## 21086

# Surface microtopography of pyroxene crystals

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### SUMMARY

The surface microtopography of pyroxene from crystallithoclastic tuff of the nyzhnoantalivs′kyi complex of the Vygorlat-Gutyn ridge (Transcarpathia, Ukraine) has been investigated. Goniometric studies have shown that the crystals have typical simple forms for orthopyroxene. The variety of microrelief surface elements of the orthopyroxene crystals faces with predominant forms of dissolution reflects the change in crystallization conditions. The inclusion of glass in orthopyroxene crystals attests to the rapid cooling of the mineral formation system.

**Introduction.** Pyroxenes are a common group of minerals found in almost all mineralogical complexes and provinces. This group of minerals is mostly studied by petrographic methods. The topic of surface microtopography of the pyroxene crystals is not fully disclosed.

Microtopography surface's studies of the crystal's faces provide a large amount of genetic information about the individual stages of mineral formation. The results of micromorphological analysis in combination with other methods of mineral study allow to create more perfect models of mineral formation processes.

The aim of this work was to analyze the microtopography of orthopyroxene (hyperstene) crystals faces from the tuffs of the Vyhorlat-Hutyn ridge (Transcarpathia, Ukraine). The main object of the study were orthopyroxene crystals from the crystallithoclastic tuff of the nyzhnoantalivsʹkyi complex of the Vygorlat-Gutyn ridge.

**Methods and Theory.** Crystal morphological analysis, microtopography surface's studies and scanning electron microscopy (JSM-6700F, JXA-8200) (Jeol, Japan) were used in the study of the mineral.

The elements of the crystal surface microtopography (microrelief) traditionally include (Feklichev, 1970; Sunagawa, 2007) figures of growth and dissolution, as well as more complex sculptures composed of a larger number of microfaces. The surfaces of real crystals are not smooth, have an uneven structure and are often covered with a large number of flat and curved microfaces. The crystal face microrelief reflects the interface between the crystal structure and the mineral formation environment. The symmetry of simple microrelief forms of a certain origin is the result of the interaction of crystal structure symmetry and environment symmetry.

It should also be noted that the crystal surface microrelief reflects the conditions of the last stage of crystal formation (Feklichev, 1970). When modeling the entire history of crystal formation, it is necessary to take into account the crystal anatomy features - optical, chemical and structural heterogeneity (zonation), inclusions distribution, morphology of zones with different composition and structure, distribution of various defects (cracks, blocks, dislocations, etc.).

**Results.** Orthopyroxene is represented by well-faceted mostly translucent elongated prismatic single crystals and their intergrowths ranging in size from 1 to 7 mm, dark greenish and brownish in color, occasionally - isometric crystals. Goniometric studies (Kvasnytsia and Shemyakina, 2011) (goniometer GD-1) on orthopyroxene crystals revealed the following simple forms: habitus - {100}, {010}, {110}, {210} and {122} (Fig. 1a); rare secondary, developed on the crystal heads - {121}, {362}, {342}, {111}, {551}, {212}, {211} and {102}; rare secondary developed in the vertical belt - {120}, {130}, {140}, {150}, {230}, {310}, {320}, {510}, {520}, {560}, {570}, {650}, {910}, {1.11.0}, {1.19.0}, {10.11.0}, {11.10.0}, {13.10.0}.

The morphology of orthopyroxene crystals is quite diverse: the most common are elongated prismatic crystals, isometric and short-prismatic crystals are very rare (Figure 1). There are also single, close to isometric shapes like "melted" crystals. A characteristic feature of orthopyroxene is the formation of parallel and irregular intergrowths of different sizes crystals, penetration twins are also observed.

Examination by electron microscopy of polished sections of orthopyroxene crystals showed that the mineral contains a number of irregular shape glass inclusions.

