite as an open system is accepted, it should be possible for the pegmatitic liquor to assimilate any constituents of mica which might be lacking, later to precipitate the mica where conditions were favorable, no matter what the wall rock might be.

To oppose this view, several estimates of muscovite content of pegmatites by Mohr¹⁰ show that the average mica mine yields only from 2.5 to 4% of mica by weight; block mica contents of 4 to 7% are not uncommon, but they characterize shoots especially rich in mica. Bearing in mind the nature of the pegmatite differentiation process, there appears to be

³ Roy, S. K. Sharma, N. L., and Chattapodhyah, G. C., The mica-pegmatites of Kodarma, India: *Geol. Mag.*, vol. 76, pp. 145-164, 1939.

⁴ *op. cit.*, p. 68.

⁵ Biswas, S. L., Origin of the mica pegmatites of Nellore: *Quart. Jour. Geol. Min. Met. Soc. India*, vol. 7, pp. 135-147, 1935.

⁶ Hess, F. L., The pegmatites of the western states: Ore deposits of the western states, (Lindgren volume), pp. 526-536, *Am. Inst. Min. Met. Eng.*, 1933.

⁷ *op. cit.*, p. 151.

⁸ Holland, T. H., Mica deposits of India: *Mem. India Geol. Survey*, vol. 34, pp. 11-121, 1902.

⁹ Smith, A. M., Mica mining in Bengal, India: *Mineral Industry*, vol. 7, pp. 512-513, 1899.

¹⁰ Mohr, H., *Der Nutzglimmer*, pp. 151-153, Berlin, Gebruder Borntraeger, 1930.

little need to go beyond the original granitic source for most of the muscovite of pegmatites. Although pegmatites yielding commercial sheet mica are only rarely found in the original batholithic source, several of the New Hampshire mica mines are in members of the New Hampshire magma series, which is apparently their source, and scattered references to similar occurrences may be found.

According to Bowen,¹¹ the pegmatitic liquor is by the very nature of its origin essentially saturated, and its reaction with the wall rock will be chiefly in the

nature of the formation of what may be termed addition compounds. Of over two hundred mica pegmatites visited by the writer, there were many in which field evidence showed no such possible amount of assimilation as could possibly produce the tonnage of mica which had been extracted, and the conclusion supporting that of previous investigators is that, while limited assimilation of muscovite or alumina necessary for its formation may take place, the source of the large muscovite books of commercial value is in the magmatic intrusion.

¹¹ Bowen, N. L., The broader story of magmatic differentiation, briefly told: Ore deposits of the western states, (Lindgren volume), pp. 106-128, Am. Inst. Min. Met. Eng., 1933.