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42. A study of intergrowth textures and their possible origins in the Alvand plutonic complex, Hamadan, Iran

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Abstract

Various types of intergrowth textures occur in the Alvand plutonic complex, Hamadan, Iran. Intergrowth textures, such as myrmekite, perthite, micrographic (± granophyric), and tourmaline-microcline intergrowth, are most common in this suite. Perthite and micrographic textures show characteristics of magmatic origin, but myrmekite and tourmaline-microcline intergrowth probably have metasomatic origin. In diorites, myrmekite was possibly generated by Ca-metasomatism, but in granodiorites and granites, it may have formed by both K- and Ca-metasomatism. The presence of anti-rapakivi texture (K-feldspar overgrowth on plagioclase) in the same rocks may be related to this process, too.

Introduction

A brief historical review of intergrowth textures and their possible origins is as follows. Myrmekite is an intergrowth of vermicular quartz and sodic plagioclase which occurs near the rim of a plagioclase crystal, either between grains of perthitic K-feldspar or along the contact of K-feldspar and plagioclase crystals (Turner and Verhoogen, 1960, p. 68; Phillips, 1974; Cox et al., 1979, p. 302; Collins, 1983). Myrmekite may form by Na- and Ca-metasomatism of K-feldspar or by exsolution from the K-feldspar (Ashworth, 1972). When found adjacent to K-feldspar, it can result from replacement (metasomatic) processes (Ramberg, 1952; Peng, 1970; Phillips, 1974; Hibbard, 1980; Best, 1982, p. 116; Hyndman, 1985, p. 156; Collins, 1988, p. 29; Philpotts, 1989, p. 117). In addition, some myrmekite may result from exsolution but are later modified by replacement processes. Three kinds of myrmekite may form in plutonic rocks: rim myrmekite, wartlike myrmekite, and isolated myrmekite (Collins, 1988, p. 28). Rim myrmekite forms as narrow borders on zoned plagioclase where the amount of deformation is slight, and interstitial microcline may or may not be present. Wartlike myrmekite is produced where the deformation is stronger and always occurs with abundant microcline or orthoclase. Isolated myrmekite grains are formed in rocks free of microcline, and they are large grains separate from other plagioclase grains (Collins, 1988, p. 29).

Phillips (1974) and Collins (1988, p. 2) classified myrmekite into several genetic groups. Phillips (1974) discussed the genesis of myrmekite under six headings: (1) simultaneous or direct crystallization, (2) replacement of K-feldspar by plagioclase, (3) replacement of plagioclase by K-feldspar, (4) solid-state exsolution, (5) recrystallizing quartz involved with blastic plagioclase, and (6) combinations of some of 1-5 hypotheses. Collins (1988, p. 2) presented seven theories to explain the origin of myrmekite: (1) simultaneous or direct crystallization from a melt, (2) replacement of K-feldspar by plagioclase, (3) replacement of plagioclase by K-feldspar, (4) replacement of plagioclase by quartz, (5) growth of blastic plagioclase around residual, recrystallized quartz, (6) exsolution of myrmekite from a high-temperature K-feldspar, and (7) combinations of some of the above theories.

Graphic and micrographic textures are intergrowths of quartz in K-feldspar host (mostly orthoclase or microcline), which can be form (a) by replacement, (b) simultaneous crystallization at the eutectic point, or (c) crystallization from supercooled liquids (Turner and Verhoogen, 1960, p. 68; Barker, 1970; Lofgren, 1974; Best, 1982, p. 111; Hyndman, 1985, p. 55).

Granophyric texture is a special form of irregular intergrowth of quartz and alkali feldspar, which generally results from eutectic crystallization (Barker, 1970; Cox et al., 1979, p. 301).

Perthite is an intergrowth of a daughter (guest) Na-rich plagioclase (albite or oligoclase) in a parent (host) K-rich feldspar (orthoclase or microcline), which can be introduced by exsolution (unmixing) or replacement (metasomatism) due to reactions between permeating fluids and primary feldspar (Moorhouse, 1959, p. 49; Cox et al., 1979, p. 296; Hyndman, 1985, p. 88). Perthite takes many forms, such as string, rod, braided, zoned, vein, and patches.

Geological setting

The Alvand plutonic complex is located in the NW Sanandaj-Sirjan Zone, Iran. It is composed of granitoids (i.e., tonalites, granodiorites, granites), pegmatites, aplites, pegmatoids, intermediate and mafic plutonic rocks (i.e., quartz diorite, diorite, microdiorite, gabbro, gabbro-norite, olivine gabbro), and some doleritic and quartz doleritic dikes. The major host rocks of these intrusive rocks are metapelites with minor metabasites, calc-pelites, calc-silicates, and metacarbonates with different degrees of metamorphism from low to high grade. The most common country rocks are slates, phyllites, garnet (± andalusite, sillimanite, kyanite, staurolite) schists, garnet-sillimanite (± cordierite, kyanite) migmatites, cordierite (± garnet, andalusite, sillimanite) hornfelses (Fig. 1). Both magmatic (plutonic) and metamorphic processes have occurred mostly in Cretaceous time (Baharifar, 1997; Sepahi, 1999).