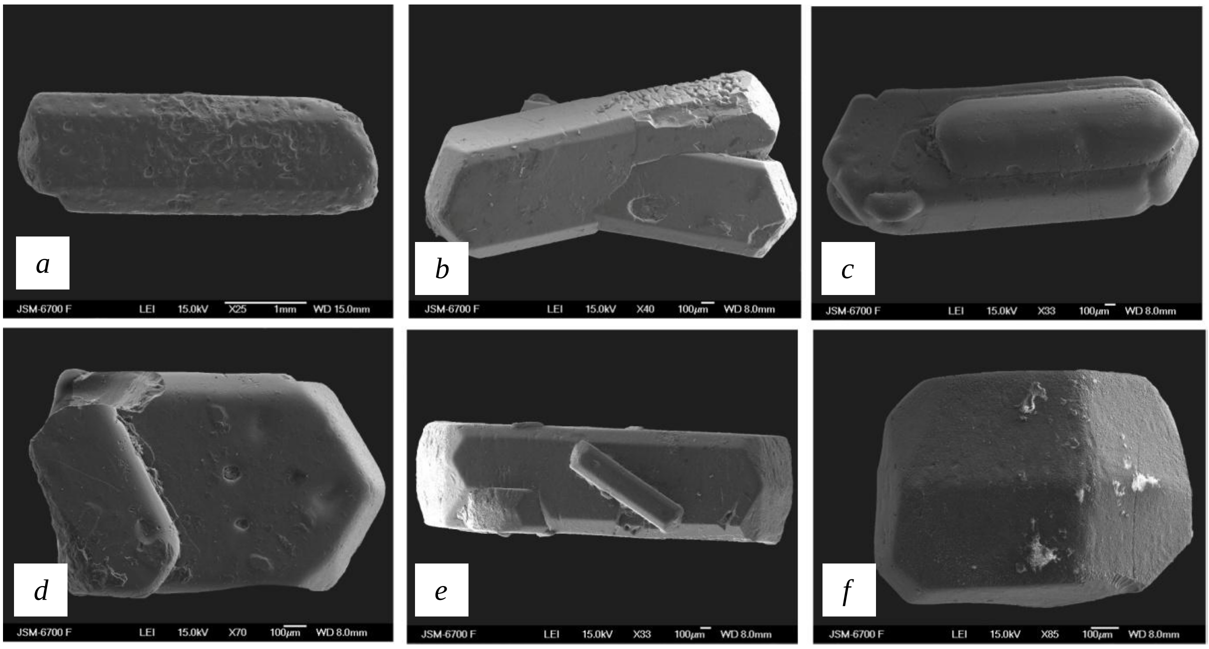


***Figure 1*** *Types of orthopyroxene crystals and their intergrowths from tuffs of Vyhorlat-Hutyn ridge (Transcarpathia, Ukraine): a - pinacoidal-prismatic (columnar); b - irregular intergrowth of two crystals; c - parallel growth of several crystals; d - irregular intergrowth of "melted" crystals; e- twin crystals with an angle of 45° between individuals along the axis [001]; f - isometric crystal. SEM images.*

The surfaces of orthopyroxene crystals are characterized by a variety of morphology. The following types of surfaces are represented on the faces of crystals - idiomorphic, xenomorphic (imprinted) and surfaces bearing traces of partial melting. The relief of the surfaces of different simple shapes differs (Figure 2), the greatest diversity is inherent in the faces developed on the crystal heads.

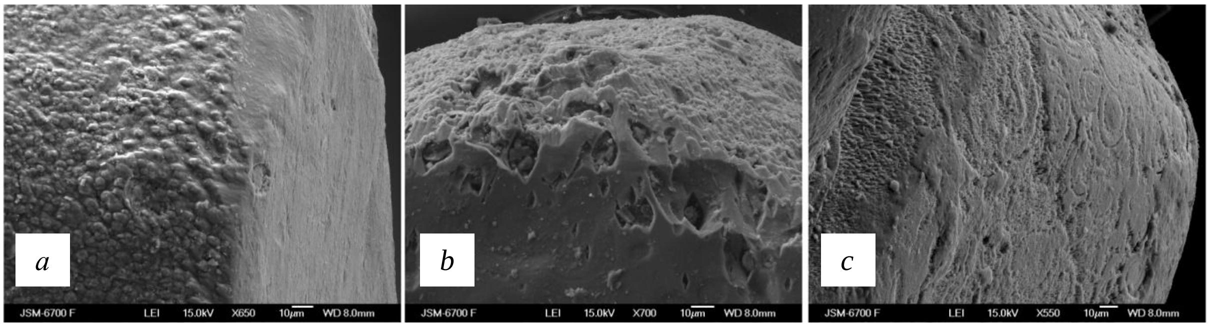


***Figure 2*** *Faces of orthopyroxene crystals and their characteristic surface micromorphology elements: a - growth forms of relief; b - xenomorphic surface of the face and dissolution forms on it; c - growth layers and dissolution patterns on the face. SEM images.*

The following forms of surface relief are observed at the macro level: rounded holes-prints of other crystals (magnetite), uneven small protrusions and depressions, deep intersecting channels. Xenomorphic surfaces are characterized by rounded holes-imprints from inclusions of isometric magnetite crystals, reaching a size in diameter up to 200µm, most often - 100µm.

Growth forms of idiomorphic surfaces are represented by various morphologically hypsometrically higher formations (Figure 3): steps and hillocks of different configuration. The most interesting type of relief is one that formed from small parallel wedge-shaped hillocks (1 µm in elongation) (Figure 3, c). These hillocks form as an almost flat surface as well as a peculiar pattern of smooth and uneven surfaces, depressions and protrusions. The protrusions themselves have a fairly smooth surface. In addition to the patterned and smooth surface, they also form a stepped relief. Apparently, this type of relief is a reflection of the layered growth of the face; it is possible to distinguish at least four layers formed by wedge-shaped protrusions.

