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Some observations on plagioclase twinning in El-Ineigi granites, Eastern Desert, Egypt

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ABSTRACT

Plagioclase from granites of Gabal El-Ineigi, Eastern Desert, Egypt exhibits most commonly albite and Manebach twinning. Carlsbad and acline (pericline) twinning plagioclase crystals are less common. The characteristics of the twinned plagioclase crystals show that the Manebach twinning is of primary origin, and that the albite twins are of secondary origin.

INTRODUCTION

Gabal El-Ineigi (Fig. 1) is one of several granitic plutons widely distributed in the Eastern Desert of Egypt, and grouped collectively as Younger Granites (El-Ramly & Akaad 1960), as Late Orogenic plutonites (Sabet 1961, 1972; El-Shazly, 1964), and as Younger granitoids (El-Ramly 1972).

The geology of El-Ineigi area has been recently studied by Heikal (1973). El-Ineigi pluton is emplaced into country rocks of schists, serpentinites and dioritic rocks, traversed by some post-granite dykes, pegmatites and quartz veins. Petrographic studies (Heikal, 1973) show that El-Ineigi granites are either porphyritic or even-grained. In both types, potash feldspar dominates over plagioclase. On the average, the volume percentages of minerals are: K-feldspar 43, plagioclase 28, quartz 25, biotite 3 and accessory minerals 1.

In the present study of the plagioclase twinning of El-Ineigi granites, twins as well as composition are optically determined by using a three-axis universal stage according to the procedure and reference curves set out by Slemmons (1961). More recent curves by Burri *et al.* (1967) were also used.

GENERAL CHARACTERISTICS

Plagioclase feldspars of El-Ineigi granites tend to occur as rectangular, subhedral to anhedral crystals. They range in composition between An_0–An_{15}, but are mostly less than An_{10} and average An_6. Some of these plagioclase crystals are zoned (normal zoning and rarely oscillatory zoning). Zoning is considered as a primary feature, i.e., developed during the formation of the crystal (Vance 1961). This is supported by the

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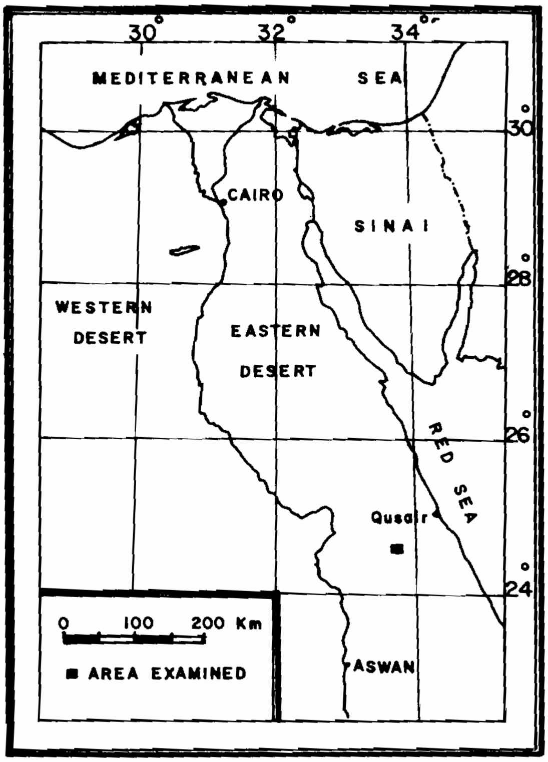

Fig. 1. Location map of El-Ineigi area, Eastern Desert, Egypt.

parallelism of the zones to the crystal outlines (Figs 2, 3, 7). Intergrowths with mutually parallel (001) and (010) faces are common. Most plagioclase crystals are clear and fresh. The larger ones are sometimes clouded, with alteration mostly confined to the core of the crystal giving rise to the core and rim structure (Figs 3, 7). Deformation of the granite pluton is clearly reflected in the constituent minerals (bending biotite flakes, granulation and deformation lamellae in plagioclase, strong undulose extinction, anomalous optical properties and deformation lamellae in quartz). In some places intense deformation is indicated by bent and ruptured plagioclase crystals with the fractures filled with quartz in optical continuity with groundmass quartz.

PLAGIOCLASE TWINS

Plagioclase twins are either primary, formed simultaneously with the formation of the crystal, or secondary, formed later than the formation of the crystal. Several workers (e.g. Gorai 1951) consider primary plagioclase twins as a significant rock property which can be used in interpreting the petrogenesis of the rock. Secondary twins have no bearing on the genesis of the rock. In making petrogenic interpretations based on twinning of plagioclase, observations should be made on primary twins.