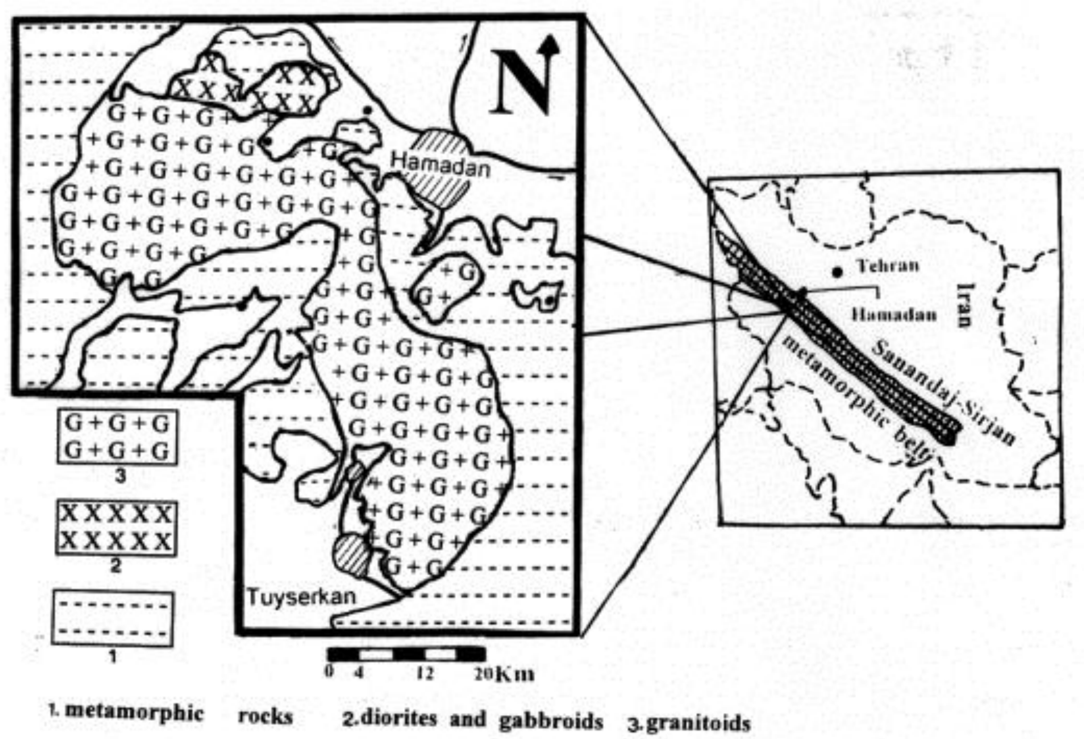

Fig. 1. The generalized geological map of the study area.

Several types of intergrowth and overgrowth textures occur in the various types of rocks of this spectacular intrusive complex, such as: myrmekite, perthite, micrographic and graphic, tourmaline-feldspar (microcline) intergrowths, and K-feldspar-plagioclase overgrowth (anti-rapakivi texture). Micrographic (± granophyric) and perthite textures are common in some microgranites. Graphic, macroperthite, microperthite, and tourmaline-microcline intergrowth are visible in many pegmatites. In microgranites, string perthite is common, but in granodiorites, granites, and pegmatites, perthite is of vein (network) type. Myrmekite is common in many rocks, such as diorites, quartz-diorites, granodiorites, and granites. These textures have various histories of formation, which are discussed in detail as follows.

Discussion of possible origins of intergrowth textures

Because of the absence of K-feldspar in diorites of the study area, the myrmekite, which is seen in these rocks, may have formed by Ca-metasomatism where more-calcic plagioclase has replaced sodic rims of zoned plagioclase crystals (Fig. 2). See also Collins (1997b; http://www.csun.edu/~vcgeo005/Nr4CaMyrm.pdf.

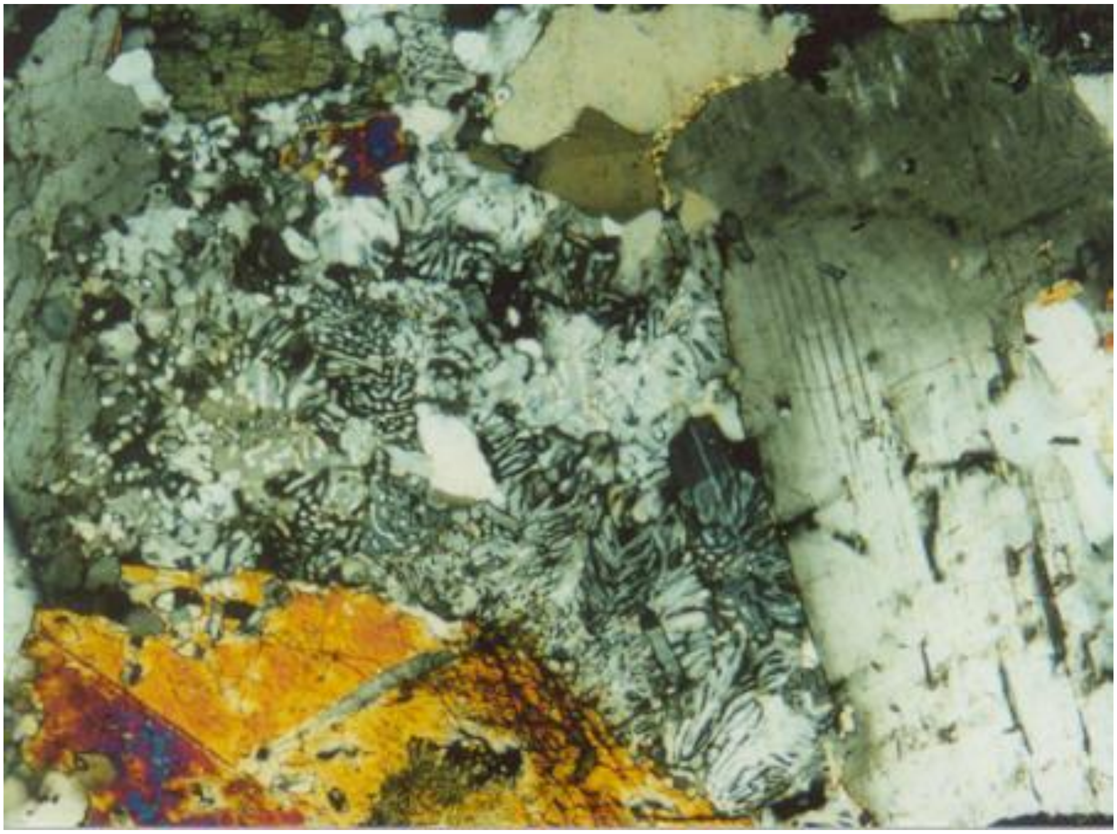

Fig. 2. Aggregates of myrmekite (left side) formed around the plagioclase crystals (right side; albite twinned; white and gray) in diorite, which may have resulted from Ca-metasomatism of sodic plagioclase. (Quartz (cream; white). Biotite (brown). See also similar aggregates of myrmekite formed by Ca-metasomatism of K-feldspar in Finland (Fig. 6 in Collins, 1997b; http://www.csun.edu/~vcgeo005/Nr4CaMyrm.pdf.

