Exsolution textures in pyroxenes have been extensively studied to understand the subsolidus phase relations of pyroxenes. Coexistence of two types of augite lamellae, '001' and '100', in one pigeonite crystal was first described by Morimoto and Tokonami (1969b). (Symbols '001' and '100' mean approximately parallel to (001) and (100), respectively.) Based on the calculation of the strain energies of the coherent interfaces between pigeonite and augite for the two types, they concluded that the '001' lamellae must be common. Smith (1969) pointed out the effect of the exsolution temperature on the orientation of the lamellae. Nakazawa and Hafner (1977) studied the genesis of '001' and '100' augite lamellae in pigeonite based on the lattice fitting (Robinson et al., 1971) and high temperature lattice data. They suggested the best fitting of the '001' and '100' planes between augite and pigeonite above and below a certain temperature between 550°C and 770°C, respectively. They called this temperature 'critical temperature'. However, this term is usually used in different meanings, e.g. the temperature of closure of immissibility gap. Therefore, the term 'morphology change temperature (MCT)' is proposed for the special temperature here concerned with.

In this paper, the morphology change of pigeonite exsolution lamellae in augite from '001' to '100' has been studied to confirm the existence of MCT for the pigeonite lamellae. For this purpose, ion-thinned specimens of augite from the Bushveld gabbro (SA-1019) were studied under a 200 kV analytical electron microscope, Hitachi-700H (Morimoto and Kitamura, 1981).

In the Bushveld augite, two types of pigeonite lamellae, '001' and '100', and orthopyroxene lamellae parallel to (100) have been observed (Robinson et al., 1977; Kitamura et al., 1981). The '001' type lamellae of pigeonite have further been divided into three different types depending upon the thickness of the lamellae and the orientation of the interface boundaries in order of decreasing thickness (Robinson et al., 1977). The pigeonite lamellae with the least thickness...
(<0.5 µm) have the composition richest in Fe among the ‘001’ pigeonite lamellae (Kitamura et al., 1981).

These thin ‘001’ lamellae can be divided into two groups according to their shapes. One group, which is rarely observed, has a tapering extremity with the habit plane of ‘001’. Each of the lamellae of the other group has an extremity bending to ‘100’ direction, which forms an obtuse angle with the ‘001’ stem portion. This bending is usually observed. Similar bending was reported of the ‘001’ pigeonite lamellae in igneous augite from Norway (Rietmeijer and Champness, 1980).

A texture with several isolated fragmental lamellae of pigeonite of the second group was observed (Fig. 1). Most parts of the isolated fragments are located in the area extrapolated from the stem portion of the ‘001’ lamellae. The crystallographic relations between the host and lamellae were studied by means of the lattice imaging technique, with the electron beam parallel to the b-axis common to both augite and pigeonite phases in the condition of ~1000 Å underfocus.

Fig. 2a is a high magnification of Fig. 1. The 4.5 Å and 9 Å fringes, corresponding to the (100) spacings of augite and pigeonite respectively, are schematically shown in Fig. 2b. In the ‘100’ tip part of the ‘001’ lamellae, the fringes of 9 Å are parallel to 4.5 Å fringes.
Fig. 2, a, b.  
(a) Magnified portion of the lattice image of pigeonite lamellae in Fig. 1.  
(b) The 4.5Å and 9Å fringes of augite and pigeonite in Fig. 2a are schematically shown.  
Anti-phase domain boundary is indicated by an arrow.
of augite, and the habit plane of the left side of the tip part is exactly in (100). The fringes of 9 Å in ‘001’ lamellae are slightly bent on the boundaries between the ‘001’ stem and ‘100’ tip part. Similar bending of the fringes is observed in the isolated fragments. The habit planes of the fragments are exactly in (100) in the left side of the fragments, but other interfaces are curved suggesting that they are assemblages of faces with high and low indices. In one fragment, an antiphase domain boundary is indicated by an arrow, where the slip vector is $\frac{1}{2}[110]$ (Morimoto and Tokonami, 1969a). The total area bounded by the extrapolated broken lines from the ‘001’ portion of the lamellae, including both pigeonite and augite (Fig. 1), is almost same as the sum of the areas of all fragmental pigeonite. No appreciable difference was observed in chemical composition between the ‘100’ tip and ‘001’ stem parts.

Rietmeijer and Champness (1980) described the texture of pigeonite lamellae with a bending extremity and attributed the change of growth direction to the existence of depleted solute regions. However, the textures consisting of the isolated fragments in this paper cannot be explained by the existence of depleted solute regions. They must have been formed by the change of the orientation of the phase boundaries from ‘001’ to ‘100’ as cooling proceeded through the MCT. Textures of the tip bending without any isolated fragments are also observed in this study. They are also considered to have been formed below the MCT, during or after the growth of the lamellae.

This change of morphology of pigeonite lamellae is considered to have occurred to reduce the interface strain energy. Finally, it is to be noted that the morphology change as above was never accompanied by the transformation of pigeonite to hypersthene, so far as our observation has gone.

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References

—— (1969b) : ibid., 54, 1101.