In El-Ineigi plagioclase, albite twinning is by far the most abundant law, followed by Manebach law. Carlsbad and acline (pericline) twins are rarely observed. Most plagioclase crystals are twinned according to a single twin law, whereas crystals following more than one twin law are rare. Criteria used in this study to distinguish primary from secondary twins are from Vance (1961), Seifert (1964), Vernon (1965), Cannon (1966) and Spry (1969).

CRITERIA FOR TWINNING

Primary

(1) Primary twinning is usually simple with lamellae of equal width or, less often, multiple consisting of a few broad lamellae generally of unequal width. Lamellae are usually rather broad and coarse; they often change width or terminate abruptly and irregularly. Individual lamellae terminate independently of each other and without relation to later bending or fracture.

(2) The occurrence of re-entrant angles at the twin boundary is logically interpreted as a primary feature, otherwise a 'mysterious diminution in volume of part of the crystal—an exceedingly unlikely occurrence—must be invoked if the lamellae are considered to be secondary' (Vance 1961, p. 1102).

(3) Plagioclase crystals containing primary twinning are usually larger than plagioclase crystals without primary twins and size differences are sometimes considerable. The largest difference in dimension is normally parallel to the primary twin composition plane. This is because crystals containing growth twinning grow faster than crystals without growth twinning. The rate of crystal growth is enhanced at the re-entrant angle between twin lamellae compared to the normal edges of the crystals.

(4) Euhedral plagioclase crystal form (or zoning) show mirror image relationships, sometimes complex, on either side of primary twinning composition planes. This feature results from the addition of material to the growing crystal equally on either side of the composition face.

(5) Large steps may occur along primary composition faces either singly in opposed pairs or in other combinations causing abrupt and irregular changes in lamellae width always independently of each other and of deformation in the crystal.

(6) Euhedral zoning in plagioclase, i.e., zones parallel to the external crystallographic faces, is a primary feature; powerful evidence supports this view (Vance 1961; Cannon 1966). In plagioclase with primary twins, such zoning, as well as cleavage and crystal faces must show a deflection at each twin boundary (Vance 1961, Fig. 1).

Secondary

(1) Secondary twinning is usually polysynthetic with numerous fine lamellae of more or less equal width. Lamellae are slender and may be extremely fine. They are usually very regular and may traverse the entire grain with uniform thickness. The probability that primary lamellae would be nucleated simultaneously on both sides of a growing crystal rhythmically, as is required to explain these lamellae, is exceedingly low.

(2) Lamellae thicken and thin gradually and regularly, in unison, and in the same direction, often in conjunction with bending of the crystal.

(3) Lamellae terminate regularly as long tapering points which are often localized in areas of bending and may be bent themselves.

(4) Termination of lamellae across fractures is common. When lamellae continue across fractures or cracks, they fail to match either in number, width, or relative

Fig. 2. A zoned plagioclase crystal with simple Manebach twinning. Notice the re-entrant angles and the large steps along the composition face. Crossed polarisers. ×30.

distribution across them. These fractures and cracks permit a different mechanical response to deformation in the separated parts of the crystal.

MANEBACH TWINS

Manebach twins in El-Ineigi granites exhibit the following characteristics, which indicate that they are primary twins:

(1) Twinning is simple with nearly equal-sized individuals (Figs 2, 3). Multiple twinning with three individuals is very rare.

(2) The occurrence of re-entrant angles at the twin boundaries of El-Ineigi Manebach twins (Fig. 2).

(3) Plagioclase crystals with Manebach twins are commonly larger than those with other kinds of twinning. The largest dimensions of these crystals are parallel to the Manebach composition face.

(4) El-Ineigi Manebach twins exhibit a mirror image form on either side of the composition face (Figs 2, 3).

(5) Large steps having a random spacing and various heights are commonly observed along composition faces of Manebach twins and normal to them (Fig. 2).

(6) In zoned crystals with Manebach twins, the zones are parallel to the crystal outlines (Figs 2, 3) and are usually deflected at the composition face (Fig. 3). Also the (010) cleavage shifts abruptly at the twin plane.

Fig. 3. Simple Manebach twinning dividing a zoned plagioclase crystal into two roughly equal parts. Notice that the crystal morphology developed in a complex mirror image form on either side of Manebach twinning (top of the crystal). Zoning parallels the external outlines and deflects at the Manebach composition face. Crossed polarisers. ×80.