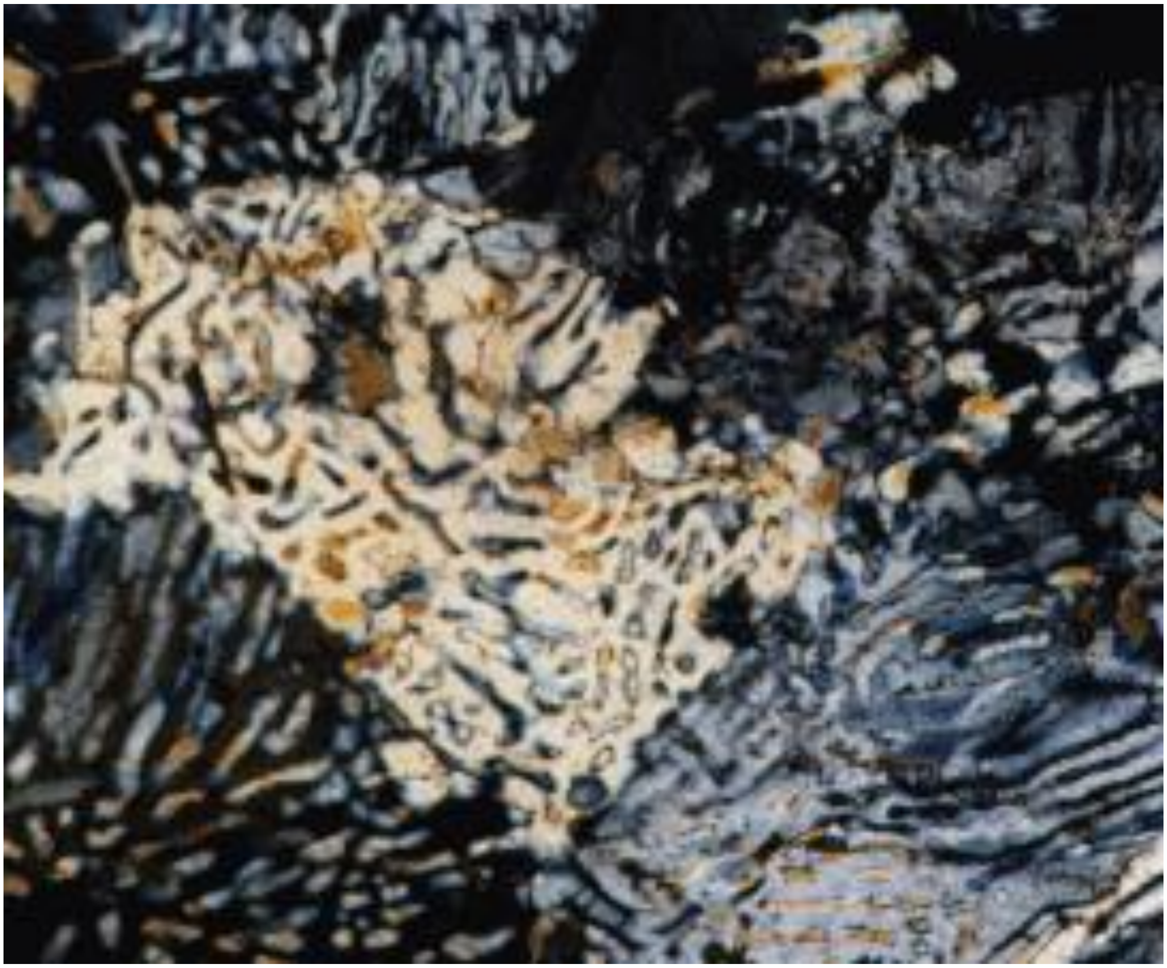

Fig. 6 in Nr4Myrm.pdf. Color photomicrograph showing aggregate masses of myrmekite which fill more than 60 percent of an original K-feldspar megacryst (2 cm long). Image shows only a tiny portion of original K-feldspar crystal.

Myrmekite in granodiorites mostly borders grid-twinned microcline (Fig. 3). In these rocks, microcline has replaced the borders and interiors of albite-twinned plagioclase (Fig. 4).

Fig. 3. Myrmekite bordering grid-twinned microcline in granodiorite.