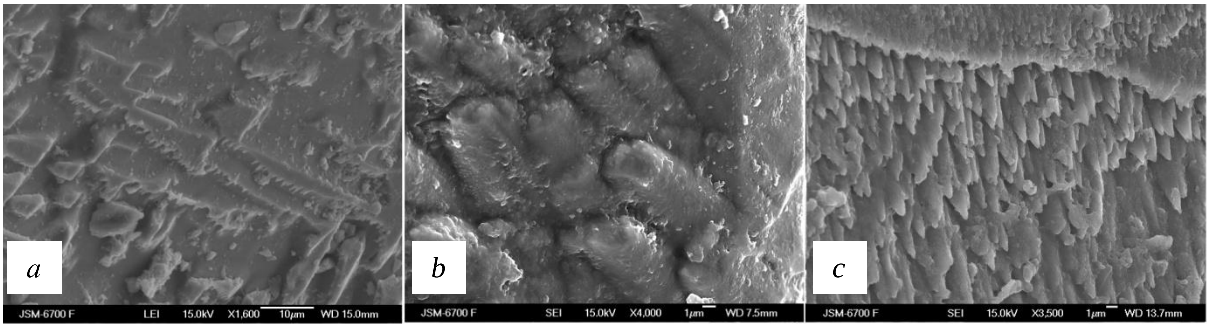


***Figure 3*** *Various growth accessories observed on the surface of the orthopyroxene faces: a, b - step patterns; c - growth hillocks and growth layers are formed by them. SEM images.*

Forms of dissolution of idiomorphic surfaces are represented by wedge-shaped grooves (Figure 4, a) and deep channels (Figure 4, e). At high magnifications, they look like rows of protrusions with a complex structure of their slopes (Figure 4, b-d). Elongated wedge-shaped depressions form the dissolution form on the face of the prism (Figure 4, a). The formation of secondary minerals which fill the formed cavities in some areas of dissolution is observed (Figure 4, e, f).

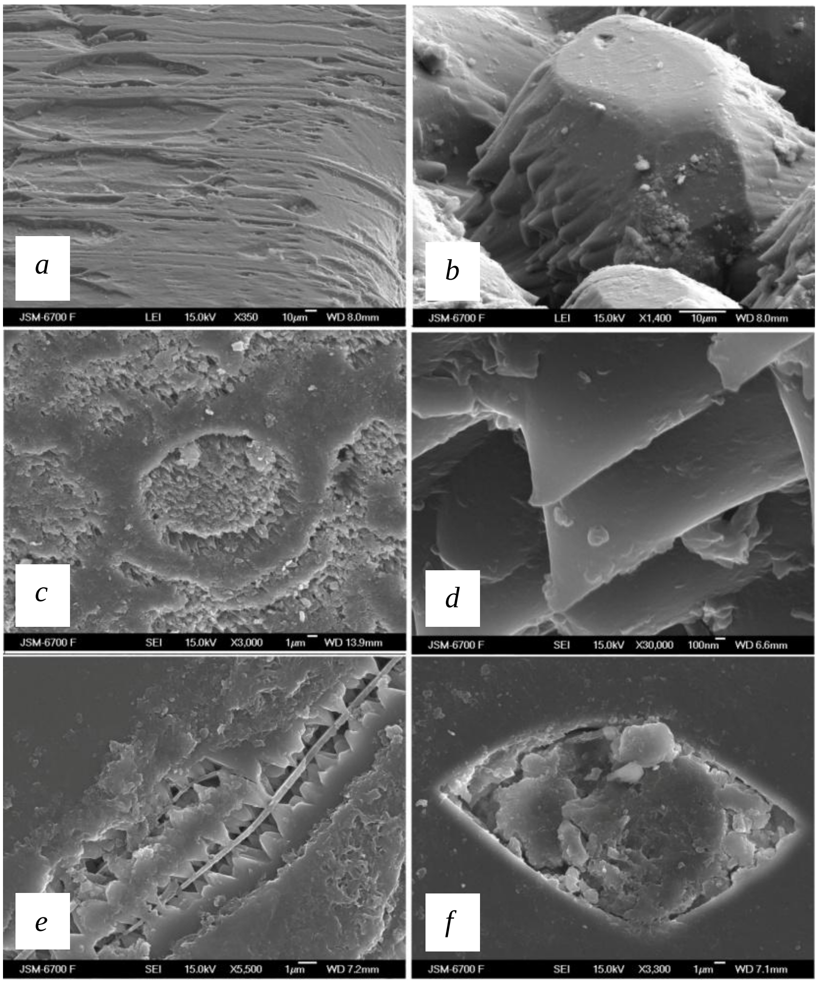


***Figure 4*** *Elements of micromorphology of the orthopyroxene crystal's surface: a - dissolution wedge-shaped forms; b - detail of dissolution channels; c, d - wedge-shaped protrusions and pattern that*

*they form on the crystal surface; e, f - secondary minerals in the cavities formed due to dissolution. SEM images.*

**Conclusions.** Goniometric studies have shown that the crystals have typical simple forms for orthopyroxene. The presence of two main morphological types of crystals (with clear and smoothed edges) with a subordinate number of the latter indicates a change in the degree of saturation of the melt during the crystallization of orthopyroxene. The variety of microrelief surface elements of the orthopyroxene crystals faces with predominant forms of dissolution also reflects the change in crystallization conditions. The inclusion of glass in orthopyroxene crystals attests to the rapid cooling of the mineral formation system.

## References

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