(7) According to Seifert (1964), the paucity of zoning in plagioclase from El-Ineigi granites would indicate that any primary twinning present should be simple with dominantly equal-sized lamellae, which is the case with Manebach twins.

ALBITE TWINS

The following characteristics of the albite twins in El-Ineigi granites indicate that they are secondary deformation twins.

(1) Albite twinning is polysynthetic with numerous lamellae (Fig. 4).

(2) Lamellae thickness is essentially uniform within each set of lamellae or for all lamellae in individual grains (Fig. 4). Lamellae tend to be slender and may be extremely fine and traverse the entire grain with uniform thickness.

(3) The lamellae sometimes taper to very long fine points which commonly transect the direction of the usual composition plane (010) at a slight angle (Fig. 5).

(4) Lamellae often terminate at planes of discontinuity within the crystal (e.g. cracks) and fail to match on either side of them (Fig. 4).

(5) Lamellae may thin out or wedge in the same direction in conjunction with bending of the crystal (Figs 5, 6).

(6) Vance (1961) described deformation twinning in which one end of a plagioclase crystal has many deformation lamellae which merge toward the other end of the

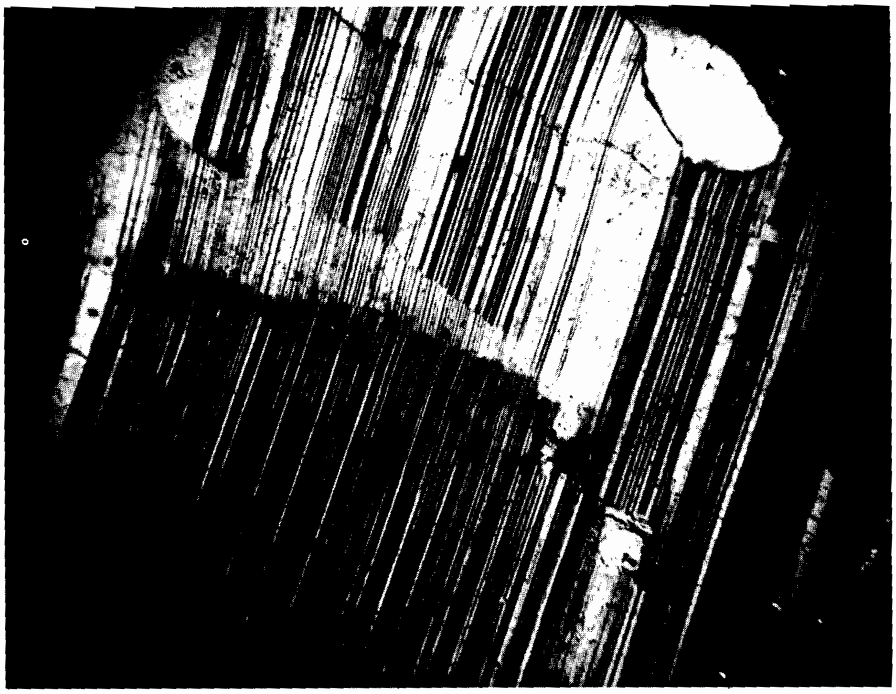

Fig. 4. A plagioclase crystal showing numerous twin lamellae with approximately uniform thickness. The twin lamellae terminate at the observed cracks. Crossed polarisers. ×45.

crystal into one broad lamella in a new twin position. This characteristic in plagioclase from El-Ineigi granites is shown in Figs 5 and 6.

With respect to the origin of deformation twins, Vance (1961, p. 1112) suggested and compiled the processes which have been invoked to account for the stresses producing them. It is argued that deformation of the plagioclase of El-Ineigi granites was caused by forces external to the rock, because petrographic and field evidences indicate that the granite has been subjected to deformation (Heikal 1973). The development of deformation twins may have obscured the presence of any primary albite twinning or any primary twinning with (010) as a composition face.

OTHER TWINS

Other types of twinning observed in El-Ineigi granites are Carlsbad and acline (pericline). The rare occurrences of these twins render the generalization of their characteristics and consequently their grouping with either primary or secondary twins difficult. However, one megacryst was observed which is simply twinned according to the Carlsbad law and shows features of primary twinning (Fig. 7).