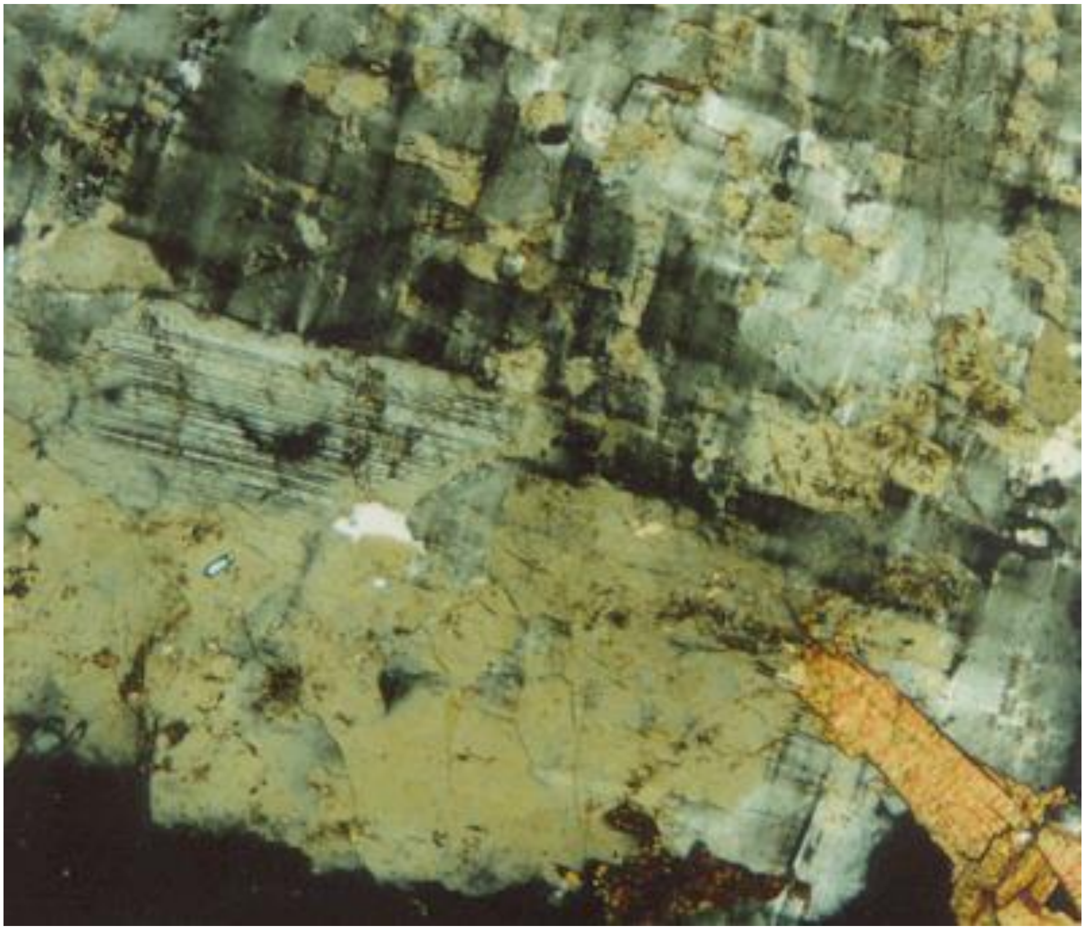

Fig. 4. Replacement of plagioclase (tan; albite-twinned; bottom) by microcline (grid-twinned; dark gray) from border and interior of plagioclase crystal in granodiorite. Note irregular islands of microcline in plagioclase with albite-twinning of the grid-twinning parallel to albite-twinning in plagioclase. Note remnant islands of plagioclase (top) in optical parallel alignment with larger plagioclase crystal at the bottom. Biotite (lower right corner; brown).

Also, irregular islands of microcline occur in the centers of some plagioclase crystals, and remnant plagioclase islands occur in the microcline (Fig. 5 and Fig. 6). So, both K- and Ca-metasomatism have occurred in these rocks. The K-feldspar overgrowth on plagioclase (anti-rapakivi texture) in these rocks provides further evidence for K-metasomatism (Fig. 7).

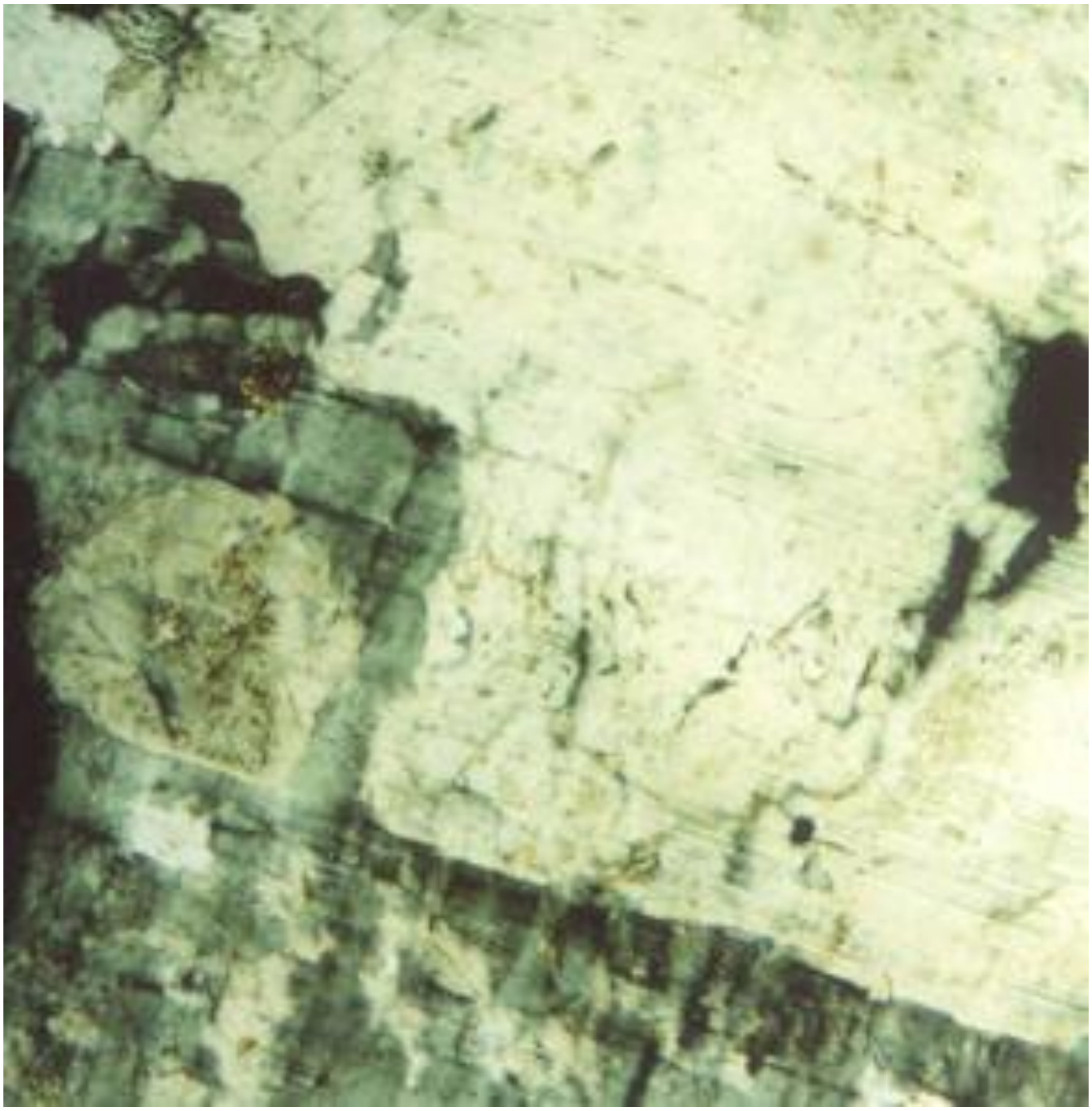

Fig. 5. Remnant plagioclase islands (tan) inside microcline (grid-twinned; gray) in granodiorite. Note that albite-twinning of the grid-twinning is in parallel optical alignment with albite-twinning of the plagioclase (light tan; upper right) and that the plagioclase islands in the microcline are in parallel optical alignment with the larger plagioclase crystal (upper right).

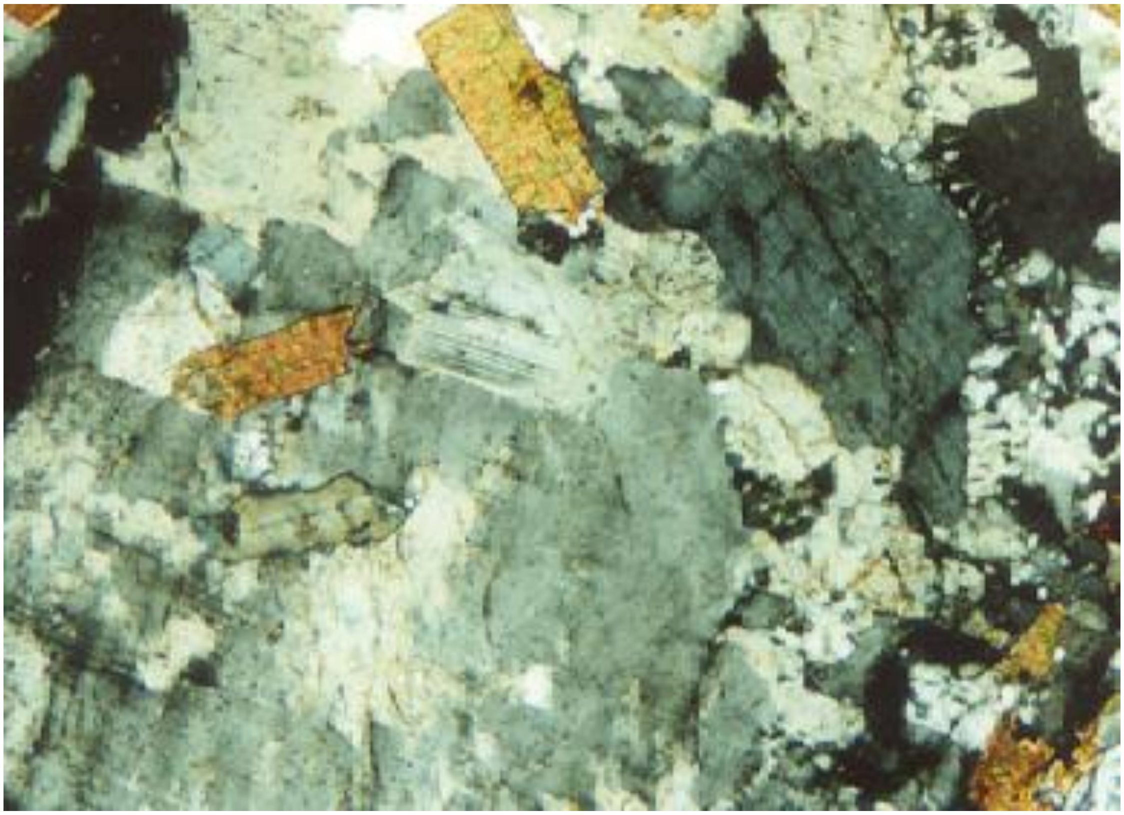

Fig. 6. Irregular plagioclase islands (light tan) in a microcline crystal (grid-twinned; gray) in granodiorite. Islands are in parallel optical continuity. Myrmekite grains (right side). Biotite (brown).