CONCLUSION

The plagioclase crystals of El-Ineigi granitic pluton exhibit abundant albite and Manebach twin laws and rare Carlsbad and pericline (acline) twins. The Manebach twins, as

Fig. 5. A plagioclase crystal with deformation twin lamellae tapering in the same direction in conjunction with the bending of the crystal. The crystal shows incipient merging of some twin lamellae into one broad lamella. Crossed polarisers. ×45.

Fig. 6. A plagioclase crystal showing deformation twin lamellae merging into one broad lamella. Crossed polarisers. ×124.

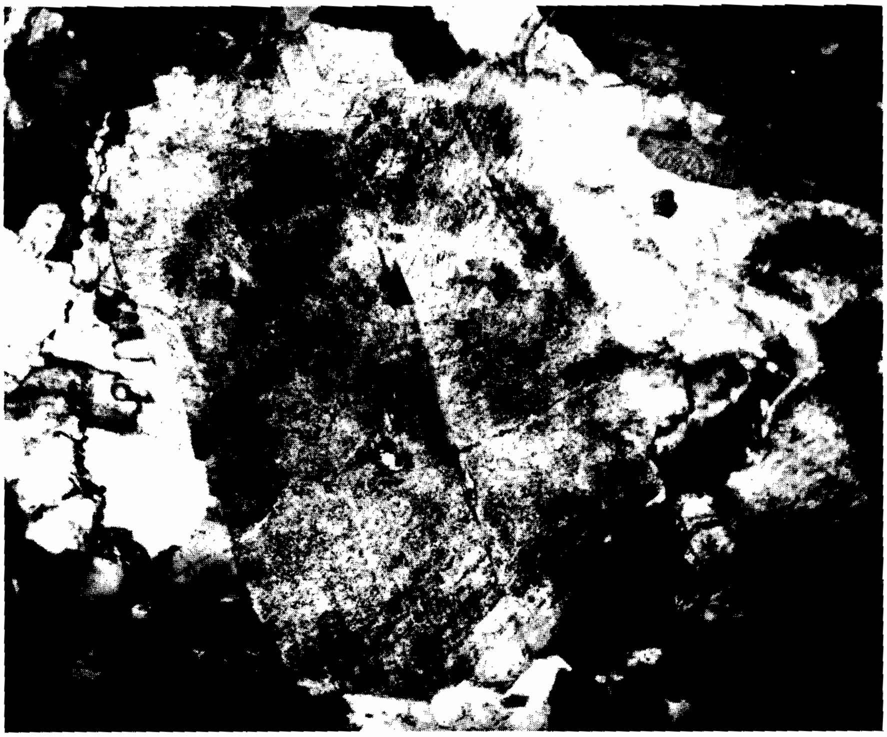

Fig. 7. Simple Carlsbad twinning dividing a zoned plagioclase crystal into roughly equal parts. Zoning parallels the external outlines and deflects the composition plane. Notice the re-entrant angles along the Carlsbad composition face. Crossed polarisers. ×45.

well as one Carlsbad twin, have the characteristics of primary twins. Albite twins show the characteristics of secondary deformation twins formed by deformation of the granites. Primary and secondary plagioclase twins have been recognized in the same rock and even in the same thin section. Nevertheless, only primary twinning is considered as a significant rock property from the point of view of petrogenesis. In using the plagioclase twins in the petrogenic interpretation of granitic rocks, discrimination must be made between primary and secondary twins by criteria such as those mentioned.

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ملخص لبعض المشاهدات على توأمية معادن البلاجيوكلاز في صخور العنيجى الجرانيتية بالصحراء الشرقية بمصر

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خلاصة

يتناول هذا البحث دراسة القوانين التوأمية لمعادن البلاجيوكلاز المتواجدة في الصخور الجرانيتية بجبل العنيجى بالصحراء الشرقية المصرية . تتبع الغالبية العظمى من هذه المعادن في توأميتها قانوني الالبيت والمانيباخ . أما قانوني الكارلسباد والاكلين (بركلين) فهما نادران . تظهر خصائص هذه التوأميات أن قانون المانيباخ قد تكون في بلورات البلاجيوكلاز أثناء تكونها أى أنه أولى . أما قانون الالبيت فقد تكون في فترة لاحقة نتيجة لعمليات التشوه التى حدثت للصخور الجرانيتية ، أى أنه ثانوى . ولذلك عند دراسة توأمية معادن البلاجيوكلاز على أنها صفة أساسية للصخر الذى تتواجد فيه ، فان هذه الدراسة يجب أن تكون مقصورة على قوانين التوأمية الأولية .

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