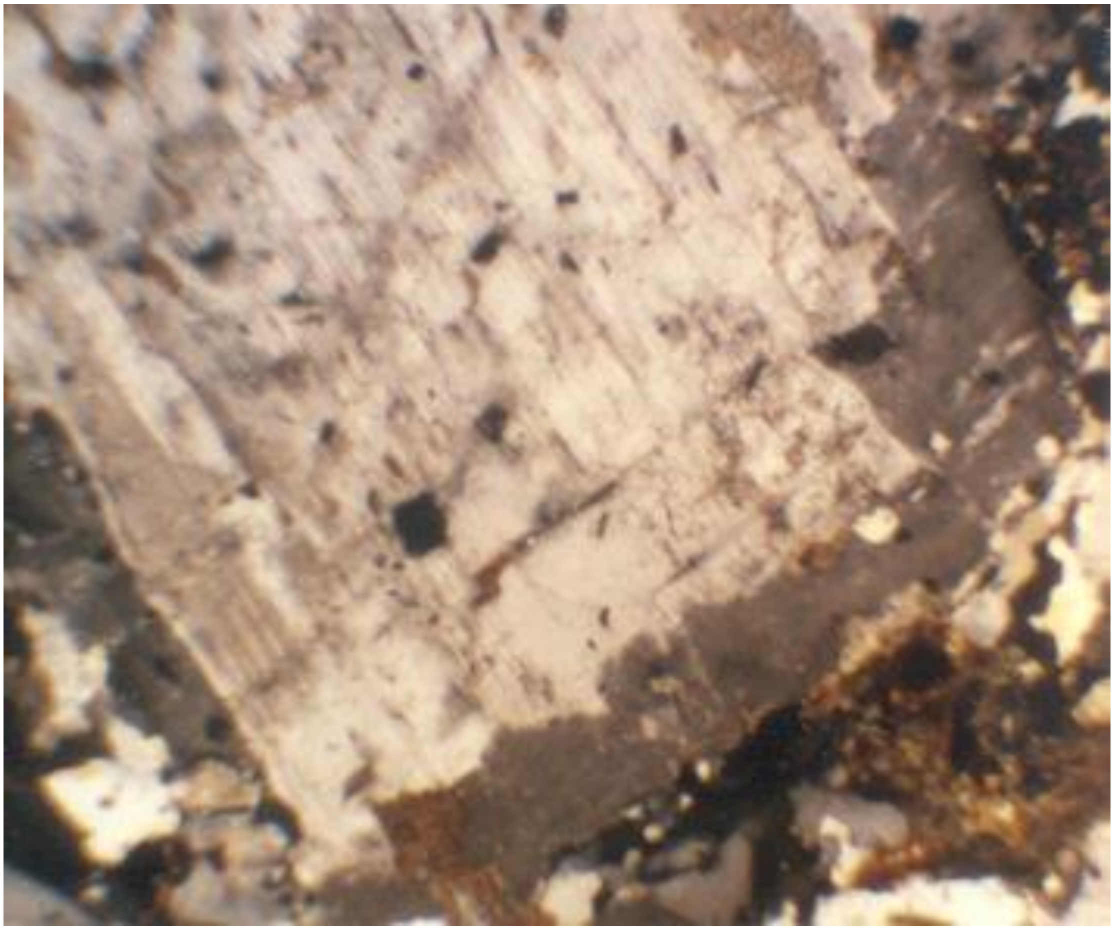

Fig. 7. Overgrowth of secondary K-feldspar (dark gray) on end and sides of albite-twinned plagioclase crystal (light gray). This is anti-rapakivi texture in granodiorite

There is a positive correlation between mylonitic zones and abundance of myrmekite, so that, among the different rock types, myrmekite is most common in mylonitic gneissose granites. Myrmekite in these rocks is unbroken and undeformed, but plagioclase crystals are mostly broken and deformed. Therefore, according to Collins (1997a), this type of myrmekite may have formed by K-metasomatism after deformation processes (Fig. 8).

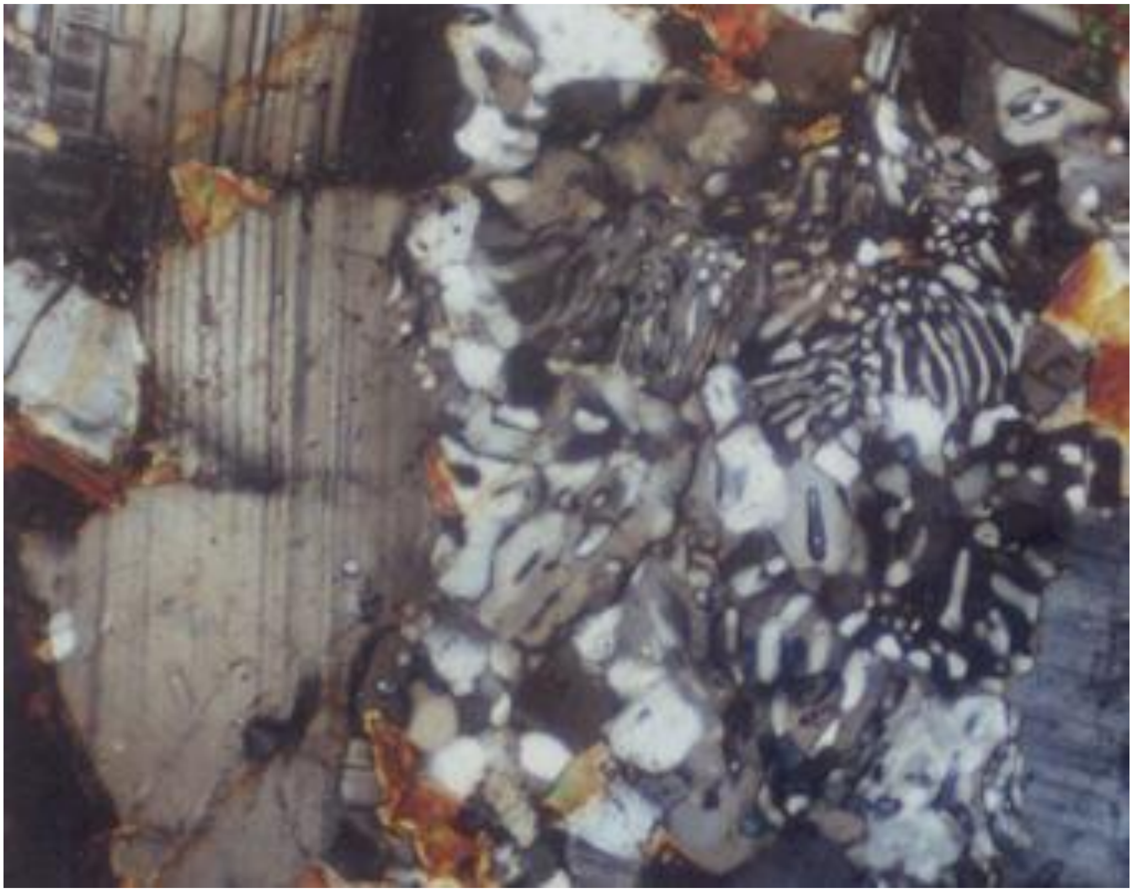

Fig. 8. Unbroken myrmekite adjacent to albite-twinned, deformed and broken plagioclase crystal (left side) in mylonitic gneissic granite.

Micrographic intergrowths of quartz in K-feldspar in micrograntes and leucogranites suggest that these rocks crystallized from magma and that simultaneous crystallization of quartz and K-feldspar probably occurred near the eutectic (Fig.9). String perthite, which occurs in these rocks, is typical of exsolution (Fig. 10).

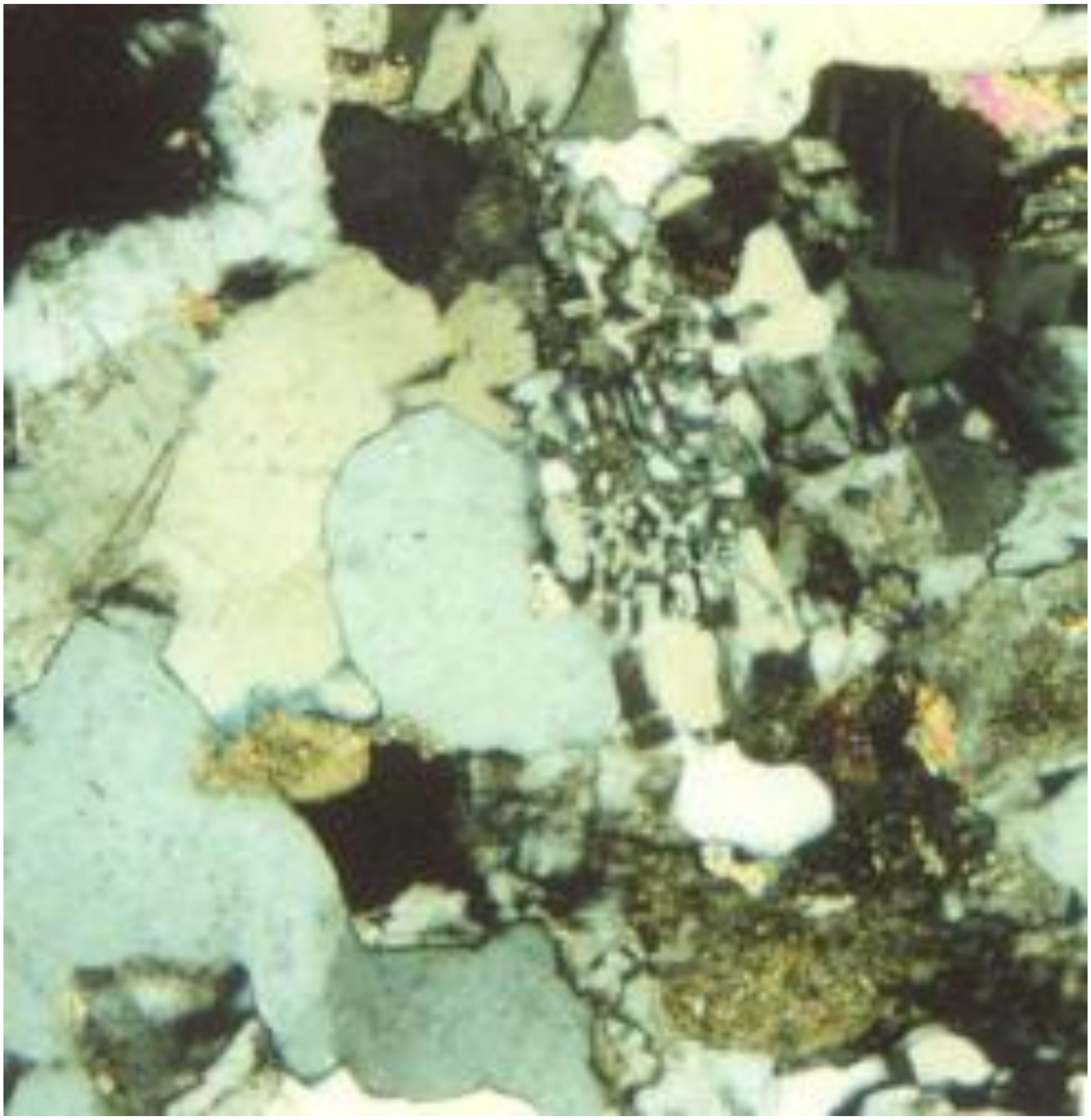

Fig. 9. Micrographic texture formed by eutectic crystallization in microgranite. Quartz (white; cream). Microcline (grid-twinned). Biotite (brown).

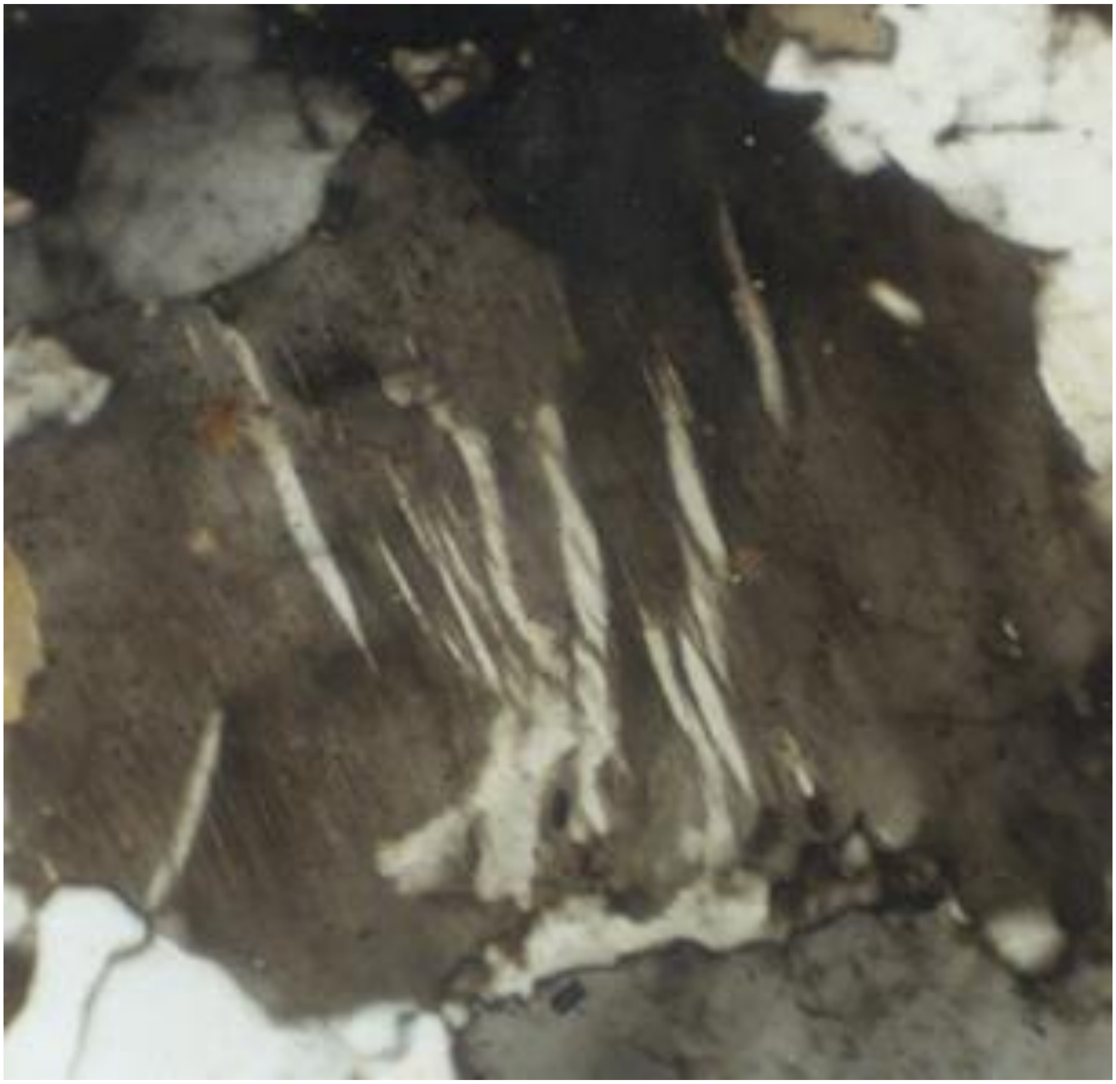

Fig. 10. String perthite formed by exsolution processes in microgranite.

Graphic texture in pegmatites is typical of magmatic intergrowths. Therefore, a magmatic origin is suggested for these rocks (Fig. 11). Perthitic microcline, showing vein (network) plagioclase, is typical of exsolution (unmixing) processes (Fig. 12).

Fig. 11. Graphic texture of runic quartz (white) in perthitic microcline (grid-twinned; dark gray), generated by magmatic processes in pegmatite.

Fig. 12. Vein perthite with albite lamellae (light gray) in microcline (dark gray; grid-twinned), formed by exsolution processes in pegmatite.

Tourmaline-microcline intergrowths in pegmatites may be formed by tourmaline replacement of the microcline crystals. This replacement started from the margins and along fractures in the microcline (Fig. 13 and Fig. 14).

Fig. 13. Hand specimen photograph of feldspar crystals (white), replaced by veins of tourmaline (black), extending along margins and into fractures in the feldspar crystals in pegmatite.

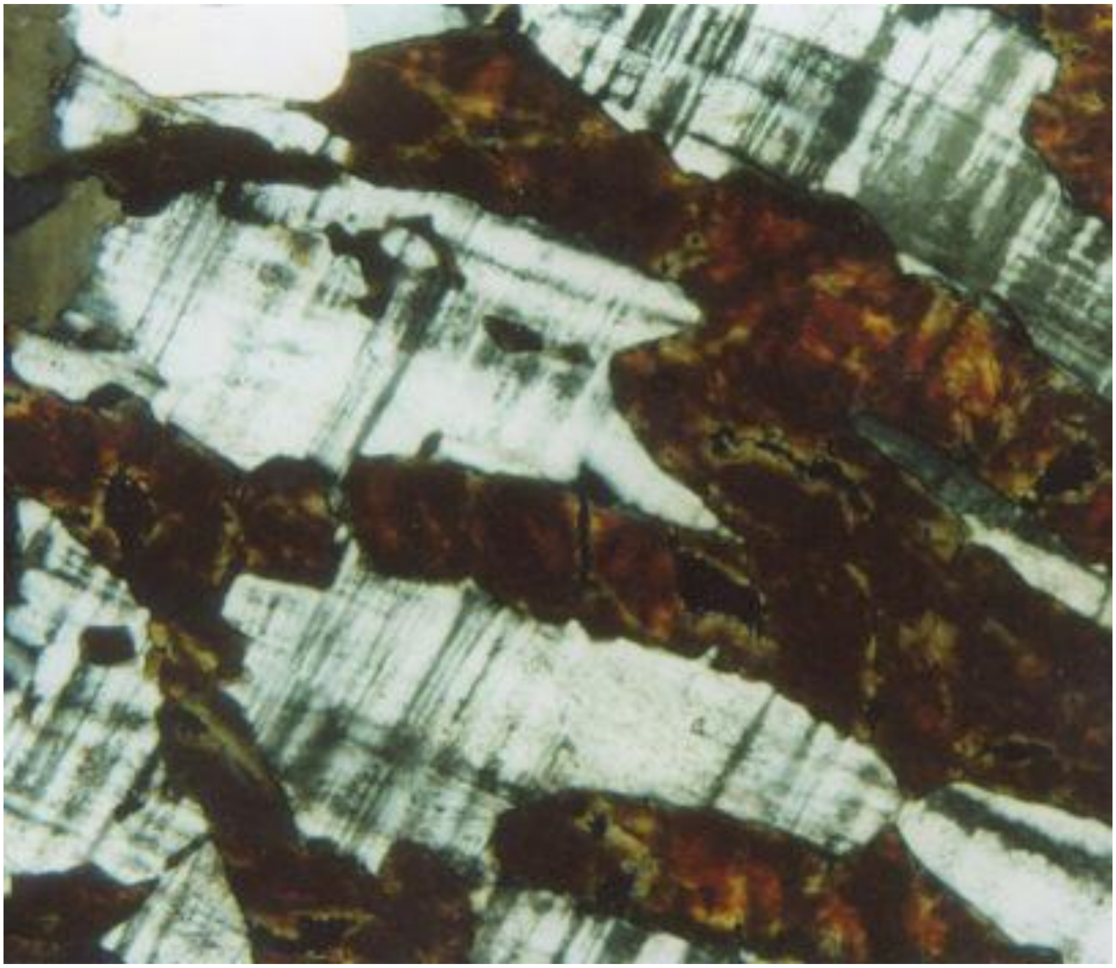

Fig. 14. Photomicrograph of intergrowth of tourmaline (brown) in microcline (grid-twinned) in pegmatite. This intergrowth may have resulted from metasomatic processes.

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